

Profiles of Contextual Risk at Birth and Adolescent Substance Use

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Compliance with Ethical Standards:

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The study was approved by the ethical committees of the Northern Ostrobothnia Hospital District and the University of Oulu.

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This study examined whether there are subgroups of families with distinct profiles of prenatal/birth contextual risk, and whether subgroup membership was differentially related to adolescent substance use. Data from the Northern Finland Birth Cohort 1986 were used. A five-class model provided the most meaningful solution. Large Family Size (7.72%) and Low Risk (69.69%) groups had the lowest levels of alcohol, cigarette, and illegal drug use. Similar high levels for each of the three substance-related outcomes were found for Parent Substance Misuse (11.20%), Maternal School Dropout (4.66%), and Socioeconomic Disadvantage (6.72%) groups. Maternal smoking and drinking while pregnant and paternal heavy alcohol use were found to be key prenatal risk factors that tended to cluster together and co-occur with other prenatal risk factors differently for different subgroups of youth.

Keywords: Contextual Risk, Adolescent Substance Use, Birth Cohort, Person-Centered, Latent Class Analysis

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It is well-documented that contextual risk factors for adolescent substance-related problems tend to co-occur (Evans, Li, & Sepanski Whipple, 2013). Less clear is how risk factors such as economic disadvantage, teenage pregnancy, poor educational attainment by parents, and parent substance misuse cluster together (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001). Improving our understanding of the interrelations among risk factors is potentially important because it can inform the development of tailored interventions that better address the specific needs of youth and their families (Jobe-Shields, Andrews, Parra, & Williams, 2015).

There likely is considerable heterogeneity among youth in terms of their exposure to different contextual risk factors (Copeland, Shanahan, Costello, & Angold, 2009). A person-centered framework offers a promising approach for investigating the co-occurrence among contextual risk factors (Lanza, Rhoades, Greenberg, Cox, & The Family Life Project Key Investigators, 2011). This perspective focuses on similarities and differences among people as opposed to relations among variables as in a more traditional variable-centered framework (Magnusson, 2003). The primary goal of a person-centered approach (PCA) is to identify subgroups of individuals with distinctive profiles of risk characteristics (Jobe-Shields et al., 2015). A key feature of a PCA is that subgroup membership is not known and must be inferred from the data (Berlin, Williams, & Parra, 2014).

There has been increased attention to person-centered methods for studying risk factors for child and adolescent psychosocial difficulties (Abner, 2014; Brody et al., 2013; Bowen, Lee, & Weller, 2007; Cavanaugh, Petras, & Martins, 2015; Copeland et al., 2009; Dunn et al., 2011; Gorman-Smith, Tolan, & Henry, 2000; Hendryx et al., 2014; Jobe-Shields et al., 2015; Lanza et al., 2011; Lanza, Rhoades, Nix, Greenberg, & The Conduct Problems Prevention Research

Group, 2010; McFeeters, Boyda, & O'Neill, 2015; Menard, Bandeen-Roche, & Chilcoat, 2004; Oliver, Kretschmer, Maughan, 2014; Parra, DuBois, & Sher, 2006; Roy & Raver, 2014; Shevlin & Elklit, 2008; Zeides, Roosa, Knight, & Gonzales, 2013). Results from this work tend to support the hypothesis that there are subgroups of youth with unique profiles of risk factors. Similarities and differences regarding the number of subgroups and their corresponding risk profiles are evident across studies. The number of subgroups ranged from three (e.g., Zeides et al., 2013) to six (e.g., Copeland et al., 2009). Two types of subgroups were found in all studies: a low-risk subgroup characterized by low endorsement rates for all risk factors and a high-risk subgroup characterized by relatively high endorsement rates for multiple risk factors.

A socioeconomic disadvantage subgroup characterized by relatively high endorsement rates for risk factors such as economic disadvantage and low levels of educational attainment by parents was evident in several studies (e.g., Copeland et al., 2009; Hendryx et al., 2014; Lanza et al., 2011). In addition, some studies found subgroups characterized by relatively high endorsement rates for parent psychosocial difficulties including substance misuse (Cavanaugh et al., 2015; Copeland et al., 2009; Lanza et al., 2010; Menard et al., 2004; Roy & Raver, 2014). Certain risk profiles were unique to particular studies. For example, Dunn et al (2011) found an “atypical parenting from both parents” subgroup characterized by a range of negative parenting practices (lax, inconsistent, very strict, “cruel-to-be-kind”). Given the relatively small number of studies that have been conducted in this area, additional research is needed to better understand which risk profiles are common across samples and can be generalized to the larger population and which are more sample specific.

There are several ways to build on prior work that uses a PCA to examine the co-occurrence of risk factors for youth adjustment outcomes. One way is to use large representative

samples (e.g., Cavanaugh et al., 2015; Parra et al., 2006). The prevalence of each risk factor in those samples should represent population rates. They thus capture population-level variation in youths' exposure to risk and likely provide the best estimates of the co-occurrence among risk factors. Relatedly, most risk profile research has used U.S. samples (for exceptions, see Dunn et al., 2011; McFeeters et al., 2015; Oliver et al., 2014). Use of large representative samples from countries outside of the U.S. would provide an opportunity to compare risk profiles across countries and possibly identify cultural differences in risk processes. Large samples are particularly important in person-centered research because they increase the likelihood that small but potentially meaningful subgroups can be identified.

Another way to build on prior risk profile research is to examine risk factors at early developmental periods. Most studies examined risk factors during childhood or adolescence and/or relied on retrospective reports of early life risk. There are three notable exceptions that assessed risk factors prenatally (Hendryx et al., 2014), during infancy (Lanza et al., 2011), between 8 weeks and 4 years (Oliver et al., 2014), and during the preschool years (Roy & Raver, 2014). The examination of risk factors assessed during the prenatal period provides a unique opportunity to better understand (a) the initial context of youth and, (b) in long-term longitudinal studies, the impact of initial contextual risk on later emotional and behavioral outcomes.

In addition to trying to identify subgroups of youth with distinct profiles, most research in this area has examined the relation between subgroup membership and the psychosocial functioning of youth and their families. A wide range of outcomes have been considered including quality of the home environment, emotional and behavioral problems, academic performance, self-regulation, post-traumatic stress disorder, heart attack risk, birth weight, and

social functioning. In general, as would be expected, results indicate youth in low-risk subgroups tend to have better adjustment outcomes than those in subgroups with elevated risk status.

Some studies also found nuanced relations between subgroup membership and youth outcomes. For example, Roy and Raver (2014) found that “children who experienced ‘single and stressed’ family settings had more behavioral problems than low-risk children while children who experienced ‘deep poverty and crowded’ family settings had worse academic performance” (p. 391) than low-risk children. A consistent pattern of differences has not been evident when subgroups with different forms of elevated risk profiles were compared with each other although some interesting differences have been found. For example, Copeland and colleagues (2009) found that youth in the “Moderate/Single/Poor/Crime” class were at increased risk for disruptive disorders compared to those in the “Moderate/Uneducated/Poor” class. Additional research is needed to better understand the associations between subgroup membership and youth psychosocial outcomes.

Our review of the literature did not reveal any person-centered risk profile studies that directly examined the relation between subgroup membership and substance-related outcomes. This is an important gap in current knowledge given the public health significance of adolescent substance misuse (Patrick & Schulenberg, 2013). Another way to extend prior research investigating the relation between subgroup membership and adjustment outcomes is to use longitudinal data with a long time span between the assessment of risk and outcomes. This type of longitudinal design can provide particularly strong evidence for the influence of contextual risk factors on psychosocial outcomes, especially if the assessment of contextual risk occurs prior to the onset of adjustment problems.

This study had two goals. One goal was to examine whether subgroups of youth with distinct profiles of prenatal/birth contextual risk factors could be identified. We considered 11 contextual risk factors observed around the time of birth: low birth weight, teenage motherhood, single parent status, multiple unions, large family size, maternal dropout, smoking while pregnant, drinking while pregnant, paternal heavy drinking, economic exclusion, and material deprivation. Based on prior empirical work, it was expected that at least four subgroups would emerge, including low- and high-risk groups as well as a socioeconomic disadvantage group and a parent substance misuse group. A second goal was to compare subgroups on substance-related outcomes during adolescence.

Method

Participants

Data from a large birth cohort (Northern Finland Birth Cohort 1986 Study [NFBC1986]) were used. The NFBC1986 is a general population-based study of individuals born during a one-year period in the two northernmost provinces of Finland. The original NFBC1986 population was defined as births expected between July 1, 1985 and June 30, 1986. Of these, 9,432 children were born alive, representing 98.5% of all deliveries that took place in the target location. For more details on the birth cohort design and data collection, please see Hurtig et al., 2007. The study was approved by the ethical committees of the Northern Ostrobothnia Hospital District and the University of Oulu.

Procedures

Data collected during two developmental periods were utilized: (a) prenatal/birth and (b) middle adolescence. Mothers were given a prenatal background questionnaire at their first antenatal visit to the local prenatal clinic, with instructions to return by their 24th gestational

week. Midwives and/or medical staff at the prenatal clinics completed additional information on pregnancy and delivery. When the participants were age 15-16 (2000 – 2001), they were asked to complete a postal questionnaire on health, living habits, and social background. They also were invited to a clinical examination. During this examination, participants completed a questionnaire on eating habits, stress, sexual behavior, substance use and mental well-being (Hurtig et al., 2007). Written informed consent from parents and assent from adolescents was obtained.

The analysis sample for the current study consists of consented youth in the cohort with data collected during adolescence, for a sample of 6,963 (74% of live births at the outset of the study). Forty-nine percent of the participants in the analysis sample were male, with a mean age of 16.0, ranging from 14.58 to 16.96 years. Attrition analyses comparing the Birth Cohort ($N = 9,432$) to the Analysis Sample for the present study ($N = 6,963$) have been described elsewhere (Miettunen et al., 2014; Parra et al., 2017). Findings indicated that the Analysis Sample was at somewhat lower risk than the Birth Cohort.

Measures

Contextual risk during the prenatal/birth period was measured with eleven indicators. All measures were collected through the pregnancy questionnaire completed by mothers, with the exception of birth weight (provided by medical staff at the time of delivery). The following 11 indicators were selected based on the existing cumulative contextual risk literature (for overview of prior work, see January et al., 2017): low birth weight, teenage motherhood, single parent status, multiple unions, large family size, maternal dropout, smoking while pregnant, drinking while pregnant, paternal heavy drinking, economic exclusion, and material deprivation.

Indicators were coded as 1 to represent presence of risk (as defined below) and as 0 to represent absence of risk.

Low birth weight was coded 1 if the child was born weighing under 2,500 grams (Zegers-Hochschile et al., 2009). *Teenage motherhood* was coded 1 if the mother was 19 or younger when she gave birth to the participant. *Single parent status* was coded 1 if the mother was not married or cohabitating?, widowed?, or divorced? (i.e., sharing a household with a romantic or other partner). *Multiple unions* was coded 1 if the mother had at least one prior registered union, such as marriage or cohabitation (note that this coding assigns zero to two kinds of mothers: those in a first relationship and those with no prior or current relationship). *Large family size* was coded 1 if there were four or more children under age 15 in the household during the prenatal period. *Maternal school dropout* was coded 1 if the mother had completed fewer than 9 years of comprehensive schooling (Grades 1-9). In Finland, 9 years is the length of compulsory education, and dropping out earlier is an indicator of risk for marginalization.

Smoking while pregnant was coded 1 if the mother smoked after the first trimester of pregnancy. If the mother drank alcohol during pregnancy, *drinking while pregnant* was coded 1. *Paternal heavy drinking* was coded 1 if the mother reported that the child's father had five or more alcoholic drinks per typical week. *Economic exclusion* represents the socioeconomic status of the household, and was coded 1 if the highest occupational status of the household adults was either unskilled worker (manual labor), unemployed, or on disability pension. *Material deprivation* was coded 1 if the household had one or none of these four items: washing machine, telephone, flushing toilet, or indoor bathroom.

Three measures of adolescent substance misuse were examined: (a) lifetime drunkenness, (b) current cigarette use, and (c) lifetime illegal drug use. This information was obtained from

adolescent reports. *Lifetime drunkenness* was measured with a question on frequency, “How many times in your life have you been drunk?” with responses coded as: 0 (*never*), 1 (*1-2 times*), 2 (*3-5 times*), 3 (*6-9 times*), 4 (*10-19 times*), 5 (*20-39 times*), and 6 (*40 times or more*). Current *cigarette use* was determined by the question, “Do you smoke now?” with responses coded as 0 (*not at all*), 1 (*occasionally*), 2 (*one day a week*), 3 (*2-4 days a week*), 4 (*5-6 days a week*), and 5 (*7 days a week*). Lifetime *illegal drug use* was measured with three questions about marijuana, hard drugs, or intravenous drug use. Each question used the stem, “Have you ever tried or used any of the following substances”: followed by “marijuana or hashish,” “Ecstasy, heroin, cocaine, amphetamine, LSD or other similar drugs,” or “intravenously injected drugs.” Response options were *never*, *once*, *2-4 times*, *5 times or more*, or *regular user*. These three items were collapsed into a single dichotomous lifetime illegal drug use (1) or non-use (0) variable due to low prevalence rates.

Data Analyses

A latent class analysis (LCA) was conducted using *Mplus* Version 7.31 with the goal of identifying subgroups of adolescents with unique profiles of contextual risk (Muthén & Muthén, 1998 - 2012). The LCA was fit using Full Information Maximum Likelihood estimation with robust standard errors. The eleven dichotomous indicators of contextual risk during the prenatal period were included as indicators of a categorical latent variable. The LCA was conducted by estimating solutions with different numbers of classes. The Akaike Information Criteria (AIC), the Sample Size Adjusted Bayesian Information Criteria (SSA-BIC), the Vuong-Lo-Mendell-Rubin Likelihood Ratio Test (VLMR-LRT), and the Bootstrapped Likelihood Ratio Test (BLRT) along with the substantive meaning of the solutions were used to determine the best fitting

solution (Berlin et al., 2014). The following analysis options were used: STARTS = 2000 80, STITERATIONS = 20, and LRTSTARTS = 2 1 80 16.

Comparisons between subgroup membership and adolescent substance-related outcomes were conducted using the 3-Step Approach developed by Asparouhov and Muthén (2014a, 2014b). Specifically, the Auxiliary function was used and separate analyses were conducted for each of the three substance-related variables. The *bch* command was used for the two continuous variables (lifetime drunkenness and current smoking) and the *dcat* command was used for the categorical lifetime illicit drug use variable.

Results

The prevalence rates for each contextual risk factor were as follows: low birth weight (3.0%), teenage motherhood (3.8%), single parent status (4.4%), multiple unions (5.8%), large family size (8.1%), maternal school dropout (9.7%), smoking while pregnant (14.4%), drinking while pregnant (11.8%), paternal heavy drinking (9.5%), economic exclusion (4.9%), and material deprivation (4.2%). Across all groups, the average Lifetime Drunkenness and Current Cigarette Use scores were $M = 2.41$ ($SD = 2.19$) and $M = 1.05$ ($SD = 1.80$), respectively. The prevalence rate for Lifetime Illicit Drug Use in the sample was 6.1%.

As noted, one goal of the study was to examine whether subgroups of youth with distinct profiles of prenatal contextual risk could be identified. Fit statistics from the LCAs for the two- through six-class solutions are reported in Table 1. Proper solutions for models with seven or more classes could not be obtained. As shown, the SSA-BIC indicated a four-class model was the best fitting solution (had lowest value). The AIC, VLMR-LRT, and BLRT suggested that a six-class model provided the best fit. Examination of the risk configurations for the two- through six-class models suggested that the six-class model did not add a substantively meaningful

subgroup compared to the five-class model. Moreover, one of the subgroups that emerged in the six-class solution only included 1.7% of the sample. Entropy for the four-class model was poor which suggested that individuals were not being classified well into the classes. The five-class model was selected as the best fitting solution because it added a substantively meaningful subgroup compared to the four-class solution. Entropy for the five-class solution was within acceptable limits (.74).

The endorsement probabilities for each contextual risk factor for each class in the five-class solution are reported in Table 2. Unless otherwise noted, values in the table represent the probability that individuals in a given class had a score of “1” on a given risk factor. Bold indicates an endorsement (score of “1”) probability of .20 or higher. Underline indicates that a given endorsement probability was *highest* for that risk factor. The patterns of endorsement probabilities both within and across classes were used to characterize each class. We labeled the five classes as follows: Parent Substance Misuse ($n = 780$; 11.20%), Large Family Size ($n = 538$; 7.72%), Maternal School Dropout ($n = 324$; 4.66%), Low Risk ($n = 4853$; 69.69%), and Socioeconomic Disadvantage ($n = 468$; 6.72%).

The *Parent Substance Misuse* group was characterized by the highest probabilities of mom drinking while pregnant and dad heavy drinking, a high probability of mom smoking while pregnant, and relatively low likelihoods of experiencing any of the other risk factors. The *Large Family Size* was characterized by a 100% likelihood of having a large family size as well as low probabilities for each of the other risk factors. The *Maternal School Dropout* class was characterized by the highest probabilities of mom school dropout and mom smoking while pregnant; relatively high probabilities of multiple unions, mom drinking while pregnant, and dad heavy drinking; and low probabilities of endorsing items that reflect economic disadvantage

(economic exclusion and material deprivation). The *Low Risk* group was by far the largest class (69.69%) and was characterized by low probabilities of experiencing any of the risk factors. The *Socioeconomic Disadvantage* class was characterized by the highest probabilities of economic exclusion, material deprivation, teenage motherhood, and single parent status, but also high probabilities of mom smoking while pregnant, dad heavy drinking, and mom drinking while pregnant.

The second goal of this study was to examine the longitudinal associations between subgroup membership and adolescent substance-related outcomes. As shown in Table 3, differences between subgroups were found for all three substances. Findings indicated that the *Low Risk* and *Large Family Size* groups had lower levels of all substance-related outcomes compared to the three other groups. Significant differences were also found between the *Low Risk* and *Large Family Size* groups. Specifically, the *Large Family Size* group had lower levels of lifetime drunkenness and lifetime illegal drug use compared to the *Low Risk* group. The *Low Risk* group, however, had significantly lower levels of current cigarette use compared to the *Large Family Size* group. The levels and patterns of substance-related outcomes were similar among the three high-risk groups (*Parent Substance Misuse*, *Maternal School Dropout*, and *Socioeconomic Disadvantage*). The only exception to these similarities was that the *Parent Substance Misuse* group was found to have significantly lower levels of current cigarette use compared to the *Maternal School Dropout* group.

Discussion

This study adds to the growing literature that uses person-centered methodology to examine the co-occurrence of contextual factors that place youth at risk for developing psychosocial difficulties. The NFBC1986 provided a unique opportunity to investigate

contextual risk profiles during an early period of human development (prenatal/birth) in a large birth cohort. Moreover, these data allowed us to examine the longitudinal associations between membership in risk groups observed around the time of birth and adolescent substance use assessed approximately 16 years later. Given that relatively few contextual risk studies have used samples from outside of the U.S., the Finnish sample permitted us to interpret the results from a cross-cultural perspective.

Findings indicated that five groups seemed to best represent the co-occurrence among the prenatal/birth contextual risk factors. Four of the groups (*Low Risk*, *Socioeconomic Disadvantage*, *Parent Substance Misuse*, and *Maternal School Dropout* groups) were similar to those found in prior person-centered research. The majority of youth (70%) were best categorized in a *Low Risk* group characterized by a low likelihood of experiencing any of the risk factors. Predictably, this group exhibited low levels of problematic substance use during adolescence.

An interesting finding was the emergence of the *Large Family Size* group characterized by low endorsement rates for all risk factors except large family size. We suspect that, in this population, large family size likely reflects the presence of a religious minority known as Leastadians in Northern Finland (Taanila, Ebeling, Kotimaa, Moilanen, & Jarvelin, 2004). It is a conservative Christian revivalist movement that originates from and remains prominent in Northern Finland. Members of this group tend to have large families and tend to adhere to a strict code of conduct prohibiting such activities as watching television, dancing, and the use of alcohol and other intoxicants. It is therefore understandable that in this cultural context large family size was associated with low levels of adolescent substance use.

Findings related to the *Low Risk* and *Large Family Size* groups indicated that approximately 78% of youth in this Finnish birth cohort were at low risk of misusing substances during adolescence. The remaining 22% of youth exhibited elevated levels of substance use. These latter youth fell into one of three groups. A similarity across these three groups in terms of risk profiles was that they were all characterized by relatively high endorsement rates of parent substance misuse. Maternal smoking and drinking while pregnant and paternal heavy alcohol use were thus key prenatal risk factors that tended to cluster together and co-occur with other prenatal risk factors differently for different subgroups of youth. More specifically, one group (*Parent Substance Misuse*) was characterized solely by elevated rates of parent substance misuse. The *Socioeconomic Disadvantage* group, in addition to elevated rates of parent substance misuse, had elevated endorsement rates for the largest number of risk factors and was the only group characterized by high rates of economic disadvantage. The third group with elevated endorsement rates on parent substance misuse variables, especially mom smoking while pregnant, also had high endorsement rates of mom dropping out of school and having multiple unions (*Maternal School Dropout*; Lotfipour et al., 2014).

In general, major differences were not observed between the three elevated risk groups and adolescent substance use outcomes (i.e., all three groups exhibited similarly high levels of adolescent substance misuse). These results are consistent with the developmental psychopathology concept of equifinality (Cicchetti & Rogosch, 1996). That is, there appears to be multiple contextual risk profiles during the prenatal/birth period that lead to adolescent substance use. Future research that examines similarities and differences in the pathways of these three at-risk groups from early development to adolescence could provide key insights into the development of substance-related problems and other psychosocial difficulties. For example, is

one mechanism that accounts for the relation between group membership and adolescent substance-related outcomes parents' continued substance use problems? Moreover, do limited economic resources in combination with parent substance-related problems increase risk for co-occurring substance misuse and other emotional and behavioral problems during adolescence?

Examination of the endorsement rates across all of the groups revealed an interesting finding. Specifically, the low-birth weight variable did not help differentiate any of the subgroups. Unlike in most Western countries, low-birth weight does not seem to be a strong risk factor for adolescent substance use in Finland. This may be because, due to universal access to high quality prenatal health care, low birth weight is weakly related to low socioeconomic status in Finland (Gissler, Meriläinen, Vuori, & Hemminki, 2003; Gissler et al., 2009; Härkönen, Kaymakçalan, Mäki, & Taanila 2012).

Limitations

Several limitations of the study should be noted. First, measures of substance use were obtained from adolescent self-reports. Second, the study focused on the use of alcohol, cigarettes, and illicit drugs. The NFBC1986 does not yet include measures of substance-related consequences. Future work in this area could benefit from the assessment of a broader range of substance outcomes using multi-methods. Third, although a broad range of contextual risk factors were examined, several risk factors for adolescent substance misuse were not available. These include neighborhood characteristics and parent emotional and behavior problems other than substance misuse.

Compliance with Ethical Standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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References

- Abner, K. S. (2014). Dimensions of structural disadvantage: A latent class analysis of a neighborhood measure in Child Welfare data. *Journal of Social Service Research, 40*, 121–134. doi: 10.1080/01488376.2013.852651
- Asparouhov, T. & Muthén, B. (2014a). Auxiliary variables in mixture modeling: Three-step approaches using Mplus. *Structural Equation Modeling, 21*, 329-341. doi: 10.1080/10705511.2014.915181
- Asparouhov, T. & Muthén, B. (2014b). *Auxiliary variables in mixture modeling: Using the BCH method in Mplus to estimate a distal outcome model and an arbitrary second model*. Retrieved from <https://www.statmodel.com/examples/webnotes/webnote21.pdf>
- Berlin, K. S., Williams, N. A., & Parra, G. R. (2014). An introduction to latent variable mixture modeling (Part 1): Cross sectional latent class and latent profile analyses. *Journal of Pediatric Psychology, 39*, 174-187. doi: 10.1093/jpepsy/jst084
- Brody, G. H., Yu, T., Chen, Y., Kogan, S. M., Evans, G. W., Beach, S. R. J., Windle, M., Simons, R. L., Gerrard, M., Gibbons, F. X., & Philibert, R. A. (2013). Cumulative socioeconomic status risk, allostatic load, and adjustment: A prospective latent profile analysis with contextual and genetic protective factors. *Developmental Psychology, 49*, 913-927. doi: 10.1037/a0028847
- Bowen, N. K., Lee, J., & Weller, B. E. (2007). Social environmental risk and protection: A typology with implications for practice in elementary school. *Children & Schools, 29*, 229-242. doi: 10.1093/cs/29.4
- Cavanaugh, C. E., Petras, H., & Martins, S. S. (2015). Gender-specific profiles of adverse childhood experiences, past year mental and substance use disorders, and their

- associations among a national sample of adults in the United States. *Social Psychiatry and Psychiatric Epidemiology*, *50*, 1257-1266. doi: 10.1007/s00127-015-1024-3
- Cicchetti, D., & Rogosch, F. A. (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology*, *8*, 597-600. doi: 10.1017/S0954579400007318
- Copeland, W., Shanahan, L., Costello, E. J., & Angold, A. (2009). Configurations of common childhood psychosocial risk factors. *Journal of Child Psychology and Psychiatry*, *50*, 451-459. doi: 10.1111/j.1469-7610.2008.02005.x
- Dunn, V. J., Abbott, R. A., Croudance, T. J., Wilkinson, P., Jones, P. B., Herbert, J., & Goodyer, I. M. (2011). Profiles of family-focused adverse experiences through childhood and early adolescence: The ROOTS project a community investigation of adolescent mental health. *BMC Psychiatry*, *11*, 109-125. doi: 10.1186/1471-244X-11-109
- Evans, G. W., Li, D., & Sepanski Whipple, S. (2013). Cumulative risk and child development. *Psychological Bulletin*, *139*, 1342-1396. doi: 10.1037/a0031808
- Gissler, M., Meriläinen, J., Vuori, E., & Hemminki, E. (2003). Register-based monitoring shows decreasing socioeconomic differences in Finnish perinatal health. *Journal of Epidemiology and Community Health*, *57*, 433-439. doi:10.1136/jech.57.6.433
- Gissler, M., Rahkonen, O., Arntzen, A., Cnattingius, S., Nybo Andersen, A. M., & Hemminki E. (2009). Trends in socioeconomic differences in Finnish perinatal health 1991-2006. *Journal of Epidemiology and Community Health*, *63*, 420-425. doi: 10.1136/jech.2008.079921

- Gorman-Smith, D., Tolan, P. H., & Henry, D. B. (2000). A developmental-ecological model of the relation of family functioning to patterns of delinquency. *Journal of Quantitative Criminology*, *16*, 169-198. doi: 10.1023/A:1007564505850
- Härkönen, J., Kaymakçalan, H., Mäki, P., & Taanila, A. (2012). Prenatal health, educational attainment, and intergenerational inequality: the Northern Finland Birth Cohort 1966 Study. *Demography*, *49*(2), 525-552. doi: 10.1007/s13524-012-0092-1
- Hendryx, M., Luo, J., Knox, S. S., Zullig, K. J., Cottrel, L., Hamilton, C. W., John, C. C., & Mullett, M. D. (2014). Identifying multiple risks of low birth weight using person-centered modeling. *Women's Health Issues*, *24*, e251-e256.
doi:10.1016/j.whi.2014.01.001
- Hurtig, T., Taanila, A., Miettunen, J., Smalley, S. L., McGough, J. J., Loo, S. K., et al. (2007). ADHD symptoms and subtypes: Relationship between childhood and adolescent symptoms. *Journal of the American Academy of Child and Adolescent Psychiatry*, *46*, 1605-1613. doi:10.1097/chi.0b013e318157517a
- January, S.-A. A., Mason, W. A., Savolainen, J., Solomon, S., Chmelka, M. B., Miettunen, J., Veijola, J., Moilanen, I., Taanila, A., & Järvelin, M.-R. (2017). Longitudinal pathways from cumulative contextual risk at birth to school functioning in adolescence: Analysis of mediation effects and gender moderation. *Journal of Youth and Adolescence*, *46*, 180-196. doi:10.1007/s10964-016-0560-9
- Jobe-Shields, L., Andrews, A. R., Parra, G. R., & Williams, N. A. (2015). Person-centered approaches to understanding early family risk. *Journal of Family Theory & Review*, *7*, 432-451. doi: 10.1111/jftr.12118

- Kraemer, H. C., Stice, E., Kazdin, A., Offord, D., & Kupfer, D. (2001). How do risk factors work together? Mediators, moderators, and independent, overlapping, and proxy risk factors. *American Journal of Psychiatry, 158*, 848-856. doi: 10.1176/appi.ajp.158.6.848
- Lanza, S. T., Rhoades, B. L., Greenberg, M. T., Cox, M., & The Family Life Project Key Investigators. (2011). Modeling multiple risks during infancy to predict quality of the caregiving environment: Contributions of a person-centered approach. *Infant Behavior and Development, 34*, 390-406. doi: 10.1016/j.infbeh.2011.02.002
- Lanza, S. T., Rhoades, B. L., Nix, R. L., Greenberg, M. T., & The Conduct Problems Prevention Research Group. (2010). Modeling the interplay of multilevel risk factors for future academic and behavior problems: A person-centered approach. *Development and Psychopathology, 22*, 313-335. doi: 10.1017/S0954579410000088
- Lotfipour, S., Ferguson, E., Leonard, G., Miettunen, J., Perron, M., Pike, G. B., ... Paus, T. (2014). Maternal cigarette smoking during pregnancy predicts drug use via externalizing behavior in two community-based samples of adolescents. *Addiction, 109*, 1718-1729. doi:10.1111/add.12665
- Magnusson, D. (2003). The person approach: Concepts, measurement models, and research strategy. *New Directions for Child and Adolescent Development, 101*, 3-23. doi: 10.1002/cd.79
- McFeeters, D., Boyda, D., O'Neill, S. (2015). Patterns of stressful life events: Distinguishing suicide ideators from suicide attempters. *Journal of Affective Disorders, 175*, 192 - 198. doi: 10.1016/j.jad.2014.12.034
- Menard, C., Bandeen-Roche, K. J., & Chilcoat, H. D. (2004). Epidemiology of multiple childhood traumatic events: Child abuse, parental psychopathology, and other family-

- level stressors. *Social Psychiatry and Psychiatric Epidemiology*, *39*, 857-865. doi: 10.1007/s00127-004-0868-8
- Miettunen, J., Murray, G. K., Jones, P. B., Maki, P., Ebeling, H., Taanila, A., Joukamaa, M., Savolaninen, J., Tormanen, S., Jarvelin, M. R., Veijola, J., & Moilanen, I. (2014). Longitudinal associations between childhood and adulthood externalizing and internalizing psychopathology and adolescent substance use. *Psychological Medicine*, *44*, 1727-1738. doi:10.1017/S0033291713002328
- Muthén, L. K., & Muthén, B. O. (1998 - 2012). *Mplus User's Guide. Seventh Edition*. Los Angeles, CA: Muthén & Muthén.
- Oliver, B. R., Kretschmer, T., & Maughan, B. (2014). Configuration of early risk and their associations with academic, cognitive, emotional and behavioural outcomes in middle childhood. *Social Psychiatry and Psychiatric Epidemiology*, *49*, 723-732. doi: 10.1007/s00127-013-0756-1
- Parra, G. R., DuBois, D. L., & Sher, K. J. (2006). Investigation of profiles of risk factors for adolescent psychopathology: A person-centered approach. *Journal of Clinical Child and Adolescent Psychology*, *35*, 386-402. doi: 10.1207/s15374424jccp3503_4
- Parra, G. R., Smith, G., Mason, W. A., Savolaninen, J., Chmelka, M. B., Miettunen, J., & Jarvelin, M. (2017). Tests of linear and nonlinear relations between cumulative contextual risk at birth and psychosocial problems during adolescence. *Journal of Adolescence*, *60*, 64-73. doi: <http://dx.doi.org/10.1016/j.adolescence.2017.07.010>
- Patrick, M. E., & Schulenberg, J. E. (2013). Prevalence and predictors of adolescent alcohol use and binge drinking in the United States. *Alcohol Research: Current Reviews*, *35*, 193-200.

- Roy, A. L., & Raver, C. C. (2014). Are all risks equal? Early experiences of poverty-related risk and children's functioning. *Journal of Family Psychology, 28*, 391-400. doi: 10.1037/a0036683
- Shevlin, M., & Elklit, A. (2008). A latent class analysis of adolescent adverse life events based on a Danish national youth probability sample. *Nordic Journal of Psychiatry, 62*, 218-224. doi: 10.1080/08039480801983992
- Taanila A., Ebeling, H., Kotimaa, A., Moilanen, I., & Jarvelin, M-R. (2004). Is a large family a protective factor against behavioural and emotional problems at the age of 8 years? *Acta Paediatr, 93*, 508–517. doi: 10.1080/08035250410023629
- Zegers-Hochschild, F., Adamson, G.D., de Mouzon, J., Ishihara, O., Mansour, R., Nygren, K., Sullivan, E., van der Poel, S., International Committee for Monitoring Assisted Reproductive Technology, & World Health Organization (2009). *Human Reproduction, 24*, 2683–2687. doi:10.1093/humrep/dep343
- Zeides, K. H., Roosa, M. W., Knight, G. P., & Gonzales, N. A. (2013). Mexican American adolescents' profiles of risk and mental health: A person-centered longitudinal approach. *Journal of Adolescence, 36*, 603-612. doi: 10.1016/j.adolescence.2013.03.014

Table 1

Fit Statistics for Two- through Six-Class Solutions from the Latent Class Analysis

	AIC	SSA-BIC	VLMR-LRT	BLRT	Entropy
2 Class	33910.98	33995.40	1121.44***	1132.00***	.57
3 Class	33662.82	33791.29	269.62***	272.16***	.52
4 Class	33556.42	<u>33728.94</u>	129.18***	130.40***	.45
5 Class	33514.97	33731.54	64.84*	65.45***	.74
6 Class	<u>33479.52</u>	33740.13	<u>58.90**</u>	<u>59.45***</u>	.77

Note. AIC = Akaike Information Criteria. SSA-BIC = Sample Size Adjusted Bayesian Information Criteria. VLMR-LRT = Vuong-Lo-Mendell-Rubin Likelihood Ratio Test. BLRT = Bootstrapped Likelihood Ratio Test. Underline indicates the best fitting solution for each fit index.

Proper solutions for models with seven or more classes could not be obtained.

The null hypothesis for the VLMR-LRT and BLRT is that a model with k classes and one with $k - 1$ classes are not different from each other. A decision to reject the null hypothesis means that a solution with k classes provides a better fit to the data. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2

Endorsement Probabilities for Each Contextual Risk Factor Across Five Classes

	Parent Substance Misuse	Large Family Size	Maternal School Dropout	Low Risk	Socioeconomic Disadvantage
Low Birth Weight	.03	.01	<u>.09</u>	.03	.05
Teenage Motherhood	.01	.00	.00	.02	.33
Single Parent Status	.05	.00	.06	.01	.43
Multiple Unions	.15	.01	.34	.03	.07
Large Family Size	.00	<u>1.00</u>	.07	.00	.01
Maternal School Dropout	.00	.16	.61	.07	.08
Smoking While Pregnant	.37	.02	.61	.06	.50
Drinking While Pregnant	<u>.51</u>	.01	.21	.05	.20
Paternal Heavy Alcohol Use	<u>.29</u>	.01	.23	.06	.21
Economic Exclusion	.00	.00	.05	.02	<u>.54</u>
Material Deprivation	.03	.03	.03	.03	.18
<i>ns</i> for each Subgroup	780	538	324	4853	468
% of Total Sample	11.20%	7.72%	4.66%	69.69%	6.72%

Note. $N = 6,963$. Unless otherwise noted, values in the table represented the probably that individuals in a particular class had a score of “1” on a specific risk factor. Bold indicates an endorsement (score of “1”) probability of .20 or greater. Underline indicates that endorsement probability was highest for that risk factor. The patterns of endorsement probabilities both within and across classes were used to characterize each class. Final class counts and proportions were based on the estimated model.

Table 3

Relations between Subgroup Membership and Adolescent Substance Misuse

	Lifetime Drunkenness		Current Cigarette Use		Lifetime Illegal Drug Use	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	%	<i>SE</i>
1. Parent Substance Misuse	3.41 _a	0.16	1.56 _a	0.16	.12 _a	0.02
2. Large Family Size	0.73 _b	0.07	0.98 _b	0.08	.02 _b	0.01
3. Maternal School Dropout	3.46 _a	0.27	2.24 _c	0.25	.11 _a	0.03
4. Low Risk	2.30 _c	0.04	0.81 _d	0.03	.04 _c	0.01
5. Socioeconomic Disadvantage	3.31 _a	0.15	1.99 _{a,c}	0.15	.10 _a	0.02
Chi-Square	641.32*		106.80*		53.94*	

Note. $N = 6,963$. Values for Lifetime Drunkenness and Current Cigarette Use are Means and Standard Errors. Values for Lifetime Illegal Drug use are Percentages Endorsed Item and Standard Errors.

Parameters that do not share a subscript are statistically different from each other at the $p < .05$ level.

* $p < .001$.