Child Abuse & Neglect 154 (2024) 106952



Contents lists available at ScienceDirect

Child Abuse & Neglect

journal homepage: www.elsevier.com/locate/chiabuneg





Child maltreatment and youth exposure to risky environments: Latent class analysis of youth activity spaces

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ARTICLE INFO

Keywords:
Child maltreatment
Activity space
Youth
Contextual risk
Latent class analysis

ABSTRACT

Background: Child maltreatment may alter the way that adolescents engage in and interact within the places they visit in their daily routines, namely youth activity spaces. Thus, it is important to understand how maltreatment experiences are linked to adolescents' exposure to environmental and contextual risks within their activity spaces.
Objective: The aim of the study was to explore the associations between child maltreatment and patterns of risk exposures within youth activity spaces among adolescents.
Participants and setting: Study participants were 1364 adolescents between the ages of 11 and 17, living in a Midwest state in the United States.
Methods: We linked data from the Adolescent Health and Development in Context (AHDC) study and the Statewide Automated Child Welfare Information System (SACWIS). A three-step latent class analysis (LCA) was employed.
Results: Three contextual risk exposure classes were identified: 1) The *aggression/violence* class (7.7 %); 2) The *smoking and drinking* class (12.3 %); and 3) The *non-risk* class (80.0 %). Adolescents with more maltreatment reports were more likely to be in the *aggression/violence* class compared to the *non-risk* class.
Conclusions: Capitalizing on the novel linkage between administrative child welfare records and ecological momentary assessment (EMA)-based youth spatial/environmental exposure data, we found a positive link between the number of maltreatment reports made to child protective services and membership in the *aggression/violence* class. Intervention efforts should be directed toward youths with a history of child maltreatment, ensuring that they have access to safe, structured, and non-violent environments during their daily routines.

Child maltreatment, which refers to the abuse and neglect of people under 18 years of age (World Health Organization [WHO], 2022), represents a prevalent and serious global public health concern. Child maltreatment can have profound adverse effects on one's life (e.g., Coelho et al., 2014; Jaffee, 2017), and the effects often persist over time (Currie & Spatz Widom, 2010; Dannlowski et al., 2012; Young & Widom, 2014). In understanding the impact of child maltreatment on health risk behaviors among youth, much of the

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https://doi.org/10.1016/j.chiabu.2024.106952
Received 21 March 2024; Received in revised form 28 June 2024; Accepted 17 July 2024
Available online 24 July 2024
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prior work has focused on individual or internal mechanisms, such as anxiety, depression, and anger (Asgeirsdottir et al., 2011; Kobulsky et al., 2018), while the roles of contextual mechanisms remain elusive. Drawing from the ecological-transactional model (Cicchetti & Lynch, 1993), one's health and developmental outcomes are not passively determined by their environment. Instead, individuals actively participate in selecting and contributing to their environment, shaping their well-being and outcomes (Cicchetti & Lynch, 1993). Child maltreatment may alter the way that people engage in and interact with their environment, which, in turn, may subsequently influence youth development (Cicchetti & Lynch, 1993). Given that the span and importance of social-environmental and spatial exposure increase substantially during adolescence (Phillips & Shonkoff, 2000), it is vital to examine the impact of child maltreatment on adolescents' environmental and contextual risks (e.g., exposure to risky settings), beyond internal/individual-level outcomes (e.g., psychological symptoms). By linking administrative child welfare records with youth activity space data collected via smartphone-based ecological momentary assessment, the current study sought to investigate the association between child maltreatment and youth's exposure to risky environments. This investigation will provide valuable insights into intervention strategies for promoting positive youth development by elucidating the under-explored connection between child maltreatment experiences and risky social-environmental exposure during adolescence.

1. Child maltreatment

Child maltreatment encompasses any act or lack thereof by a caregiver that results in harm or potential harm to children's physical and psychological wellbeing (World Health Organization, 2022). Child maltreatment takes on multiple forms and includes all types of physical or emotional ill-treatment, abuse, neglect, and commercial or other exploitation (World Health Organization, 2022). Unfortunately, child maltreatment is not a rare occurrence, with physical abuse, emotional abuse, sexual abuse, and neglect representing the main types of maltreatment experienced by children (Gonzalez et al., 2017). It is estimated that the lifetime prevalence of child physical abuse, emotional abuse, sexual abuse, and neglect are 24.3 %, 13.7 %, 14.1 %, and 16.6 %, respectively, in North America (Moody et al., 2018).

Child maltreatment yields extensive detrimental consequences. Individuals who have experienced child maltreatment face elevated risks of impaired brain development (Teicher et al., 2016) and compromised psychological and physical health (Coelho et al., 2014; Jaffee, 2017), which are further linked to increased health expenses (Florence et al., 2013), reduced educational and economic outcomes (Bunting et al., 2018; Romano et al., 2015), difficulties in interpersonal relationships (Kim & Cicchetti, 2010), and intergenerational transmission of maltreatment (Langevin et al., 2021). Moreover, child maltreatment not only affects individuals or their immediate social networks but also has negative impacts on society as a whole (Peterson et al., 2018).

2. Child maltreatment and youth activity space

One of the less understood areas in relation to child maltreatment is youth activity space. Activity space refers to areas or places a person visits in their daily routines (Browning & Soller, 2014). It reveals temporal and spatial characteristics of one's social-environmental and contextual exposure and reflects people's resources, needs, and preferences (White et al., 2021). The importance of investigating activity space beyond household and caregiver characteristics increases substantially as children transition to adolescence. Adolescents, compared to young children, spend more time away from home and interact with people who are not in their immediate families (Phillips & Shonkoff, 2000). Studying activity spaces beyond home settings may offer a fruitful avenue for gaining insights into adolescent health and development in context. Additionally, accumulating evidence has shown that the attributes of activity space can shape youth development, such that the presence of activity space risk is associated with elevated levels of substance use, externalizing behavior problems, and internalizing behavior problems (see White et al., 2021 for a review).

Adolescents who experience child maltreatment may have unique and different activity spaces compared to those with no maltreatment histories. For instance, maltreatment may result in frequent placement changes (e.g., out-of-home placements, placement disruptions), dropping out of school, running away, and homelessness (Ferguson, 2009; Kim et al., 2009; Trout et al., 2008), which may further predispose them to unsupervised, unstructured, and violent locations. According to the risk amplification model (Whitbeck et al., 1999), adolescents who experience child maltreatment in the home, including physical and sexual abuse, often run away from home and/or spend increased time in unsupervised settings (e.g., on the streets, hanging out with deviant peers) to escape from a negative home environment. Additionally, empirical evidence suggests that victims of maltreatment are more prone to sensation-seeking and risk-taking propensity due to altered brain development associated with maltreatment, including reduced reward sensitivity (Mueller et al., 2010; Whittle et al., 2013). Such impaired cognitive control (e.g., disinhibition) and a diminished ability to accurately appraise risk (Bornovalova et al., 2008; Smith et al., 2004) may place youth with maltreatment histories at greater risk for exposure to risky, unsafe, and unsupervised activity spaces.

3. Child maltreatment and exposure to risky environments/risk-taking behaviors

There is a dearth of literature on how child maltreatment shapes youth activity space. To our knowledge, only one study has directly explored the impact of child abuse on later activity space. In that study, Friedmann et al. (2020) employed global positioning systems (GPS) to track the activity space of women with and without a history of child abuse. Authors found that adult women with a maltreatment history had smaller movement radii on weekends than women without a history of child abuse and these differences remained after controlling for contextual and individual health characteristics. Importantly, this study did not delve into the experiential aspects or attributes of what individuals encounter in their activity spaces, which could also be affected by child maltreatment

history. Given the limited research on this topic, we turn to the broader literature on maltreatment and youth exposure to risky environments and behaviors, including community violence and crime and peer substance use, deviance, and delinquency.

Positive correlations between child maltreatment and exposure to environmental and contextual risks have been identified among school-age children (Lynch & Cicchetti, 1998), adolescents (Cecil et al., 2014; Wright et al., 2013), and young adults (Cecil et al., 2014). In a longitudinal study, physical abuse in childhood was positively related to cumulative environmental stress from childhood to adulthood, including but not limited to household conflict, substance abuse, and incarceration, as well as neighborhood crime (Sousa et al., 2018). Rosen et al. (2018) found that low-income children with a history of child maltreatment were more likely to experience pervasive trauma, such as witnessing and victimization of community violence and illness or injury to oneself and loved ones. More frequent and severe child maltreatment has been associated with exposure to parental intimate partner violence (Cecil et al., 2014) and community violence (Cecil et al., 2014; Lynch & Cicchetti, 1998; Wright et al., 2013).

Moreover, child maltreatment can increase adolescents' exposure to risky peer behaviors. For example, Yoon, Snyder, and Yoon (2020) found that adolescents who experienced childhood emotional abuse were more likely to be affiliated with deviant peer groups who engage in risky behaviors, such as substance use and fighting. Tay et al. (2021) found that emotional abuse was positively associated with the frequency of peer perpetrating and experiencing violence in 7- to 17-year-old children. Similarly, Faus et al. (2019) found that childhood emotional abuse, sexual abuse, and physical neglect increased the odds of adolescents having friends perpetrating or experiencing violence. Physical abuse and emotional neglect, particularly when cooccurring with community violence, also increased the odds of having friends perpetrating or experiencing violence.

In addition, adolescents with a childhood maltreatment history may not only have an increased likelihood of exposure to risky environments but contribute to environmental risk. A robust body of research indicates that adolescents with a history of child maltreatment are at higher risk for engaging in risk-taking behaviors, such as substance use (e.g., Afifi et al., 2020; Yoon, Shi, et al., 2020; Zhen-Duan et al., 2023), risky sexual behavior (e.g., Jones et al., 2010; Richter et al., 2014), and delinquent behaviors (e.g., Brown & Shillington, 2017; Evans & Burton, 2013; van Berkel et al., 2018).

All in all, previous studies have suggested the positive association between child maltreatment and youth social-environmental risk exposure. However, most studies have adopted self-report measures of neighborhood characteristics and peer behavior. Although these measures offer valuable insights, they may fall short of capturing the full spectrum of youth social-environmental and contextual exposure. For example, a study of 1405 youth aged 11 to 17 years found that youth spent 60 % of their waking time in their home, 5.7 % in the neighborhood (census tract) outside their home, and 34.3 % outside their neighborhood (Browning et al., 2021). A narrow focus on characteristics of neighborhood/community and family, and even adding that of peer interactions, may not adequately illuminate youth social-environmental risk exposure. Moreover, youth do not experience different contexts (e.g., neighborhood, home) to the same degree, and the effect of exposure to a certain context may vary across individuals. This also underscores the advantage of adopting an activity space framework and real time assessment (e.g., ecological momentary assessment; EMA) to examine youth social-environmental and contextual risk exposure, which offers higher ecological validity than conventional approaches.

4. The current study

Although considerable theoretical and empirical evidence suggests the significance of social-environmental contexts for adolescent health outcomes following early adversity, little research has examined youth activity spaces among adolescents with a history of childhood maltreatment. Adolescent health risk behaviors, such as substance use, are largely influenced by their routine social-environmental and spatial exposures during their daily lives (Browning et al., 2015; Browning & Soller, 2014; Mason et al., 2015); therefore, examining the nature of youth *activity spaces*, such as socio-environmental and contextual risk exposure, among adolescents with maltreatment experiences is important. The current study aims to explore the associations between child maltreatment and patterns of risk exposures within youth activity spaces among adolescents. It was hypothesized that adolescents with greater maltreatment experiences (measured by greater number of reports made to child protective services) will have greater exposure to violent and risky activity spaces.

5. Method

5.1. Participants and procedure

We used data from the Adolescent Health and Development in Context (AHDC) study and the Statewide Automated Child Welfare Information System (SACWIS). The AHDC study, conducted in a Midwest state in the United States, collected data on 1405 youths between the ages of 11 and 17 who were randomly selected using vendor- and school-based address lists. Data were collected at two timepoints (Wave 12,014–2016; Wave 22,016). At each wave, an entrance survey was conducted first to gather geographical information on the routine activities of caregivers and youths, followed by a 7-day ecological momentary assessment (EMA) to obtain real-time information on places where youth spend time. SACWIS is a case management information system used by state and local government to prevent and respond to reports of child abuse, neglect, and dependency. Among the data SACWIS captures and manages relevant to this study are reports of abuse and neglect by type, investigation outcomes, out-of-home removals, and placement. In collaboration with the local child welfare agency, we linked the AHDC data with SACWIS data. Specifically, probabilistic matching was conducted using Link Plus (The Centers for Disease Control and Prevention, n.d.), with the following matching variables: the child's first name, child's last name, child's middle name, child's date of birth, mother's first name, mother's last name, mother's date of birth, child's partial (last two digits) SSN, maternal partial SSN, address, child's sex, and child's race.

After excluding 41 adolescents who had missing data on all contextual risk exposure indicators, the final analytic sample included 1364 adolescents. Table 1 presents sample characteristics. Youth gender distribution was roughly even, with 52.8 % of youths being boys. The mean age of youths was 14.26 years. As for race and ethnicity, 46.9 % of the participants identified as White, 37.6 % as Black, 5.3 % as Hispanic, and 10.1 % as others. About 36.2 % of families had an annual household income of $30,000 or less, and 78.9 % of caregivers had some college or higher education.

5.2. Measures

5.2.1. Contextual risk factors

Participants were asked to respond to the smartphone-based EMA survey five times a day for 7 days. The EMA notifications were sent to request prompt response, once in the morning, three times after school within random 1–2 h intervals, and once at the end of the day. To measure contextual risk factors within youth activity spaces, we used the items that asked the participants whether certain risk behaviors were happening 1) at the moment and 2) since the last EMA prompt. The following risk behaviors were asked: 1) yelling/cursing, 2) physical fights or violence, 3) harassing/threatening/bullying, 4) stealing/destroying property, 5) drinking alcohol, 6) smoking, 7) using prescription drugs, using illegal drugs, or buy/sell drugs, 8) sexual activity. If a specific risk exposure/risk behavior occurred at least once at the locations and places that a youth visited during the EMA period, the corresponding contextual risk exposure was coded as "1", and otherwise, it was coded as "0."

5.2.2. Maltreatment experience

Child maltreatment was assessed using administrative child protective services records of child abuse and neglect obtained vis SACWIS data (i.e., any reports made to a public children services agency in an urban city in a Midwest state). We aggregated the cumulative number of reports made to child protective services (i.e., child protective services referrals) from birth to age 17.

5.2.3. Covariates

To better estimate the effects of maltreatment on contextual risk exposure patterns, we controlled for the effects of a set of covariates that have been found in prior research to be associated with adolescent risk exposure (Afifi et al., 2020; Jones et al., 2010; Richter et al., 2014; Van Berkel et al., 2018; Yoon, Shi, et al., 2020; Yoon, Snyder, & Yoon, 2020). Covariates included youths' gender (0 = girls, 1 = boys), age, and race/ethnicity (dummy coded using Black as a reference group), annual household income (0 = household income last year was $30,000 or less, 1 = household income last year was greater than $30,000), parental education (0 = high school or lower, 1 = some college or higher) and physical aggression and psychological aggression. Physical and psychological aggression were reported by parents regarding their acts of physical and psychological aggression. Specifically, parents completed the AHDC parent survey and responded to four psychological aggression items (e.g., "called the child dumb or some other name like that"; Cronbach's alpha = 0.74) and four physical assault items (e.g., "spanked the child on the bottom with a bare hand"; Cronbach's alpha = 0.62) from the Parent-Child Conflict Tactics Scales (Straus et al., 1998). Higher scores indicate higher levels of physical and psychological aggression.

5.3. Analytic plan

To explore patterns of adolescents' exposure to risky environments, we employed Latent class analysis (LCA). LCA allows an identification of unobserved subpopulations that have distinct item response probability patterns from each other but are similar within subpopulations (Collins & Lanza, 2009; Vermunt & Magidson, 2004; Weller et al., 2020). In the present study, we used the manual three-step approach of LCA, following the recommendations by Asparouhov and Muthén (2014), Nylund-Gibson et al. (2014), and Nylund-Gibson et al. (2019). This approach contains the following steps: 1) estimating the unconditional model; 2) assigning all individuals into latent classes; and 3) examining the relationship between auxiliary and latent class variables after controlling for

Table 1
Demographic Characteristics of Participants ($N = 1364$).

Variable	Maltreated ($N = 262$)		Not maltreated ($N = 1102$)		t	p
	%/M (SD)	Range	%/M (SD)	Range		
Youth gender (boys)	43.1 %	–	48.1 %	–		
Youth age (in years)	13.77 (1.90)	11–17	14.37 (1.83)	11–17	4.70	<0.001
Race and ethnicity						
White	27.9 %	–	51.5 %	–		
Black	55.0 %	–	33.5 %	–		
Hispanic	5.0 %	–	5.4 %	–		
Other	12.2 %	–	9.6 %	–		
Annual household income ($30,000 or less)	65.4 %	–	29.2 %	–		
Parental education (some college or higher)	69.0 %	–	81.2 %	–		
# of maltreatment reports	5.12 (6.10)	1–41	–	–		
Physical aggression	0.32 (0.62)	0–3.5	0.15 (0.43)	0–5	−5.35	<0.001
Psychological aggression	1.86 (1.51)	0–6	1.30 (1.17)	0–5.5	−6.51	<0.001

measurement error in the class assignments.

First, a series of unconditional LCA models were estimated by increasing the number of latent classes one by one to find the optimal number of classes. Given that LCA is an exploratory method that does not have a definite solution, deciding the number of latent classes is a critical issue. To do so, various fit indices were considered, including information criteria and likelihood ratio tests (LRT). For the information criteria, we employed the Akaike information criterion (AIC), the Bayesian information criterion (BIC), and the sample size–adjusted BIC (ABIC). Smaller information criteria values indicate a better model (Nylund-Gibson & Choi, 2018). For the LRT tests, we adopted the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT) and the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR-LRT). These tests compare the improvement in fit between a *k* class model and a *k-1* class model. A significant *p-value* in the LRT tests indicates that a *k* class model fits the data better than a *k-1* class model (Nylund-Gibson & Choi, 2018; Spurk et al., 2020). We additionally considered theoretical meaningfulness of extracted classes and the proportion of each class to determine the optimal number of classes (Weller et al., 2020). After selecting the best fitting model, we added covariates to examine their effects on class membership, while controlling for measurement error in the class assignments.

6. Results

6.1. Contextual risk exposure classes

Table 2 presents the fit indices of the unconditional LCA models (2 through 5 classes) of contextual risk exposure. The model fit indices provided mixed information regarding the optimal number of classes. The AIC and ABIC indicated the 4-class model to be the best fitting model, but the BIC suggested that the 3-class solution was the optimal model. The LMR-LRT and VLMR-LRT results favored the 4-class model over the 3-class model. We gave further consideration into the size of each class as well as the interpretability and meaningfulness of the classes to determine the optimal number of classes. The examination of graphic outputs revealed that the 4-class model included two classes that were not meaningfully different from each other. Further, one of these classes included only 1 % of the sample ($n = 14$). The 3-class model showed distinct and meaningful classes, with adequate sample size for each class. Therefore, we selected the 3-class model as the final model.

The 3-class model is shown in Fig. 1. We named each class based on the nature and characteristics of contextual risk factors in youth activity spaces. The *Aggression/violence* class (Class 1) consisted of 7.7 % of the adolescents in the study. This class included adolescents who had greater exposure to physical or psychological violence (e.g., yelling/cursing, physical fights, harassing/threatening/bullying). The *Smoking and drinking* class (Class 2) contained 12.3 % of the adolescents in the study. Adolescents in this class showed greater exposure to substance use, including alcohol or tobacco use. Lastly, the *Non-risk* class (Class 3) consisted of the majority of the participants in the study (80.0 %). Adolescents in this class showed very low levels of exposure to risky environments.

6.2. Predictors of class membership

Table 3 shows the results of the conditional LCA model in which we examined the number of maltreatment reports and other covariates (i.e., youth gender, race/ethnicity, age, household income, parental education, physical aggression, psychological aggression) as predictors of class membership. For the *Aggression/violence* class, the number of maltreatment reports and youth age were identified as significant predictors. Adolescents with more maltreatment reports were more likely to be in the *Aggression/violence* class. That is, for every additional report made to child protective services, the odds of being in the *Aggression/violence* class, compared to the *Non-risk* class, were 1.060 times higher (Odds ratio = 1.060, $p = 0.049$). Youth age was also positively associated with membership in the *Aggression/violence* class. For every 1-year increase in youth age, the odds of being in the *Aggression/violence* class, compared to the *Non-risk* class, were 1.149 times higher (Odds ratio = 1.149, $p = 0.035$).

Youth gender, age, race/ethnicity, and psychological aggression were significant predictors of membership in the *Drinking and smoking* class, compared to the *Non-risk* class. Boys were less likely than girls to be in to the *Drinking and smoking* class (Odds ratio =

Table 2
Fit Indices and Proportion of Latent Class for Unconditional Latent Class Models (N = 1364).

	2-class	3-class	4-class	5-class
Likelihood	−3020.935	−2972.234	−2944.137	−2934.038
AIC	6075.869	5996.469	5958.273	5956.075
BIC	6164.578	6132.141	6140.910	6185.675
ABIC	6110.576	6049.550	6029.729	6045.905
Entropy	0.787	0.770	0.806	0.725
LMR-LRT	<0.001	0.288	0.026	0.385
VLMR-LRT	<0.001	0.284	0.027	0.388
% of class 1	16.4 %	7.7 %	80.0 %	0.1 %
% of class 2	83.6 %	12.3 %	1.0 %	18.5 %
% of class 3		80.0 %	12.9 %	3.9 %
% of class 4			6.1 %	9.0 %
% of class 5				67.8 %

Note. AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion; ABIC: Sample–Size Adjusted Bayesian Information Criterion; LMR-LRT: Lo-Mendell-Rubin Likelihood Ratio Test: VLMR-LRT: Vuong-Lo-Mendell-Rubin Likelihood Ratio Test.

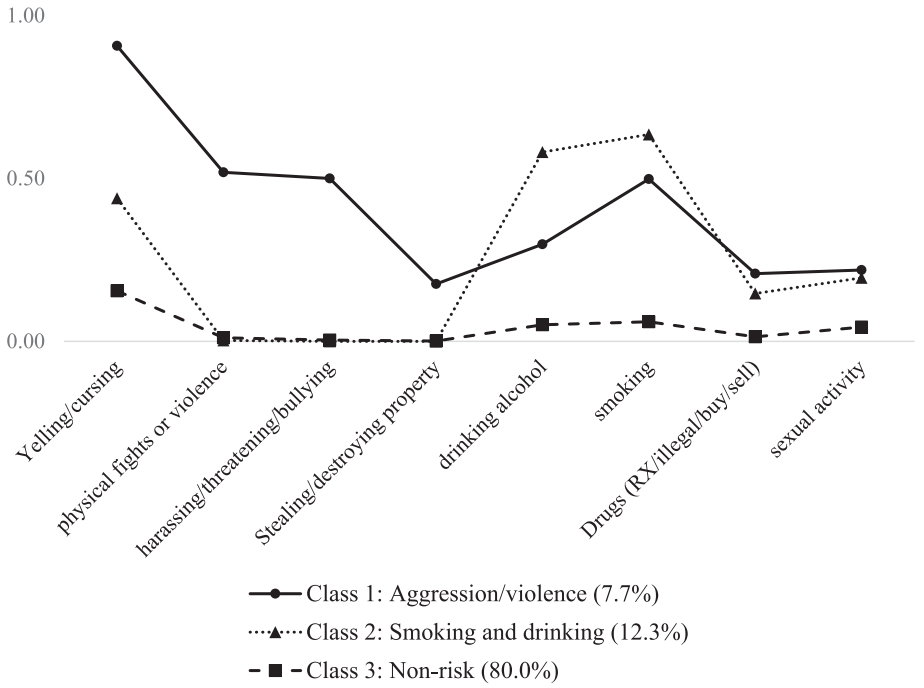


Fig. 1. Probability of contextual risk exposure within youth activity spaces.

Table 3
Predictors of Latent Class Membership ($N = 1255$).

	[Reference class] Class 3 (80.0 %): *Non-risk*			
	Class 1 (7.7 %): *Aggression/violence*		Class 2 (12.3 %): *Smoking and drinking*	
	Logit	Odds ratio	Logit	Odds ratio
Youth gender (boys)	−0.179	0.836	−0.735**	0.479
Youth age (in years)	0.139*	1.149	0.357***	1.428
Race and ethnicity				
Hispanic	0.230	1.259	0.607	1.835
White	−0.453	0.635	0.968**	2.633
Others	−0.280	0.756	0.630	1.878
Annual household income > $30,000	−0.050	0.951	0.114	1.120
Parental education (some college or higher)	−0.134	0.875	0.141	1.151
# of maltreatment reports	0.058*	1.060	0.004	1.004
Physical aggression	0.116	1.123	0.015	1.016
Psychological aggression	0.182†	1.200	0.240†	1.272

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. *Note*. OR: Odds Ratio; For race and ethnicity, Non-Hispanic Black is the reference group.

0.479, $p = 0.009$). White youths were more likely than Black youths to be in the *Drinking and smoking* class (Odds ratio = 2.633, $p = 0.008$). Youth age was positively associated with membership in the *Drinking and smoking* class. For every 1-year increase in youth age, the odds of being in the *Drinking and smoking* class, compared to the *Non-risk* class, were 1.428 times higher (Odds ratio = 1.428, $p < 0.001$). The association between psychological aggression and membership in the *Drinking and smoking* class was marginally significant. For every 1-point increase in psychological aggression score, the odds of being in the *Drinking and smoking* class, compared to the *Non-risk* class, were 1.272 times higher (Odds ratio = 1.272, $p = 0.058$).

7. Discussion

Although there are theoretical tenets supporting elevated vulnerability to environmental and contextual risks among adolescents with a history of child maltreatment, this is the first study to use empirical data to probe the association between reports of child maltreatment and patterns of contextual risk exposures within activity spaces among adolescents. The use of administrative child welfare data and EMA (ecological momentary assessment) youth activity space data represents significant innovation and strength of the study, enabling a robust investigation of the link between maltreatment histories and youth exposure to risk environments. Using latent class analysis, we identified three distinct classes that feature adolescents' different types and levels of contextual risk exposure

within their activity spaces. These findings provide empirical evidence of heterogeneity in youth's spatial exposure to risky environments and behaviors in their daily routines.

The largest class we found was the *Non-risk* class which consisted of approximately 80 % of the participants. This finding is encouraging in that the majority of adolescents, when assessed in real time, indicated no to an extremely low level of exposure to contextual risk factors (e.g., physical fights or violence, stealing/destroying property, using illegal drugs, or buy/sell drugs) at the locations and places they visited during their daily routines. Put differently, most adolescents appeared to perceive their routine activity locations and settings as safe and free of major risk factors. Conversely, the other two classes (*Aggression/violence*, *Smoking and drinking*) signaled potential risk and safety concerns within youth activity spaces.

The *Aggression/violence* class, even though small in size (7.7 %), featured distinct characteristics, namely the most elevated level of risk probabilities across all contextual risk indicators, except for drinking and smoking. As hypothesized, our results showed that adolescents with a greater number of maltreatment reports were more likely to be in this class, compared to the *Non-risk* class. These findings could be understood through a lens of criminology theories, such as social learning theory and social control theory. Building on social learning theory's principle that learning occurs through the observations of others' behaviors (Akers & Jennings, 2015; Bandura & Walters, 1977), youths with a history of child maltreatment may be more likely to seek violent and aggressive environments as they observe and imitate parental violent actions, which they perceive to be normative and even effective. Drawing from social control theory that emphasizes a person's connections to society in the prevention of criminal activities (Hirschi & Stark, 1969), adolescents who experience maltreatment may be more prone to being exposed to risky environments and/or committing crimes due to their weak bonds with parents and others.

The findings are also in line with previous studies that found positive associations between childhood maltreatment and youth exposure to various forms of aggression and violence, including peer violence (Faus et al., 2019; Tay et al., 2021), parental intimate partner violence (Cecil et al., 2014), and community violence (Cecil et al., 2014; Wright et al., 2013). The current findings meaningfully extend prior work by capturing youth's experiences in activity locations through a location-based real-time data collection method (i.e., EMA) and by highlighting the connection between maltreatment histories and youth's selection into risky and violent settings during their daily activities. Although the current study did not test the mechanisms by which adolescents with maltreatment experiences choose risky and violent settings, there are a few plausible explanations. First, drawing from the risk amplification model (Whitbeck et al., 1999), adolescents who have experienced maltreatment in the home may spend increased time in risky and unsupervised settings to escape from a negative home environment, for example wandering the abandoned streets or hanging out with peers who commit violence. Alternatively, given that the frequency of previous episodes of maltreatment is a key risk factor for child maltreatment recurrence (White et al., 2015), our results might suggest that youths with a history of child welfare involvement continue to be at risk for exposure to violence and aggression at home (e.g., maltreatment recurrence). However, more research is needed to decipher these complexities. Additionally, our results indicated that older youths were more likely than younger youths to belong to the *Aggression/violence* class. As youths get older, their mobility increases significantly, and their activity spaces widen substantially beyond their home neighborhoods (Browning et al., 2021). Our findings suggest that continued and increased attention, monitoring, and support should be provided throughout adolescence to ensure safe and positive activity spaces for adolescents of all ages.

The *smoking and drinking* class (Class 2) contained approximately 12.3 % of the youths in the study. This class was characterized by higher probabilities of exposure to substance use, including alcohol and tobacco use. Although the number of maltreatment reports to Child Protective Services did not predict membership in this class, the parent's report of parent-to-child psychological aggression was found to be a marginally significant predictor of membership in this class. Previous studies have indicated a significant link between psychological abuse and adolescent substance use (Rosenkranz et al., 2012; Tonmyr et al., 2010). Adolescents who experience psychological abuse may choose to visit places where substances are available and accessible as they use substances to cope with psychological distress and emotion dysregulation associated with psychological aggression (Barahmand et al., 2016). White youths (compared to Black youths) and older youths (compared to younger youths) were also more likely to be in this class. These findings are consistent with previous studies that found greater alcohol, tobacco, and marijuana use among White and older adolescents (Substance Abuse and Mental Health Services Administration, 2022). One unexpected finding was that girls, compared to boys, were more likely to belong to this *Smoking and drinking* class than the *Non-risk* class. This finding appears to corroborate the national trend of a narrowing gender gap in adolescent alcohol and cigarette use. In fact, the national report on demographic subgroup trends in adolescent substance use showed that female 8th graders reported higher levels of alcohol and cigarette use than male 8th graders in the past decade (Johnston et al., 2022), suggesting high levels of early substance use among girls than boys. Given this, our finding that girls were more likely to be in the *Smoking and drinking* class may be attributed to the relatively young age of our sample (mean age approximately 14 years).

8. Limitations and future directions

The study has several limitations. First, the study data were collected from a single urban city in a midwestern state, and thus the findings may not be generalizable to other populations or geographical regions. Future work should involve youths across diverse geographical areas to increase generalizability. It would be interesting to examine if similar contextual risk exposure classes emerge in suburban and rural areas. Second, despite the novelty and benefits of smartphone-based EMA, this data collection method was not without challenges and drawbacks, including EMA non-response and missingness that might bias the study results. Nonetheless, the examination of exposure to contextual risk factors via EMA measures in this study offer valuable insights into the utility of innovative, technology-based data collection methods (e.g., smartphone-based EMA, GPS-tracking, digital wearables, the Internet of Things; Nabi

et al., 2023) that could be applied in future child welfare and youth development research. A third limitation involves the lack of fully populated and precise identifiers with which to match SACWIS and AHDC participants and the data loss associated with probabilistic matching. A fourth limitation relates to the measurement of child maltreatment in this study. We relied solely on data from the SACWIS system (i.e., official reports made to child protective services) to measure child maltreatment in the study, yet this may introduce bias and measurement error, given that not all cases of maltreatment may be reported or recorded in the system. Further, child welfare reports were recorded in a legacy system prior to 2007 and some data loss may have occurred during conversion of these legacy data to SACWIS. Future studies should consider conducting validation studies, using multiple informants and different data sources, such as youth self-reports, parent-reports, teacher interviews, and case records, to assess child maltreatment.

9. Implications

The findings of the study offer significant insights for future research. Capitalizing on the novel linkage between administrative child welfare records and EMA-based real-time youth spatial/environmental exposure data, the current study contributes to an enhanced understanding of the association between childhood maltreatment and adolescents' contextual risk exposure in their activity spaces. Building upon the current study's finding, future research could examine the ways in which various attributes within youth activity spaces mediate or moderate the pathways from child maltreatment to adolescent health outcomes, such as mental health and substance use problems.

Our findings also have several important public health implications. Considering the positive link between the number of maltreatment reports made to child protective services and membership in the aggression/violence class, more targeted intervention efforts should be directed toward youths who experience risk factors, such as child maltreatment. For instance, practitioners working with these youths could provide them with resources and services, such as free after-school programs or community-based youth programs, to help them spend time in safe, structured, and non-violent environments during daily routines. Our results further indicate parent-to-child psychological aggression as a risk factor associated with adolescents' increased likelihood of experiencing and being exposed to drinking and smoking within their daily environments. These findings support the need for more investment in maltreatment prevention and positive parenting education, with a particular focus on helping parents recognize the detrimental effects of psychological abuse on youth development.

Funding

This research was funded by the National Institute on Drug Abuse (NIDA) of the National Institutes of Health (NIH) under award number K01DA050778. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIDA or the NIH. National Institute on Drug Abuse (Browning, R01DA032371); the Eunice Kennedy Shriver National Institute on Child Health and Human Development (the Ohio State University Institute for Population Research, 2P2CHD058484), and the W.T. Grant Foundation.

CRediT authorship contribution statement

Susan Yoon: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Junyeong Yang:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Jingyi Wang:** Writing – review & editing, Writing – original draft. **Bethany Boettner:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Christopher Browning:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Data availability

The authors are unable or have chosen not to specify which data has been used.

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