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Violence exposure is associated with adolescents' same and next day mental health symptoms

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Abstract

Background—Young people exposed to violence are at increased risk for mental health and behavioral problems. However, very little is known about the immediate, or same-day, associations between violence exposure and adolescents' mental health symptoms or whether daily symptom or behavioral reactivity marks future problems.

Methods—Young adolescents were assessed three times a day for 30 consecutive days using mobile-phone-based Ecological Momentary Assessment (EMA) (N = 151 adolescents). Over 12,500 assessments and 4,329 person days were obtained via the EMA. Adolescents were recruited from low-income neighborhoods based on parent-reported risk for externalizing symptoms. Mental health symptoms were assessed via: parent and child report at baseline, multiple times per day via EMA assessments of the adolescents, and again 18 months later when 93% of the adolescents were re-interviewed

Results—Results from multi-level models illustrated that young adolescents were more likely to experience symptoms of anger (OR=1.74, CI:1.31–2.30), depression (OR=1.66, CI:1.26–2.19), and conduct problems (OR=2.63, CI:1.71–4.04) on days that they were exposed versus not exposed to violence. Increases in depressive symptoms were also observed on days following violence exposure (OR=1.46, CI: 1.09–1.97). Adolescents with the highest levels of violence exposure across the 30-day EMA were *less* behaviorally reactive to violence exposures in daily life and heightened behavioral reactivity predicted increased risk for substance use across early adolescence.

Conclusions—Findings support the need to focus on both the immediate and long-term associations between violence exposure and adolescents' mental health and behavior. Results also suggest that heightened behavioral reactivity during early adolescence may signal emerging substance use problems.

Keywords

violence exposure; daily stressors; aggression; depression; health-risk behaviors; mobile technologies; ecological momentary assessment; early adolescence

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Adolescents exposed to violence in their families, schools, and communities are at increased risk for depression, anxiety, conduct problems and health-risk behaviors (Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Baltes, 2009; Guerra, Rowell Huesmann, & Spindler, 2003; Kitzmann, Gaylord, Holt, & Kenny, 2003; Margolin & Gordis, 2000). Understanding both the immediate and long-term associations between mental health symptoms and violence exposure is important given that approximately one in four young people in the United States have witnessed violence in their home or community over the past year (Finkelhor, Turner, Shattuck, & Hamby, 2013). For youth living in urban neighborhoods, approximately one incident of community violence exposure is reported per week using daily sampling methods (Richards et al., 2015).

Witnessing violence is both common among adolescents and reliably associated with adolescents' mental health across studies, within diverse subpopulations, and over time (for a review see Fowler et al., 2009). However, questions remain as to whether this form of violence exposure *causes* mental health problems versus shares a common cause(s), such as poverty or familial risk. In addition, very little is known about the immediate, or same-day, associations between violence exposure and adolescents' mental health and behavior, or whether adolescents' who experience same-day elevations in mental health symptoms when violence exposure occurs are at heightened risk for future problems.

In the present study, young adolescents were recruited from low-income neighborhoods based on parent-reported risk for externalizing symptoms. The sample was selected to examine predictors and patterns of daily mental health symptoms among young adolescents embedded in violence-prone neighborhoods and families. Mental health symptoms were assessed via parent and child report at baseline and then multiple times per day via a mobile-phone based ecological momentary assessment (EMA) across 30 consecutive days. Adolescents reported on whether they witnessed people fighting in their homes, schools, communities or somewhere else each day as part of the EMA (hereafter referred to as violence exposure). Approximately 18 months later, 93% of the adolescents were re-interviewed and reported on their mental health symptoms and substance use involvement. Violence exposure and mental health symptoms are captured during a key developmental period that is characterized by rapid biological, cognitive, and social changes (Dahl, 2004). Early adolescence is also a time when depressive symptoms first emerge (Angold, Costello, & Worthman, 1998) and when persistent conduct problem symptoms become a strong signal of a wide range of later problems (Moffitt, 1993; Odgers, Moffitt, et al., 2008).

Using this novel approach to capturing adolescents' daily mental health symptoms and violence exposure in early adolescence we address the following three sets of questions:

Question 1. Do young adolescents exposed to violence in her homes, schools, or neighborhoods experience same-day increases in mental health symptoms and behavioral problems?

First, we asked whether adolescents are more likely to experience mental health symptoms and behavior problems on days when they were, versus were not, exposed to violence. Each

adolescent was used as his or her own control to test whether witnessing violence was associated with *within-individual* elevations in risk for same-day symptoms and behavior. This approach facilitates causal inference by holding constant all time-invariant factors within the adolescent. Although not sufficient to establish a causal connection, this approach provides a strong test of whether there are unique associations between violence exposure and symptoms that cannot otherwise be explained by often powerful invariant and potentially confounding factors, including sex, age, and socioeconomic status.

The within-person association between daily stressors and affect has been termed affective “reactivity” in past research (e.g., Charles et al., 2013) and the term reactivity is used here in a similar way connect to this body of research to reference the *within-person association* between daily violence exposure and symptoms/behaviors, with the acknowledgement that the term represents a correlational versus causal link.

Are adolescents who are exposed to violence more frequently less “reactive” when it occurs?

Second, we tested the “emotional desensitization” hypothesis in daily life. Desensitization to violence is conceptualized as a diminished emotional, affective, or physiological reaction to repeated violence exposure. This type of calibrated response to repeated exposure to adversity may be an adaptive response that preserves health and normal functioning for children living in difficult contexts (Ellis, Jackson, & Boyce, 2006). Desensitization has been most frequently studied in the context of exposure to violent media and video games (Fanti, Vanman, Henrich, & Avraamides, 2009) and less is known about desensitization to violence that is encountered in real life (Mrug, Madan, Cook III, & Wright, 2015). However, recent support for the desensitization hypothesis has been found within large-scale community-based studies of violence exposed youth (Kennedy & Ceballo, 2016) as well as within experimental laboratory-based research with children where those with higher levels of prior violence exposure exhibit “blunted” cortisol reactivity in response to an experimental stressor (Ouellet-Morin et al., 2011).

Question 2. Are adolescents who witness violence more likely to experience mental health symptoms or behavioral problems the following day?

The repeated daily assessments allowed us to test whether exposure to violence increases the risk for next-day mental health symptoms. That is, we ask whether, and for how long, carry over associations between violence exposure and mental health symptoms can be detected among young adolescents. Similarly, to explore whether, for example, adolescents’ symptoms may be leading them to select into contexts where violence is more likely to occur, we test whether mental health symptoms predict next-day violence exposure.

Question 3. Are adolescents who exhibit heightened symptom or behavioral reactivity at increased risk for substance use or behavioral problems across early adolescence?

We tested whether adolescents' daily symptom or behavioral reactivity predicted the worsening of substance use or behavioral problems across early adolescence. Among adults, the strength of the association between daily stressors and affect, termed "affective reactivity" predicts both immediate and long-term mental (Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013) and physical health (DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982) problems. However, to our knowledge, this is one of the first studies to capture adolescents' daily symptom and behavioral reactivity related to violence exposure and to predict future mental health problems.

Methods

Participants

The miLife Study used EMA via mobile phones to track daily experiences, symptoms, and behaviors of young adolescents (N=151) at heightened risk for both exposure to violence and mental health problems. Adolescents were, on average, 13 years of age (with ages ranging from 11 to 15 years, SD = 0.91). The sample was 48% female and ethnically diverse (57.3% White, 23.3% Hispanic, 4.0% African-American, 4.7% Native American, 4.0% Asian, 6.7% Other). One in three families in the sample "occasionally" or "often" had difficulty paying for food or other necessities, 40% reported difficulties paying for bills, and 8% reported that they were currently receiving government services or assistance. Parental reports were collected for 93% of the adolescents in the sample (n=141).

Ethical considerations—All measures and procedures in the study were approved by the University's Institutional Review Board.

Procedures

Adolescents from low socioeconomic status neighborhoods were recruited via a brief telephone screen (full details regarding recruitment are provided elsewhere: Russell, Wang, & Odgers, 2015). Adolescents with 3 or more risk factors reported by the parent (i.e., behavioral difficulties, inattention or hyperactivity, or early initiation of substances, or a parent with a substance use problem) were invited to participate in the study. Parents provided consent and the adolescents provided assent.

The study had three phases: a baseline assessment, an EMA, and an 18-month follow-up. At baseline, parents and adolescents completed self-report inventories about family characteristics and the adolescents' mental health and behavioral problems. During the EMA, adolescents were provided with smart phones that were programmed with the adolescents' schedules to "beep" three times a day for 30 consecutive days. The morning survey (i.e., 7 to 10 AM) took, on average, 2.3 minutes, the afternoon survey (2 to 5 PM) took, on average, 3.8 minutes, and the evening survey (5 PM to 12 AM) took, on average, 8.3 minutes to complete. The average response rate across the mobile assessment period was

92%. Over 13,000 assessments and 4,329 person days were obtained via the EMA. At the follow-up assessment, adolescents (93% of sample) were interviewed to assess their self-regulation behaviors and conduct problems.

Daily Measures

Violence exposure was measured in the evening each day. Adolescents were asked whether they witnessed people fighting: (a) at home, (b) in school, (c) in their neighborhoods, or (d) somewhere else (e.g., “Did you see people fighting in your home today?” Yes/No). If exposure was reported in any context, violence exposure was coded 1 for the day, 0 if not. Violence exposure occurred on 9.7% of the over 4300 study days. Violence exposure was most frequently reported outside (8%) versus inside the home (4%), with girls versus boys reporting a higher proportion of violence-exposed days (10.7% vs. 8.8%, respectively). The majority of adolescents in our sample were exposed to violence on at least one of the study days ($n=113$, 75%). Reactivity coefficients did not differ across contexts or gender. Therefore, results are presented for the entire sample and collapsed across contexts. The intraclass correlation (ICC) for violence exposure was 0.20, suggesting that 20% of the variation was between adolescents, while the remaining 80% $[(1-ICC)*100]$ was within adolescents over time.

Depressive symptoms were measured in the morning, after-school, and evening diaries each day using items modified for EMA from the Beck Depression Inventory (Beck, Steer, & Brown, 1996). Adolescents responded to five items measuring symptoms such as sadness (e.g., I feel sad), hopelessness (e.g., I feel hopeless, like nothing matters), and guilt (e.g., I feel guilty for no reason) (Yes/No). Depressive symptoms were coded 1 for the day (0 if not) if symptoms were reported at any of the day’s three assessments. At least one depressive symptom was reported on 25.9% of days (ICC = 0.33).

Anger was measured in the morning, after-school, and evening diaries each day based on an adapted item from the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). Adolescents responded to “Right now I feel mad” (Yes/No). If the adolescent responded “Yes” at any point during the day, anger was coded 1 (0 if not). Anger was experienced on 14.6% of days (ICC = 0.16).

Irritability was measured in the morning, after-school, and evening diaries each day using an item adapted from the Affective Reactivity Index (Stringaris et al., 2012). Adolescents responded to “This morning/today/evening, even little things are getting on my nerves” (Yes/No). If the adolescent responded “Yes” at any point throughout the day, irritability was coded 1 (0 if not). Irritability was experienced on 14.6% of days (ICC = 0.31).

Conduct problems were measured in the evening diary each day using six items (Yes/No) measuring aggression (e.g., “Today did you hit or hurt someone?”), vandalism (e.g., “Today did you damage someone else’s property?”), and theft (e.g., “Today did you steal something that did not belong to you?”). Items were adapted for the EMA based on Conduct Disorder symptoms listed in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1994) and from the Child Behavior Checklist (Achenbach &

Rescorla, 2001). If any symptoms were reported, conduct problem symptoms was coded 1 for the day, 0 if not. Conduct problem symptoms occurred on 7.7% of days (ICC = 0.27).

Health-risk behaviors were measured in the evening diary of each day using four items (Yes/No) adapted from the Youth Risk Surveillance Survey (Eaton et al., 2008). Adolescents were asked whether they (1) rode a bike without a helmet (4.5% of days), (2) rode in a car without a seatbelt (7.3% of days), (3) rode in a car with a drunk driver (0.6% of days), or (4) skateboarded without a helmet (4.2% of days). If any of these were reported, health-risk behavior was coded 1 for the day (0 if not). Health-risk behavior occurred on 13.1% of days (ICC = 0.36).

Baseline and follow-up measures

Substance use was measured at both baseline and follow-up assessments using items adapted from the Monitoring the Future Study (Johnston, O'Malley, Bachman, & Schulenberg, 2010). Adolescents reported whether they had ever tried (a) drinking alcohol, more than a few sips; (b) smoking a cigarette; (c) marijuana; (d) pills like Ritalin to get high; or (e) sniffing glue or gas to get high. A count of substances used was created at each wave (baseline $M=0.50$, $SD=0.87$; follow-up $M=0.98$, $SD=1.27$).

Antisocial behaviors were assessed using items from the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001), with additional items added to include DSM-IV listed symptoms of Conduct Disorder. Parents and adolescents reported on antisocial behaviors at the baseline and adolescents reported on symptoms at the follow-up assessment. The scale included 11 types of antisocial behavior (e.g. Does your child get into many fights? Do you destroy things that belong to other people?). Each item was rated on a 3-point scale of not true (0), somewhat/ sometimes true (1), and very/often true (2) in the past six months. A summary score of the 11 antisocial behaviors assessed at both waves was created at the baseline ($M=2.46$, $SD=2.07$) and follow-up ($M=2.47$, $SD=2.19$) assessments. Adolescent ratings of conduct problems were used because they are often the most reliable informants regarding behavioral problems at this age. Agreement between parents and children on reporting of specific symptoms (e.g., aggression, $r=.18$, $p=.03$; runs away from home $r=.40$, $p<.001$) were similar to those reported in prior studies where informant discrepancies are both well documented and potentially meaningful sources of information (De Los Reyes & Kazdin, 2005).

Analyses

Analyses proceeded in three steps. First, we tested whether exposure to violence was associated with same-day, within-person increases in depressive symptoms, anger, irritability, conduct problems, and health-risk behaviors. Next, we tested whether these within-person associations differed by adolescents' overall levels of violence exposure. Across all models we tested for interactions across gender and self-identified minority status. Second, we tested whether violence exposure on a given day increased the likelihood of experiencing problems on the next day. We also tested whether mental health symptoms predicted next-day violence exposure. Third, we tested whether individual differences in 'reactivity', that is differences in the strength of the same-day association between violence

exposure and mental health symptoms and behaviors, predicted the worsening or emergence of substance use or behavior problems 18 months following the initial assessments.

Analyses in steps 1 and 2 were conducted in a multi-level modeling (MLM) framework (Raudenbush & Bryk, 2002), which allows for the separation of between-and within-person levels of analysis and accounts for the clustering of assessments within adolescents. Daily behavioral outcomes were dichotomous and therefore were analyzed in models specifying logit links and binomial distributions. These models included random intercepts (accounting for the clustering of observations), random slopes (allowing within-person violence exposure slopes to differ between adolescents), and a random covariance between the intercept and slope.

Equation 1 shows the logistic multilevel model testing the same-day within-person association between violence exposure and conduct problems.

$$\text{Log Odds}(CP_{ij}) = \beta_0 + \beta_1(\text{Violence_Day}_{ij}) + \beta_2(\text{Violence_Freq}_j) + u_{0j} + u_{1j}(\text{Violence_Day}_{ij})$$

(1)

where β_0 is the sample average intercept representing the log odds of conduct problem behavior on non-violence exposure days, $\beta_1(\text{Violence_Day}_{ij})$ is the sample average within-person slope describing the change in the log odds of conduct problem behavior across violence exposure and non-violence exposure days, and $\beta_2(\text{Violence_Freq}_j)$ is the between-person association testing whether adolescents who are more frequently exposed to violence show higher likelihood of conduct problems across the 30-day assessment. The Violence_Freq_j variable is the proportion of days the adolescent was exposed to violence, multiplied by 100 to yield a percentage. When the Violence_Freq_j variable is included in the model, the between-person variance in the Violence_Day_{ij} variable is removed, which ensures that the violence exposure association [$\beta_1(\text{Violence_Day}_{ij})$] is truly a within-person association (Hoffman & Stawski, 2009). The random effects in this model include a random intercept [u_{0j}] which captures between-person variation in adolescents' likelihood of conduct problems on non-exposure days, and a random violence exposure slope [$u_{1j}(\text{Violence_Day}_{ij})$], which captures between-person differences in the within-person association between violence exposure and conduct problems. This modeling strategy was repeated for each of the five daily outcomes (conduct problems, health-risk behavior, anger, depression, and irritability).

Equation 2 shows a model testing for next-day effects of violence exposure on the likelihood of conduct problems.

$$\begin{aligned} \text{Log Odds}(CP_{ij}) = & \beta_0 + \beta_1(\text{Violence_PreviousDay}_{ij}) + \beta_2(\text{CP_PreviousDay}_{ij}) \\ & + \beta_3(\text{Violence_Freq}_j) + u_{0j} + u_{1j}(\text{Violence_PreviousDay}_{ij}) \end{aligned} \quad (2)$$

This model includes a lagged association for violence exposure on the previous day [$\beta_1(\text{Violence_PreviousDay}_{ij})$] while adjusting for previous-day conduct problems [$\beta_2(\text{CP_PreviousDay}_{ij})$] and adolescents' differences in violence exposure frequency [$\beta_3(\text{Violence_Freq}_{ij})$]. Random effects included a random intercept [u_{0j}] and a random lagged violence exposure slope [$u_{1j}(\text{Violence_PreviousDay}_{ij})$].

Logistic multilevel models were used to estimate *symptom and behavioral reactivity scores* for each adolescent, which represented the change in the likelihood of symptoms or behavioral problems across violence exposure versus non-violence exposure days *for each adolescent*. The reactivity score was calculated from the same-day models (see Equation 1 in S1) by adding the sample average violence exposure slope [$\beta_1(\text{Violence_Day}_{ij})$] to each adolescents' deviation from the sample average [$u_{1j}(\text{Violence_Day}_{ij})$] so that it represented an adolescent-specific slope describing the relationship between violence exposure and the outcome for each adolescent. Violence exposure reactivity scores were generated for each outcome and used in models predicting 18-month follow-up outcomes. All models controlled for two daily level variables: (1) adolescents' overall violence exposure frequency (proportion of days exposed), which adjusts for individual differences in daily violence exposure levels; and (2) adolescents' frequency of emotional or behavioral problems on non-violence exposure days (proportion of days experiencing problems), which adjusts for each adolescents' tendency to experience day-to-day problems when not exposed to violence. These measures, along with the violence exposure reactivity scores, were Z-scored to control scaling and enhance interpretability of model effects. Additionally, models controlled for adolescents' levels of problem behavior at baseline (substance use and antisocial behavior) which allowed us to interpret model effects as predicting *change* in substance use and antisocial behavior from baseline to follow-up.

Results

Question 1. Is violence exposure associated with same-day increases in emotional and behavioral problems?

Table 1 shows results from MLMs testing (a) the same-day, within-person relationships between violence exposure and emotional and behavioral problems and (b) the person-level relationships between violence exposure frequency and odds of emotional and behavioral problems on any given day. Table 1 illustrates two main findings. First, daily-level relationships showed that on days when adolescents witnessed violence in the neighborhood, home, or at school, their odds of experiencing symptoms of anger, depression, and irritability significantly increased relative to themselves on non-violence exposure days. Witnessing violence was also associated with increased same-day odds of engaging in health-risk behaviors and conduct problem behavior (which included fighting, lying, stealing, and substance use). Second, person-level relationships showed that adolescents who were exposed to violence more frequently experienced more frequent symptoms of depression and irritability, and engaged in health-risk and antisocial behavior more frequently across the 30-day EMA period.

Do adolescents exposed to high levels of violence become desensitized to violence?—Next, we tested whether the same-day associations between witnessing violence and emotional-behavioral problems differed by overall levels of violence exposure. Adolescents who did not experience violence during the study period were removed from these analyses ($n=38$, 25% of the sample). Consistent with the desensitization hypothesis we found that adolescents who witnessed violence more frequently across the 30-day EMA period were *less* likely to exhibit heightened behavioral reactivity on violence-exposure days ($OR=0.98$, 95% CI: 0.96, 1.00, $p=.033$). Simple slopes estimation illustrated that for adolescents at low levels of violence exposure (25th percentile and below) the odds of exhibiting conduct problems on a violence exposure versus non-exposure day were 4 times higher ($OR=4.03$, 95% CI: 2.41, 6.73, $p<.001$), whereas for adolescents at high levels of violence exposure (above the 75th percentile) the odds were 2.9 times higher ($OR=2.91$, 95% CI: 1.98, 4.29, $p<.001$). Frequency of violence exposure across the 30-day EMA period did not moderate associations between violence exposure days and any of the other outcomes.

Question 2. Does violence exposure predict *next-day* increases in emotional and behavioral problems?

Table 2 shows the associations between violence exposure and next day mental health and behavioral problems and illustrated two main findings. First, previous-day problems consistently predicted next-day problems across all five emotional and behavioral outcomes (the auto-correlation for all outcomes was statistically significant). Second, previous-day violence exposure significantly predicted next-day depression and irritability, suggesting that adolescents' likelihood of depression and irritability significantly increased on the days following violence exposure. Previous-day violence exposure did not predict next-day anger, conduct problems, or health-risk behavior. We repeated the lagged models to test whether daily mental health symptoms predicted next-day violence exposure. Our findings illustrated two main points. First, violence exposure was not randomly distributed over the series. When adolescents reported witnessing violence their odds of witnessing violence the following day increased by a factor of 3 ($O.R \sim 3.0$, $p<.001$ across all models). Second, daily conduct problem symptoms and health risk behaviors were associated with reports of *next day* violence exposure ($OR = 1.98$, $p<.001$ and $OR= 1.82$, $p<.01$ respectively). However, no other lagged associates were found between daily symptoms and next-day violence exposure.

Consistent with the same-day results, we found evidence that the association between violence exposure and *next-day* conduct problems differed by adolescents' levels of violence exposure, although the interaction term was not significant at the conventional $p<.05$ level ($OR=0.98$, 95% CI: 0.96, 1.00, $p=.065$). Adolescents with low frequency of violence exposure (25th percentile) showed greater next-day increases in conduct problem symptoms ($OR=1.90$, 95% CI: 1.08, 3.36, $p=.027$) than adolescents at high frequency of violence exposure ($OR=1.45$, 95% CI: 0.96, 2.20, $p=.078$). We found no evidence that violence exposure and other next day mental health symptoms differed by violence exposure frequency.

Question 3. Does heightened reactivity to violence exposure during early adolescence predict future problem behavior?

Finally, we tested whether daily symptom and behavioral reactivity (captured here by the reactivity coefficient which captures the strength of the daily associations between violence exposure and mental health from the MLMs) predicted the emergence and/or worsening of substance use problems and antisocial behavior across early adolescence. We found that adolescents who showed heightened behavioral reactivity – greater increases in conduct problem symptoms and health-risk behavior on violence exposure days – showed greater increases in substance use behavior from early to mid-adolescence. As shown in Table 3, for each one standard deviation increase in conduct problem reactivity, the number of substances used in mid-adolescence increased by 22% (IRR=1.22), and for each standard deviation increase in health-risk behavior reactivity, the number of substances used in mid-adolescent substance use increased by 24% (IRR=1.24); the direction of effects was similar but not statistically significant for the prediction of antisocial behavior across early adolescence. Models predicting substance use at follow-up included baseline substance use as a covariate; models predicting antisocial behavior at follow-up included baseline antisocial behavior, allowing us to interpret the model effects as predicting *change* over time. Daily symptom reactivity (increased risk for depressive symptoms, anger and irritability on violence versus non-violence exposure days) did not predict future substance use or antisocial behavior.

Discussion

The present study advances what is known about the immediate and longer-term associations between violence exposure and adolescents' mental health in the following ways. First, young adolescents were more likely to experience symptoms and problem behaviors on violence exposure versus non-violence exposure days. Because each adolescent was used as their own control in the analyses, our findings provide strong support for the same-day coupling of violence exposure and a wide range of mental health symptoms and behaviors (versus an association that is driven solely by shared contextual, family risk, or other common factors). Violence exposure also predicted next-day depressive symptoms and irritability, supporting the idea that witnessing violence may be *leading to* elevations in mental health symptoms. However, it is also important to note that conduct problems and health risk behaviors were also predictive of next-day exposure to violence, suggesting that adolescents own engagement in antisocial and risky behaviors may be leading them to select into settings where violence exposure was likely to occur and/or there was a bidirectional relationship between behavioral symptoms and violence exposure across days, similar to findings in prior research (e.g., Mrug & Windle, 2009).

Second, our findings suggest that adolescents who are exposed to violence more frequently in their daily lives may be *less* behaviorally reactive to violence when it occurs. This finding is consistent with prior evidence showing that adults with a history of childhood maltreatment exhibit a diminished cortisol response when faced with a stressor (Elzinga et al., 2008; Tyrka et al., 2008), laboratory based experiments where children with a history of maltreatment exhibit a blunted cortisol response to a psychosocial stressor (Lovallo, Farag,

Sorocco, Cohoon, & Vincent, 2012; Ouellet-Morin et al., 2011), and longitudinal studies of youth documenting emotional desensitization as exposure to community violence increases (Kennedy & Ceballo, 2016). Future research is required to test the mechanisms underlying adolescents' responses to diverse and repeated forms of violence exposure in community and real-life contexts and test whether repeated violence exposure could be underlying the development of adaptive, or maladaptive traits and patterns of coping among adolescents living in high-risk neighborhoods and families.

Third, adolescents who were more behaviorally reactive in their daily lives were also more likely to experience a worsening of substance use problems across early adolescence. Population-based studies have consistently documented an increased risk for substance use problems among children exposed to acute and chronic violence (Fowler et al., 2009; Kilpatrick et al., 2000; Vermeiren, Schwab-Stone, Deboutte, Leckman, & Ruchkin, 2003). Our results showed that the *frequency* of violence exposure over the 30 day EMA was not associated increases in substance use or antisocial behavior among our high-risk sample of adolescents. However, heightened 'behavioral reactivity' (stronger same-day association between violence exposure and conduct problem symptoms) was predictive. This finding suggests that it is not necessarily the amount of violence that these already at-risk adolescents are exposed to that predicts increases in substance use, but that the heightened daily co-occurrence of violence exposure and behavioral problems may be a stronger signal of worsening of substance use problems across the early adolescent period. Identifying predictors of early adolescent substance use is important as this has been shown to predict a wide array of mental and physical health problems well into young adulthood (Grant & Dawson, 1998; Odgers, Caspi, et al., 2008).

Future research using experimental study designs, as well as a more diverse set of violence exposure measures and multi-informant measures at the follow-up time points, is required to fully understand what heightened reactivity signals for young adolescents.

This study also has limitations. First, the adolescents were drawn from high-risk neighborhoods and were already experiencing mental health and behavioral problems. We recruited adolescents from these settings as we were interested in capturing repeated exposures to violence in daily life among adolescents at risk for psychopathology. Future research with larger and more diverse populations of adolescents is required to test whether these findings will generalize. Second, exposure to violence was restricted to witnessing fights in the adolescent's home, school and/or community and captures only a narrow range of violence exposure and was captured only one time per day. Additional research focused adolescents experiences of poly-victimization in daily life (Fisher et al., 2015) is required with multiple assessments of more frequent conflict and stressors throughout the day. Similarly, we measured health-risk behaviors using a small set of items related to wearing helmets, seatbelts and getting into a car with drunk drivers. Future research is required, especially among older adolescents where these behaviors are more frequent, to capture a more comprehensive battery of health-risk behaviors, including: behaviors related to unintentional injuries and self-harm, sexual behaviors related to unintended pregnancy and sexually transmitted diseases, and experimentation with substances. Third, while adolescents are often considered the most reliable sources of information on both their daily experiences

and symptoms, future research should examine whether these findings hold when alternative sources of information are used (e.g., informant or official record reports of violence exposure) and/or with experimentally-induced stressors in daily life. Finally, we did not measure internalizing behaviors at the follow-up assessment and, as such, we were unable to test whether symptom reactivity predicted future internalizing problems.

With these limitations in mind the implications of our findings for future research and practice can be considered. First, these findings provide strong evidence that witnessing violence is uniquely associated with young adolescents' mental health and behavioral problems, both in the moment and across early adolescence. Violence prevention efforts should be directed not only at directly experiencing, but also towards the witnessing of violence by adolescents. More generally, understanding the daily coupling of violence exposure and symptoms/behavior may provide a new and dynamic target for intervention.

Second, the finding that adolescents who are exposed to violence more frequently in their daily life were less behaviorally reactive *and* that lower reactivity to violence predicted better behavioral outcomes over time, suggests that young adolescents in high-risk neighborhoods may be developing potentially adaptive coping mechanisms in the face of repeated violence exposure. However, from a public health and policy perspective, these findings are also concerning as they suggest that high-levels of violence exposure within low-income neighborhoods may lead young people to become emotionally or behaviorally unresponsive. Future research is required to better understand how young people react to repeated and chronic violence exposure across contexts and whether these experiences lead to responses that are adaptive and potentially protective given the adverse contexts, or alternatively, whether they lead to maladaptive coping responses and mental health problems over time.

Third, daily behavior reactivity was predictive of increases in substance use problems across early adolescence, suggesting that "highly reactive" adolescents may benefit from targeted interventions and/or that heightened reactivity to violence could be used to identify those at greatest risk. Finally, mobile devices were effectively used to capture the experiences, symptoms and behaviors of young adolescents and provided new insights into daily violence exposure. Moving forward, mobile devices, currently held in the hands of over 90% of adolescents in the United States, should be leveraged as intervention and prevention tools to help young people more safely navigate and respond to violent homes, schools, and neighborhoods.

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Abbreviations

EMA Ecological Momentary Assessment

MLM	Multilevel Modeling
DSM	Diagnostic and Statistical Manual of Mental Disorders;

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Key Points

- Adolescents exposed to violence are more likely to suffer from mental health problems. This study provides evidence that witnessing violence in daily life is associated with same-day increases in a mental health symptoms and behavioral problems.
- Violence exposure predicted adolescents' next day depressive symptoms and irritability. But, evidence for bidirectional associations between violence exposure and behavioral problems was also found.
- Adolescents exposed to violence more frequently appear to be less behaviorally reactive when violence occurs – supporting the violence desensitization hypothesis.
- Heightened behavioral reactivity among adolescents on violent versus non-violent days predicts increasing substance use problems across early adolescence.
- For policy and practice, these findings suggest that heightened reactivity to daily stressors may be an important marker of future risk among young adolescents and a potentially

Table 1
Same-Day Within-Person Relationships between Violence Exposure and Emotional-Behavioral Problems

	Anger		Depression		Irritability		Conduct Problems		Health-Risk Behavior	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Fixed effects</i>										
Violence Exposure Day (Daily Level)	1.74 ^{***}	(1.31, 2.30)	1.66 ^{***}	(1.26, 2.19)	2.75 ^{***}	(1.99, 3.79)	2.63 ^{***}	(1.71, 4.04)	2.14 ^{***}	(1.48, 3.12)
Violence Exposure Frequency (Person-Level)	1.01	(1.00, 1.03)	1.03 ^{**}	(1.01, 1.05)	1.03 ^{**}	(1.01, 1.04)	1.05 ^{***}	(1.03, 1.07)	1.04 ^{***}	(1.02, 1.07)
Intercept	0.13 ^{***}	(0.10, 0.16)	0.26 ^{***}	(0.20, 0.33)	0.08 ^{***}	(0.06, 0.11)	0.03 ^{***}	(0.02, 0.04)	0.05 ^{***}	(0.03, 0.07)
<i>Random Effects</i>										
Intercept	1.14 ^{***}	(0.19)	2.16 ^{***}	(0.32)	2.53 ^{***}	(0.38)	2.32 ^{***}	(0.39)	3.70 ^{***}	(0.56)
Violence Exposure Day Slope	0.10	(0.21)	0.17	(0.24)	0.58 [*]	(0.32)	1.71 ^{**}	(0.58)	1.01 ^{**}	(0.43)
Covariance (Intercept, Violence Slope)	0.10	(0.19)	-0.15	(0.27)	-0.72	(0.30)	-0.55	(0.39)	0.36	(0.48)

*** p<.001,
 ** p<.01,
 * p<.05,
 † p<.10

Table 2
Next-Day Within-Person Relationships between Violence Exposure and Emotional-Behavioral Problems

	Anger		Depression		Irritability		Conduct Problems		Health-Risk Behavior	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
<i>Fixed effects</i>										
Previous Day Violence Exposure (Daily Level)	0.96	(0.71, 1.31)	1.46*	(1.09, 1.97)	1.85**	(1.25, 2.74)	1.13	(0.71, 1.79)	0.95	(0.60, 1.50)
Previous Day Outcome (Daily Level)	2.12***	(1.75, 2.59)	2.57***	(2.16, 3.06)	2.84***	(2.31, 3.50)	2.55***	(1.97, 3.30)	5.72***	(4.60, 7.11)
Violence Exposure Frequency (Person-Level)	1.02**	(1.01, 1.03)	1.03***	(1.01, 1.04)	1.03***	(1.01, 1.04)	1.06***	(1.04, 1.08)	1.04***	(1.02, 1.06)
Intercept	0.11***	(0.09, 0.13)	0.18***	(0.14, 0.23)	0.06***	(0.04, 0.08)	0.03***	(0.02, 0.04)	0.04***	(0.03, 0.05)
<i>Random Effects</i>										
Intercept	1.07	(0.19)***	1.69	(0.27)***	2.42	(0.39)***	2.23	(0.39)***	2.49	(0.42)***
Previous Day Violence Exp Slope	0.12	(0.31)	0.32	(0.26)	1.23	(0.45)**	1.12	(0.53)*	1.23	(0.56)*
Covariance (Intercept, Slope)	-0.23	(0.20)	-0.44	(0.24)†	-1.06	(0.36)**	-0.32	(0.40)	0.03	(0.49)

*** p<.001,
 ** p<.01,
 * p<.05,
 † p<.10

Table 3

Regression models predicting problem behavior at the 18-month follow-up from daily-level violence exposure parameters

	Substance Use	Antisocial Behavior
	IRR [95% CI]	IRR [95% CI]
<i>Conduct Problems</i>		
Reactivity to Violence Exposure	1.22* [1.02, 1.41]	1.11 [0.94, 1.29]
Conduct Problem Frequency on non-Violence Exposure Days	1.00 [0.81, 1.19]	1.09 [0.92, 1.26]
Violence Exposure Frequency	1.07 [0.74, 1.40]	1.05 [0.90, 1.20]
<i>Health -Risk Behavior</i>		
Reactivity to Violence Exposure	1.24* [1.02, 1.46]	1.07 [0.86, 1.28]
Health-Risk Behavior Frequency on non-Violence Exposure Days	1.11+ [0.98, 1.24]	1.15* [1.01, 1.30]
Violence Exposure Frequency	0.97 [0.74, 1.20]	1.06 [0.92, 1.20]

IRR=incident rate ratio.

*p<.05, p<. 10.

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