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## Within-Person Variability in Firearm Carriage Among High-Risk Youth

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### Abstract

**Introduction:** Youth who carry firearms—and peers that surround them—are at increased risk for violent injuries. Because firearm carriage behaviors can change over time within an individual, it is important to identify individual and social-contextual determinants that explain this within-person variability in carriage.

**Methods:** The authors identified individual and social-contextual determinants of firearm carriage in the past 6 months using multilevel logistic models on five waves of panel data from the Flint Youth Injury Study ( $n=597$ ; ages 14–24 years), collected in 2009–2011 and analyzed in 2019.

**Results:** Regarding within-person effects, when an individual had more positive peer affiliations compared with their average, their odds of carrying a firearm decreased (OR=0.88; 95% CI=0.81, 0.96). Conversely, an individual's odds of carrying a firearm increased when they had more negative peer affiliations (OR=1.08, 95% CI=1.02, 1.14), experienced more victimization

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(OR=1.03, 95% CI=1.01, 1.05), perceived greater community violence (OR=1.12, 95% CI=1.05, 1.21), or exhibited greater retaliatory attitudes (OR=1.10, 95% CI=1.01, 1.19) than their average.

**Conclusions:** Peer affiliations, victimization, community violence perceptions, and retaliatory attitudes explain within-person variability in firearm carriage. Strategies for reducing carriage among youth should consider individual- and environmental-level interventions to address these individual and social-contextual determinants.

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## INTRODUCTION

Firearms are the leading cause of death among youth aged 14–24 years, with nearly 8,000 reported firearm deaths annually<sup>1</sup> and an estimated 35,000 non-fatal firearm-related injuries.<sup>2</sup> Among these injuries, 60% are due to interpersonal violence. Firearm research, however, has lagged behind other areas of injury prevention.<sup>3,4</sup> Youth who carry a firearm—and their peers—are at increased risk for involvement in interpersonal violence, including fatal and non-fatal violent injuries.<sup>5-12</sup> Yet, the field has limited data about the individual and social-contextual determinants of firearm carriage and how these determinants change over time to explain when an individual might carry.

Firearm carriage behaviors among urban youth are primarily episodic—not persistent—throughout adolescence.<sup>13-17</sup> Thus, it is vital to identify factors that influence the decision to carry at a given time to inform the development and implementation of interventions focused on decreasing carriage among youth. Detecting between-person factors that are associated with firearm carriage identifies individuals who may be in need of an intervention, whereas isolating within-person factors that change a specific individual's risk for firearm carriage identifies the content focus of such interventions. One illustration of the differences among between- and within-person effects is the relationship between exercise and heart rate. Individuals who exercise regularly have lower heart rates than individuals who do not—a between-person effect. If an individual is currently exercising, however, their current heart rate is higher than their average—a within-person effect. With respect to firearm carriage, longitudinal data provide the opportunity to examine within-person effects by determining what time-varying covariates are associated with within-person changes in firearm carriage. Estimating within-person effects can identify potentially modifiable factors that could change a specific individual's risk of carrying.

Oliphant et al.<sup>14</sup> found that substance use, firearm availability, violence exposure, mental health issues, poor school performance, delinquent behaviors, risk-taking behaviors, retaliatory attitudes, fear of safety, peer delinquency, lack of family support, and higher perceived community violence increased risk of youth firearm carriage across several studies. Owing to the cross-sectional nature of many analyses, findings have overwhelmingly identified between-person differences that describe which individuals or social contexts are more likely to associate with firearm carriage. Between-person explanations are not equivalent to causal factors that drive an individual's firearm carriage. Yet, within-person explanations indicate if changes in a specific variable for a particular individual would correspond to changes in carriage for that same individual.

Individual-level (e.g., biological sex, mental health) and social-contextual factors (e.g., violence exposure, family support) have emerged as predictors of firearm carriage in prior studies.<sup>14</sup> Not all studies, however, have included robust sets of predictors that cover both individual and social-contextual domains, and studies that include social context often limit to family and friends rather than the broader community.<sup>14</sup> Thus, the field has yet to explore if comprehensive social-contextual factors are associated with carriage at a given timepoint beyond the explanation that individual factors offer.

This study seeks to identify the individual and social-contextual determinants of changes in firearm carriage using multilevel models on panel data from the Flint Youth Injury (FYI) Study. Although researchers have examined substance use,<sup>18</sup> emergency department recidivism,<sup>19</sup> criminal justice involvement<sup>20</sup>, and firearm violence<sup>21,22</sup> longitudinally using FYI data, researchers have not examined firearm carriage longitudinally. Thus, to inform interventions, the goal of this study is to assess within-person differences in individual and social-contextual factors that describe when a given individual would be more likely to carry a firearm.

## METHODS

### Study Sample

The FYI Study is a longitudinal study of the natural course of service needs, use, and trajectories among high-risk youth (aged 14–24 years) with drug use who presented to an urban Emergency Department (ED) between 2009 and 2011 (N=599).<sup>19,23,24</sup> The study oversampled youth presenting for an assault injury and proportionally balanced these individuals by age and sex with youth presenting for other reasons (e.g., ankle sprain). At baseline, consenting youth completed a self-administered computerized survey and research assistant–administered diagnostic interviews. The FYI study team conducted in-person follow-up assessments at 6, 12, 18, and 24 months. Prior literature describes specific study procedures for the FYI study<sup>19</sup> and provides the FYI screening flowchart.<sup>24</sup> Of the youth who were approached, 85.4% completed the screen.<sup>24</sup> The current study analyzes data collected at five assessments. The FYI study team obtained informed consent (and assent, with parental consent, for minors) for all participants and an NUT certificate of confidentiality. IRBs at Hurley Medical Center and the University of Michigan approved study protocols.

### Measures

Respondents provided information on the primary outcome, any past 6-month firearm carriage, at each assessment by answering: *In the past 6 months, how often have you: carried a gun with you when you were outside your home—including in your car? Don't count the times you've carried a gun for hunting or target shooting.*<sup>25,26</sup> Analyses dichotomized this measure (firearm carriage: yes/no).

At each wave (i.e., every 6 months), survey assessments measured depression/anxiety symptoms and retaliatory attitudes, while research assistant-administered interviews assessed whether the participant met diagnostic criteria for either post-traumatic stress

disorder (PTSD) or a substance use disorder (abuse/dependence). Twelve items from the Brief Symptom Inventory ( $\alpha > 0.7$ )<sup>27</sup> were summed to assess depression and anxiety symptoms (e.g., *During the past week, how uncomfortable have you felt because of: thoughts of ending your life?; nervousness or shakiness inside?*) on a scale of 0 (*not at all*) to 4 (*extremely*). The research assistant–administered Mini International Neuropsychiatric Interview<sup>28</sup> evaluated whether an individual met criteria for PTSD or substance use (alcohol/drug) disorder. Seven items from the retaliation subscale of the Children’s Perceptions of Environmental Violence scale assessed retaliatory attitudes (e.g., *I believe that if someone hits you, you should hit them back*; scale: 1 [*strongly disagree*] to 4 [*strongly agree*]).<sup>29</sup> Higher scores indicated a greater willingness to retaliate. These items created a summary score of retaliatory attitudes for each individual at each assessment. These above individual predictors are time-varying (i.e., they could change over time within a person).

The FYI study included assessments of social context at each wave: victimization, positive peer influences, negative peer influences, prosocial community involvement, parental support, family conflict, and perceptions of community violence. Thirteen items from the Conflict Tactics Scale<sup>30</sup> assessed victimization from a partner (e.g., *In the past 6 months, did your partner throw something at you that could hurt?*), and 13 parallel items assessed victimization from a non-partner on a scale of 0 (*never*) to 6 (*20 times*). The sum of scores across these 26 items created a victimization score for each respondent at each wave. Because the authors wanted to capture victimization comprehensively, they elected to sum both partner and non-partner victimization. They also conducted sensitivity analyses that considered only non-partner victimization—not additional partner-based victimization (Appendix Table 1). Four items from the Flint Adolescent Study (FAS) assessed positive peer influences (e.g., *friends get all A or B grades*; scale: 1 [*none*] to 5 [*all*])<sup>31</sup>; seven questions adapted from FAS assessed negative peer influences (e.g., *My friends get into fights*; scale: 1 [*none*] to 5 [*all*]); three modified FAS questions assessed community involvement (e.g., *number of times you took part in extracurricular school activities*; scale: 0 [*not at all*] to 6 [*more than once a week*]); six questions adapted from FAS assessed parental support (e.g., *parents enjoy hearing what I think*; scale: 1 [*not true*] to 5 [*very true*]); five questions adapted from FAS assessed family conflict (e.g., *We fight in our family*; scale: 1 [*hardly ever*] to 4 [*often*]); and five questions from the “Things I’ve Seen and Heard” Survey assessed perceptions of community violence (e.g., *In the past six months, I have seen gangs in my neighborhood*; scale: 0 [*never*] to 3 [*many times*]).<sup>32</sup> For analysis, a summary score was created for each individual at each time point for each construct outlined above. These social-contextual factors are time-varying.

The analyses controlled for demographic characteristics, including age, biological sex, race/ethnicity (black versus other), public assistance (e.g., receipt of welfare, disability benefits), and if the individual presented to the ED for an assault injury. These characteristics were assessed at baseline and considered stable factors with the exception of age, which varied with time.

## Statistical Analysis

The team analyzed the data in 2019 through a series of multilevel logistic models to evaluate individual and social-contextual determinants of firearm carriage. Models included a person-level random intercept to account for correlations between repeated measures. Analyses included individuals in the sample (N=599) that had complete information on all variables for at least one assessment period, resulting in an analytic sample of  $n=597$ . The team person-mean centered all time-varying predictors to evaluate within-person effects (Level 1), and analyses included person-means for all time-varying predictors to evaluate between-person effects (Level 2).<sup>33,34</sup> Analyses included all demographic predictors as Level 2 predictors (i.e., explaining between-person variability) with the exception of age, which the authors partitioned to explain both between- and within-person variability. The team conducted multilevel analyses within SAS, version 7.1.

The team built the final model in a series of steps to evaluate if specific predictor sets significantly improved the model. The first model was a baseline model with no covariates. Next, the model added demographic characteristics as predictors of firearm carriage and the team conducted a likelihood ratio test (compared with the baseline model) to evaluate if the inclusion of demographic characteristics improved model fit. Following the demographics-only model, the model added individual characteristics as predictors of firearm carriage and the team conducted a likelihood ratio test to evaluate if the inclusion of individual factors improved model fit. If adding individual factors significantly improved model fit, the model retained individual predictors and added social-contextual predictors to the model. The team again conducted a likelihood ratio test to evaluate if the inclusion of social-contextual states improved model fit.

## RESULTS

At baseline, the majority of the sample was male (58%), black (58%), and receiving public assistance (75%). Prevalence of past 6-month firearm carriage in the analytic sample decreased from 13% at baseline to 8% at the 24-month follow-up. Table 1 presents additional descriptive statistics. Among respondents, 73% ( $n=436$ ) reported never carrying a firearm in the past 6 months at each wave, 3% ( $n=15$ ) reported carrying a firearm in the past 6 months at every wave, and 24% ( $n=146$ ) reported carrying a firearm in the past 6 months at some—not all—waves. When testing multilevel models, significant likelihood ratios at each point indicated that the more complex models fit the data significantly better. Thus, the final model included demographic, individual, and social-contextual predictors together.

Individuals who exhibited a substance use disorder at more waves were more likely to carry a firearm than those who exhibited a substance use disorder at fewer waves (OR=3.81, 95% CI=1.82, 7.97; a between-person effect), but when a given person either developed or resolved a substance use disorder, their likelihood of carrying a firearm did not change (a within-person effect). This suggests that individuals with a substance use disorder may be more likely to carry weapons, but individual changes in substance use do not change risk of firearm carrying.

Retaliatory attitudes had both significant between- and within-person effects. Individuals who exhibited greater retaliatory attitudes were more likely to carry a firearm (OR=1.23, 95% CI=1.13, 1.34), and at waves when a given individual exhibited greater retaliatory attitudes compared with their average retaliatory attitudes over the entire 24-month period, they were more likely to carry a firearm (OR=1.10, 95% CI=1.01, 1.19).

Mental health variables (i.e., depression/anxiety symptoms and PTSD diagnosis) did not explain within- or between-person variability in carriage.

There were significant within-person—but not between-person—effects for positive peer affiliations. The odds of carrying a firearm were lower at waves when an individual had more positive peer affiliations compared with when they had fewer positive affiliations (OR=0.88, 95% CI=0.81, 0.96).

Victimization, perceptions of community violence, and negative peer affiliations had significant between- and within-person effects. Individuals who experienced greater victimization were more likely to carry a firearm (OR=1.05, 95% CI=1.02, 1.07), and at waves when a given individual experienced more victimization than usual, they were more likely to carry a firearm (OR=1.03, 95% CI=1.01, 1.05). Similarly, individuals who perceived greater community violence had higher odds of carrying a firearm (OR=1.22, 95% CI=1.10, 1.35), and at waves when a given individual perceived higher levels of community violence compared with their typical perceptions, their odds of carrying a firearm increased (OR=1.12, 95% CI=1.05, 1.21).

Lastly, individuals who had more negative peer affiliations were more likely to carry a firearm (OR=1.11, 95% CI=1.02, 1.21) and at waves when a given individual had more negative affiliations relative to their typical affiliations, they were more likely to carry a firearm (OR=1.08, 95% CI=1.02, 1.14).

## DISCUSSION

The present study found modifiable factors that could be the foci of individual-level youth firearm carriage prevention programs. The finding that past 6-month victimization and retaliatory attitudes moderately correspond to within-person changes in firearm carriage supports a body of literature that cites retaliation as a major impetus for youth violence and a primary motivation underlying firearm aggression.<sup>14</sup> Moreover, this finding suggests that prevention strategies might need to help victims develop alternative strategies for coping with victimization, violence avoidance skills, and non-violent conflict resolution skills. Similarly, the finding that peer affiliations explain within-person variability in firearm carriage suggests that interventions that help assault victims develop and enhance supportive connections with positive peers—and more so avoid negative peer affiliations—may help reduce firearm carriage. The results suggest that individual-level interventions to reduce firearm carriage among youth may benefit by focusing on improving individual-level skills, like reducing retaliatory attitudes, and improving social-contextual-factors, specifically peer relationships.

A recent review of primary prevention of firearm injuries among youth identified 21 articles that described interventions focused on reducing firearm handling/carriage/use.<sup>35</sup> Of these studies, however, none rigorously performed behavioral trials examining individual-level programs with firearm-specific outcomes. Yet, promising individual-level violence prevention interventions exist. Researchers have established that single-session ED-based interventions (e.g., SafERteens; Project Sync) combining motivational interviewing-based behavioral therapy and cognitive skills training (e.g., non-violent conflict resolution skills, anger management) reduced violence outcomes among teens with a history of recent fighting behaviors for up to a year following the session.<sup>36,37</sup> Because firearm carriage is associated with violence, the findings suggest that expanding on the ED-based framework—potentially with more intensive multi-session behavioral therapy—might be effective for addressing firearm-specific outcomes among a high-risk population of youth.

Social-contextual factors explained significant within-person variability in firearm carriage beyond the effect of individual factors, suggesting the need for community- and system-level changes in addition to individual-level interventions. The findings that increased perceptions of community violence corresponded to increases in carriage is consistent with “protection” and “self-defense” being the most common reasons why adolescents carry a firearm.<sup>38,39</sup> Dong and colleagues<sup>40</sup> also found that gang presence in the neighborhood during adolescence and emerging adulthood was associated with handgun carrying trajectories characterized by a higher likelihood of carriage. These findings suggest that efforts to improve neighborhood safety would be expected to reduce the perceived need among youth to carry a firearm. Researchers have demonstrated that neighborhood greening (i.e., the restoration and remediation of distressed and abandoned properties) can enhance neighborhood health and safety and decrease subsequent firearm assaults, violent crime, and community stress.<sup>5,41-43</sup> Further, combining such community-level interventions (greening, community policing) with interventions at other levels of the socio-ecological model (e.g., mentoring programs, hospital-based behavioral interventions) is an effective strategy to decrease violent crime and violent assault injuries throughout the community.<sup>44</sup>

In addition to within-person effects, this study also identified between-person effects similar to previous studies. Several individual (i.e., substance use disorder, retaliatory attitudes) and social contexts (i.e., victimization, negative peer affiliations, community violence) are associated with between-person differences in firearm carriage.<sup>6,14,45</sup> Although detecting such characteristics may help identify those who are at risk for future firearm carriage and firearm violence,<sup>45</sup> these associated characteristics are not equivalent to causal factors that drive an individual’s decision to carry a firearm.

The analyses did not provide evidence that mental health was a predictor of within-person or between-person variability in firearm carriage. Prior analyses of the FYI sample showed that anxiety and PTSD were related to more severe firearm violence (e.g., victimization/aggression) and repeat violent injury over the follow-up period.<sup>19,21,46,47</sup> Such differences may indicate that although anxiety/depression and/or PTSD do not influence an individual’s decision to start carrying firearms, carriage by youth at risk for retaliatory violence and mental health issues may escalate lower level violence encounters to more severe outcomes.<sup>48,49</sup>

## Limitations

The present study has a number of strengths, including its use of a longitudinal data set with rich variables that provided the opportunity to isolate within-person variability in firearm carriage, and the importance of both social-contextual and individual factors in explaining this variability.

Although this study implies a causal framework, it does not verifiably establish causation. Multiple assessments per individual provide counterfactuals for each person assessment. To illustrate, the counterfactual for Person A at the 6-month assessment is Person A at the baseline, 12-month, 18-month, and 24-month assessments. This counterfactual, however, is only valid with respect to time-invariant features. Moreover, this study cannot rule out reverse causation. For example, increases in victimization may encourage an individual to carry a firearm, or conversely, firearm carriage may precede more victimization involvement.

Because the FYI study contained a high-risk population from a specific city, results may not generalize to other populations and geographic locations. Specifically, at baseline the sample had a high prevalence of firearm carriage, PTSD, victimization, and negative peer influences that decreased over time. This decrease is likely due to participants joining the study when they were at highest risk (i.e., in the ED). Likewise, findings may not generalize to lower-risk populations. Though the FYI sample included only drug-using youth, even low levels of use in the prior 6 months qualified for study inclusion, likely making the sample similar to general ED samples within this community. Finally, FYI collected data nearly a decade ago. Americans are now more aware of firearm violence,<sup>50</sup> but it is unclear if this change in awareness has implications for determinants of firearm carriage. Therefore, future studies should confirm if findings generalize to the present.

## CONCLUSIONS

Through analyzing data from a longitudinal cohort, this study identified modifiable factors that can change a given individual's risk of firearm carriage. Researchers have previously identified between-person determinants of carriage, and this study extended this literature by isolating within-person determinants that encompassed both individual and social-contextual factors.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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RLS developed the present study aims and analytic plan, ran the analyses, and led manuscript writing. PMC was involved in the concept and data collection of the FYI sample, advised the development of the present study aims, advised the analyses, and contributed to manuscript writing and editing. JG advised the development of the present study aims, advised the analyses, and contributed to manuscript writing and editing. ALM advised the development of the present study aims and contributed to manuscript writing and editing. MAW was a co-investigator involved in the concept and data collection of the FYI sample, advised the development of the present study aims, advised the analyses, and contributed to manuscript writing and editing.

MAZ advised the development of the present study aims, advised the analyses, and contributed to manuscript writing and editing. RMC is the Principal Investigator of the FYI study, advised the development of the present study aims, advised the analyses, and contributed to manuscript writing and editing.

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**Table 1.**

## Baseline Descriptive Statistics of the Analytic Sample

Variable	Baseline	6 months	12 months	18 months	24 months
Age, mean (SD)	20.1 (2.4)	20.5 (2.5)	21.0 (2.4)	21.5 (2.5)	22.0 (2.4)
Biological sex, %					
Male	58	–	–	–	–
Female	42	–	–	–	–
Race/Ethnicity, %					
Black	58	–	–	–	–
Other	42	–	–	–	–
Public assistance, %					
Receive	75	–	–	–	–
Does not receive	25	–	–	–	–
Reason for ED presentation, %					
Assault-injured	59	–	–	–	–
Other	41	–	–	–	–
Firearm carriage, %	13	13	10	9	8
Depression/anxiety symptoms, mean (SD)	8.93 (9.83)	7.47 (9.03)	7.07 (9.36)	6.49 (9.17)	5.41 (8.21)
PTSD, %	11	4	5	5	4
Substance use disorder, %	34	46	39	38	36
Retaliatory attitudes, mean (SD)	17.7 (3.7)	17.9 (3.8)	17.9 (0.8)	17.6 (3.7)	17.4 (3.4)
Victimization, mean (SD)	13.7 (17.3)	7.3 (11.8)	5.6 (11.2)	3.8 (9.3)	3.2 (9.6)
Positive peer influences, mean (SD)	12.6 (2.7)	8.5 (2.8)	8.5 (2.9)	8.3 (2.9)	8.2 (2.9)
Negative peer influences, mean (SD)	17.1 (3.7)	11.1 (3.8)	10.8 (3.8)	10.8 (3.9)	10.5 (3.8)
Parental support, mean (SD)	22.8 (6.2)	18.2 (7.7)	18.5 (7.9)	18.7 (7.8)	18.9 (8.1)
Family conflict, mean (SD)	9.4 (4.1)	8.9 (3.9)	8.7 (3.8)	8.3 (3.65)	8.4 (3.7)
Community violence, mean (SD)	6.6 (3.6)	6.5 (3.8)	5.9 (3.9)	5.5 (3.8)	5.1 (3.8)
Community involvement, mean (SD)	2.6 (3.5)	2.8 (3.6)	2.4 (3.2)	2.1 (3.0)	1.9 (3.0)
<i>n</i>	568	512	502	505	512

ED, emergency department

PTSD, post traumatic stress disorder.

**Table 2.**

Predicting Firearm Carriage Using Data From the Flint Youth Injury Study (n=597)

Characteristic	Between-person effect OR (95% CI)	Within-person effect OR (95%CI)
Individual factors		
Depression/anxiety symptoms	0.96 (0.92, 1.01)	1.02 (0.99, 1.05)
PTSD	4.91 (0.92, 26.35)	0.75 (0.36, 1.55)
Retaliatory attitudes	<b>1.23 (1.13, 1.34) ***</b>	<b>1.10 (1.01, 1.19) *</b>
Substance use disorder	<b>3.81 (1.82, 7.97) ***</b>	1.48 (0.93, 2.36)
Social-contextual factors		
Victimization	<b>1.05 (1.02, 1.07) ***</b>	<b>1.03 (1.01, 1.05) **</b>
Positive peer influences	1.04 (0.92, 1.16)	<b>0.88 (0.81, 0.96) **</b>
Negative peer influences	<b>1.11 (1.02, 1.21) *</b>	<b>1.08 (1.02, 1.14) *</b>
Community involvement	1.03 (0.92, 1.14)	1.01 (0.95, 1.08)
Parental support	1.00 (0.96, 1.05)	1.01 (0.98, 1.05)
Family conflict	0.98 (0.89, 1.07)	1.01 (0.95, 1.07)
Community violence	<b>1.22 (1.10, 1.35) ***</b>	<b>1.12 (1.05, 1.21) **</b>
Demographics		
Age, years	1.09 (0.99, 1.21)	0.87 (0.66, 1.13)
Assault-injured [ref=non-assault injured]	0.88 (0.55, 1.40)	–
Male sex [ref=female]	<b>4.50 (2.56, 7.92) ***</b>	–
Black [ref=other]	1.46 (0.88, 2.40)	–
Public assistance	1.10 (0.66, 1.86)	–

Notes: Boldface indicates statistical significance

\*  
 $p < 0.05$

\*\*  
 $p < 0.01$

\*\*\*  
 $p < 0.001$

PTSD, post traumatic stress disorder.