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Siblings and Adolescent Weapon Carrying: Contributions of Genetics, Shared Environment, and Nonshared Environment

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Abstract

Many past studies have observed evidence of sibling similarity and influence for delinquency and substance use. However, studies of sibling similarity for adolescent weapon carrying, particularly for weapons beyond firearms, are largely absent from the literature. The present study assesses sibling similarity in weapon carrying as well as the relative contributions of genetics, shared environment, and nonshared environment. Data are obtained from the first two waves of the National Longitudinal Study of Adolescent to Adult Health and analyzed using biometrical genetic models for twins and actor–partner interdependence models for nontwins. Results indicate little, if any, contribution stemming from genetics. There is also no evidence of a significant shared environment effect. Instead, all or nearly all of the variation and similarity in weapon carrying among siblings are related to the nonshared environment, particularly gang affiliation. Implications and possible extensions of these findings are discussed.

Keywords

siblings; weapon carrying; genetics; nonshared environment

Introduction

In 2009, an average of 20 U.S. children and adolescents were hospitalized each day due to firearm injuries (Leventhal, Gaither, & Sege, 2014). Juvenile offenders account for the majority of violent crimes against those aged 8–15 (Office of Juvenile Justice and Delinquency Prevention [OJJDP], 2005). As a result, understanding firearm-related behavior among adolescents is one avenue through which these crimes can potentially be prevented. The present article focuses on adolescent weapon carrying, which can include both firearms and other weapon types. Nearly 18% of respondents (28% of males) to the 2013 High School Youth Risk Behavior Survey reported carrying a weapon at some point in the past

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Declaration of Conflicting Interests

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month; more than 5% reported carrying a gun (Centers for Disease Control and Prevention, 2014). Although less common, some adolescents also bring weapons to school. More than 5% of respondents to the 2013 High School Youth Risk Behavior Survey reported carrying a gun, knife, or club to school in the past 30 days (Centers for Disease Control and Prevention, 2014). Approximately 7% of respondents reported that they were threatened or injured with a weapon on school property at least once in the past year (Centers for Disease Control and Prevention, 2014). Unfortunately, much is still unknown about peer and sibling influence for this problematic behavior.

This study focuses on the role of siblings in particular. Sibling concordance of delinquent behavior has been well established in the literature (Slomkowski, Rende, Conger, Simons, & Conger, 2001; Tuvblad & Baker, 2011; Whiteman, Jensen, & Maggs, 2013). Lauritsen's (1993) research, for example, indicated that adolescent delinquency was concentrated among households; 10% of households in the sample accounted for 76% of all delinquent acts reported (Lauritsen, 1993, p. 399). Similarly, Rowe, Rodgers, and Meseck-Bushey (1992) found that the correlation for delinquency in same-sex sibling dyads was roughly .30 for brothers, .28 for sisters, and .21 for mixed-sex sibling pairs. Although these trends hold for various forms of delinquency, sibling similarity for weapon carrying has not been underexplored.

Past research, however, indicates two key explanations for why similarity in this behavior might be expected. The first, based on the principles of social learning, simply suggests that siblings influence one another through imitation and modeling as well as through the process of interaction (Akers, 2009; Whiteman et al., 2013). In other words, if one sibling carries a weapon, another sibling may perceive this as acceptable or desirable and imitate the behavior. Since siblings report similar, if not identical, access to guns in the home (Mocan & Tekin, 2006), this possibility is certainly plausible. A second explanation is heritability. Research on aggression has found that roughly half of the variation in aggressive behavior can be attributed to genetics (Tuvblad & Baker, 2011). Both explanations suggest that siblings should be similar in weapon carrying behavior.

In contrast, some authors argue that siblings may be greatly influenced by nonshared environments. More than 40% of the respondents assessed by Daniels and Plomin (1985), for instance, reported experiences that differed from those of their siblings in areas including parental treatment, peer groups, and subjective experiences of events such as divorce, romantic relationships, and family problems. These differences were not significantly related to genetics and were believed to originate with environmental variation either inside or outside of the home (Daniels & Plomin, 1985). If these nonshared experiences are indeed the driving factors behind adolescent weapon carrying, then divergence between siblings would be expected rather than similarity. Unfortunately, little research has empirically evaluated these possibilities.

One study that has addressed sibling similarity in weapon carrying found that 27% of variation in weapon carrying is attributable to genetics (Connolly & Beaver, 2015). However, the study only considered handgun carrying. Estimates for weapon carrying beyond handguns are unknown. To address this omission, the present study examines three

key questions. First, do siblings have similar school weapon carrying frequencies? Second, to what extent does the weapon carrying of one sibling in adolescence influence the subsequent weapon carrying behavior of another sibling? Third, how does weapon carrying behavior among sibling pairs differ by genetic relatedness (R)? Together, these questions address the degree of sibling similarity for weapon carrying as well as the origins of similarity among siblings for this behavior.

The answers to these questions are important for youth violence prevention. Existing prevention efforts focus on factors that influence juveniles outside of the home, such as gangs and peers. Little research has investigated the possibility that weapon carrying might originate from influences within the home, namely, siblings. If some influence does, indeed, come from siblings, then family-based prevention efforts may be appropriate for at-risk youth. Knowledge of whether or not weapon carrying behaviors are similar across siblings also informs screening procedures for relevant programs; if siblings are found to be similar for this behavior, then programs targeting weapon carrying should be inclusive of all adolescents within a home. Expanded prevention of weapon carrying within families, in turn, may reduce the amount of violence perpetrated by siblings of at-risk youth. This is of especial interest, given known sibling concordance for delinquent behavior overall (Slomkowski et al., 2001; Tuvblad & Baker, 2011; Whiteman et al., 2013). Although this study is specific to weapon carrying, a discussion of sibling similarity for related behaviors provides useful context.

Sibling Similarity in Gang Membership and Victimization

Gang membership and victimization are both factors known to co-occur with or result in weapon carrying. Lizotte, Krohn, Howell, Tobin, and Howard (2000), drawing on the Rochester Youth Development Survey, examined illegal gun carrying among young, urban males. For respondents in early adolescence, gang membership was strongly predictive of gun carrying. Similar findings have been noted by other authors (Steinman & Zimmerman, 2003; Watkins, Huebner, & Decker, 2008; Webster, Gainer, & Champion, 1993). Lizotte et al. (2000) attributed this link to a desire for protection from dangerous situations. Gang members may not feel protected by more traditional forces of social control, like police, and use guns as a form of social control instead (Lizotte, Krohn, Howell, Tobin, & Howard, 2000). In the past studies, personal protection was the primary reason adolescents expressed for owning or carrying firearms (Lizotte, Tesoriero, Thornberry, & Krohn, 1994; May, 1999; Sheley & Wright, 1993). Ash, Kellermann, Fuqua-Whitley, and Johnson (1996), for example, used structured interviews with incarcerated juveniles to examine this possibility. In their sample, 40% of respondents reported that they felt safer with a gun (Ash, Kellermann, Fuqua-Whitley, & Johnson, 1996).

The studies highlighted to this point, however, do not address siblings. Among monozygotic (MZ) twins, Barnes, Boutwell, and Fox (2012) found that having one sibling involved in a gang increased the odds of the other sibling being a gang member by roughly 250% (p. 235). Peterson, Taylor, and Ebensen (2004) also found self-report evidence that an adolescent was more likely to join a gang if another sibling was already a member. For each year that the authors studied, between 19% and 36% of youth gang members reported that at least one of

the reasons they joined was because a brother or sister was already a member of the gang (Peterson, Taylor, & Ebensen, 2004). Similarly, Kissner and Pyrooz (2009) determined that adult inmates who reported having an older sibling involved in a gang growing up were more than 29 times more likely to be current gang members than those who did not report this family history. Lastly, Connolly and Beaver (2015) found that genetics explained 77% of the variance in gang membership among adolescent sibling pairs in the 1997 National Longitudinal Survey of Youth. Overall, the above studies indicate that sibling gang membership is positively associated with one's own gang membership status.

As with gang affiliation, victimization experiences have also been linked to weapon carrying among adolescents. Vaughn, Howard, and Harper-Chang (2006), examining a sample of incarcerated youth, found that prior victimization and trauma increased the likelihood of weapon carrying. Young, Black male victims described weapon carrying as a response to a lack of faith in police in a study by Rich and Grey (2005). As with gang membership, there is evidence that siblings are sometimes similar in victimization history. Among 10-year-old twin pairs, Ball et al. (2008) determined that the within-pair correlation for victimization among MZ twins was more than .7, with victimization including teasing, bullying, and like behaviors. Barnes et al. (2012) also found that individuals with a sibling who had been victimized were more likely to report a history of victimization themselves. Explanations for why these similarities occur merit further explanation.

Social Learning

One key explanation for why sibling similarity might develop is social learning. Social learning theories propose that individuals learn behaviors by observing others, by modeling the behavior of others, and through the reinforcement and punishment of behavior (Bandura & McClelland, 1977). Akers (2009) argued that individuals are likely to adopt the behavior of those they positively regard. Thus, one sibling may emulate another simply because the sibling is a valued, primary model of behavior whose approval and acceptance are also valued. For these reasons, greater similarity might be expected if siblings are of the same sex or frequently spend time together. Akers' (2009) elaboration of social learning theory also argued that individuals are more likely to adopt behavior that appears to bring positive consequences.

Existing research has found that adolescents view weapon carrying positively. Dijkstra et al. (2010), in a longitudinal study of high-risk middle school and high school students, found that weapon carrying was associated with an increase in the number of students who indicated the respondent as a friend. Weapon carrying also reduced the number of individuals the respondent listed as a friend, another indicator of increasing social standing (Dijkstra et al., 2010). In line with these findings, Williams, Mulhall, Reis, and De Ville (2002) found that adolescents with peers who carried weapons and adolescents who felt weapon carrying would be perceived as "cool" were more likely to carry weapons. Dijkstra et al. (2010) argued that weapon carrying might be viewed as marker of maturity or dangerousness, traits that are socially desirable among adolescents. As such, emulation of this behavior among siblings might be expected.

For this reason, determining the extent of sibling influence for weapon carrying is of practical use. Should siblings be a strong social influence, then family-based programs or other programs targeting the sibling relationship may be able to interrupt the social learning process for weapon carrying. The straight talk about risks program (OJJDP, 2015), for example, is a school-based curriculum that, among other topics, teaches youth to resist peer pressure in regard to weapons. A component like this might be adaptable to reduce sibling influence for weapon carrying, thereby reducing violence. However, there are other explanations for sibling similarity that must be addressed. These include heritability and shared environment.

Heritability, Shared Environment, and Nonshared Environment

Heritability refers to the extent a behavior can be explained by variation in genetics versus variation in other factors. In other words, siblings might be similar to one another for certain traits because of the genes they share. Existing research found evidence of sibling similarity that varied by the degree of R . For example, Barnes et al. (2012) found sibling similarity in gang membership but primarily for MZ twins. The authors did not observe the same degree of gang involvement similarity with other types of sibling pairs, such as full siblings (FS) or half siblings (HS; Barnes, Boutwell, & Fox, 2012). Likewise, similarity in victimization history was most prevalent among MZ twins, accounting for more than a third of the variance in victimization in adolescence (Barnes et al., 2012). Ball et al. (2008) also determined that similarity in victimization history was more prevalent among siblings who shared more genetic material (MZ vs. DZ twins). Nearly two thirds of the variance in repeat victimization was accounted for by genetic factors in another study (Beaver, Boutwell, Barnes, & Cooper, 2009).

A key challenge is disentangling the contribution of genetics from the contribution of environment. One might argue, for instance, that twins are more similar to one another than FS because they are of the same age, attend the same school, and so on. These are all characteristics of siblings' shared environment. Indeed, research by Rende, Slomkowski, Lloyd-Richardson, and Niaura (2005) found that variation in sibling contact and mutual friendships was attributable to sibling age gap and shared environment rather than degree of R . As a result, it is important to distinguish sibling similarity due to genetics from similarity due to shared environmental influences. It may be argued that prevention efforts will be more successful if developing similarities are due to some environmental factor that can be adjusted or impacted.

Yet, the possibility remains that weapon carrying may be driven by environmental influences that siblings do not share, the nonshared environment. As observed by Turkheimer and Waldron (2000), studies of nonshared environment generally find small effect sizes, particularly when genetic confounds are taken into account. When nonshared environmental influence is indicated, its origin is not always clear. Beaver (2008), however, found that maternal disengagement stood out as a nonshared environmental predictor of adolescent delinquency, while other elements of nonshared environment did not have significant influence. A later study by Beaver, Schutt, et al. (2009) found that both genes and nonshared environment influenced delinquency, while shared environment was not a consistent or

significant influence. Connolly and Beaver (2015) found no influence of shared environment for gang involvement or weapon carrying; instead, all variations were attributable to nonshared environment. Unlike some of the studies discussed previously, these results suggest that siblings may differ in weapon carrying behavior as a result of unshared influences. If this is the case, then existing prevention efforts targeting the nonshared environment may not need to extend to the family.

To address these competing expectations, the present article uses models that simultaneously estimate the contributions of genetics and environment. Specifically, this study addresses the following questions:

1. To what extent are siblings similar for weapon carrying behavior?
2. To what extent does the weapon carrying of one sibling in adolescence influence the subsequent weapon carrying behavior of another sibling?
3. How does weapon carrying similarity vary by the degree of R ?

Data

This study uses data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a longitudinal study of a nationally representative sample of individuals who were in Grades 7 through 12 in 1994 (Harris, Halpern, Smolen, & Haberstick, 2006). The purpose of Add Health is to study health and risk behaviors, predictors of these behaviors, later trajectories of health and risk behaviors, and related topics. The sampling design of Add Health is school based; 80 high schools were selected as representative of the United States in 1994 (Harris et al., 2006). Another 52 lower level schools were selected with probability proportional to the number of students contributed to the high school (Harris et al., 2006). The present study uses in-home interview data from Wave 1 collected in 1994/1995, and Wave 2 collected in 1996.

These in-home interviews were also conducted with an oversample that includes pairs of siblings with varying degrees of R (Harris et al., 2006). Although FS were not oversampled (many were automatically included in the study by chance), twins and HS were included with certainty (Harris et al., 2006). Some nonrelated pairs (adolescents raised together but not genetically related) were also included in the oversample. In total, there are 2,842 pairs of individuals who can broadly be described as siblings with known R (Harris et al., 2006). These include 741 twin pairs, 1,251 FS pairs, 442 HS pairs, and 408 nonbiologically related (NR) sibling pairs. Each member of these pairs was administered the same questionnaires and resided in the same home environment (Harris et al., 2006).

Measures

Weapon carrying—Weapon carrying is the dependent variable in all models. In Waves 1 and 2, respondents were asked, during the past 30 days, on how many days did you carry a weapon—such as a gun, knife, or club—to school? Response categories were *never*, *1 day*, *2 or 3 days*, *4 or 5 days*, or *6 or more days*. Since so few respondents (<6%) report any weapon carrying, these responses are dichotomized as *never* or *at least once*.

Sibling contact—Each respondent was asked to report how often they spent time with their sibling on a Likert-type scale ranging from 1 (*highest*) to 4 (*lowest*). These scores are reverse coded so that higher scores reflect more frequent contact between siblings. To maintain consistency, this measure is based on the responses of the older sibling and treated as a dyad-level covariate.

Delinquency and victimization—Delinquency is measured using a 15-item Delinquency Scale asking respondents to report how often (*never*, *once or twice*, *3 or 4 times*, or *5 or more times*) they engaged in certain behaviors during the past 12 months. Behaviors included vandalism, lying to parents or guardians, theft of varying amounts, fighting, running away from home, joyriding, burglary, robbery, selling drugs, and being overly loud in a public place. A summative scale of these items, however, would be problematic. The modal score for delinquency items is 0, and items tend to be highly correlated, leading to poor distribution of the overall sum (Osgood, McMorris, & Potenza, 2002). As a result, each item's responses are dichotomized as *never* or *at least once*, and analyses use an item response theory (IRT)-scaled delinquency measure. IRT makes use of mathematical models that map item-level responses for a set of items to a position on a latent, continuous, equal-interval variable, with a mean of 0 (Osgood et al., 2002). These measures were generated using Samejima's Graded Response Model implemented using the generalized linear latent and mixed model module in the *Stata* Version 13 software (StataCorp; Samejima, 1997). Gang membership is assessed by a Wave 2 question that asks respondents if they have been initiated into a named gang (yes/no).

Victimization is measured using a series of questions that asked respondents how often in the past 12 months certain events occurred. These items include "someone pulled a knife or gun on you," "someone shot you," "someone cut or stabbed you," and "you were jumped." Each is coded as *never* (0), *once* (1), or *more than once* (2). Since few respondents experienced these forms of victimization, this article uses a variety score that indicates how many of these four types of victimization were experienced in the past year (range: 0–4; a α .62 in Wave 1; a α .81 in Wave 2).

Difficulty in school—Difficulty in school is operationalized with two measures. The first is based on an item that asks respondents how often this school year they have had trouble paying attention in school. The other asks respondents how often this school year they have had trouble completing homework. Both are scored as *never* (0), *just a few times* (1), *about once a week* (2), *almost every day* (3), or *every day* (4).

Other controls—Other controls include the age of each sibling and whether both members of the sibling pair are of the same sex.

Method

This article employs actor-partner interdependence models (APIMs) as well as biometrical genetic models. Across both types of estimation, *R* is coded as 1 for MZ twins, 0.5 for dizygotic (DZ) twins, 0.5 for FS, 0.25 for HS, and 0 for siblings who are not biologically related. Unfortunately, 35% of pairs in the sibling pairs sample are missing sample weight

information for at least one member of the pair (Chantala, 2001). All analyses will be unweighted for this reason. However, by omitting sample weights, results cannot be interpreted as nationally representative (Chantala, 2001).

Biometrical Genetic Models for Twins

Using the conventions developed by Fisher (1918), this article estimates the relative influence of heritability, shared environment, and unique environment for MZ and DZ twins. The first of these components is denoted A for additive genetics. The second is denoted C for common environment. The third is denoted E and refers to unique environment. An additional term sometimes referred to as dominance, denoted D , refers to nonadditive genetic effects. The full ACDE model for individual i in family j can be expressed as an error components model:

$$y_{ij} = \mu + A_{ij} + B_{ij} + C_{ij} + D_{ij} + E_{ij}.$$

Here, μ is the overall mean. Remaining terms in the model are normally distributed, with mean 0 (Rabe-Hasketh, Skrondal, & Gjessing, 2007). All components are assumed to be mutually independent so that they constitute a decomposition of the total variance.

This article estimates AE, ACE, and ADE models, all using parameterizations detailed by Rabe-Hasketh, Skrondal, and Gjessing (2007) in the Stata software. The reader is referred to Rabe-Hasketh et al. (2007) for a thorough explanation of these equations and their estimation. To summarize, however, the AE model decomposes effects into an additive genetic component, A , and an environment component, E . Relative contributions of shared versus unique environments are not estimated by the AE model. The ACE model, in contrast, decomposes effects into an additive genetic component, a common environment component, and a unique environment component. The AE and ACE models address only additive genetic effects; these models assume that all heritabilities are due to the independent effects of alleles that additively influence the outcome of interest. ADE models are used to assess the relative contribution of additive and nonadditive genetic effects. A dominance effect occurs when there is an interaction between alleles or loci. When nonadditive effects are present, MZ twins share 100% of the nonadditive effects, while DZ twins share only 25% of the nonadditive effects (Benson, 2012). For this reason, it is important to estimate ADE models if there is any indication of a dominance effect.

Actor–Partner Interdependence Models for Nontwins

APIMs simultaneously estimate the effects of each sibling's past behavior on his or her later behavior ("actor" effects) as well as the influence of each sibling's past behavior on the current behavior of the other sibling in the pair ("partner" effects). These are sometime referred to as two-intercept models. Although research has shown that influence typically travels from older to younger siblings (Needle et al., 1986; Trim, Leuthe, & Chassin, 2006), some interdependence within a sibling pair is likely. To address this possibility, data are analyzed using APIMs (Cook & Kenny, 2005) with logistic regression. APIMs require a clear and consistent distinction between the two individuals in each pair. In this article, actor and partner are distinguished by age (younger vs. older siblings). Twins are omitted from

APIM analyses for this reason; 59 sibling pairs could not be distinguished due to missing age characteristics for one or both siblings. This leaves an APIM sample of 2,042 sibling pairs. For further details on how data are structured for APIMs, the reader is referred to Cook and Kenny (2005). In its basic form, APIMs treat the dyad as the highest level of analysis with individuals nested within dyads. R is entered as a covariate at the dyad level.

Results

Table 1 displays the summary statistics for the sibling pairs included in this study, which is divided into categories by R . Across groups, the mean age at Wave 1 is approximately 16, which is consistent with the Add Health target sample of middle and high school youth. Age gaps are quite low, averaging just over 2 years in most cases. As prior literature has indicated, sibling differences in delinquency and victimization appear to vary by R (Ball et al., 2008; Barnes et al., 2012; Beaver, Boutwell, et al., 2009). Differences are smaller for twins than for FS and HS or NR siblings. In terms of time spent together, twins spend more time together, on average, than nontwins. FS also spend more time together than those with lesser degrees of R .

Trends are less clear-cut for weapon carrying. Most sibling pairs have the same value on this measure. However, for most sibling pairs, this is because neither sibling carried a weapon to school in the past 30 days. In total, 314 respondents (5.6%) reported weapon carrying in the past 30 days at Wave 1, while 154 respondents (3%) reported weapon carrying in the past 30 days at Wave 2. Among MZ and DZ twins, 66 pairs included a respondent who reported weapon carrying at Wave 1. Although a minority, this article is concerned with whether other siblings are likely to carry weapons when one sibling reports doing so. Trends by R are not clear from Table 1, however. Although there is some drop-off in agreement as relatedness declines, this is not as consistent as it is for delinquency. More detailed models, discussed in the pages that follow, are needed to distinguish the influence of genetics from shared or nonshared environment.

Table 2 displays maximum likelihood estimates of AE, ACE, and ADE models for MZ and DZ twins. For Wave 1, all variations are attributed to additive genetics in models that leave out a term for common environment. When common environment is included in the model, however, most variance is attributed to common environment. For Wave 2, this is not the case. All Wave 2 models indicate that genetics are primarily driving similarity. Heritability, h^2 , is defined as the proportion of outcome (weapon carrying) variance explained by the additive genetic factor. For Wave 2, h^2 is .33 in the AE and ADE models. For Wave 1, h^2 is .55 for the AE and ADE models. Although these results largely indicate that similarity in weapon carrying is driven by heritability, the inconsistencies demand additional exploration. Further, the models in Table 2 did not include covariates, did not take into account change over time, and only consider twin pairs. ACDE models also sometimes overestimate the influence of additive genetics while underestimating or overestimating other components (Ozaki, Toyoda, Iwama, Kubo, & Ando, 2011). APIMs provide a second test that may help to confirm these preliminary results.

To further investigation, this article employs APIMs to assess sibling and genetic influence among nontwins with the inclusion of covariates in the models. These models predict Wave 2 weapon carrying based on the behaviors of each sibling at Wave 1. Results are shown in Table 3. In all models, odds ratios are shown. Readers are referred to Sribney and Wiggins (2009) for a thorough explanation of how standard errors, confidence intervals, and statistical significance are calculated in the Stata software for odds ratios. Models 1 and 2 omit a measure of *R*. As shown, younger sibling weapon carrying at Wave 1 is significantly predictive of the younger sibling's weapon carrying at Wave 2. This is also true of older siblings. In Model 2, which includes covariates, a respondent is approximately 8 times more likely to carry a weapon in Wave 2 if he or she did so at Wave 1. However, this effect declines to marginal significance for younger siblings in the presence of covariates.

The first two models in Table 3 also indicate some, although limited, presence of sibling influence. Specifically, there is a marginally significant effect of younger sibling weapon carrying on older sibling weapon carrying. Namely, having a younger sibling who carries a weapon at Wave 1 reduces the older sibling's likelihood of carrying a weapon at Wave 2. As expected, gang membership increases the likelihood of weapon carrying. Intermediate models (not shown) indicated a significant influence of victimization as well, although this effect failed to achieve statistical significance when controls for trouble paying attention and completing homework were added to the model. Being older at Wave 1 decreases the likelihood of weapon carrying, which is consistent with a pattern of desistance (Wallace, 2015). Interestingly, having trouble completing homework is marginally associated with an increase in likelihood of weapon carrying for older siblings, while this same predictor is marginally associated with a decrease in likelihood of weapon carrying for older siblings. Neither time spent together nor being of the same sex is significant predictor once other controls are taken into account, however. Together, these results suggest an influence from nonshared environment rather than shared environment.

The remaining models shown in Table 3 take into account the possible influence of *R*. Across models, there is no significant effect stemming from genes, with or without the inclusion of covariates in the models. Examining Model 4, which includes a term for genetics as well as all covariates, the effect of one's past weapon carrying behavior is statistically significant for older siblings and marginally significant for younger siblings. Having carried a weapon in the past makes a person roughly 8 times more likely to carry a weapon at the later wave. The influence of younger sibling weapon carrying on older sibling weapon carrying also remains; older siblings with a younger sibling who carried a weapon in Wave 1 are less likely to report carrying a weapon at Wave 2, although this effect decreases to marginal significance in the presence of controls. Effects stemming from other covariates (e.g., victimization, delinquency) are the same as observed with Models 1 and 2. As before, time with siblings and being of the same sex as one's sibling do not appear to have a significant impact on this outcome. Again, these results suggest an influence from nonshared environment rather than shared environment or genetics.

As a final examination, two basic logistic regression models were used to test for pair-level factors that might predict pair-level change in weapon carrying across time. Results are shown in Table 4. The outcome of the first model is a pair-level increase in weapon carrying

behavior (i.e., one or both siblings start weapon carrying when they did not do so before). The outcome of the second model is a pair-level decrease in weapon carrying behavior (i.e., one or both siblings stop weapon carrying). Results of the first model indicate that a wider age gap is positively associated with a drop in weapon carrying at the pair level. Being in a sibling pair with a greater degree of R is associated with lower likelihood of a pair-level drop in weapon carrying. In the increase model, only being in a same-sex sibling pair emerged as statistically significant. Being in a same-sex sibling pair is associated with a reduced likelihood of a pair-level increase in weapon carrying.

Additional models (not shown) tested for a possible interaction between R and sibling influence. However, interaction effects were nonsignificant and so close to 0 that they caused estimation errors in estimates of other covariates. APIMs were also conducted separately by race (White vs. non-White, based on the race of the first sibling in the pair) to assess the possible race differences in results. No substantive differences emerged, so these tables are also omitted for the sake of brevity.

Discussion

This study set out with three questions to address. First, do siblings have similar weapon carrying frequencies? Second, to what extent does the weapon carrying of one sibling in adolescence influence the subsequent weapon carrying behavior of another sibling? Third, how does weapon carrying behavior among sibling pairs differ by R ? Findings show that siblings do have similar weapon carrying behavior but primarily because most sibling pairs do not engage in weapon carrying at all. Some evidence does indicate that younger sibling weapon carrying may actually reduce the likelihood of older sibling weapon carrying. Biometrical genetic models for twins demonstrated inconsistent results in regard to genetic influence, while APIMs consistently showed no significant influence of genetics. Lastly, shared environment did not seem to influence weapon carrying in adolescence. Possible explanations for and implications of these results are discussed below.

Prior research has shown that sibling influence tends to flow from older to younger siblings, at least for substance use (Needle et al., 1986; Trim et al., 2006). However, findings of the present study indicate that the one significant sibling influence effect operates in the reverse direction. Older siblings are less likely to carry weapons if their younger siblings previously reported doing so. There are several possible explanations for this unexpected result. One is simply rarity. Very few sibling pairs had even one sibling who reported weapon carrying. It may be that those pairs with a younger sibling reporting weapon carrying were especially unique in some way that is not accounted for by other covariates in Table 3. Further, the occurrence of weapon carrying in the sample declines with age (Wallace, 2015), which is the characteristic distinguishing siblings in APIMs.

Younger sibling influence is also not unheard of for delinquency, particularly for substance use. Trim, Leuthe, and Chassin (2006) found evidence of younger sibling influence for alcohol use among sibling pairs very close in age. The authors suggested that this may indicate reciprocal influence among pairs with a low age gap. On average, sibling pairs in Add Health have a fairly low age gap (see Table 1), so such an effect would not be

implausible in the present data. Similarly, Vink, Willemsen, and Boomsma (2003) found no difference in the relative risk of smoking between those having an older sibling who smoked and those having a younger sibling who smoked. For this reason, it is critical that studies assessing sibling influence for violence and related behaviors address reciprocal influence, particularly with siblings close in age.

An alternative explanation for younger sibling influence is more theoretical in nature. Some researchers have proposed that siblings compete with one another for parental attention and love, leading some siblings to “deidentify” or attempt to distinguish their behavior from that of other siblings (Schachter, Shore, Feldman-Rotman, Marquis, & Campbell, 1976; Whiteman, McHale, & Crouter, 2007). From this perspective, it is possible that one sibling will avoid weapon carrying if another sibling does so. Otherwise, this would garner competition and rivalry, something Schachter, Shore, Feldman-Rotman, Marquis, and Campbell (1976) argued that siblings hope to avoid through deidentification. This argument is consistent with this article’s finding that having a younger sibling weapon carry makes an older sibling less likely to do so.

This finding would also be consistent with the notion that modeling a younger sibling may be less socially acceptable than emulating an older sibling. Indeed, Furman and Buhrmester (1985) found that older siblings were more likely to be admired by their younger siblings than vice versa. Ironically, such a result also identifies a potential avenue for intervention. This article shows that older siblings may be more cognizant of and sensitive to younger sibling behavior than prior studies have assumed. If this is the case, then existing violence prevention efforts may be able to extend efforts by incorporating younger siblings of at-risk youth.

Another trend in results that merits further explanation is the inconsistent estimates for genetic influence. While ADE, ACE, and AE models among siblings indicated a genetic component to weapon carrying might be present, estimates from those models did not clearly imply whether these were additive or dominant genetic effects. Further, results varied wave to wave. APIMs, which used Wave 2 weapon carrying as an outcome, did not show variation by genes. One reason for this gap may be the way genetic similarity was operationalized in the two model types. The APIMs address genetics via a control variable, much like a traditional regression design. ADE, ACE, and AE models, in contrast, allow for a precise decomposition of outcome variance where components are assumed to be mutually independent (Rabe-Hasketh et al., 2007). Pair-level estimates for change in Table 4 do indicate that sibling pair change in weapon carrying is less likely among more closely related siblings, though possible explanations for this result are unclear.

A second factor that may have contributed to the genetic estimate inconsistencies is the inclusion of key covariates. The ADE, ACE, and AE models took into account only R and variation on the outcome variable estimated separately by wave. No additional covariates were included. In contrast, the APIMs focused on later wave behavior, while taking known factors from a previous time point into account. These covariates included behaviors of each sibling as well as the degree to which siblings influence one another. The inclusion of these

covariates may have sharply attenuated what was interpreted as a genetic effect in the earlier models.

One finding that is consistent is the absence of a shared environment effect. The only time such an effect emerged was in the ACE model for Wave 1 weapon carrying. This effect did not persist into Wave 2. These results contradict expectations of social learning theories, which would suggest siblings to develop behavioral similarities through observation and modeling. These results, however, are consistent with a study by Barnes et al. (2012) which determined that 26% of the variation in gang affiliation was due to genetics, while remaining variation was attributed to nonshared environment; the authors found no significant evidence for a shared environment effect. Barnes et al. (2012) also found no significant evidence of a shared environment effect for victimization. The authors observed that the influence of genetics faded with time; nearly all variations were due to nonshared environment in the later waves of their study (Barnes et al., 2012). This decline in variation attributable to genetics was also observed in the present study and may help to explain the lack of a significant genetic effect in APIMs predicting weapon carrying at Wave 2. The results of the present article are also consistent with Connolly and Beaver (2015) who found no evidence of a shared environment effect for handgun carrying.

For weapon carrying as an outcome, it appears that nonshared environmental experiences trump shared environmental experiences in predicting later behavior. Gang affiliation, as shown in prior studies (Connolly & Barnes, 2015), is a strong and significant predictor of all models. Although attaining only marginal significance, another nonshared environment predictor that emerged was trouble completing homework. For younger siblings, this was associated with an increase in weapon carrying, while for older siblings the effect is in the opposite direction. While it is unclear why this connection to weapon carrying might exist (beyond other controls included), it does indicate a potential risk factor that can be addressed when trying to identify youth at risk for violence and weapon carrying.

Practical Implications

Models accounting for present and past covariates as well as cross sibling influence showed no significant variation in weapon carrying by *R*. This observation indicates that just because one sibling carries a weapon to school does not mean all siblings are at risk of doing so. Rather, most sibling pairs did not include a weapon carrying adolescent. Most of those pairs that did included only one adolescent who reported weapon carrying at either time point. However, siblings may obtain weapons from the same source, so identifying the source may remain an important concern for violence prevention. According to one study, siblings have similar access to weapons within the home (Mocan & Tekin, 2006). As a result, knowing that one sibling has access is an indication that the other sibling may have gun access as well. Addressing this concern may prevent violence among siblings of at-risk youth.

A second implication of the present study is the importance of nonshared environment, particularly gang activity. Contrary to expectations from social learning theories, little sibling influence for weapon carrying was apparent. The effect that did surface actually reduced the likelihood of weapon carrying among older siblings. In contrast, elements of the

nonshared environment were found to have a strong, positive impact on likelihood of weapon carrying. Like prior studies (Lizotte et al., 2000; Webster et al., 1993), the present article identifies gang affiliation as co-occurring with or contributing to adolescent weapon carrying. These results highlight the importance of primarily focusing on nonshared environment as an avenue for intervention.

One example of a program targeting these problems is the Gang Resistance Education and Training program, a school-based program implemented by law enforcement through a series of lessons designed to reduce gang affiliation and delinquent behavior more generally. Evaluation of this program indicated that it indeed reduced both gang affiliation and delinquency (Esbensen & Osgood, 1999). Family-based programs seem less appropriate, given the lack of (or greatly limited) sibling and genetic influence found in this article. However, possible family influences need to be explored further before this can be stated with certainty.

Future Research

The present article can be extended in several ways. First, this study examined only siblings as a potential source of influence for weapon carrying. Siblings, however, are only one part of the larger family unit. Parental firearm use and weapon carrying habits may be of particular interest for families in which one or more children also weapon carry. Steinman and Zimmerman (2003), for instance, found that 8% of adolescents who did not carry guns, 17% of occasional gun carriers, and 33% of persistent (repeated) gun carriers had a parent who carried a gun. The number of adults known to carry guns was also a factor distinguishing those who did not carry a gun from those who occasionally did so (Steinman & Zimmerman, 2003). Moderators and mediators of this link remain unknown, however, making it unclear why some children model this parental behavior while others do not.

A second possibility is to explore weapon carrying beyond the school. Results of the 2013 High School Youth Risk Behavior Survey indicated that nearly 18% of respondents reported carrying a weapon at some point in the past month (Centers for Disease Control and Prevention, 2014). Carrying a weapon to school was much less common, indicating that the bulk of weapon carrying may be occurring during nonschool hours. Although the data used in the current study do not permit such an examination, studying weapon carrying across multiple contexts may be more informative as to the origin of weapon carrying. Since weapon carrying was so rare in the present sample, this study may have missed effects that might otherwise appear in a more cross-context or larger sample with greater statistical power.

Limitations

Although informative, the present study does need to be interpreted with the following caveats in mind. First, weapon carrying is a relatively rare event within schools. As a result, statistical power in this study was limited. The Add Health sample is a general sample of schools across the United States. A more precise estimate of social and genetic influence might be obtained from a larger sample or a sample focused on a high-risk population among whom weapon carrying might be more common. Second, the Add Health data are

becoming dated and may not reflect today's youth, particularly as reproductive rates change among some populations. Third, the present article did not address peer influence as a covariate, an element identified by Dijkstra and colleagues (Dijkstra, Gest, Lindenberg, Veenstra, & Cillessen, 2012; Dijkstra et al., 2010) as potentially informative for this outcome. As with any regression-based model, omitted variable bias is always a possibility.

Conclusion

This study examined the extent to which adolescent siblings have similar weapon carrying tendencies as well as the relative contributions of genetics, shared environment, and nonshared environment to these similarities. Using two waves of data from the Add Health, results indicate that weapon carrying is a rare event among sample respondents. There is little, if any, evidence of a genetic contribution to sibling similarity. Contrary to the expectations of social learning theories, there is also no significant evidence of sibling modeling. Rather, having a younger sibling who weapon carries appears to deter an older sibling from doing so. Findings indicate a strong contribution of nonshared environment, primarily gang affiliation, rather than any sort of shared environmental influence. Together, these observations highlight the importance of focusing on the nonshared environment as an avenue for gun violence intervention.

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Biography

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Table 1

Summary Statistics for Sibling Pairs.

Pair Characteristics	MZ	DZ	FS	HS	NR
Number of pairs	289	452	1,251	442	408
Number of same-sex pairs	—	223 (49.34%)	631 (50.44%)	197 (44.57%)	166 (40.69%)
Number of pairs same W1 weapon carrying score	274 (94.8%)	428 (94.69%)	1,184 (94.64%)	402 (90.95%)	381 (93.38%)
Number of pairs same W2 weapon carrying score	267 (92.39%)	416 (92.04%)	1,144 (91.45%)	394 (89.14%)	356 (87.25%)
W1 mean age	16.18 (1.59)	16.01 (1.65)	16.17 (1.72)	15.74 (1.97)	16.06 (1.73)
W1 mean age gap in years	—	—	2.23 (1.09)	2.83 (1.42)	1.77 (1.43)
W1 mean time with sibling score	3.55 (0.74)	3.22 (0.86)	3.11 (0.85)	2.89 (0.90)	2.99 (0.91)
W1 mean delinquency difference between siblings	0.29 (0.50)	0.34 (0.54)	0.39 (0.61)	0.44 (0.71)	0.45 (0.70)
W1 mean victimization difference between siblings	0.26 (0.63)	0.22 (0.56)	0.26 (0.65)	0.34 (0.71)	0.38 (0.80)

Note. Standard errors are displayed in parentheses for means. W1 = Wave 1; W2 = Wave 2; MZ = monozygotic twins; DZ = dizygotic twins; FS = full siblings; HS = half siblings; NR = nonbiologically related siblings.

Table 2
Maximum Likelihood Estimates of AE, ACE, and ADE Models for Weapon Carrying.

Parameter	Wave 1 Weapon Carrying			Wave 2 Weapon Carrying		
	AE	ACE	ADE	AE	ACE	ADE
$\sigma^2 A$	1.24	0.00	1.24	0.51	0.51	0.00
$\sigma^2 C$		0.83			0.00	
$\sigma^2 D$			0.00			0.67
$\sigma^2 E$	1	1	1	1	1	1
Log likelihood	-286.77	-285.87	-286.78	-154.28	-154.28	-154.08

Table 3

Actor–Partner Interdependence Models Predicting Wave 2 Weapon Carrying.

Predictors	Model 1	Model 2	Model 3	Model 4
Younger → younger weapon carrying	13.491 ** (10.512)	8.110 [†] (9.313)	13.385 ** (10.445)	8.197 [†] (9.436)
Older → older weapon carrying	17.719 ** (13.197)	8.128 * (8.069)	17.579 ** (13.112)	8.212 * (8.182)
Younger → older weapon carrying	0.029 ** (0.036)	0.069 [†] (0.111)	0.029 ** (0.036)	0.069 [†] (0.112)
Older → younger weapon carrying	1.159 (1.117)	1.257 (1.349)	1.150 (1.109)	1.276 (1.373)
Younger sibling victimization		1.369 (0.577)		1.379 (0.582)
Older sibling victimization		1.797 (0.665)		1.807 (0.671)
Younger sibling gang membership		19.689 ** (15.272)		19.658 ** (15.225)
Older sibling gang membership		8.172 * (7.079)		8.292 * (7.183)
Younger sibling age		0.502 * (0.154)		0.498 * (0.153)
Older sibling age		0.477 ** (0.138)		0.474 ** (0.138)
Younger sibling trouble paying attention		1.057 (0.352)		1.050 (0.351)
Older sibling trouble paying attention		1.359 (0.461)		1.370 (0.466)
Younger sibling trouble with homework		1.704 [†] (0.522)		1.711 [†] (0.526)
Older sibling trouble with homework		0.530 [†] (0.191)		0.527 [†] (0.190)
Genes (<i>R</i>)			0.795 (1.106)	1.889 (3.478)
Time with sibling		0.762 (0.300)		0.760 (0.299)
Same-sex siblings		0.761 (0.518)		0.748 (0.511)
Younger sibling constant	0.000 ** (0.000)	0.753 (3.249)	0.000 ** (0.000)	0.674 (2.917)
Older sibling constant	0.000 ** (0.000)	16.956 (80.861)	0.000 ** (0.000)	14.957 (71.591)

Note. Values are odds ratio, with standard errors of coefficients in parentheses. Arrows indicate the direction of influence.

**
 $p < .01$.

*
 $p < .05$.

[†]
 $p < .10$.

Table 4

Logistic Regression Models Predicting Pair-Level Change in Weapon Carrying.

Predictors	Pair-Level Drop in Weapon Carrying	Pair-Level Increase in Weapon Carrying
Same sex	1.025 (0.192)	0.493 ** (0.132)
White	0.864 (0.162)	0.641 † (0.167)
Genes	0.369 * (0.171)	0.347 † (0.218)
Age gap in years	1.156 * (0.079)	0.837 (0.092)
Time with sibling	1.154 (0.127)	0.965 (0.145)
Constant	0.062 ** (0.027)	0.172 ** (0.096)

Note. Values are odds ratio, with standard errors of coefficients in parentheses.

**
 $p < .01$.

*
 $p < .05$.

†
 $p < .10$.