The Contagious Spread of Violence Among US Adolescents Through Social Networks

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Objectives. To test the hypothesis that violence among US adolescents spreads like a contagious disease through social networks.

Methods. Participants were a nationally representative sample of 90 118 US students aged 12 to 18 years who were involved in the National Longitudinal Study of Adolescent Health. Violence was assessed by having participants report the number of times in the preceding 12 months they had been involved in a serious physical fight, had hurt someone badly, and had pulled a weapon on someone.

Results. Participants were 48% more likely to have been involved in a serious fight, 183% more likely to have hurt someone badly, and 140% more likely to have pulled a weapon on someone if a friend had engaged in the same behavior. The influence spread up to 4 degrees of separation (i.e., friend of friend of friend of friend) for serious fights, 2 degrees for hurting someone badly, and 3 degrees for pulling a weapon on someone.

Conclusions. Adolescents were more likely to engage in violent behavior if their friends did the same, and contagion of violence extended beyond immediate friends to friends of friends. (*Am J Public Health*. Published online ahead of print December 20, 2016: e1–e7. doi:10.2105/AJPH.2016.303550)

Throughout history, contagious diseases and violence have been among the greatest killers of human beings. Although violence and contagious diseases may seem to share little in common, several scholars have proposed that they are similar.[1] For example, a 5-year longitudinal study revealed that teenagers who had witnessed gun violence were more than twice as likely as those who had not to commit gun violence themselves.[2] The study's lead author, Felton J. Earls of Harvard Medical School, concluded that "based on this study's results, showing the importance of personal contact with violence, the best model for violence may be that of a socially infectious disease. Preventing one violent crime may prevent a downstream cascade of 'infections.'"[3] The present research adds to this body of work.

SIMILARITY OF VIOLENCE TO CONTAGIOUS DISEASE

Although imperfect, the analogy that violence is like a contagious disease might shed light on how violence can spread within communities. People exposed to a contagious disease are at increased risk of contracting the disease themselves. Numerous studies have shown that people who are exposed to violence—as observers or victims—are more likely to become perpetrators of violence themselves.[1]

Contagious diseases and violence tend to cluster in similar ways.[4] A cluster is an "aggregation of cases of a disease that are closely grouped in time and place."[1] There are geographic "hot spots" for contagious diseases, such as the 2015 measles outbreak linked to Disneyland in California involving clusters of unvaccinated children.[5] Likewise, there are geographic hot spots for violent crime on specific streets and in specific neighborhoods.[6]

People exposed to contagious diseases can develop a wide spectrum of possible outcomes (e.g., no disease at all, chronic or relapsing syndrome, disability, death).[5] The same is true for people exposed to violence.

Both contagious diseases and violence can spread quickly or slowly, depending on a host of factors. For example, some diseases spread quickly (e.g., measles, whooping cough), whereas others spread much more slowly (e.g., AIDS, tuberculosis). Similarly, some types of violence spread quickly (e.g., gang wars, riots) and others more slowly (e.g., victims of child abuse become perpetrators of family violence years later). The intervening time is called the incubation period.[1] However, the underlying cause is more direct for contagious diseases than for violence, because many other risk factors for violence might occur during the incubation period. Unfortunately, our data cannot be used to test this aspect of the analogy.

PSYCHOLOGICAL MECHANISMS UNDERLYING THE SPREAD OF VIOLENCE

To understand how violence spreads, one must understand the underlying psychological mechanisms. One key mechanism is imitation. According to social learning theory,[7] people learn aggressive and violent behaviors the same way they learn other social behaviors: by direct experience and by observing others and imitating their behavior. According to social cognitive theory,[8] observers do not simply imitate the specific social

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behaviors they witness; they also make cognitive inferences on the basis of these observations, and these inferences lead to generalizations in behavior.

In addition to imitation, other mechanisms influence adolescents. For example, as children become adolescents, peer groups become more important and influential.[9] Peer pressure has been linked to a wide variety of adolescent behaviors, including delinquency and aggression.[10–12] There is also a growing literature on the biological changes associated with exposure to violence.[13,14]

USING SOCIAL NETWORKS TO ANALYZE THE SPREAD OF VIOLENCE

Although previous studies have investigated how peers can affect one's likelihood of engaging in violent behavior,[15,16] they differ from the present study in 2 important ways. First, they have not isolated violent behavior from other delinquent behaviors. Second, they have not assessed how far (i.e., by how many degrees of social separation) delinquent, or violent, behavior may spread within a network. We empirically tested the contagion of violence hypothesis by investigating whether violence spreads like a contagious disease in social networks and, if so, how far the influence spreads.

METHODS

Participants were a nationally representative sample of 90 118 US students from 142 schools. All were in grades 7 to 12 and were involved in the National Longitudinal Study of Adolescent Health (Add Health).[17] Fifty-one percent of the students were female, and their mean age was 15.8 years (SD = 1.6); 61% were White, 23% were African American, 17% were Hispanic, 7% were Asian American, and 9% were of other racial/ethnic backgrounds. The students' median household income was $41 000, and their mothers' educational levels were as follows: 18% less than high school, 29% high school degree or equivalent, 10% some college, 14% college degree, and 9% professional or graduate degree.

A subset of this group of students was selected for in-depth home-based follow-up interviews in wave 1 (1994–1995; n = 20 745), wave 2 (1996; n = 14 738), and wave 3 (2001–2002; n = 15 197) of Add Health. Overall response rates were 79% for wave 1 and 89% for wave 2. We analyzed data from wave 1 and wave 2 only, because by wave 3 the participants were young adults and were no longer embedded in their high school social networks (summary statistics for the sample are presented in Table A, available as a supplement to the online version of this article at http://www.ajph.org). We assessed the subset of participants selected for in-depth interviews that included social network measures, which left us with a sample of 5913 students who were connected to at least 1 other student through a friendship and 4904 students who were connected to at least 1 sibling.

Participants were interviewed in their homes by National Opinion Research Center interviewers. Three questions were used to assess violent behavior; specifically, participants were asked how often, in the preceding 12 months, they had been involved in a serious physical fight, they had hurt someone badly enough that the person needed bandages or care from a doctor or nurse, and they had pulled a knife or gun on someone (0 = never, 1 = 1 or 2 times, 2 = 3 or 4 times, 3 = 5 or more times). Data from wave 1 showed that 32% of participants had been involved in at least 1 serious fight, 14% had hurt someone badly, and more than 2% had pulled a knife or gun on someone. In wave 2, 20% of participants had been in at least 1 serious fight, 6% had hurt someone badly, and approximately 3% had pulled a knife or gun on someone. Because of differences in their frequency, we analyzed the 3 items separately rather than combining them into 1 measure.

As a means of identifying social networks, participants nominated up to 5 female and 5 male friends among the roster of students within their school. We dropped from the analysis all students who either did not nominate at least 1 friend or was not nominated by any other students as a friend, as no information concerning his or her friendship network could be identified. Each nomination was treated as a link from the participant to the named friend. The names participants provided were matched to school rosters to identify each named friend who was also involved in the study, allowing us to determine whether participants' friends had engaged in violent behavior in the preceding 12 months.

Because 4904 participants had siblings who were taking part in Add Health, we also tested whether violent behavior spreads among siblings. (Note that the social influence of siblings is more likely than that of friends to be confounded by shared environments, including the home environment. As such, we present our sibling measures of influence primarily as reference points for our friend measures.)

RESULTS

As a means of establishing whether friends, friends of friends, and so forth exhibited correlated behaviors at a single point in time (within a given wave), we used permutation methodology (see the appendix, available as a supplement to the online version of this article at http://www.ajph.org) to assess behavior clustering in social networks. The results of this analysis did not indicate a causal relationship; rather, they indicated a baseline of clustered behaviors on which we based our regression analyses. These results helped us understand the degree to which clusters of adolescents with similar behaviors were present in social networks.

We considered observed networks to exhibit clustering greater than chance when the probability that a participant engaged in violent behavior given that a friend engaged in violent behavior was higher than the same probability in networks in which network topology was unchanged but the assignment of behavior was randomly assigned. These results established the baseline level of clustering in the social network. Importantly, our permutation tests did not control for the level of clustering at any other degree of social separation. However, we conducted regression analyses to establish probable causal relationships that accounted for other factors that might be responsible for such clustering.

Distinguishing among the 3 processes that might account for clustering (influence, homophilic selection, and confounding; see the supplementary appendix for further

details) required repeated measures of the variable of interest and longitudinal information about network ties.[18,19] We conducted regressions of participants' violent behavior in wave 2 as a function of their violent behavior in wave 1, the violent behavior of their nominated friends in both waves 1 and 2, and a host of control variables (see the supplementary appendix for further details). We included variables for friends' violent behavior in wave 1, which helped control for homophilic selection. Figure 1 provides a graphical representation of the results of the regression analyses focusing on hurting someone badly (similar figures for fighting and pulling a weapon, respectively, are presented in Figures A and B, available as supplements to the online version of this article at http://www.ajph.org). These models included only friendship dyads in which the friendships were present in both wave 1 and wave 2.

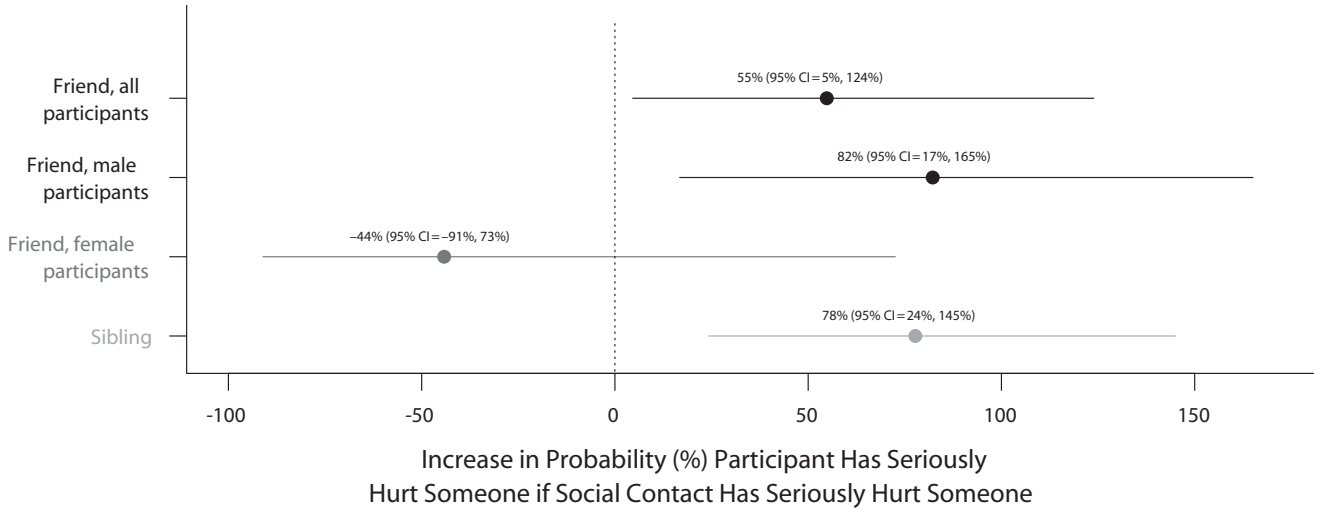
Influence of Friends on Involvement in a Serious Fight

Figures 2 through 4 show the results of the network permutation analysis. To the extent possible, our regression analyses accounted for factors such as social selection through the estimation procedures outlined earlier. Figure 2 depicts the results of analyses examining, via the network permutation method, the extent to which adolescents who had been involved in a serious fight tended to be friends with other adolescents who had been involved in a serious fight (network clustering). Data from wave 2 showed that participants with friends who had been in a serious fight were 48% (95% confidence interval [CI] = 35%, 62%) more likely to have been in a serious fight themselves. The association between friends was significant for up to 4 degrees of separation in wave 1 (i.e., friend of friend of friend of friend), when the increase in probability that a participant had been in a serious fight when a friend had been in a serious fight was 4% (95% CI = 2%, 5%). These results show that there was significant network clustering among peers who had been in a serious fight.

Table C (available as a supplement to the online version of this article at http://www.ajph.org) presents the results of the regression analysis controlling for demographic factors, violent behavior in wave 1, and violent behavior among participants' nominated friends in both wave 1 and wave 2. Overall, we found no significant effect of a friend having been involved in a serious fight on a participant having been in a serious fight. However, we found that when a participant's sibling had been in a serious fight, the participant's likelihood of having been in a serious fight increased by 38% (95% CI = 16%, 62%; $P < .01$). These results show that although there was significant network clustering, only siblings exhibited evidence of an increased probability of fighting given that a sibling had been in a fight once social selection and demographic factors had been taken into account.

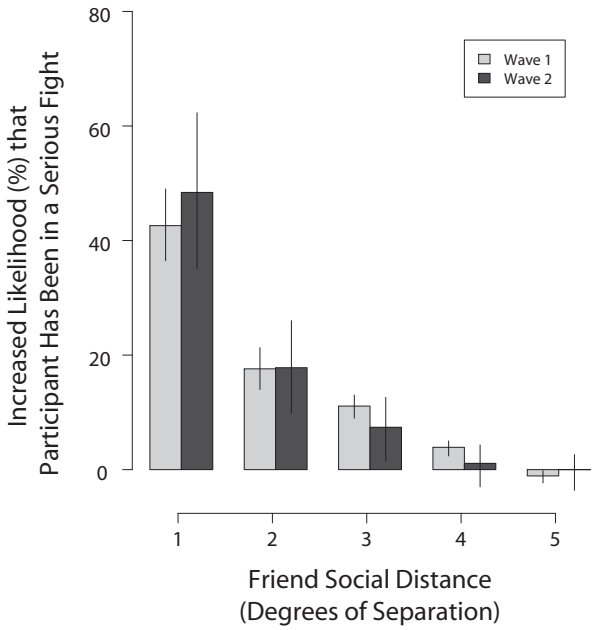
Influence of Friends on Hurting Someone Badly

Figure 3 depicts the results of analyses examining, again via the network permutation method, the extent to which adolescents who had hurt someone badly tended to be friends with other adolescents who had hurt someone badly (network clustering). In wave 2, participants with a friend who had hurt someone badly were 183% (95% CI = 150%, 220%) more likely to have hurt someone badly themselves. In both waves, the association between friends was significant for up to 2 degrees of separation (i.e., to friends of friends), and in wave 2 the increase in probability that a participant had seriously hurt someone when a friend had seriously hurt someone was 34% (95% CI = 13%, 56%). These results suggest



Note. CI = confidence interval. Effects were estimated with generalized estimating equation logit models of hurting someone badly; the models focused on several different social network subsamples. All of the models controlled for participants' lagged behavior from wave 1, friends' or siblings' behavior from both waves 1 and 2, and participant covariates (see the appendix, available as a supplement to the online version of this article at http://www.ajph.org). Circles denote means.

FIGURE 1—Influence of Friends and Siblings on Participants' Likelihood of Seriously Hurting Someone: Wave 2 of the National Longitudinal Study of Adolescent Health, United States, 1996



Note. Vertical bars denote 95% confidence intervals. Friend social distance (degree of separation) refers to the closest social distance between participants and friends (1 = friend, 2 = friend of a friend, 3 = friend of a friend's friend, etc.).

FIGURE 2—Percentage Increases in Participants' Involvement in a Serious Fight if Friends Were Also Involved in a Serious Fight: Waves 1 and 2 of the National Longitudinal Study of Adolescent Health, United States, 1994–1996

that there was significant network clustering among peers who had hurt someone badly.

Table D (available as a supplement to the online version of this article at http://www.ajph.org) presents the results of the regression analysis controlling for demographic factors, violent behavior in wave 1, and violent behavior among participants' nominated friends in both waves. We found that for each additional friend who had seriously hurt someone, the likelihood that a participant had seriously hurt someone increased by 55% (95% CI = 5%, 124%; $P = .02$). When we restricted our analysis to male participants, we found that for each additional friend who had seriously hurt someone, the likelihood of a participant doing the same increased by 82% (95% CI = 17%, 165%; $P < .01$). Similarly, we found that when a participant's sibling had seriously hurt someone, the participant's likelihood of having seriously hurt someone increased by 78% (95% CI = 24%, 145%; $P < .01$). These results show that the influence of friends on participants' likelihood of hurting someone badly was still significant after social selection and demographic factors have been taken into account.

Influence of Friends on Pulling a Gun or Knife on Someone

Figure 4 depicts the results of analyses examining the extent to which adolescents who had pulled a gun or knife on someone tended to have friends who had done the same. In wave 2, participants with a friend who had pulled a gun or knife on someone were 140% (95% CI = 82%, 208%) more likely to have themselves pulled a gun or knife on someone. In both waves, the association between friends was significant for up to 3 degrees of separation (i.e., to friends of friends of friends), and in wave 2 the increase in probability that a participant had pulled a knife or gun on someone when a friend had pulled a knife or gun on someone was 54% (95% CI = 27%, 77%). These results show that there was significant network clustering among peers who had pulled a knife or a gun on someone.

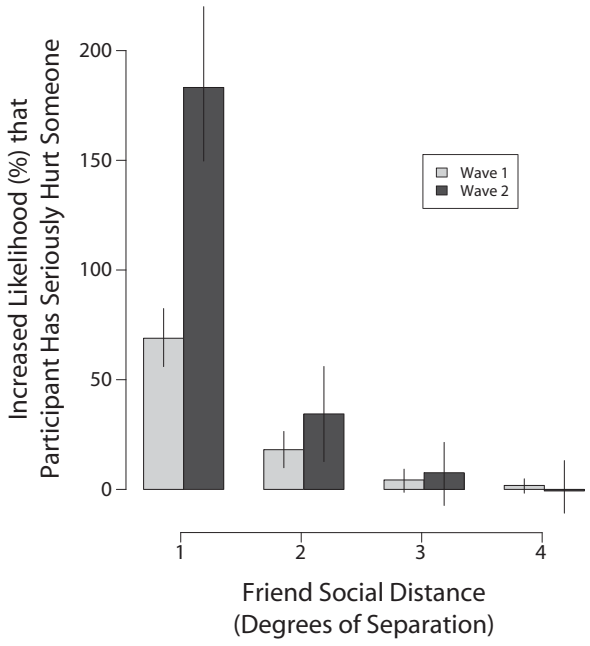
Table E (available as a supplement to the online version of this article at http://www.ajph.org) presents the results from the regression analysis controlling for demographic factors, violent behavior in wave 1, and violent behavior among participants' nominated friends in both waves. Overall, we found no significant effect of a friend having pulled a knife or gun on someone on a participant having done the same. We also found no significant effects when we restricted our analysis to male participants, female participants, or siblings through dichotomous specifications of the dependent variable. These results suggest that the influence of friends on participants' likelihood of pulling a knife or gun on someone was insignificant after social selection and demographic factors had been taken into account.

DISCUSSION

Considerable evidence shows that individuals who observe violence in their home, school, community, or even the mass media are at increased likelihood for committing violence themselves, both inside and outside the home.[1] Considerable evidence also shows that having been a victim of violence increases the likelihood that one will also become a perpetrator of violence, inside as well as outside the home.[1]

Our results from adolescent social networks are consistent with those of other studies showing that gun violence passes from person to person.[8,20–22] Recent work has also suggested that more serious violent crimes, such as homicide, may be transmitted through social networks in social and physical space.[23,24] The consequences of violence seem to pass through social networks as well: gunshot victims in a given area are likely to be socially connected to one another.[25] Our study adds to the body of work showing that violence may spread through social networks in a manner similar to how a contagious disease spreads.

However, our study is the first to our knowledge to examine how far violence can spread in social networks. Our results suggest that violence can spread through such networks, especially in the case of male adolescents and between siblings. Using permutation tests, we showed that participants were more likely to engage in violent



Note. Vertical bars denote 95% confidence intervals. Friend social distance (degree of separation) refers to the closest social distance between participants and friends (1 = friend, 2 = friend of a friend, 3 = friend of a friend's friend, etc.).

FIGURE 3—Percentage Increases in Whether Participants Had Hurt Someone Badly if Friends Had Also Hurt Someone Badly: Waves 1 and 2 of the National Longitudinal Study of Adolescent Health, United States, 1994–1996

behavior if their friends also engaged in violent behavior. Indeed, the association of violence likely extended beyond immediate friends to 4 degrees of separation for serious fights, 2 degrees for causing serious injuries, and 3 degrees for pulling a weapon on someone. These initial findings are consistent with previous work showing that violent crime spreads in networks and that this spread largely decreases after 2 degrees of separation.[26]

Clinical and Policy Implications

Violence, similar to contagious diseases, can be treated or prevented. Efforts can be directed at preventing individuals from being exposed to violence or at inoculating individuals against the effects of such exposures. Because friends have a significant impact on the violent behavior of adolescents, parents and other adults should encourage adolescents to interact with nonviolent peers. If adolescents are already aggressive, they can be taught alternative nonviolent ways of solving conflicts. Parents can also discourage violent interactions among siblings[27]; because parental violence is associated with sibling violence, they can start by modeling nonviolent behaviors themselves.[19]

There are many other factors that may protect people from violence, such as increasing supportive and prosocial climates in schools and communities, providing resources for young people to achieve academically, offering substance abuse programs, and encouraging the development of social skills and empathy.[11,12]

One program used to reverse the spread of violence is Cure Violence[28] (previously known as CeaseFire[29]), which begins by analyzing the clusters involved in the transmission of violence. Trained individuals (e.g., community coordinators) then use modern methods of persuasion and behavior change in their efforts to stop the spread of violence and change underlying norms. The Cure Violence methodology has been shown to be effective in at least 20 US cities (e.g., Baltimore, MD; Chicago, IL; New York, NY) as well as in South Africa, reducing shootings by 16% to 100%.[4] This research should help inform future programs intended to reduce violent behavior. When such programs are effective, they are likely to reduce violence not only for those who are directly impacted by the program, but also for those with whom they come into contact. Such programs may be more effective, and more cost-effective, than currently understood because the effects of such programs may be socially transmitted.

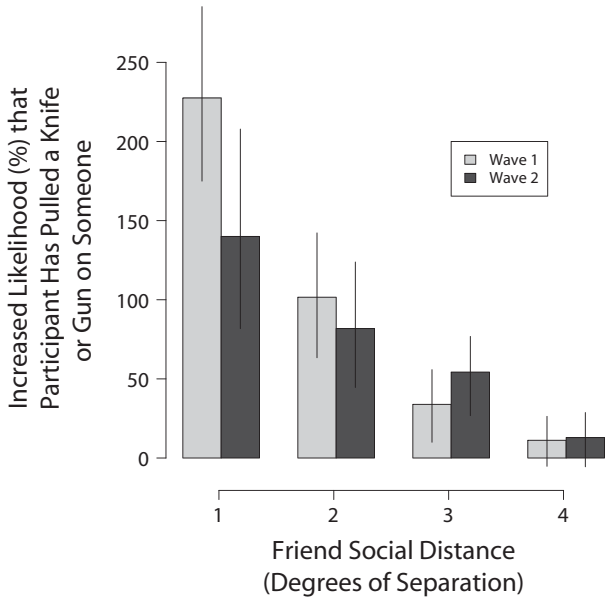
Limitations and Future Research

As do all studies, this study involves limitations. Our study's major limitation is the correlational nature of the data. However, because the design was longitudinal, we can establish the direction of the relationship between exposure to violent acts committed by participants' friends and subsequent violent acts committed by participants themselves.

Another limitation is the measures of violence we used. The interviews conducted in Add Health covered a wide array of topics related to adolescent health and behavior; assessment of violent behavior was not one of the main objectives of the study, and only 3 questions were used to measure such behavior. An inventory with more items would have been more reliable. The 3 measures were based on self-reports, and responses may have been biased with respect to participants' willingness or lack thereof to divulge details of their violent behavior. Future research should collect reports from other individuals (e.g., peers, parents, teachers) and especially behavioral data (e.g., criminal records).

A third limitation is that Add Health data were collected from 1994 to 2002. Future longitudinal studies are needed to replicate and extend the results of our study.

Our study was also limited in the way in which social networks were measured. At most schools, a subset of Add Health students were selected for in-depth interviews. As such, the networks of these schools were likely to include a substantial amount of missing data. (It is important to note, however, that a number of schools were mapped much more fully. We have included replications of our main findings on one such school in the supplementary appendix.) In addition, the Add Health data did not include out-of-school friendships. Thus, the



Note. Vertical bars denote 95% confidence intervals. Friend social distance (degree of separation) refers to the closest social distance between participants and friends (1 = friend, 2 = friend of a friend, 3 = friend of a friend's friend, etc.).

FIGURE 4—Percentage Increases in Whether Participants Had Pulled a Knife or Gun on Someone if Friends Had Also Pulled a Knife or Gun on Someone: Waves 1 and 2 of the National Longitudinal Study of Adolescent Health, United States, 1994–1996

relationships we identified were restricted to within-school friendships.

Another important limitation is that we were unable to account for spatial contagion in violence that might be related to social contagion. A growing literature has shown that violent behaviors cluster both socially and spatially,[16,30] and recent work has emphasized the importance of integrating social as well as spatial networks.[31] Future research that incorporates measures related to both types of networks will be key to understanding how the various contexts to which individuals are exposed facilitate, or potentially inhibit, violent behavior. (Note that Add Health has established policies and processes through which supplemental geographical data, such as the census tract locations of participants' homes, may be merged with the survey data. Although geospatial relationships in social networks are beyond the scope of this article, we encourage future researchers to use these or other data to investigate how spatial and social relationships may contribute to violent behavior.)

Although the methods we used to identify peer effects are widely used, they are not without criticism[32] (see the supplementary appendix for more details). Disentangling influence effects from selection effects is among the most difficult problems faced by social network researchers, and, as a result of the methods we used, we cannot definitively rule out selection as an explanation for the relationships observed in our study.[33] As new statistical techniques and research designs emerge (e.g., experiments in which peer effects can be identified[34]), researchers should employ these methods to study peer effects on violent behavior among adolescents as a means of better understanding the social transmission of violence.

Conclusions

Youth violence is a serious problem, both in the United States and around the world. The rates at which young people in this country perpetrate and experience violence are very high relative to rates among youths in many other developed nations.[35] In the United States, more young people die from homicide each year than from cancer, heart disease, birth defects, flu and pneumonia, respiratory diseases, stroke, and diabetes combined.[35] US youth homicide rates are 3 to 40 times higher than rates in similarly high-income countries.[35] Although no analogy is perfect, we agree that it is useful to conceptualize the spread of violence as similar to the spread of a contagious disease.[1] By treating violence as a contagious disease, perhaps we can reduce its transmission. AJPH

CONTRIBUTORS

R. M. Bond originated the study, analyzed the data, and contributed to the writing of the article. B. J. Bushman originated the study and contributed to the writing of the article.

HUMAN PARTICIPANT PROTECTION

No protocol approval was needed for this study because secondary data were analyzed.

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