



## Short Communication

## Gun violence in Americans' social network during their lifetime

Bindu Kalesan, PhD, MPH <sup>a,\*</sup>, Janice Weinberg, ScD, Prof. <sup>b</sup>, Sandro Galea, DrPH, MPH, Prof. <sup>c</sup><sup>a</sup> Center for Clinical Translational Epidemiology and Comparative Effectiveness Research, Department of Medicine, Boston University School of Medicine, Boston, MA, USA<sup>b</sup> Department of Biostatistics, Boston University School of Public Health, Boston University, Boston, MA, USA<sup>c</sup> Department of Epidemiology, Boston University, Boston, MA, USA

## ARTICLE INFO

## Article history:

Received 1 July 2016

Received in revised form 10 September 2016

Accepted 19 September 2016

Available online 22 September 2016

## ABSTRACT

**Introduction.** The overall burden of gun violence death and injury in the US is now well understood. However, no study has shown the extent to which gun violence is associated with the individual lives of Americans.

**Methods.** We used fatal and non-fatal gun injury rates in 2013 from Centers for Disease Control and Prevention's Web-based Injury Statistics Query and Reporting System (WISQARS) and generally accepted estimates about the size of an American's social network to determine the likelihood that any given person will know someone in their personal social network who is a victim of gun violence during their lifetime. We derived estimates in the overall population and among racial/ethnic groups and by gun-injury intent.

**Results.** The likelihood of knowing a gun violence victim within any given personal network over a lifetime is 99.85% (99.8% to 99.9%). The likelihood among non-Hispanic white, black, Hispanic and other race Americans were 97.1%, 99.9%, 99.5% and 88.9% respectively.

**Conclusion.** Nearly all Americans of all racial/ethnic groups are likely to know a victim of gun violence in their social network during their lifetime.

© 2016 Elsevier Inc. All rights reserved.

## 1. Introduction

The epidemic of gun violence in the US has now become part of the ongoing American conversation, with substantive efforts to bring about change seeming unlikely barring unanticipated shifts in the political landscape. The burden of gun violence in the US is as follows. Approximately one third of gun injuries are fatal with an average of 33,000 shot and killed annually, while two-thirds of those shot (annual average of 82,000) survive and suffer severe health consequences (Centers for Disease Control and Prevention, 2016). The majority of the fatal gun injuries are suicide while most of the non-fatal gun injuries are due to assault (Centers for Disease Control and Prevention, 2016). Despite the overwhelming evidence of this, in no small part preventable, epidemic, efforts towards regulation continue to meet political gridlock. Well-documented pervasive racial/ethnic disparities in gun violence (Kalesan et al., 2014) implicitly color the debates around this issue, suggesting perhaps that gun violence is a problem of the "other", that gun violence cannot happen to me, but happens to other people.

In 1992, Robin Dunbar, an anthropologist suggested a cognitive limit for the magnitude of social relationships maintained by a person (Dunbar, 1992). Based on the average brain size, Dunbar proposed that the size of the social network (SN) for a person to be between

100 and 250, most commonly 150 stable relationships. More recent evidence suggest that current online SN is similar to a person's offline SN despite the overwhelming influence of social media (Dunbar et al., 2015). Bernard and Killworth used network scale up method (NSUM) to determine the size of hard-to-count populations and estimated the average size of SN to be distributed around 291 and changes across societies (McCarty et al., 2001).

Most people experience clustering of their social networks on socio-demographic characteristics, primarily because people generally have significant contact only with others like themselves; this phenomenon is called "homophily" (McPherson et al., 2001; Sackett et al., 1975; Barabasi and Albert, 1999). Homophily has been demonstrated and reported in multiple social science fields and therapeutic areas such as concordance of coronary disease risk factors among spouses, (Sackett et al., 1975) interactions in HIV communities (Shi et al., 2016) and consumer intentions (Smith et al., 2016). Social network homophily based on race are also well-documented, (Carrarini et al., 2010; Jacoby-Senghor et al., 2015) where people establish friendships based on race and race-specific biases.

Building on these estimates of the number of stable relationships a person accrues during a lifetime, we aimed to understand the likelihood that gun violence will affect any given person in the US. We used evidence from social network analysis particularly using Bernard and Killworth's NSUM results (McCarty et al., 2001) and an assumption of homophilic SN (McPherson et al., 2001) to determine the likelihood that any given person will know someone in their personal SN who is

\* Corresponding author.

E-mail addresses: [kalesan@bu.edu](mailto:kalesan@bu.edu) (B. Kalesan), [janicew@bu.edu](mailto:janicew@bu.edu) (J. Weinberg), [sgalea@bu.edu](mailto:sgalea@bu.edu) (S. Galea).

a victim of gun violence during their lifetime, in the overall population and among racial/ethnic groups and by intent.

## 2. Methods

### 2.1. Data source

We used the aggregate counts of fatal and non-fatal gun injuries in 2013 obtained from Centers for Disease Control and Prevention's Web-based Injury Statistics Query and Reporting System (WISQARS) (Centers for Disease Control and Prevention, 2016). In 2013, there were a total of 2,596,993 deaths registered in the US. The age-adjusted death-rate was 731.9 deaths per 100,000 population with the life expectancy at birth to be 78.8 years (Xu et al., 2016). There were 33,636 gun deaths and 84,258 non-fatal gun injuries in 2013 in a total population of 316,497,531. In 2013, there were 200,866,119 non-Hispanic whites, 43,785,446 blacks (Hispanic and non-Hispanic), 51,331,391 Hispanics and 20,514,575 other race. There were 22,149 and 18,743 fatal and non-fatal injuries among non-Hispanic whites; 7797 and 30,127 among blacks; 2866 and 12,623 among Hispanics and was 749 and 1837 among other races. Overall, there were 75,078 assault, 25,166 suicide, 17,650 unintentional or undetermined gun injuries in 2013. Among fatal gun injuries 11,675 were of assault, 21,175 suicide and 786 were unintentional/undetermined intent. Among non-fatal gun injuries 63,403 were of assault, 3991 of suicide and 16,884 of unintentional/undetermined intent.

### 2.2. Social network assumptions

NSUM estimated the average size of a person's SN to be 291 (standard deviation = 259); with 95% confidence intervals from 270 to 312 (McCarty et al., 2001). Using the NSUM assumption that the number of people in a person's SN in a particular sub population is a function of the overall number of people known, we assumed a person to have roughly 291 persons in his/her social network. For race/ethnicity-specific likelihood, we assumed homophily, where people with different characteristics appear to have different qualities and contact between similar people occurs at a higher rate than dissimilar people (McPherson et al., 2001). Taking into consideration the homophily of social networks, we assumed that the majority of the social network of a person of a certain race is of the same race.

### 2.3. Gun violence injury rates in 2013

We assessed the probability of gun violence exposure considering the overall annual rate of fatal (10.4 per 100,000) and non-fatal (26.8 per 100,000) gun violence in 2013 population of 316,497,531 (37.2 per 100,000) (Centers for Disease Control and Prevention, 2016). We also assessed race/ethnicity-specific probability of gun violence exposure in a person's SN among non-Hispanic whites, blacks, Hispanics and other. In 2013, the rates of fatal, non-fatal and combined gun injuries among non-Hispanic whites was 11.0 per 100,000, 9.3 per 100,000 and 20.4 per 100,000; among blacks was 17.8 per 100,000, 68.8 per 100,000 and 86.6 per 100,000; among Hispanics was 5.6 per 100,000, 24.6 per 100,000 and 30.2 per 100,000; and among other races was 3.7 per 100,000, 9.0 per 100,000 and 12.6 per 100,000 (Centers for Disease Control and Prevention, 2016). The overall (fatal and non-fatal) intent-specific rates were 23.7, 7.9 and 5.6 per 100,000 for assault, suicide and unintentional/undetermined respectively. The fatal intent-specific rates were 3.7, 7.0 and 0.2 per 100,000 while non-fatal intent-specific rates were 20.0, 1.3 and 5.3 per 100,000 for assault, suicide and unintentional/undetermined respectively.

### 2.4. Assumptions

In order to simplify calculations, we assumed 1) gun violence (fatal and non-fatal) happens at random to any individual within a social network so that all individuals are at the same risk; 2) homophilic SN; 3) a constant number of social contacts with some entering and some leaving the pool each year (291, with a sensitivity range of 270 to 312); and 4) the probability of experiencing gun violence in a given year is independent of other years. We also defined "lifetime" as a period of 60 years of adult life and considered that a person develops majority of his or her personal social network (those that are stable relationships) during 60 years of their life out of their total life expectancy.

### 2.5. Statistical analysis

All calculations were carried out using the overall, race/ethnicity-specific and assault-specific national estimates of gun deaths and injuries. First, we obtained the proportion of those who are gun violence victims in the given population. Second, we calculated the probability of having no one with gun violence experience in a person's SN during one year using the formula:  $((1 - \text{rate of fatal and non-fatal gun injuries})^{291})$ . The SN size used was 291 with a sensitivity analysis range of 270 to 312. Third, we calculated the proportion of those who have not been affected by gun violence in the specific population; the probability of not knowing anyone exposed to gun violence during 60 years of life when a person establishes stable relationships using the formula:  $[(1 - \text{rate of fatal and non-fatal gun injuries})^{291}]^{60}$ . Fourth, we calculated the probability of having a gun violence victim in a person's SN during a lifetime using the formula:  $1 - [100 * ((1 - \text{rate of fatal and non-fatal gun injuries})^{291})^{60}]$ . We used R statistical software package to calculate probabilities of gun violence exposure.

## 3. Results

Table 1 presents the likelihood of gun violence in a person's social network. We found that the likelihood of knowing a gun violence victim within any given personal network over a lifetime is 99.85% using overall national estimates and ranges between 99.8% to 99.9% considering a range of SN from 270 to 312. We also found considerable racial differences in gun violence extent within a person's SN. The non-Hispanic whites have a likelihood of 97.1% of knowing at least one gun violence victim within their SN while blacks have a 99.9%, Hispanics have 99.5% and other racial groups have an 88.9% likelihood.

The likelihood of knowing a gun violence victim who died using overall estimates is 84.3%, ranging between 82.0% to 86.3%. The non-Hispanic whites have a likelihood of 85.3% of knowing at least one gun violence victim who died within their SN while blacks have a 95.5%, Hispanics have 62.4% and other racial groups have 46.7% likelihood. The likelihood of knowing a gun violence victim who survived using overall estimates is 99.0%, ranging between 98.6% to 99.3%. The non-Hispanic whites have a likelihood of 80.3% of knowing at least one gun violence victim who survived within their SN while blacks have a 99.9%, Hispanics have 98.6% and other racial groups have 78.9% likelihood.

Table 2 presents the likelihood of different intent of gun violence in a person's social network. We found that the likelihood of knowing an assault gun violence victim in their personal network over a lifetime is 98.4%, for suicide is 74.8% and unintentional/undetermined is 62.4%.

## 4. Discussion

We found that the probability of never knowing someone who experiences gun violence over a lifetime is very small. We also found that it is more likely to know someone who has survived a gun injury than died of it. It is highly that a non-Hispanic white person will know a victim of gun violence and even more likely that a black person will know a victim of gun violence. Conversely, the likelihood of knowing over a

**Table 1**  
Likelihood of gun violence in a person's social network using data in 2013.

Group	GV rate <sup>a</sup>	SN no GV in 1 year <sup>b</sup> (range)	SN no GV in a lifetime <sup>c</sup> (range)	SN GV in a lifetime <sup>d</sup> (range)
All				
Overall	37.2 * 10 <sup>-5</sup>	0.90 (0.90–0.89)	1.5 * 10 <sup>-3</sup> (2.4 * 10 <sup>-3</sup> –0.9 * 10 <sup>-3</sup> )	99.8% (99.8%–99.9%)
Non-Hispanic whites	20.3 * 10 <sup>-5</sup>	0.94 (0.95–0.94)	29.0 * 10 <sup>-3</sup> (37.3 * 10 <sup>-3</sup> –22.4 * 10 <sup>-3</sup> )	97.1% (96.3%–97.8%)
Blacks	86.6 * 10 <sup>-5</sup>	0.78 (0.79–0.76)	2.7 * 10 <sup>-7</sup> (8.03 * 10 <sup>-7</sup> –9.04 * 10 <sup>-8</sup> )	99.9% (99.9%–99.9%)
Hispanics	30.2 * 10 <sup>-5</sup>	0.92 (0.92–0.91)	5.1 * 10 <sup>-3</sup> (7.5 * 10 <sup>-3</sup> –3.5 * 10 <sup>-3</sup> )	99.5% (99.3%–99.6%)
Other race	12.6 * 10 <sup>-5</sup>	0.96 (0.97–0.96)	11.1 * 10 <sup>-2</sup> (13.0 * 10 <sup>-2</sup> –9.5 * 10 <sup>-2</sup> )	88.9% (87.0%–90.6%)
Fatal				
Overall	10.6 * 10 <sup>-5</sup>	0.97 (0.97–0.97)	15.7 * 10 <sup>-2</sup> (17.9 * 10 <sup>-2</sup> –13.7 * 10 <sup>-2</sup> )	84.3% (82.0%–86.3%)
Non-Hispanic whites	11.0 * 10 <sup>-5</sup>	0.97 (0.97–0.97)	14.7 * 10 <sup>-2</sup> (16.8 * 10 <sup>-2</sup> –12.7 * 10 <sup>-2</sup> )	85.3% (83.2%–87.2%)
Blacks	17.8 * 10 <sup>-5</sup>	0.95 (0.95–0.95)	4.5 * 10 <sup>-2</sup> (5.6 * 10 <sup>-2</sup> –3.6 * 10 <sup>-2</sup> )	95.5% (94.4%–96.4%)
Hispanics	5.6 * 10 <sup>-5</sup>	0.98 (0.98–0.98)	37.6 * 10 <sup>-2</sup> (40.4 * 10 <sup>-2</sup> –35.1 * 10 <sup>-2</sup> )	62.4% (59.6%–64.9%)
Other race	3.6 * 10 <sup>-5</sup>	0.99 (0.99–0.99)	53.3 * 10 <sup>-2</sup> (55.8 * 10 <sup>-2</sup> –50.9 * 10 <sup>-2</sup> )	46.7% (44.2%–49.0%)
Non-fatal				
Overall	26.6 * 10 <sup>-5</sup>	0.93 (0.93–0.92)	0.9 * 10 <sup>-2</sup> (1.3 * 10 <sup>-2</sup> –0.7 * 10 <sup>-2</sup> )	99.0% (98.6%–99.3%)
Non-Hispanic whites	9.3 * 10 <sup>-5</sup>	0.97 (0.97–0.97)	19.7 * 10 <sup>-2</sup> (22.2 * 10 <sup>-2</sup> –17.5 * 10 <sup>-2</sup> )	80.3% (77.8%–82.5%)
Blacks	68.8 * 10 <sup>-5</sup>	0.82 (0.83–0.81)	6.0 * 10 <sup>-6</sup> (1.4 * 10 <sup>-5</sup> –2.5 * 10 <sup>-6</sup> )	99.9% (99.9%–99.9%)
Hispanics	24.5 * 10 <sup>-5</sup>	0.93 (0.94–0.93)	1.4 * 10 <sup>-2</sup> (1.9 * 10 <sup>-2</sup> –1.0 * 10 <sup>-2</sup> )	98.6% (98.1%–98.9%)
Other race	8.9 * 10 <sup>-5</sup>	0.97 (0.98–0.97)	21.1 * 10 <sup>-2</sup> (23.6 * 10 <sup>-2</sup> –18.9 * 10 <sup>-2</sup> )	78.9% (76.3%–81.1%)

GV denotes gun violence, SN denotes social network.

<sup>a</sup> Proportion of those who are gun violence victims (both, fatal and non-fatal) in the specific population.

<sup>b</sup> Probability of having no one with gun violence in SN is calculated using (1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>. Range indicates the range of social network size between 270 and 312.

<sup>c</sup> Probability of no one with gun violence in SN in a lifetime: We assumed first 60 years to be the time period a person develops his or her personal SN. We calculated using the formula 100 \* ((1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>)<sup>60</sup>.

<sup>d</sup> Having a gun violence victim in SN in a lifetime was calculated using the formula 1 – [100 \* ((1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>)<sup>60</sup>].

lifetime at least one person who was shot will be the greater among blacks as compared to whites. The likelihood is also higher that blacks will know someone who was a victim of assault-related gun injury than someone who was a victim of a gun-related suicide or an unintentional/undetermined intent.

Our findings are based on best assumptions about social network structures. A longitudinal study using high-risk individuals in Boston provides some corroborating evidence of the relationship between an individual's position in a social network and the risk of being a victim of gun violence (Papachristos et al., 2012). However, this study and similar studies focused on victimization and crime (Papachristos et al., 2012; Papachristos and Wildeman, 2014; Papachristos et al., 2015) without addressing the proximity to gun violence in one's social network. While the current evidence points to the obvious risk of gunshot victimization as concentrated in small identifiable social network of individuals engaged in criminal activity, (Papachristos et al., 2015) all these studies were conducted in neighborhoods that had high criminal activity. It is also the case that there is a much higher risk of violence exposure among those previously exposed to violence. This may result in an underestimation of the differential likelihood of violence exposure among blacks for assault-related violence. Using our assumptions, exposure to gun violence is certain for some individuals. For others the likelihood would still be far from zero even if the simplifying assumption of randomness is not accurate.

We provide preliminary evidence that US residents are closer to gun violence than they perceive. Although our calculations indicate a closer

proximity to assault related gun violence we suggest a more cautious interpretation since we based our calculations and assumptions on national level estimates. Our estimates should not to be applied to individuals characterized by particular demographic characteristics. Therefore, our results should not be interpreted with specific spatial attributes such as those applicable to areas or pockets of high crime or areas where gun suicide rates are known to be high, but should be interpreted more generally as pertaining to the population as a whole. We assumed that gun violence was independent to make calculations easier to interpret. This however is clearly a simplifying assumption and one that likely provides an under-estimate of the density of gun violence in particular people's social networks (Kalesan et al., 2016).

In conclusion, leaving aside constitutional debates about approaches to controlling gun violence, it might inform our national conversation to recognize that nearly all Americans, of all racial/ethnic groups will know a victim of gun violence in their social network. This should bring the issue closer to home. Our findings need to be validated using large scale longitudinal social network studies, suggesting strongly the need for more firearm-related research.

**Author contribution**

All authors conceived the study. Kalesan and Galea supervised the study. Kalesan and Weinberg completed the analyses. Kalesan and Galea led the writing. All authors assisted with the study and analyses. Kalesan obtained data.

**Table 2**  
Likelihood of intent-specific gun violence in a person's social network using data in 2013.

Group	GV rate <sup>a</sup>	SN no GV in 1 year <sup>b</sup> (range)	SN no GV in a lifetime <sup>c</sup> (range)	SN GV in a lifetime <sup>d</sup> (range)
Assault	23.7 * 10 <sup>-5</sup>	0.93 (0.94–0.93)	1.6 * 10 <sup>-2</sup> (2.1 * 10 <sup>-2</sup> –1.2 * 10 <sup>-2</sup> )	98.4% (97.9%–98.8%)
Suicide	7.9 * 10 <sup>-5</sup>	0.98 (0.98–0.98)	25.2 * 10 <sup>-2</sup> (27.8 * 10 <sup>-2</sup> –22.8 * 10 <sup>-2</sup> )	74.8% (72.2%–77.2%)
Unintentional/undetermined	5.6 * 10 <sup>-5</sup>	0.98 (0.98–0.98)	37.6 * 10 <sup>-2</sup> (40.4 * 10 <sup>-2</sup> –35.1 * 10 <sup>-2</sup> )	62.4% (59.6%–64.9%)

GV denotes gun violence, SN denotes social network.

<sup>a</sup> Proportion of those who are gun violence victims (both, fatal and non-fatal) in the specific population.

<sup>b</sup> Probability of having no one with gun violence in SN is calculated using (1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>. Range indicates the range of social network size between 270 and 312.

<sup>c</sup> Probability of no one with gun violence in SN in a lifetime: We assumed first 60 years to be the time period a person develops his or her personal SN. We calculated using the formula 100 \* ((1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>)<sup>60</sup>.

<sup>d</sup> Having a gun violence victim in SN in a lifetime was calculated using the formula 1 – [100 \* ((1 – rate of fatal and non-fatal gun injuries)<sup>291</sup>)<sup>60</sup>].

## Role of funding

No external sources of funding were used for this study.

## Conflict of interest

No conflict of interest declared by any of the authors.

## Acknowledgement

We thank Jennifer L Longdon for posing the research question. She is a gun violence prevention policy advocate as a result of surviving gun violence and lives with T2 paraplegia.

## References

- Barabasi, A.L., Albert, R., 1999. Emergence of scaling in random networks. *Science* (New York, N.Y.) 286, 509–512.
- Centers for Disease Control and Prevention, 2016. National Centers for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System) (WISQARS) [online]. Atlanta, GA. <http://www.cdc.gov/ncipc/wisqars> (Accessed March 20).
- Currarini, S., Jackson, M.O., Pin, P., 2010. Identifying the roles of race-based choice and chance in high school friendship network formation. *Proc. Natl. Acad. Sci. U. S. A.* 107, 4857–4861.
- Dunbar, R.I.M., 1992. Neocortex size as a constraint on group size in primates. *J. Hum. Evol.* 22, 469–493.
- Dunbar, R.I.M., Arnaboldi, V., Conti, M., Passarella, A., 2015. The structure of online social networks mirrors those in the offline world. *Soc. Networks* 43, 39–47.
- Jacoby-Senghor, D.S., Sinclair, S., Smith, C.T., 2015. When bias binds: effect of implicit outgroup bias on ingroup affiliation. *J. Pers. Soc. Psychol.* 109, 415–433.
- Kalesan, B., Vasan, S., Mobily, M.E., et al., 2014. State-specific, racial and ethnic heterogeneity in trends of firearm-related fatality rates in the USA from 2000 to 2010. *BMJ Open* 4, e005628.
- Kalesan, B., Adhikarla, C., Pressley, J.C., et al., 2016. The hidden firearm epidemic: increasing firearm injury rates 2001–2013. *Am. J. Epidemiol.* (in press).
- McCarty, C., Killworth, P.D., Bernard, H.R., Johnsen, E., Shelley, G.A., 2001. Comparing two methods for estimating network size. *Hum. Organ.* 60, 28–39.
- McPherson, M., Smith-Lovin, L., Cook, J.M., 2001. Birds of a feather: homophily in social networks. *Annu. Rev. Sociol.* 27, 415–444.
- Papachristos, A.V., Wildeman, C., 2014. Network exposure and homicide victimization in an African American community. *Am. J. Public Health* 104, 143–150.
- Papachristos, A.V., Braga, A.A., Hureau, D.M., 2012. Social networks and the risk of gunshot injury. *J. Urban Health* 89, 992–1003.
- Papachristos, A.V., Wildeman, C., Roberto, E., 2015. Tragic, but not random: the social contagion of nonfatal gunshot injuries. *Soc. Sci. Med.* (1982) 125, 139–150.
- Sackett, D.L., Anderson, G.D., Milner, R., Feinleib, M., Kannel, W.B., 1975. Concordance for coronary risk factors among spouses. *Circulation* 52, 589–595.
- Shi, J., Wang, X., Peng, T.Q., Chen, L., 2016. Understanding interactions in virtual HIV communities: a social network analysis approach. *AIDS Care* 1–5.
- Smith, R.A., Zhu, X., Shartle, K., Glick, L., M'ikanatha, N.M., 2016. Understanding the public's intentions to purchase and to persuade others to purchase antibiotic-free meat. *Health Commun.* 1–9.
- Xu, J., Murphy, S.L., Kochanek, D., Bastian, B.A., 2016. Deaths: Final Data for 2013. Hyattsville, md: National Vital Statistics Reports.