Brief report: Using global positioning system (GPS) enabled cell phones to examine adolescent travel patterns and time in proximity to alcohol outlets

Hilary F. Byrnes[a,]

Brenda A. Miller[a]

Christopher N. Morrison[a, b, c,]

Douglas J. Wiebe[c]

Lillian G. Remer[a]

Sarah E. Wiehe[d, e, f]

[a] Prevention Research Center, Pacific Institute for Research and Evaluation, 180 Grand Avenue, Suite 1200, Oakland, CA 94612, USA

[b] Monash University, Department of Epidemiology and Biostatistics, 99 Commercial Rd, Melbourne, VIC 3004, Australia

[c] University of Pennsylvania, Perelman School of Medicine, Department of Biostatistics and Epidemiology, Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104, USA

[d] Indiana University School of Medicine, Indianapolis, IN, USA

[e] Indiana University Purdue University, Indianapolis, IN, USA

[f] Regenstrief Institute for Health Care, Fairbanks Hall, 340 West 10th Street, Suite 6200, Indianapolis, IN 46202-3082, USA

Abstract

As adolescents gain freedom to explore new environments unsupervised, more time in proximity to alcohol outlets may increase risks for alcohol and marijuana use. This pilot study: 1) Describes variations

in adolescents' proximity to outlets by time of day and day of the week, 2) Examines variations in outlet proximity by drinking and marijuana use status, and 3) Tests feasibility of obtaining real-time data to study adolescent proximity to outlets. U.S. adolescents (N = 18) aged 16–17 (50% female) carried GPS-enabled smartphones for one week with their locations tracked. The geographic areas where adolescents spend time, activity spaces, were created by connecting GPS points sequentially and adding spatial buffers around routes. Proximity to outlets was greater during after school and evening hours. Drinkers and marijuana users were in proximity to outlets 1½ to 2 times more than non-users. Findings provide information about where adolescents spend time and times of greatest risk, informing prevention efforts.

Keywords: GPS; Alcohol outlets; Adolescents; Alcohol use; Marijuana use

As adolescents age, risky behaviors such as alcohol and marijuana use increase as they gain access to unsupervised environments (Byrnes et al., 2011 and Voas and Kelley-Baker, 2008). Based on an "expanded horizon" perspective (Kelley-Baker & Voas, 2009), increased time in risky environments, lessened parental monitoring (Bourdeau et al., 2011 and Voas and Kelley-Baker, 2008), greater access to alcohol and other drugs (AOD), and modeling of AOD use (Kelley-Baker and Voas, 2009, McCarthy and Brown, 2004 and Voas and Kelley-Baker, 2008) are evident.

Ecological theories emphasize that individuals are embedded in, and are inseparable from, their social context (Bronfenbrenner, 1979). Specifically, social disorganization, defined as residents' difficulty maintaining community social and physical order (Shaw & McKay, 1942) is related to problematic outcomes for youth (e.g., Byrnes, Chen, Miller, & Maguin, 2007).

Alcohol outlets are frequently used as indicators of disorganization and lessened normative controls (Gruenewald, 2007). Although adolescents are more likely to obtain alcohol from non-outlet sources (Paschall, Grube, Black, & Ringwalt, 2007), proximity to outlets may influence use (Pasch, Hearst, Nelson, Forsyth, & Lytle, 2009) through increased access for social contacts (Reboussin, Song, & Wolfson, 2011) and perceptions of use as normative (Pasch et al., 2009). Greater outlet density in

residential neighborhoods is related to youths' alcohol use and drinking problems (e.g., Treno, Ponicki, Remer, & Gruenewald, 2008). Although few studies have examined the link between marijuana use and alcohol outlets, marijuana use has been linked to other markers of disorganization (Byrnes et al., 2015 and Furr-Holden et al., 2011).

Prior studies (e.g., Ahern, Margerison-Zilko, Hubbard, & Galea, 2013) have focused on the presence of alcohol outlets near the home. Focusing on the home area may not capture actual proximity to outlets based on where a person spends time (Basta et al., 2010 and Kwan, 2012). In addition, time spent near outlets does not necessarily correlate with the prevalence of outlets near the residence (Basta et al., 2010 and Byrnes et al., 2015). Preliminary work using global positioning system (GPS) technology suggests that adolescents were in proximity to nine times more outlets in their activity spaces than were present in their residential census tracts (Byrnes et al., 2015). The time of day and day of the week of proximity may also be important for substance use.

Our objectives are to: 1) Describe adolescent travel patterns and variations in the proportion of time in proximity to alcohol outlets by time of day and day of the week. Weekends and after school hours (times of greater mobility) were hypothesized to be times of greater proximity. 2) Examine variations in the proportion of time adolescents are proximal to alcohol outlets by drinking and marijuana use status. We hypothesized that adolescents who use substances will be proximal to outlets for greater proportions of their time. 3) Assess the feasibility of a protocol to monitor adolescents in real time to obtain data on their experiences in activity spaces.

Method

A convenience sample of English-speaking 16–17 year olds (N = 18) was recruited via Craigslist.org in the urban and suburban areas of a medium-sized Northeastern U.S. city. Participants were tracked by GPS-enabled smartphones (AT&T Fusion2) for one week, during which they were sent 10 brief text-prompted web surveys periodically to assess behaviors. Participants earned up to $75 for

participation: $10 for an online survey, $2.50 per text, and $40 for equipment return. Parental consent and adolescent assent were obtained. Procedures were approved by an Institutional Review Board.

ActSoft Comet Tracker (ActSoft Inc., Tampa, FL) on the phones was used to track locations approximately every 60 s. There were 107,305 location records, and 95.9% of these were able to be identified with latitude/longitude values, as opposed to cell towers. Participants were tracked for 143,373 min out of 167,256 (85.7%) total minutes.

The average age of participants was 16.5 years (SD = 0.5), and half (50.0%) were female. Ethnicity was similar to the metropolitan area where the study was conducted (Bureau, 2013): 61.1% White, 22.2% African-American, and 16.7% multi-ethnic.

Measures

Texts read: "Have you [had any alcoholic drinks/used marijuana] since the last text we sent you?" Any use of alcohol or any use of marijuana during the week categorized participants as "drinkers," or "marijuana users," respectively.

Data and geocoded alcohol outlet locations were obtained from the state's Liquor Authority Mapping Project for off- (e.g., liquor stores) and on-premise (e.g., bars) establishments. The License Category variable was used to tabulate establishment type. Counts were tallied for number of alcohol outlets in activity spaces and residential census tracts.

Handling of GPS data was guided by prior research (Sherman, Spencer, Preisser, Gesler, & Arcury, 2005). Activity spaces were constructed by connecting sequential GPS points to create a polyline with embedded timestamps. Each line segment represented the aggregated spatial and temporal location for an adolescent between two space-time points. We then dichotomously coded each line segment for the presence or absence of any alcohol outlet within 30 m, 100 m and 200 m spatial buffers. The 100 m buffer was used for this paper, as it represents an area roughly equivalent to one city block, and represents a distance where youth may be able to see. Results for 30 m and 200 m buffers were similar (not shown).

For 3173 (1.7%) instances, there was a gap in the GPS readings lasting between two and 60 min. If two readings were 100 m or less by Euclidean distance, points were imputed (1851 cases (58.3%)) and equally spaced along a straight line at 2 min intervals. However, results were similar to non-imputed data, so non-imputed data are presented.

Analyses

We partitioned time into 24 h for each day, then calculated the proportion of each hour that participants were in proximity to any alcohol outlet (i.e., we summed the total minutes for which the participant was within a buffer distance of any outlet, then denominated by the total minutes for which data were available). We compared the mean proportion of time that participants were in proximity to outlets for weekends (5 pm Friday to 12 am Monday) and weekdays; and for drinkers and marijuana users.

Results

Compliance was demonstrated by a 100% return rate for phones and chargers, and a 93% response rate to texts (range: 70–100%). More than half (55.6%) responded to all texts. Over one third (38.9%) of adolescents reported drinking alcohol and a quarter (27.8%) used marijuana during the week. Adolescents spent 28.5% of their time away from home, and 25.4% of their time away from their residential census tract. Adolescents were in proximity to significantly more ($p < .001$) alcohol outlets in activity spaces than were present in their residential census tract ($M = 94.39$ vs. 10.44).

On weekdays, proximity to any alcohol outlet within the activity space was greatest after school and evenings (23.49% weekdays 2–8 pm vs. 16.96% all times, $p < .001$; Fig. 1). On weekends, proximity was also greater during the afternoons and evenings (20.29% weekends 2–10 pm vs. 15.28% all times, $p < .05$).

On weekend afternoons and evenings, drinkers were in proximity to alcohol outlets about twice as much as were non-drinkers (29.39% drinkers vs. 14.51% non-drinkers; Fig. 2). On weekday evenings,

drinkers were in proximity to outlets about one-and-a-half times as much as were non-drinkers (34.67% drinkers vs. 21.43% non-drinkers). However, these comparisons did not reach statistical significance.

Adolescents who used marijuana during the study period were in proximity to alcohol outlets more than twice as much on weekdays and weekends as compared to non-users (Weekdays: 27.65% users vs. 12.85% non-users; Weekends: 25.60% users vs. 11.32% non-users), although differences were not statistically significant.

Discussion

Proximity to alcohol outlets appears to vary according to days of the week and time of day for adolescents. As hypothesized, there is generally greater proximity in the afternoon and evening. When comparing drinkers to non-drinkers, there appears to be more difference on weekends and weekday evenings. Drinkers were in proximity to outlets 1½ to 2 times more on the weekends and 6–9 pm on weekdays, compared to their non-drinking counterparts. Drinkers had greater proximity during times when they may be more able to choose their environments. Marijuana users were in proximity to outlets about twice as much as their counterparts. Proximity to outlets may be related to more generalized patterns of deviance, given that marijuana users have consistently higher levels of proximity. Although we found several systematic patterns, the comparisons did not reach statistical significance, which may be due to the small sample size.

Limitations include the small sample size, which lowered power to detect significant relationships. The convenience sample also lowers generalizability. Selective mobility bias (Chaix et al., 2013) could also have influenced results, as adolescents who plan to engage in alcohol/marijuana use may seek out contexts with greater access to substances or less monitoring, and such areas may have more outlets.

These preliminary findings based on GPS technology show evidence of feasibility of the methods used. Findings suggest further examination is warranted, as there was variation in adolescents' proximity

6

to alcohol outlets. By providing more specific information about where adolescents spend time and their times of greatest proximity to contextual risk, this could inform adolescent prevention research by allowing for more accurate determinations of how environmental contexts influence adolescent health-related risk behaviors. Future studies should also delineate the temporal sequence of proximity to alcohol outlets and substance use, and explore mediators and moderators of these associations.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

References

Ahern, J., Margerison-Zilko, C., Hubbard, A., & Galea, S. (2013). Alcohol outlets and binge drinking in urban neighborhoods: the implications of nonlinearity for intervention and policy. American Journal of Public Health, 103(4), e81e87.

Basta, L. A., Richmond, T. S., & Wiebe, D. J. (2010). Neighborhoods, daily activities, and measuring health risks experienced in urban environments. Social Science and Medicine, 71(11), 1943e1950.

Bourdeau, B., Miller, B. A., Duke, M. R., & Ames, G. M. (2011). Parental strategies for knowledge of adolescents' friends: distinct from monitoring? Journal of Child and Family Studies, 20(6), 814e821.

Bronfenbrenner, U. (1979). The ecology of human development: experiments by nature and design. Cambridge, MA: Harvard University Press.

Bureau, U. C. (2013). 2013 American community survey. from http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid¼ACS_13_1YR_DP05 &prodType¼table.

Byrnes, H. F., Chen, M.-J., Miller, B. A., & Maguin, E. (2007). The relative importance of mothers' and youths' neighborhood perceptions for youth alcohol use and delinquency. Journal of Youth and Adolescence, 36, 649e659.

Byrnes, H. F., Miller, B. A., Chen, M. J., & Grube, J. W. (2011). The roles of mothers' neighborhood perceptions and specific monitoring strategies in youths' problem behavior. Journal of Youth and Adolescence, 40, 347e360.

Byrnes, H. F., Miller, B. A., Wiebe, D. J., Morrison, C. N., Remer, L. G., & Wiehe, S. E. (2015). Tracking adolescents with GPS-enabled cell phones to study contextual exposures and alcohol and marijuana use: a pilot study. Journal of Adolescent Health, 57(2), 245e247.

Chaix, B., Meline, J., Duncan, S., Merrien, C., Karusisi, N., Perchoux, C., et al. (2013). GPS tracking in neighborhood and health studies: a step forward for environmental exposure assessment, a step backward for causal inference? Health Place, 21, 46e51.

Furr-Holden, C. D., Lee, M. H., Milam, A. J., Johnson, R. M., Lee, K. S., & Ialongo, N. S. (2011). The growth of neighborhood disorder and marijuana use among urban adolescents: a case for policy and environmental interventions. J Stud Alcohol Drugs, 72(3), 371e379.

Gruenewald, P. J. (2007). The spatial ecology of alcohol problems: niche theory and assortative drinking. Addiction, 102(6), 870e878.

Kelley-Baker, T., & Voas, R. B. (2009). Lack of information from national surveys: What we still need to learn about transition teens. Paper presented at the Young Impaired Drivers: The Nature of the Problem and Possible Solutions, Woods Hole, MA.

Kwan, M.-P. (2012). The uncertain geographic context problem. Annals of the Association of American Geographers, 102(5), 958e968.

McCarthy, D. M., & Brown, S. A. (2004). Changes in alcohol involvement, cognitions and drinking and driving behavior for youth after they obtain a driver's license. Journal Of Studies On Alcohol, 65(3), 289e296.

Paschall, M. J., Grube, J. W., Black, C., & Ringwalt, C. L. (2007). Is commercial alcohol availability related to adolescent alcohol sources and alcohol use? Findings from a multi-level study. Journal of Adolescent Health, 41(2), 168e174.

Pasch, K. E., Hearst, M. O., Nelson, M. C., Forsyth, A., & Lytle, L. A. (2009). Alcohol outlets and youth alcohol use: exposure in suburban areas. Health and Place, 15(2), 642e646.

Reboussin, B. A., Song, E. Y., & Wolfson, M. (2011). The impact of alcohol outlet density on the geographic clustering of underage drinking behaviors within census tracts. Alcoholism: Clinical and Experimental Research, 35(8), 1541e1549.

Shaw, C. R., & McKay, H. D. (1942). Juvenile delinquency and urban areas. Chicago: The University of Chicago Press.

Sherman, J. E., Spencer, J., Preisser, J. S., Gesler, W. M., & Arcury, T. A. (2005). A suite of methods for representing activity space in a healthcare accessibility study. International Journal of Health Geography, 4, 24.

Treno, A. J., Ponicki, W. R., Remer, L. G., & Gruenewald, P. J. (2008). Alcohol outlets, youth drinking, and self-reported ease of access to alcohol: a constraints and opportunities approach. Alcoholism: Clinical and Experimental Research, 32(8), 1372e1379.

Voas, R. B., & Kelley-Baker, T. (2008). Licensing teenagers: nontraffic risks and benefits in the transition to driving status. Traffic Injury Prevention, 9(2), 88e97.

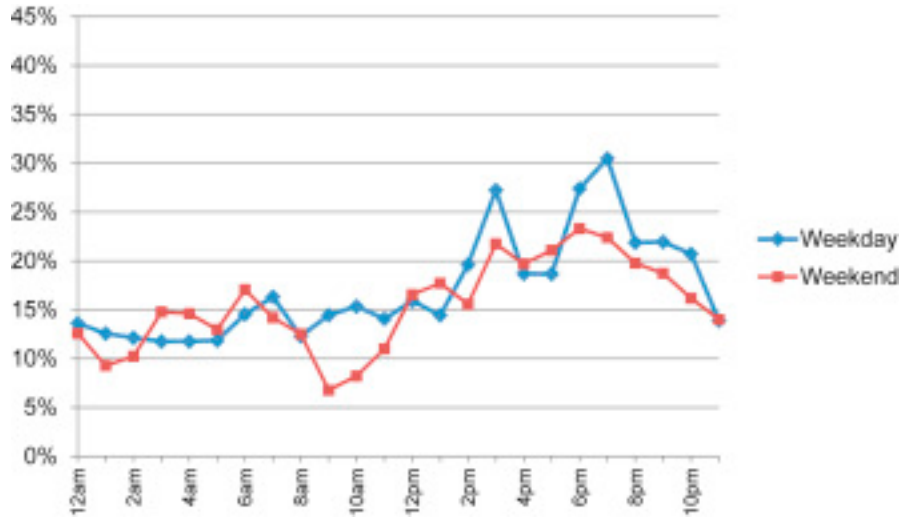Figure 1. Average percentage of time in proximity to an alcohol outlet.

Figure 2. a–d. Average percentage of time in proximity to alcohol outlets by substance use status