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Authors
Ahern, Jennifer
Balzer, Laura
Galea, Sandro

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The roles of outlet density and norms in alcohol use disorder

Jennifer Ahern[a,*], Laura Balzer[b], Sandro Galea[c]

[a] Division of Epidemiology, School of Public Health, University of California, Berkeley, 101 Haviland Hall, Berkeley, CA 94720-7358, USA
[b] Division of Biostatistics, School of Public Health, University of California, Berkeley, 101 Haviland Hall, Berkeley, CA 94720-7358, USA
[c] School of Public Health, Boston University, 715 Albany Street—Talbot 301, Boston, MA 02118, USA

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ABSTRACT

Background: Alcohol outlet density and norms shape alcohol consumption. However, due to analytic challenges we do not know: (a) if alcohol outlet density and norms also shape alcohol use disorder, and (b) whether they act in combination to shape disorder.
Methods: We applied a new targeted minimum loss-based estimator for rare outcomes (rTMLE) to a general population sample from New York City ($N = 4000$) to examine the separate and combined relations of neighborhood alcohol outlet density and norms around drunkenness with alcohol use disorder. Alcohol use disorder was assessed using the World Mental Health Comprehensive International Diagnostic Interview (WMH-CIDI) alcohol module. Confounders included demographic and socioeconomic characteristics, as well as history of drinking prior to residence in the current neighborhood.
Results: Alcohol use disorder prevalence was 1.78%. We found a marginal risk difference for alcohol outlet density of 0.88% (95% CI 0.00–1.77%), and for norms of 2.05% (95% CI 0.89–3.21%), adjusted for confounders. While each exposure had a substantial relation with alcohol use disorder, there was no evidence of additive interaction between the exposures.
Conclusions: Results indicate that the neighborhood environment shapes alcohol use disorder. Despite the lack of additive interaction, each exposure had a substantial relation with alcohol use disorder and our findings suggest that alteration of outlet density and norms together would likely be more effective than either one alone. Important next steps include development and testing of multi-component intervention approaches aiming to modify alcohol outlet density and norms toward reducing alcohol use disorder.

1. Introduction

A substantial body of research indicates that characteristics of the physical and social environment play a role in patterns of alcohol use (Becares et al., 2012; Campbell et al., 2009; Karriker-Jaffe, 2011; Lindstrom, 2008; Murayama et al., 2012; Popova et al., 2009; Renalds et al., 2010). Interventions informed by this work that target physical and social aspects of environments have been developed and shown to be efficacious (Campbell et al., 2009; Moreira et al., 2009). Alcohol outlet density and group norms around alcohol consumption are two of the features of the alcohol environment for which the best evidence exists.

Higher alcohol outlet density is related to more alcohol consumption and related harms. A recent systematic review of outlet density and hours and days of sale concluded that these aspects of alcohol access are related to drinking levels and drinking related harms (Popova et al., 2009). Interventions to reduce outlet density indicate some success; two studies have documented violence reductions following outlet density reduction and targeted outlet closures (Xu et al., 2012; Yu et al., 2008). A college based program that included alcohol access restrictions among a set of activities documented modest reductions in alcohol consumption and related problems (Weitzman et al., 2004).

Individual perceptions of norms have been consistently found to influence drinking behavior; in the college setting, individual web-based approaches to correct students' misperceptions of how peers drink have effectively reduced drinking related harms (Moreira et al., 2009). Research on group norms in workplace and community environments has found that norms against drinking and drunkenness are related to lower levels of those behaviors (Ahern et al., 2008; Barrientos-Gutierrez et al., 2007). Interventions that target norms at the group level through broad social marketing campaigns have documented success in reducing consumption among adolescents and college students (DeJong et al., 2006; Stead et al., 2007); for general adult populations there is less evidence, but

* Corresponding author. Tel.: +1 510 643 4350; fax: +1 510 643 5163.
E-mail addresses: jahern@berkeley.edu (J. Ahern), lbbalzer@berkeley.edu (L. Balzer), sgalea@bu.edu (S. Galea).

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some research suggests drinking related risks, such as drinking and driving, can be reduced with social marketing campaigns (Perkins et al., 2010).

It is important to understand of how aspects of environments in combinations may contribute to alcohol consumption because many interventions include multiple components and combined relations need to be understood to inform multi-component intervention designs. For example, outlet density and norms could have a strong positive interaction such that there is no effect on alcohol use unless both are targeted. In contrast, there could be negative interaction such that once outlet density or norms is altered, the other has no additional effect on alcohol use. This scenario would indicate that interventions could target outlets or norms, depending on which was more feasible. Two studies have examined alcohol outlet density or access together with aspects of drinking norms; in those studies both characteristics were related to alcohol use, but a possible combined relation or interaction was not examined (Paschall et al., 2012; Weitzman et al., 2003). We are aware of one study that has considered the relation of outlet density and norms in combination related to drinking behavior. A study of a social norms marketing campaign to reduce college drinking found that the effect of the campaign was modified by alcohol outlet density such that the intervention had an effect where density was low, but did not have an effect where density was high (Scribner et al., 2011). This suggests the positive interaction scenario above, with protection conferred by norms only when outlet density is low, but this question has not been examined in a general population sample.

Across research on how the physical and social environment relate to alcohol use, it is notable that the more severe potential consequences, such as alcohol use disorder, have not been frequently studied. This is, in part, because uncommon outcomes are challenging to analyze due to data sparsity (e.g., the number of outcome events is smaller than the number of confounder strata; Harrell et al., 1996; King and Zeng, 2001; Peduzzi et al., 1996). Recently, Balzer and colleagues proposed an extension of targeted minimum loss-based estimation (TMLE) to facilitate the examination of rare outcomes (Balzer and van der Laan, 2013; van der Laan and Rose, 2011). TMLE is a semi-parametric algorithm, incorporating machine learning methods with an additional targeting step to reduce bias. The rare outcomes TMLE (rTMLE) further incorporates an upper bound on the risk of the infrequent outcome.

In this paper, we examine the relation of neighborhood alcohol outlet density and norms around drunkenness with alcohol use disorder using the rare outcomes analysis approach rTMLE. We consider the possible combined relation of outlet density and norms with alcohol use disorder. Specifically, we estimate the marginal risk of alcohol use disorder under exposure and no exposure to high outlet density, permissive drunkenness norms, and combinations of these exposures. If assumptions for causality are met (elaborated in Section 4), these risks can be interpreted as the counterfactual risks of alcohol use disorder under different exposure conditions. We estimate all relations on the additive scale rather than the multiplicative scale, because it is more relevant to public health and more appropriate when considering combined relations or interaction (Greenland, 1993; Poole, 2010).

2. Materials and methods

New York Social Environment Study (NYSES) is a multilevel study designed to examine neighborhood level exposures, including economic, social and structural characteristics, and mental health and substance use in New York City (NYC). The NYSES was conducted in 2005; we used random-digit-dial methods to contact and interview 4000 NYC residents. Only land-line telephones were included due to rules prohibiting random-digit-dialing to cell phones at that time; only 5% of households were cell phone only in 2005 (Blumberg and Luke, 2011). One adult 18 years or older was interviewed by telephone in each household; the respondent was the person who either most recently or would next celebrate their birthday (randomly selected). Interviews were conducted in English or Spanish. The cooperation percentage was 54%. Respondents were offered $10 in compensation for their participation. Informed consent was obtained from all participants, and the study protocol was approved by the institutional review boards of the New York Academy of Medicine, the University of Michigan, and the University of California, Berkeley.

2.1. Neighborhoods

Respondents provided information about their residential address or nearest cross-streets so that their locations could be geocoded and linked to their neighborhoods of residence (Ahern et al., 2009). The neighborhood units were the 59 community districts in NYC. Community districts are recognizable neighborhood areas, each headed by an administrative community board, and many characteristics of these neighborhoods have been associated with aspects of health (see for example, Ahern and Galea, 2011; Ahern et al., 2008, 2009; Galea et al., 2007, 2005).

2.2. Measures

Respondents were interviewed with a structured questionnaire that included questions on demographic and socioeconomic characteristics that were confounders of the relation of interest including age, race/ethnicity, gender, marital status, place of birth, interview language, education, income, employment status, and years lived in the current neighborhood. Details on the confounders can be found in Table 1.

Neighborhood drinking norms were measured using questions modified from the National Survey on Drug Use and Health (Ahern et al., 2008; NSDUH, 2008). Respondents were asked their opinion about adults getting drunk at least once a week, and given the response options of "acceptable", "unacceptable" and "don't care". The neighborhood measures were the proportions of residents who believed it was "unacceptable" for adults to get drunk at least once a week in each neighborhood. For analysis, norms were dichotomized at the median as more permissive (exposed) and less permissive (unexposed); this avoided analysis challenges we would have faced with positivity violations (Petersen et al., 2012).

Alcohol license data were acquired from the New York State Division of Alcoholic Beverage Control/State Liquor Authority using the online public license query. We calculated the number of off-premise active liquor licenses per neighborhood; these are licenses that permit only the retail sale of alcoholic beverages directly to consumers for their consumption (i.e., alcoholic beverages may not be sold for resale). Alcoholic beverages cannot be consumed on the premises of establishments holding these licenses, nor are any open containers of alcoholic beverages allowed on the premises. License type abbreviations included in this category are: A, AX, C, DS, DX, E, L, ST, W, and AW (class 122). Density of alcohol outlets was calculated as outlets per square mile. For analysis, the density was dichotomized as above the median (exposed) or below the median (unexposed).

Drinking behavior was assessed using the World Mental Health Comprehensive International Diagnostic Interview (WMH-CIDI) alcohol module (Kessler et al., 2004; Kessler and Ustun, 2004). The outcome for this analysis was symptoms consistent with alcohol

Table 1
New York Social Environment Study characteristics and bivariable associations with alcohol use disorder.

	Alcohol use disorder				p-Value[a]
	N	%	N	%	
Total	4000	100.00	71	1.78	
Age					
18–24	350	8.84	17	4.86	<0.01
25–34	685	17.30	21	3.07	
35–44	815	20.58	13	1.60	
45–54	808	20.40	15	1.86	
55–64	612	15.45	5	0.82	
≥65	690	17.42	0	0.00	
Race/ethnicity					
White	1616	41.56	30	1.86	0.38
African American	1055	27.13	17	1.61	
Asian	164	4.22	6	3.66	
Hispanic	958	24.64	18	1.88	
Other	95	2.44	0	0.00	
Gender					
Male	1880	47.00	48	2.55	<0.01
Female	2120	53.00	23	1.08	
Marital status					
Married	1632	41.39	16	0.98	<0.01
Divorced	479	12.15	7	1.46	
Separated	208	5.28	8	3.85	
Widowed	354	8.98	2	0.57	
Never married	1270	32.21	38	2.99	
Birth place					
NYC	1810	45.86	32	1.77	0.45
Other US location	731	18.52	17	2.33	
Different country	1406	35.62	22	1.56	
Interview language					
English	3545	88.63	67	1.89	0.13
Spanish	455	11.38	4	0.88	
Education					
Less than high school	508	12.95	6	1.18	0.67
High school/GED	923	23.53	16	1.73	
Some college	879	22.41	15	1.71	
College graduate	883	22.51	17	1.93	
Graduate work	730	18.61	17	2.33	
Income					
≤$40,000	1605	40.13	31	1.93	0.14
$40,001–$80,000	1093	27.33	23	2.10	
>$80,000	722	18.05	14	1.94	
Missing	580	14.50	3	0.52	
Unemployed					
No	3679	91.98	63	1.71	0.31
Yes	321	8.03	8	2.49	
Years lived in neighborhood					
<8 yr	1330	33.39	44	3.31	<0.01
8–21 yr	1318	33.09	22	1.67	
>21 yr	1335	33.52	5	0.37	
Drinking before moved to neighborhood					
Ever drank/tried drinking	706	17.65	3	0.42	<0.01
Monthly drinker	1948	48.70	55	2.82	
Never drank	1346	33.65	13	0.97	
Neighborhood alcohol outlet density					
Low	2080	52.00	26	1.25	0.01
High	1920	48.00	45	2.34	
Neighborhood drunkenness norms					
Restrictive	1979	49.48	25	1.26	0.02
Permissive	2021	50.53	46	2.28	

[a] Chi-square p-value comparing alcohol use disorder by covariate categories.

use disorder, assessed using the DSM-V criteria within the past 12 months. This is a combination of the previously distinct alcohol abuse and dependence classification, consistent with the DSM-V in which these are grouped in one diagnosis (Hagman and Cohn, 2011). The WMH-CIDI alcohol measures that include a retrospectively recalled history of alcohol use were used to capture the history of drinking prior to residence in the current neighborhood.

2.3. Analysis

For our primary analysis, we applied a targeted minimum loss-based estimation (TMLE) approach designed for examination of rare outcomes, known as rTMLE (Balzer and van der Laan, 2013; van der Laan and Rose, 2011). In general, TMLE is a semi-parametric substitution estimator that involves estimation of the average outcome conditional on exposure and covariates (i.e., the outcome regression) as well as the probability of being exposed, conditional on the covariates (i.e., the exposure mechanism or the propensity score). Both the outcome regression and exposure mechanism were estimated using SuperLearner, a machine-learning approach, which avoids the potential bias inherent in assuming a parametric form for the relations amongst variables (Sinisi et al., 2006; van der Laan et al., 2007). In particular, SuperLearner uses cross-validation to create the best combination of algorithm specific estimates from a library of algorithms. In this application, the library for outcome regression included the unadjusted mean, stepwise logistic regression, all logistic regressions with a single main term, and all logistic regressions with a main term for the exposure and one additional covariate. The library for the exposure mechanism included all logistic regressions with a single main term as well as stepwise logistic regression with and without interactions. These routines were selected for interpretability and to avoid instability due to data sparsity. Analyses were adjusted for demographic and socioeconomic characteristics as well as history of drinking prior to residence in the current neighborhood (confounders are listed in Table 1).

In TMLE, the initial estimator of the outcome regression is modified to reduce bias for the parameter of interest and to ensure valid inference. This modification augments the initial outcome regression with information in the estimated exposure mechanism. rTMLE further incorporates bounds on the conditional risk of the rare outcome within exposure-covariate strata (code is available from the authors upon request). In this application, the lower bound was set to the natural limit of 0 and the upper bound of 10% was selected with cross-validation from the set of possible upper bounds (2.5%, 5%, 7.5%, 10%, 12.5%). Results based on upper bounds at 7.5% and 12.5% yielded equivalent results.

Overall, we estimated the marginal risk of alcohol use disorder under exposure and no exposure to high outlet density, and under exposure and no exposure to permissive drunkenness norms, controlling for individual covariates. We then estimated the risk of alcohol use disorder under the four combinations of these exposures, analogous to joint or simultaneous intervention on these two neighborhood characteristics, controlling individual covariates. Estimates were compared on the absolute scale (i.e. marginal risk differences). Confidence intervals were based on the estimated influence curve, with clustering by neighborhood (Schnitzer et al., 2014).

In recent years, a variety of methods have been developed that allow the scientific question to define the parameter of interest, in our case the marginal risk difference, rather than having the analysis approach define the parameter of interest (e.g., if logistic regression is utilized, the parameter estimated is the conditional odds ratio). For the purposes of comparison, we estimated the same relations using the other estimators that allow this flexibility, including the standard TMLE algorithm (van der Laan and Rose, 2011), inverse probability of treatment weighting (IPTW) and augmented-IPTW (A-IPTW; Hernan et al., 2000; Robins, 1999; van der Laan and Robins, 2003). The latter algorithms are based on solving an estimating equation and are thereby not substitution estimators.

3. Results

Study participants were demographically similar to the overall population of New York City based on the 2000 census, with 41.6% White, 27.1% African American, 4.2% Asian, 24.6% Hispanic, and 2.4% of other racial groups. Mean age was 47 years (range 18–94), 53.0% of respondents were female, and 35.6% were born outside the United States. As expected, alcohol use disorder was uncommon; the past 12 months prevalence was 1.78%. A full description of the sample, and bivariable associations of covariates with alcohol use disorder are provided in Table 1. Outlet density ranged from 9.8 to 132.1 outlets per square mile, with a median of 58.3. The proportions of residents who believed it was "unacceptable" for adults to get drunk at least once a week in each neighborhood ranged from 53% to 89% with a median of 80%.

Based on our analysis with rTMLE, the marginal estimated risk of alcohol use disorder under high alcohol outlet density in all neighborhoods was 2.20%, and under low outlet density it was 1.32%. The marginal difference in the risk of alcohol use disorder associated with high alcohol outlet density in all neighborhoods compared with low density in all neighborhoods was 0.88% (95% CI 0.00–1.77%—the lower confidence limit does not cross the null, the p-value is less than 0.05), adjusted for confounders.

In examination of alcohol norms, the marginal estimated risk of alcohol use disorder under permissive norms in all neighborhoods was 3.15%, and under restrictive norms it was 1.10%; this translated to a marginal risk difference of 2.05% in alcohol use disorder associated with permissive norms compared with restrictive norms (95% CI 0.89–3.21%), adjusted for confounders.

When considering the combined relation of outlet density and norms, we found that under conditions of low outlet density and restrictive norms the estimated risk of alcohol use disorder was 0.70%—this was the estimated baseline level of the outcome in the absence of either exposure. Under permissive norms, leaving outlet density low, the estimated risk of alcohol use disorder was 2.55%; thus we estimated a marginal risk difference of 1.85% from a change in norms in the absence of high outlet density (the difference between 2.55% and 0.70%). Under high outlet density, leaving norms restrictive, the estimated risk of alcohol use disorder was 1.49%; this indicated an estimated marginal risk difference of 0.79% for a change in outlet density in the absence of permissive norms (the difference between 1.49% and 0.70%). Based on these values, we calculated the expected value of alcohol use disorder in the absence of additive interaction between norms and outlets. The expected value was the baseline level, plus the relation for each exposure in the absence of the other: 0.70% + 1.85% + 0.79% = 3.34% (Rothman et al., 2008). The estimated risk of alcohol use disorder under conditions of permissive norms and high outlet density was 3.43%, only slightly higher than that expected in the absence of interaction (p-value for the difference from the expected value = 0.22). This indicated that there was no additive interaction between outlet density and norms in relation to alcohol use disorder.

Analysis results from TMLE, IPTW, and A-IPTW were similar to those from rTMLE, with estimates of the marginal risk difference for outlet density between 0.87% and 1.00%, for norms between 2.01% and 2.10%. Differences between the expected risks in the absence of interaction and estimated risks under both exposures were smaller, there was no significant additive interaction between outlets and norms in relation to alcohol use disorder (see Supplementary material for full results[1]).

4. Discussion

Among a general population sample of adults in New York City, we found that both higher alcohol outlet density and permissive norms around drunkenness had substantial and statistically significant relations with alcohol use disorder, with a stronger relation for norms. We did not find evidence of additive interaction between the two neighborhood characteristics in relation to alcohol use disorder.

The findings on outlets and norms are consistent with past research that indicates these exposures are related to alcohol use and alcohol related harms, and add to that research by providing evidence that these exposures also shape alcohol use disorders (Ahern et al., 2008; Barrientos-Gutierrez et al., 2007; Popova et al., 2009). This suggests that the environment plays a role in both behaviors and in clinical outcomes, and thus effective intervention with the environment has the potential to reduce the need for treatment in the population.

There are several limitations to this study. The cooperation percentage was 54%, which is consistent with many other recent telephone based studies (Galea and Tracy, 2007). However, this cooperation percentage does raise concern about how well the study sample represents the city of New York. Participants were informed that they would be participating in a "survey about the neighborhoods where New Yorkers live and what people think about their neighborhoods", and thus they were not likely to refuse based on their alcohol use. Rules prohibited random-digit-dialing to cell phones in 2005, and thus we were unable to contact the 5% of households that were cell phone only at that time (Blumberg and Luke, 2011). The distribution of demographic characteristics such as age, race, and sex is very similar to the 2000 Census data for NYC. However, the individuals we were able to reach and who agreed to participate may still differ from those in the City overall in ways that we were unable to capture. Furthermore, the survey was only administered in English and Spanish due to cost constraints, and thus individuals who could not respond in one of these languages are not represented. Self-report is standard practice in alcohol research and telephone interviews are thought to elicit more accurate reports than in-person interviews (Midanik et al., 2001); however, there may be differences between a clinical diagnosis of alcohol use disorder and our assessment of symptoms consistent with alcohol use disorder. This study examines only off-premises alcohol outlet density. It was not possible to distinguish restaurants from bars in the on-premises data, and thus relations of this heterogeneous group of establishments with alcohol use disorder would have been difficult to interpret. Finally, we were not able to examine whether outlets and norms influence each other because we lacked time varying data on these exposures and alcohol use disorder; this is an important avenue for future research.

Among several strengths, this study included a large population based sample. Social selection has been considered one of the major barriers to determining whether the environment has an influence on people, or whether people who have worse health are unable to leave or move into worse types of environments (Oakes, 2004; Sampson, 2003). We accounted for one potential contributor to social selection by adjusting for history of drinking prior to each person's residence in his/her current neighborhood. Associations observed were not due to an effect of people with certain drinking histories being likely to move to high alcohol outlet density or permissive drunkenness norm neighborhoods. Our application of a rare outcomes analysis approach, rTMLE, facilitated examination of alcohol use disorder despite its infrequent occurrence. Estimates from this new method were similar to those from the TMLE algorithm, IPTW and A-IPTW. Theoretical and finite sample simulations, however, suggest that the rTMLE algorithm is more robust and provides more power estimate associations with rare outcomes (Balzer and van der Laan, 2013). We thus focused on rTMLE results in our discussion.

The estimated associations of alcohol outlet density and drunkenness norms with alcohol use disorder do not necessarily represent how alcohol use disorder might change following a policy or intervention that reduces one or both of these exposures (Kaufman, 2007; Oakes, 2004; Sampson, 2003). The assumptions necessary for causal interpretation of associations in observational research generally and observational neighborhood research specifically have been well elaborated elsewhere (van der Laan and Robins, 2003; Vanderweele, 2008). In brief, exposure must precede the outcome (temporal ordering), all confounders must be controlled (ignorability), outcomes in one neighborhood under a given exposure value cannot be affected by the exposures in another neighborhood (neighborhood-level stable unit treatment value assumption), and the outcomes observed for a given exposure value must reflect those that would have been observed if the exposure had been counterfactually assigned to that value (consistency assumption). Given the cross-sectional design of our study, we cannot establish temporal ordering between the exposure and outcome. Longitudinal consideration of these relations will be necessary to establish that temporal relation and improve the potential for causal interpretation. While we controlled many confounders, notably including history of drinking prior to residence in the current neighborhood, ignorability cannot be assessed empirically and can only ever be approximated with observational data. In the analyses of outlet density and norms separately, we also have to assume the exposures are independent of each other, conditional on the confounders; analyses relaxing this assumption yielded similar results. The stability assumption may be violated since the outlet density or norms in one area could affect outcomes in another area, particularly near the borders of neighborhoods.

Our findings support frameworks that consider different elements of the context in which behaviors such as drinking take place, and emphasize the importance of considering these in combinations for intervention (Cohen et al., 2000; Wechsler and Nelson, 2008). Despite the lack of additive interaction between outlet density and norms in relation to alcohol use disorder, each exposure had a substantial relation with alcohol use disorder. Our results indicate that alteration of both aspects of the context would likely result in a larger reduction in alcohol use disorder than either one alone. Of course, there are substantial challenges in translating this research into intervention. While social norms marketing approaches are well developed for the college setting, they are less developed for general populations (DeJong et al., 2006; Perkins et al., 2010; Stead et al., 2007). Although there are some models for reducing outlet density, it can be done in a variety of ways, such as targeting problematic outlets, or waiting for attrition of businesses, and these may have distinct effects on outcomes. Access can also be altered by modifying pricing or hours and days of sale without outlet closures (Popova et al., 2009). Important next steps include development and testing of multi-component environment intervention approaches for general populations, building on what has been learned from intervention in college and other settings (DeJong et al., 2006; Moreira et al., 2009; Perkins et al., 2010; Stead et al., 2007; Wechsler and Nelson, 2008; Weitzman et al., 2004; Xu et al., 2012; Yu et al., 2008).

[1] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:10.1016/j.drugalcdep.2015.03.014.

Author disclosures

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The funder had no role: in the study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

Contributors

JA collaborated on the design and implementation of the study, conceptualized the analysis, conducted the literature review, and wrote the article. LB developed the analysis approach, implemented the analysis, and substantially edited all sections of the article. SG obtained study funding, collaborated on the design and implementation of the study, and substantially edited all sections of the article. All authors have approved the final article.

Conflict of interest

No conflict declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.drugalcdep.2015.03.014.

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