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Utility of digital Respondent Driven Sampling to recruit community-dwelling emerging adults for assessment of drinking and related risks

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HIGHLIGHTS

- Efficacious alcohol interventions with college drinkers are well established.
- Emerging adult (EA) risky drinkers in communities are harder to reach.
- Peer-driven Respondent Driven Sampling was adapted to a digital platform (d-RDS).
- d-RDS recruited EAs at risk on drinking practices and alcohol-related consequences.
- d-RDS offers a tool to extend alcohol interventions to this underserved risk group.

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ABSTRACT

Introduction: Emerging adulthood often entails heightened risk-taking, including risky drinking, and research is needed to guide intervention development and delivery. This study adapted Respondent Driven Sampling, a peer-driven recruitment method, to a digital platform (d-RDS) and evaluated its utility to recruit community-dwelling emerging adult (EA) risky drinkers, who are under-served and more difficult to reach for assessment and intervention than their college student peers.

Materials and methods: Community-dwelling EA risky drinkers ($N = 357$) were recruited using d-RDS (M age = 23.6 years, 64.0% women). Peers recruited peers in an iterative fashion. Participants completed a web-based cross-sectional survey of drinking practices and problems and associated risk and protective factors.

Results: d-RDS successfully recruited EA risky drinkers. On average, the sample reported recent drinking exceeding low-risk drinking guidelines and 8.80 negative consequences in the past three months. Compared to age-matched respondents from the representative U.S. National Survey on Drug Use and Health, the sample reported more past month drinking days and more drinks consumed per drinking day ($ps < 0.001$). At higher consumption levels, predicted positive associations were found with lower education and receipt of public assistance.

Conclusions: Results supported the utility of d-RDS as a sampling method and grassroots platform for research and intervention with community-dwelling EA drinkers who are harder to reach than traditional college students. The study provides a method and lays an empirical foundation for extending efficacious alcohol brief interventions with college drinkers to this underserved population.

1. Introduction

Emerging adulthood spans adolescence to young adulthood and is a critical period for positive growth and development, but it is often accompanied by risk-taking behaviors (Arnett, 2007), including risky substance use. Compared to other age groups, emerging adults (EAs) have higher rates of past-month alcohol binge drinking (34.9%; Substance Abuse and Mental Health Services Administration, 2019),

which peaks by around age 25 and then declines slowly with continued elevated risk until the mid-30s (Lee & Sher, 2018; Chen, Dufour, & Yi, 2004). Thus, the 20s are generally when risky drinking peaks and then either resolves or consolidates into a chronic adult alcohol use disorder (AUD), making this a crucial age group for prevention-oriented interventions.

In-person and online social networks, especially peer relationships, are dominant influences on EA substance misuse (Cook, Bauermeister,

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Gordon-Messer, & Zimmerman, 2013; Hahm, Kolaczyk, Jang, Sweson, & Bhindarwala, 2012) and are key targets for prevention-oriented research and intervention (e.g., Valente et al., 2007). However, most preventive interventions for substance misuse have been school-based with limited reach into the broader population and social networks of young adults. For example, alcohol brief interventions for traditional college students are well-established (NIAAA, 2019a), but the needs of young adults in the community who do not attend college or work while doing so are poorly understood. They tend to come from less advantaged backgrounds and to have distinct and heightened risk profiles that are not well researched (Slutske, 2005; White, Labouvie, & Papadaratsakis, 2005) and are relevant to developing and disseminating interventions to this underserved risk group.

The dearth of substance-related research and intervention with community-dwelling EAs is partly due to difficulties locating and recruiting them compared to relatively captive traditional college students who live on campus. Chain referral strategies such as snowball sampling have been used, but the non-random recruitment may bias resulting samples and limit inferences about the role of social networks in substance misuse. Respondent Driven Sampling (RDS) is an improved chain referral method that reduces sampling biases through statistical weighting procedures while maintaining the benefits of peer-driven access to hard-to-reach groups (Heckathorn, 1997, 2007; Gile & Handcock, 2010). Originally developed to recruit community-dwelling individuals engaged in very high risk, stigmatizing behaviors such as injection drug use, sex work, and risky sex (e.g., Iguchi et al., 2009; Ramirez-Valles, Garcia, Campbell, Diaz, & Heckathorn, 2008), RDS has been extended to recruit subgroups with above average risk factors at the group level based on demographics, geography, and behaviors such as substance use (e.g., Cheong, Tucker, Simpson, & Chandler, 2014; Tucker, Cheong, Chandler, Crawford, & Simpson, 2015) and sexual practices (Davies et al., 2014).

In addition, a limited number of studies have adapted RDS from in-person peer-to-peer recruitment to online platforms (e.g., Bauermeister et al., 2012; Bengtsson et al., 2012; Wejnert & Heckathorn, 2008; Zhang et al., 2017). Although promising for broadening the utility of RDS and providing an online intervention dissemination channel through peer networks (Tucker, Cheong, & Chandler, 2020), particularly among younger people who are digital natives, more research and development are needed concerning feasibility and implementation of online RDS with risky EA drinkers.

Therefore, we investigated the feasibility of implementing digital RDS (d-RDS) to recruit community-dwelling EA drinkers who were not traditional college students for assessment of drinking practices, problems, and associated risk and protective factors. The utility of the application was evaluated in three ways: First, RDS sample chain development was evaluated for recruitment bias and analytic assumptions (Heckathorn, 1997, 2007; Gile & Handcock, 2010). Second, following from common population patterns, drinking-related risks were evaluated as a function of sex and socio-economic status (SES) to assess whether males had higher risks than females (Nolen-Hoeksema, 2004) and whether relative disadvantage was associated with higher risks (Collins, 2016). Third, the RDS-generated sample was compared with age-matched respondents from the representative U.S. National Survey of Drug Use and Health (NSDUH; Substance Abuse and Mental Health Administration [SAMSHA], 2019) to determine whether our recruitment criteria and procedures yielded the desired sample. Successful results would support d-RDS as a viable recruitment method for this underserved population and facilitate expansion of dissemination of alcohol brief interventions from fulltime college students to community-dwelling EAs.

2. Materials and method

2.1. Sample recruitment and characteristics

The study received university Institutional Review Board approval and was conducted in line with STROBE (von Elm et al., 2007) and

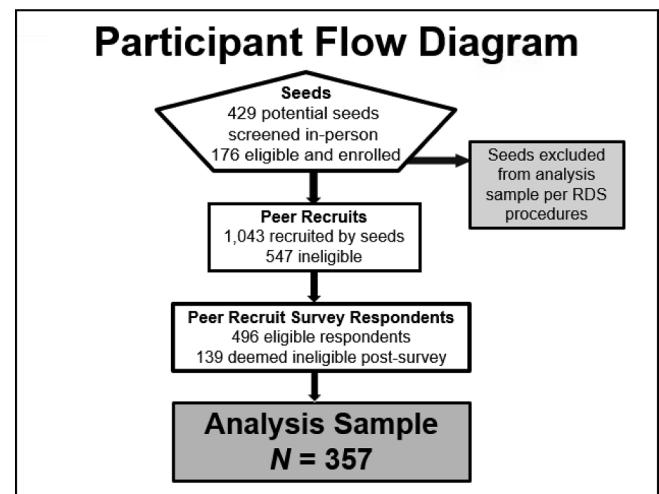


Fig. 1. Flow diagram summarizing each stage of Respondent Driven Sampling including seed recruitment, peer recruitment, and determination of the final analysis sample.

STROBE-RDS (White et al., 2015) guidelines for observational studies. “Seeds” to start RDS were recruited over 20 months (April 2018 to November 2019) by research staff similar in age to the target sample. The in-person recruitment served to verify that RDS was initiated by EAs from the desired target group. Eligibility criteria were: (1) Men and women ages 21–29 living in Florida at enrollment; (2) > 1 heavy drinking day in the past month (4+/5+ drinks for women/men; NIAAA, 2019b) and > 1 alcohol-related negative consequences in the past 90 days; and (3) web access via smartphone or computer. Although emerging adulthood is often defined as ages 18–25 (e.g., Arnett, 2007), we focused on the twenties because this is a dynamic developmental period for drinking-related risks and risk reduction (Lee & Sher, 2018).

Fig. 1 shows the RDS process from seed recruitment to determination of the final analysis sample, which included 176 seeds and 357 peer recruits. Seeds directly recruited 95 peers, who in turn recruited 262 peers. Overall, 1547 coupons were issued to seeds and peers, and 357 were redeemed by successfully enrolled peers. Enrollment was limited to a maximum of three peers from a given seed or peer recruiter to ensure network branching and prevent over-recruitment from any one subgroup. Recruitment chains were allowed to develop naturally to facilitate independence of characteristics between seeds and recruits (Gile & Handcock, 2010). Mean chain length among those with at least one recruit was 2.33 ($SD = 2.31$, range = 1 to 12). Reasons for exclusion were low risk drinking (29.61%); age out of range (3.62%); duplicate enrollment attempt (11.08%); insufficient/missing responses needed to verify eligibility (35.04%) or to provide study compensation (16.72%); and non-Florida resident (3.94%). Seeds and recruits received \$30 for their initial assessment and \$15 for each enrolled peer they recruited up to 3 (maximum compensation = \$75). Compensation was delivered using electronically reloadable Visa™ gift cards.

Table 1 presents the peer recruit characteristics. The sample as a whole was in their lower mid-twenties, most were educated beyond high school and were employed full or part-time, but over half had annual personal incomes < \$20,000. Less than 20% were married, and less than 10% were parents. As in our past in-person RDS research (e.g., Tucker et al., 2016), more women enrolled than men. Seeds and peer recruits had similar drinking practices, social network characteristics, employment status, and parental status, although recruits reported more alcohol-related consequences (8.79 vs. 5.98; $p < .01$).

2.2. Seed procedures

“Seeds” to start RDS were recruited in person by study staff at high

Table 1
Sample Characteristics of Peer Recruits.

Variable	Frequency (%) / Mean (SD)
<i>Demographic characteristics</i>	
Age in years	23.64 (2.60)
Gender (% women)	228 (64.04)
Asian	68 (19.21)
Black	23 (6.50)
White	228 (64.41)
Other ^a	35 (9.89)
Hispanic	61 (17.18)
Education > high school	307 (86.72)
Student (full or part-time)	229 (64.15)
Employed (full or part-time)	275 (77.46)
Personal annual income < \$20 k	183 (53.35)
Married	26 (7.28)
Have children	22 (6.16)
<i>Drinking risk variables</i>	
Number of past month drinking days	9.93 (5.77)
% with typical past-month drinking exceeding high risk drinking thresholds ^b	167 (46.91)
% with typical past-month drinking exceeding very high risk drinking thresholds ^c	27 (7.58)
Drinks consumed per drinking day (past month)	4.71 (4.76)
Drinks consumed on high risk drinking days ^b	7.03 (6.14)
Drinks consumed on very high risk drinking days ^c	17.00 (10.96)
<i>Alcohol-related negative consequences (BYAACQ)</i>	
BYAACQ total consequences (mean, SD)	8.80 (5.86)
Hangovers (frequency, %)	299 (83.75)
Less energy/tired	262 (73.39)
Very sick stomach/vomiting	233 (65.27)
Drank despite plans not to	213 (59.66)
Engaged in regrettable impulsive behavior while drinking	174 (48.74)
Blackouts/brownouts	127 (35.56)
Tolerance	125 (35.01)
<i>Social network characteristics</i>	
Size of young adult online network (# members)	27.32 (51.79)
Productive peer recruiters (> 1 recruit)	153 (42.86)

N = 357 ^aIncludes American Indian/Alaska Native (0.6%), Native Hawaiian/Other Pacific Islander (1.1%), and more than one race (5.4%); 3 additional participants indicated "I choose not to answer." ^b4+/5+ drinks for women/men for 141 participants (39.61%) who reported any high risk drinking. ^c8+/10+ drinks for women/men for 27 participants (7.58%) who reported any very high risk drinking. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire (past 3 months). Table reports BYAACQ total consequences (maximum = 24) and individual consequences reported by about half of the sample or more plus two serious consequences reported by about one-third. All variables were calculated using the unweighted data set.

traffic community venues (e.g., outdoor markets, sporting events, art and music festivals) in north central Florida. After initial contact, all procedures were completed online in the presence of study staff using a study computer tablet or the participant's personal electronic device. Data were collected and managed using Research Electronic Data Capture (REDCap), a secure web application for online survey databases accessible by smartphone or computer and maintained by the University of Florida Clinical and Translational Science Institute (Harris et al., 2009). The REDCap application presented video and text material, including study description, informed consent for screening, and questions that assessed the eligibility criteria. A female EA staff member was the actor in the video material. If eligible, participants completed additional questions about their demographic characteristics, drinking patterns, and young adults aged 21–29 in their social networks, including those with whom they had interacted online during the past 3 months. Seeds were not administered the longer survey completed by peer recruits.

Seeds were then asked to enter a personal code other than their name or personal identifier and click a link that directed them to a

separate questionnaire to provide information necessary for compensation, including a physical address to mail them a Visa™ card. The questionnaire included video instructions by the same female EA actor about recruitment compensation and how to recruit up to 3 peers like themselves who were not relatives using 3 unique codes that potential peer recruits could use to access the web-based screening and, if eligible, enroll. Specific drinking risk eligibility criteria were not disclosed to avoid creating demand characteristics or potential deceptive responding. Each recruitment code was valid for two weeks and could be used only once. Recruiters were not informed which referrals were enrolled. These features helped safeguard freedom of choice to participate, minimized undue pressure from recruiters to enroll, and protected confidentiality. The unique codes allowed tracking of network chain development and sample characteristics using the RDS Coupon Manager (<http://www.respondentdrivensampling.org>).

Finally, seeds re-entered their code word to verify participation. If code words matched, the study coordinator mailed their Visa™ card and sent their 3 unique codes for peer recruitment by text or email. Those who did not choose a code word, failed to provide it, or gave the wrong word were removed from the sample.

2.3. Peer recruit procedures

Peer recruitment and data collection were conducted entirely by digital means using standard RDS procedures adapted to a digital platform (e.g., Bauermeister et al., 2012; Zhang et al., 2017). Recruits completed online informed consent and screening procedures via REDCap using the same materials and videos presented to seeds. Those who met study eligibility criteria were administered a longer survey that averaged 30.69 min to complete (*SD* = 18.71). Upon completion, the remaining peer procedures were identical to the seed procedures for obtaining information for compensation, providing 3 unique referral codes for peer recruitment, and video and text instructions about how to recruit peers. Digital peer-to-peer recruitment then continued in an iterative fashion until the desired sample was obtained. Chain development was checked regularly to identify duplicate or fake enrollment attempts, which were uncommon, and to verify that peer recruits met eligibility criteria. The peer sample size was powered (> 0.80) to detect small-to-medium effects, taking into account that RDS sample size requirements are up to 4 times as large as those needed for random sampling due to non-random recruitment (Heckathorn, 1997, 2007; Wejnert, Pham, Krishna, Le, & DeNinno, 2012).

2.4. Drinking risk measures

This report focuses on measures of drinking practices and problems as described below. Other measures (e.g., alcohol reinforcement value; social network drinking-related feedback) will be reported elsewhere. Initial questions asked for brief information about participants' substance use histories (e.g., age of first intoxication; substance-related help-seeking) followed by the primary measures of recent drinking practices and consequences. An abbreviated Daily Drinking Questionnaire-Revised (DDQ-R; Collins, Parks, & Marlatt, 1985; cf. Leeman et al., 2016) assessed the number of drinking days and typical number of standard drinks consumed per drinking day during the past 30 days. The scale is widely used with young adults and yields reliable drinking reports that are highly correlated with self-monitoring reports of alcohol consumption (Kivlahan, Marlatt, Fromme, Coppel, & Williams, 1990). The Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ; Kahler, Strong, & Read, 2005) assessed 24 negative consequences in the past 3 months, which were summed for analysis. The BYAACQ has high internal consistency (Cronbach's α = 0.90), is reliable yet sensitive to changes in alcohol use, and assesses common but less severe consequences (Kahler et al., 2005, 2008).

2.5. Data analysis plan

Following standard RDS analysis procedures (Gile, Johnston, & Salganik, 2015), the analysis sample excluded seeds who were purposively selected to start RDS and did not complete the survey. The analysis sample of peer recruits was examined for analytic assumptions and recruitment bias using RDSAT 7.1 (www.respondentdrivensampling.org) (Heckathorn, 1997, 2007; Salganik & Heckathorn, 2004). Age, sex, race/ethnicity, and past month drinking days were checked for potential non-random recruitment (homophily), which can range from -1.0 (group members not recruiting any fellow group members) to 1.0 (group members recruiting exclusively from their own group). Age, sex, and past month drinking days evidenced no homophily. Homophily for race/ethnicity (Whites, Asians, other) indicated a moderate bias in favor of Asian participants recruiting among themselves (0.665), but it was below levels at which weighting is considered necessary (Schonlau, & Liebau, 2012). As recommended (Johnston & Sabin, 2010), a weighting variable based on the reciprocal of participants' peer online social network size was created using the Volz and Heckathorn (2008) RDSII estimator (http://wiki.stat.ucla.edu/hpmpg/index.php/RDS_Analyst_Install) and applied in analyses evaluating hypothesized associations between behavioral economic and drinking risk indicators, as reported elsewhere (Tucker, Lindstrom et al., 2020).

Hypothesized associations among drinking risk, sex, and SES indicators were examined using SAS® software, version 9.4. Drinking risk was examined using past-month drinking days, drinks per drinking day, and BYAACQ scores, and a binary variable reflecting whether reports of typical past-month drinking exceeded high risk drinking thresholds ($4+/5+$ drinks for women/men). SES indicators included household income above or below the federal poverty line, employment status (fulltime or not), education (some post-high school education or high school/GED or less), and receipt of public assistance (yes/no). Directional hypotheses for sex and SES indicators were evaluated using *t*-tests or ANOVAs for continuous variables and Fisher's Exact Test for categorical variables.

The d-RDS sample was compared with respondents from the representative 2018 NSDUH (SAMHSA, 2019) selected on age (21–29) and response items to match the samples as closely as possible. The NSDUH comparison sample included all drinkers and excluded abstainers to evaluate whether we successfully recruited a higher risk sample of drinkers. Z-tests examined potential prevalence differences between the study and NSDUH samples.

3. Results

As shown in Table 1, d-RDS successfully recruited community-dwelling EA risky drinkers. On average, participants reported drinking about a third of days during the past month, typically consuming quantities per drinking day above low-risk drinking thresholds ($< 3/4$ drinks for women/men), and experiencing more than eight negative consequences in the past three months. The table shows the five individual consequences reported by about half of the sample or more (e.g., hangovers, very sick stomach/vomiting), as well as two consequences reflecting more serious consequences typically seen in clinical samples (tolerance, blackouts/brownouts).

No significant differences were found as a function of sex or SES based on continuous measures of drinking risk, whereas limited support for directional predictions was found for two SES indicators based on whether participants' typical past month drinking exceeded gender-adjusted high risk drinking thresholds. Consistent with predictions, typical high risk drinking was more common among participants living in households receiving public assistance (62.86% vs. 37.14%; $p < .042$) and among those with education less than or equal to high school/GED (60.87% vs. 39.13%; $p < .03$). Typical high risk drinking did not differ significantly between men and women.

The RDS-NSDUH comparisons indicated that the RDS sample had significantly higher drinking-related risks than their age-matched peer

drinkers in the U.S. population. Compared to the NSDUH sample, the RDS sample reported significantly more past-month drinking days (9.93 vs. 5.17, $z = 15.54$ [95% CI: 4.16, 5.36], $p < .001$) and more drinks per drinking day (4.71 vs. 2.33, $z = 9.45$ [95% CI: 1.89, 2.88], $p < .001$).

4. Discussion

The results showed that d-RDS is an effective method to recruit community-dwelling risky drinkers who are harder to reach than groups accessible by location (e.g., campuses, clinics). As found in prior RDS studies (e.g., Bauermeister et al., 2012; Tucker et al., 2016), peer recruitment started slowly, and a sizeable percentage of seeds and peers were unproductive recruiters. Recruitment then accelerated as participants were recruited by seeds and growing numbers of peer recruits, and there was no evidence of non-random recruitment as a function of participant age, sex, and past month drinking frequency. The only exception was a modest tendency for Asians to recruit other Asians that did not rise to the level requiring sample weights.

As intended, the peer sample reported elevated risk with respect to drinking practices and negative consequences, with levels ranging from relatively moderate to potentially serious. Average drinks consumed per drinking day exceeded gender-adjusted thresholds for low-risk drinking, and close to half of the sample reported typical consumption above heavy drinking levels, even though study eligibility criteria required only one such day (NIAAA, 2019b). Similarly, although only one negative consequence was required for enrollment, on average the sample reported almost nine consequences during the past three months, and more than a third reported serious consequences typically seen in clinical samples (e.g., tolerance, blackouts/brownouts). Drinking eligibility criteria at screening were deliberately set low to establish a basic level of risk prior to enrollment, while keeping screening brief and minimizing potential under-reporting that may have occurred if continuous scales ranging from low to high risk had been used for screening. This approach worked well to screen in participants who were risky drinkers, as verified by the subsequent survey assessment.

The RDS-NSDUH comparisons provided further evidence of successful recruitment of EA risky drinkers. The RDS sample reported significantly higher past-month drinking frequency and quantity compared to their age-matched peer drinkers in the U.S. population. Some support was found for predicted differences in drinking-related risks as a function of lower SES but not for participant sex. The lack of support for the predicted sex difference may be due in part to under-representation of males in the sample relative to the population of risky drinkers and persons with AUD (SAMSHA, 2019). Also, sex differences in heavy drinking among 18-to-25 year olds have narrowed in recent years (SAMSHA, 2019).

More generally, the study adds to evidence that RDS can be implemented effectively in both online and in-person applications and further extends research beyond original applications with high-risk individuals to sample hard-to-reach population subgroups based on risks associated with subgroup membership. This is important for addressing alcohol misuse, which is broadly distributed throughout the general population and, in the case of young adults, is heavily influenced by social networks that can be accessed using RDS. The study laid an empirical foundation for extending efficacious alcohol brief interventions with traditional college student drinkers to the underserved population of community-dwelling EA risky drinkers. Because RDS makes social networks accessible, it has potential for delivering scalable drinking interventions through peer networks, which may enhance dissemination and positive outcomes given the robust influence of peers on drinking among young adults (Cook et al., 2013; Hahm et al., 2012). Although RDS requires larger samples than probability sampling to support inferences about population characteristics and dynamics, it is often easier and less costly to implement and typically yields moderate

to large sample sizes in a reasonable timeframe (e.g., Iguchi et al., 2009; Tucker et al., 2016).

The study has several limitations. First, the cross-sectional design does not support causal inferences. Second, data were necessarily collected via participant self-reports for this web-based survey, conducted entirely online for peers. Although this raises questions about reporting accuracy, several procedures facilitated obtaining reliable and accurate self-reports from eligible human participants. In-person recruitment of seeds ensured that the sample was generated by members of the target population of interest; regular checks on chain development ensured that peer recruits retained for analysis also met the eligibility criteria; and all participants were required to enter valid unique referral codes and correct passwords and provide a physical address to compensate them using Visa™ cards delivered by mail. Furthermore, study measures selected for conceptual relevance, predictive utility, measurement quality, brevity, and ease of online administration yielded findings in line with behavioral economic theory and previous research on substance use (see Tucker, Cheong, & Chandler, 2020; Tucker, Lindstrom et al., 2020).

A third qualification is that more women enrolled than men, which is common in survey research (Korkeila et al., 2001), including prior RDS studies with EAs (e.g., Tucker et al., 2016). Although inconsistent with the greater percentages of male than female risky drinkers and persons with AUD in the population, it does suggest that women are the more accessible channel to reach EA social networks, an attribute that can be used to advantage in community-based research and for promoting intervention dissemination. Fourth, sample recruitment took place in a particular region of a Southern state, and determination of generalizability to other EA populations requires further study. Finally, web-based RDS is a more recent application than in-person RDS and may have unknown limitations. This is presently difficult to evaluate because existing studies vary in ways other than the type of RDS used (e.g., sample characteristics, number of seeds required, duration of data collection), and this issue warrants more systematic investigation.

With these qualifications, the study demonstrated the utility of d-RDS as a sampling method and grass-roots platform for research and intervention with community-dwelling EA drinkers who are harder to reach than traditional college students. The COVID-19 pandemic will almost certainly increase reliance on phone and web-based applications, and d-RDS has promise for expanding the focus of much alcohol brief intervention research from relatively advantaged fulltime college students to under-served community-dwelling EAs.

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6. Author agreement

We warrant that the article is the authors' original work, it has not received prior publication except in abstract/poster form as noted in the Acknowledgements, and it is not under consideration for publication elsewhere.

CRedit authorship contribution statement

Jalie A. Tucker: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Funding acquisition. **Joseph P. Bacon:** Methodology, Formal analysis,

Data curation, Visualization, Writing - review & editing. **Susan D. Chandler:** Data curation, Writing - review & editing, Investigation, Project administration. **Katie Lindstrom:** Investigation, Formal analysis, Writing - review & editing. **JeeWon Cheong:** Methodology, Formal analysis, Data curation, Visualization, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

- Arnett, J. J. (2007). Emerging adulthood: What is it, and what is it good for? *Child Development Perspectives*, 1(2), 68–73. <https://doi.org/10.1111/j.1750-8606.2007.00016.x>.
- Bauermeister, J. A., Zimmerman, M. A., Johns, M. M., Glowacki, P., Stoddard, S., & Volz, E. (2012). Innovative recruitment using online networks: Lessons learned from an online study of alcohol and other drug use utilizing a web-based, respondent-driven sampling (webRDS) strategy. *Journal of Studies on Alcohol and Drugs*, 73(5), 834–838. <https://doi.org/10.15288/jasad/2012.73.834>.
- Bengtsson, L., Lu, X., Nguyen, Q. C., Camitz, M., Hoang, N. L., Nguyen, T. A., ... Thorson, A. (2012). Implementation of web-based respondent-driven sampling among men who have sex with men in Vietnam. *PLoS ONE*, 7(11), Article e49417. <https://doi.org/10.1371/journal.pone.0049417>.
- Chen, C. M., Dufour, M. C., & Yi, H. (2004). Alcohol consumption among young adults ages 18–24 in the United States: Results from the 2001–2002 NESARC Survey. *Alcohol Research and Health*, 28(4), 269–280.
- Cheong, J., Tucker, J. A., Simpson, C. A., & Chandler, S. D. (2014). Time horizons and substance use among African American youths living in disadvantaged urban areas. *Addictive Behaviors*, 39, 818–823. <https://doi.org/10.1016/j.addbeh.2013.12.016>.
- Collins, S. E. (2016). Associations between socioeconomic factors and alcohol outcomes. *Alcohol Research: Current Reviews*, 38, 83–94.
- Collins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology*, 53, 189–200. <https://doi.org/10.1037/0022-006X.53.2.189>.
- Cook, S. H., Bauermeister, J. A., Gordon-Messer, D., & Zimmerman, M. A. (2013). Online network influences on emerging adults' alcohol and drug use. *Journal of Youth and Adolescence*, 42, 1674–1686. <https://doi.org/10.1007/s10964-012-9869-1>.
- Davies, S. L., Cheong, J., Lewis, T. H., Simpson, C. A., Chandler, S. D., & Tucker, J. A. (2014). Sexual risk typologies and their relationship with early parenthood and STI outcomes among urban African-American emerging adults: a cross-sectional latent profile analysis. *Sexually Transmitted Infect.* 90, 475–477. <https://doi.org/10.1136/sextrans-2013-051334>.
- Gile, K. H., & Handcock, M. S. (2010). Respondent-driven sampling: An assessment of current methodology. *Sociological Methodology*, 40, 285–327. <https://doi.org/10.1111/j.1467-9531.2010.01223.x>.
- Gile, K. H., Johnston, L. G., & Salganik, M. J. (2015). Diagnostics for respondent-driven sampling. *Journal of the Royal Statistical Society Series A (Statistics in Society)*, 178(1), 248–269. <https://doi.org/10.1111/rssa.1259>.
- Hahm, H. C., Kolaczyk, E., Jang, J., Swenson, T., & Bhindarwala, A. M. (2012). Binge drinking trajectories from adolescence to young adulthood: The effects of peer social network. *Substance Use & Misuse*, 47, 745–756. <https://doi.org/10.3109/10826084.2012.666313>.
- Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, 42, 377–381. <https://doi.org/10.1016/j.jbi.2008.08.010>.
- Heckathorn, D. D. (1997). Respondent-driven sampling: A new approach to the study of

- hidden populations. *Social Problems*, 44, 174–199. <https://doi.org/10.1525/sp.1997.44.2.03x0221m>.
- Heckathorn, D. D. (2007). Extensions of respondent-driven sampling: Analyzing continuous variables and controlling for differential recruitment. *Sociological Methodology*, 37, 151–207 <https://doi.org/10.1111/j.1467-9531.2007.00188.x>.
- Iguchi, M. Y., Ober, A. J., Berry, S. H., Fain, T., Heckathorn, D. D., Gorbach, P. M., & Zule, W. A. (2009). Simultaneous recruitment of drug users and men who have sex with men in the United States and Russia using respondent-driven sampling: Sampling methods and implications. *Journal of Urban Health*, 86, 5–31 <https://doi.org/10.1007/s11524-009-9365-4>.
- Johnston, L. G., & Sabin, K. (2010). Sampling hard-to-reach populations with respondent driven sampling. *Methodological Innovations Online*, 5, 38–48. <https://doi.org/10.4256/mio.2010.0017>.
- Kahler, C. W., Hustad, J., Barnett, N. P., Strong, D. R., & Borsari, B. (2008). Validation of the 30-day version of the Brief Young Adult Alcohol Consequences Questionnaire for use in longitudinal studies. *Journal of Studies on Alcohol and Drugs*, 69, 611–615. <https://doi.org/10.15288/jsad.2008.69.611>.
- Kahler, C. W., Strong, D. R., & Read, J. P. (2005). Toward efficient and comprehensive measurement of the alcohol problems continuum in college students: The brief young adult alcohol consequences questionnaire. *Alcoholism: Clinical & Experimental Research*, 29(7), 1180–1189. <https://doi.org/10.1097/01.ALC.0000171940.95813.A5>.
- Kivlahan, D. R., Marlatt, G. A., Fromme, K., Coppel, D. B., & Williams, E. (1990). Secondary prevention with college drinkers: Evaluation of an alcohol skills training program. *Journal of Consulting and Clinical Psychology*, 58, 805–810. <https://doi.org/10.1037/0022-006X.58.6.805>.
- Korkeila, K., Suominen, S., Ahvenainen, J., Ojanlatva, A., Rautava, P., Helenius, H., & Koskenvo, M. (2001). Non-response and related factors in a nation-wide health survey. *European Journal of Epidemiology*, 17(11), 991–999. <https://doi.org/10.1023/a:1020016922473>.
- Lee, M. R., & Sher, K. J. (2018). “Maturing out” of binge and problem drinking. *Alcohol Research*, 39(1), 31–42.
- Leeman, R. F., Demartini, K. S., Nogueira, C., Corbin, W. R., Neighbors, C., & O’Malley, S. S. (2016). Randomized controlled trial of a very brief, multicomponent web-based alcohol intervention for undergraduates with a focus on protective behavioral strategies. *Journal of Consulting and Clinical Psychology*, 84, 1008–1015 <https://doi.org/10.1037/ccp0000132>.
- National Institute on Alcohol Abuse and Alcoholism (2019a). Planning alcohol interventions using NIAAA’s College Alcohol Intervention Matrix. https://www.college-drinkingprevention.gov/CollegeAIM/Resources/NIAAA_College_Matrix_Booklet.pdf.
- National Institute on Alcohol Abuse and Alcoholism (2019b). Drinking levels defined. <https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking>.
- Nolen-Hoeksema, S. (2004). Gender differences in risk factors and consequences for alcohol use and problems. *Clinical Psychology Review*, 24, 981–1010. <https://doi.org/10.1016/j.cpr.2004.08.003>.
- Ramirez-Valles, J., Garcia, D., Campbell, R. T., Diaz, R. M., & Heckathorn, D. D. (2008). HIV infection, sexual risk behavior, and substance use among Latino gay and bisexual men and transgender persons. *American Journal of Public Health*, 98, 1036–1042. <https://doi.org/10.2105/AJPH.2006.102624>.
- Salganik, M. J., & Heckathorn, D. D. (2004). Sampling and estimation in hidden populations using respondent-driven sampling. *Sociological Methodology*, 34(1), 193–239. <https://doi.org/10.1111/j.0081-1750.2004.00152.x>.
- Schonlau, M., & Liebau, E. (2012). Respondent-driven sampling. *The Stata Journal*, 12, 72–93.
- Slutske, W. S. (2005). Alcohol use disorders among US college students and their non-college-attending peers. *Archives of General Psychiatry*, 62, 321–327. <https://www.stata-journal.com/article.html?article=st0247>.
- Substance Abuse and Mental Health Services Administration (2019). Results from the 2018 National Survey on Drug Use and Health: Detailed tables. Rockville, MD.
- Tucker, J. A., Cheong, J., & Chandler, S. D. (2020). Predicting HIV testing in low threshold community contexts: A naturalistic study of test choices among young African American women in the Southern United States. *AIDS Care: Psychological and Sociomedical Aspects of AIDS/HIV*, 32, 175–181. <https://doi.org/10.1080/09540121.2019.1668522>.
- Tucker, J. A., Cheong, J., Chandler, S. D., Crawford, M. S., & Simpson, C. A. (2015). Social networks and substance use among at-risk emerging adults living in disadvantaged urban areas in the southern United States: a cross-sectional naturalistic study. *Addiction*, 110, 1524–1532. <https://doi.org/10.1111/add.13010>.
- Tucker, J.A., Lindstrom, K., Chandler, S.D., Bacon, J.P., Cheong, J., 2020. Behavioral economic indicators of risky drinking among community-dwelling emerging adults. Manuscript under review.
- Tucker, J. A., Simpson, C., Chandler, S. D., Borch, C. A., Davies, S. L., Kerbawy, S. J. S., & Michael, M. (2016). Utility of respondent driven sampling to reach disadvantaged emerging adults for assessment of substance use, weight, and sexual behaviors. *Journal of Health Care for the Poor and Underserved*, 27, 194–208. <https://doi.org/10.1353/hpu.2016.0006>.
- Valente, T. W., Ritt-Polsen, A., Stacy, A., Unger, J. B., Okamoto, J., & Sussman, S. (2007). Peer acceleration: Effects of a social network tailored substance abuse prevention program among high-risk adolescents. *Addiction*, 102, 1804–1815. <https://doi.org/10.1111/j.1360-0443.2007.01992.x>.
- Volz, E., & Heckathorn, D. (2008). Probability based estimation theory for respondent driven sampling. *Journal of Official Statistics*, 24, 79–97.
- Von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Götzsche, P. C., & Bandenbroucke, J. P. (2007). STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *Epidemiology*, 18, 800–804 <https://doi.org/10.1097/EDE.0b013e3181577511>.
- Wejnert, C., & Heckathorn, D. D. (2008). Web-based network sampling: Efficiency and efficacy of respondent-driven sampling for online research. *Sociological Methods & Research*, 37, 105–134. <https://doi.org/10.1177/0049124108318333>.
- Wejnert, C., Pham, H., Krishna, N., Le, B., & DeNinno, E. (2012). Estimating design effect and calculating sample size for respondent-driven sampling studies of injection drug users in the United States. *AIDS & Behavior*, 16(4), 797–806. <https://doi.org/10.1007/s10461-012-0147-8>.
- White, R. G., Hakim, A. J., Salganik, M. J., Spiller, M. W., Johnston, L. G., Kerr, L., Kendall, C., Drake, A., Wilson, D., Orroth, K., Egger, M., & Haldik, W. (2015). Strengthening the reporting of observational studies in epidemiology for respondent-driven sampling studies: STROBE-RDS Statement. *Journal of Clinical Epidemiology*, 68(12), 1463–1471. <https://doi.org/10.1016/j.jclinepi.2015.04.002>.
- White, H., Labouvie, E., & Papadaratsakis, V. (2005). Changes in substance use during the transition to adulthood: A comparison of college students and their noncollege age peers. *Journal of Drug Issues*, 35, 281–306. <https://doi.org/10.1177/002204260503500204>.
- Zhang, M. W., Tran, B. X., Nguyen, H. L. T., Le, H. T., Long, N. H., Hinh, N. D., ... Tu, N. H. (2017). Using online respondent driven sampling for Vietnamese youths’ alcohol use and associated risk factors. *Healthcare Informatics Research*, 23, 109–118. <https://doi.org/10.4258/hir.2017.23.2.109>.