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Original article

Assessing differences in groups randomized by recruitment chain in a respondent-driven sample of Seattle-area injection drug users

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ABSTRACT

Purpose: Respondent-driven sampling (RDS) is a form of peer-based study recruitment and analysis that incorporates features designed to limit and adjust for biases in traditional snowball sampling. It is being widely used in studies of hidden populations. We report an empirical evaluation of RDS's consistency and variability, comparing groups recruited contemporaneously, by identical methods and using identical survey instruments.

Methods: We randomized recruitment chains from the RDS-based 2012 National HIV Behavioral Surveillance survey of injection drug users in the Seattle area into two groups and compared them in terms of sociodemographic characteristics, drug-associated risk behaviors, sexual risk behaviors, human immunodeficiency virus (HIV) status and HIV testing frequency.

Results: The two groups differed in five of the 18 variables examined ($P \leq .001$): race (e.g., 60% white vs. 47%), gender (52% male vs. 67%), area of residence (32% downtown Seattle vs. 44%), an HIV test in the previous 12 months (51% vs. 38%). The difference in serologic HIV status was particularly pronounced (4% positive vs. 18%). In four further randomizations, differences in one to five variables attained this level of significance, although the specific variables involved differed.

Conclusions: We found some material differences between the randomized groups. Although the variability of the present study was less than has been reported in serial RDS surveys, these findings indicate caution in the interpretation of RDS results.

Purpose

Surveys of populations at risk for human immunodeficiency virus (HIV) can provide important information on HIV prevalence, risk behavior, testing practices, and access to medical care which can help guide public health response to HIV. However, accessing populations at elevated risk for HIV, such as injection drug users (IDU) and men who have sex with men (MSM), can be challenging, as these populations are to greater or lesser extent covert due to stigma and legal jeopardy associated with drug injection and homosexuality.

Respondent-driven sampling (RDS) is an approach which has been proposed to be advantageous for surveying such hidden populations [1]. In RDS, participants are provided with coupons with which to recruit their peers and are compensated when the coupons are redeemed by new participants. Methods have been developed to analyze RDS-recruited study populations, which provide adjustment for differences among participants in their social network size and for differential recruitment among participants with differing characteristics [2–6]. Mathematical theory and modeling studies have asserted that the resulting estimates of population characteristics are asymptotically unbiased and independent of the characteristics of the initial participants [4,5,7]. In recent years, RDS has become a widely used methodology for surveying populations at risk for HIV throughout the world [8–10].

The mathematics of RDS adjustments, however, are based on a number of assumptions (such as random recruitment within a participant's social network and consistent reporting of network sizes among participants), which may not reflect actual conditions [11–13]. The accuracy and variability of RDS have been assessed by several approaches. The characteristics of the same target population recruited by RDS and by other methods have been compared [14–23]. Variability in RDS measurements has been evaluated in computer modeling based on populations with a known network structure [24,25] and with computer-generated network structures [2,11]. Sequential RDS-derived study populations have been compared [21,26–30]. Although useful, the interpretation of each of

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these approaches has limitations: comparisons with other methods beg the question of which method more accurately reflects the target population; computer modeling methods are dependent on the extent to which the models reflect reality; sequential comparisons are affected by temporal changes in study populations and potential differences in survey methods and administration.

In 2005, 2009, and 2012, the National HIV Behavioral Surveillance system (NHBS) conducted surveys of IDU using RDS in some 20 US cities, including Seattle, as part of a program of serial surveys of IDU, MSM, and persons at elevated risk of heterosexual HIV transmission [31]. In this report, we use the 2012 Seattle-area NHBS survey of IDU to evaluate consistency and variability in an RDS-recruited study population. We divided the study population into two groups based on allocating recruitment chains by a randomization algorithm. We then compared the groups in terms of sociodemographic characteristics, drug-associated risk behaviors, sexual risk behaviors, and HIV status and testing behavior. This study design allows a comparison of two groups recruited simultaneously by identical methods and evaluated by the same survey instruments. It thus avoids the effects of changes over time and differences in study design and implementation, which could have affected previous evaluations of RDS methodology.

Methods

Recruitment

Following standardized NHBS protocols, seeds were recruited to provide representation of the diversity of Seattle-area IDU in race, sex, age, area of residence, drug of choice, and sexual orientation. Seeds were given five coupons. Subsequent participants were originally issued three coupons, which was decreased to two, then one coupon to balance the number of interviews with the study appointment slots available. The study protocol closely matched that of the 2009 NHBS IDU survey [29] although study offices were located in a different area of downtown Seattle. Eligibility criteria required participants to be aged 18 years or older, residents of King or Snohomish Counties, able to complete the interview in English and to display either physical evidence of recent drug injection or demonstrate convincing knowledge of injection practices. Participants were screened, interviewed, and gave informed consent in face-to-face interviews conducted with hand-held computers. HIV testing was by a rapid test on a fingerstick blood sample (OraSure technologies, Bethlehem, PA) followed by a blood-based Western Blot on those with reactive rapid test results (Bio-Rad, Hercules, CA). Study procedures were approved by the Washington State Institutional Review Board.

Randomization procedure

We used recruitment chain as the basis to assign participants to one of two groups. This ensured availability of complete data on who recruited whom from which the adjustments of RDS-based estimates could be calculated. A random number between 0 and 1 was assigned to each recruitment chain. In many RDS study populations, there are substantial differences in the size of the different recruitment chains. Preliminary investigations using groups simply defined by random number (>0.50 vs. ≤ 0.50) produced one group, which exceeded 70% of the total survey study population more frequently than thought desirable; for instance, this occurs in the randomization depicted in Table 1.

To ensure more comparable group sizes, we used a two-step randomization procedure (illustrated in Table 1). First, the chains were ordered by random number. Participants in recruitment chains below a certain breakpoint would be assigned to group 1, those above to group 2. The breakpoint was defined in the following manner: for each potential breakpoint in the randomization, the number of participants in recruitment chains above and below the breakpoint was calculated. The breakpoint which produced the smallest difference in the number of participants between groups was chosen to define the two analysis groups for this randomization. *A priori*, we chose the first randomization performed to present more detailed findings and then summarize results from all five randomizations that were conducted using this procedure to further assess variability across randomizations.

Table 1
Details of the procedure for randomization by recruitment chain, Seattle-area participants in the 2012 NBHS IDU survey: first randomization

	Recruitment chain	Random number	*N* participants	Cumulative number: group 1	Cumulative number: group 2	Difference group1: group2
Group 1	6	0.05	229	229	459	230
	1	0.18	65	294	394	100
	5	0.19	1	295	393	98
Group 2	2	0.32	156	451	237	214
	8	0.39	152	603	85	518
	4	0.54	10	613	75	538
	3	0.58	27	640	48	592
	7	0.66	6	646	42	604
	9	0.79	42	688	0	688

Variable definitions

We compared the randomized groups in terms of a collection of 16 variables with a total of 46 variable categories. There were constructed to be comparable with a previous comparison of participants in the 2005 and 2009 NHBS surveys of Seattle-area IDU [29] and used a questionnaire that was similar to, and in most cases identical to, the 2009 survey. One difference is that in the 2012 questionnaire unprotected, HIV nonconcordant male-to-male anal sex was evaluated by a series of questions on the number of male-to-male main and casual anal sex partners, the number with whom a condom was not used, the number for whom HIV status was known, and the number HIV-positive and HIV-negative. For heterosexual contacts, the same more general question was asked as in previous surveys: “Did you have vaginal or anal sex without a condom with a woman (or for women, a man) who was HIV-negative?” followed by analogous questions for HIV-positive partners and partners of unknown status. As serologic testing for HIV and hepatitis C was performed in 2012, we present serologic status for these viruses rather than the self-reported status of the earlier study.

Statistical evaluation

We used statistical testing (using a criterion of $p \leq .001$) as a means to identify differences between groups that merit attention to provide an objective measure of the extent of such differences across randomizations and to compare the number of such differences with those found in previous comparisons of serial RDS study populations [21,26–30]. Several means of adjusting RDS-generated data have been proposed [2–6]. We used the Salganik-Heckathorn estimator-based RDSAT software package, which is freely available and widely used [32]. Statistical testing in RDS-generated data remains problematic, and no method has gained general acceptance. The *P* values we present incorporate RDSAT-derived weights for individual participants in logistic regression analyses [27,30]. This allows a summary measure across multiple categories of a variable incorporating adjustments for network size and differential recruitment patterns.