“Starfish Sampling”: a Novel, Hybrid Approach to Recruiting Hidden Populations

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Abstract We sought to leverage the strengths of time location sampling (TLS) and respondent-driven sampling (RDS) for surveys of hidden populations by combining elements of both methods in a new approach we call “starfish sampling.” Starfish sampling entails random selection of venue-day-time units from a mapping of the locations where the population can be found, combined with short chains of peer referrals from their social networks at the venue or presenting to the study site later. Using the population of transmen in San Francisco as a case example, we recruited 122 eligible participants using starfish sampling: 79 at randomly selected venues, 11 on dating applications, and 32 by referral. Starfish sampling produced one of the largest community-recruited samples specifically for transmen to date. Starfish sampling is a flexibility method to recruit and sample hidden populations for whom conventional TLS and RDS may not work in theory or practice.

Keywords Hidden populations · Sampling methods · Time-location sampling · Respondent-driven sampling

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Introduction

Surveys of marginalized and hidden populations who experience health disparities face challenges in obtaining inclusive and representative samples. This is particularly the case for populations at high risk for HIV, such as men who have sex with men (MSM), people who inject drugs, sex workers, and transgender persons. General population surveys with true probability-based sampling methods typically do not obtain large enough samples of these relatively small populations. Additionally, stigma may prevent individuals from disclosing sexual orientation, illegal drug use, sex work, or transgender status in household surveys. Alternative methods held to approximate probability-based sampling have been developed to efficiently and inclusively recruit from hidden populations. For example, specialized sampling methods for hard-to-reach populations include snowball sampling [1], targeted sampling [2], time-location sampling (TLS) [3], and respondent-driven sampling (RDS) [4].

TLS and RDS in particular have been used around the world to sample hidden populations for HIV surveillance under the assumption that they yield representative, reproducible samples [5–8]. TLS purports to strengthen the rigor of venue-based sampling methods by comprehensive mapping of all visible places where the population congregates and including randomization of the places and times to conduct outreach recruitment. Several approaches to statistical adjustments based on patterns of venue attendance have been proposed [3, 9–11]. A theoretical challenge to TLS

is that not all members of the target population attend the venues included in the sampling frame. RDS can reach members of the population who do not attend venues using peer referrals. RDS purports to strengthen the rigor of peer-referral sampling methods by monitoring recruitment and framing theoretical assumptions to correct for differential probabilities of recruitment according to social networks [4, 8, 12–16]. TLS and RDS have been compared to each other indicating that both sampling methods have potential biases and inefficiencies that may operate in different directions [17–19]. For example, a comparison in Fortaleza, Brazil concluded that TLS reached MSM of higher socio-economic status (SES) while RDS reached lower SES strata [17]. In general, venue-based approaches such as TLS work when sampling visible segments of populations who can be approached by study staff for recruitment. TLS is therefore constrained when venues are few or only frequented by part of the population. However, some populations have social networks that are not sufficiently large or interconnected to sustain long chains of peer referrals required for RDS [15, 20]. Figure 1 illustrates the recruitment pattern that arises when RDS generates the desired long chains of peer referrals needed to meet theoretical requirements. However, in practice, RDS studies may generate short recruitment chains that do not meet theoretical requirements for adjustments, as illustrated by the “starfish” pattern in Fig. 2.

After multiple encounters with these dilemmas (e.g., too few venues for TLS, insufficiently dense social networks for RDS) in surveys of key populations at risk for HIV, we conceptualized a hybrid sampling approach. We sought to leverage the strengths of TLS (e.g., randomization to mitigate selection bias, more control over participation bias) and RDS (e.g., access to less visible segments of the population) by combining key elements of both methods. Based on the recruitment pattern of many short chains of peer referrals, we call this hybrid method “starfish sampling.” In this paper, we use a survey conducted among transmen in San Francisco as a case example of starfish sampling. We previously published the primary results of HIV prevalence and risk behaviors [21]. The current paper focusses on the methods of starfish sampling as a flexible design for sampling and recruitment that may have broader applicability for research in other hidden, hard-to-reach populations.

Methods

Study Population We sampled individuals who reported being born or were assigned female sex at birth but currently identify as something other than female (i.e., “transmen”). Participants were 18 years of age or older and lived in one of the ten San Francisco Bay Area counties.

Fig. 1 Long-chain recruitment pattern of respondent-driven sampling (actual study example for illustrative purposes)

Fig. 2 “Starfish” patterns of short chains of peer referrals (actual study sample for illustrative purposes)

Formative Assessment We conducted key informant interviews and field observations to understand the diversity, geographic distribution, venue attendance, and social network structure of the trans male community in the San Francisco Bay Area. Key informant interviews ($n = 17$) included transmen and other participants who were knowledgeable about the community. Formative assessment participants were recruited by referral from community organizations and by peer referral of other key informants. Interviews and observations were conducted by trans male staff.

Sampling Methods Overview We conceived starfish sampling is a systematic yet flexible hybridization of a randomized venue-based approach combined with a peer-referral approach. Sampling procedures were added progressively. Recruitment was launched with a randomized venue-based (TLS-like) phase, followed by the addition of randomized time-geographic locations for recruitment through mobile dating applications, followed by the addition of a peer-referral recruitment (RDS-like) phase.

Venue-Based Sampling Methods As with conventional TLS [3, 5], a formative phase, employing focus group discussions, key informant interviews, literature review, and observation, gathered information on venues where transmen could be found and days and times where attendance was highest. From this list of venue-day-time (VDT) periods, a random sample of VDT was

selected for recruitment events each week. At each recruitment event, study staff counted the number of potential participants (i.e., any individual who presented as male) in a 4-h period and consecutively approached and screened for eligibility. If eligible and willing to participate, they were consented and interviewed. Dating and other online applications were considered virtual venues with VDT defined by users self-identifying as transmen and providing geo-locating information. For example, dating applications identified locations and times where transmen were seeking partners within a 0.5-mile radius, which were randomly selected as VDT, followed by systematically approaching persons online within that area who indicated transmen in their profile.

Peer Referral-Based Sampling Methods Conventional RDS also starts with a formative phase where the goals are to understand the characteristics of the social networks of the population of interest and the selection “seed” participants who initiate the recruitment chains [4, 7]. In starfish sampling, seeds were those individuals approached at the randomly selected VDT sampling events. Once a participant at a sampling event completed the survey, he was invited to recruit peers. The participant was instructed that the peers could be present at the venue concurrently or referred to the study site at another time. In this manner, we conceived that starfish sampling would facilitate the venue-based screening as well as expanding recruitment beyond those attending the venue. Participants were given recruitment coupons,

without expiration dates, to give to their peers to link recruit and recruiter as in RDS. Individuals could redeem their recruitment coupon and participate either during the sampling event or later at our study office. Referred participants were also invited to recruit their peers for further waves of enrollment as in conventional RDS. The peer referral remained open to study end, covering most of the year-long period of recruitment.

Combined Starfish Sampling Methods Combining the above principles and procedures, starfish sampling began with a formative phase of mapping the target population. The mapping generated a sampling frame of 35 venues where transmen could be approached for recruitment, including 5 dating applications, 5 bars, 1 community-based organization, 4 clinics, 19 community events, and 1 sex club in San Francisco. From this sampling frame, 118 recruitment events were randomly selected in weekly blocks by assigning a unique number to each 4-h VDT period when transmen were present and using a random number generator. Sampling was structured in three phases, progressively adding recruitment approaches. Phase I, lasting 2 weeks, recruited only through consecutive intercepts at randomly selected VDT (i.e., no peer referral yet). Phase II, lasting 4 weeks, added social media dating applications as virtual venues for recruitment. Phase III, lasting to the study end, added peer referral to the ongoing selection of physical and virtual venues by inviting all transmen enrolled to recruit up to five eligible peers each. Participants were given \$50 in compensation for their time; persons in the peer recruitment phase were also given \$10 for each successful referral.

Analysis Since the late 1990s, several statistical weights have been proposed to adjust for the peer recruitment methods of RDS [4, 8, 12–16, 22] and the venue-based methods of TLS [3, 9–11]. All weighting approaches require assumptions that are difficult to meet, measure, or prove. For example, RDS weighting assumes that persons recruit randomly from their social networks. TLS weighting assumes that persons in the population will attend venues in the sampling frame with measurable frequencies. The lack of a gold standard census for many stigmatized populations challenges validation of the different weighting approaches. Often, weighting in RDS and TLS is ignored [11, 23–26]. For the present first attempt at starfish sampling, we conceptualized the

sampling frame as clusters of transmen present at venues with their immediate acquaintances as sampling units with equal probability of inclusion through randomization. We adjusted standard errors for clustering, but we did not calculate weights to distinguish differential probabilities of inclusion.

Results

Recruitment occurred from June 3, 2014 to June 26, 2015, enrolling a total of 122 transmen. Figure 3 shows the recruitment pattern for the sample, with boxes indicating venues, diamonds indicating randomly-selected recruitment events, and ovals indicating participants. Of the 122 participants, 79 were recruited by intercept at randomly selected venues, 11 by intercept on dating applications, and 32 by peer referrals from those who were previously enrolled at venues or on dating applications. Peer referrals occurring at the time of the recruitment event are shown on same level as other venue recruits; those who presented later at the study offices are shown as extending to second and third levels from their recruiters.

Eighteen of the 35 (51.4%) venues in the sampling frame yielded eligible recruits when randomly selected. By venue type, at least 1 participant was enrolled from 3 of 5 dating applications, 2 of 5 bars, 1 in community-based organization, 2 of 4 clinics, 9 of 19 community events, and 1 in sex club. Moreover, 45 of the 118 (38.1%) randomly selected recruitment events yielded eligible recruits.

Table 1 shows the characteristics of the sample with 95% confidence intervals adjusted for clustering at the recruitment event level. Nearly one third (30.3%) of transmen participants were age 18 to 24 years; a majority were white (77.0%) and employed (73.0%); and a plurality (49.2%) had a college degree or higher education level. Over four fifths (86.1%) had taken hormones; just under half (49.2%) had any gender transition surgery.

Discussion

In our survey of transmen, starfish sampling achieved the methodological and logistical goals for which it was

We believe the hybridized components of starfish sampling were complementary in reducing potential biases and inefficiencies inherent in RDS and TLS methods separately. The TLS-like randomization of VDT periods for recruitment provides starfish sampling with a probability basis; that is, it incorporates the element of chance that defines sampling methodologies. Recruitment at venues purely by convenience is likely to produce selection bias. Recruiting purely by Internet (i.e., relying on self-referral) is likely to face participation bias. The TLS-like component also produced a random selection of persons to provide peer referrals, rather than the purposeful choice of seeds as in conventional RDS. Also, unlike conventional RDS, our sample was not predominantly the result of peer referrals. RDS does not include the element of chance (i.e., it is driven

On the other hand, the RDS-like component had several practical and theoretical advantages over conventional TLS. Peer referral was needed to approach the targeted sample size, recruiting one fourth of the study, most outside of the recruitment events in the field. The RDS-like component may have capitalized on the advantages of validation of the study by trusted friends and the convenience of interviewing at the study site rather than in the field. The TLS-like component was inefficient in that only half of the venues in the sampling frame and less than half of random recruitment events yielded any eligible participants. Of additional practical advantage, peer referrals during the recruitment event helped distinguish eligible transmen from the many other persons presenting as male. Of theoretical importance, peer referral may have recruited transmen who may not visit any of the venues in our sampling frame. Such persons would have had zero probability of inclusion if we relied entirely on venue-based recruitment, thus weakening claims for inclusiveness and representativeness. Future work should include an assessment of venue attendance.

We acknowledge that we cannot prove that starfish sampling is representative. It is currently not possible to validate the final sample against a gold standard. The

Table 1 Characteristics of transmen recruited through a hybrid venue- and peer referral- based sampling method (“starfish sampling”), San Francisco, 2015 ($N = 122$).

Characteristic	Number (%)	95% Confidence interval ^a
Age group (years):		
18–24	37 (30.3)	18.3–42.4
25–34	61 (50.0)	37.7–62.3
35–44	13 (10.7)	5.5–15.8
45+	11 (9.0)	4.4–13.7
Race/ethnicity:		
Asian	6 (4.9)	0.5–9.4
Black	8 (6.6)	2.6–10.5
Latino	4 (3.3)	0–6.7
White	94 (77.0)	69.7–84.4
Mixed	2 (1.6)	0–3.9
Other	8 (6.6)	2.0–11.1
County of residence:		
San Francisco	62 (50.8)	41.6–60.0
Alameda	43 (35.2)	27.2–43.2
Other	17 (13.9)	8.1–19.8
Employed	89 (73.0)	63.1–82.8
Education:		
High school or less	14 (11.5)	6.4–16.5
Some college	48 (39.3)	29.7–49.0
College degree or more	60 (49.2)	38.4–60.0
Ever took hormones	105 (86.1)	80.4–91.7
Ever had any gender transition surgery	60 (49.2)	40.5–57.9

^a Adjusted for clustering at the recruitment event level

US Census does not include transgender status for comparison to our sample’s demographic characteristics or to post-weight survey results. We previously reported that our sample includes fewer persons of Asian race/ethnicity and more persons of white race/ethnicity than would be expected from the San Francisco census of the general population [21, 27, 28]. As noted, the discrepancy may be due to in-migration of transmen from outside San Francisco as the makeup of our sample is closer to the USA as a whole or due to differential occurrence of trans male identity in race/ethnicity groups. Meanwhile, relying on true population-based surveys to achieve representativeness is challenged by enormous sample size requirements. For example, the household phone-based Behavioral Risk Factor Survey included 151,456 persons in order to interview 212 transmen across 50 states and three territories [29].

We also acknowledge that our current analysis is overly simplistic. We adjusted for clustering but did not weight for differential probabilities of individuals to be intercepted or referred. A more complex analysis might be developed to account for frequency of venue attendance, network sizes, and mode of recruitment. While weighting appears amply justified, there is considerable debate on how it should be done. The weighting for TLS and RDS surveys has undergone multiple changes [3, 4, 8–16, 22], remains under discussion, or is ignored [23–26]. For the present, we highlight starfish sampling as a recruitment tool while acknowledging the statistical approaches as a sampling methodology need to be developed in line with those for RDS and TLS.

We envision that starfish sampling can be further developed and adapted to address challenges in studies of populations for whom conventional TLS and RDS do not work and for whom true population-based survey methods are untenable. Situations that may lend themselves to starfish sampling include sparse numbers at venues (e.g., trans gender persons), low density of social networks (e.g., street children), few connections to others within the population (e.g., partners of transwomen, clients of sex workers), small sub-groups (e.g., high socioeconomic status sex workers, transgender youth), and other hard-to-reach populations (e.g., trafficked women, LGBT in the military). Populations with numerous venues (e.g., men who have sex with men in San Francisco), dense social networks (e.g., homeless people who inject drugs in urban settings), or large homogenous groups (e.g., Hmong refugees in specific urban settings) might be better reached through TLS or RDS. We coined the name “starfish sampling” from the empirically observed pattern of recruitment that occurs in RDS and TLS surveys when networks and venues are sparse. We hope this pattern is recognizable to others using these methods and prompts further investigation in diverse populations. New tools are needed to produce inclusive and robust data on marginalized populations experiencing health disparities. We offer that starfish sampling could be considered for recruitment in populations when available tools are inadequate.

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