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Review article

Respondent-Driven Sampling for an Adolescent Health Study in Vulnerable Urban Settings: A Multi-Country Study

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A B S T R A C T

The global adolescent population is larger than ever before and is rapidly urbanizing. Global surveillance systems to monitor youth health typically use household- and school-based recruitment methods. These systems risk not reaching the most marginalized youth made vulnerable by conditions of migration, civil conflict, and other forms of individual and structural vulnerability. We describe the methodology of the Well-Being of Adolescents in Vulnerable Environments survey, which used respondent-driven sampling (RDS) to recruit male and female youth aged 15–19 years and living in economically distressed urban settings in Baltimore, MD; Johannesburg, South Africa; Ibadan, Nigeria; New Delhi, India; and Shanghai, China (migrant youth only) for a cross-sectional study. We describe a shared recruitment and survey administration protocol across the five sites, present recruitment parameters, and illustrate challenges and necessary adaptations for use of RDS with youth in disadvantaged urban settings. We describe the reach of RDS into populations of youth who may be missed by traditional household- and school-based sampling. Across all sites, an estimated 9.6% were unstably housed; among those enrolled in school, absenteeism was pervasive with 29% having missed over 6 days of school in the past month. Overall findings confirm the feasibility, efficiency, and utility of RDS in quickly reaching diverse samples of youth, including those both in and out of school and those unstably housed, and provide direction for optimizing RDS methods with this population. In our rapidly urbanizing global landscape with an unprecedented youth population, RDS may serve as a valuable tool in complementing existing household- and school-based methods for health-related surveillance that can guide policy.

IMPLICATIONS AND CONTRIBUTION

This multi-country study confirms the feasibility and efficiency of RDS in quickly reaching diverse samples of youth. Lessons learned from multisite implementation provide direction for optimizing RDS with youth, particularly those in disadvantaged setting.

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Globally, the current population of youth ages 10–24 years is larger than ever before in history, with an estimated one in four individuals worldwide within this age group; the vast majority lives in low- and middle-income nations [1]. Although adolescents are considered a healthy population, youth suffer morbidity and mortality stemming from intentional and unintentional injury, and sexual and reproductive health issues spanning sexually transmitted infections including HIV, and unintended pregnancy [1,2]. Health risk behavior in the forms of tobacco, alcohol, and other substance use and lack of physical activity can initiate and intensify during this life stage and impart risk for subsequent chronic health conditions [1,2].

The 2012 global synthesis of adolescent health [2] illustrates that much of our knowledge of population-level adolescent health is derived from household- and school-based surveillance systems, including the household-based Demographic and Health Survey (DHS) and Multiple Indicator Cluster Survey (MICS). Both systems include adolescents ages 15 years and older. The international Health Behaviour in School-Aged Children and the Global School Health Survey include younger adolescents up to age of 15 years. Despite the insights and international comparisons enabled by these systems [3–9], significant gaps remain in our understanding of global adolescent health. The school-based sampling strategies of the Health Behaviour in School-Aged Children and Global School Health Survey, although efficient, risk biased estimates in settings with chronic school absenteeism and high dropout rates. These biases are particularly salient for women and girls, who are less likely to be in school in some settings [2,10]. The household-based sampling of DHS and MICS risks overlooking the most vulnerable youth who risk housing instability for reasons of poverty, institutionalization, migration, civil conflict, and other forms of individual and structural instability. The health of youth who risk being missed by these surveillance systems is likely compromised. Experiences of housing instability, food insecurity, poverty, and gender inequity constitute powerful social determinants of health [11]. Adequate housing protects urban children from disease, injuries, and accidents; living environments are closely linked with psychological stress and overall health [12].

The confluence of heightened risk and limited access to health services for youth who are out of school and unstably housed, coupled with the lack of globally comparable data on health outcomes and determinants using samples that adequately include these populations, has prompted calls for the exploration of respondent-driven sampling (RDS) [2,13] to reach a broader spectrum of youth, much in the way that it has been applied to other marginalized populations often made invisible through more traditional sampling methods. RDS [14] is a chain-based recruitment method that has been widely adopted for HIV-related research [15] with marginalized hidden populations including injection drug users [16], men who have sex with men [17], and female sex workers [18]. More recently, the method has been adopted for other hidden populations, such as migrant workers [19], street children, and homeless youth [20,21].

We undertook a comparative investigation of adolescent health spanning domains of substance use, sexual and reproductive health, mental health, and gender-based violence, in distressed urban setting in five countries using RDS. Here, we describe recruitment in these five geocultural settings, including challenges and solutions, and illustrate the extent to which RDS reaches into populations of youth who risk exclusion from household- and school-based surveillance systems.

Methods

In 2013, the cross-sectional Well-Being of Adolescents in Vulnerable Environments study surveyed youth aged 15–19 years living in economically distressed urban settings in Baltimore, MD; Johannesburg, South Africa; Ibadan, Nigeria; New Delhi, India; and Shanghai, China (migrant youth only, as they constitute a particularly vulnerable population in this setting). RDS was selected for this study population given feasibility concerns for household- or school-based sampling, for example, inaccessible households (e.g., locked apartment buildings in Johannesburg) and many migrant youth not enrolled in school (Shanghai). A shared protocol enabled cross-site comparability. At each site, an extensive formative phase was conducted, including key–informant interviews, community mapping, focus groups, and in-depth interviews [22]. This phase informed RDS acceptability and logistics; we assessed evaluated youths network properties including subgroupings and the level of networking within and across subgroupings, identified necessary seed characteristics and potential seeds, and refined survey domains, consistent with formative RDS recommendations [23,24].

Eligible seeds and participants were adolescents aged 15–19 years and residing in the geographically designated target communities at each site. Adolescent seed participants were purposefully selected to serve as the initial contacts for recruiting from the target population through the formative phase, and through existing relationships with youth, community advisory boards, and other service providers at each site. Seeds represented diverse school enrollment, gender, employment, and residential statuses. Consistent with RDS methods [15], seeds and subsequent recruits were provided with up to three recruitment coupons each to recruit additional adolescents into the study until recruitment goals were reached. Each coupon had an expiration date, after which it could not be redeemed. Coupon expiration dates were used to control recruitment pace and to end recruitment when the sample size was achieved. Controlling chain referral recruitment through restricting the number of referrals per person encourages long recruitment chains and reaches into the target population. Coupons were identifiable by sequential numbers which linked recruits to their recruiters, enabling creation of recruitment chains. Several steps ensured the tracing of these links, including duplicative documentation of coupon links in both hard copy recruitment logs and electronically collected survey data. Procedures were piloted extensively in the Baltimore, MD site, with iterative discussion of pilot findings and challenges with partners at all sites. All other sites were able to transition directly into data collection from the pilot phase when logistics were finalized. Many made minor procedural adaptations through the pilot to maximize participant comfort, minimize coupon tampering, and ensure capacity to link participants with recruiters via coupon number documentation.

Consistent with RDS methods, participants self-reported the size of their social network to account for potential bias because of differences in selection probability for participants with larger versus smaller networks. To improve accuracy [23], network size questions were asked sequentially and structured to ensure reciprocity in social ties. The sequence was how many youth [age and location eligibility] … do you know, … do you know that know you, … do you know that know you and that you have seen in the past two weeks, … do you know that know you and that you have seen and talked to in the past two weeks, with the final question serving as the participant's network size.

When a seed or recruit presented for data collection, staff assessed eligibility, obtained informed consent including parental consent for youth under age of 18 years, and oriented participants to survey procedures. To maximize confidentiality and minimize bias, the anonymous survey was self-administered directly in audio computer-assisted self-interview instrument, which has been demonstrated to enhance accuracy in reporting on sensitive topics among many populations [25] and can overcome literacy issues through the audio component. On occasion, participants requested research staff assistance. Youth aged 17 years and younger were required to obtain parent/guardian consent to participate. All study procedures were approved by Institutional Review Boards at Johns Hopkins Bloomberg School of Public Health and at each participating site.

The survey

The survey included domains of physical, mental, and sexual and reproductive health, violence, family, community and school environments, and demographics. It was developed in English, professionally translated and back-translated into local languages at each site, and piloted with native speakers to ensure comprehension. Discrepancies were resolved through an iterative process. Here we present data on housing instability and school enrollment. Housing instability was defined as reporting not having a regular place to stay, OR having a regular place to stay but staying there on average, four or less nights per week in the past 30 days, and having stayed in four or more places in the past week. School enrollment was assessed via a single item, "Are you currently in school?" Among participants in school, past month absenteeism was assessed via a single item, "About how many days of school did you miss in the last 30 days, even if it was just part of a day?"; responses were categorized for analysis.

The present article describes recruitment parameters following RDS reporting recommendations [26]. We describe challenges and adaptations across settings based on our monthly research team meetings and a brief survey on challenges and adaptations completed by research staff in each site following data collection. We also present the prevalence of housing instability and school absenteeism within our sample, to approximate our reach into populations of youth who may be missed by household or school-based surveys. Prevalence estimates for each outcome were generated by site in STATA both overall and by gender; school enrollment estimates were stratified by age group. Analysis procedures accounted for the nonindependence of observations using complex SVY procedures and were weighted using the RDSII estimator [27]. After identifying differences in age distribution across sites, we developed a poststratification age weight which is used in conjunction with the RDSII weight.

Results

Recruitment parameters

Recruitment parameters are presented in Table 1. A total of 44 (range, 5–14) seeds were enrolled across the sites, and 5,175 (range, 657–1,347) recruitment coupons distributed. Among returned coupons (2,391 total), some (n = 39) were ineligible or opted not to participate (n = 3). We enrolled a total of 2,393 participants across sites including seeds (range, 455–500). The sample was reduced to 2,339 (range, 438–500 per site) after identifying a small number of duplicate, noncomplete, and otherwise inaccurate surveys. Overall data quality was high, with most participants in each site providing complete data.

Implementation challenges and solutions

Several challenges arose in implementing RDS with youth; Table 2 summarizes challenges and adaptations.

Pace, ineligible individuals, and coupon misuse. One of the most consistent challenges was the slow start of recruitment, followed by the rapid pace of RDS once implemented. Figure 1 illustrates recruitment pace by gender in each site. Baltimore and Johannesburg in particular experienced a slow start to recruitment, followed by rapid redemption of coupons and participant enrollment. Sites adapted to the pace by shortening the expiration time frame for coupons in the beginning of data collection to quicken the pace and then by lengthening the expiration time to slow the pace of data collection. Coupon expiration time frames ranged from 3 to 14 days with most sites settling on 7 days for the bulk of their data collection.

The other consistent challenge was young people trying to gain access to the study outside the eligibility requirements. Most sites experienced young people suspected of being over or under the age eligibility trying to enroll. In turn, prospective participants in Delhi and Shanghai were required to produce identification and/or proof of age. In the other sites where documented proof of age was less common, young people were asked to provide their birth date, name of/year in school, or even contact information for a parent or guardian who could confirm age. Site staff also stressed that the secondary incentives were contingent on recruiting eligible participants. Research staff in Shanghai, Baltimore, and Johannesburg noticed instances of participants selling their own coupons or collecting coupons from other participants to recruit more respondents. In Johannesburg, the coupon was revised to state "NOT FOR SALE," and in Baltimore and Shanghai, staff stressed that coupons were to be distributed only by the participant. In cases of suspected misuse, coupons were canceled or not distributed.

Baltimore, Shanghai, and Johannesburg each had at least one recruitment chain that grew at a much more rapid pace than the others and at least one seed that was not productive. These sites addressed the nonproductive seeds by recruiting additional seeds. In Baltimore, outreach to nonproductive seeds was also attempted to encourage coupon distribution. Shanghai and Baltimore handled their large fast-growing recruitment chains differently. In Shanghai, the research team established a waiting period before the coupons were active. In Baltimore, the team limited the number of coupons distributed to respondents in the fast-growing chain while exploring potential misuse and ultimately identified and stopped distributing coupons to respondents in one branch after confirming coupon misuse.

In Baltimore, Johannesburg, and Shanghai, research staff noted a handful of participants who attempted to complete the survey twice. In Baltimore, a core research staff was familiar with participant faces and able to stop repeat enrollees, and in one case, identifying a repeat enrollee who made it through screening so that their second round of data could be dropped from the data set. In Shanghai, similarly, staffing consistency enabled participant familiarity that deflected any attempted repeat efforts. In Johannesburg, the team implemented a computer-based fingerprint biometric system to record all participants, which allowed them to identify repeat attempts before they were consented.

Table 1
Respondent-driven sampling recruitment summary by site

	Baltimore	Delhi	Ibadan	Johannesburg	Shanghai	Total
Catchment area	Five zip codes of East Baltimore	Badarpur area of Delhi	Ibadan north local government area	Inner city Johannesburg	Taopu community of the Putuo district of Shanghai (migrant youth only)	
(1) Total # seeds	8	7	10	14	5	44
(2) Total # coupons given	1,158	657	847	1,347	1,166	5,175
(3) Total # coupons returned (sum 4, 5, and 6)	488	493	458	483	469	2,391
(4) Of returned coupons, # ineligible	20	0	3	0	16	39
(5) Of returned coupons, # nonparticipating	0	0	0	0	3	3
(6) Of returned coupons,# eligible and participating	468	493	455	483	450	2,349
(7) Total number of participants (sum 1 and 6)	476	500	465	497	455	2,393
(8) Participants providing incomplete or nonsensical data	15	0	5	1	17	38
(9) Duplicate participants dropped	1	0	0	0	0	1
(10) Lost or unsaved interviews	4	0	11	0	0	15
(11) Final analytic sample	456	500	449	496	438	2,339
(12) Number of recruits by seed (range)	1–369	4–212	2–228	1–424	2–329	—
(13) Number of recruitment waves (range)	1–14	1–8	1–16	1–15	1–20	—
(14) Primary incentive	20 USD	None	N500	R100	100 CNY	—
(15) Secondary incentive	10 USD per recruit, up to three recruits	None	N250 per recruit, up to three recruits	R10 per recruit, up to three recruits	50 CNY per recruit, up to three recruits	—
(16) Location of data collection	Johns Hopkins School of Public Health	Population Council offices	University College Hospital; Lifebuilders	Wits Reproductive Health and HIV Institute offices	Taopu family planning service station	—
(17) Language(s) of survey data collection	English	English, Hindi	English, Yoruba	English, isiZulu, Sesotho	English, Mandarin	—
(18) Data collection dates	April–May 2013	August–September 2013	September–October 2013	August–September 2013	May–July 2013	—
(19) Elements of variation for seed matrix and seed characteristics	• School status • Employment status • Housing status • Drug involvement • Race	• School status • Employment status (males) • Marital status (females)	• School status • Employment status • Parental contact and living arrangements	• School status • Employment status • Engagement in community activities • Living arrangements • Migrant status	• School status • Employment status • Living arrangements	-

Staff in Baltimore, Ibadan, and Shanghai noticed a handful of participants not answering the survey questions seriously and attributed this to participants who were rushing through the survey to join their friends who often were waiting onsite or just outside the interview venue. All sites intervened with respondents who were observed to be mindlessly clicking through the survey, who were informed that they would not receive recruitment coupons if they appeared to complete the survey haphazardly. In Baltimore and Shanghai, the researchers did not allow youth to recruit on the same day that they received coupons. The Baltimore team also discouraged participants who had already taken the survey from waiting for their friends. In Shanghai, an appointment system was established to minimize waiting times. Analytically, a protocol for identifying incomplete and nonsensical data was developed to identify and eliminate poor responders.

Differential recruitment pace by gender. In each site, recruitment fluctuated on a daily basis. Recruitment was faster for male than that for female participants. Even with female seeds, the recruitment of male participants outpaced the recruitment of female participants. Near the end of data collection, some sites restricted coupons by gender in an effort to achieve a more gender-balanced sample. For example in Baltimore, toward the end of data collection as coupons were distributed, participants were informed that they could only recruit young women, and in Johannesburg, respondents were allowed to recruit only one

Table 2
Challenges in respondent-driven sampling implementation across sites

Challenges	Baltimore	Delhi	Ibadan	Johannesburg	Shanghai
Sample imbalance (e.g., gender, student status)	X		X	X	X
Ineligible individuals trying to gain entry to study	X	X		X	X
Attempts at repeat enrollment	X			X	X
Unbalanced recruitment chains	X		X		X
Participants not taking survey seriously	X		X	X	X
Nonproductive seeds	X			X	X
Recruitment pace	X	X	X	X	X

young man with their three coupons. In Shanghai and Ibadan, recruitment moved at a faster pace for those enrolled in school compared with those not enrolled. To slow the pace of student enrollment, coupons distributed to students had a 7-day waiting period before they were active.

Reach into unstably housed and schooled populations of youth

Housing instability in the current sample ranged widely from just under 2% to nearly 17% (Table 3). In total, across all sites, an estimated 9.61% were unstably housed. School enrollment naturally varied by age in all sites. In Baltimore, nearly all 15-year olds were enrolled in school, whereas more than 40% of 18-year olds were not in school. In Shanghai, where the sample of adolescents was migrant adolescents, nearly 30% of those aged 15 years were not in school and 97% were not in school by age of 19 years. Among those enrolled, school absenteeism was pervasive; in total, across sites, 29.4% had missed six or more days of school in the past month, ranging from less than 1% in Shanghai to upward of 64% in Ibadan.

Discussion

Our study represents the first attempt at a multi-country RDS survey on adolescent health in distressed urban environments. It was successful in achieving recruitment goals and ensuring consistent procedures across sites. Lessons learned provide direction for optimizing RDS procedures with similar populations.

RDS recruitment enabled rapid recruitment of a diverse sample of youth in each of the five study sites. Our implementation challenges, including ensuring eligibility criteria, coupon tampering and misuse and pacing, were strikingly similar to those identified across a variety of other settings and populations. For example, entrepreneurial individuals seeking to evade eligibility criteria or attempting duplicate enrollment to receive more incentives has been previously noted, as have research "hustlers" who sell, duplicate, or otherwise attempt to misuse coupons [23,28,29]. It is possible that our target population of adolescents in distressed environments may be uniquely susceptible to some of these issues due to the disadvantage communities in which they reside.

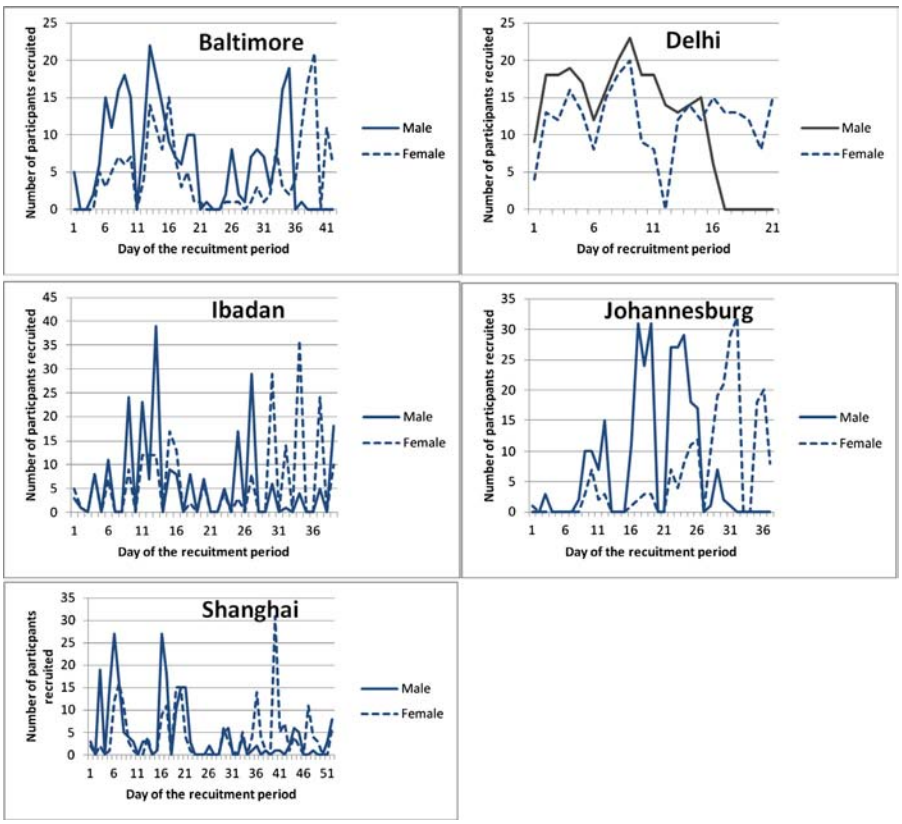

Figure 1. Daily recruitment by gender and site.

Table 3
Participation of high mobility and out-of-school youth, by site

	Baltimore	Delhi	Ibadan	Johannesburg	Shanghai	All sites
	Weighted percentage[a]	Weighted percentage[a]	Weighted percentage[a]	Weighted percentage[a]	Weighted percentage[a]	Weighted percentage[a]
Housing status[b]	N = 475	N = 500	N = 465	N = 497	N = 455	N = 2,388
Stably housed	95.85	71.66	78.41	78.04	88.74	82.44
Unstably housed	4.15	28.34	21.59	21.96	11.26	17.56
School enrollment by age group						
Ages 15–16 years	N = 252	N = 284	N = 267	N = 123	N = 127	N = 1,086
In school	97.80	92.63	93.57	90.58	59.43	87.53
Out of school	2.20	7.37	6.43	9.42	40.57	12.47
Ages 17–19 years	N = 203	N = 216	N = 181	N = 371	N = 311	N = 1,302
In school	68.10	73.69	69.51	77.92	21.13	61.50
Out of school	31.90	26.31	30.49	22.08	78.87	38.50
Past-month school absenteeism[c]	N = 388	N = 428	N = 364	N = 406	N = 125	N = 1,745
0 days	19.41	4.77	12.08	16.96	69.48	18.89
1–2 days	23.24	27.34	11.38	36.41	27.03	25.20
3–5 days	35.6	33.42	11.77	34.55	2.65	26.51
>6 days	21.76	34.48	64.77	12.09	.84	29.40

[a] Weighted percentage adjusted for respondent-driven sampling and age.
[b] Does not have a regular place to stay or has a regular place to stay but (1) stayed there, on average, less than four nights per week in the past 30 days and (2) stayed in two or more different places in the past week.
[c] Number of days of school missed in the past 30 days among those currently in school.

Gender differences in recruitment patterns were notable, with women recruiting more slowly than their male counterparts, and young men recruiting men to a greater extent than women, suggesting that their networks are more accessible. This created challenges in gender balance across the sample and concern for small cell sizes for the women's sample. By their nature, past RDS studies with MSM [17] and FSWs [18] are gender-stratified and thus do not allow observations on potential gender differences in recruitment pace. The consistency of our findings on gender recruitment pace across sites is striking, and strongly suggests gender as a critical dimension in RDS recruitment. Gender-stratification of coupons could mitigate this issue in future mixed-gender RDS research.

Evidence of inclusion of unstably housed (nearly 10%) and out of school youth (12-38%) suggests that RDS enabled the study to reach into adolescent populations that may have been missed by traditional household- or school-based survey methods. For example, in household surveys, a respondent to the survey is selected after his/her household is selected, usually from a complete listing of households in the survey target area. Using this sampling strategy, the household is the primary sampling unit and thus any respondent who is not stably housed might be missed, biasing the results of the survey. In school-based surveys, respondents are usually selected to participate from a listing of all students in a school or a particular classroom. With this sampling strategy, any potential respondent must be enrolled in school and be present on the day of interview (not absent and regularly attending school). Any adolescent who has dropped out of school, has graduated, or is frequently truant risks being missed by school-based sampling. RDS can offer a means of overcoming these limitations; in turn, it can complement the knowledge gleaned from school- and household-based surveillance systems for youth, particularly where concerns for housing instability and out-of-school youth are pervasive.

Housing instability and missed school estimates should be considered with some caution, despite measurement piloting. In Delhi sample, the 17% housing instability estimate was felt to be unrealistically high. Cultural differences were felt to have prompted misinterpretation in the assessment, particularly as it relates to what constitutes "home." For example, child of migrants may not have considered Delhi as a permanent home and in turn responded having lived away from home. Youth who co-reside with their parents are strictly supervised such that the very concept of staying away from their parents was alien to them. In addition, due to delays, some data collection overlapped with holiday breaks, particularly in Ibadan. This introduces potential inaccuracies in housing instability and missed school days, where participants may have included school days missed due to being on vacation, and/or housing instability due to traveling during this time.

While findings indicate that RDS enabled inclusion of respondents who risk being missed in school based survey or a household survey, a more rigorous evaluation of reach into these populations would require a comparative design. The broader generalizability of our sample is unknown. It is possible that unknown barriers restricted participation and potentially created bias. The advantages of data collection via ACASI may vary across contexts [25,30–32], which is a challenge for its use in a protocol shared across geo-cultural settings. Several limitations of RDS also warrant consideration in interpreting the current results and in considering the value of RDS for youth in distressed urban settings. Some evidence indicates that RDS sampling inference methods can fail to mitigate bias - with youth in particular under-represented [33]. This unmitigated bias can emerge where specific sub-populations are over- or under-recruited by all groups, rather than specific groups, and where under-represented groups have network sizes comparable to those of their non-under-represented peers [33]. These and other evaluations of RDS highlight the need to optimize the inferences that can be made using this method [34], and underscore the value of formative research before implementing RDS. Many of the ethical issues associated with RDS are unique to marginalized populations more so than the method itself [35]. One exception is that of monetary incentives; where RDS is used in HIV research, obtaining test results is a dominant participation motivation [36]. By contrast, participation motivations remain unclear for studies that lack additional benefits, such as ours, highlighting the need to ensure that monetary incentives are sufficient, but not so high as to coerce participation [36]. Finally

geospatial elements can influence RDS recruitment; for example residential location and proximity to study site relates to recruitment probability in some settings [37], and geospatial bottlenecks can also occur, rending some geographic areas effectively excluded [38]. While we did not collect the identifiers, e.g., geocoding data, necessary to evaluate potential geospatial biases, our study sites represented smaller, predesignated geographic areas within large cities.

Overall, our findings illustrate the feasibility, efficiency, and utility of RDS for adolescent surveillance in distressed urban environments across multiple geocultural settings. Our study is timely given the rapid urbanization and growth of the youth population globally, coupled with recognition of the social-structural hazards of vulnerable urban environments. RDS may well serve as a valuable recruitment tool to monitor health and well-being among young people in these urban environments, particularly where they risk being overlooked by household and school-based surveillance systems. It is critical to ensure the voices and experiences of homeless, marginally and unstably housed, and out-of-school youth in the surveillance that guides health-related policy.

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References

[1] Sawyer SM, Afifi RA, Bearinger LH, et al. Adolescence: A foundation for future health. Lancet 2012;379:1630–40.
[2] Patton GC, Coffey C, Cappa C, et al. Health of the world's adolescents: A synthesis of internationally comparable data. Lancet 2012;379:1665–75.
[3] Gray N, Azzopardi P, Kennedy E, et al. Improving adolescent reproductive health in Asia and the Pacific: Do we have the data? A review of DHS and MICS surveys in nine countries. Asia Pac J Public Health 2013;25:134–44.
[4] Reynolds HW, Wong EL, Tucker H. Adolescents' use of maternal and child health services in developing countries. Int Fam Plan Perspect 2006;32:6–16.
[5] Akmatov MK. Child abuse in 28 developing and transitional countries—results from the Multiple Indicator Cluster Surveys. Int J Epidemiol 2011;40:219–27.
[6] Kennedy E, Gray N, Azzopardi P, Creati M. Adolescent fertility and family planning in East Asia and the Pacific: A review of DHS reports. Reprod Health 2011;8:11.
[7] Magadi MA, Agwanda AO, Obare FO. A comparative analysis of the use of maternal health services between teenagers and older mothers in sub-Saharan Africa: Evidence from Demographic and Health Surveys (DHS). Soc Sci Med 2007;64:1311–25.
[8] Peltzer K. Early sexual debut and associated factors among in-school adolescents in eight African countries. Acta Paediatr 2010;99:1242–7.
[9] Roberts C, Currie C, Samdal O, et al. Measuring the health and health behaviours of adolescents through cross-national survey research: Recent developments in the health behaviour in school-aged children (HBSC) study. J Public Health 2007;15:179–86.
[10] UNICEF. The state of the world's children 2011: Adolescence—an age of opportunity; 2011.
[11] Marmot M, Friel S, Bell R, et al. Closing the gap in a generation: Health equity through action on the social determinants of health. Lancet 2008; 372:1661–9.
[12] UNICEF. The state of the world's children 2012: Children in an urban world. New York, NY; 2012:2012.
[13] Woan J, Lin J, Auerswald C. The health status of street children and youth in low- and middle-income countries: A systematic review of the literature. J Adolesc Health 2013;53:314–321.e21.
[14] Heckathorn DD. Respondent-driven sampling: A new approach to the study of hidden populations. Social Probl 1997:174–99.
[15] Magnani R, Sabin K, Saidel T, Heckathorn D. Review of sampling hard-to-reach and hidden populations for HIV surveillance. AIDS 2005;19-(Suppl 2):S67–72.
[16] Burt RD, Thiede H. Evaluating consistency in repeat surveys of injection drug users recruited by respondent-driven sampling in the Seattle area: results from the NHBS-IDU1 and NHBS-IDU2 surveys. Ann Epidemiol 2012; 22:354–63.
[17] Baral SD, Ketende S, Mnisi Z, et al. A cross-sectional assessment of the burden of HIV and associated individual- and structural-level characteristics among men who have sex with men in Swaziland. J Int AIDS Soc 2013; 16(Suppl 3):18768.
[18] Decker MR, Wirtz AL, Moguilnyi V, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV Prevention. AIDS Behav 2014;18:562–72.
[19] Qiu P, Yang Y, Ma X, et al. Respondent-driven sampling to recruit in-country migrant workers in China: A methodological assessment. Scand J Public Health 2012;40:92–101.
[20] Johnston LG, Thurman TR, Mock N, et al. Respondent-driven sampling: A new method for studying street children with findings from Albania. Vulnerable Child Youth Stud 2010;5:1–11.
[21] Gwadz MV, Cleland CM, Quiles R, et al. CDC HIV testing guidelines and the rapid and conventional testing practices of homeless youth. AIDS Educ Prev 2010;22:312–27.
[22] Mmari K, Blum R, Sonenstein F, et al. Adolescents' perceptions of health from disadvantaged urban communities: Findings from the WAVE study. Soc Sci Med 2014;104:124–32.
[23] Johnston LG, Malekinejad M, Kendall C, et al. Implementation challenges to using respondent-driven sampling methodology for HIV biological and behavioral surveillance: Field experiences in international settings. AIDS Behav 2008;12(4 Suppl):S131–141.
[24] Johnston LG, Whitehead S, Simic-Lawson M, Kendall C. Formative research to optimize respondent-driven sampling surveys among hard-to-reach populations in HIV behavioral and biological surveillance: Lessons learned from four case studies. AIDS Care 2010;22:784–92.
[25] Ghanem KG, Hutton HE, Zenilman JM, et al. Audio computer assisted self interview and face to face interview modes in assessing response bias among STD clinic patients. Sex Transm Infect 2005;81: 421–5.
[26] White RG, Lansky A, Goel S, et al. Respondent driven sampling—where we are and where should we be going? Sex Transm Infect 2012;88: 397–9.
[27] Volz E, Heckathorn D. Probability based estimation theory for respondent driven sampling. J Official Stat 2008;24:79–97.
[28] Robinson WT, Risser JM, McGoy S, et al. Recruiting injection drug users: A three-site comparison of results and experiences with respondent-driven and targeted sampling procedures. J Urban Health 2006;83(6 Suppl): i29–38.
[29] Yeka W, Maibani-Michie G, Prybylski D, Colby D. Application of respondent driven sampling to collect baseline data on FSWs and MSM for HIV risk reduction interventions in two urban centres in Papua New Guinea. J Urban Health 2006;83(6 Suppl):i60–72.
[30] Jaya, Hindin MJ, Ahmed S. Differences in young people's reports of sexual behaviors according to interview methodology: A randomized trial in India. Am J Public Health 2008;98:169–74.
[31] Mensch BS, Hewett PC, Erulkar AS. The reporting of sensitive behavior by adolescents: A methodological experiment in Kenya. Demography 2003; 40:247–68.
[32] Rathod SD, Minnis AM, Subbiah K, Krishnan S. ACASI and face-to-face interviews yield inconsistent estimates of domestic violence among women in India: The Samata Health Study 2005-2009. J Interpers Violence 2011;26:2437–56.
[33] McCreesh N, Frost SD, Seeley J, et al. Evaluation of respondent-driven sampling. Epidemiology 2012;23:138–47.
[34] Salganik MJ. Commentary: respondent-driven sampling in the real rorld. Epidemiology 2012;23:148–50.
[35] Semaan S, Lauby J, Liebman J. Street and network sampling in evaluation studies of HIV risk-reduction interventions. AIDS rev 2002;4: 213–23.
[36] DeJong J, Mahfoud Z, Khoury D, et al. Ethical considerations in HIV/AIDS biobehavioral surveys that use respondent-driven sampling: illustrations from Lebanon. Am J Public Health 2009;99:1562–9.
[37] McCreesh N, Johnston LG, Copas A, et al. Evaluation of the role of location and distance in recruitment in respondent-driven sampling. Int J Health Geogr 2011;10:56.
[38] Toledo L, Codeco CT, Bertoni N, et al. Putting respondent-driven sampling on the map: insights from Rio de Janeiro, Brazil. J Acquir Immune Defic Syndr 2011;57(Suppl 3):S136–43.