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DOI

[10.1159/000336118](https://doi.org/10.1159/000336118)

Publication date

2012

Document Version

Author accepted manuscript

Published in

European Addiction Research

[Link to publication](#)

Citation for published version (APA):

Oteo Pérez, A., Benschop, A., & Korf, D. J. (2012). Differential profiles of crack users in respondent-driven and institutional samples: a three-site comparison. *European Addiction Research*, 18(4), 184-192. <https://doi.org/10.1159/000336118>

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Oteo Pérez, A., Korf, D. J., & Benschop, A. (2012). Differential profiles of crack users in respondent-driven and institutional samples: A three-site comparison. *European Addiction Research*, 18, 192. DOI: 10.1159/000336118.

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Differential Profiles of Crack Users in Respondent-Driven and Institutional Samples: A Three-Site Comparison.

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Abstract

Background/aim: Respondent-driven sampling (RDS) is increasingly applied in social epidemiological surveys among ‘hidden populations’ of hard drug users. The objective was to assess whether the profile of frequent crack users recruited through RDS differed from those surveyed in two random institutional samples: low threshold opiate substitution treatment (ST) and user rooms (UR).

Methods: A total of 1039 crack users (mean age 45.1 ± 9.1 , 81.5% males, 49.5% non-western ethnicity) were interviewed in three Dutch cities, using each sampling strategy in each city. Characteristics of respondents in the three samples (per city and aggregated) were compared.

Results: Crack users in RDS were more likely to be younger, and less likely to be low educated, to have a long crack-using career (≥ 10 years), to use opiates and to attend ST than those in both other samples. RDS and UR samples showed most differences, with more female and western crack users in RDS, and UR participants more likely to have been arrested and to have entered in-patient drug treatment in the last year.

Conclusion: RDS resulted in a different profile of crack users. It is a valuable methodology to reach a more diverse representation of crack-using populations than institutional random samples.

Keywords: Crack cocaine, hidden populations, social epidemiology, respondent-driven sampling, institutional sampling, profile of users, Netherlands.

Introduction

Since the mid-1980s, first freebasing cocaine and then smoking crack has become more and more popular among hard drug users in The Netherlands [1, 2], making crack one of the drugs of most concern [3-5]. According to qualitative field studies, frequent and continued crack use often evokes a process of marginalization [6-8]. Registration data on treatment demand show that the average age of crack users in The Netherlands has been increasing for many years, a growing proportion is in contact with the judicial system and many are unemployed and homeless [9, 10]. Most

of these research findings are derived from institutionalized crack users (captive samples) or from ‘street scenes’ and therefore lack an unbiased sampling frame from which to draw a probabilistic sample. This is a common problem among populations defined by illicit and/or stigmatized behaviour, as is typically the case with crack users. Several studies have found differences between the demographic characteristics and drug-using patterns of drug users in treatment and not in treatment [11-13]. This raises the question: to what extent can findings be understood as statistically representative of the whole population of crack users?

Since the mid-1980s, many Dutch researchers have used recruitment methods like snowball sampling in order to avoid selectivity by studying institutionalized drug users only [8, 14-17]. However, as with captive populations, a major methodological issue in snowball sampling is the problem of selectivity [14, 18, 19]. In attempting to address this problem, some Dutch drug researchers introduced and implemented randomization into snowball sampling. Respondents were first asked to nominate all their acquaintances in the population and then a limited number (usually two), was randomly selected from their list [2, 20, 21].

A major step forward in snowball sampling methodology has been the introduction of respondent-driven sampling (RDS), a modified chain-referral method developed by Heckathorn [22-24]. With RDS, first, an initial group of respondents (‘seeds’) is selected. Seeds are offered two types of incentives: one for completing the interview and another for recruiting new respondents, who become part of referral chains and are requested to recruit other new respondents who in turn are asked to recruit others, and so on. Information on who recruited whom is collected through a numerated coupon system and the number of referrals per recruiter is limited. Because RDS relies on social networks, it can potentially reach individuals not found in public

venues. If recruitment chains are long enough (i.e. there are enough ‘waves’ of recruitment), the sample will reach ‘equilibrium’, indicating that the final sample is not biased by the purposive selection of seeds. In addition, RDS can generate unbiased population estimates and confidence intervals accounting for each individual’s probability of being included in the sample (i.e. personal network size) and for the probability that persons with certain characteristics recruit others with similar characteristics [22-24].

From the late 1990s onwards, RDS has cautiously been adopted in many countries to conduct surveys among ‘hard-to-reach’ populations [25, 26]. Several studies have compared RDS samples of injection drug users (IDUs) with other chain referral methods [27], as well as with other sampling methods, including targeted and outreach sampling [28-31] and time location sampling [32]. Only one study, by Burt et al. in Seattle (U.S.A.) [33] tested differences between IDUs recruited through RDS and those in three institutional samples, reporting the RDS estimated population to be older. As Rudolph et al. [29] point out, most of these studies, including the one by Burt et al., compared samples obtained within different time frames [31, 32], sometimes up to a decade [33], and sometimes from different geographic locations [31], thereby introducing a possible source of bias due to temporal trends or geographic differences.

The underlying assumption in RDS theory is that it can produce representative samples. Testing this assumption would require data from a normative sample as reference (e.g. a household survey). However, crack use prevalence in the general population is so low that very large, thus costly, samples would be required to generate reliable estimates. Moreover, a significant proportion of crack users might

not be reached with general population surveys, due to homelessness, incarceration, etc.

The objective of this study is to assess whether sampling through RDS yields a different profile of crack users than through random samples in two institutional settings: low threshold substitution treatment (ST) and consumption or user rooms (UR). We compare samples that are drawn in the same period within each of the three cities under study.

Although there is no consistency in the cited literature, we explore differences in demographic variables, as well as drug use and institutional contact. Contrary to the findings of Burt et al., our first hypothesis is that crack users in RDS will be younger because, in practice, the minimum age for entry into UR and ST is 23 years. Secondly, since UR facilities, in order to keep drug users from the street, also function as day shelters, we hypothesize that homelessness is less frequent in RDS. Our third hypothesis is that heroin use will be less prevalent in RDS because a history of heroin use is a prerequisite for ST.

Methods and samples

This study was conducted as a social epidemiological part of the multidisciplinary project “Prevalence, treatment needs and new pharmacotherapeutical options for crack users in The Netherlands”. The full study design was approved by the ethical committee of the Faculty of Medicine of the University of Amsterdam. In total, 1039 frequent crack users in the three largest Dutch cities (Amsterdam, Rotterdam, and The Hague, with approx. 770,000, 590,000 and 490,000 residents respectively) were interviewed consecutively during a six-month period in each city, starting in March 2009 in Amsterdam and ending in

January 2011 in Rotterdam. Inclusion criteria were: ≥ 18 years of age, living within the city area, currently using crack at least two days/week, and speaking the Dutch language. Participants had to show the researchers their ID in order to create an 11-digit code (first last name letters, birth date and gender). This was done to prevent repeated interviews, as well as for matching purposes in capture-recapture estimations at a later stage in the study. Respondents signed an informed consent form before being interviewed face-to-face with a structured questionnaire, lasting 30 to 45 minutes and including items about demographic characteristics, drug use, the crack market and their interest in new treatment options. Additionally, RDS respondents provided information regarding their network size. Participants received ten euro for the interview, and RDS respondents an additional five euro for each successfully recruited respondent.

Respondent-driven Sampling: Before starting RDS in each city, relevant geographic areas were identified, followed by ethnographic field research. Informal conversations with outreach workers, police, drug user associations, dealers, community members, and other key informants were carried out to identify user networks and ‘scenes’. We selected seeds from different neighborhoods taking into account diversity (age, gender, ethnicity, contact with institutions), access to large social networks of crack users and initial motivation to start the recruitment process [23, 34]. A total of 25 seeds were selected, out of which 16 were productive (i.e. recruited other crack users). Participants received two coupons to invite other crack users they knew to the study. Only recruits presenting their coupons were allowed to participate. Duplicate interviews were prevented by verifying the recruit’s ID, although attempts to do this barely happened. After a first screening, appointments were made where it most suited respondents (bars, parks, shelters and private

households) as long as confidentiality was assured. Of all recruits, 18 did not meet the inclusion criteria. Most of the 16 recruitment chains ended naturally; only the two longest chains in Amsterdam and Rotterdam were stopped at the end of the six-month period. By then recruitment had slowed down considerably. Rotterdam produced the longest chain with 26 waves, compared to 20 in The Hague and 18 in Amsterdam.

A probabilistic sampling procedure was followed in the two other settings in order to avoid selection and volunteerism biases.

User rooms: These are facilities where hard drug users can administer their drugs under supervision. Their aim is to reduce drug-related street nuisance and health problems. First, we obtained an inventory of crack using clients of all URs within each city. The sampling frame included all twelve relevant locations: six in Amsterdam, four in Rotterdam and two in The Hague. A stratified randomized sample was drawn from each location, based on the number of crack using clients in each UR. The final samples represent 46.5%, 44.3% and 78.1% respectively of all crack users currently in contact with these facilities.

Substitution treatment: ST are low threshold outpatient facilities for opiate substitution treatment (mainly methadone and sometimes also heroin). In these programs abstinence is not required and crack use is very common among clients [35]. The same procedure as for UR was followed. An inventory of all current ST patients with crack use as primary or secondary problem was obtained, and a sampling frame was created including all 14 main ST facilities: five in Amsterdam, six in Rotterdam and three in The Hague. A stratified randomized sample was drawn from each location according to its number of clients. The samples represent 29.6%, 19.8% and 30.0% respectively of all crack users currently registered in these programs.

Duplicate interviews

Some individuals can be found in two or even three samples in each city. Rather than repeating the lengthy interview, the interviews of those who had already completed it as a member of one sample were re-used if they were recruited to a second or third sample. RDS recruits who had already been interviewed in an ST or UR sample answered additional questions regarding their network size, and received two coupons to continue the recruitment process. Individuals appearing in two or three samples are referred to as duplicates.

Table 1 shows the number of unique and duplicate interviews in each city, response rates and coupon return rates. Non-productive seeds were excluded from analysis, since they were not part of any referral chain and, therefore, do not contribute to RDSAT corrections (Johnston, L., personal communication). Hence, a total of 1039 respondents were included in the total sample, of which 915 were only in one sample, 111 were in two, and 13 were in three samples.

Data analysis

We tested differences between RDS and the other two samples in each city on three topics:

- Demographic characteristics: Gender (*Female*), Age (*Younger than 35*, the 10th percentile), Ethnicity (*Non-western*, according to Statistics Netherlands classification [36], Education (*Low education*, completed primary school or lower), Homelessness (*Homeless*, slept mostly on the street or in a shelter in the last 30 days), Employment (*Working*, legally paid job or low threshold work project).
- Drug use: Lifetime and last month heroin use (*Heroin LT*, *Heroin LM*), Lifetime intravenous drug use (*IDU Lifetime*), Frequent crack use (*Near-daily crack*, six or

seven days of crack use per week), Crack use career (*Long crack career*, 10 or more years since onset, the 80th percentile).

- Institutional contact: Arrested last year (*Arrested last year*), Substitution treatment last month (*ST last month*), In-patient drug treatment last year (*IDT last year*, short stay detoxification or in-patient rehabilitation treatment in the last 12 months).

All data was analyzed using PASW 17.0. Adjusted population proportions and 95% confidence intervals for RDS were calculated with RDS Analysis Tool 6.0 (RDSAT). This software adjusts for participants' network sizes and recruitment patterns in order to provide asymptotically unbiased population estimates [37]. Network size estimation was based on successive questions about the number of frequent crack users a respondent knew (who also knew him/her) in the city and how many they had seen in the last month and could speak Dutch.

Several researchers have compared data obtained through RDS with data from other sampling methods through different statistical approaches, but to date, no method has found general acceptance [26, 38]. A method commonly used is comparing RDS population estimates with sample proportions of other samples using their confidence intervals (CIs) [30, 39]. When CIs of two point estimates do not overlap, the difference between them is significant but stating that the difference between two overlapping CIs is not significant would be too conservative [40]. An alternative method is to compare RDS sample proportions with sample proportions of other samples using traditional χ^2 analysis [29]. This method does not account for RDS design effects. We used a method published by Burt et al. [33], which compares RDS population estimates with sample proportions of other samples using a χ^2 test after adjusting for RDS design effects. RDS design effect (DE) is calculated as $(S.E._{bootstrap})^2 / (p(1-p)n)$, where $S.E._{bootstrap}$ is the RDSAT generated standard error for

the population estimate (p) and n is the sample size. The RDS population estimate, multiplied by the sample size, divided by the design effect ($p*n/DE$) and the actual number of ST and UR participants in each category of interest were entered in the adjusted χ^2 analysis. Table 2 shows RDS sample proportions and population estimates with their 95% confidence intervals for each city, as well as standard errors and design effects needed for the adjusted χ^2 test.

Non-significant differences between samples could be due to relatively small sample sizes in each city. For this reason, after assessing if differences were consistent across the three cities, we conducted a second analysis aggregating the three cities within each sampling method to test differences with a larger sample size. Since RDS design effects could only be calculated for each city, traditional χ^2 and RDS sample proportions were used in this case, thus not correcting for sampling biases. We compared sample characteristics with and without duplicate interviews to assess whether the inclusion of the same subjects in various samples had a significant effect on the final results.

Results

A total of 1039 unique participants were recruited, mostly males (81.5%) and in their forties and fifties (mean age: 45.1; s.d: 9.09). Less than 10% were younger than 35, half of them were non-western (49.5%), approximately one in five had finished the secondary school (20.8%), 11.6% were homeless and less than half had work (44.3%). Most respondents used heroin (89.3% LT and 72.1% LM). One third had ever injected drugs (32.8%), more than the half used crack near-daily (52.1%) and 85.5% had been using crack for 10 or more years. 44.5% had been arrested in the last year, 72.1% had attended ST in the last month and 18.4% had attended IDT in the last year.

Table 1. Number of respondents per sample and subsample and response rates.

City	All included				Unique respondents								Coupon return rates (%)	Response rates			No. of productive seeds/Total
	Respondents per sample			Total	Respondents in one sample			Respondents in two or three samples				Total		Response rates (%)			
	RDS	UR	ST		RDS	UR	ST	RDS/UR	RDS/ST	UR/ST	RDS/UR/ST			RDS	ST	UR	
Amsterdam	200	79	198	477	177	59	168	6	16	13	1	440	50.9	81.2	93.8	4/8	
Rotterdam	192	78	104	374	153	52	67	12	23	10	4	321	50.2	79.2	95.0	5/7	
The Hague	144	76	105	325	113	42	84	18	5	8	8	278	55.9	88.3	96.2	7/10	
Total	536	233	407	1176	443	153	319	36	44	31	13	1039	51.9	80.0	95.0	16/25	

Table 2. RDS samples and estimates characteristics per city

	Amsterdam (N=200)				Rotterdam (N=192)				The Hague (N=144)			
	sample				sample				sample			
	%	pop. % (95% CI)	s.e.	d.e.	%	pop. % (95% CI)	s.e.	d.e.	%	pop. % (95% CI)	s.e.	d.e.
<i>Demographic characteristics</i>												
Female	25.5	22.9 (14.7-31.9)	0.044	2.19	18.8	21.3 (13.1-30.2)	0.044	2.22	19.4	14.2 (7.6-23.3)	0.040	1.47
Younger than 35	8.0	9.1 (4.1-13.8)	0.025	1.51	9.4	11.7 (4.0-23.8)	0.051	4.83	23.6	24.8 (14.4-37.3)	0.058	2.60
Non-western	50.3	43.3 (33.5-55.0)	0.057	2.65	45.8	42.7 (32.4-52.4)	0.050	1.96	38.9	35.9 (22.4-48.6)	0.067	2.83
Low education	69.0	63.9 (51.4-74.0)	0.057	2.82	77.6	76.1 (67.0-84.5)	0.044	2.04	81.9	85.9 (77.7-92.3)	0.037	1.63
Homeless	12.5	9.7 (4.4-16.0)	0.030	2.06	8.9	9.6 (3.9-16.8)	0.033	2.41	17.4	15.3 (6.6-26.0)	0.050	2.78
Work	50.5	42.8 (31.7-55.1)	0.060	2.94	41.7	40.2 (31.0-49.9)	0.048	1.84	52.1	48.9 (35.5-61.9)	0.068	2.66
<i>Drug use</i>												
Heroin LT	86.5	80.9 (69.7-90.5)	0.053	3.64	84.9	80.9 (70.4-90.6)	0.052	3.36	73.6	68.4 (51.7-83.3)	0.081	4.37
Heroin LM	70.5	57.4 (45.1-68.7)	0.060	2.94	74.5	72.2 (61.0-81.5)	0.052	2.59	51.4	49.1 (34.2-64.2)	0.076	3.33
IDU Lifetime	32.5	33.0 (22.3-44.9)	0.055	2.74	33.3	32.8 (24.2-41.8)	0.045	1.76	34.7	35.6 (22.4-49.5)	0.068	2.90
Near-daily crack	53.5	48.8 (37.3-60.8)	0.059	2.79	59.4	50.1 (41.6-60.6)	0.048	1.77	45.8	42.6 (29.7-55.8)	0.067	2.64
Long crack career	83.5	79.0 (71.0-87.6)	0.042	2.13	83.9	81.8 (73.7-89.1)	0.039	1.96	75.0	75.7 (64.7-85.5)	0.053	2.20
<i>Institutional contact</i>												
Arrested last year	50.0	46.3 (34.8-57.3)	0.057	2.61	35.1	31.9 (23.5-43.5)	0.050	2.18	48.2	46.7 (35.4-60.2)	0.061	2.08
ST last month	60.5	50.2 (38.6-61.4)	0.060	2.88	58.3	53.7 (42.6-64.0)	0.055	2.34	47.9	50.7 (34.9-65.3)	0.077	3.42
IDT last year	10.5	7.1 (3.1-11.9)	0.018	0.98	20.3	16.3 (10.2-22.3)	0.034	1.56	16.0	11.4 (6.1-18.3)	0.033	1.46

Table 3 shows characteristics of the three samples (duplicates included) and adjusted χ^2 test for differences between samples per city. Equilibrium was reached for all variables under study.

Demographic characteristics: the proportion of women was higher in RDS than in UR in Amsterdam and Rotterdam. RDS crack users were more often younger than 35 years than in ST in Rotterdam and The Hague, and were less often non-western than in UR in Amsterdam and The Hague. In Amsterdam, RDS showed fewer low-educated crack users than UR and ST and also fewer homeless people than UR. The proportion of working crack users was similar in all samples in each city.

Drug use: RDS consistently showed less heroin use than the other two samples but higher lifetime IDU than UR in Amsterdam and The Hague. Near-daily use was less frequent in RDS than in UR in Amsterdam, and a long crack use career was less frequent in RDS than in UR in Amsterdam and than ST in all three cities.

Institutional contact: Around half of the RDS population in the three cities was estimated to have attended ST in the last month, less than UR in Amsterdam and Rotterdam. Crack users in RDS were also less likely to have entered IDT in the last year than in ST in Amsterdam and in UR in Rotterdam and The Hague. The proportion of crack users arrested in the last year was similar for all samples in each city.

Table 3. Comparison RDS population estimates with institutional samples per city

	Amsterdam			Rotterdam			The Hague			Amsterdam		p-values Rotterdam		The Hague	
	RDS pop. %	UR %	ST %	RDS pop. %	UR %	ST %	RDS pop. %	UR %	ST %	RDS vs. UR	RDS vs. ST	RDS vs. UR	RDS vs. ST	RDS vs. UR	RDS vs. ST
<i>N</i>	200	79	198	192	78	104	144	76	105						
<i>Demographic characteristics</i>															
Female	22.9	11.4	15.2	21.3	9.0	16.3	14.2	17.1	22.9	0.046	0.101	0.033	0.417	0.700	0.608
Younger than 35	9.1	6.3	7.6	11.7	3.8	1.0	24.8	19.7	7.6	0.476	0.623	0.118	0.002	0.505	0.003
Non-western	43.3	87.2	51.3	42.7	57.7	46.2	35.9	63.2	37.1	<0.001	0.261	0.051	0.672	0.002	0.861
Low education	63.9	83.5	82.8	76.1	83.3	86.5	85.9	89.5	81.9	0.005	<0.001	0.259	0.065	0.544	0.401
Homeless	9.7	22.8	7.6	9.6	14.1	5.8	15.3	27.6	9.5	0.013	0.615	0.428	0.283	0.104	0.278
Work	42.8	50.6	49.5	40.2	43.6	30.8	48.9	35.5	33.3	0.333	0.329	0.664	0.148	0.149	0.069
<i>Drug use</i>															
Heroin LT	80.9	94.9	100	80.9	97.4	100	68.4	81.6	100	0.008	<0.001	<0.001	<0.001	0.169	<0.001
Heroin LM	57.4	86.1	72.7	72.2	87.2	88.5	49.1	72.4	79.0	<0.001	0.018	0.020	0.005	0.010	<0.001
IDU Lifetime	33.0	15.2	33.8	32.8	34.6	40.4	35.6	17.1	44.8	0.010	0.882	0.821	0.265	0.016	0.301
Near-daily crack	48.8	74.7	42.4	50.1	61.5	57.7	42.6	53.6	43.8	<0.001	0.365	0.119	0.261	0.116	0.883
Long crack career	79	93.7	89.4	81.8	85.9	96.2	75.7	81.6	88.6	0.005	0.014	0.449	<0.001	0.397	0.027
<i>Institutional contact</i>															
Arrested last year	46.3	60.8	48.0	31.9	45.5	27.9	46.7	56.6	42.9	0.066	0.775	0.081	0.518	0.218	0.660
ST last month	50.2	68.4	100	53.7	79.6	100	50.7	63.2	100	0.023	<0.001	0.002	<0.001	0.165	<0.001
IDT last year	7.1	15.2	18.2	16.3	32.1	25.0	11.4	34.2	19.0	0.062	0.005	0.014	0.142	<0.001	0.184

We observed that although differences between RDS and institutional samples vary according to city, results point mostly in the same direction. We therefore aggregated the data from the three cities for each sample, including duplicates, and tested for differences (Table 4).

Demographic characteristics: Crack users in the RDS sample were more often female than in UR, more often younger than 35 than in ST, less often non-western than in UR, and less likely to be low-educated than in UR and ST. RDS recruited less homeless crack users than UR, but more than ST. RDS crack users were also more likely to be working than those in ST.

Drug use: Heroin use was lowest in RDS while lifetime IDU was lowest in UR. Those in the RDS sample were less likely to be near-daily crack users than in UR but more than in ST. RDS recruited less individuals with a long crack-using career than the other two samples.

Institutional contact: RDS showed differences in all three variables compared to UR, but no differences with ST, except last month ST attendance. Crack users recruited through RDS were less likely to have been arrested last year than those in the UR sample and to have attended ST last month and IDT last year.

When excluding duplicate interviews from the analysis, we found very similar results. In conclusion, the observed differences between RDS and the other two samples are quite consistent either with or without aggregated samples or duplicate interviews.

Table 4. Comparison between aggregated samples of the three cities with and without duplicates

Aggregate with duplicates						Aggregate unique interviews					
	RDS sample %	UR %	p	ST %	p	RDS sample %	UR %	p	RDS sample %	ST %	p
N	536	233		407		487	184		479	350	
<i>Demographic characteristics</i>											
Female	21.5	12.4	0.003	17.4	0.125	21.4	9.8	<0.001	22.3	18.0	0.127
Younger than 35	12.7	9.9	0.267	5.9	<0.001	12.3	8.2	0.126	13.4	5.7	<0.001
Non-western	45.5	69.1	<0.001	46.2	0.838	45.2	74.5	<0.001	45.0	45.3	0.933
Low education	75.6	85.4	0.002	83.5	0.003	74.3	84.8	0.004	73.9	82.6	0.003
Homeless	12.5	21.5	0.001	7.6	0.015	10.7	19.0	0.004	12.3	6.9	0.010
Work	47.8	43.3	0.259	40.5	0.027	47.8	42.4	0.206	47.4	39.1	0.018
<i>Drug use</i>											
Heroin LT	82.5	91.4	0.001	100	<0.001	81.3	90.8	0.003	80.4	100	<0.001
Heroin LM	66.8	82.0	<0.001	78.4	<0.001	65.1	81.5	<0.001	64.7	77.4	<0.001
IDU Lifetime	33.4	22.3	0.002	38.3	0.117	33.5	19.6	<0.001	32.2	37.4	0.114
Near-daily crack	53.5	64.4	0.005	46.7	0.037	52.4	64.1	0.006	52.6	44.0	0.014
Long crack career	81.3	87.1	0.049	90.9	<0.001	81.1	88	0.033	80.4	91.1	<0.001
<i>Institutional contact</i>											
Arrested last year	44.2	54.3	0.010	41.5	0.476	43.1	54.1	0.011	45.1	42.0	0.382
ST last month	56.3	69.5	<0.001	100	<0.001	54.6	69.0	<0.001	51.6	100	<0.001
IDT last year	15.5	27.0	<0.001	20.1	0.062	13.6	25.0	<0.001	14.6	19.7	0.052

Conclusion and discussion

Our objective was to assess whether crack users recruited through RDS are different than those found in random institutional samples (ST and UR). RDS resulted in a different profile of crack users, with differences being mostly consistent across cities.

In line with our first hypothesis, RDS resulted in more crack users in the younger age group (< 35 years of age) as well as in less crack users with a long crack-using career (> 10 years). However, most RDS respondents belonged to the older age group and very few (9/440) were younger than 23 (the minimum age in practice for UR and ST). This is in accordance with the findings in earlier studies that crack use in the Netherlands is very uncommon among young people [6, 7]. It might be argued that RDS underestimated young crack users because these are less involved in crack user networks. However, it is very unlikely for frequent crack users to remain isolated

from these networks [7]. Sometimes we found young crack users involved in older networks and sometimes also in more exclusive networks of young people, but only in small numbers. Our second hypothesis, stating that homelessness would be more prevalent in UR than in RDS, was also verified. Our third hypothesis, that heroin is less prevalent in RDS because a history of heroin use is a prerequisite for ST, was also confirmed. Lifetime and last month heroin use were lower in RDS than in UR and ST. The confirmation of our hypotheses suggests that a different subpopulation of crack users was found through RDS.

In addition to younger age, less heroin use and less homelessness, RDS resulted in a different user profile with regard to other characteristics. Overall, more demographic differences were found between RDS and UR than between RDS and ST. Most notably, RDS recruited more female and western crack users, while ST was quite similar to RDS in these characteristics. Low education was more frequent in both institutional samples than in RDS, and more working crack users were found in RDS than in ST. Regarding institutional contacts (other than ST and UR), UR crack users were more likely than those in RDS and ST to have been arrested and to have entered in-patient treatment in the last year.

We did not claim to assess which sampling method was most representative. However, institutional samples only include crack users with a predefined set of characteristics (e.g. previous heroin use in ST, precarious living conditions in UR), while RDS includes a large number of clients of these institutions plus members of the population not to be found in them. The findings confirm that different sampling frames and sampling methodologies result in different profiles of drug users. Acknowledging these differences is important, because also non-institutional sampling strategies, such as targeted or snowball sampling, are often implemented

close to these services [3, 41] and relying more or less on them as a source of recruits might yield different results. In our study, RDS generated more diverse samples of frequent crack users and indicated more completeness, thus suggesting better representativeness than institutional samples. However, representativeness could only be tested against a normative sample like a general household survey, but, as we already noted, such a sample is very difficult to realise with regard to frequent crack users. More empirical evidence of RDS's capability to obtain unbiased population estimates is recommended.

This study had several limitations. Since speaking the Dutch language was a requirement for participation, an unknown segment of the population of frequent crack users was excluded, and this might particularly be the case for undocumented migrants. Also, minimum age for participation was 18 years. Apart from age and gender, our results are based on self-report data. Although we applied an established methodology that ensured participants were informed of the purpose of the study and assured of its confidentiality, there is still the risk of under-reporting illegal activities. However, all samples in our study would account for such bias. Finally, when testing differences between aggregated samples, we could not account for non-random sampling biases and, admittedly, the risk of type 1 error has been increased by multiple testing. Nevertheless, adjusting for this by changing the significance threshold to ≤ 0.01 in the aggregated samples comparison, does not change substantially the main final results in relation to our hypotheses.

Our results might be different if the study is replicated in other countries. For many years, the Netherlands has adopted a harm reduction-oriented drug policy. Dutch drug services are characterized by a rather pragmatic low threshold approach, and it is not unlikely that crack users in the Netherlands are less reluctant than those

from other countries to enter and stay in the care system. This broad coverage could make these institutions suitable for convenience samples which are closer to representative. However, as we have observed, certain categories within the target population remain underrepresented in these services when compared to RDS estimates. These differences could be even larger in countries where low threshold care is not available or not so widespread. Further studies comparing drug users recruited through RDS with those in institutional settings in other countries is encouraged.

Acknowledgments

This research was funded by a grant (# 31160012) from ZonMw, the Netherlands Organization for Health Research and Development. The authors would like to thank Petra Houwing for her indispensable assistance in the fieldwork; Wim van de Brink (AMC), Vincent Hendriks and Peter Blanken (Parnassia) for their valuable contribution to the project design; Lisa Johnston, Jean Paul Grund and Richard Burt for their advice on RDS methodology. The authors have no conflicts of interest.

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