Respondent-Driven Sampling for Surveying Ethnic Minorities in Ecuador

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Abstract: In this work, we consider the problem of surveying a population of young Indigenous, Montubios and Afro-Ecuadorians to study their living conditions and socioeconomic issues. We conducted a Respondent-driven sampling (RDS) survey in the canton of Riobamba, Ecuador. RDS is a network-based sampling method intended to survey hidden or hard-to-reach populations. We have obtained RDS estimates and confidence intervals of these characteristics. We have illustrated and discussed some of the assumptions of the method using some available diagnostic tools. Our results suggest that RDS is an effective methodology for studying social and economic issues of this ethnic minority in Ecuador. This technique is relatively easy to implement and has the potential to be applied to survey other hidden populations in other settings.

Keywords: respondent-driven sampling; Indigenous people; Ecuador; housing satisfaction; poverty; well-being; social exclusion; quality of life

1. Introduction

Like any other South American country, Ecuador is ethnically diverse [1–3]. Most of their population is identified as mestizo (71.93%), which comprises a mixed Amerindian and Spanish heritage and the following minorities: Montubio (7.39%), Afro-ecuadorians (7.19%), Indigenous (7.03%), Whites (6.09%), and other (0.37%) [4]. Poverty and unsatisfied basic needs affects more Indigenous and Afro-Ecuadorian households, than those with mixed origins [5]. Furthermore, the incidence of extreme poverty in Indigenous and in Afro-Ecuadorian households is even higher than in mestizo families, which results in less access to education and difficulties to getting decent housing [5]. Several studies have highlighted that housing is one of the most important components in a person's subjective well-being and overall satisfaction [6–8]. Chica et al. [9] recently studied the quality of life of households in Colombia, and Chica and Cano [10] studied the prices of houses using a regression-kriging method. There is evidence that issues with housing and the living standard of some groups in the population and their social exclusion can lead to health issues [11,12].

Some studies and data collected from official statistical agencies highlight the higher rate of unemployment and poor access to health, education and housing of Indigenous people and other ethnic minorities compared to those with mixed origins. [13–17]. Nevertheless, most ot these studies are based on sources of data and information on the living conditions of ethnic minorities in Ecuador as the Census of population and housing (CPV) 2010, the Survey on living conditions (ECV) 2014, or the National survey of employment, unemployment, and underemployment (ENEMDU) 2018, but they are not representative at the canton level and are outdated or do not take into account

specific subgroups of the indigenous population (i.e., minority youth at the province or canton level). Recently, Rotondi et al. [18] showed in a Respondent-driven sampling (RDS) study held in Canada, that the Indigenous population in Toronto is also underrepresented, as the census of Statistics Canada (Canada's National Statistical Agency) undercounts this population. More information on this group and its health issues are given in Reference [19,20]. Generally, obtaining reliable information about minority groups and ethnic minorities, in particular, is challenging for survey research professionals [21]. These groups usually represent a small size of the overall population, making it difficult to access them and typically obtaining lower response rates [22]. Furthermore, there are signs that Indigenous people may be underrepresented in the Ecuadorian National Statistics Agency. According to FENOCIN (National Confederation of Farmers, Indigenous and Black People Organizations) up to 70% of the Ecuadorian population belong to these social groups [23], but they are reluctant to be identified as members of these groups because of social prejudice and stigma [23–26]. Therefore, they are difficult to reach, they are often underestimated in surveys of official statistics [27] and using using traditional sampling to survey them can become utterly expensive.

There are some non-probabilistic methods available that account for small groups within a population and address some of these issues, like snowball sampling or Respondent-driven sampling (RDS). RDS is a snowball-type sampling method used to survey hidden populations. Those are populations that lack a reliable sampling frame and therefore are difficult to reach. RDS was first introduced by Heckathorn [28] and was developed afterwards by Salganik and Heckathorn [29] and Volz and Heckathorn [30]. RDS make use of community members' social networks. The selection process start with a set of initial members of the target population, selected by convenience, called seeds. These respondents are given recruitment coupons (typically three), so that they recruit the next wave of participants among their known contacts within the hidden group, usually with incentives [28]. When these respondents return their coupons, they recruit the next wave of participants. This process continues until the desired sample size is reached [29]. Some popular examples of RDS are HIV at risk people, LGBTI community and injection drug users [31–33]. A homeless population is surveyed in Reference [34], and examples of application of RDS to migrant populations are given in Reference [35–38]. RDS is useful for overcoming limitations of traditional sampling, as it reduces privacy concerns among the participants. RDS does not require an ordinary sampling frame, and it reduces the costs involved compared to traditional sampling.

We address the problem of surveying a population of Indigenous and other ethnic minorities conducting a RDS survey in the Canton of Riobamba, Ecuador. This work may fill a gap as no such an approach has been done to study this ethnic group in Ecuador. We study their living conditions focusing on variables, such as work, income, housing, social exclusion, poverty, perception of standard of living, etc. We obtained accurate estimates on social and living conditions of these groups using the most relevant estimators in RDS. We illustrate and discuss some important characteristics of a RDS survey, such as the homophily scores and the convergence and bottleneck plots, typically used to assess that some the assumptions of this methodology are met.

2. Materials and Methods

The present study is a cross-sectional survey conducted by the University of Granada and the Superior Technical College of Chimborazo, Ecuador in collaboration with the National Confederation of Farmers, Indigenous and Black People Organizations (FENOCIN). Inclusion criteria for participants in the survey were: self-identification as Indigenous, Montubio, or Afro-ecuadorian, being 18 to 29 years old; living in city of Riobamba, having a valid ID number and giving their consent to participate in the study. First of all, the authors evaluated the suitability of RDS for surveying this group of people. The non-random selection of initial respondents, called seeds, is critical as they must have a large social network. They were selected using face to face and telephone interviews among 40 youth leaders who work on issues of interculturality, justice and solidarity for FENOCIN. They were interviewed several times to ensure their suitability. Ten seeds were selected, diverse in terms of sex, age, marital status,

ethnicity, and instruction (see Table 1). The selection was based on two criteria: personal characteristics and number of connections within their social group.

Table 1. Initial sample (seeds) for the Respondent-driven sampling (RDS) survey according to sociodemographic characteristics.

Seed	Gender	Age	Marital Status	Ethnic Group	Formal Education
1	Female	29	Married or free union	Indigenous	Postgraduate
2	Female	21	Married or free union	Indigenous	High school
3	Female	29	Married or free union	Indigenous	University
4	Female	28	Single	Indigenous	University
5	Female	21	Married or free union	Indigenous	High school
6	Female	28	Married or free union	Montubio	Postgraduate
7	Male	26	Married or free union	Indigenous	High school
8	Male	21	Single	Indigenous	University
9	Female	21	Single	Afro-ecuadorian	High school
10	Male	22	Single	Indigenous	High school

RDS methodology requires that the group of interest is a hidden population and that they form a well-connected social network. Indigenous, Montubio, and Afro-Ecuadorian populations have been studied so far in the CPV, ECV, and ENEMDU surveys, but there is no available survey focused on excluded young ethnic populations in Ecuador. More importantly, young Indigenous, Montubio, and Afro-Ecuadorians find it difficult to self-identify [23–26]. Therefore, we lack a reliable sampling frame for this group, which makes traditional sampling difficult to implement. As RDS reduces privacy concerns, it can be a convenient method for surveying such populations [28].

The Riobamba canton is home to the highest proportion of Indigenous youth in Ecuador and has the presence of young Montubios and Afro-Ecuadorians [39]. Evidence from different studies show that the Indigenous population in the canton of Chimborazo and particularly in the city of Riobamba, concentrates the vast majority of the poorest Indigenous population in the country, with essential living conditions being far from ideal [15–17]. The city of Riobamba has approximately 39,000 students in universities, technological institutes, etc. Most of the Montubios and Afro-Ecuadorians living in Riobamba are students that have migrated from rural areas (from the Ecuadorian coast mostly) to the city of Riobamba seeking education and better life conditions. This has led to a fusion of different social groups, that have merged into a single social network [26]. Therefore, Indigenous, Montubio, and Afro-Ecuadorian youngsters are a hidden population, and they are an interesting socio-economic group and form a social network, so that we aim to to survey this young ethnic group using RDS.

The questionnaire included eight different sections covering the following information: contact and eligibility data, informed consent, socio-demographics, housing and home, health, habits, practices and use of time, poverty, discrimination, and general satisfaction with life (see Table A1 of Appendix A). Once it was completed, respondents became recruiters and could access a different form to recruit new respondents. Both the questionnaire and the recruitment forms were hosted on the website (www.ugremina.com). After collecting the contact information on new participants at each wave, the computer system sent an email with instructions on how to use the website for filling out the survey and how to recruit up to three new participants. The computer system awaited their response in the two following weeks with up to four texts reminding them to complete the questionnaire and to invite new peers. Each recruit received a username and password by email for logging in the website. The identifiers of both the recruit and its recruiter were stored in a database, which allowed tracking the chains created from each seed. We followed the recruitment process, making sure that the RDS sample is large enough to overcome the potential bias introduced with the initial selection of seeds. We used the convergence and bottleneck plots (Figures 1 and 2) to check the evolution of the RDS estimated chains. The final RDS sample is consistent with the CPV 2010 and the ENEMDU 2018 surveys. A dual system of incentives was used for promoting recruitment, as it is usually done with

RDS surveys [28]. The incentive was the right to participate in a lottery where the prize was a holiday trip to Galapagos. Participants received one raffle ticket immediately after filling out the web survey and another for each (up to three) successfully recruited peer.

To account for the RDS assumptions, we considered the convergence and bottleneck plots and the homophily ratio of variables. Homophily is the tendency to associate with those with similar characteristics. The RDS survey homophily scores are shown on Table 2 and interpreted in the next section. Convergence plots show the true population parameter with the number of recruits on the horizontal axis. This plot can help assess whether the sample is biased by the initial set of seeds. Bottleneck plots can show differences between seeds. Illustration of these two plots for the RDS ethnic survey data are given and interpreted in the next section.

We used the most usual estimators in RDS, which are the RDS-I ratio estimator, the RDS-II estimator [30], and the Gile and Hanckock [40] version for sampling with replacement. The RDS-I estimator for estimating proportions with binary response and groups A and B is defined as

$$\hat{p}_A = \hat{C}_{BA}\hat{D}_B / (\hat{C}_{BA}\hat{D}_B + \hat{C}_{AB}\hat{D}_A), \tag{1}$$

with $\hat{C}_{AB} = \frac{r_{AB}}{r_{AB}+r_{AA}}$, r_{AB} is the number of people of $A's$ recruiting $B's$ in the sample, r_{AA} the number of people of $A's$ recruiting $A's$ in the sample,

Table 2. Recruitment homophily estimates for respondents in the ethnic urban youth RDS survey.

Variable	Homophily Estimates
Occupation	1.15
Harvest	1.09
Number people	1.08
Number quarters	1.06
Land	1.03
Clothing	1.03
Ethnic self-identification	1.03
Animals	1.02
Marital status	1.02
Social security	1.02
Instruction	1.02
Mother instruction	1.02
Water service	1.01
Father instruction	1.01
Poverty	1.00
Energy service	1.00
Disability	1.00
School type	1.00
Class language	1.00
General satisfaction	0.99
Victim	0.99
Language	0.98
Work	0.98
Parents language	0.98
Reason not enrollment	0.96
Enrollment	0.93
Salary	0.93
Sex	0.93
Canton	0.93
Age	0.92
Employment relation	0.75

The RDS-SS [40] estimator for estimating proportions:

$$\hat{p}_A = \sum_{i \in s_A} (\hat{\pi}(d_i)^{-1}) / \sum_{i \in s} \hat{\pi}(d_i)^{-1}, \quad (2)$$

with $\hat{\pi}(d_i)$ the estimated population distribution of degrees through successive sampling.

The RDS-II estimator takes the form of the Hajek estimator as follows:

$$\hat{p}_A = \sum_{i \in s} (d_i^{-1} y_i) / \sum_{i \in s} d_i^{-1}, \quad (3)$$

with d_i the degree reported by respondent i.

Estimators RDS-SS and RDS-II have desirable statistical properties as they are consistent and asymptotically unbiased. We used the software environment R, in particular, the RDS library (Handcock et al. 2017) and the igraph library for drawing social networks.
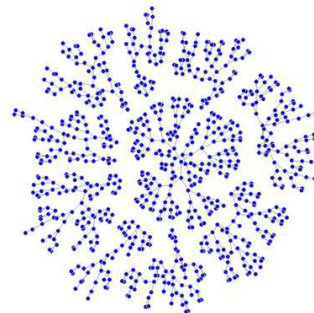
Figure 1. Representation of the network recruitment chains for the RDS of ethnic minority urban youth in the canton of Riobamba, Ecuador.
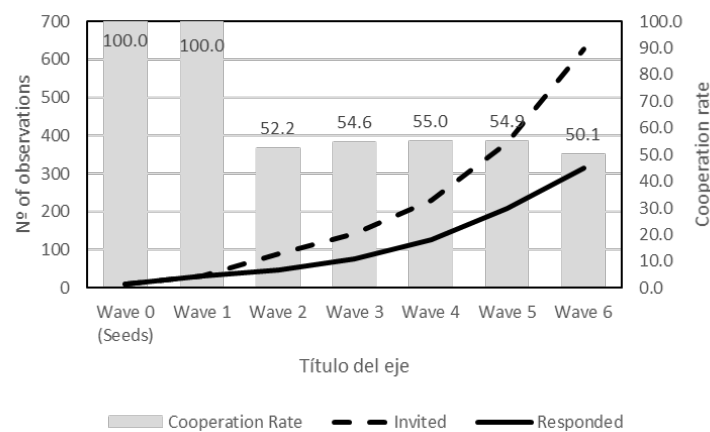
Figure 2. Number of invitations, number of participants, and cooperation rates per RDS fieldwork wave.

3. Results

As mentioned before, ten initial seeds were selected to participate and recruit up to three more respondents. Every new respondent was given the opportunity to recruit another three new participants in the study. Thirty-two of the recruits used the three coupons to recruit, 300 just two of them, 108 one, and 60 did not recruit anybody. Three of the seeds were very successful (86 or more recruited within their chains), four had a moderate success (from 66 to 85 recruited within their chains), and three a lower performance (65 or less recruited). The survey reached six waves for the 10 seeds (see Figures 1 and 2).

A total of 1510 invitations were sent to potential eligible participants, and 814 completed the questionnaire, which gives a 53.9% overall cooperation rate. Valid cases and cooperation rates are distributed from the first wave to the sixth as shown in Figure 2.

3.1. Living Conditions of the Ethnic Group

We studied the living conditions of this ethnic group and compared the RDS estimates with the values obtained with official surveys CPV 2010 and ENEMDU 2018 for the regular Ecuadorian (blue color values) and those belonging to ethnic minorities (green color values). RDS estimates and confidence intervals are reported in Table 3. We computed the three usual RDS estimators (given in Section 2) for every characteristic under study and obtained similar results, which are reported in the Table A2 of Appendix A.

RDS allows recruiting participants who would not normally be part of a probabilistic sample in the context of studying hidden populations. Age, marital status, and salary characteristics (for ENEMDU survey of ethnic minorities) fall outside the 95% RDS confidence interval, indicating that people who are reluctant to be identified as part of those ethnic minorities (who were captured by RDS) tend to be younger (21.81 years) than those who have no problem with their ethnic self-identification (23.25 years). Similarly, they tend to be single (81.31% compared to 55.09%) and with lower median income ($295.50 compared to $379.64). In contrast, the characteristics sex, instruction, language, work, social security, and extreme poverty fall within the interval, showing that there is no difference for these variables between those who self-identify as part of the ethnic minority and those who do not.

We compare the estimates of the total ENEMDU survey with the 95% RDS confidence intervals with the intention of identifying gaps. Table 3 shows large differences in socio-economic characteristics, such as the total ENEMDU salary and the RDS estimate ($523.58 compared to $295.496), falling the former well outside the 95% RDS confidence interval. There are also differences in instruction and social security coverage between these two groups, with the total ENEMDU values outside the confidence intervals. Moreover, 90.63% of the ethnic youngsters claim to have occasionally been victims of discrimination. Following the same arguments, there are differences in most of the housing characteristics considered in the survey (number of people living in a house, water, and energy service). Despite the important effort being done by the Ecuadorian administrations to avoid social exclusion and discrimination of these ethnic groups, there is evidence of socio-economic differences.

Table 3. RDS estimates and 95% confidence intervals for Indigenous, Montubio, and Afro-Ecuadorian urban youth in the canton of Riobamba (n = 814) and official data for this ethnic group and for the regular Ecuadorian in Riobamba according to ENEMDU 2018.

Characteristic	Category	ENEMDU Total	ENEMDU Ethnic Minority	RDS Estimate	95% Confidence Interval		Design Effect	SD	n
Sex	Man	0.4575	0.497	0.4261	0.347	0.5051	5.8066	0.0403	364
	Woman	0.5425	0.503	0.5739	0.4949	0.653	5.8066	0.0403	450
	Age	23.1970 (3.6322)	23.2482 (3.4481)	21.8133	21.3022	22.3243	5.7469	0.2607	814
Marital status	Married-free union	0.2310	0.3896	0.1827	0.133	0.2323	3.7594	0.0253	163
	Divorced-separated	0.0310	0.0576	0.037	0.0015	0.0058	0.2806	0.0011	4
	Single	0.7380	0.5509	0.8131	0.7632	0.863	3.7236	0.0254	646
	Widower	0	0.0019	0.0006	0.0003	0.0008	0.0316	0.0001	1
Ethnic self-identification	Afro-Ecuadorian		0.0586 *	0.0504	0.0324	0.0683	1.532	0.0092	44
	Indigenous		0.9256 *	0.9197	0.8804	0.959	4.762	0.0201	749
	Montubia		0.0158 *	0.0299	0	0.0658	10.0818	0.0183	21
Instruction	Secondary or less	0.5450	0.8179	0.7985	0.7546	0.8424	2.7214	0.0224	624
	Higher	0.4550	0.1821	0.2015	0.1576	0.2454	2.7214	0.0224	190

Table 3. *Cont.*

| Characteristic	Category	ENEMDU Total	ENEMDU Ethnic Minority	RDS Estimate	95% Confidence Interval		Design Effect	SD	n
Language	Spanish	0.8422	0.7672	0.7585	0.6918	0.8253	5.5309	0.0341	608
	Indigenous	0.1578	0.2328	0.2415	0.1747	0.3082	5.5309	0.0341	206
Work	No	0.5372	0.4398	0.5009	0.4216	0.5801	5.7114	0.0404	375
	Yes	0.4628	0.5602	0.4991	0.4199	0.5784	5.7114	0.0404	439
Social security	Insured	0.3160	0.1535	0.1505	0.0983	0.2026	2.5221	0.0266	71
	Not insured	0.6840	0.8465	0.8495	0.7974	0.9017	2.5221	0.0266	368
Salary	Salary per month	523.58 (381.61)	379.64 (267.43)	295.496	259.599	331.393	1.7204	18.3148	439
Extreme poverty	Yes	0.0803	0.0629	0.0935	0.0506	0.1364	4.8907	0.0219	71
	No	0.9197	0.9371	0.9065	0.8636	0.9494	4.8907	0.0219	737
Energy service	Public company	0.9861		0.9524	0.9345	0.9704	1.6166	0.0092	774
	Generator, candle or other	0.0139		0.0476	0.0296	0.0655	1.6166	0.0092	40
Water service	Well, bulk or other	0.0113		0.0793	0.0539	0.1047	2.0048	0.0129	66
	Pipeline	0.9887		0.9207	0.8953	0.9461	2.0048	0.0129	748
Housing	Number quarters	2.69 (1.06)		2.8083	2.6214	2.9952	5.9538	0.0954	814
	Number people	2.96 * (2.54 *)		4.6901	4.4354	4.9448	3.7184	0.13	814
Discrimination perception	Victim	-		0.9063	0.8633	0.9493	49493	0.0219	727
	General satisfaction	-		8.5506	8.2982	8.8029	6.7684	0.1288	814

Blue color values: The numbers in blue color are from those RDS-SS estimates, for which the official for regular Ecuadorian in Riobamba value is outside the RDS-SS interval at 95% confidence. Green color values: The numbers in green color are from those RDS-SS estimates, for which the official value for Ecuadorians belonging to ethnic minorities in Riobamba is outside the RDS-SS interval at 95% confidence.
*: Estimates using CPV 2010.

3.2. Assessment of the RDS Survey

We computed the homophily ratios of the characteristics under study, as shown in Table 2. Homophily is computed as the ratio of the number of recruits with the same characteristic as their recruiter to the number expected by chance [41]. A value of 1 means that there is not preferential recruitment, while values over 1 indicate homophily and values under 1 heterophily (i.e., a value a bit over 1 indicate modest homophily).

In order to assess the recruitment, we computed the homophily scores for every variable under study. Nevertheless, there are socio-economic variables that are more connected with what homophily represent, the tendency to associate with those with similar characteristics. The occupation group they work at, appear to have modest homophily. For other socio-economic characteristics, such as clothing or social security, there is very small homophily . Generally, most of the values are close to 1, indicating modest homophily or modest heterophily and therefore a satisfactory recruitment.

Convergence plots in Figure 3 show the sample values converging to the true population parameter for variables sex, instruction level, working status and income. It indicates the stabilization of values as recruitment continues, suggesting that the resulting sample is not biased by the initial selection of seeds. Similar plots and similar results have been obtained for all the other characteristics under study and for RDS-I and RDS-II estimators, but they are not reported here for ease of presentation.
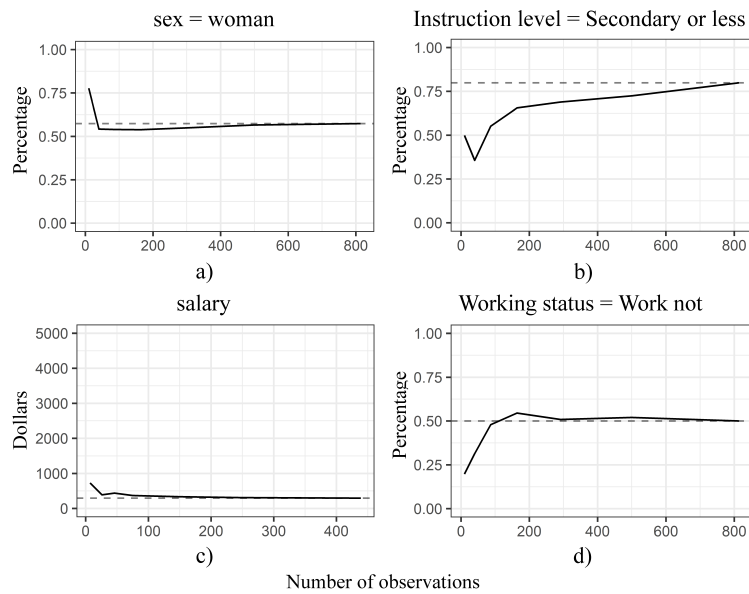
Figure 3. Convergence plots showing the sample observations with the selected trait: (**a**) women, (**b**) lower than secondary, (**c**) salary and (**d**) not working. The dashed line shows the estimate based on the complete sample.

Figure 4 shows the bottleneck plots, which appear to converge on one point estimate for each variable, suggesting estable estimates (instead of converging on two or three, which would indicate unstable estimates and important differences between the data from different seeds). Examples of bottleneck plots are available in Reference [42]. We computed RDS-II and RDS-SS estimates for every variable in the survey. Differences between the RDSII and RDS-SS estimators are very small (under 0.01) for all variables in the survey (see Table A2 of Appendix A), indicating that the size of the population is not inducing bias in our estimates [42].
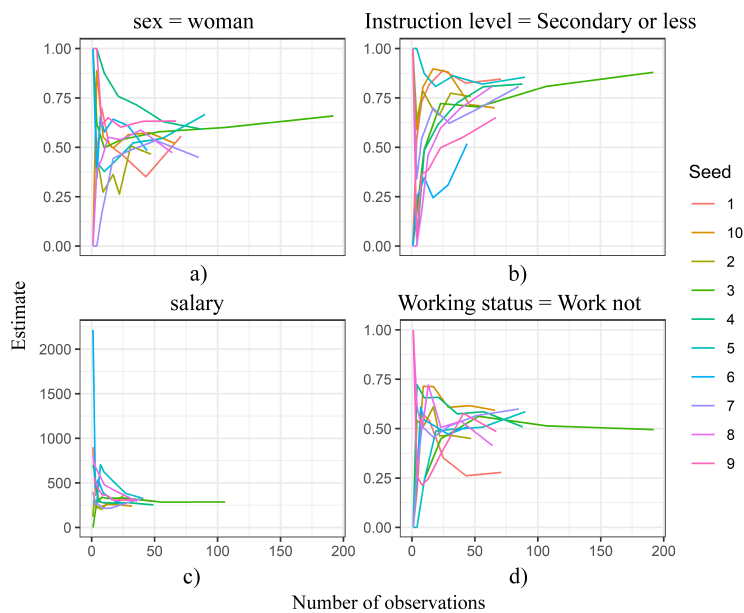
Figure 4. Bottleneck plots showing the observations on each seed chain with the selected trait: (**a**) women, (**b**) lower than secondary, (**c**) salary and (**d**) not working.

4. Discussion

RDS has been widely used in public health studies, particularly for studying the prevalence of a desease, but there are very few examples of application to survey ethnic minorities.

We carried out a RDS survey to study the socioeconomic and living conditions of the youngest segments of Indigenous, Montubio, and Afro-Ecuadorian population in the cities of the Riobamba canton in Ecuador. We considered dimensions, such as housing, social welfare, income, poverty, social exclusion, and perception of life. We compared the RDS estimates of these characteristics for the ethnic population in Riobamba with the average Ecuadorian to check for potential gaps and differences on such dimensions.

We showed that RDS can collect information on participants who would not be recruited using traditional sampling. We showed there are differences in some socio-economic characteristics between those who self-identify as part of the ethnic group and those who are relunctant to do it. These differences suggest that RDS is an effective method for studying social and economic issues of ethnic minority urban youth in Ecuador. Furthermore, we used the RDS-II and the RDS-SS estimators, the two most important estimators in RDS, well-known among RDS practitioners for their good theoretical and practical properties.

We recruited a sample of 814 Indigenous, Montubio, and Afro-descendant urban youth over five months of fieldwork in the Riobamba canton in Ecuador. 93% of participants in the study (including the 10 initial seeds) successfully recruited at least one peer. The resulting sample is ethnically, demographically, and socioeconomically diverse and was large enough to produce estimates on the population.

A well-documented social problem is the under-registration of ethnic minorities in surveys and censuses in Ecuador. These populations can be better represented with the RDS methodology. RDS also has the potential to be useful to study sensitive issues in hidden populations, like having been victim of discrimination. With further information about a sensitive issue of interest in hidden populations, we can have a better understanding of the actual state of that issue and use it to design knowledgeable policies to address that problem, like, for instance, eradicating all forms of discrimination.

There are some limitations to this study. Its results deals with an urban young ethnic population in the Riobamba canton and cannot be generalized to other areas in Ecuador or to the rural youth in the canton (due to poor internet access). Nevertherless, RDS has the potential to be applied at the national level by studying it separately at the 24 capital cities of provinces in Ecuador. The survey is subjected to coverage bias as approximately 20% of this social group in Ecuador does not use the internet regularly. Finally, it is not clear how the network responding process could be affected by social-desirable responding in surveys using RDS sampling methods. Future research is needed on this issue as most studies using RDS deal with topics that are deemed sensitive.

RDS is an useful methodology that can be applied to a wide range of populations and contexts that are difficult to address with probability-based sampling techniques. Social researchers may consider using these techniques other hidden and/or difficult-to-reach populations.

Abbreviations

The following abbreviations are used in this manuscript:

RDS   Respondent-driven sampling
FENOCIN   National Confederation of Farmers, Indigenous and Black People Organizations

Appendix A

Table A1. Variables and question wording of the RDS survey among Indigenous, Montubio and Afro-Ecuadorian urban youth in the Riobamba canton of Ecuador.

Components	Characteristic	Question
Sociodemographic characteristics	Sex *	Gender
	Age	How old are you?
	Marital status	What is your marital status?
	Ethnic self-identification	How do you identify according to your culture and customs?
	Canton *	In what canton were you born?
	Clothing *	Do you use the traditional wear of your ethnic group?
	Instruction *	What is the highest level of education you have successfully completed?
	Mother instruction	What is the highest level of education your mother successfully completed?
	Father instruction	What is the highest level of education your father successfully completed?
Housing and home	Number quarters	How many bedrooms are in your house or apartment?
	Number people	How many people live in your household?
	Water service	What is the main source of water in your household?
	Energy service	What is the main source of lighting for your household
Health	Disability	Does any member of your household have any permanent physical, sensory or mental disability?
	Visited	Was he/she visited by the Manuela Espejo Mission?
Habits, practices and use of time	Language *	What language or languages do you commonly speak?
	Parents language	What language or languages do your parents use with you?
	Enrollment	This school year, were you enrolled in…?
	Reason for not enrolling	If you did not enroll, what was your main reason?
	Class language	What is the main language of the classes in the establishment where you are enrolled?
	School type	What type is the establishment where you enrolled or registered?
Poverty	Work *	What did you do the last week?
	Social security	If worked, what kind of social security do you have?
	Occupation	If worked, in which of the following occupation groups did you work?
	Employment relation	If worked, in which of the following occupation categories did you work?
	Salary	If worked, what was the salary or total monthly wage (in dollars and before discounts) that you received for working last month?
	Land	Do you or any other member of your household have lands intended for agricultural uses (lots, parcels or farms)?
	Harvest	During the last 12 months, did you harvest or receive any agricultural product from this land?
	Animals	During the last 12 months, did you or any other member in your household raised animals, such as chickens, turkeys, guinea pigs, rabbits, pigs, sheep, cattle, etc., on this farm or land?
	Poverty *	How do you consider your household according to its economic condition?
Discrimination perception	Victim *	Have you been a victim of episodes of discrimination?
	General satisfaction	On a scale of 1 to 10 where 1 means totally unhappy and 10 means totally happy, how is your overall satisfaction considering all aspects of your life?

An estimate of N = 11,920 (according to CPV 2010 survey) has been used. It is required for computing RDS-SS estimator. * Binary responses not conditioned to responses to other survey questions.

Table A2. RDS-I, RDS-II and RDS-SS estimates for all the variables in the survey.

Variable	Category	RDS Estimate		95% Confidence Interval		Design Effect	SD	n
Sex	Man	RDS-I	0.4268	0.3896	0.4640	1.2865	0.0190	
		RDS-II	0.4254	0.3460	0.5048	5.8653	0.0405	364
		RDS-SS	0.4261	0.3470	0.5051	5.8066	0.0403	
	Woman	RDS-I	0.5732	0.5360	0.6104	1.2865	0.0190	
		RDS-II	0.5746	0.4952	0.6540	5.8653	0.0405	450
		RDS-SS	0.5739	0.4949	0.6530	5.8066	0.0403	
	Age	RDS-I	21.7910	21.5480	22.0340	1.3243	0.1241	
		RDS-II	21.8060	21.2930	22.3180	5.7834	0.2615	814
		RDS-SS	21.8130	21.3020	22.3240	5.7469	0.2607	
Marital status	Married-free union	RDS-I	0.1783	0.1523	0.2043	1.0471	0.0133	
		RDS-II	0.1820	0.1321	0.2319	3.7991	0.0254	163
		RDS-SS	0.1827	0.1330	0.2323	3.7594	0.0253	
	Divorced-separated	RDS-I	0.0040	0.0008	0.0072	0.5995	0.0017	
		RDS-II	0.0036	0.0015	0.0057	0.2821	0.0011	4
		RDS-SS	0.0037	0.0015	0.0058	0.2806	0.0011	
	Single	RDS-I	0.8170	0.7908	0.8432	1.0439	0.0134	
		RDS-II	0.8138	0.7638	0.8639	3.7616	0.0255	646
		RDS-SS	0.8131	0.7632	0.8630	3.7236	0.0254	
	Widower	RDS-I	0.0007	0.0000	0.0016	0.2444	0.0004	
		RDS-II	0.0005	0.0003	0.0008	0.0271	0.0001	1
		RDS-SS	0.0006	0.0003	0.0008	0.0316	0.0001	
Ethnic self-identification	Afro-Ecuadorian	RDS-I	0.0456	0.0349	0.0564	0.6019	0.0055	
		RDS-II	0.0502	0.0322	0.0682	1.5400	0.0092	44
		RDS-SS	0.0504	0.0324	0.0683	1.5320	0.0092	
	Indigenous	RDS-I	0.9250	0.9073	0.9428	1.0331	0.0091	
		RDS-II	0.9197	0.8798	0.9596	4.8974	0.0203	749
		RDS-SS	0.9197	0.8804	0.9590	4.7620	0.0201	
	Montubio	RDS-I	0.0294	0.0148	0.0439	1.6982	0.0074	
		RDS-II	0.0301	0.0000	0.0665	10.3560	0.0186	21
		RDS-SS	0.0299	0.0000	0.0658	10.0820	0.0183	
Canton	Other	RDS-I	0.5549	0.5151	0.5947	1.4589	0.0203	
		RDS-II	0.5502	0.4690	0.6314	6.0572	0.0414	475
		RDS-SS	0.5514	0.4699	0.6328	6.0943	0.0415	
	Riobamba	RDS-I	0.4451	0.4053	0.4849	1.4589	0.0203	
		RDS-II	0.4498	0.3686	0.5310	6.0572	0.0414	339
		RDS-SS	0.4486	0.3672	0.5301	6.0943	0.0415	
Clothing	No	RDS-I	0.4417	0.4025	0.4809	1.4188	0.0200	
		RDS-II	0.4407	0.3587	0.5227	6.2000	0.0418	340
		RDS-SS	0.4401	0.3583	0.5219	6.1688	0.0417	
	Yes	RDS-I	0.5583	0.5191	0.5975	1.4188	0.0200	
		RDS-II	0.5593	0.4773	0.6413	6.2000	0.0418	474
		RDS-SS	0.5599	0.4781	0.6417	6.1688	0.0417	
Instruction	Secondary or less	RDS-I	0.8040	0.7795	0.8284	0.8639	0.0125	
		RDS-II	0.7999	0.7559	0.8438	2.7416	0.0224	624
		RDS-SS	0.7985	0.7546	0.8424	2.7214	0.0224	
	At least university	RDS-I	0.1960	0.1716	0.2205	0.8639	0.0125	
		RDS-II	0.2001	0.1562	0.2441	2.7416	0.0224	190
		RDS-SS	0.2015	0.1576	0.2454	2.7214	0.0224	
Mother instruction	Secondary or less	RDS-I	0.8937	0.8772	0.9102	0.6537	0.0084	
		RDS-II	0.8897	0.8367	0.9428	6.5288	0.0271	712
		RDS-SS	0.8893	0.8375	0.9411	6.2066	0.0264	
	At least university	RDS-I	0.1063	0.0898	0.1228	0.6537	0.0084	
		RDS-II	0.1103	0.0572	0.1633	6.5288	0.0271	102
		RDS-SS	0.1107	0.0589	0.1625	6.2066	0.0264	

Table A2. *Cont.*

Variable	Category	RDS Estimate		95% Confidence Interval		Design Effect	SD	n
Father instruction	Secondary or less	RDS-I	0.9426	0.9325	0.9527	0.4280	0.0051	
		RDS-II	0.9417	0.9270	0.9564	0.8974	0.0075	754
		RDS-SS	0.9412	0.9264	0.9560	0.8955	0.0075	
	At least university	RDS-I	0.0574	0.0473	0.0675	0.4280	0.0051	
		RDS-II	0.0583	0.0436	0.0730	0.8974	0.0075	60
		RDS-SS	0.0588	0.0440	0.0736	0.8955	0.0075	
	Number quarters	RDS-I	2.7550	2.6792	2.8308	1.0495	0.0387	
		RDS-II	2.8098	2.6223	2.9974	5.9969	0.0957	814
		RDS-SS	2.8083	2.6214	2.9952	5.9538	0.0954	
	Number people	RDS-I	4.9082	4.7044	5.1121	1.9424	0.1040	
		RDS-II	4.6912	4.4334	4.9490	3.8184	0.1315	814
		RDS-SS	4.6901	4.4354	4.9448	3.7184	0.1300	
Water service	Bulk water or other	RDS-I	0.0802	0.0600	0.1004	1.2623	0.0103	
		RDS-II	0.0793	0.0538	0.1049	2.0368	0.0131	66
		RDS-SS	0.0793	0.0539	0.1047	2.0048	0.0129	
	Pipeline	RDS-I	0.9198	0.8996	0.9400	1.2623	0.0103	
		RDS-II	0.9207	0.8951	0.9462	2.0368	0.0131	748
		RDS-SS	0.9207	0.8953	0.9461	2.0048	0.0129	
Energy service	Public company	RDS-I	0.9531	0.9381	0.9681	1.1484	0.0077	
		RDS-II	0.9525	0.9345	0.9705	1.6318	0.0092	774
		RDS-SS	0.9524	0.9345	0.9704	1.6166	0.0092	
	Generator. candle or other	RDS-I	0.0469	0.0319	0.0619	1.1484	0.0077	
		RDS-II	0.0475	0.0295	0.0655	1.6318	0.0092	40
		RDS-SS	0.0476	0.0296	0.0655	1.6166	0.0092	
Disability	No	RDS-I	0.8809	0.8514	0.9105	1.8925	0.0151	
		RDS-II	0.8823	0.8243	0.9403	7.3672	0.0296	728
		RDS-SS	0.8827	0.8250	0.9405	7.3228	0.0295	
	Yes	RDS-I	0.1191	0.0895	0.1486	1.8925	0.0151	
		RDS-II	0.1177	0.0597	0.1757	7.3672	0.0296	86
		RDS-SS	0.1173	0.0595	0.1750	7.3228	0.0295	
Visited	No	RDS-I	1.0000	-	-	-	-	
		RDS-II	0.6520	0.4504	0.8535	4.0361	0.1028	56
		RDS-SS	0.6520	0.4507	0.8533	4.0270	0.1027	
	Yes	RDS-I	0.0000	-	-	-	-	
		RDS-II	0.3480	0.1465	0.5496	4.0361	0.1028	30
		RDS-SS	0.3480	0.1467	0.5493	4.0270	0.1027	
Language	Spanish	RDS-I	0.7578	0.7266	0.7890	1.2048	0.0159	
		RDS-II	0.7589	0.6914	0.8264	5.6623	0.0344	608
		RDS-SS	0.7585	0.6918	0.8253	5.5309	0.0341	
Language	Indigenous	RDS-I	0.2422	0.2110	0.2734	1.2048	0.0159	
		RDS-II	0.2411	0.1736	0.3086	5.6623	0.0344	206
		RDS-SS	0.2415	0.1747	0.3082	5.5309	0.0341	
Parents language	Spanish	RDS-I	0.2100	0.1766	0.2433	1.5252	0.0170	
		RDS-II	0.2079	0.1455	0.2703	5.3802	0.0318	156
		RDS-SS	0.2074	0.1457	0.2690	5.2522	0.0314	
	Foreign	RDS-I	0.0023	0.0000	0.0079	3.1621	0.0029	
		RDS-II	0.0018	0.0003	0.0032	0.2714	0.0007	1
		RDS-SS	0.0018	0.0003	0.0032	0.2834	0.0008	
	Foreign-Spanish	RDS-I	0.0020	0.0000	0.0118	10.7650	0.0050	
		RDS-II	0.0018	0.0000	0.0057	2.0257	0.0020	1
		RDS-SS	0.0018	0.0000	0.0058	2.0728	0.0020	
	Indigenous	RDS-I	0.1034	0.0788	0.1281	1.4900	0.0126	
		RDS-II	0.1031	0.0605	0.1457	4.4593	0.0217	81
		RDS-SS	0.1031	0.0611	0.1450	4.3376	0.0214	

Table A2. *Cont.*

Variable	Category	RDS Estimate		95% Confidence Interval		Design Effect	SD	n
	Indigenous-Spanish	RDS-I	0.6823	0.6442	0.7205	1.5268	0.0195	
		RDS-II	0.6855	0.6150	0.7560	5.2381	0.0360	575
		RDS-SS	0.6861	0.6165	0.7557	5.1144	0.0355	
Enrollment	Yes	RDS-I	0.5480	0.5092	0.5868	1.3825	0.0198	
		RDS-II	0.5398	0.4593	0.6203	5.9341	0.0411	452
		RDS-SS	0.5405	0.4609	0.6201	5.8004	0.0406	
	No	RDS-I	0.4520	0.4132	0.4908	1.3825	0.0198	
		RDS-II	0.4602	0.3797	0.5407	5.9341	0.0411	362
		RDS-SS	0.4595	0.3799	0.5391	5.8004	0.0406	
Reason not to enroll	Other	RDS-I	0.7702	0.6904	0.8500	3.5045	0.0407	
		RDS-II	0.8079	0.6800	0.9359	10.2810	0.0653	306
		RDS-SS	0.8088	0.6803	0.9373	10.4040	0.0656	
	Finalisation of Studies	RDS-I	0.2298	0.1500	0.3096	3.5045	0.0407	
		RDS-II	0.1921	0.0641	0.3200	10.2810	0.0653	57
		RDS-SS	0.1912	0.0627	0.3197	10.4040	0.0656	
School type	State	RDS-I	0.8921	0.8627	0.9216	1.1049	0.0150	
		RDS-II	0.8981	0.8539	0.9423	2.6084	0.0225	401
		RDS-SS	0.8977	0.8538	0.9417	2.5703	0.0224	
	Private	RDS-I	0.1079	0.0784	0.1373	1.1049	0.0150	
		RDS-II	0.1019	0.0577	0.1461	2.6084	0.0225	51
		RDS-SS	0.1023	0.0583	0.1462	2.5703	0.0224	
	Salary	RDS-I	301.81	281.49	322.13	0.4440	10.367	
		RDS-II	294.60	258.43	330.77	1.7861	18.453	439
		RDS-SS	295.50	259.60	331.39	1.7204	18.315	
Class language	Spanish	RDS-I	0.8972	0.8768	0.9177	0.5552	0.0104	
		RDS-II	0.8740	0.8403	0.9078	1.2645	0.0172	386
		RDS-SS	0.8733	0.8393	0.9072	1.2735	0.0173	
	Foreign	RDS-I	0.0118	0.0040	0.0195	0.6357	0.0040	
		RDS-II	0.0125	0.0013	0.0237	1.2494	0.0057	7
		RDS-SS	0.0126	0.0013	0.0239	1.2486	0.0057	
	Foreign and spanish	RDS-I	0.0616	0.0468	0.0765	0.4672	0.0076	
		RDS-II	0.0742	0.0503	0.0982	1.0181	0.0122	39
		RDS-SS	0.0747	0.0507	0.0986	1.0184	0.0122	
	Foreign, spanish and indigenous	RDS-I	0.0146	0.0079	0.0213	0.3825	0.0034	
		RDS-II	0.0173	0.0092	0.0254	0.4697	0.0041	10
		RDS-SS	0.0175	0.0093	0.0257	0.4823	0.0042	
	Indigenous	RDS-I	0.0036	0.0000	0.0076	0.5446	0.0020	
		RDS-II	0.0043	0.0000	0.0098	0.8708	0.0028	2
		RDS-SS	0.0043	0.0000	0.0098	0.8739	0.0028	
	Indigenous and spanish	RDS-I	0.0112	0.0073	0.0151	0.1696	0.0020	
		RDS-II	0.0177	0.0110	0.0245	0.3205	0.0034	8
		RDS-SS	0.0177	0.0109	0.0246	0.3277	0.0035	
Work	No	RDS-I	0.5046	0.4648	0.5444	1.4400	0.0203	
		RDS-II	0.5021	0.4224	0.5818	5.7754	0.0407	375
		RDS-SS	0.5009	0.4216	0.5801	5.7114	0.0404	
	Yes	RDS-I	0.4954	0.4556	0.5352	1.4400	0.0203	
		RDS-II	0.4979	0.4182	0.5776	5.7754	0.0407	439
		RDS-SS	0.4991	0.4199	0.5784	5.7114	0.0404	
Social security	Insured	RDS-I	0.1487	0.1194	0.1781	0.8064	0.0150	
		RDS-II	0.1500	0.0973	0.2027	2.5840	0.0269	71
		RDS-SS	0.1505	0.0983	0.2026	2.5221	0.0266	
	Uninsured	RDS-I	0.8513	0.8219	0.8806	0.8064	0.0150	
		RDS-II	0.8500	0.7973	0.9027	2.5840	0.0269	368
		RDS-SS	0.8495	0.7974	0.9017	2.5221	0.0266	

Table A2. *Cont.*

Variable	Category	RDS Estimate		95% Confidence Interval		Design Effect	SD	n
Occupation	Directors of administration	RDS-I	0.0190	0.0127	0.0253	0.2513	0.0032	
		RDS-II	0.0399	0.0000	0.0838	5.9572	0.0224	15
		RDS-SS	0.0397	0.0000	0.0826	5.7393	0.0219	
	Administrative employees	RDS-I	0.0628	0.0457	0.0798	0.5866	0.0087	
		RDS-II	0.0678	0.0353	0.1003	1.9862	0.0166	33
		RDS-SS	0.0680	0.0359	0.1002	1.9356	0.0164	
	Facility and machinery operators	RDS-I	0.0250	0.0098	0.0401	1.1213	0.0077	
		RDS-II	0.0171	0.0071	0.0270	0.7012	0.0051	8
		RDS-SS	0.0171	0.0073	0.0269	0.6763	0.0050	
	Operators and craftsmen	RDS-I	0.1116	0.0722	0.1510	1.8564	0.0201	
	Operators and craftsmen	RDS-II	0.0890	0.0394	0.1387	3.6012	0.0253	40
		RDS-SS	0.0891	0.0404	0.1379	3.4739	0.0249	
	Scientists and intellectuals	RDS-I	0.0417	0.0220	0.0613	1.1491	0.0100	
		RDS-II	0.0397	0.0084	0.0710	3.0509	0.0160	15
		RDS-SS	0.0395	0.0088	0.0702	2.9523	0.0157	
	Mid level technicians	RDS-I	0.0342	0.0120	0.0564	1.7716	0.0113	
		RDS-II	0.0298	0.0136	0.0460	1.0788	0.0083	12
		RDS-SS	0.0296	0.0135	0.0457	1.0716	0.0082	
	Agricultural and fisheries	RDS-I	0.0141	0.0102	0.0179	0.1260	0.0020	
		RDS-II	0.0166	0.0108	0.0223	0.2389	0.0029	13
		RDS-SS	0.0171	0.0112	0.0229	0.2449	0.0030	
	Service and commerce workers	RDS-I	0.1896	0.1498	0.2295	1.2255	0.0203	
		RDS-II	0.1961	0.1257	0.2666	3.7358	0.0359	98
Occupation		RDS-SS	0.1971	0.1273	0.2669	3.6485	0.0356	
	Unskilled workers	RDS-I	0.5020	0.4481	0.5560	1.3822	0.0275	
		RDS-II	0.5040	0.4005	0.6075	5.0865	0.0528	205
		RDS-SS	0.5027	0.3996	0.6059	5.0480	0.0526	
Land	No	RDS-I	0.6374	0.6001	0.6747	1.3689	0.0190	
		RDS-II	0.6414	0.5675	0.7153	5.4001	0.0377	512
		RDS-SS	0.6408	0.5681	0.7135	5.2201	0.0371	
	Yes	RDS-I	0.3626	0.3253	0.3999	1.3689	0.0190	
		RDS-II	0.3586	0.2847	0.4325	5.4001	0.0377	302
		RDS-SS	0.3592	0.2865	0.4319	5.2201	0.0371	
Harvest	No	RDS-I	0.2524	0.1989	0.3060	1.2255	0.0273	
		RDS-II	0.2504	0.1139	0.3868	8.0024	0.0696	76
		RDS-SS	0.2505	0.1154	0.3855	7.8356	0.0689	
	Yes	RDS-I	0.7476	0.6940	0.8011	1.2255	0.0273	
		RDS-II	0.7496	0.6132	0.8861	8.0024	0.0696	226
		RDS-SS	0.7495	0.6145	0.8846	7.8356	0.0689	
Employment relation	Salaried	RDS-I	0.3594	0.3021	0.4167	1.6911	0.0292	
		RDS-II	0.3420	0.2357	0.4483	5.9597	0.0542	138
		RDS-SS	0.3411	0.2364	0.4458	5.7840	0.0534	
	Own account	RDS-I	0.3754	0.3256	0.4252	1.2555	0.0254	
		RDS-II	0.3925	0.2918	0.4933	5.0492	0.0514	183
		RDS-SS	0.3935	0.2945	0.4925	4.8738	0.0505	
	Domestic employee	RDS-I	0.1275	0.0894	0.1657	1.5496	0.0195	
		RDS-II	0.1237	0.0681	0.1794	3.3866	0.0284	51
		RDS-SS	0.1234	0.0683	0.1784	3.3275	0.0281	
	Employer or active partner	RDS-I	0.0351	0.0189	0.0513	0.9242	0.0083	
		RDS-II	0.0331	0.0162	0.0500	1.0615	0.0086	16
		RDS-SS	0.0332	0.0163	0.0501	1.0588	0.0086	
	Unpaid family worker	RDS-I	0.1025	0.0758	0.1293	0.9216	0.0136	
		RDS-II	0.1086	0.0639	0.1534	2.4549	0.0228	51
		RDS-SS	0.1089	0.0644	0.1533	2.4155	0.0227	

Table A2. *Cont.*

Variable	Category	RDS Estimate		95% Confidence Interval		Design Effect	SD	n
Animals	No	RDS-I	0.2879	0.2190	0.3567	1.8633	0.0351	
		RDS-II	0.2569	0.1231	0.3907	7.5658	0.0683	73
		RDS-SS	0.2566	0.1234	0.3897	7.4986	0.0679	
	Yes	RDS-I	0.7121	0.6433	0.7810	1.8633	0.0351	
		RDS-II	0.7431	0.6093	0.8769	7.5658	0.0683	229
		RDS-SS	0.7434	0.6103	0.8766	7.4986	0.0679	
Poverty	Extreme poverty	RDS-I	0.0902	0.0677	0.1126	1.3843	0.0114	
		RDS-II	0.0938	0.0509	0.1366	4.8772	0.0219	71
		RDS-SS	0.0935	0.0506	0.1364	4.8907	0.0219	
	No extreme poverty	RDS-I	0.9098	0.8874	0.9323	1.3843	0.0114	
		RDS-II	0.9062	0.8634	0.9491	4.8772	0.0219	737
		RDS-SS	0.9065	0.8636	0.9494	4.8907	0.0219	
Victim	Frequently	RDS-I	0.0925	0.0748	0.1102	0.8476	0.0090	
		RDS-II	0.0932	0.0502	0.1362	4.9735	0.0219	87
		RDS-SS	0.0937	0.0507	0.1367	4.9493	0.0219	
	Occasionally	RDS-I	0.9075	0.8898	0.9252	0.8476	0.0090	
		RDS-II	0.9068	0.8638	0.9498	4.9735	0.0219	727
		RDS-SS	0.9063	0.8633	0.9493	4.9493	0.0219	
	General satisfaction	RDS-I	8.5455	8.4242	8.6669	1.6210	0.0619	
		RDS-II	8.5468	8.2907	8.8028	6.9519	0.1306	814
		RDS-SS	8.5506	8.2982	8.8029	6.7684	0.1288	

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