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Method Article

The Niakhar Social Networks and Health Project

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A B S T R A C T

This paper presents details of the design and implementation of the Niakhar Social Networks and Health Project (NSNHP), a large, mixed-methods project funded by the U.S. National Institute of General Medical Sciences (NIGMS). By redressing fundamental problems in conventional survey network data collection methods, the project is aimed at improving inferences concerning the association between social network structures and processes and health behaviors and outcomes. Fielded in collaboration with an ongoing demographic and health surveillance system in rural Senegal, the NSNHP includes qualitative data concerning the dimensions of social association and health ideologies and behaviors in the study zone, two panels of a new social network survey, and several supplementary and affiliated data sets.

- Longitudinal social network survey linked to pre-existing surveillance data
- Addresses fundamental methodological constraints in previous social network data
- Enables social network analyses of health beliefs, behaviors, and outcomes

A R T I C L E I N F O
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Keywords: Social networks, Demography, Public health, Survey methodology
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Specifications Table

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Method name:	*Social network survey*
Name and reference of original method	*N/A*
Resource availability:	www.nsnhp.org

Method details

Social network processes, through the content of network ties and their structural characteristics, are key to understanding diffusion of innovation and adoption of new behaviors with regard to health. Critical limitations in prior data collection designs, however, generally preclude unbiased estimates of social learning, influence and diffusion processes through networks, and inferences concerning them. These design limitations include censoring of the types of ties (or relationships) between individuals elicited, the number of network associates (alters) elicited within each type of tie, and respondent (or ego) reports of alters' characteristics and behaviors. Further, the vast majority of social network data that have been collected to date concerning health are egocentric (eliciting network ties from respondents but not between members of the full network), making it impossible to analyze the potentially critical impact of structural characteristics of networks on health behaviors and outcomes [1,2].

The Niakhar Social Networks and Health Project (NSNHP), funded by the U.S. NIGMS, was set up to address these problems and provide a unique source of individual-level, longitudinal social network data on health behaviors. The NSNHP collected two panels of survey data (in 2014 and 2016) from a rural population in Eastern Senegal through an innovative research design whereby network alters cited by survey respondents are linked to longitudinally-collected data concerning their health behaviors in a long-standing demographic surveillance system, the Niakhar Health and Demographic Surveillance System (NHDSS), member of Indepth-Network [3].[1] This innovation allows for the

[1] www.indetph-network.org.

identification of more network members across more types of ties than generally possible with conventional survey designs. It further allows linkage of both respondents and their network alters (as well as their kin and community members) to high-quality, prospectively collected longitudinal health, demographic and economic data available in the NHDSS. Together, these data make possible more fine-grained analyses of social learning and diffusion than have generally been previously possible in epidemiological, demographic, and public health research.

Setting

The NHDSS is located in the Niakhar and Diarère districts of the department of Fatick (Sine-Saloum), 135 km east of Dakar, Senegal. It encompasses 8 villages which have been under demographic surveillance since 1963, and 22 other villages which were brought under surveillance for the first time in 1983 (Fig. 1). The population of the surveillance area has doubled in the past 30 years, covering more than 44 000 people at the time of data collection for the first panel of the NSNHP in 2014.

The economy is characterized by rainfed agriculture (with rotation of millet, groundnuts and fallow), and livestock production of cattle, sheep and goats [4]. Diversification of crops has been ongoing for several decades due to the government's withdrawal of support from the production of groundnuts and a rise in rainfall levels that favors the cultivation of watermelon and market gardening [5]. Circular movements of migration towards urban areas, particularly the capital, Dakar, have intensified in recent decades [6].

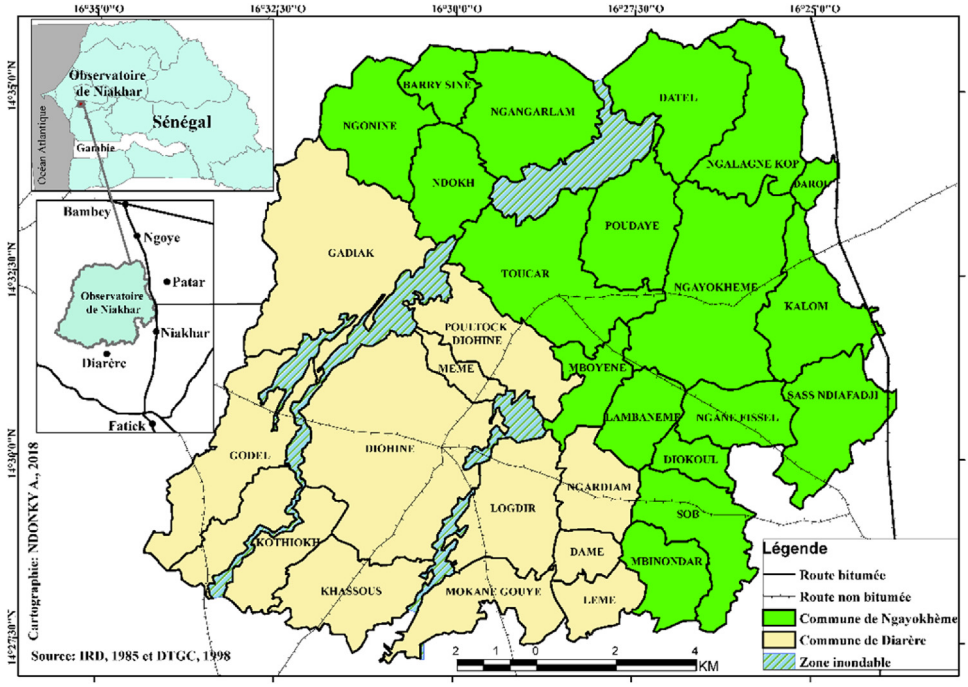

Fig. 1. Niakhar Demographic and Health Surveillance System study area.

Niakhar Demographic and Health Surveillance System (NDHSS) data

Surveillance data

As discussed above, the fundamental innovation of this project is to field the social network survey instrument over a population that has been (for the last 50 years), and continues to be, under continuous demographic surveillance by the IRD, through the Niakhar Demographic and Health Surveillance System (NDHSS). The NDHSS collects data, longitudinally, on a variety of demographic, social, and health phenomena. These include, but are not limited to, pregnancies, maternal health visits, antenatal care, weaning, births, stillbirths, miscarriages, traditional and modern medical assistance at birth, fever-inducing illness, the use of health facilities, vaccinations for children, use of medical treatments and prophylaxes such as anti-malarial medications and treated bed-nets, mortality (including verbal autopsies for the deceased), geospatial location of residence and complete migration histories. Investigators are able to link these data to respondents, members of respondents' households and communities, and, using the name identifiers collected in the main survey instrument, respondents' network alters.

The household survey of household goods and equipment

Investigators are also capable of linking respondents, their network alters, and all other individuals in the surveillance zone to extensive information concerning household wealth, material possessions, facilities (power, building materials, water and sanitation among others), and agricultural and non-agricultural production through a household census conducted in the zone by the IRD at the same time as the first panel in 2014.

NSNHP instruments and data

Qualitative data on sociability in the study zone

In 2007, semi-structured in-depth interviews were conducted with a stratified random sample of 24 adults in the NHDSS study zone. The interview guide was structured using 30 commonly used questions designed to elicit names of individuals with whom the respondent had a certain type of tie, or relationship (knows as 'name generators' in the social network literature) as prompts for discussion. The aim of this investigation was to assess the dimensionality of sociability in the zone and to identify major types of and modalities of social ties between individuals. Available on the project website, these transcribed and translated interviews were used to identify a discrete set of name generators hypothesized to capture the most comprehensive personal networks possible in this population.

Pilot network survey

In 2008, a pilot survey was fielded over a stratified random sample of 141 adults from the study zone. This pilot contained 15 name generator questions derived from the qualitative study of sociability in the zone, across 4 theoretically key domains of interaction. These included affective ties, those primarily associated with exchange or support, those whose saliency was primarily due to frequency of or time spent in interaction, and role-relational ties, structural or institutional ties potentially entailing obligation, and one residual name generator [11–15]. Alter elicitation for each name generator was free choice, with respondents allowed (and prompted) to name as many alters as they wished in each, allowing for multiplexity, or the naming of unique alters across multiple name generators.

For each alter elicited in the name generators, the survey instrument gathered additional information. These included a discrete set of 'name identifiers', or questions, derived from qualitative research concerning how residents in this population uniquely identify each other, that were hypothesized collectively to provide dispositive identification of alters in the NDHSS surveillance data. In addition, extensive 'name interpreters', or questions concerning the characteristics of alters or the relationship between ego and alter were also collected. These included questions concerning relationship with the alter, kinship status, time spent (and desired to be spent) with them, as well as

measures of tie strength, including a psychophysical measure of subjective value of each alter to the respondent.

Qualitative disease narratives

In 2012, semi-structured qualitative interviews consisting of illness or disease narratives were conducted with a simple random sample of 98 individuals above the age of 16 in the study zone from the surveillance system database with the primary aim of develop survey measures of ideational context capable of discriminating cognitive schemas related to health. The interview guide asked respondents to discuss a recent episode when they or someone close to them in the family had become sick, and when time allowed, a second episode was discussed. For each episode, respondents discussed the initial recognition of illness, symptoms, perceived nosology and etiology (including broader discussion of these topics), sequential therapeutic steps taken (auto-medical and professional, biomedical and ethnomedical) reasons for the particular sequencing pursued, logistical arrangements and financial costs, and perceived outcomes of therapy as the role of others (family, neighbors, social network members, medical practitioners) in each of these areas. Interviews were conducted in the local language, transcribed and translated into French, then entered into NVIVO qualitative software and coded for references to detailed items within the broad categories of cause of illness, place of treatment, illness/symptoms, help given/received type of treatment, judgements of responsibility, perception of good health and other individuals implicated.

Main panel survey

The NSNHP fielded its baseline survey (or panel 1) in 2014, consisting two data collections with identical instruments. The first, or 'population sample' was a simple random sample of resident adults and adolescents age 16 and above drawn from the NDHSS surveillance data. The second was a complete census of adults and adolescents aged 16 and above in one village (the 'sociocentric village'). This village was purposively selected from the 30 villages in the surveillance zone because of several desirable characteristics. It is one of the original 8 villages with surveillance data dating back to 1963. It is a relatively large community, with established institutions (a health post, schools, commercial area and town center), but is not of the same size and geographic dispersion of the two major towns in the zone. It is also ethnically homogenous but religiously diverse (with a significant community of Catholics in addition to the majority Muslim population). Most importantly, it has three characteristics which constrain sociability and interpersonal interaction to other individuals within its boundaries to a greater degree than in other villages in the zone, a critical criterion for adequate identification of sociocentric network structure [7]. First, residences in the village are concentrated in a small set of neighborhoods around the center of the village, and these neighborhoods are relatively isolated geographically from population centers of the neighboring villages which surround it. Second, while in many villages in the surveillance area land used for agriculture can be located at some distance from the users' households, in the sociocentric village agricultural land is located in relatively close proximity to households, within and on the immediate outskirts of the residential neighborhoods, limiting residents' exposure to those from other villages while in the fields. Finally, unlike other larger villages in the zone, it is located on only one local road, removed from the highway connecting the major regional population centers. These characteristics in combination strengthen the assumption of a realist boundary specification with regard to social association within the village.

The NSNHP follow-up survey (or panel 2), fielded in 2016, attempted re-interviews with all population sample respondents from the first panel the still resident in the zone. This sample was refreshed with a simple random sample from the surveillance system of residents newly aged 16 and over, or newly arrived in the zone, to maintain population representativeness. Interviews were also attempted with all first panel respondents from the sociocentric village who were still resident there, as well as residents who had moved into the village or had turned 16 years old between panels.

Table 1 presents the summary interview results for both NSNHP longitudinal panels. For panel 1, 1310 respondents were interviewed in the sociocentric village, and 882 respondents in the population sample. Those marked 'absent' were either not reachable after 3 attempts or were identified by key

Table 1
Interview results panels 1 and 2, NSNHP.

	Sociocentric village sample				Population sample			
		Panel 2				Panel 2		
	Panel 1	Complete panel 1	Supplement	Total	Panel 1	Complete panel 1	Supplement	Total
Complete	1310	966	258	1224	882	606	251	857
Incomplete								
partial	14	9	3	12	48	12	6	18
absent	193	184	114	298	290	93	120	213
incapacitated	32	7	8	15	0	6	3	9
dead	–	11	3	14	–	1	6	7
not started	0	23	6	29	12	62	6	68
refusal	48	29	16	45	6	12	6	18
removed from surveillance	26	81	–	81	–	90	–	90
Total	1623	1310	408	1718	1238	882	398	1280

Source: compiled by authors.

respondents as having migrated outside of the zone, though they were retained as residents in the surveillance system. Removing these respondents, as well as those too incapacitated to be interviewed, and sample members who had been removed from the surveillance system after compilation of the sample list, we obtain response rates of 96% for the sociocentric village and 99% for the population sample among de facto, non-incapacitated resident sample members.

Information concerning retention and attrition in panel 2, of those interviewed in panel 1 is also presented in Table 1. Overall, for those interviewed in panel 1, we obtain retention rates of 73.4% and 69% for the sociocentric village and population samples, respectively. As in the first panel, however, sample members in each group were absent due to migration but maintained in the surveillance system as residents, had died or become too incapacitated for interview. Additionally, a number of sample members in each group had been removed from the surveillance system for one of these reasons. Taking these issues into account, we obtain retention rates across the panels of 94% and 88% among the sample among de facto, non-incapacitated resident sample members in the sociocentric village and population samples, respectively.

Finally, Table 1 indicates that, in panel 2, 251 new respondents were added to the sociocentric sample and 258 to the population sample. These represent response rates among the de facto population of those eligible as defined above of 94% and 98%, respectively.

Survey questions in the main panel included 16 name generators and name identifiers as described above concerning the pilot data collection with minor modifications, including two new name generators aimed at eliciting alters from whom respondents received help when sick, and to who they provided such help. Information was also collected for each alter elicited concerning relationship type and duration, kinship affiliation, frequency of interaction, relative socioeconomic position,

Table 2
Mean (std. dev) numbers of alters elicited, unique alters, alters identifiable in the NDHSS and proportion of alters identifiable by sample and panel wave, NSNHP 2014–16.

	Named	Alters	Identifiable	Proportion identifiable
Population sample				
Panel 1	45.61 (15.83)	26.48 (9.1)	21.94 (8.37)	0.828 (0.138)
Panel 2	47.02 (18.88)	28.19 (11.42)	23.58 (10.02)	0.838 (0.140)
Sociocentric village				
Panel 1	40.11 (14.55)	23.58 (8.19)	19.51 (7.58)	0.821 (0.132)
Panel 2	43.55 (17.32)	25.09 (10.4)	20.57 (9.07)	0.822 (0.142)

Source: compiled by author.

psychometric tie strength and indicators of type of health aid received or given from/to alters in those specific name generators.

Table 2 presents summary statistics for number of alters elicited from respondents for the population sample and sociocentric village by survey panel. The first column 'named', refers to the total number of names elicited regardless of repetition (or multiplexity) across name generators. The column 'alters' refers to unique alters cited eliminating multiplexity, and that for 'identifiable' to unique alters who had lived or currently live in the surveillance zone and therefor are potentially identifiable in the NDHSS data. The final column presents estimates of the respondent-level proportions of alters potentially identifiable. As seen here, relatively small, but non-negligible proportions of unique alters elicited are from areas outside the surveillance zone, and therefore have no NDHSS data associated with them. On average, about 3–4 out of 20–24 uniquely cited alters are not identifiable in the NDHSS.

In addition to the network instruments, the first panel survey included a large respondent questionnaire including of 20 questions concerning health ideation and behavior derived from analysis of the qualitative disease narratives aimed at measuring cognitive and behavioral schemas of health and illness in this population. The respondent questionnaire also included batteries of questions concerning health and demographic phenomena of wide public health interest including family planning and reproductive health, the status of women and perceptions of the acceptability of intimate partner violence (IPV) as well as mental health.

Social networks in both the sociocentric and population samples are found to radiate outward with a decaying density function from the household, to the residential compound, residential neighborhood, village of residence and other areas in Senegal and beyond [8]. For both panels, approximately 90% of all unique alters elicited were residents of the same village as the respondent. The numbers of respondents' alters who were administered the main panel instruments are negligible in the (randomly selected) population sample. However, since 96% of all respondents over the age of 16 were interviewed in the sociocentric village, the vast majority of alters cited were also interviewed with the main survey instruments. This allows the full complement of characteristics from the respondent questionnaire to be employed as characteristics of respondents' within-village social networks.

Supplementary data

In 2015, between the two panels of the main survey, a smaller re-interview survey with a random sample of 300 first panel respondents was conducted using the main survey instrument, augmented with questions to test a variety of issues concerning social network survey methodology and reliability. These included questions concerning respondents knowledge of alters' characteristics, including health ideation, fertility history, and household characteristics to assess the validity of alter reports as generally collected in social network surveys.

At the same time, a roster-based version of the main network instrument was fielded on 500 individuals who had been cited as network alters by respondents in the first panel to enable an alternative estimate of network density from the alter's perspective. In this instrument, respondents were read a list of names, randomly selected from the population to be proportionally representative of the residential and geographic distribution of alters among respondents in the main survey. One of these names was substituted with the name of the first panel respondent who had cited the roster respondent as an alter. For each name read to the respondent, they were asked if that person would be cited each of the name generators used in the first panel instrument, and if so, to complete the name interpreters from that survey for those alters.

Linking alters cited to NDHSS surveillance records

One of the principal challenges of this research has been linking network alters identified in the survey instrument to their corresponding records (if they exist) in the NDHSS surveillance system. This is a deceptively simple problem until one considers the potential sources of error on both sides, especially concerning names. As discussed above, a series of 'name identifier' questions were asked

concerning each alter elicited to accomplish this. These included alters' and alters' parents' names, the names of the head of alters' residential compound and their current residential localization (in the same residential compound, in a different compound in the same village, in a different village in the study zone, in the capital Dakar, somewhere else in Senegal, international, or deceased). In the case of localizations outside the surveillance zone, prior residential localization within it, if any, was also ascertained. Also collected were basic information on sex, age relative to the respondent (older, younger, about the same age), matrilineal clan, whether the alter had ever been married, and for current migrants, their duration of absence. An algorithm was developed which evaluated the likelihood of identical information in each of these identifiers in surveillance system records conditional on the joint the distribution of other identifiers in the set. In panel one, an identifier weighting matrix was developed from the pilot data and the algorithm was implemented as part of the CAPI survey data collection, evaluating the likelihood of improvement in candidate matching with any subsequent piece of information after every response to a name identifier. This was done with the goal of minimizing survey time, stopping collection after further name identifiers were unnecessary. Matching results using this method were unsatisfactory, however, as respondent error rates in early identifiers elicited were not adequately accounted for, and it was discovered that substantial heterogeneity in the identifier weight matrix existed by residential location. To remedy this, trained local research assistants evaluated a sample of 2000 alters in comparison to the full surveillance system by hand to identify certain and high likelihood matches. Monte-Carlo methods were then used to develop identifier weighting matrixes capable if identifying the highest percentage of correct matches at each category of current or prior residential localization. Based on this experience, in the reinterview and panel 2 data collection, all name identifiers were collected concerning each alter cited, and the matching algorithm was implemented in an identical fashion in post-processing.

Estimates of the proportion of alters correctly identified by the algorithm in random verification samples of matches stratified by current (or prior) residential localization in the surveillance zone for both panels of the survey and for the intervening reinterview instrument are presented in Table 3. Overall, the sensitivity of the matching process was lower in panel one (81.8%) than the reinterview or second panel (91% and 86%, respectively) for reasons outlined above. In both main panels, correct linkage of alters diminshed with decreasing residential proximity. The estimated proportions of alters correctly matched for the second panel were lower than those for the reinterview largely because alters' parents' names were not collected at the same rate as in the reinterview instrument, a deficiency in interviewer training and quality control. Current research is proceeding with the aim of

Table 3
Proportion of identifiable alters successfully matched to NDHSS surveillance records by localization of alters and panel, NSNHP 2014–2016 (95% CI).

	Proportion matched	Proportion alters	Proportion alters matched
Panel 1 (n = 200/strata)			
same residential compound	0.875 (0.831, 0.919)	0.387	0.339 (0.322, 0.356)
same village	0.793 (0.737, 0.848)	0.518	0.411 (0.382, 0.439)
other village	0.709 (0.648, 0.769)	0.096	0.068 (0.062, 0.074)
Total			*0.818 (0.766, 0.869)*
Reinterview (n = 100/strata)			
same residential compound	0.917 (0.866, 0.974)	0.377	0.345 (0.326, 0.367)
same village	0.942 (0.893, 0.987)	0.528	0.497 (0.471, 0.521)
other village	0.714 (0.62, 0.8)	0.096	0.068 (0.059, 0.076)
Total			*0.910 (0.856, 0.964)*
Panel 2 (n = 200/strata 1, 3, 500 strata 2)			
same residential compound	0.915 (0.879, 0.951)	0.371	0.34 (0.326, 0.353)
same village	0.842 (0.809, 0.876)	0.518	0.436 (0.419, 0.453)
other village	0.762 (0.704, 0.82)	0.111	0.085 (0.078, 0.091)
Total			*0.861 (0.823, 0.897)*

Source: compiled by authors.

increasing the proportion of alters correctly matched to the surveillance data through the use of a new algorithm developed to evaluate concordance of alter matches across surveys panels.

Strengths and limitations

The main strengths of the NSNHP data are the broad and comprehensive network component, and the linkage between this component and the surveillance data of the NHDSS. Elicitation of social networks took place across a wide, theoretically warranted, and culturally appropriate range of types of interaction, without placing constraints on the number of alters elicited as in the vast majority of prior network survey designs. Detailed data was also collected concerning each network tie, as well as a wide range of health and demographic beliefs and behaviors from respondents, and, as discussed above, in the sociocentric village sample, their network alters.

The population sample can be used to produce estimates of associations between health beliefs and behaviors and network characteristics that are representative of the broader rural population of the surveillance zone in a manner identical to data from conventional egocentric network designs. The sociocentric sample, which identifies network ties between all members of the population of the sociocentric village, allows additionally for the estimation of effects associated with the structural properties of networks.

Fig. 2 presents the sociogram from the first panel of the NSNHP for the sociocentric village. This is a graphic depiction of network connections between respondents. This figure depicts 8 distinct network clusters, or sub-networks identified through the Louvain modularity method [9], roughly corresponding to neighborhoods within the village.

Sociocentric data such as these are capable of generating critical measures network structure and position that cannot be obtained with egocentric data. These include (but are not limited to, network density, reciprocity and transitivity, as well network centrality, all of which have been hypothesized to have important implications for the explanation of health beliefs and behaviors [10]. This type of data, concerning broad personal networks across multiple domains of association has rarely collected in the context of health research, and where it has been, it has been limited by design in the ways discussed above [1], and has never been collected before as a prospective panel.

Of equal importance, the NSNHP network data is linked to the ongoing, prospective data collection in the NHDSS for all members of the population, including respondents, members of their social networks, households, kin groups, neighborhoods, and communities as well as extensive supplementary socioeconomic data collected on the same population. In combination with the network survey panels and substantive elements of the NSNHP surveys, this makes possible systems analyses of change in social context on health and health behaviors, including their diffusion, not possible before, including estimation of the impact of changes in the structure of social networks and the substantive characteristics of alters within them over time.

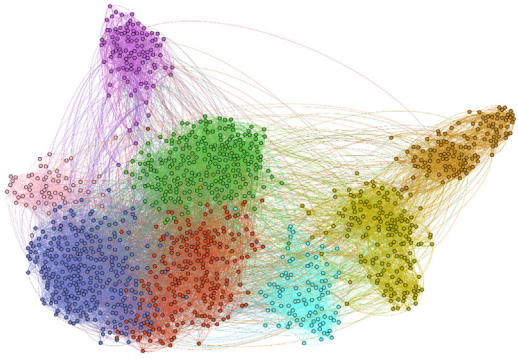

Fig. 2. Sociocentric village sociogram, NSNHP panel I 2014.

The main weaknesses of the NSNHP data are the limited interval between panels and the integration with the NHDSS data. The interval between the first two panels of the NSNHP was only two years, limiting the ability to assess the association between changes in network structure and composition, and change in health beliefs and behaviors. Funding has been requested to extend the NSNHP cohort to two further panels to address this issue. Like any complex longitudinal data source, the NDHSS data themselves can be cumbersome to use, and doing so generally requires close collaboration with IRD data managers or other experts in its structure to ensure quality measurement. Though linking this vast data to the network survey data is a significant strength, it also presents challenges for inferences about associations between individual and social network characteristics which are the focus of the project. As discussed above, the process of linking alters to their surveillance records was not perfect. This will have no effect on estimates related to network characteristics and structure derived solely from the survey, but is a source of measurement error in indicators and structural characteristics derived from linkage to the NDHSS data.

Data access

Data collected from the qualitative interviews and deidentified is publicly available on the project website (http://www.nsnhp.org). All survey data from the population sample, stripped of identifying information will be made available for restricted use through existing data access protocols maintained by the NSNHP and NDHSS (requiring appropriate use justification and institutional review board approval by the IRD and requesting institution). Data from the sociocentric sample are more sensitive. This data will also be made available to the research community, but a more stringent screening and security process will be implemented following NSNHP and NDHSS protocols for access and confidentiality. The data contained in the surveillance system and the survey which will be linked to the network survey are highly sensitive and are the property of the NDHSS. They will be made available to the research community at the discretion of and following NDHSS conventional restricted access protocols as well.

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