



Conducting Social Network and Social Norm Research in Low-Resource Settings: Food Insecurity, Depression, and HIV Testing in Rural Uganda

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Conducting Social Network and Social Norm Research in Low-Resource Settings:
Food Insecurity, Depression, and HIV Testing in Rural Uganda

A dissertation presented

by

Jessica Mayson Perkins

to

The Program in Health Policy

in partial fulfillment of the requirements

for the degree of

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in the subject of

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Conducting Social Network and Social Norm Research in Low-Resource Settings:
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Abstract

This dissertation examines the role of social networks and social norms in health outcomes and behaviors among low-and middle-income countries (LMICs), with a particular focus on Uganda. Paper 1 presents a systematic review of sociocentric network studies conducted in LMICs on health-related outcomes and other development topics. I first discuss the sociocentric network study designs employed in 36 selected papers, and provide a catalog of 105 name generator questions used to measure social ties. Second, I show that network composition, individual network centrality, and network structure are associated with health behaviors and health and development outcomes in different contexts across multiple levels of analysis and across distinct network types. Lastly, I highlight opportunities for health researchers and practitioners in LMICs to 1) design effective studies and interventions that account for the sociocentric network positions of certain individuals and overall network structure, 2) measure the spread of outcomes or intervention externalities, and 3) enhance the effectiveness and efficiency of aid based on knowledge of social structure.

Papers 2 and 3 exploit a population-based dataset on eight villages from rural Southwest Uganda, arising from a pilot study which myself and colleagues designed to collect sociocentric network data. There were a total of 1,669 adults interviewed representing a response rate of 96%. Paper 2 assesses the relationship between food insecurity and depression symptom severity in the general adult population, and the

potential confounding or moderating roles of social network position, structure, and composition in that relationship. I find that severe and moderate food insecurity was associated with greater depression symptom severity among both men and women, and that none of the social network characteristics were directly associated with the outcome. Moreover, there were no interactions between food insecurity and network characteristics among women. For severely food insecure men, however, personal network centrality was positively associated with symptoms and personal network poverty composition was negatively associated with symptoms. Findings reveal that nutrition interventions aimed at improving food security in rural areas may have significant beneficial effects in terms of mental health outcomes for the whole population. I discuss the possible role of shame in affecting depression among severely food insecure men with wealthier networks and in more central network locations.

Paper 3 examines the extent to which individuals underestimate the prevalence of HIV testing in their village and misperceive the norm, and also assesses the relationship between perception of the HIV testing norm in one's village with personally never having been tested. I find that although a majority of people had been tested in each of the villages, a majority of people underestimated the actual prevalence and thought that testing was not normative. Men who perceived testing as not normative were much more likely to never have been tested, and both men and women who felt they didn't know anything about the norm were also more likely to never have been tested. Results suggest that interventions promoting true HIV testing norms may help increase uptake of testing.

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**Paper I: Social Networks and Health: A Systematic Review of Sociocentric Network
Studies in Low- and Middle-Income Countries**

ABSTRACT

In low- and middle-income countries (LMICs), naturally occurring social networks may be particularly vital to health outcomes as extended webs of social ties often are the principal source of various resources. Understanding how social network structure and influential individuals within a network may amplify the effects of interventions in LMICs, by creating, for example, cascade effects to non-targeted participants, presents an opportunity to improve the efficiency and effectiveness of public health interventions in such settings. We conducted a systematic review of PubMed, Econlit, Sociological Abstracts, and PsycINFO to identify a sample of 17 sociocentric network papers (arising from 10 studies) that specifically examined health issues in LMICs. We also separately selected to review 19 sociocentric network papers (arising from 10 other studies) on development topics related to wellbeing in LMICs. First, to provide a methodological resource, we discuss the sociocentric network study designs employed in the selected papers, and then provide a catalog of name generators used to measure social ties across all the LMIC network papers cited in this review. Second, we show that network composition, individual network centrality, and network structure are associated with important health behaviors and health and development outcomes in different contexts across multiple levels of analysis and across distinct network types. Lastly, we highlight the opportunities for health researchers and practitioners in LMICs to 1) design effective studies and interventions in LMICs that account for the sociocentric network positions of certain individuals and overall network structure, 2) measure the spread of outcomes or intervention externalities, and 3) enhance the effectiveness and efficiency of aid based on knowledge of social structure. In summary, human health and wellbeing are connected through complex webs of dynamic social relationships. Harnessing such information may be especially important in contexts where resources are limited

and people depend on their direct and indirect connections for support.

INTRODUCTION

Measuring the role of social networks in low- and middle-income countries (LMICs) may be particularly critical for interpreting health outcomes in these contexts. As there are often limited social protection schemes in LMICs and significant geographic and infrastructural barriers in accessing those that do exist, many sources of formal support are simply not available when needed. Instead, direct or indirect connections up to several degrees of separation (e.g., friends of friends) may be one's only source of assistance (e.g. Apicella et al, 2012; Comola, 2012; De Weerd & Dercon, 2006; Ware et al, 2009) or influence. Critically, individuals with few informal social connections and no access to other sources of formal support in resource-limited contexts may suffer serious consequences. Indeed, Tsai, Bangsberg, and Weiser (2013) reviewed a number of qualitative studies describing how the "social death" from HIV stigma, and the resulting loss of instrumental support, is often feared more than HIV itself.

Many network studies related to health and health behaviors in LMICs have measured specific social ties representing actors' personal networks (e.g. Adams et al., 2002; Avogo & Agadjanian, 2008; Bignami-Van Assche, 2005; Edmonds et al., 2012; Fonseca-Becker & Valente, 2006; Green et al., 2011; Kohler et al., 2007; Miguel & Kremer, 2003; Moore, 2014; Moser & Mosler, 2008; Ruiz-Casares, 2010; Sandberg, 2012; White & Watkins, 2000; Wutich & McCarty, 2008; Zhang et al., 2012). Although these studies typically collect data about an actor's immediate contacts and the actor's perceptions of ties between those contacts, they cannot fully reveal structural aspects of the larger network in which actors are embedded nor explore the diffusion of behaviors, resources, technologies, and diseases through a larger set of people. In contrast, sociocentric network studies attempt to depict the entire network by collecting data on the social ties between all targeted individuals within a defined population (Marsden, 1990).

Such data permit calculation of network structure and function, and increase our understanding of the mechanisms through which social networks may affect health-related attitudes, behaviors, and outcomes (or vice versa). Relevant network effects may include provision of perceived or actual social support, social influence and learning, social engagement, person-to-person transmission of diverse sorts, and/or access to resources (Berkman et al, 2000). Crucially, networks create pathways for the spread of attitudes, behaviors, and emotions, as well as financial, physical, informational, labor, and social resources.

Understanding the formation of social ties, sociocentric network structure and function, and associated mechanisms linking these to health or health behaviors, may be extremely relevant in the context of allocating limited resources or targeting public health and economic development interventions in LMICs (Christakis, 2004; Honeycutt, 2009; Rasul & Hernandez, 2012; Valente, 2012). For example, the most efficient allocation of budgetary resources for a given intervention may depend on how the network structure affects health behaviors or how it affects the flow of diverse phenomena through the network. Importantly, information about network structure and function might be exploited in two broad ways. First, interventions could manipulate the topology of the network or rewire social ties (e.g., by directly introducing people to each other or by indirectly causing people to become more connected). Second, interventions may try to facilitate the contagion of phenomena within an extant network – for example, by encouraging adoption of vaccines, clean water methods, contraception, neonatal assistance, or other public health interventions. Both types of interventions can, in turn, have two effects. Manipulating peer reinforcement might increase the probability that the treated will respond to the treatment. In addition, network effects can also be exploited to enhance the response to treatment among the untreated as treatment effects may ripple outward from targeted individuals,

affecting others to whom they are connected (Philipson, 2002). Thus, measuring social networks -- and studying contagion in a network and how it may be amplified across individuals indirectly connected to the targeted recipients (Christakis and Fowler, 2013) -- is critical for determining both intervention efficiency and effectiveness, particularly in LMICs.

AIMS

To summarize existing knowledge about network structure and function in relation to health in LMICs, we conducted a systematic review of sociocentric network studies exploring health-related issues in LMICs. The goals of this review were to provide a resource for the design and analysis of sociocentric network research in LMICs; summarize extant evidence regarding social network associations with health and health-related issues in varying cultural, political, and economic contexts in LMICs; and provide a framework for thinking about the role of social network analysis in research, intervention design and evaluation, and creation of public health policy. We were guided by three main questions:

1. How are sociocentric social networks quantitatively measured in LMICs for health-related research?
2. What common observations can we make about how network composition, network position, and network structure are associated with health and health behaviors in these settings?
3. How can sociocentric network data collection be improved in LMICs and what directions might future research on social networks and health in LMICs take?

We begin this review by outlining some conceptual considerations relevant to social networks and health. This is followed by a description of the methods used to conduct the review and then a summary of findings extracted from the studies reviewed.

CONCEPTUAL FRAMEWORK

Numerous studies have shown that social relationships in general matter for health and health-related outcomes (e.g. House et al 1988; Seeman 1996; Umberson et al 2010), and that the quantity, quality, and type of social ties are associated with wellbeing (e.g. Berkman & Krishna, 2014; Cornwell et al, 2009; O'Malley & Christakis, 2011; Wellman, 1992). In addition, specific arrangements of social ties into social networks, and certain positions within social networks, may be associated with health-related outcomes (e.g. Ali & Dwyer, 2010; Christakis and Fowler, 2009; Ennett & Baumann, 1994; Haas et al, 2010; Luke and Harris, 2007; Pollard et al, 2010; Smith & Christakis, 2008; Valente, 2010). Furthermore, social network structure may affect health and development by providing a basis for phenomena as diverse as cooperation (Apicella et al, 2012; Fowler & Christakis, 2010; Rand et al, 2011), generosity (D'Exelle et al, 2010), altruism (De Weerd & Fafchamps, 2011), social norms (Coleman, 1988) and social capital (Lin, 1999; Moore et al, 2013). Indeed, research has shown that social networks are a fundamental aspect of human sociality (Apicella et al 2012; Henrich & Broesch, 2013).

Measuring Social Structure

While some researchers use the term 'social networks' to refer to an individual's general subset of social relationships, such as family members, friends, or religion-based contacts, other researchers discuss social networks in relation to the structural arrangement of social relationships in which people are embedded (Berkman et al, 2000; Smith & Christakis, 2008). This social structure is typically assessed by identifying specific social ties, measuring

characteristics of those social ties, and linking them together in an extended web of interaction. Therefore, the tie is the important unit of measurement (Freeman, 1979; Marsden, 1990, 2002; Scott & Carrington, 2011; Wasserman & Faust, 1994). Name generators (NGs) are survey questions used to elicit social ties between pairs of people (or households). Such questions request respondents to name specific people with whom respondents have a certain type of connection (Marin, 2004; Marsden, 1990). Thus, the NG often determines the type of network measured. A 'name roster' of all the names is typically created and follow-up questions (name interpreters) may be asked about perceived attributes of the named people or of ties.

In general, NGs may elicit how a tie exists (e.g., the tie is realized through participation in shared activity, conversation, exchange of physical resources, sharing of feelings, having the same bloodline, being in the same neighborhood) or by what is given or received across a tie. Some studies refer to four approaches to measuring ties, such as the role-relation, interaction, affective or exchange approaches (Marin & Hampton, 2007; van der Poel, 1993; Sandberg, 2012), and other studies discuss the type of support that is provided through a tie (e.g., emotional support, financial and instrumental support, or informational support (Cohen & Wills, 1985)). Frequently, NGs will refer to multiple characteristics of a tie. Alternatively, some studies may employ a general NG that simply requests people to name whom one knows (McCarty et al, 2007).

Figure 1.1 depicts four separate egocentric networks (A, B, C, D) within one sociocentric network.

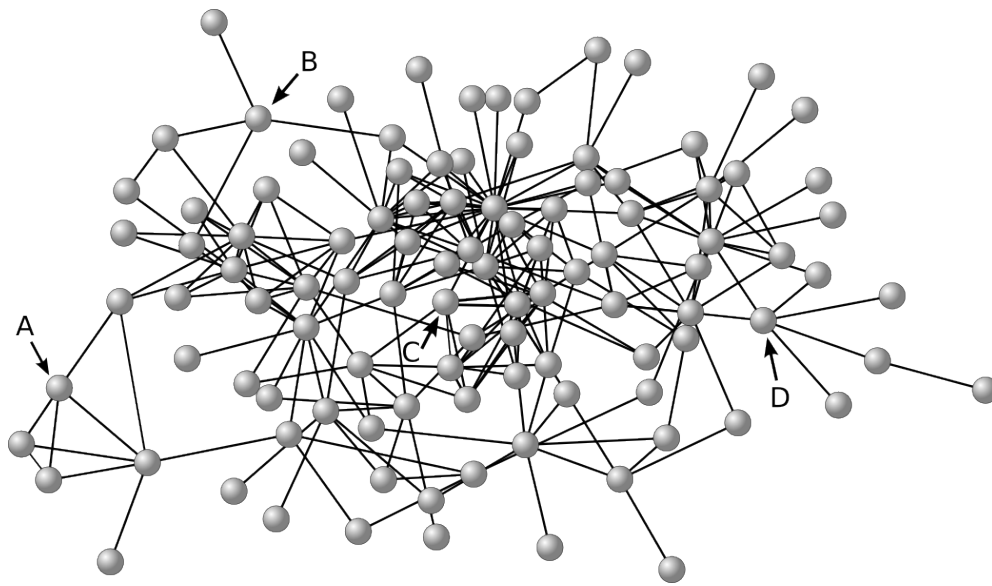


Figure 1.1. This image depicts example egocentric networks (A, B, C, and D) within a sociocentric network. In this natural network of close friendships among 105 college students living in the same dorm, each circle (“node”) represents a student and each line (“tie”) a mutual friendship. Even though persons A and B both have four friends, A’s four friends are more likely to know one another (there are ties between them) whereas none of B’s friends know each other. A has greater “transitivity” than B. Also, even though persons C and D both have six friends, they have very different “locations” in the social network. C is much more “central” than D, and C’s friends have many friends themselves, whereas D’s friends tend to have few or no friends.

By convention, the index actors are referred to as “egos” and the actors’ immediate contacts are referred to as “alters.” This image shows that an egocentric study would simply measure the immediate network around A, B, C, and D and, for example, could only provide information about ego-perceived social support from proximal alters. However, a sociocentric study can provide information about how support might arise from more distal alters or how the overall structure of the larger network might influence outcomes. Typically, to collect sociocentric network data, a census-like survey must be first conducted on the targeted population in order to identify all eligible respondents, who may then be referred to as potential “nodes” in the network.

This census then allows linkage of nodes and ties into a complete social network after data on participants' social connections are collected.

In general, sociocentric network data permit calculation of (a) actual network composition of egos' immediate alters, by which we mean the identity and attributes of the alters a person is directly connected to (as opposed to ego-perceived alter characteristics, which are sometimes collected in egocentric network studies though the information may be often inaccurate (White & Watkins, 2000; Valente et al, 1997)); (b) network composition up to various degrees of separation from an individual, e.g. actual characteristics of alters' alters; (c) the extent of an ego's embeddedness (or prominence) in the network, a construct otherwise known as individual centrality or network position; (d) structural characteristics of the whole network, also known as macro structure; and, (e) social contagion (for example, how health and health behaviors may spread across the network), in particular when longitudinal data are available.

METHODS

Paper selection criteria

We selected papers that met the following network-related criteria: (a) used quantitative data collected via census-based inclusion of participants (i.e., not just respondent-driven sampling); (b) enumerated a sociocentric social network within a circumscribed boundary by identifying specific person-to-person or household-to-household ties through a name-generation method in a defined population; and (c) provided a description of sociocentric network data collection methods, calculated some sort of network measure (either at the level of the individual, such as centrality, or at the level of the whole network, such as the number of components), or provided a map of a complete social network. We excluded studies of contact-

tracing networks, which did not attempt to enumerate a full population sociocentrically. In addition, only papers that were focused on health and health behaviors in an LMIC and written in English were included. Studies of mobile communication networks, school-based networks, networks of institutional or corporate entities, or 'dark' networks (terrorism, corruption, drug, or sex-trade networks) were excluded.

Systematic Search

Systematic searches of public health, social science, and medical peer-reviewed journals using PubMed, Econlit, Sociological Abstracts, and PsychINFO search databases were conducted prior to December, 2013. The following search terms were used: (network[ti] or networks[ti]), and (an LMIC country name[anywhere] or “developing country”[anywhere] or "Sub-Saharan Africa"[anywhere]), and health[anywhere]. A total of 2379 records (including duplicates) were identified with 1724 from PubMed, 92 from EconLit, 176 from Sociological Abstracts and 387 from PsychINFO. After eliminating duplicates, and sequentially screening titles and then abstracts for relevance, 166 articles were selected for full-text review (see Figure 1.2). Twelve articles met the criteria from the systematic search. Five more articles were identified by a careful hand search of citation lists, Google Scholar, and the databases from the Social Science Research Network (SSRN) and the National Bureau of Economic Research (NBER). Thus, a total of 17 papers providing information on quantitative, sociocentric network analyses in relation to health and health behaviors were included in this review. These 17 "health-focused" papers describe data derived from 10 unique studies.

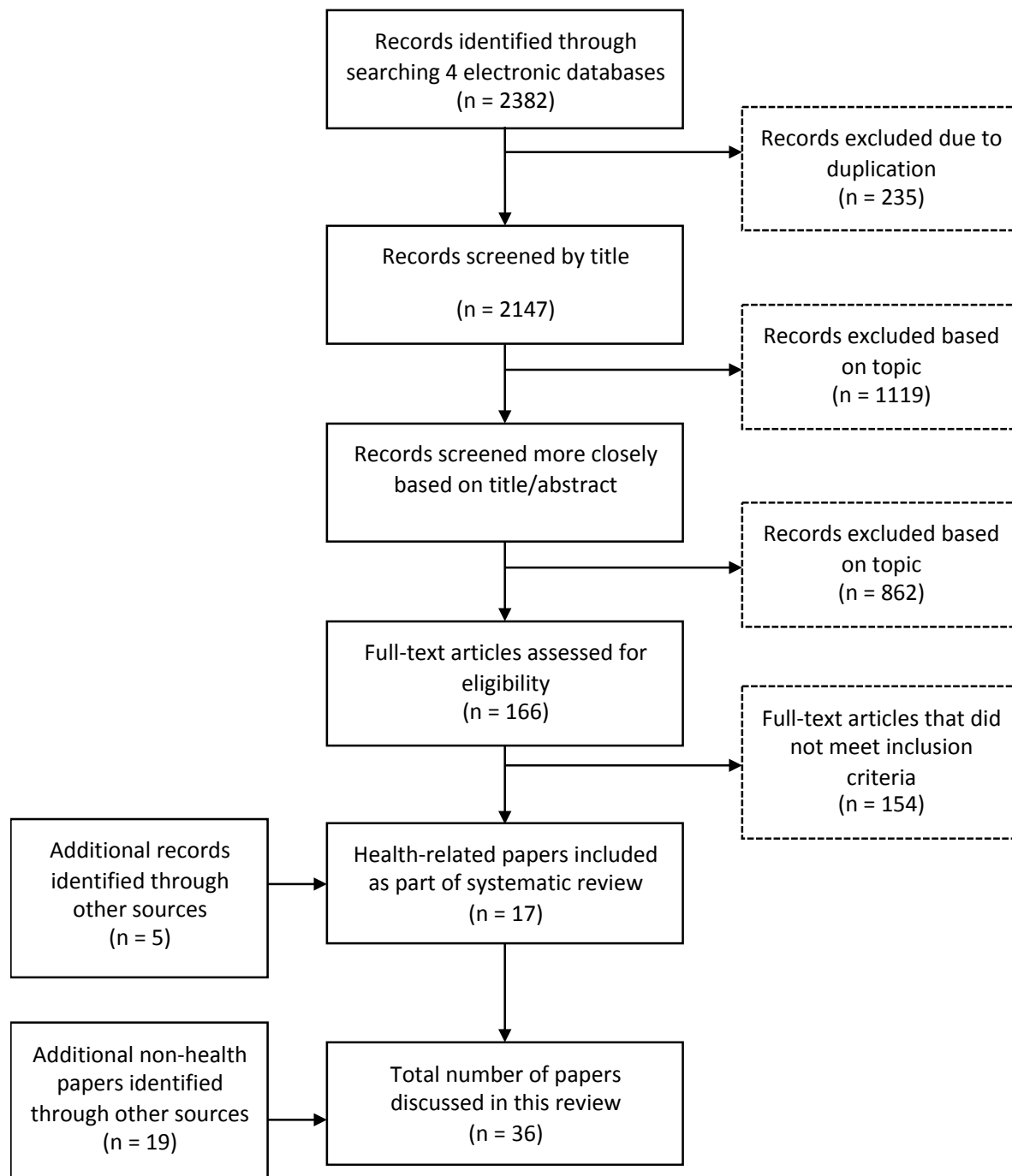


Figure 1.2. QUOROM flow chart of paper search and selection process for a systematic review of studies on sociocentric networks and health conducted in low- and middle-income countries.

Additional Papers

Although discussing health-focused sociocentric network studies in LMICs was the primary motivation for this review, other studies on more general aspects of wellbeing may offer additional insights for sociocentric network measurement in LMICs, especially given the extent of connection between health and development. Thus, our review also examined 19 “development-related” papers (based on data collected from 10 unique sociocentric network studies). This additional set of papers was selected via a thorough, but not systematic, search of the same online databases and bibliographies as well as authors' familiarity with certain studies. Although these 19 papers should not be understood as an exhaustive presentation of sociocentric network research on development topics (e.g., studies on conservation, agriculture, or migration were not included), they likely reflect a substantial portion of the literature that can be identified when conducting an interdisciplinary social science search for studies measuring sociocentric network structure in LMICs.

Style of Analytical Review

The 17 health-focused papers covered an array of contexts, populations, study designs, network types, and network analyses. Given the diversity of methodological and analytical designs, we did not conduct a meta-analysis although we were able to identify common themes in relation to network composition, individual network centrality, and network structure. Thus, we first offer a synthesis of the methodological choices made in the selected studies. We then describe how (a) individual network composition was related to family planning, (b) individual network centrality was associated with potential for behavior change, and (c) macro network characteristics were associated with disease transmission. Information from the 19 development-

related papers is incorporated. Finally, we focus our discussion on challenges and future directions for network-based research in LMICs.

RESULTS

Study Characteristics

Among the 10 health-focused studies, nine countries were represented: Ethiopia, Nepal, Bangladesh, Madagascar, Mali, Brazil, China, Malawi, and Ecuador. These studies generally focused on the possible diffusion of behaviors and diseases, with seven papers on contraception use and family planning, two on mercury consumption, five on HIV transmission, and three on diarrheal disease transmission (Table 1.1). Among the 10 development-related studies, eight countries were represented: Tanzania, Nicaragua, Gambia, Indonesia, Thailand, Nepal, China, and India. These studies covered a wide range of topics, including risk-sharing and insurance, generosity, gender issues, economic development, food-sharing, cooperation, kinship and dwelling proximity, poverty identification, microfinance, favor exchange, and latrine ownership (Table 1.2). These papers, however, generally either focused on the formation of social ties and network structure or on the adoption of a new 'technology' (loosely defined).

Given that 17 out of the 20 studies were cross-sectional in nature, very little could be determined about actual diffusion. Therefore, most of these studies interpreted evidence between network characteristics and outcomes as possible predictors of behavioral change, diffusion, and network formation. A few health-focused studies used outcome or predictor data representing multiple time points, but only collected network data at one time point (Alvergne et al, 2011; Comola, 2008; Sandberg, 2005, 2006). Also, only one health study (Helleringer et al, 2013) and two development studies (Comola & Prina, 2013; De Weerd, 2004) collected network data at more than one time point.

Table 1.1 Sociocentric network studies of health and health behaviors in low- and middle-income countries (N=17 unique papers from 10 studies).

Papers	Topic	Targeted Population	Study and Paper Design	Network Types Measured and Analyzed	Focus of Network Analysis	Sample of Basic Network Position and Structural Characteristics^a	Network Map
Alvergne et al, 2011	The spread of contraception use	All ever married women of reproductive age and their husbands across four rural villages in Ethiopia	Cross-sectional study of person-centric networks with current and self-reported historical data	1 type: same-sex friendships	Direct and indirect composition; Individual centrality	The mean number of out-going nominations was 2.7 for women and 3.8 for men.	No
Comola, 2008	Communication and adoption of contraception use	All married women of reproductive age in three rural villages in Nepal	Cross-sectional study of person-centric networks with two waves of outcome data	1 type: same-sex contraception advice	Direct and indirect composition	The average number of links per woman was 1.8 and the shortest distance between women was 4.5 links. The number of isolates was 71 out of 337.	Yes
Gayen & Raeside, 2010	Perceived peer encouragement and contraception use	One married woman of reproductive age with children for every household from seven rural villages in Bangladesh	Cross-sectional study of person-centric networks, but only one person per household was included	1 type: same-sex friendships	Direct composition; Individual centrality; Macrostructure	None available.	Yes

Table 1.1 (Continued)

Sandberg, 2005	Expected family size and uncertainty about local infant mortality	All women of reproductive age in one rural village in Nepal	Cross-sectional study of person-centric networks with current and self-reported historical data	3 types: receiving assistance when sick, giving assistance to someone, and work-colleagues (types combined for analysis)	Direct composition	The average number of outgoing nominations was 5.4.	No
Sandberg, 2006	Fertility tempo and local infant mortality	Same as above	Same as above	Same as above	Direct composition	Same as above.	No
Stoebenau & Valente, 2003	Contraception use and connection to family planning distribution agents	All adults of reproductive age in one rural village in Madagascar	Cross-sectional study of person-centric networks	2 types: general advice; family planning advice (analyzed separately)	Direct composition; Individual centrality	There were 46 out of 159 isolates in a general advice network and 117 in the family planning advice network. Density was 0.25 and 0.11 in each respective network. Only 20% of the ties were the same across the two network types.	Available from authors

Table 1.1 (Continued)

Hurley et al, 2013	Midwives as potential change agents	All adult women from two rural villages in Mali	Cross-sectional study of person-centric networks	1 type: friendship	Individual centrality; Macrostructure	The average outgoing nominations was 1.2 and 0.4 in Village A and B, respectively.	Yes
Mertens et al, 2008	Communication about mercury consumption and health	All heads of household (usually a couple) in one rural village in Brazil	Cross-sectional study of a person-centric network	1 type: health discussion	Macrostructure	There were 25 isolates out of 158 nodes with 130 linked in one dense component. The average distance between people in the main component was 3.4 links.	Yes
Mertens et al, 2012	Adoption of new fish consumption behavior and participatory research	Same as above	Same as above	Same as above	Direct composition; Individual centrality	The average outgoing nominations was 3.5 for women and 2.6 for men and the average incoming nominations was 2.1 for women and 2.0 for men.	Yes

Table 1.1 (Continued)

Fu et al, 2011	HIV transmission	All adults in ten villages clustered within one rural community in China	Cross-sectional study of person-centric networks	1 type: sexual	Dyadic characteristic; Macrostructure	Among 628 sexual ties, there were 336 components with 80% representing dyads. Sixty components contained partners outside of the defined network.	Yes
Helleringer & Kohler, 2007 ^b	HIV transmission	All people aged 18 to 35 (and older spouses) in seven villages on one island in Malawi	Cross-sectional study of person-centric networks	4 types: sexual; friendship; assistance during unexpected hardship; shared group (only analyzed the sexual network)	Macrostructure	There were 256 components with 86% of size five or smaller representing 34% of sexually active respondents during the recall period. Two-thirds of respondents were part of 35 components of size six or larger. 56% of males and 46% of females constituted a single giant component, with a high prevalence of paths that begin and end at the same person.	Yes

Table 1.1 (Continued)

Helleringer et al, 2007 ^b	HIV transmission	Same as above	Same as above	Same as above	Same as above	Dyadic characteristics	Among ongoing relationships, 22.5% were with external partners.	No
Helleringer et al, 2009 ^b	HIV transmission	Same as above	Same as above	Same as above	Same as above	Individual centrality; Dyadic characteristics; Direct and indirect composition; Macrostructure	The mean outgoing nomination was 2.4 among men and 1.8 among women during the three years prior to survey. The mode in-coming nomination for the same period was 1 with a large number of people with no sexual contacts.	No
Helleringer et al, 2013 ^b	HIV transmission	All people aged 18 through 49 in more than the seven original villages on the same island in Malawi	Longitudinal study of person-centric networks	2 types: sexual; friendship (only analyzed the sexual network)	Focused on describing study design and data collection methods	None available.	(repeated from prior paper)	Yes

Table 1.1 (Continued)

Bates et al, 2007 ^c	Diarrheal disease transmission	All men and women aged 13 and older across 9 rural villages in Ecuador	Cross-sectional study of household-centric networks that were calculated from person-centric network information by combining responses from everyone in the household	7 types: spending time; one food-sharing/prepping; five more that were not described (separately analyzed only the first two types)	Household centrality; Macrostructure	The village-average number of contacts per household ranged from 4.8 to 18.7 for the spend time network and from 0.4 to 10.4 for the food-sharing network.	No
Trostle et al, 2008 ^c	Diarrheal disease transmission	All individuals aged 13 and older across 21 rural villages in Ecuador	Cross-sectional study of person-centric network	7 types: food-sharing/prepping; six more that were not described (only analyzed first network)	Individual centrality; Macrostructure	The village-average number of contacts per person ranged from 0.02 to 4.8. The most remote villages had, on average, two more connections per person than villages close to the main town.	Yes

Table 1.1 (Continued)

Zelner et al, 2012 ^c	Diarrheal disease transmission	All men and women aged 13 years and older across 18 rural villages in Ecuador	Cross-sectional study of household-centric networks that were calculated from person-centric network information, by only counting the social ties for the person in the household with the most connections	7 types: spend time; general advice; and five more that were not described (separately analyzed only the first two types)	Direct composition; Household centrality; Macrostructure	The village-average number of contacts per household ranged from 0.8 to 4.5 for the important matters network and from 2.6 to 7.8 for the passing time network. The global village-level extent to which households clustered together ranged from 0.12 to 0.37, and from 0.15 to 0.46, for the important matters and passing time networks, respectively.	No
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^aPresentation of measures was contingent upon availability.

^bData for the four Malawi-based papers come from the same long-term study, called the Likoma Network Study.

^cData for the three Ecuador-based papers come from the same long-term study, called EcoDess.

Table 1.2. Sociocentric network studies of development-related issues in low- and middle-income countries (N = 19 unique papers from 10 studies).

Papers	Topic	Targeted Population	Study and Paper Design	Network Types Measured and Analyzed	Focus of Network Analysis	Sample of Basic Network Position and Structural Characteristics^a	Network Map
De Weerdt, 2004	Risk-sharing and network formation	All adults in one rural village in Tanzania	Longitudinal study of household-centric networks created from person-centric network information (with ties calculated in different ways)	2 types: kinship; general assistance (only the assistance network is analyzed)	Dyadic characteristics	Among all mentioned network members, 34% of contacts lived outside of the study population. Out of 7021 possible household dyads, 93% had no relationship, and 33% of the existing dyads had a friend in common.	Yes
De Weerdt & Dercon, 2006	Risk-sharing and formation of insurance networks (in response to past health shocks)	Same as above	Same as above with ties aggregated from person-centric network information	Same as above	Direct composition; Dyadic characteristics	The mean number of links between individuals was 3.5 and the mean number of links between households was 6.3.	No

Table 1.2 (Continued)

De Weerd & Fafchamps, 2011	Risk-Sharing and formation of insurance networks (in response to current health shocks)	Same as above	Same as above	Same as 2004 paper, but created 4 types: kinship; general assistance broken into three separate types - transfers/gifts, loans, and labor	Dyadic characteristics	None available.	No
Comola, 2012	Network externalities and formation of social ties	Same as above	Same as above	Same as the 2004 paper	Direct and indirection composition	The mean average shortest distance between households was 2.5 links with a maximum of 5 links. All households were connected in one component.	Yes

Table 1.2 (Continued)

D'Exelle & Riedl, 2010	Generosity, differences across network types and network formation	All household heads in one rural village in Nicaragua	Cross-sectional study of person-centric networks	1 type that was separated into 6 types: any-type of relation, then split into friendship; general support; activities; economic exchanges; neighbors; family (analyzed separately)	Individual centrality; Macrostructure	Across five network types (excluding family), the proportion of all possible ties that were present ranged from 0.032 (support network) to 0.186 (friendship network), and the extent to which individuals were clustered ranged from 0.040/0.041 (support/economic network) to 0.133 (friendship network). There were no isolates in the combined network.	Yes
D'Exelle & Holvoet, 2011	Gender and network formation	Same as above	Same as above	Same as above	Dyadic regression; Individual centrality	The average ego-network size for both men and women, separately, was greatest in the friendship network and least in the support network (excluding the family network).	Yes

Table 1.2 (Continued)

Jaimovich, 2011	Economic predictors of social tie formation and macrostructure	Household heads across 60 rural villages in Gambia	Cross-sectional study of household-centric networks	6 types: labor support, land use; agricultural input support; economic support; two more types (each type analyzed separately and also separately analyzed two combined types of economic and family ties)	Dyadic characteristics; Household centrality; Macrostructure	The average number of links per household was around 1-2% of the total possible links for all network types except for kinship with 10%. In the economic network, less than 10% of households have at least one outside-village tie. The village average percentage of actual ties observed between households ranged from 2-5% except for the kinship network (14%). At the village level, the inputs network showed the greatest average number of links (39.8) apart from the kinship network (147.7).	Yes
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Table 1.2 (Continued)

Nolin, 2010; 2012	Formation of food-sharing ties	At least one or more adult(s) per household in one rural village in Indonesia	Cross-sectional study of a household-centric network	1 type: food-sharing	Household centrality; Exponential random graph modeling	The mean out-going nominations and incoming nominations were both 9.8 though the standard deviation was greater for out-going than in-coming links. 96% of ties were within village. 67% of ties were reciprocated.	Yes
Apicella et al, 2012	Cooperation and social proximity	All adults in 17 Hadza hunter-gatherer camps in rural areas in Tanzania	Cross-sectional study of person-centric networks combined with a public goods game	2 types: desired same-sex campmates; gifts (analyzed separately)	Individual centrality; Direct and indirect composition; Dyadic characteristics; Macrostructure	None available.	Yes

Table 1.2 (Continued)

Entwisle et al, 2007	Variation in the structure of social ties	All people aged 18-35 in all households in 51 villages in one district in Thailand	Cross-sectional study of household-centric networks	2 types: siblings; labor support (analyzed separately)	Macrostructure	Across villages, the mean percentage of households reached directly was about 11% for both network types, and the mean percentage of isolates was 26% and 58% for the sibling and labor networks, respectively. The correlation between sibling ties and labor ties was 0.1, on average.	Yes
Verdery et al, 2012	Kinship and dwelling proximity	Same as above	Same as above	2 types: siblings; labor support (only analyzed sibling network)	Dyadic characteristics; Macrostructure	None available.	Yes
Comola & Prina, 2013	Intervention driven network changes in social ties and network spillover effects on household outcomes	All female heads of households in 19 slums in Nepal	Longitudinal study of household-centric networks in relation to an exogenous intervention	2 types: gifts and loans with regular partners; gifts and loans with occasional partners (the two types were combined and analyzed, and then split as gifts and loans)	Direct composition; Household centrality; Dyadic characteristics	On average, households had 1.7 financial partners with 0.7 within the village and 0.8 among relatives (regardless of location).	No

Table 1.2 (Continued)

Alatas et al., 2012	Information accuracy, network structure, and community-based targeting	15% of household heads (which provided complete data on 65% of all households) in each of 631 neighborhoods in Indonesia	Cross-sectional study of household-centric networks compared with simulations	2 types: kinship; shared group (analyzed as one network)	Household centrality; Macrostructure	Across the villages, the average number of ties per household was 8.3, with households reporting being related to an average of 3.1 households in the village. The average path length between households was 2, and 41% of a household's contacts were themselves linked to each other, on average.	No
Cai et al., 2012	Take-up of weather insurance and diffusion of knowledge	All household heads from rice-farming households in 185 rural villages in China	Cross-sectional study of household-centric networks combined with a randomized experiment	1 type: friendship-economic advice	Direct and indirect composition; Household centrality; Macrostructure	The average number of out-going and in-coming nominations per household were 4.9 and 3.3, respectively, with an average path length of 3.6 between households. On average across villages, 18% of a household's contacts were also connected to each other, 17% of social ties were reciprocated, and 99% of households were connected to a main giant component.	No

Table 1.2 (Continued)

Banerjee et al, 2013	Diffusion of participation in a microfinance intervention program	50% of households with a woman of about reproductive age (where both the household head and spouse were included) in 43 rural villages in India	Cross-sectional study of household-centric networks	12 types: frequent communication; spends time (both directions); borrow rice/kerosene (both directions); borrow money (both directions); advice (both directions); transport assistance; kinship; attend temple together (one network synthesized from all types)	Household centrality; Macrostructure	The average number of ties per household was almost 15, with an average path length of 2.2 between households, and 26% of a household's contacts were also connected to each other..	No
Jackson et al, 2012	Network patterns of favor exchange and support	Same as above, but in 75 rural villages in India	Same as above	Same as above, but some networks analyzed separately and other analyses used partial synthetic networks	Dyadic characteristics; Macrostructure	None available.	No

Table 1.2 (Continued)

Shakya et al, 2014a	Latrine ownership	Same as above	Same as above	Same as the Banerjee et al, 2013 paper.	Direct composition; Strength of ties; Household centrality	The average total number of household ties was 9.1. The average path length between households per village across all villages was 3.2 and the average proportion of observed ties out of the total possible per village was 0.04. The average number of components per village was 1.1.	Yes
Shakya et al, 2014b	Latrine ownership	Same as above	Same as above	Same as the Banerjee et al, 2013 paper.	Direct composition; Network community composition; Macrostructure of network communities and villages	None available.	Yes

^aPresentation of measures was contingent upon availability.

No interventions were conducted or evaluated in any of the health-focused studies, nor were any experiments conducted. Among the development-related studies, two discussed randomized intervention experiments (Cai et al, 2012; Comola & Prina, 2013), one discussed results in relation to an intervention (Banerjee et al, 2013), two discussed manipulated games (Apicella et al, 2012; D'Exelle & Riedl, 2010), and one discussed simulations as compared to real world data (Alatas et al, 2012).

Sociocentric Network Study Design

All of the health-focused studies collected data on person-centric networks where each specific individual within the defined target population could represent an ego as a node in a network. Fifteen out of the 17 health-focused papers presented data on person-centric networks while two papers actually presented data on household-centric networks where households represented the egos as nodes in the network (Table 1.1). To do so, one paper merged individual-based ties at the household level (Bates et al., 2007), and another paper only counted ties for the most well-connected person in the household (Zelner et al., 2012). In contrast, 16 out of the 19 development-related papers described household-centric networks (Table 1.2). Several of these papers arose from studies where only household heads (and sometimes their spouses) were included in the surveyed population. Likely related, the number of networks included in the development-focused studies was notably greater than the number included in the health-focused studies (median = 31 and 3.5, respectively) (Tables 1.1 and 1.2).

Name Generators and Network Types

Table 1.3 presents a catalog of 105 NGs used among all of the ego- and sociocentric network studies conducted in LMICs that were cited in this review. The exact text (or as close as possible) for all NGs from 37 out of 38 studies (including the 20 sociocentric network health and

development studies) are provided, and organized according to network type. (NGs were not available for one study). We provide this catalog because it is often requested by people wishing to design a network-based study or intervention, and it provides a context for assessing the NGs used in the 20 studies discussed in this review. Further, the NGs used in egocentric studies were included because social ties, as previously described, are measured in the same way regardless of design. Table A1.1 in the appendix provides the same NGs, but it is organized according to study and includes the paper references and country of use.

Table 1.3. A catalog of 105 'Name Generators' (survey questions employed to elicit social ties) sorted by network type, which were collected from 37 social network studies conducted in low- and middle-income countries.

Network Type	Text of Name Generators
Kinship	<ol style="list-style-type: none"> <li data-bbox="496 940 1425 1010">1. Asked to name all other households in the hamlet to whom they were related (either through blood or marriage). <li data-bbox="496 1052 1425 1157">2. "Does this person have other siblings besides the ones [living in the household] that are still living?" If so, then name and contact's location were recorded. <li data-bbox="496 1199 1425 1268">3. "With which households do your family members have kinship relationships?" <li data-bbox="496 1310 1425 1379">4. "Can you tell me about people who are close to you and are kin or faux kin?" <li data-bbox="496 1421 1425 1453">5. Asked to name five relatives respondent speaks with most frequently. <li data-bbox="496 1495 1425 1564">6. "Name any close relatives, aside from those in this household, who also live in this village. Plus people in those same households." <li data-bbox="496 1606 1425 1711">7. "Have any of your household members married members of other households?" [Direction was indicated and Names given as response]. <li data-bbox="496 1753 1425 1785">8. Asked to name siblings (no other criteria). <li data-bbox="496 1827 1425 1858">9. Asked to name spouse (no other criteria).

Table 1.3 (Continued)

Sex Partners

10. Asked to name with sexual partners within the past five years.
 11. Asked to name five most recent sexual partners in the past three years.
-

Friends:
General

12. "Name up to five other women/men [same-sex as respondent] with whom you talk most and perceive as among your best friends."
 13. Asked to name up to five women in the village with whom they talked most and perceived as their best friends.
 14. Asked to name five friends speak with most frequently.
 15. Asked to name four closest friends on the island.
 16. "Who are your closest friends in the village?"
 17. Asked to name best friends.
 18. Who are the people that you really enjoy socializing with?
 19. Ask to name all people perceived as available for recreation and companionship (e.g. have fun or relax).
-

Affective
Support:
General

20. Asked to name people who provide emotional support.
 21. Asked to name the people perceived as available for emotional or affective support (e.g. share secrets and discuss feelings)
 22. "Can you tell me about people who you share your secrets with?"
 23. "Can you tell me about people who are closest to your heart?"
 24. "Can you tell me about people who are close but don't live in area?"
 25. "Can you tell me about people who are in your age grade who you are close to?"
 26. Asked to name all people available for validation or positive feedback (e.g. tell good things about yourself)
-

Table 1.3 (Continued)

Spend-Time:
General

27. "In your free time, whose house do you visit (up to 8 people)?"
 28. "Who visits your house in his or her free time (up to 8 people)?"
 29. "In general, with whom do you spend time [outside your household, but in your community]?"
 30. Asked to name with whom outside the household the subject spent time in the last week.
 31. "Can you tell me about people who you gather with regularly in your free time?"
 32. "Can you tell me about people who you pass your days with in the dry season?"
-

Communication:
General

33. "Whom have you talked to in the past week (besides family members living in the same household)?"
 34. "Name the 5 non-relatives whom you speak to the most."
 35. "With whom do you talk most often (up to four people other than spouse or kin)?"
 36. "Can you tell me about people who you talk with on the telephone?"
 37. Asked to name 20 people with whom they had communicated in the last 6 months by e-mail, phone, person, or any other means, starting with those most important first.
 38. Asked to name 40 people that respondent knew. Knowing was defined as "you know them and they know you by sight or by name, you could contact them, and that there has been some contact (in person, by telephone, by mail or email) in the last two years".
-

Advice:
General

39. Asked to name to whom outside the household the subject talks about important matters.
 40. Who are the people with whom you discuss matters that are important to you?
 41. Asked to name (up to five) people to whom respondents go for
-

Table 1.3 (Continued)

advice or to discuss personal topics.

42. "If you had to make a difficult personal decision, whom would you ask for advice (up to 8 people)?"
43. Asked to name people perceived as available for advice and information (e.g. useful information on how to care for a sick sibling).
44. Asked to name people who provide cognitive support.
45. "Who do you talk to, here in the village of [name], when you have a big decision to make in your life, or when you need advice about a problem? Can you name four people?"
46. "In this packet, you will find a photograph of all/most of the adults in this village. Pick out the photographs of all the people you usually talk to about any kind of problem in this village."
47. "Are there any other people outside this village you usually talk to about any kind of problem in this village? Please list all of them."
48. "Who comes to you for advice (up to 8 people)?"

Advice:
Specific

49. Asked to name five close friends (not including parents or children), either within or outside the village, with whom he/she most frequently discusses rice production or financial related problems.
 50. Asked to name the individuals with whom they usually discussed mercury issues, whether in the context of health, dieting, or fishing.
 51. Asked to name five close friends (not including parents or children), either within or outside the village, with whom he/she most frequently discusses rice production or financial related problems.
 52. "Have you spoken to anyone here in [name of village] about ways to avoid pregnancy? Can you name four people you have spoken with?"
 53. "Have you spoken to anyone about ways to avoid pregnancy outside of the village of X? Can you name four people you have spoken with?"
 54. "How many people have you chatted with about modern methods of child spacing/family planning? I mean people other than your
-

Table 1.3 (Continued)

husband/wife. [If Yes,] Could you please give me the names of (up to) four of these?"

55. "How many people have you chatted with about AIDS? I mean people other than your husband/wife. [If Yes,] Could you please give me the names of (up to) four of these?"
56. Asked to name the people to whom respondents had spoken about place of delivery during pregnancy. Probing continued until 20 names were given.
57. "Who would you go to for advice if you had a question about fish or fishing?"
58. "Who would you go to for advice if you had a question about planting or growing yams?"
59. "Who would you go to for advice if you had a question about using a plant as a medicine?"
60. Asked to name individuals with whom the respondent specifically speaks about child health issues.
61. "Who had respondent talked to about the forthcoming referendum?"

Instrumental
Support:
General

62. Asked to name people outside the subject's immediate household whom the subject had helped.
63. Asked to name people who provide material support.
64. Asked to name people who provide practical support.
65. Asked to name five people to turn to for help in case of unexpected hardship.
66. Asked to name people perceived as available for instrumental or tangible aid (e.g. food, transportation, or help thatching a roof).
67. "Can you tell me about people whom you can ask for help in a crisis?"
68. "Can you tell me about people whom you would ask to be responsible for your family when you travel?"
-

Table 1.3 (Continued)

Instrumental
Support:
Specific

Food

69. "In the past week, outside your household, with whom did you participate in activities having to do with food, like preparing or sharing it?"
70. Asked to name individuals to whom the subject had given gifts of food, usually more than once, during the preceding hunting season.
71. Asked to name individuals from whom the subject had received gifts of food, usually more than once, during the preceding hunting season.
72. Asked to name the person from whom food was acquired outside the household.
73. "If you need to kerosene or rice, to whom would you go?"
74. "Who would come to you if he or she needed to borrow kerosene or rice"?

Health (likely related to transport or money)

75. "If you had a medical emergency and were alone at home, whom would you ask for help in getting to a hospital (up to 8 people)?"
76. Suppose you suddenly become seriously ill at night, who will you call for help?
77. Asked to name people outside the subject's immediate household to whom the subject had turned for help when sick.
78. "Who had helped respondent the last time they had drinking water or health problems?"

Money

79. "If you suddenly needed to borrow Rs. 50 (a small amount) for a day, whom would you ask (up to 8 people)?"
 80. "Whom do you trust enough that if he or she needed to borrow Rs. 50 (a small amount) for a day you would lend it to him or her (up to 8 people)?"
 81. Suppose you need to borrow a large sum of money, say 250,000 FCFA (about \$500), whom would you ask for help?
-

Table 1.3 (Continued)

82. "Did you lend out or borrow in money from other households in the last year?" [Direction was indicated]
83. Asked to name people inside or outside the village that a participant could rely on most and with whom the participant or members of the participant's household regularly exchanged gifts and/or loans.
84. "Can you give a list of people from inside or outside of [this village], who you can personally rely on for help and/or that can rely on you for help in cash, kind or labour?"

Labor

85. "Did anyone from this village help [the participant] to harvest rice?" If so, then name and contact's location were recorded.
86. "Did anyone from another village come to help [the participant] harvest rice?" If so, then name and contact's location were recorded.
87. "Did you, or any members of your household, work for other households during the last year?" [Names and direction was indicated]
88. Asked to name people outside the subject's immediate household to with whom the subject had worked in the previous year.

Other

89. "Of the land you cultivated last year, did you lend out or borrow in land from other villagers?" [Names and direction was indicated]
90. "Did you lend out or borrow in any means of production (such as tools or fertilizer) from other households in the last year?" [Direction was indicated]

Shared Group:
General

91. "Can you tell me about people who you talk to in associations or committees you belong to?"

Shared Group:
Specific

92. "Whom do you go to temple with (up to 8 people)?"
93. "Can you tell me about people who you talk to in religious group you belong to?"
94. Asked to name social contacts whose children attend local primary schools.
-

Table 1.3 (Continued)

	95. "Please tell me the complete names of five people in your [voluntary association] group that you talked to most often in the past six months?"
	96. "Can you tell me about people who you talk to in your work or work association?"
Other Ties: Specific	97. "With whom would you like to live after this camp ends?" [choosing from among the entire same-sex adult Hadza population].
	98. Asked to name up to six people to whom they would like to give an actual gift of honey from among members of their particular camp.
	99. "Can you tell me about people who have a style of living which pleases you?"
Negative Ties	100. Asked to name all people who sometimes make the respondent feel bad or upset.
Follow-up	101. Asked to name husband, mother-in-law or co-wife, if conspicuously absent from the list generated from the previous questions.
	102. "Who are the people that you are close to, but did not mention earlier?"
	103. "Can you tell me about people who you may have forgotten among those you have cited?"
	104. Asked to name the five most important people among the people already listed from the previous questions.
Not free re-call	105. Asked whether the interviewed person knew the household [a card with the name for every household was displayed] and whether the subject had a social relation of any kind with one of the household members. Then, asked about the content of the relation: friendship, support, social-public, economic, neighbor, or family.

Notes: Exact wording, and the number of responses permitted, are provided if available. Table A1.1 lists the same name generators, but organizes them according to the study in which they were used.

In general, some NGs focused on specific characteristics, such as types of people, feelings towards a person, advice topics, supports, or interactions, while others asked about more general ties (Table 1.3). Moreover, the vast majority of NGs elicited seemingly positive social ties. Only one NG explicitly stipulated a negative type of social tie. NGs were frequently oriented such that the ego was the origin of the tie-defining activity (e.g., To whom did one go for advice) and not in the other direction (e.g., Who came to you for advice). In addition, some NGs stipulated that alters be residents of the target population (so as to also be included in the study), and some NGs included a time boundary (i.e. in the past six months). Frequently, the number of nominations was limited to a maximum amount, with a few studies requesting an exact number of nominations. Among all studies except for one (D'Exelle & Riedl, 2010), responses to NGs were based on free recall of names and collected during in-person interviews. Finally, a few NGs were used as follow-up questions to elicit any important social ties that may have been missed by other NGs employed.

The number of NGs used in data collection among the 20 studies in this review ranged from 1 to 12 (Table 1.1 and Table 1.2), with the health-focused studies including slightly fewer NGs (median = 1 NG) than the development-related studies (median = 2 NGs). Two studies also elicited ties by asking about participation in community groups and then the studies assumed ties between people who participated in the same community group (Alatas et al, 2012; Helleringer & Kohler, 2007). Some papers with multiple network types available combined the ties into one synthesized network for analysis (see the India development-related papers for an example). In contrast, a few papers used other information collected about the ties to allocate ties into separate network types for analysis (D'Exelle & Riedl, 2010; Comola & Prina, 2013). Most papers with multiple NGs, however, either analyzed the network types separately or analyzed just one or two

of the network types out of the total number available (Table 1.1 and Table 1.2). Interestingly, out of 23 papers included in this review with access to data on multiple network types, only a few examined the extent of overlap between different types of networks (D'Exelle & Riedl, 2010; Entwisle et al, 2007; Stoebenau & Valente, 2003).

Among the 20 reviewed studies, the health behavior studies commonly measured advice networks and friendship networks while the disease transmission studies typically measured sexual networks, spending-time networks, and food-sharing/preparation networks (Table 1.1). Kinship and instrumental support networks were most typically measured among the development-related studies (Table 1.2). Very few of the reviewed studies discussed why certain network types were measured (as compared to others) though some chosen network types were obviously related to the study topic.

Social Networks, Health Behaviors, Health Outcomes, and Development

Network Composition and Family Planning

Six studies examined immediate network composition in relation to family planning/fertility-related issues (Alvergne et al., 2011; Comola, 2008; Gayen & Raeside, 2010; Sandberg, 2005; Sandberg, 2006; Stoebenau & Valente, 2003). Together, these studies demonstrate mixed results regarding the relationship between attributes of immediate alters and ego outcomes. For example, a study of family planning advice networks in Madagascar showed that personal knowledge of family planning methods was associated with the average level of knowledge among directly connected advice-network members (Stoebenau & Valente, 2003). However, actual contraception use was not associated with knowledge of, nor use of contraception among directly connected network members. This latter finding was consistent with those obtained in a study of friendship networks in Ethiopia (Alvergne et al., 2011). In

contrast, among friendship networks in Bangladesh, women using similar contraceptive methods were more likely to be connected to each other than women using dissimilar methods (Gayen & Raeside, 2010).

Only one study examined the relevance of indirectly connected alter composition to egos' family planning outcomes. Among contraception discussion networks in Nepal, exposure to a family planning radio show among both immediate alters and alters' alters (i.e. "friends of friends") predicted contraception adoption decisions among egos (Comola, 2008). Moreover, this study demonstrated that exposure to the radio show spread across the network through peers and determined contraception adoption.

Individual Network Centrality and Potential for Behavior Change

Three studies demonstrated a positive relationship between centrality and positive outcomes, including contraception use (Gayen & Raeside, 2010), dietary changes (Mertens et al., 2008), and latrine ownership (Shakya et al, 2014a). For example, three measures of egos' centrality in a Bangladesh friendship network were associated with perceptions of alters' approval of contraception use and encouragement of family planning discussion, as well as with frequency of discussion with friends (Gayen & Raeside, 2010). This study provided some evidence that women who were centrally located in the network were more likely to use contraception than women located on the periphery of the network. However, this finding was not consistent with those obtained in a contraception network study from Ethiopia (Alvergne et al, 2011)). In contrast, the association between ego latrine ownership and the portion of alters with latrines was greater for people on the periphery of a network in India than for more centrally-located individuals (Shakya et al, 2014a). Similarly, actual contraception use among women in Bangladesh was associated with having a tie to someone outside the village network

(though this does not necessarily indicate location within the overall network) (Stoebenau & Valente, 2003).

Three studies showed that 'change agents' were central to the community network. For example, the local intervention collaborator dominated a mercury discussion network in a village in Brazil (Mertens et al., 2012). Likewise, midwives were centrally located in a friendship network in Mali (Hurley et al. 2013), and community-based family planning distribution agents were central in family planning discussion networks (Stoebenau & Valente, 2003). None of these papers, however, indicated the extent to which these persons were central to their networks before they participated in the intervention roles, nor did they indicate how these individuals were chosen as 'change agents.'

Finally, two development-focused network studies showed that behavior change was associated with centrality of the first person to adopt. For example, among villages in China, take-up of weather insurance by rice-farming households was greater in villages where the first people to receive information about insurance were central to rice/finance discussion networks (Cai et al., 2012). Similarly, a study from India showed that participation in a microfinance program was greater across a village when the first person to be informed of the program was more central than others in a network synthesized from multiple tie types (Banerjee et al., 2013). Interestingly, both of these studies showed that neither the decision to take-up insurance nor the decision to participate in a microfinance program was associated with the decisions of participants' immediate social contacts. Instead, the decisions were associated with diffusion of knowledge about these issues from contacts to participants. This is similar to some of the contraception studies linking composition and knowledge, but not composition and use as previously described.

Network Structure and Disease Transmission

All of the health-focused papers assessing network structure analyzed structural characteristics in relation to risk of disease transmission. In particular, the Likoma Network Study (LNS) in Malawi has significantly contributed to the literature on sexual network structure and HIV-related outcomes (Helleringer & Kohler, 2007; Helleringer et al 2007, 2009, 2013). For example, even though individuals typically had less than 3 or 4 sexual partners during a three-year period, half of the Likoma population was connected together in a giant network component with evidence of substantial cyclical structures in the network (Helleringer & Kohler, 2007). Moreover, several individuals had multiple partners in common and more than one-quarter were connected through multiple chains. The authors suggested that the high connectivity could support broad diffusion of pathogens despite the overall low number of partners and a low rate of partner change. Notably, the LNS' structural findings differed from a study examining sociocentric sexual networks in rural China where neither large components nor cycles existed within the overall network (Fu et al., 2011).

Furthermore, in the LNS, the relative risk of HIV was higher among people who were involved in bridge relationships with in-coming visitors, and use of condoms was lower in such relationships (Helleringer et al., 2007). The authors argued that these bridge relationships may play a critical role in increasing the spread of HIV across the network. The prevalence of HIV was higher in sparser regions of the network, which tended to be populated with older respondents, widows, and women, than in more dense areas of the network (Helleringer & Kohler, 2007).

A group of papers from Ecuador assessed the relationship between network structure and diarrheal transmission in food-sharing, spending time, and discussing-important-matters

networks while including information on road access, housing density, and distance to main town (Bates et al 2007; Trostle et al, 2008; Zelner et al, 2012). Bates et al (2007) showed that households in villages with road access and greater housing density had a greater total number of ties and that the number of ties was inversely associated with risk of diarrheal transmission. A second study from Ecuador showed that estimates of disease transmissibility through food-sharing networks varied considerably from village to village due to variation in average personal network size per village, which, in turn, was inversely associated with village distance to the nearest town (Trostle et al, 2008). The threshold for disease transmissibility was higher in 'closer' villages. Finally, a third study demonstrated that a greater density of spending time and discussion networks among households in more remote villages facilitated the spread of, and adherence to, sanitation practices, which reduced the risk of disease transmission (Zelner et al., 2012).

Development Outcomes and Community Social Cohesion

Community-level social connectedness, as measured by several network structure characteristics, may exert different effects on various outcomes across different network types (Alatas et al, 2012; Cai et al, 2012; Entwisle et al, 2007; Shakya et al, 2014b; Zelner et al 2012). For example, one study in China showed that take-up of weather insurance among rice-farming households was much greater in villages where households were clustered together. Similarly, another study of 51 villages in Thailand showed that more cohesive villages tended to exhibit lower out-migration and greater involvement in agricultural cultivation (Entwisle et al., 2007). In contrast, the same study showed that villages with less internal cohesion displayed more connections to outside villages and exhibited lower fertility and greater affluence. Likewise, a study of latrine ownership in India demonstrated that households were more likely to own a

latrine in less cohesive network communities (Shakya et al, 2014b). Finally, a study in Indonesia showed that people in more networked villages were better at identifying which community members were poor than people in less networked villages (Alatas et al, 2012). Likely related to social cohesion, several studies demonstrated clustering of kin within close proximity in sociocentric networks (i.e. Nolin, 2010; Verdery et al, 2012).

DISCUSSION

This systematic review summarizes the relatively small body of work on social networks and health derived from sociocentric studies conducted in LMICs. Logistically, it highlights the heterogeneous methods and designs that may be used to measure sociocentric networks, the importance of multiple levels of analysis, and the relevance of distinct network types. In addition, we show that network composition, individual network centrality, and network structure are associated with individual and community health and development outcomes in different contexts, and that geography and spatial context may interact with both network characteristics and outcomes.

Specifically, we offer three main findings from this review. First, behavioral change among people in a network may be more likely to occur and diffuse through a network if the first people to change their behaviors are central to the community network. Second, both the structural arrangement of ties and the spatial context within which the ties occur have important implications for the way that various diseases (and other outcomes) may pass from person to person. Third, the collective assessment of the studies in this review raises several issues that may be more challenging to address for sociocentric network data collection in LMICs than in higher-income countries. These challenges include methodological decisions regarding level of analysis and boundary specification (of network units, actor eligibility and network type)

(Marsden, 1990), as well as data collection feasibility and accuracy. Importantly, this body of work and these general findings suggest a number of ways to improve future sociocentric network research in LMICs.

Addressing Sociocentric Network Data Collection Challenges in LMICs

First, several papers mention the issue of 'level' (such as at the person, household, community, or village level) in their methodological and analytical decisions and interpretations. For example, Jaimovich (2011) showed that indicators of economic development were differently related to network information at the dyadic-, household-, and macro levels. Likewise, Shakya et al (2014b) demonstrated that the proportion of latrine ownership among an ego's immediate contacts, network-based community contacts, and village contacts were each differently related to the ego's likelihood of owning a latrine (see Bannerjee et al, 2013 for a further example). Also relevant is a study conducted in Thailand by Faust et al. (1999), which showed that the spatial arrangement of villages and various geographic features determined village-level social and economic ties between villages. Thus, decisions about the level of data collection and analysis are relevant to the potential use of network information for conducting and evaluating future interventions.

Unfortunately, the ability to collect multilevel sociocentric network data may be limited given the substantial effort required to collect network data (considering extant methods) in LMICs. One solution, particularly for studies wishing to include several villages, may be to measure household-level ties (i.e. by only interviewing one household head) instead of individual-level ties. The cost of such a study design is that important micro-level information may be lost. For example, if the node of choice represents a single gender, then a study may fail to uncover important gender differences in access to support (D'Exelle & Holvoet, 2011),

particularly in gender-separated societies. Thus, choices regarding what a node should represent and the number of whole networks to measure require serious consideration in relation to study aims.

Second, to collect sociocentric network data, information on the boundary of the target area is needed so that a population of potentially eligible actors can be defined and ties within the population can be established (Laumann et al, 1983). Although villages almost exclusively represented the whole network unit of choice in the studies reviewed, village boundaries were heterogeneously specified, and few studies described significant qualitative data or formative research on actors' understanding of the boundaries within which they were supposed to make nomination choices in response to NGs. If the whole network unit is geographically based, network boundary specification can be challenging in LMICs (compared to high-resource settings) as legal or physical boundaries are not always clearly documented, and can be very fluid (Entwisle et al, 2007; Entwisle et al, 1998). Indeed, community boundaries may be subjectively understood rather than legally defined, or they may differ markedly from existing documentation, particularly if the legal boundaries tend to change over time. Participatory community mapping, combined with use of geographic information systems and any available official information, may yield useful data on community boundaries.

In addition, the network boundaries chosen for a specific sociocentric network study should be sufficient to support the study aims though they may not always be obvious at the outset. For example, consider a hypothetical study consisting of a single index village. Actors in this village may regularly interact in-person with alters in a nearby village (see Koster, 2011 for an example), or they may be strongly influenced by alters whose main households are in the index village, but who spend most of their nights outside of the village (such as partners who

work away for significant periods of the year). Such alters may represent important 'bridge' positions in a larger network, bringing significant influence or disease into the network from beyond the boundaries of the index village (Helleringer et al, 2007; Helleringer et al, 2009). Expanding the definition to permit inclusion of such 'bridge' people, and attempting to engage them in the study, perhaps by conducting work during nights, weekends or holidays, may provide more accurate network data.

Third, selecting appropriate NG questions (and therefore network types) is a critical consideration, and depends on the topic of the study, the theory supporting evidence of ties in relation to that topic, and the culture and context in which the research is conducted. Indeed, there is substantial diversity in the NGs that have been employed in network studies in terms of specificity versus globality, function, target, and overlap (Table 1.3). Although using functionally-specific NGs may produce more reliable information on network characteristics (Marin & Hampton, 2007), and on the association between networks and health (Perry & Pescosolido, 2010), deciding which NGs to use may be quite complex in LMICs where the meaning of words and relationships can change across cultures and languages. Likewise, including multiple NGs to describe various network types may be better than using a single NG (Marin and Hampton, 2007). However, if resources are scarce or data are collected via in-person interviews requiring significant coordination, care is needed to choose one or two of the most relevant network types. To that end, NGs focused on identifying close kin, friends, important-matters discussion partners, or instrumental support partners seemed common and widely applicable in the studies covered by this review. Alternatively, there may be other viable methods for reducing question burden (McCarty et al, 2007).

Importantly, NG choice matters for research outcomes because network characteristics and the associations between network characteristics and outcomes may differ across network types (Bates et al, 2007; D'Exelle & Riedl, 2010; Jackson, 2012; Jaimovich, 2011; Stoebenau & Valente, 2003). For example, generosity exhibited different associations with network characteristics when comparing several types of village networks in Nicaragua (D'Exelle & Riedl, 2010), and a structural network measure of support was greater in favor networks than in hedonic (visiting) networks across multiple villages in India (Jackson et al, 2012). In addition, critical reflection on NGOs may be even more important in LMICs where reduced access to formal support (or even informal support) may cause overlap of social ties across different forms of interaction and support. Indeed, a recent review discussed the implications of relationships between network types on outcomes (Kivela et al, 2014).

Fourth, feasibility of network data collection, in terms of time and resources, may be more difficult in LMICs than in higher-income countries. Often, accurate recent census data about who resides within the target boundaries is not easily available although it is needed in order to know whom to interview and who is an eligible response to NGOs. If complete census data cannot be obtained prior to NG-based data collection, then an understanding of what percentage of the network is needed for relatively accurate network descriptions should be taken into careful consideration, as some studies have done (e.g. Alatas, 2012; Banerjee et al, 2013). Moreover, if a longitudinal outcomes study is planned, then both census and network data may need to be collected multiple times as part of an open-cohort research design. Critically, people may fluidly move in and out of eligibility, e.g. by becoming 'of age' to be named as an alter, by marrying a resident and moving into a targeted village, by leaving the household for two years and then returning after a divorce, or by being a migrant worker whose main household is in the

targeted village and who may be an important alter, but who many not often be physically available. To address some of these complexities, a recent paper offers methodological insight to collecting multiple rounds of sociocentric network data (Helleringer et al., 2013). Indeed, it may be necessary to account for changes in network structure over time when measuring health outcomes, especially for examining the impact of interventions. One study of 19 slums in Nepal demonstrated that an intervention providing access to savings accounts changed the network of financial transactions between two waves of data collection (Comola & Prina, 2013). This study also showed that accounting for these network changes improved estimation of peer-effect estimates.

In addition, as shown by some of the studies included in this review, physical distance to infrastructure and distance between nodes may be related to formation of network ties, network characteristics and health outcomes. Thus, distance is an additional factor to account for that may be important in LMICs where slowly-changing infrastructure and technology have not reduced the relevance of this factor in ways that have changed for higher-income countries. Indeed, a group of studies not included in this review demonstrated that risk of diarrheal disease was associated with spatial clustering but not with kinship clustering of related-households (Emch et al, 2012; Giebultowicz et al, 2011; Perez-Heydrich et al 2013). Thus, collecting spatial information via GPS devices and information on actual geographic characteristics, such as the existence of mountains or swamps within the targeted area, seems important to incorporate in sociocentric network studies where environmental challenges might affect certain properties of social networks and thus determine the flow of resources or influence (Matous et al, 2013).

Finally, very few of the reviewed studies discussed methods to ensure accuracy of tie identification. There are many scenarios in LMICs that may delay or block the ability of the

research staff to link an ego to a specific alter. For example, alters may have the same names or be informally identified as 'my friend's mother's neighbor's brother' or as 'the older woman who stays by the water tap.' In these cases, accurate identification of alters may involve time-consuming, iterative processes. A few sociocentric network studies, however, have used photographic confirmation of named alters during the interview process to improve accuracy of tie identification (Apicella et al., 2012; Ensminger et al, 2011; Stafford et al., 2010). In addition, accurate entry of social ties into a data collection system may be quite complex (again due to the possibility of name overlap), which may prove difficult to address in resource-limited settings. Combining photographic search systems with computer-assisted mobile data collection, however, may help increase the speed and accuracy at which network data can be collected. Assessing local connectivity may then become increasingly important (Seidner et al, 2012).

Advancing Research on Social Networks and Health in LMICs

Sociocentric network studies involving health in LMICs are still uncommon. Although it is possible we may have missed some articles, inclusion of a few additional studies is unlikely to have permitted robust comparisons of results between countries or the conduct of a formal a meta-analysis on the importance of network centrality, composition, or structure in relation to outcomes. Thus, there is a strong need for more in-depth sociocentric network and health studies in LMICs, particularly in relation to intervention and evaluation, using standardized metrics. Indeed, our review identifies a number of gaps in the literature. Many of the reviewed studies calculated few network characteristics, despite having sociocentric data that could be used to study network structure, composition, and function in depth. Similarly, few studies provided visually rich network maps or looked at overlap in social ties across network types. Moreover, many of the health-related studies did not measure enough village networks to permit

conclusions about how differences in macrostructure are related to outcomes. Thus, despite the potential richness of sociocentric network data, analyses have not progressed beyond basic calculations, particularly for studies conducted in LMICs.

Critically, little is known in these settings about the importance of network characteristics for certain sub-populations (e.g. youth and older adults or urban residents), how networks influence outcomes over time and vice versa, and the extent of network-related intervention effects (i.e. spillovers or externalities). Moreover, network comparisons across cultures are needed. In addition, the potentially negative influence of social networks on health was not discussed in the reviewed studies. In high-income countries, social ties have been associated with harms ranging from substance use (Ennett et al, 2006) to suicidal behaviors (Bearman & Moody, 2004). Certainly networks may involve antagonism as well as friendship (Christakis & Fowler, 2009), particularly in LMICs where people may not have as much of a choice regarding to whom they are connected.

These gaps, however, present opportunities for future research to explain how networks affect health outcomes (and vice versa) and how network information can be used to improve health outcomes in LMICs. In particular, longitudinal data and experiments are needed to increase understanding of pathways and causality. The association between network characteristics and individual outcomes demonstrated by many extant studies using observational data are subject to all the usual sorts of constraints affecting observational studies, (e.g. the observed association not necessarily reflecting causal effects) plus other limitations that are distinctive to network data settings (Aral et al, 2009; Christakis and Fowler, 2007, 2013; Manski, 1993; Shalizi & Thomas, 2011). Ongoing development of tools for faster and more accurate network data collection, testing of non-census-based data collection methods to determine

whether such information can provide reliable estimates of sociocentric network measures, and advances in analytical techniques for use with sociocentric, longitudinal network data or with randomized experiments or instrumental variable methods will facilitate these endeavors (Aral & Walker, 2011; Bond et al, 2012; Christakis & Fowler, 2013; Fowler and Christakis 2009; O'Malley, 2013; O'Malley et al, 2014; VanderWeele, 2013).

Conclusion

Individuals in communities around the world are linked together through strong and weak ties representing many types of relationships. Collectively, these ties lead to extended webs of interaction and connect people to others whom they may not even know exist. The evidence presented in this review suggests that research and applications should account for the networks in which individuals are embedded. If this recommendation is followed, then, based on the findings, global health policymakers and practitioners could potentially plan for more efficient and effective use of limited development aid to improve health outcomes across a larger number of people or to reach those who are more isolated. Crucially, experimenting with how to use sociocentric network knowledge to improve health outcomes through innovative intervention design and evaluation may be a worthy endeavor in resource-limited contexts, particularly in areas with substantial competition for development funds. Moreover, findings from the development-related studies provide an impetus for cross-disciplinary collaboration in the design and interpretation of network studies. This is particularly important in LMICs given the need for social change across highly-related sectors, especially in rural and/or resource-limited settings where the social network may be the only reliable source of multiple types of support. In sum, this review provides a foundation on which studies, interventions, and policies may begin to

more systematically capitalize on social ties that assist the spread of positive outcomes (and to stop the spread of negative outcomes) among individuals and communities in LMICs.

REFERENCES

- Adams, A.M., Madhavan, S., & Simon, D. (2002). Women's social networks and child survival in Mali. *Social Science & Medicine*, 54, 165-178.
- Alatas, V., Banerjee, A., Chandrasekhar, A.G., Hanna, R., & Olken, B.A. (2012). Network structure and the aggregation of information: theory and evidence from Indonesia. *National Bureau of Economic Research*, No. 18351. Last accessed at <http://www.nber.org/papers/w18351> on November 14, 2013.
- Ali, M.M., & Dwyer, D.S. (2010). Social network effects in alcohol consumption among adolescents. *Addictive Behaviors*, 35, 337-342.
- Alvergne, A., Gibson, M.A., Gurmu, E., & Mace, R. (2011). Social transmission and the spread of modern contraception in rural Ethiopia. *PLoS ONE*, 6, e22515. <http://dx.doi.org/10.1371/journal.pone.0022515>.
- Apicella, C.L., Marlowe, F.W., Fowler, J.H., & Christakis, N.A. (2012). Social networks and cooperation in hunter-gatherers. *Nature*, 481, 497-501.
- Aral, S. Muchnik, L., & Sundararajan, A. (2009). Distinguishing influence-based contagion from homophily-driven diffusion in dynamic networks. *Proceedings of the National Academy of Sciences*, 106, 21544-21549.
- Aral, S., & Walker, D. (2011). Identifying social influence in networks using randomized experiments. *Intelligent Systems, IEEE*, 26, 91-96.
- Avogo, W., & Agadjanian, V. (2008). Men's social networks and contraception in Ghana. *Journal of Biosocial Science*, 40, 413-429.
- Bignami-Van Assche, S. (2005). Network stability in longitudinal data: a case study from rural Malawi. *Social Networks*, 27, 231-247.
- Banerjee, A., Chandrasekhar, A.G., Duflo, E., & Jackson, M.O. (2013). The diffusion of microfinance. *Science*, 341, 1236498, <http://dx.doi.org/10.1126/science.1236498>
- Bates, S.J., Trostle, J., Cevallos, W.T., Hubbard, A., & Eisenberg, J.N. (2007). Relating diarrheal disease to social networks and the geographic configuration of communities in rural Ecuador. *American Journal of Epidemiology*, 166, 1088-1095.
- Bearman, P.S., & Moody, J. (2004). Suicide and friendships among American adolescents. *American Journal of Public Health*, 94, 89-95.
- Berkman, L.F., & Krishna, A. (2014) Social network epidemiology. In Berkman, L.F, Kawachi, I., & Glymour, M. (Eds). *Social Epidemiology (2nd Edition)*, pp. 234-289. New York: Oxford University Press.

- Berkman, L.F., Glass, T., Brissete, I., & Seeman, T.E. (2000). From social integration to health: Durkheim in the new millenium. *Social Science & Medicine*, 51, 843-857.
- Bond, R.M., Fariss, C.J., Jones, J.J., Kramer, A.D.I, Marlow, C., Settle, J.F., & Fowler, J.H. (2012). A 61-million person experiment in social influence and political mobilization. *Nature*, 489, 295-298.
- Cai, J., De Janvry, A., & Sadoulet, E. (2012). Social networks and the decision to insure: evidence from randomized experiments in China. Available at SSRN 2161686. Last accessed at <http://papers.ssrn.com/abstract=2161686> on May 13, 2014.
- Christakis, N.A. (2004). Social networks and collateral health effects. *British Medical Journal*, 329, 184-185.
- Christakis, N.A. (2007). Social networks and collateral health effects. *New England Journal of Medicine*, 357, 370-379.
- Christakis, N.A., & Fowler, J.H. (2009). *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives*. New York, NY: Little Brown and Company.
- Christakis, N.A., & Fowler, J.H. (2013). Social contagion theory: examining dynamic social networks and human behavior. *Statistics in Medicine*, 32, 556-577.
- Cohen, S. & Willis, T.A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, 98, 310-357.
- Coleman, J.S. (1988). Human capital in the creation of social capital. *The American Journal of Sociology*, 94, S95-S120.
- Comola, M. (2008). Educational programs in rural Nepal: peer communication and information spillovers. Available at SSRN 1019237. Last accessed at <http://ssrn.com/abstract=1019237> on May 13, 2014.
- Comola, M. (2012). Estimating local externalities. Available at SSRN 946093. Last accessed at <http://ssrn.com/abstract=946093> on May 13, 2014.
- Comola, M., & Prina, S. (2013). Intervention-driven changes in social networks and their effects on household outcomes. Available at SSRN 2250748. Last accessed at <http://ssrn.com/abstract=2250748> on May 13, 2014.
- Cornwell, B., Schumm, L.P, Laumann, E.O., & Graber, J. (2009). Social networks in the NSHAP Study: rationale, measurement, and preliminary findings. *Journal of Gerontology: Social Sciences*, 64B, i47-i55.
- D'Exelle, B., & Holvoet, N. (2011). Gender and network formation in rural Nicaragua: a village case study. *Feminist Economics*, 17, 31-61.

- D'Exelle, B., & Riedl A. (2010). Directed generosity and network formation: network dimension matters. Discussion paper 5356, IZA. Available at SSRN 1723994. Last accessed at <http://ssrn.com/abstract=1723994> on May 13, 2014.
- De Weerd, J. (2004). Risk-sharing and endogenous network formation. Chapter 10 in Dercon, S. Ed. *Insurance Against Poverty*. UK: Oxford University Press, p. 197-216.
- De Weerd, J., & Dercon, S. (2006). Risk sharing networks and insurance against illness. *Journal of Development Economics*, 81, 337-356.
- De Weerd, J. & Fafchamps, M. (2011). Social identity and the formation of health insurance networks. *Journal of Development Studies*, 47, 1152-1177.
- Edmonds, J.K., Hruschka, D., Bernard, H.R., & Sibley, L. (2012). Women's social networks and birth attendant decisions: application of the network-episode model. *Social Science & Medicine*, 74, 452-459.
- Emch, M., Root, E.D., Giebultowicz, S., Ali, M., Perez-Heydrich, C., & Yunus, M. (2012). Integration of spatial and social network analysis in disease transmission studies. *Annals of the Association of American Geographers*, 102, 1004-1015.
- Ennett, S.T., & Baumann, K.E. (1994). The contribution of influence and selection to adolescent peer group homogeneity: the case of adolescent cigarette smoking. *Journal of Personality and Social Psychology*, 67, 653-663.
- Ennett, S.T., Baumann, K.E., Hussong, A., Faris, R., Foshee, V.A., Cai, L., & DuRant, R.H. (2006). The peer context of adolescent substance use: findings from social network analysis. *Journal of Research on Adolescence*, 16, 159-186.
- Ensminger, J. et al. (2011). Roots of Human Sociality Phase II: Social Network Analysis. Last accessed at <http://jee.caltech.edu/files/2011/06/Social-Network-Analysis.pdf> on July 2, 2014.
- Entwisle, B., Faust, K., Rindfuss, R., & Kaneda, T. (2007). Networks and contexts: variation in the structure of social ties. *American Journal of Sociology*, 112, 1495-1533.
- Entwisle, B., Walsh, S.J., Rindfuss, R.R., & Chamratrihirong, A. (1998). Land use/land-cover and population dynamics, Nang Rong Thailand, in D. Liverman et al (eds), *People and Pixels*, Washington: National Academy Press, pp. 121-144.
- Faust, K., Entwisle, B., Rindfuss, R.R., Walsh, S.J., & Sawangdee, Y. (1999). Spatial arrangement of social and economic networks among villages in Nang Rong District, Thailand. *Social Networks*, 21, 311-337.

- Fonseca-Becker, F., & Valente, T.W. (2006). Promoting breastfeeding in Bolivia: do social networks add to the predictive value of traditional socioeconomic characteristics? *Journal of Health, Population, and Nutrition*, 24, 71-80.
- Fowler, J.H., & Christakis, N.A. (2010). Cooperative behavior cascades in human social networks. *Proceedings of the National Academy of Sciences*, 107, 5334-5338.
- Freeman, L.C. (1979). Centrality in social networks conceptual clarification. *Social Networks*, 1, 215-239.
- Fu, Z., He, N., Duan, S., Jiang, Q., Ye, R., Pu, Y., et al. (2011). HIV infection, sexual behaviors, sexual networks, and drug use among rural residents in Yunnan Province, China. *AIDS and Behavior*, 15, 1017-1025.
- Gayen, K., & Raeside, R. (2010). Social networks and contraception practice of women in rural Bangladesh. *Social Science & Medicine*, 71, 1584-1592.
- Giebultowicz, S., Ali, M., Yunus, M., & Emch, M. (2011). The simultaneous effects of spatial and social networks on cholera transmission. *Interdisciplinary Perspectives on Infectious Diseases*, 604372, <http://dx.doi.org/10.1155/2011/604372>
- Green, H.D., Jr., Atuyambe, L., Ssali, S., Ryan, G.W., & Wagner, G.J. (2011). Social networks of PLHA in Uganda: implications for mobilizing PLHA as agents for prevention. *AIDS and Behavior*, 15, 992-1002.
- Haas, S.A., Schaefer, D.R., & Kornienko, O. (2010). Health and the structure of adolescent social networks. *Journal of Health and Social Behavior*, 51, 424-439.
- Helleringer, S., & Kohler, H.P. (2007). Sexual network structure and the spread of HIV in Africa: evidence from Likoma Island, Malawi. *AIDS*, 21, 2323-2332.
- Helleringer, S., Kohler, H.P., & Chimbiri, A. (2007). Characteristics of external/bridge relationships by partner type and location where sexual relationship took place. *AIDS*, 21, 2560-2561.
- Helleringer, S., Kohler, H.-P., Chimbiri, A., Chatonda, P., & Mkandawire, J. (2009). The Likoma Network Study: context, data collection, and initial results. *Demographic Research*, 21, 427-468.
- Helleringer, S., Mkandawire, J., Kalilani-Phiri, L., & Kohler, H.P. (2013). Cohort profile: the Likoma Network Study (LNS). *International Journal of Epidemiology*, 1-13, <http://dx.doi.org/10.1093/ije/dyt001>.
- Henrich, J., & Broesch, J. (2011). On the nature of cultural transmission networks: evidence from Fijian villages for adaptive learning biases. *Philosophical Transactions of the Royal Society: Biological Sciences*, 366, 1139-1148.

- Honeycutt, T. (2009). Making connections: using social network analysis for program evaluation. *Mathematica Issue Brief*, November. Last accessed at <http://files.eric.ed.gov/fulltext/ED507482.pdf> on November 14, 2013.
- House, J.S., Landis, K.R., & Umberson, D. (1988). Social relationships and health. *Science*, 241, 540-545.
- Hurley, E.A., Warren, N.E., Doumbia, S., & Winch, P.J. Exploring the connectedness of rural auxiliary midwives to social networks in Koutiala, Mali. *Midwifery*, <http://dx.doi.org/10.1016/j.midw.2013.03.002>.
- Jackson, M.O., Rodriguez-Barraquer, T., & Tan, X. (2012). Social capital and social quilts: network patterns of favor exchange. *The American Economic Review*, 102, 1857-1897.
- Jaimovich, D. (2011). Macrostructure and microstructure: evidence from overlapping village networks in the Gambia. MPRA Working Paper No. 38932. Last accessed at <http://mpra.ub.uni-muenchen.de/38932/> on Aug 25, 2014.
- Kivela, M., Arenas, A., Barthelemy, M., Gleeson, J.P., Moreno, Y., & Porter, M.A. (2014). Multilayer networks. *Journal of Complex Networks*, <http://dx.doi.org/10.1093/comnet/cnu016>.
- Kohler, H.P., Behrman, J.R., & Watkins, S.C. (2007). Social networks and HIV/AIDS risk perceptions. *Demography*, 44, 1-33.
- Koster, J. (2011). Interhousehold meat sharing among Mayangna and Miskito horticulturalists in Nicaragua. *Human Nature*, 22, 394-415.
- Laumann, E., Marsden, P., & Prensky, D. (1983). The boundary specification problem in network analysis. In Burt, R.S., & Minor, M.J. Eds., *Applied Network Analysis: A Methodological Introduction*. London: Sage Publications, p. 18-34.
- Lin, N. (1999). Social networks and status attainment. *Annual Review of Sociology*, 467-487.
- Luke, D.A., & Harris, J.K. (2007). Network analysis in public health: history, methods, and applications. *Annual Review of Public Health*, 28, 69-93.
- Manski, C.F. (1993). Identification of endogenous social effects: the reflection problem. *The Review of Economic Studies*, 60, 531-542.
- Marin, A. (2004). Are respondents more likely to list alters with certain characteristics? Implications for name generator data. *Social Networks*, 26, 289-307.
- Marin, A., & Hampton, K.N. (2007). Simplifying the personal network name generator: alternatives to traditional multiple and single name generators. *Field Methods*, 19, 163-193.

- Marsden, P.V. (1990). Network data and measurement. *Annual Review of Sociology*, 16, 435-463.
- Marsden, P.V. (2002). Egocentric and sociocentric measures of network centrality. *Social Networks*, 24, 407-422.
- Matous, P. Todo, Y., & Mojo, D. (2013). Boots are made for walking: interactions across physical and social space in infrastructure-poor regions. *Journal of Transport Geography*, 31, 226-235.
- McCarty, C., Killworth, P.D., & Rennell, J. (2007). Impact of methods for reducing respondent burden on personal network structural measures. *Social Networks*, 29, 300-315.
- Mertens, F., Saint-Charles, J., Lucotte, M., & Mergler, D. (2008). Emergence and robustness of a community discussion network on mercury contamination and health in the Brazilian Amazon. *Health Education & Behavior*, 35, 509-521.
- Mertens, F., Saint-Charles, J., & Mergler, D. (2012). Social communication network analysis of the role of participatory research in the adoption of new fish consumption behaviors. *Social Science & Medicine*, 75, 643-650.
- Miguel, E., & Kremer, M. (2003). Networks, social learning and technology adoption: the case of deworming drugs in Kenya. Working Paper 61. Last accessed at <http://cle.berkeley.edu/wp/wp61.pdf> on May 13, 2014.
- Moore, A. (2014). Older people living with HIV/AIDS (OPLWHA) in Lome, Togo: personal networks and disclosure of serostatus. *Ageing International*, 38, 218-232.
- Moore, S., Salsberg, J., & Leroux, J. (2013). Advancing social capital interventions from a network and population health perspective. In I. Kawachi, S. Takao, & S.V. Subramanian (Eds.), *Global Perspectives on Social Capital and Health* pp. 189-204). New York: Springer.
- Moser, S., & Mosler, H-J. (2008). Differences in influence patterns between groups predicting the adoption of solar disinfection technology for drinking water in Bolivia. *Social Science and Medicine*, 67, 497-504.
- Nolin, D.A. (2010). Food-sharing networks in Lamalera, Indonesia: reciprocity, kinship and distance. *Human Nature*, 21, 243-268.
- Nolin, D.A. (2012). Food-sharing networks in Lamalera, Indonesia: status, sharing and signaling. *Evolution and Human Behavior*, 33, 334-345.
- O'Malley, A.J., & Christakis, N.A. (2011). Longitudinal analysis of large social networks: estimating the effects of health traits on changes in friendship ties. *Statistics in Medicine*, 30, 950-964.

- O'Malley, A.J. (2013). The analysis of social network data: an exciting frontier for statisticians. *Statistics in Medicine*, 32, 539-555.
- O'Malley, A.J., Elwert, F., Rosenquist, J.N., Zaslavsky, A.M., & Christakis, N.A. (2014). Estimating peer effects in longitudinal dyadic data using instrumental variables. *Biometrics*, <http://dx.doi.org/10.1111/biom.12172>
- Perez-Heydrich, C., Furgurson, J.M., Giebultowics, S., Winston, J.J., Yunus, M., Streatfield, P.K., & Emch, M. (2013). Social and spatial processes associated with childhood diarrheal disease in Matlab, Bangladesh. *Health and Place*, 19, 45-52.
- Perry, B.L., & Pescosolido, B.A. (2010). Functional specificity in discussion networks: the influence of general and problem-specific networks on health outcomes. *Social Networks*, 32, 345-357.
- Philipson, T.C. (2002). Design of HIV trials for estimating external effects. In *Quantitative Evaluation of HIV Prevention Programs*. Eds. Kaplan, E.H. & Brookmeyer, R. New Haven, CT: Yale University.
- Pollard, M.S., Tucker, J.S., Green, H.D., Kennedy, D., & Go, M.H. (2010). Friendship networks and trajectories of adolescent tobacco use. *Addictive Behaviors*, 35, 678-685.
- Rand, D.G., Arbesman, S., & Christakis, N.A. (2011). Dynamic social networks promote cooperation in experiments with humans. *Proceedings of the National Academy of Sciences*, 108, 19193-19198.
- Rasul, I., & Hernandez, M. (2012). Programme evaluation and social networks. ESRC Research Methods Festival. London, UK: Institute for Fiscal Studies. Last accessed at http://www.ifs.org.uk/docs/PEPA_RMF_Imran.pdf on November 14, 2013.
- Ruiz-Casares, M. (2010). Kin and youths in social networks of youth-headed households in Namibia. *Journal of Marriage and Family*, 72, 1408-1425.
- Sandberg, J. (2005). The influence of network mortality experience on nonnumeric response concerning expected family size: evidence from a Nepalese mountain village. *Demography*, 42, 737-756.
- Sandberg, J. (2006). Infant mortality, social networks, and subsequent fertility. *American Sociological Review*, 71, 288-309.
- Sandberg, J. (2012). Social learning about levels of perinatal and infant mortality in Niakhar, Senegal. *Social Networks*, 34, 264-274.
- Scott, J.P., & Carrington, P.J. (Eds.) (2011). *The Sage Handbook of Social Network Analysis*. London, UK: SAGE Publications Limited.

- Seeman, T. (1996). Social ties and health: the benefits of social integration. *Annals of Epidemiology*, 6, 442-451.
- Seidner, M.J., Lankowski, A., Musinga, D., Jackson, J., Muzoora, C., Hunt, P.W., Martin, J.N., Bangsberg, D.R., & Haberer, J.E. (2012). Optimizing network connectivity for mobile health technologies in sub-Saharan Africa. *PLoS One*, 7, e45643, [http://dx.doi: 10.1371/journal.pone.0045643](http://dx.doi.org/10.1371/journal.pone.0045643).
- Shakya, H.B., Christakis, N.A., & Fowler, J.H. (2014a). Social network predictors of latrine ownership. *Social Science and Medicine*, <http://dx.doi.org/10.1016/j.socscimed.2014.03.009>
- Shakya, H.B., Christakis, N.A., & Fowler, J.H. (2014b). Association between social network communities and health behavior: an observational sociocentric network study of latrine ownership in rural India. *American Journal of Public Health*, [http://dx.doi: 10.2105/AJPH.2013.301811](http://dx.doi.org/10.2105/AJPH.2013.301811).
- Shalizi, C.R., & Thomas, A.C. (2011). Homophily and contagion are generically confounded in observational social network studies. *Sociological Methods & Research*, 40, 211-239.
- Smith, K., & Christakis, N. (2008). Social networks and health. *Annual Review of Sociology*, 34, 405-429.
- Stafford, D., Hughes, A.D., & Abel, B. (2010). A pictures is worth a thousand words: photographic identification in rural networks and an introduction to Netriks. Last accessed at http://polisci2.ucsd.edu/dhughes/Netriks_Design.pdf on November 14, 2013.
- Stoebenau, K., & Valente, T.W. (2003). Using network analysis to understand community-based programs: a case study from highland Madagascar. *International Family Planning Perspectives*, 29, 167-173.
- Trostle, J.A., Hubbard, A., Scott, J., Cevallos, W., Bates, S.J., & Eisenberg, J.N.S. (2008). Raising the level of analysis of food-borne outbreaks: food-sharing networks in rural coastal Ecuador. *Epidemiology*, 19, 384-390.
- Tsai, A.C., Bangsberg, D.R., & Weiser, S.D. Harnessing poverty alleviation to reduce stigma of HIV in Sub-Saharan Africa. *PLoS Medicine*, 10, e1001557, [http://dx.doi: 10.1371/journal.pmed.101557](http://dx.doi.org/10.1371/journal.pmed.101557).
- Umberson, D., Crosnoe, R., & Rezeck, C. (2010). *Annual Review of Sociology*, 36, 139-157.
- Valente, T.W., Watkins, S.C., Jato, M.N., Van der Straten, A., & Tsitsol, L.M. (1997). Social network associations with contraceptive use among Cameroonian women in voluntary associations. *Social Science and Medicine*, 45, 677-687.

- Valente, T.W. (2010). *Social Networks and Health: Models, Methods, and Applications*. New York: Oxford University Press.
- Valente, T.W. (2012). Network interventions. *Science*, 337, 49-53.
- Van der Poel, M.G.M. (1993). Delineating personal networks. *Social Networks*, 15, 49-70.
- VanderWeele, T.J. (2013). Inference for influence over multiple degrees of separation on a social network. *Statistics in Medicine*, 32, 591-596.
- Verdery, A.M., Entwisle, B., Faust, K., & Rindfuss, R.R. (2012). Social and spatial networks: kinship distance and dwelling unit proximity in rural Thailand. *Social Networks*, 34, 112-127.
- Ware, N.C., Idoko, J., Kaaya, S., Biraro, I.A., Wyatt, M.A., Agbaji, O., Chalamilla, G., & Bangsberg, D.R. (2009). Explaining adherence success in Sub-Saharan Africa: an ethnographic study. *PLoS Medicine*, 6, e11, [http://dx.doi:10.1371/journal/pmed.1000011](http://dx.doi:10.1371/journal.pmed.1000011).
- Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge, UK: Cambridge University Press.
- Wellman, B. (1992). Which types of ties and networks give what kinds of social support? *Advances in Group Processes*, 9, 207-235.
- White, K., & Watkins, S. (2000). Accuracy, stability and reciprocity in informal conversational networks in rural Kenya. *Social Networks*, 22, 337-355.
- Wutich, A., & McCarty, C. (2008). Social networks and infant feeding, in Oaxaca, Mexico. *Maternal and Child Nutrition*, 4, 121-135.
- Zelner, J.L., Trostle, J., Goldstick, J.E., Cevallos, W., House, J.S., & Eisenberg, J.N. (2012). Social connectedness and disease transmission: social organization, cohesion, village context, and infection risk in rural Ecuador. *American Journal of Public Health*, 102, 2233-2239.
- Zhang, T., Cao, W., Lv, J., Wang, N., Reilly, K., Zhu, Q., et al. (2012). Size, composition, and strength of ties of personal social support networks among adult people living with HIV/AIDS in Henan and Beijing, China. *AIDS and Behavior*, 16, 911-919.

**Paper II: Food Insecurity, Social Networks, and Symptoms of Depression in Rural
Uganda: A Cross-Sectional Population-Based Study**

ABSTRACT

Background Food insecurity is associated with mental health outcomes in high-income countries, but much less is known about this relationship in the general population in low and middle-income countries. In addition, social network position, structure and composition characteristics have yet to be included in such studies.

Objective With the use of population-based data from eight villages in rural southwest Uganda, we examined the associations between food insecurity and depression symptom severity and whether these differed by social network characteristics and gender.

Methods All residents aged 18 years or older were included with a 96% response rate. Food insecurity was assessed with the nine-item Household Food Insecurity Access Scale, generating a total score and food insecurity categories. Depression symptom severity was assessed with a 16-item version of the Hopkins Symptom Checklist for Depression producing a continuous score. Multilevel linear regression models examined the associations between food insecurity and symptoms, adjusting for social network and sociodemographic characteristics, and interactions between food insecurity categories and network variables.

Results Severe food insecurity was associated with greater depression symptom severity among both men and women, though the relationship was slightly stronger for women. None of the social network characteristics were directly associated with the outcome for either gender, and there were no interactions between food insecurity and network characteristics among women. For severely food insecure men, however, personal network centrality was positive associated with symptoms and personal network poverty composition was negatively associated with symptoms. These interactions were not significant for men reporting no or mild food insecurity.

Conclusions Food insecurity remains associated with mental health even after controlling for well-known predictors of depression and social network characteristics for both men and women. The possible role of shame arising from being severely food insecure on depression among men with wealthier networks needs to be explored.

INTRODUCTION

According to the Food and Agricultural Organization (FAO) of the UN, about “805 million people were chronically undernourished in 2012–14, with insufficient food for an active and healthy life” (FAO, IFID, & WFP, 2014). Moreover, despite a global focus on the first Millennium Development Goal calling for reductions in undernourishment, there were nine countries in Sub-Saharan Africa where the number and proportion of undernourished people had actually increased since 1990-1992 (FAO et al., 2014). Such high levels of food insecurity and undernutrition present global challenges as food insecurity (and food insufficiency) experienced as adults can lead to serious physical health consequences (Lee & Frongillo, 2001; Seligman, Laraia, & Kushel, 2010; Siefert, Heflin, Corcoran, & Williams, 2001; Stuff et al., 2004; Vozoris & Tarasuk, 2003). In addition, research has demonstrated relationships between food insecurity and mental health outcomes (Carter, Kruse, Blakely, & Collings, 2011; Friel, Berry, Dinh, O'Brien, & Walls, 2014; Heflin, Siefert, & Williams, 2005; Maes, Hadley, Tesfaye, & Shifferaw, 2010; Siefert et al., 2001). A systematic review on food insecurity and mental health outcomes in low-or middle-income countries, however, highlighted the need for more rigorous studies on this issue in these contexts (Weaver & Hadley, 2009). Given that depression is the world’s leading cause of disability for both men and women, and is the leading cause of disease burden among women in both high- and low-income countries (Marcus, Taghi Yasamy, van Ommeren, Chisholm, & Saxena, 2012), a focus on clarifying the relationship between food insecurity and depression in the general population is warranted, particularly in resource-limited settings.

In the Sub-Saharan Africa context, a few recent quantitative studies have linked food insecurity to mental health among specific sub-groups, such as community health workers in Ethiopia (Maes et al., 2010), HIV positive patients on antiretroviral treatment in Uganda (Tsai et

al., 2012), women who were three months post-birth in South Africa (Dewing, Tomlinson, le Roux, Chopra, & Tsai, 2013), and participants in an on-going growth study in rural Ethiopia (C Hadley et al., 2008). In addition, one population-based, longitudinal study in Zambia found that food insecurity affected mental health and even more so during the dry season (Cole & Tembo, 2011). Only one of these studies examined the role of social support as a moderator of the relationship between food insecurity and mental health (Tsai et al., 2012), and none have looked at the relevance of specific measures of social network position and structure. Yet, previous studies have separately linked social support and networks to mental health (with most studies coming from high-income countries) (Kawachi & Berkman, 2000; Kawachi & Berkman, 2001; Myer, Stein, Grimsrud, Seedat, & Williams, 2008), and social support and networks to food insecurity (Dhokarh et al., 2011; Craig Hadley, Mulder, & Fitzherbert, 2007; Kaschula, 2011; Lemke, Vorster, van Rensburg, & Ziche, 2003; Nagata et al., 2015; Tsai et al., 2011). Thus, in addition to the need for further studies documenting the relevance of food insecurity for mental health outcomes in the general population in low- and middle-income countries, research assessing whether social network characteristics act as potential confounders or moderators of the relationship between food insecurity and mental health in these contexts is also needed.

It is possible that personally having many support ties or being in a central location within an overall community network could be associated with greater access to resources preventing or addressing either food insecurity or mental health issues or both. Alternatively, having few ties or being on the periphery of a network might enhance the feeling of stress associated with food insecurity and thus affect the relationship between food insecurity and depression. Relatedly, the way in which ties are arranged around an individual (personal network structure) may be associated with both food insecurity and depression or act as a moderator. For

example, if one's contacts are all tightly linked together, the relationship between food insecurity and depression might be attenuated because the network may be more aware of the individual's situation and thus be able to provide greater (or perhaps more coordinated) support. Some qualitative studies, however, have documented feelings of shame and embarrassment associated with food insecurity (Nanama & Frongillo, 2012; Oliva et al., 2008; Weaver & Hadley, 2009). Therefore, if an individual is trying to hide his or her level of food insecurity due to perceived or actual food insecurity-related stigma, then having a tight network might be more stressful for the individual as gossip about the situation could quickly saturate his or her network.

Another extension in this line of investigation would be to account for the socioeconomic composition of one's social contacts. Having a wealthier network may provide better access to resources, which could ostensibly predict both food insecurity and mental health, thus confounding the true relationship between food insecurity and depression. Alternatively, feelings of shame may be more acutely felt by severely food insecure people with a personal network they assume to be less understanding of food insecurity, such as networks with a lower composition of visibly poor people. These feelings might then directly lead to greater depression symptoms, or indirectly by reducing the likelihood that such people will request assistance from their networks. Therefore, the socioeconomic composition of one's network could act as a moderator of the relationship between food insecurity and depression. Similarly, food insecure people with a network comprising a large proportion of food insecure contacts may experience fewer depression symptoms because they might not feel as ashamed or isolated, but this might only be true if people do not attempt to hide their food insecurity status.

Finally, there is limited evidence regarding gender-based differences in the relationship between food insecurity and depression in the general population and whether any moderating

relationships differ by gender. In cultures where women may traditionally be responsible for food, the relationship between food insecurity and depression may stronger for women (Tsai et al., 2012). Alternatively, despite women typically being responsible for food preparation, men might feel responsible (or are made responsible) for making sure that enough money is available to purchase (or grow) sufficient food. In this case, there could be few gender differences in the direct relationship between food insecurity and depression. However, men reporting substantial food insecurity and who have a wealthier network might feel more embarrassed and thus depressed because they could perceive being food insecure as a visible sign to their wealthier peers of failing to provide for the family.

To address these gaps in the literature regarding food insecurity and depression, we undertook a cross-sectional, population-based study in rural Uganda, a low-income country in Sub-Saharan Africa. According to the FAO, about 9.7 million people in Uganda (or 26% of its population) in 2012-2014 were undernourished (FAO et al., 2014). Furthermore, the proportion of undernourished people in Uganda actually increased from 1990-92 to 2012-14 (FAO et al., 2014). Given these statistics and the fact that most people live in rural areas and many are subsistence farmers (DHS, 2011; "Uganda," 2015), the potential for significant mental health consequences in this country further motivated this study. The objective was to assess the association between food insecurity and depression symptoms severity in a general adult population, and to measure to what extent, if at all, do measures of social network position, structure, and composition act as confounding or moderating variables in the association between food insecurity and depression symptoms severity for men and women.

METHODS

Study Population. The study targeted all adults (aged 18 years or older) whose main household was located within one parish (containing eight villages) in rural Southwestern Uganda. Using a census enumeration, the study team searched for 1,939 potential participants in 716 households continuously during the data collection period. By the end of the period, there were 1,669 participants. Among the remaining 270 people, 16 refused, 62 could not be contacted (because the person was away from the parish during every attempted contact), 166 became ineligible as their primary residence had shifted outside the parish, 11 were consistently too incapacitated/sick to participate, and 15 had died. Thus, after excluding the people who were ineligible, incapacitated or who had died, the response rate was $1669/1747 = 96\%$. There was little variation in response rates across villages. The final analytic population consisted of 1499 people (677 men and 822 women) after removing participants with missing responses on any of the variables included in this study.

Procedures. Ethical approval for all study procedures was obtained from the Committee on the Use of Human Subjects in Research, Harvard University; the Partners Human Research Committee, Massachusetts General Hospital; and the Institutional Review Committee, Mbarara University of Science and Technology. We also received clearance for the study from the Uganda National Council for Science and Technology and from the Research Secretariat in the Office of the President. Interview materials were translated, back-translated, and pilot-tested to ensure accuracy, consistent word choice, and linguistic equivalence. Between October 2011 and August 2012, trained local research assistants conducted one-on-one structured interviews (lasting about an hour) with eligible participants, typically at a participant's place of residence. All participants provided written informed consent, either with a signature or, if there were cultural literacy reasons why a signature was not appropriate, a thumbprint.

Depression Symptoms Severity. We used a slightly modified version of the 15-item Hopkins Symptom Checklist for Depression (HSCL-D) (Derogatis, Lipman, Rickels, Uhlenhuth, & Covi, 1974a), by including a 16th item (“feeling like I don’t care about my health”) that prior studies had included for use in the Ugandan context (Bolton & Ndogoni, 2001; Martinez et al., 2008; Tsai et al., 2012). Participants were asked how often in the last 7 days they had experienced each symptom using a 4-point scale representing not at all to extremely (coded 0 to 3). Cronbach’s alpha was 0.84. A summary score was created (no missing permitted). Higher scores represented more symptoms. For use in sensitivity analyses, participants with a score of 1.75 or greater were classified as having probable depression (Derogatis, Lipman, Rickels, Uhlenhuth, & Covi, 1974b).

Food Insecurity. Individual perception of household food insecurity was measured using the nine-item Household Food Insecurity Access Scale (HFIAS or simply food insecurity) (Coates, Swindale, & Bilinsky, 2006), which a previous study had slightly adapted for use in the Uganda (Tsai et al., 2012). Participants were asked how often in the past 30 days they had experienced different food insecurity-related situations using a 4-point scale representing never to often (coded 0 to 3). Cronbach’s alpha was 0.85. A summary score was created (no missing was permitted). Higher scores represented more food insecurity (max = 27). Using a validated scoring algorithm, the scores on the raw scale were used to assign respondents to categories of food insecurity severity: none (food secure), mildly food insecure, moderately food insecure, and severely food insecure (Coates et al., 2006).

Social Network Position, Structure, and Composition. We employed “name generators” to elicit study participants’ social ties. The canonical example of a name generator frequently used in U.S.-based surveys is the question embedded in the U.S. General Social Survey: “From

time to time, most people discuss important matters with other people. Looking back over the last six months -- who are the people with whom you discussed matters important to you?" (Burt, 1984). Consistent with the literature (Perkins, Subramanian, & Christakis), we adapted name generators for the local context. All participants were asked to name up to six adult parish residents in response to each of five name generator questions. The questions inquired about with whom or to whom, in the past 12 months, the participant a) spent free time, b) discussed financial topics, c) discussed health matters, d) went to for emotional support, and e) shared, exchanged, received, or gave food. Names could be repeated for each network type.

Previous research has shown that by utilizing information from across multiple name generators, network characteristics are more accurate (Marin & Hampton, 2007). Therefore, by collapsing information across the five network types, we calculated three measures of individual network position, otherwise referred to as measures of centrality as traditionally used in social network analysis (Wasserman & Faust, 1994): a) out-degree (the number of people whom an individual nominated), b) total degree (out-degree plus the number of nominations an individual received not counting any duplicates), and c) reciprocal degree (the number of people who an individual nominated who also nominated the individual). In addition, by using all nominations within a village and dropping any inter-village nominations, we calculated how structurally close a participant was to all other participants in his or her village network, which represents another measure of individual network centrality traditionally referred to as 'closeness' (Sabidussi, 1966). Based on this calculation, we then created equally-distributed quintile categories representing an individual's network location, which could range from very peripheral village network position (lowest quintile) to a very central village network position (highest quintile).

The set of people directly connected to a participant (ignoring nomination direction) represents his or her personal social network. To measure its structure, we calculated the density of the personal network by dividing the total number of ties among a participant's contacts by the total number of ties that could have possibly existed among a participant's contacts (without regards to direction of tie). To measure personal network composition, we calculated the percentage of the personal network that was poor (see next paragraph for wealth definition) and the percentage of the network that reported moderate or severe food insecurity. We then categorized these composition percentages of 0 to 100 into quintiles.

Covariates. Participants also reported age, tribe, marital status, educational attainment, alcohol consumption frequency, and HIV status. Age was categorized as a) less than 30 years old, b) 40-49 years, c) 50-59 years, d) 60-69 years, and e) 70 years or older. Education was categorized as primary schooling or less versus secondary schooling or more, and alcohol consumption as two or more times per week. Household-level measures included whether there had been a death in the household in the past 12 months and household wealth. The latter was measured via a household asset index, by conducting a principal components analysis on 26 separate variables representing household assets and housing characteristics as reported by the household head. We retained the first principal component to define the asset index (Filmer & Pritchett, 2001), and categorized anyone in the first two quintiles of the asset index as 'poor'. We also created a variable representing whether the interview was conducted in the rainy season. All these variables were included as covariates because prior research has linked them to food security and mental health outcomes in similar populations (Anema, Vogenthaler, Frongillo, Kadiyala, & Weiser, 2009; Carter et al., 2011; Ciesla & Roberts, 2001; Cole & Tembo, 2011; Tsai et al., 2012; Whitaker, Phillips, & Orzol, 2006). Therefore, we sought to control for these

potentially confounding variables in order to more accurately determine the relationship between food security and depression symptom severity.

Statistical Analyses. The distribution of men and women across categories of predictor variables were calculated to characterize the population, along with the mean depression symptom severity score for each category and the mean food insecurity score for each category. To test for differences between men and women, we used Pearson's chi-squared test for categorical variables and the nonparametric equality-of-medians test for continuous variables. To assess the association between food insecurity and depression symptom severity, we fit several series of random intercepts, linear regression models that accounted for clustering of observations at the household level as well as village fixed effects and a series of fixed effects for all covariates. As a preliminary check for a direct association between food insecurity and depression symptom severity in the general population and whether there was a gender difference in this relation, we regressed depression symptom severity on the continuous measure of food insecurity for both men and women and included an interaction effect between gender and food insecurity score. We then ran the same model, but stratified it by gender and used the categorical version of food insecurity, which was the basis for all further models. (We also ran the same analysis, but using a logistic model and probable depression as the outcome to check whether the pattern of results was similar to analyses using symptom severity as the outcome).

A second series of analyses added main effects for individual network position, personal network structure, and personal network composition, separately. (The models including personal network structure or composition variables also controlled for total degree). The results from these models were used to assess whether any of the social network variables confounded the relationship between food insecurity and the outcome. A third series of models added

interaction effects between each of the social network variables and food insecurity (entered into separate models) to demonstrate whether any network characteristics acted as moderators of the relationship between food insecurity status and depression symptoms severity. After showing the initial findings, only findings from the second and third series of models with statistically significant estimates are displayed in subsequent tables.

RESULTS

Overall, the mean level of depression symptom severity was greater among women than among men (1.52 vs. 1.28, $p < .001$) as was the prevalence of probable depression (205 women (25%) and 63 men (9%) ($p < .001$)). Likewise, 76% of women and 67% of men reported any degree of food insecurity ($p < .001$) with 24% of women and 16% of men reporting severe food insecurity ($p < .001$). Both depression symptom severity and food insecurity scores appeared greater among women compared to men across most socio-demographic sub-categories (Table 2.1). Table A2.1 in the appendix provides descriptive statistics on personal network position, structure, and composition by gender and the correlation between these variables and depression symptom severity as well as food insecurity.

Table 2.1. Descriptive characteristics, and average food insecurity and average depression symptom severity by descriptive characteristics, of men and women aged 18 years or older across eight villages in one parish in rural Southwestern Uganda.

	Population				Food Insecurity		Depression Symptom Severity	
	Women		Men		Women	Men	Women	Men
Characteristics	N	%	N	%	Mean (std)	Mean (std)	Mean (std)	Mean (std)
<i>Gender</i>								
Men	-	-	677	45	-	5.2 (5.6)	-	1.28 (0.34)
Women	822	55	-	-	6.8 (6.1)	-	1.52 (0.50)	-

Table 2.1 (Continued)

<i>Food Insecurity</i>								
None	194	24	218	32	0.1 (0.3)	0.1 (0.3)	1.35 (0.34)	1.20 (0.28)
Mild	141	17	138	20	3.1 (1.6)	3.0 (1.7)	1.37 (0.45)	1.20 (0.27)
Moderate	291	35	213	31	8.0 (3.4)	8.2 (3.4)	1.51 (0.47)	1.29 (0.33)
Severe	196	24	108	16	14.2 (5.2)	12.7 (6.1)	1.84 (0.56)	1.53 (0.42)
<i>Age</i>								
Less than 30 years	356	43	284	42	5.8 (5.8)	4.6 (5.1)	1.44 (0.49)	1.22 (0.29)
30-39 years	159	19	145	21	7.9 (6.5)	6.2 (6.4)	1.55 (0.51)	1.27 (0.33)
40-49 years	124	15	118	17	7.8 (6.4)	5.7 (6.1)	1.51 (0.49)	1.32 (0.38)
50-59 years	66	8	61	9	7.5 (5.8)	5.1 (5.1)	1.61 (0.49)	1.29 (0.32)
60-69 years	52	6	33	5	5.3 (4.4)	5.4 (4.9)	1.62 (0.51)	1.29 (0.30)
70+ years	65	8	36	5	7.9 (7.0)	5.2 (5.3)	1.78 (0.45)	1.60 (0.41)
<i>Tribe</i>								
Other tribe	89	11	36	5	7.0 (6.4)	4.6 (5.9)	1.62 (0.56)	1.27 (0.27)
Banyankore	733	89	641	95	6.7 (6.1)	5.3 (5.6)	1.51 (0.49)	1.28 (0.34)
<i>Married</i>								
No	352	43	261	39	6.5 (6.3)	4.4 (5.0)	1.52 (0.49)	1.23 (0.32)
Yes	470	57	416	61	7.0 (6.0)	5.7 (5.9)	1.53 (0.50)	1.32 (0.34)
<i>HIV Positive</i>								
No	755	92	641	95	6.6 (6.0)	5.2 (5.6)	1.51 (0.49)	1.27 (0.33)
Yes	67	8	36	5	9.1 (6.7)	5.6 (6.1)	1.75 (0.59)	1.45 (0.46)
<i>Drinks alcohol 2+ times per week</i>								
No	807	98	520	77	6.8 (6.1)	4.8 (5.3)	1.53 (0.50)	1.27 (0.32)
Yes	15	2	157	23	4.5 (5.4)	6.5 (6.4)	1.42 (0.52)	1.31 (0.38)
<i>Education</i>								
Secondary or more	221	27	253	37	4.0 (4.8)	3.9 (4.6)	1.35 (0.37)	1.23 (0.29)
Primary or less	601	73	424	63	7.8 (6.3)	6.0 (6.0)	1.59 (0.53)	1.31 (0.36)
<i>Poor</i>								
No	526	64	454	67	5.2 (5.5)	4.0 (4.8)	1.47 (0.47)	1.27 (0.33)
Yes	296	36	222	33	9.4 (6.3)	7.6 (6.2)	1.63 (0.53)	1.30 (0.36)
<i>Household deaths</i>								
No	757	92	624	92	6.7 (6.1)	5.2 (5.5)	1.51 (0.49)	1.28 (0.34)
Yes	65	8	53	8	7.3 (6.2)	5.8 (6.2)	1.73 (0.58)	1.32 (0.36)

The preliminary regression analyses showed that total food insecurity was positively associated with depression symptom severity in the general adult population ($b = 0.026$, 95% CI 0.021 to 0.031). However, men were predicted to have lower depression symptom severity scores than women ($b = -0.138$, 95% CI -0.196 to -0.080) and the relationship between food insecurity and depression symptom severity was not as strong for men ($b = -0.008$, 95% CI -0.015 to -0.001). The main gender-stratified model including the four categories of food insecurity demonstrated that severe food insecurity was associated with a 0.41 point increase in depression symptom severity for women (95% CI 0.31, 0.50) and with a 0.31 point increase in depression symptom severity for men (95% CI 0.24, 0.39) compared to people reporting no food insecurity. Moderate food insecurity was also associated with greater depression symptom severity for both men and women though the estimate was three to four times less than the estimate for severe food insecurity (Table 2.2). In relative terms, the magnitude of the association of severe (and moderate) food insecurity with depression symptom severity was greater than that of all the other sociodemographic variables.

Logistic regression models using the binary outcome of probable depression demonstrated similar results; women and men reporting severe food insecurity were about 5.2 times (95% CI, 2.9 to 9.4) and 4.6 times (95% CI, 1.9 to 11.0) respectively, more likely to be depressed than adults reporting no food insecurity. In addition, women who experienced moderate food insecurity were 2.0 times more likely to be depressed (95% CI, 1.1 to 3.5). The estimate for the parallel group of men was similar, but not significant.

Table 2.2. Multilevel linear regression estimates for food insecurity and descriptive characteristics predicting depression symptom severity among men and women (aged 18 years or older) in eight villages in rural Southwestern Uganda.

	Women		Men	
	b	95% CI	b	95% CI
Intercept	1.28***	1.12 to 1.44	1.03***	0.90 to 1.17
No food insecurity (ref)	-	-	-	-
Mild food insecurity	0.03	-0.07 to 0.13	0.004	-0.06 to 0.07
Moderate food insecurity	0.12*	0.03 to 0.20	0.08**	0.02 to 0.15
Severe food insecurity	0.41***	0.31 to 0.50	0.31***	0.24 to 0.39
Age (10 year categories)	0.05***	0.03 to 0.07	0.05***	0.03 to 0.06
Banyankore (vs other)	-0.11*	-0.21 to -0.01	0.01	-0.09 to 0.12
Married (vs. not)	0.005	-0.06 to 0.07	-0.02	-0.07 to 0.03
HIV positive (vs. not)	0.13*	0.02 to 0.25	0.15**	0.04 to 0.26
Drinks alcohol 2+ times per week (vs. less often)	-0.07	-0.30 to 0.16	-0.01	-0.07 to 0.05
Primary education or less (vs. secondary education or more)	0.10*	0.02 to 0.18	0.03	-0.01 to 0.08
Household asset index	-0.001	-0.02 to 0.01	0.0004	-0.01 to 0.01
Death in household in past year (vs. none)	0.21**	0.09 to 0.33	0.02	-0.07 to 0.11

* $p < .05$; ** $p < .01$; *** $p < .001$.

Notes: Estimates were obtained using a two-level, random intercepts linear regression model accounting for clustering at the household level and including fixed effects for rainy season and villages.

The second series of analyses showed that none of the social network variables exhibited a statistically significant direct association with depression symptoms severity for men or women. Nor did any of these variables appear to confound the relationship between food insecurity and depression symptoms severity. Moreover, the third series of analyses found no statistically significant interaction effects between any of the social network variables and food insecurity categories for women. However, the interaction between food insecurity and closeness quintiles (e.g. location within the village network) was statistically significant for men ($F = 3.41$, $p = 0.019$) as was the interaction between food insecurity and the poverty composition (e.g. percent poor) of one's personal network ($F = 2.71$, $p = 0.047$) (Table 2.3).

Table 2.3. Multilevel linear regression estimates of potential interaction effects between food insecurity and social network characteristics in predicting depression symptom severity among men (aged 18 years or older) in eight villages in one parish in rural Southwestern Uganda.

	b	95% CI	b	95% CI
<i>Main Effects</i>				
Intercept	1.16***	1.05 to 1.26	1.04***	0.86 to 1.21
No food insecurity (ref)	-	-	-	-
Mild food insecurity	-0.06	-0.19 to 0.06	0.04	-0.11 to 0.20
Moderate food insecurity	-0.03	-0.14 to 0.08	0.05	-0.08 to 0.19
Severe food insecurity	0.16*	0.08 to 0.33	0.49**	0.32 to 0.65
Closeness Centrality (continuous quintiles)	-0.04**	-0.07 to -0.01	-	-
Percent of network who are poor (based on quintiles representing 0 to 100 percent)	-	-	0.01	-0.04 to 0.05
<i>Interaction Effects</i>				
Closeness centrality (continuous quintiles) x No food insecurity	-	-	-	-
Closeness centrality (continuous quintiles) x Mild food insecurity	0.03	-0.01 to 0.08	-	-
Closeness centrality (continuous quintiles) x Moderate food insecurity	0.06**	0.01 to 0.10	-	-
Closeness centrality (continuous quintiles) x Severe food insecurity	0.07**	0.02 to 0.13	-	-
Percentage of contacts who are poor (continuous quintiles) x No food insecurity	-	-	-	-
Percentage of contacts who are poor (continuous quintiles) x Mild food insecurity	-	-	-0.02	-0.09 to 0.05
Percentage of contacts who are poor (continuous quintiles) x Moderate food insecurity	-	-	0.01	-0.05 to 0.07
Percentage of contacts who are poor (continuous quintiles) x Severe food insecurity	-	-	-0.07*	-0.15 to -0.01

~p = 0.0499; * p < .05; ** p < .01; *** p < .001.

Notes: Estimates were obtained using a two-level, random intercepts linear regression model accounting for clustering at the household level and village fixed effects as well as adjusting for total degree and all covariates listed in Table 2.2.

For men reporting mild and no food insecurity, there was simply a negative main effect between closeness and depression symptom severity ($b = -0.04$, 95% CI -0.07 to -0.01) with no statistically significant interaction effect. Thus, for all men in these two categories, increasing closeness centrality in the village network was associated with reduced symptoms. However, for men reporting severe food insecurity, (and to some extent for men reporting moderate food insecurity), a positive interaction effect between their food security status and closeness counterbalanced the negative main effect and actually created a reverse relationship between closeness and predicted symptom score. Thus, for moderately and severely food insecure men, increasing village network centrality was associated with a higher depression symptoms severity score. For example, severely food insecure men in the very center of the network (given a fixed set of other characteristics) had a predicted score of 1.43 while severely food insecure men on the periphery of the network (with the same set of fixed characteristics) had a predicted score of 1.31, which is 8% lower.

Separately, for men reporting anything less than severe food insecurity, the poverty composition of their personal network did not change the relationship between their food insecurity status and depression symptom severity. Nor was there a significant main effect of personal network poverty composition. However, among men reporting severe food insecurity, personal network poverty composition was negatively associated with depression symptoms severity score ($b = -0.07$, 95% CI -0.13 to -0.01). For example, severely food insecure men whose network was 80 to 100% poor had a predicted depression symptom severity score of 1.26 (given a fixed set of other characteristics) whereas severely food insecure men whose network

was primarily not poor (0 to 20%) had a predicted score of 1.52 (given the same set of fixed characteristics), which translates into a score 20% higher.

Given results showing that social network characteristics neither confounded nor moderated the relationship between food insecurity and depression for women, we chose to conduct a supplementary regression analysis examining whether food insecurity could be a mediator between social network characteristics and depression symptom severity. Using the continuous food insecurity score as the outcome and controlling for the same set of sociodemographic characteristics as in previous models, analyses demonstrated only one statistically significant relationship between a social network characteristic (moderate/severe food insecurity composition of the personal network) and food insecurity score among women ($b = 0.43$, 95% CI 0.05 to 0.81, $p < .05$). For men, food insecurity was related to total degree ($b = -0.12$, 95% CI -0.20 to -0.05, $p < .01$), reciprocal degree ($b = -0.45$, 95% CI -0.75 to -0.15, $p < .01$) and the moderate/severe food insecurity composition of the personal network ($b = 0.45$, 95% CI 0.05 to 0.85, $p < .05$), separately. None of the other social network characteristics measured in this study were directly related to food insecurity.

DISCUSSION

The first novel contribution of this study to the literature is to demonstrate that within a general population of adults in a rural setting in Uganda, severe food insecurity (and to some extent moderate food insecurity) was a primary predictor of depression symptom severity for both men and women. Moreover, although the relationship was slightly stronger for women than men, the relationship was not attenuated for either gender even when controlling for several measures of social network position, structure, and composition as well as many well-known

predictors of depression. (Also notable was the lack of direct relationships between social network characteristics and depression symptom severity for either gender).

This study's other major contribution to the knowledge base on food insecurity and mental health is that some aspects of men's social context may moderate the way that perceived food insecurity is related to depression (and other aspects of men's social context may predict men's food insecurity). These findings differ from the results for women showing that social networks do not seem to matter much in the food insecurity and depression dynamic. It could be that severely food insecure women experience food insecurity more regularly or more profoundly than men so social factors are not able to play as much of a role in predicting depression for women. Alternatively, an inability to provide for oneself or family may be viewed much more harshly for men than for women in patriarchal settings. This possibility is supported by the current moderator results among men and highlight a role for how perceived food insecurity-related stigma and shame could be possible mechanisms through which social networks moderate the role of food insecurity on men's mental health.

For example, severely food insecure men in the center of their network may be more embarrassed than peripheral men because of the possibility for more people to find out their severe food insecurity status is greater. This stress (of worrying about an information leak) may, in turn, increase depression symptom severity. Similarly, severely food insecure men may make judgments about whether their contacts are experiencing food insecurity based on their contacts' visible assets, which may not be a good indicator if men tend to hide food insecurity. Such judgments could create a heightened sense of shame for men with fewer poor contacts if they assume a significant proportion of their network to not understand their situation. The lack of moderation, by the prevalence of moderate to severe food insecurity among men's personal

networks on the relationship between personal food insecurity and symptoms, supports this theory about the potential role of food-related stigma; if men generally try to hide their food insecurity status, then men may not be aware of others' food insecurity in the same way they are aware of others' tangible assets. Thus, this could increase shame and, therefore, depression symptoms, among severely food insecure men with less poor networks, as well as reduce their likelihood to ask for help.

Interpretation of our findings is subject to several important limitations. First, we lacked data on the extent to which study participants met formal diagnostic criteria for major depressive disorder. Sub-syndromal symptoms are commonly experienced during the course of mood disorders, however, and are associated with significant psychosocial impairment (Judd et al., 1998, 2000). Second, we lacked data to control for any physical health outcomes that may be linked to both food insecurity and depression. Third, the cross-sectional design precludes our ability to make causal claims. However, a couple of recent studies have demonstrated a causal relationship where food insecurity affects depression symptom severity (Cole & Tembo, 2011; Tsai et al., 2012). Fourth, the data are self-reported and therefore are subject to the challenges inherent to all studies based on self-reported data. Finally, we lacked measures of perceived social support. Taken together, the results (and limitations) from this study highlight a need for further research on the relevance of personal network composition to the relationship between severe food insecurity and mental health. In addition, including measures of the extent of perceived food insecurity-related stigma, social support, and overall time spent experiencing food insecurity may uncover some potential mechanisms linking social network characteristics, food insecurity and depression, particularly for men.

Conclusion. This study demonstrated a robust relationship between food insecurity and depression symptom severity for both men and women in a population-based sample in rural Uganda, regardless of social network characteristics. Therefore, nutrition interventions aimed at improving food security in rural areas may have significant beneficial effects in terms of mental health outcomes for the whole population. In addition, this study highlights a need for investigation on why men suffering from severe food insecurity who have a smaller proportion of poor contacts, or who are centrally located in their village network, may be more likely to experience greater depression symptoms compared to men with a larger proportion of poor contacts or men on the periphery, and why this moderating relationship does not appear for women.

REFERENCES

- Anema, A., Vogenthaler, N., Frongillo, E., Kadiyala, S., & Weiser, S. (2009). Food insecurity and HIV/AIDS: Current knowledge, gaps, and research priorities. *Current HIV/AIDS Reports*, 6(4), 224-231. doi: 10.1007/s11904-009-0030-z
- Bolton, P., & Ndogoni, L. (2001). Cross-cultural assessment of trauma-related mental illness (Phase II): A report of research conducted by World Vision Uganda and the Johns Hopkins University. Baltimore: Johns Hopkins University.
- Burt, R. S. (1984). Network items and the general social survey. *Social Networks*, 6(4), 293-339. doi: [http://dx.doi.org/10.1016/0378-8733\(84\)90007-8](http://dx.doi.org/10.1016/0378-8733(84)90007-8)
- Carter, K. N., Kruse, K., Blakely, T., & Collings, S. (2011). The association of food security with psychological distress in New Zealand and any gender differences. *Social Science & Medicine*, 72(9), 1463-1471. doi: <http://dx.doi.org/10.1016/j.socscimed.2011.03.009>
- Ciesla, J. A., & Roberts, J. E. (2001). Meta-Analysis of the Relationship Between HIV Infection and Risk for Depressive Disorders. *American Journal of Psychiatry*, 158(5), 725-730. doi: doi:10.1176/appi.ajp.158.5.725
- Coates, J., Swindale, A., & Bilinsky, P. (2006). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: Indicator guide. . Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development.
- Cole, S. M., & Tembo, G. (2011). The effect of food insecurity on mental health: Panel evidence from rural Zambia. *Social Science & Medicine*, 73(7), 1071-1079. doi: <http://dx.doi.org/10.1016/j.socscimed.2011.07.012>
- Derogatis, L. R., Lipman, R. S., Rickels, K., Uhlenhuth, E. H., & Covi, L. (1974a). The Hopkins Symptom Checklist (HSCL): A self-report symptom inventory. *Behavioral Science*, 19(1), 1-15. doi: 10.1002/bs.3830190102
- Derogatis, L. R., Lipman, R. S., Rickels, K., Uhlenhuth, E. H., & Covi, L. (1974b). The Hopkins Symptom Checklist (HSCL). A measure of primary symptom dimensions. *Modern Problems of Pharmacopsychiatry*, 7(0), 79-110.
- Dewing, S., Tomlinson, M., le Roux, I. M., Chopra, M., & Tsai, A. C. (2013). Food insecurity and its association with co-occurring postnatal depression, hazardous drinking, and suicidality among women in peri-urban South Africa. *Journal of Affective Disorders*, 150(2), 460-465. doi: <http://dx.doi.org/10.1016/j.jad.2013.04.040>
- Dhokarh, R., Himmelgreen, D. A., Peng, Y.-K., Segura-Pérez, S., Hromi-Fiedler, A., & Pérez-Escamilla, R. (2011). Food Insecurity is Associated with Acculturation and Social Networks in Puerto Rican Households. *Journal of Nutrition Education and Behavior*, 43(4), 288-294. doi: <http://dx.doi.org/10.1016/j.jneb.2009.11.004>

- DHS, M. (2011). Uganda Demographic and Health Survey 2011. Calverton, Maryland: ICF International.
- FAO, IFID, & WFP. (2014). The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition. . Rome: FAO.
- Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. *Demography*, 38(1), 115-132.
- Friel, S., Berry, H., Dinh, H., O'Brien, L., & Walls, H. (2014). The impact of drought on the association between food security and mental health in a nationally representative Australian sample. *BMC Public Health*, 14(1), 1102.
- Hadley, C., Mulder, M. B., & Fitzherbert, E. (2007). Seasonal food insecurity and perceived social support in rural Tanzania. *Public Health Nutrition*, 10(06), 544-551. doi:10.1017/S1368980007246725
- Hadley, C., Tegegn, A., Tessema, F., Cowan, J. A., Asefa, M., & Galea, S. (2008). Food insecurity, stressful life events and symptoms of anxiety and depression in east Africa: evidence from the Gilgel Gibe growth and development study. *Journal of Epidemiology and Community Health*, 62(11), 980-986. doi: 10.1136/jech.2007.068460
- Heflin, C. M., Siefert, K., & Williams, D. R. (2005). Food insufficiency and women's mental health: Findings from a 3-year panel of welfare recipients. *Social Science & Medicine*, 61(9), 1971-1982. doi: <http://dx.doi.org/10.1016/j.socscimed.2005.04.014>
- Kaschula, S. (2011). Using people to cope with the hunger: Social networks and food transfers amongst HIV/AIDS afflicted households in KwaZulu-Natal, South Africa. *AIDS and Behavior*, 15(7), 1490-1502. doi: 10.1007/s10461-011-0006-z
- Kawachi, I., & Berkman, L. F. (2000). Social cohesion, social capital, and health. In L. F. Berkman & I. Kawachi (Eds.), *Social Epidemiology* (pp. 174-190). New York: Oxford University Press.
- Kawachi, I., & Berkman, L. F. (2001). Social ties and mental health. *Journal of Urban Health*, 78(3), 458-467.
- Lee, J. S., & Frongillo, E. A. (2001). Nutritional and Health Consequences Are Associated with Food Insecurity among U.S. Elderly Persons. *The Journal of Nutrition*, 131(5), 1503-1509.
- Lemke, S., Vorster, H., van Rensburg, N. J., & Ziche, J. (2003). Empowered women, social networks and the contribution of qualitative research: broadening our understanding of underlying causes for food and nutrition insecurity. *Public Health Nutrition*, 6(08), 759-764. doi: doi:10.1079/PHN2003491

- Maes, K. C., Hadley, C., Tesfaye, F., & Shifferaw, S. (2010). Food insecurity and mental health: Surprising trends among community health volunteers in Addis Ababa, Ethiopia during the 2008 food crisis. *Social Science & Medicine*, 70(9), 1450-1457. doi: <http://dx.doi.org/10.1016/j.socscimed.2010.01.018>
- Marcus, M., Taghi Yasamy, T., van Ommeren, M., Chisholm, D., & Saxena, S. (2012). Depression: A Global Public Health Concern: WHO.
- Marin, A., & Hampton, K. N. (2007). Simplifying the Personal Network Name Generator Alternatives to Traditional Multiple and Single Name Generators. *Field Methods*, 19(2), 163-193.
- Martinez, P., Andia, I., Emenyonu, N., Hahn, J. A., Hauff, E., Pepper, L., & Bangsberg, D. R. (2008). Alcohol use, depressive symptoms and the receipt of antiretroviral therapy in southwest Uganda. *AIDS and Behavior*, 12(4), 605-612.
- Myer, L., Stein, D. J., Grimsrud, A., Seedat, S., & Williams, D. R. (2008). Social determinants of psychological distress in a nationally-representative sample of South African adults. *Social Science & Medicine*, 66(8), 1828-1840.
- Nagata, J. M., Fiorella, K. J., Salmen, C. R., Hickey, M. D., Mattah, B., Magerenge, R., . . . Cohen, C. R. (2015). Around the Table: Food Insecurity, Socioeconomic Status, and Instrumental Social Support among Women Living in a Rural Kenyan Island Community. *Ecology of Food and Nutrition*, 1-12. doi: 10.1080/03670244.2014.995790
- Nanama, S., & Frongillo, E. A. (2012). Altered social cohesion and adverse psychological experiences with chronic food insecurity in the non-market economy and complex households of Burkina Faso. *Social Science & Medicine*, 74(3), 444-451. doi: <http://dx.doi.org/10.1016/j.socscimed.2011.11.009>
- Oliva, G. S., de Mendonca, R. G., Sant'Anna, M. J., Passarelli, M. L., Coates, V., & Omar, H. A. (2008). Integral care for pregnant adolescents: impact on offspring. *International Journal of Adolescent Medicine and Health*, 20(4), 537-546.
- Perkins, J. M., Subramanian, S. V., & Christakis, N. A. Social networks and health: A systematic review of sociocentric network studies in low- and middle-income countries. *Social Science & Medicine*(0). doi: <http://dx.doi.org/10.1016/j.socscimed.2014.08.019>
- Sabidussi, G. (1966). The centrality index of a graph. *Psychometrika*, 31(4), 581-603. doi: 10.1007/BF02289527
- Seligman, H. K., Laraia, B. A., & Kushel, M. B. (2010). Food Insecurity Is Associated with Chronic Disease among Low-Income NHANES Participants. *The Journal of Nutrition*, 140(2), 304-310. doi: 10.3945/jn.109.112573
- Siefert, K., Heflin, C. M., Corcoran, M. E., & Williams, D. R. (2001). Food Insufficiency and the Physical and Mental Health of Low-Income Women. *Women & Health*, 32(1-2), 159-177. doi: 10.1300/J013v32n01_08

- Stuff, J. E., Casey, P. H., Szeto, K. L., Gossett, J. M., Robbins, J. M., Simpson, P. M., . . . Bogle, M. L. (2004). Household Food Insecurity Is Associated with Adult Health Status. *The Journal of Nutrition*, *134*(9), 2330-2335.
- Tsai, A. C., Bangsberg, D. R., Emenyonu, N., Senkungu, J. K., Martin, J. N., & Weiser, S. D. (2011). The social context of food insecurity among persons living with HIV/AIDS in rural Uganda. *Social Science & Medicine*, *73*(12), 1717-1724.
- Tsai, A. C., Bangsberg, D. R., Frongillo, E. A., Hunt, P. W., Muzoora, C., Martin, J. N., & Weiser, S. D. (2012). Food insecurity, depression and the modifying role of social support among people living with HIV/AIDS in rural Uganda. *Social Science & Medicine*, *74*(12), 2012-2019. doi: 10.1016/j.socscimed.2012.02.033
- Uganda. (2015). Retrieved March 30th, 2015, from <http://data.worldbank.org/country/uganda>
- Vozoris, N. T., & Tarasuk, V. S. (2003). Household Food Insufficiency Is Associated with Poorer Health. *The Journal of Nutrition*, *133*(1), 120-126.
- Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge, UK: Cambridge University Press.
- Weaver, L. J., & Hadley, C. (2009). Moving Beyond Hunger and Nutrition: A Systematic Review of the Evidence Linking Food Insecurity and Mental Health in Developing Countries. *Ecology of Food and Nutrition*, *48*(4), 263-284. doi: 10.1080/03670240903001167
- Whitaker, R. C., Phillips, S. M., & Orzol, S. M. (2006). Food Insecurity and the Risks of Depression and Anxiety in Mothers and Behavior Problems in their Preschool-Aged Children. *Pediatrics*, *118*(3), e859-e868. doi: 10.1542/peds.2006-0239

Paper III: Perceived and Actual HIV Testing Norms and Personal HIV Testing Behavior in Rural Uganda: A Cross-sectional, Population-based Study

ABSTRACT

Background Many people in Sub-Saharan Africa have never been tested for HIV though it is essential for treatment and prevention. We aimed to assess the accuracy of perceptions of HIV testing norms as compared to actual village norms, and examine the relationship between perception and personal testing.

Methods Utilizing population-based data from 1,664 adults across eight rural villages in Southwestern Uganda, we compared personal estimates of the village prevalence of ever having been tested for HIV to the actual village norm and quantified the prevalence of misperception and the extent of underestimation of HIV testing in one's village. In addition, multilevel models assessed how one's perception of the HIV testing norm predicted personal testing while controlling for stigma, spousal testing status, and sociodemographic characteristics.

Results Although the majority of both men and women had been tested for HIV across all villages and across most sociodemographic sub-groups, 59% of men and 62% of women underestimated the HIV testing prevalence in their village (by 42 percentage points, on average), and thought that having been tested was not normative. Men who perceived testing as not normative (e.g. estimated less than 51% testing prevalence) were 2.6 times more likely (95% CI 1.7-3.9) to never have been tested for HIV as compared to men who thought testing was normative. The association was even stronger for both men and women who felt they did not know anything about the norm.

Conclusions Results suggest that interventions promoting true HIV testing norms may help increase uptake of testing.

INTRODUCTION

Early identification of persons with HIV is a critical component of “test and treat” strategies for addressing the HIV epidemic (Granich, Gilks, Dye, De Cock, & Williams, 2009; Walensky & Bassett, 2011; Walensky et al., 2011). Although uptake of HIV testing has increased in sub-Saharan Africa, a recent review of data from the Demographic and Health Surveys showed that the majority of men and women in many countries -- particularly men -- had never been tested (Staveteig, Wang, Head, Bradley, & Nybro, 2013). Uptake of HIV testing is driven by a complex interplay of factors, including routine antenatal screening among women (Byamugisha et al., 2010; Hensen et al., 2012); economic expenses associated with health facility-based testing, including the costs of traveling to the clinic and waiting times (Lankowski, Siedner, Bangsberg, & Tsai, 2014); scheduling difficulties or perceived lack of sufficient services (Musheke et al., 2013; Siu, Wight, & Seeley, 2014); worries about confidentiality of services (Musheke et al., 2013) or stigma (Kalichman & Simbayi, 2003; Sambisa, Curtis, & Mishra, 2010; Young et al., 2010;) and gender-unequal norms (Musheke et al., 2013; Remien et al., 2009). Although community-based (Coates et al., 2014; Suthar et al., 2013) or home-based (Dalal et al., 2013; Sabapathy, Van den Bergh, Fidler, Hayes, & Ford, 2012) counseling and testing services and community-wide health campaigns may address some of these barriers, they are unlikely to achieve universal coverage of testing, thus requiring complementary approaches to increase uptake of HIV testing (Chamie et al., 2014) .

Social norms represent potentially important, but understudied, drivers of HIV testing uptake. Consensus in the field of social psychology (Asch, 1956; Sherif, 1936, 1937) holds that people tend to conform to social norms as they look to others in their midst to help define the situation and give guidance on expected behaviors in the group or cultural setting. In addition, a

growing body of research has purposely distinguished normative behavior (i.e., what most people actually do in a given population (also referred to the descriptive norm (Cialdini, Reno, & Kallgren, 1990)) from an individual's perception of the normative behavior (i.e., one's perception of what most others do in a given population (the perceived descriptive norm)) (H. W. Perkins, 2014; Rimal & Real, 2003). These studies have shown that, on average, people consistently underestimate the prevalence or extent of positive behaviors in a population, and often perceive positive behaviors to not be normative even when such behaviors are actually normative. Similarly, people consistently overestimate the prevalence or extent of problem behaviors in a population, on average, and often perceive problem behaviors to be normative even when such behaviors are actually not normative (Lewis, Litt, Crouce, Blayney, & Gilmore, 2012; Litt, Lewis, Linkenbach, Lande, & Neighbors, 2014; C. Neighbors et al., 2010; H. W. Perkins, 2007, 2014; H. W. Perkins & Craig, 2012; H. W. Perkins, Haines, & Rice, 2005; Raisamo & Lintonen, 2012; Reid & Aiken, 2013; Sandstrom, Makover, & Bartini, 2012). Moreover, this line of research has further shown that perceptions of behavioral norms are more predictive of personal behaviors than are the actual behavioral norms.

No studies on HIV testing behavior, however, have distinguished between these two related, but distinct, constructs (actual norms versus perceived norms), nor have any studies compared the gap between the two constructs. Doing so requires measuring and labeling what most people in a defined population actually do (i.e. the normative behavior, defined by aggregated, population-based data) and what people perceive most others to do (i.e. one's perception of what is normative behavior). Thus, the present study was motivated by the potential challenge that if substantial numbers of people underestimate the prevalence of HIV testing or believe it to not be the norm even in places where HIV testing is normative, and if

perception predicts behavior, then efforts to increase uptake of HIV testing would be hampered. Moreover, only a few studies have demonstrated a positive relationship between personal HIV testing and perceptions of HIV testing norms (Bradley, Tsui, Kidanu, & Gillespie, 2011; Do, Kincaid, & Figueroa, 2014; Hendriksen et al., 2009; Young et al., 2010). Extensions on this work would include specifying the reference population about which a perception is made, and testing whether the relationship between personal testing and the perceived prevalence and normativity of testing is monotonic or dichotomous.

To address these gaps in the literature, we undertook a cross-sectional, population-based study to quantify the extent to which the prevalence of HIV testing was underestimated and the norm was misperceived and how perception of the norm was related to personal testing history. First, we hypothesized that the majority of people across all villages would underestimate the prevalence of people in their village who had ever received an HIV test, and that, in addition to underestimating the prevalence, most people would have also perceived that ever having been tested for HIV was not normative in their village (even in villages where the majority had been tested) (H1). We also hypothesized that people who thought HIV testing was not normative in their village would be at greater risk for never having been tested for HIV as compared to people who perceived testing to be normative (H2). Lastly, we hypothesized that the relationship between perception and testing history would be much stronger for men than for women because, for men, HIV testing is likely more about making a deliberate choice whereas, for most women who have had or are planning to have multiple children women, free HIV testing is a routine part of antenatal care in Uganda (H3).

METHODS

Study population

The study targeted all adults (aged 18 years or older) whose main household was located within one parish (containing eight villages) in rural Southwestern Uganda. Using a census enumeration, the study team searched for 1,939 potential participants in 716 households continuously during the data collection period. By the end of the period, there were 1,669 participants. Among the remaining 270 people, 16 refused, 62 could not be contacted (because the person was away from the parish during every attempted contact), 166 became ineligible as their primary residence had shifted outside the parish, 11 were consistently too incapacitated/sick to participate, and 15 had died. Thus, after excluding the people who were ineligible, incapacitated or who had died, the response rate was $1669/1747 = 96\%$. There was little variation in response rates across villages. The final analytical sample consisted of 1,664 participants after excluding five people who did not provide HIV testing history.

Procedures

Ethical approval for all study procedures was obtained from the Committee on the Use of Human Subjects in Research, Harvard University; the Partners Human Research Committee, Massachusetts General Hospital; and the Institutional Review Committee, Mbarara University of Science and Technology. We also received clearance for the study from the Uganda National Council for Science and Technology and from the Research Secretariat in the Office of the President. Interview materials were translated, back-translated, and pilot-tested to ensure accuracy, consistent word choice, and linguistic equivalence. Between October 2011 and August 2012, trained local research assistants conducted one-on-one structured interviews (lasting about an hour) with eligible participants, typically at a participant's place of residence. All participants

provided written informed consent, either with a signature or, if there were cultural literacy reasons why a signature was not appropriate, a thumbprint.

Measures

Uptake of HIV Testing - Participants reported whether they had ever had an HIV/AIDS test (yes/no). Using those responses, we calculated the actual prevalence of ever having been tested in each village (the “descriptive norm”). We then categorized HIV testing as “normative” in a village if more than 50% of people in the village reported having previously tested for HIV.

Perceived HIV Testing Norm- Participants were asked to estimate the percentage (0 to 100) of people in their village who had ever received an HIV test: "I would like to know how many people in your cell you think have been tested for HIV/AIDS. I am going to give you an example to help you think about this question. If there were 100 people in your cell, how many of them do you think would have been tested for HIV/AIDS?" From these responses, we created a categorical variable indicating a) perceived HIV testing as not normative in their village (response within 0 to 50%), b) perceived HIV testing as normative in village (response within 51 to 100%), and c) did not know so did not provide an estimate (despite prompting for his or her best estimate). For use in testing whether the relationship between perception and behavior was monotonic or dichotomous, we further split the perception categories into 'highly not normative' (0-24%), 'moderately not normative' (25-49%), 'perceived equality between testing and not testing' (50%), 'moderately normative' (51-75%) and 'highly normative' (76 to 100%) categories. (We created this variable instead of focusing on the continuous measure of the estimated prevalence because such categories carried more meaning than single 1 point increases in perceived prevalence.)

Accuracy of Perceived Norm - We determined the accuracy of participants' estimate of their village's prevalence of HIV testing by subtracting their estimates from the actual prevalence of HIV testing in the participant's village. If a participant's estimate was more than 10 points less than the actual norm, then the participant was categorized as having underestimated the HIV testing norm in his or her village. If the participant's estimate was more than 10 points above the actual norm, then the participant was categorized as having overestimated the norm. If the estimate was within 10 points of the actual norm, then the participant was labeled as having accurately estimated the HIV testing norm. We chose 10 points as a cutoff to provide a conservative estimate of accuracy, but also used a 20 point cutoff in sensitivity analyses.

Control variables – We measured personal expression of AIDS-related stigma, marital status and spousal testing history, gender, age, education, household wealth, and whether the participant had children because prior studies and reports have identified patterns of prior HIV testing according to these sociodemographic characteristics (Lépine, Terris-Prestholt, & Vickerman, 2014; Pettifor, MacPhail, Suchindran, & Delany-Moretlwe, 2010; Shand, Thomson-de Boor, van den Berg, Peacock, & Pascoe, 2014; Staveteig et al., 2013; Venkatesh et al., 2011; Young et al., 2010). Moreover, some of these variables (e.g. stigma and spousal testing status) could have also theoretically been associated with perception. Data A3.1 in the appendix describes how all of these variables were measured and categorized.

Statistical Analyses

We first described the prevalence of self-reported HIV testing across the villages and sociodemographic subgroups (i.e. showing the actual prevalence and whether HIV testing was actually normative) and described the percentage of people in each of the perceived norm

categories. To demonstrate the extent of misperception of the HIV testing norm, we showed the percentage of people within each of the perception accuracy categories by whether people thought HIV testing was normative in their village and provided the average amount of under- or over- estimation of the village HIV testing prevalence. To test robustness of results, we also showed results using the perception accuracy categories created using the more lenient cutoff.

We then estimated the log-odds of a participant never having been tested for HIV as a function of whether the participant thought HIV testing was normative in his or her village, controlling for personal expression of AIDS-related stigma, marital status and spouse/main partner's HIV testing status, and several individual socio-economic variables, using a two-level random intercepts model stratified by gender. The model accounted for clustering of observations within households and fixed effects at the village level. To assess whether the relationship between testing and perception was strictly dichotomous or more monotonic, we also regressed personal testing on the perception variable representing several, purposefully chosen categories of perceived levels of normativity, using the same gender-stratified model.

RESULTS

Prevalence of Ever Having Been Tested for HIV and its Normativity

Overall, 503 (67%) men and 713 (78%) women had been tested for HIV at least once. HIV testing was normative across all socio-demographic categories of men except for two sub-categories, with the prevalence of testing ranging from 53% to 81% depending on the sub-category (Table 3.1). The village-level prevalence for ever having been tested among adults ranged from 64-79% (57-75% of men and 69-85% of women), indicating that HIV testing was normative for adults in all eight villages.

Table 3.1. Sociodemographic characteristics of men and women aged 18 years or older across eight villages in one parish in rural Southwestern Uganda and the proportion of people who had ever been tested for HIV.

Characteristics	Men (N=752)			Women (N = 912)		
	n	%*	% in sub-category ever having been tested for HIV	n	%*	% in sub-category ever having been tested for HIV
<i>Age</i>						
Less than 30 years	315	41.9	64.4	377	41.3	82.5
30-39 years	158	21.0	69.0	171	18.8	89.5
40-49 years	131	17.4	77.9	135	14.8	86.7
50-59 years	64	8.5	73.4	70	7.7	75.7
60-69 years	37	4.9	56.8	60	6.6	70.0
70 years or more	40	5.3	37.5	90	9.9	33.3
<i>Marital Status</i>						
Not married	295	39.2	58.0	409	44.9	68.7
Married and unknown spousal testing	36	4.8	77.8	73	8.0	84.9
Married and spouse not tested	58	7.7	50.0	117	12.8	75.2
Married and spouse tested	363	48.3	75.8	312	34.2	90.4
<i>Had Children</i>						
No	248	33.0	59.7	150	16.5	64.7
Yes	470	62.5	70.0	746	81.8	81.4
<i>Education</i>						
No education	66	8.8	53.0	208	22.8	67.3
Primary	387	51.5	66.4	459	50.3	82.6
Secondary	201	26.7	66.2	202	22.2	78.7
Post-graduate	72	9.6	80.6	37	4.1	83.8
<i>Household Asset Quintile</i>						
Lowest	110	14.6	69.1	163	17.9	75.5
2nd	140	18.6	64.3	176	19.3	84.7
3rd	147	19.6	62.6	179	19.6	80.5
4th	174	23.1	66.7	206	22.6	73.3
Highest	181	24.1	71.3	188	20.6	77.7

*Column percentages within category do not add to 100% due to small amount of missing data (6% for men overall and 3% for women overall).

Perception of HIV Testing as Normative and Estimated Testing Prevalence

Overall, only 273 (36%) men and 282 (31%) women perceived that HIV testing was normative in their village (i.e., they estimated that more than half of people in their village had been tested with an average estimate of 75%). 1,109 people (51%) estimated that HIV testing was not normative (with an average estimate of 32%) and 256 people (15%) felt they did not know enough to provide an estimate. Figure A3.1 in the appendix shows the distribution of perception of HIV testing as normative in more refined categories for men and women, which directly represent categories of estimated prevalence. For example, 116 men (15%) and 195 women (21%) perceived HIV testing to be highly not normative; on average, they estimated that only 13% of people in their village had been tested for HIV at least once. Across the eight villages, the percentage of people who perceived HIV testing as normative ranged from 22-42% (Table 3.2).

Table 3.2. Village-level prevalence of ever having been tested for HIV, percentage perceiving HIV testing to be normative, and the extent to which people underestimated the prevalence of HIV testing in their village.

Village	N of adults	Prevalence of ever having been tested for HIV	Percentage who perceived that ever being tested for HIV was normative in village (estimated >50% testing prevalence)	Percentage who underestimated the actual village HIV testing prevalence by more than 10 percentage points*	Quantity of underestimation of the actual village HIV testing prevalence (mean and s.d. in percentage points)*
A	214	63.7%	22.0%	68.5%	30 (15)
B	146	67.6%	35.6%	60.0%	38 (15)
C	230	71.2%	28.3%	76.5%	34 (18)
D	263	73.0%	39.9%	68.2%	38 (18)
E	237	73.4%	27.8%	73.3%	37 (17)
F	153	77.8%	35.3%	70.4%	45 (18)
G	209	78.4%	41.6%	63.5%	40 (17)
H	217	79.3%	36.4%	67.9%	45 (19)

* Among the 85% of participants who gave a numeric estimation.

Accuracy of Perceived Norms

Among people providing a numeric estimate of the HIV testing prevalence in their village, 385 (59%) men and 468 (62%) women underestimated the actual prevalence by more than 10 percentage points and thought that HIV testing was not normative (Table 3.3). Moreover, this was the case (underestimating the prevalence while also perceiving testing as not normative) for the majority of men in 7 out of 8 villages and women in all 8 villages. 116 participants (8%) underestimated the actual prevalence by more than 10 percentage points but at least thought testing was normative. 293 participants (21%) accurately estimated the prevalence of HIV testing in their village, and 146 (10%) overestimated the prevalence. On average, the actual prevalence of HIV testing exceeded the estimates of participants who both underestimated and perceived testing to not be normative by 42 percentage points (s.d. = 17 percentage points). When using the less restrictive cutoff (+/- 20 percentage points) to designate accuracy, 796 people (57%) still underestimated the norm and thought that HIV testing was not normative (Table A3.1). The extent of underestimation remained quite large as well in that scenario.

Table 3.3. Perception of ever being tested for HIV as normative in one's village (> 50% prevalence) and the extent of under- or over-estimation of prior HIV testing in one's village (using a cutoff of +/- 10 percentage points to calculate accuracy) by men and women (aged 18 years or older) in eight villages in rural Southwestern Uganda (n = 658 men and n = 750 women).

		Perceived HIV testing as not normative			Perceived HIV testing as normative		
		Under-estimated the prevalence of prior HIV testing	Accurately estimated the prevalence of prior HIV testing	Over-estimated the prevalence of prior HIV testing	Under-estimated the prevalence of prior HIV testing	Accurately estimated the prevalence of prior HIV testing	Over-estimated the prevalence of prior HIV testing
% in category	Men	59%	0%	0%	9%	22%	10%
	Women	62%	0%	0%	8%	19%	11%
Range of % in category across 8 villages	Men	47%-66%	0%	0%	0%-16%	12%-29%	5%-30%
	Women	58%-71%	0%	0%	0%-13%	12%-26%	6%-26%
Quantity of mis-estimation (Q1-Q3 of IQR)	Men	28 to 51 percentage points less than the norm	-	-	13 to 18 percentage points less than the norm	-	12 to 22 percentage points greater than the norm
	Women	28 to 58 percentage points less than the norm	-	-	13 to 18 percentage points less than the norm	-	12 to 22 percentage points greater than the norm

Notes: Prior HIV testing was normative (>50% prevalence) in all 8 villages in the study. Percentages are calculated based on the 85% of participants who gave a numeric estimation of the HIV testing prevalence in their village.

Predictors of HIV testing

Perception had a statistically significant association with HIV testing (Table 3.4). Men who perceived HIV testing as not normative were 2.6 times more likely (95% CI 1.7-3.9) to never have been tested for HIV compared to men who perceived HIV testing to be normative in their village; similarly, men who did not know anything about their village HIV testing norm were 4.0 times more likely (95% CI 2.2-7.4) to never have been tested. Higher expressions of AIDS-related stigma (AOR = 1.4; 95% CI 1.0-2.1), having a spouse/main partner who had not been tested (AOR = 2.3, 95% CI 1.1-4.5), and being single (AOR = 2.0, 95% CI 1.1-3.7) also predicted never having been tested among men.

When using the perceived norm variable with more refined categories, the likelihood of never having been tested for HIV did not differ between men who thought that HIV testing was ‘moderately normative’ and men who thought that HIV testing was ‘highly normative’ in their village (Table A3.2). However, men who perceived equality between testing as normative and not normative (i.e. estimated 50% prevalence) and men who perceived testing to be moderately non-normative were more than 2 times more likely to never have been tested for HIV compared to men who perceived testing to be highly-normative. Furthermore, men who perceived HIV testing to be highly non-normative and men who had no idea about the testing norm were about 4 times more likely to never have been tested.

Table 3.4. Multilevel logistic regression odds-ratios for never having been tested for HIV among men and women (aged 18 years or older) in eight villages in one parish in rural Southwestern Uganda.

	Men (n = 707)			Women (n = 882)		
	OR	95% CI		OR	95% CI	
<i>Perception of HIV testing norm in one's village</i>						
Didn't have any idea (no estimation)	4.0***	2.2	7.4	2.8***	1.6	5.1
Testing not normative (estimated prevalence <51%)	2.6***	1.7	3.9	1.1	0.7	1.7
Testing normative (estimated prevalence >50%) [REF]	1.00	-	-	1.00	-	-
<i>Aids-related stigma (unit change from mean)</i>						
	1.5*	1.0	2.1	0.9	0.6	1.3
<i>Spousal HIV testing status</i>						
Not married	2.0*	1.1	3.7	1.6	1.0	2.8
Unknown spousal status	1.0	0.4	2.4	1.0	0.4	2.4
Spouse not tested	2.3*	1.1	4.5	2.2*	1.1	4.2
Spouse has tested [REF]	1.00	-	-	1.00	-	-
<i>Had children</i>						
No	1.6	0.8	3.2	3.9***	2.0	7.4
Yes [REF]	1.00	-	-	1.00	-	-

* p < .05; *** p < .001.

Notes: Estimates were obtained using a two-level, random intercepts logistic regression model including fixed effects for age, education, household wealth quintiles, and village, and random effects at the household level.

Among women, perception was only a statistically significant predictor of HIV testing for women who did not know anything about the testing norm in their village; they were more likely to never have been tested (AOR = 2.8 95% CI, 1.6-5.1) compared to women who perceived HIV testing to be normative in their village (Table 3.4). Other statistically significant factors associated with never having been tested for women included having a spouse/main partner who had not been tested (AOR = 2.2; 95%CI, 1.1-4.2), and not having any children (AOR = 3.9; 95% CI, 2.0-7.4). Results using the more refined perceived norm variable were comparable (Table A3.2).

DISCUSSION

Our first novel contribution to the literature is to demonstrate that in an HIV-endemic country, more than two-thirds of people in this study population substantially underestimated the extent to which HIV testing was normative in their village. Indeed, only one-third of the entire population believed testing to be normative in their village even though nearly three-quarters of the population reported having been tested for HIV, a pattern consistent across villages. Similar findings have been reported in research on alcohol and other drug use, seat belt use, sexual risk behaviors, intimate partner violence, bullying and unhealthy food and beverage consumption (Carey et al., 2011; Lally, Bartle, & Wardle, 2011; Lewis et al., 2012; Litt et al., 2014; C. Neighbors et al., 2010; H. W. Perkins, 2007, 2014; H. W. Perkins & Craig, 2012; H. W. Perkins, Craig, & Perkins, 2011; H. W. Perkins et al., 2005; J. M. Perkins, Perkins, & Craig, 2010; Raisamo & Lintonen, 2012; Sanders, Stogner, Seibert, & Miller, 2014).

Our second novel contribution to the literature is that perception of HIV testing as anything less than normative in one's village was a strong risk factor for never having been tested among men, and not knowing anything about HIV testing norms had a strong negative association with testing among both men and women. Our findings are consistent with results from other studies of the relevance of perceived norms to various personal health-related behaviors (Carey et al., 2011; DeJong et al., 2006; Kapadia et al., 2012; Mattern & Neighbors, 2004; Clayton Neighbors et al., 2014; Pedersen, LaBrie, & Hummer, 2009; H. W. Perkins, 2007, 2014; H. W. Perkins & Craig, 2012). However, as expected, perceptions of local norms for HIV testing may be less important for women as a motivation for getting tested because in having or expecting to have children, testing may just be accepted as a part of routine antenatal care in Uganda. This observation would be consistent with the finding that women who reported no

children were much less likely to have ever been tested for HIV, which is similar to results among South African women (Venkatesh et al., 2011). Overall, our findings are also consistent with initial findings from the Project Accept study (HPTN 043), which attempted to increase perceived normativity of HIV counseling and testing by not concealing HIV testing provision in a community-based testing intervention (Sweat et al., 2011). The intervention resulted in a large increase in HIV testing and HIV detection across 32 communities in Tanzania, Zimbabwe, and Thailand. Thus, our findings underscore the need to engage both men and women in HIV prevention programming in sub-Saharan Africa (Hensen, Taoka, Lewis, Weiss, & Hargreaves, 2014; Edward J. Mills, Beyrer, Birungi, & Dybul, 2012; Edward J Mills, Ford, & Mugenyi, 2009; Shand et al., 2014), particularly as it relates to perceptions.

Taken together, the results of our study suggest that public health interventions designed to disseminate information on true norms about HIV testing may help increase testing among men (and among women who lack any understanding of HIV testing norms or, perhaps, women before they have children). Social norms interventions could focus on community-wide dissemination of true norms via traditional media such as billboards or radio messages. Sending population-wide SMS text-messages like 'Most people in this parish have been HIV tested in the past' or 'Most men and women and their friends in this parish have been tested for HIV at least once' might also be effective (de Tolly, Skinner, Nembaware, & Benjamin, 2011; Siedner, Haberer, Bwana, Ware, & Bangsberg, 2012). Alternatively, health workers could provide personalized feedback to men when they go to clinics for reasons unrelated to HIV or to people whom they may know as being disconnected from local realities. Regardless of format, such interventions would answer the call for novel health communication interventions for HIV prevention (Tomori et al., 2014), make better use of information about community –level social

norms (Underwood, Hendrickson, Van Lith, Lengwe Kunda, & Mallalieu, 2014), may be more effective than traditional health-based messages (Robinson, Fleming, & Higgs, 2014), and would likely be relatively inexpensive, and faster and easier to implement than more complex interventions. Moreover, such norms-based campaigns may help increase the impact of other HIV testing interventions, by increasing acceptance of community-based testing or by complementing health communication interventions designed to increase self-efficacy, encourage HIV/AIDS-related discussion, and promote positive behaviors (Do et al., 2014; Kaufman et al., 2014).

Interpretation of our findings is subject to several important limitations. First, the cross-sectional design precludes our ability to make causal claims. Reverse causality could potentially explain the estimated associations given that one's perceptions about behavior norms may be influenced by one's own personal behaviors. It is perhaps most plausible, however, that causal effects run in both directions. Nevertheless, research on perceived norms and personal behavior for other topics has demonstrated a causal effect of perceived norms on personal behavior through longitudinal experiments and case studies that provide normative feedback and campaigns to correct misperceptions as interventions (DeJong et al., 2006; Haines & Spear, 1996; LaBrie, Hummer, Grant, & Lac, 2010; Mattern & Neighbors, 2004; C. Neighbors, Dillard, Lewis, Bergstrom, & Neil, 2006; C. Neighbors, Larimer, & Lewis, 2004; Pedersen et al., 2009; H. W. Perkins et al., 2011; H. W. Perkins, Linkenbach, Lewis, & Neighbors, 2010; Reid & Aiken, 2013; Schultz, 1999; Turner, Perkins, & Bauerle, 2008). Second, the data are self-reported and therefore are subject to the challenges inherent to all studies based on self-reported data. Third, our measure of one's perception of the actual HIV testing norm in their village was fairly general. More specific questions (e.g., inquiring about "men" or "young women" instead

of simply “people”) could have potentially yielded different responses. Fourth, our data were derived from a population-based survey conducted in rural Uganda. The findings may not generalize to settings where HIV is non-endemic. However, the consistency between our findings and findings of other studies conducted in different settings suggests that the existence of misperceptions and the association between perceived norms and behavior may be generalizable. In addition, in settings where the descriptive norm (i.e. actual behavioral norm) is to not get tested, it would be worth measuring both perceived and actual injunctive norms (i.e. attitudinal norms) to find out if a majority of people thought that people in a given population should get tested and also what people perceived most others thought people should do. It might be that many people do not perceive the majority to hold a positive attitude about HIV testing, and therefore, might not follow up on their personal attitudes with personal behavior consistent with that attitude.

Conclusions

In this cross-sectional, population-based study conducted in rural Uganda, we report two main findings: First, participants substantially underestimated the extent to which HIV testing behavior in their village was normative. Moreover, the majority misperceived HIV testing as not normative when it actually was normative. Second, people who thought HIV testing was not normative (despite it being so) or who reported not knowing the norm were much more likely to never have been tested for HIV. The estimated associations were statistically significant, large in magnitude, and robust. Our findings have important implications for HIV prevention programming in sub-Saharan Africa.

REFERENCES

- Asch, S. (1956). Studies of independence and conformity: a minority of one against a unanimous majority. *Psychological Monographs*, 70, 1-10.
- Bradley, H., Tsui, A., Kidanu, A., & Gillespie, D. (2011). Client Characteristics and HIV Risk Associated with Repeat HIV Testing Among Women in Ethiopia. *AIDS and Behavior*, 15(4), 725-733. doi: 10.1007/s10461-010-9765-1
- Byamugisha, R., Tylleskar, T., Kagawa, M., Onyango, S., Karamagi, C., & Tumwine, J. (2010). Dramatic and sustained increase in HIV-testing rates among antenatal attendees in Eastern Uganda after a policy change from voluntary counselling and testing to routine counselling and testing for HIV: a retrospective analysis of hospital records, 2002-2009. *BMC Health Serv Res*, 10(1), 290.
- Carey, K., Scott-Sheldon, L. J., Carey, M., Cain, D., Mlobeli, R., Vermaak, R., . . . Kalichman, S. (2011). Community norms for HIV risk behaviors among men in a South African township. *Journal of Behavioral Medicine*, 34(1), 32-40. doi: 10.1007/s10865-010-9284-6
- Chamie, G., Kwarisiima, D., Clark, T. D., Kabami, J., Jain, V., Geng, E., . . . Havlir, D. V. (2014). Uptake of Community-Based HIV Testing during a Multi-Disease Health Campaign in Rural Uganda. *PLoS ONE*, 9(1), e84317. doi: 10.1371/journal.pone.0084317
- Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, 58(6), 1015-1026. doi: 10.1037/0022-3514.58.6.1015
- Coates, T. J., Kulich, M., Celentano, D. D., Zelaya, C. E., Chariyalertsak, S., Chingono, A., . . . Eshleman, S. H. (2014). Effect of community-based voluntary counselling and testing on HIV incidence and social and behavioural outcomes (NIMH Project Accept; HPTN 043): a cluster-randomised trial. *The Lancet Global Health*, 2(5), e267-e277. doi: [http://dx.doi.org/10.1016/S2214-109X\(14\)70032-4](http://dx.doi.org/10.1016/S2214-109X(14)70032-4)
- Dalal, W., Feikin, D. R., Amolloh, M., Ransom, R., Burke, H., Lugalia, F., . . . Bunnell, R. (2013). Home-based HIV testing and counseling in rural and urban Kenyan communities. *Journal of Acquired Immune Deficiency Syndromes*, 62(2), e47-e54. doi: 10.1097/QAI.1090b1013e318276bea318270.
- de Tolly, K., Skinner, D., Nembaware, V., & Benjamin, P. (2011). Investigation into the Use of Short Message Services to Expand Uptake of Human Immunodeficiency Virus Testing, and Whether Content and Dosage Have Impact. *Telemedicine and e-Health*, 18(1), 18-23. doi: 10.1089/tmj.2011.0058

- DeJong, W., Schneider, S. K., Towvim, L. G., Murphy, M. J., Doerr, E. E., Simonsen, N. R., . . . Scribner, R. A. (2006). A multisite randomized trial of social norms marketing campaigns to reduce college student drinking. *Journal of Studies on Alcohol and Drugs*, 67(6), 868-879. doi: 10.1080/08897070902802059
- Do, M., Kincaid, D. L., & Figueroa, M. E. (2014). Impacts of four communication programs on HIV testing behavior in South Africa. *AIDS Care*, 26(9), 1109-1117. doi: 10.1080/09540121.2014.901487
- Granich, R. M., Gilks, C. F., Dye, C., De Cock, K. M., & Williams, B. G. (2009). Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. *The Lancet*, 373(9657), 48-57. doi: [http://dx.doi.org/10.1016/S0140-6736\(08\)61697-9](http://dx.doi.org/10.1016/S0140-6736(08)61697-9)
- Haines, M. P., & Spear, S. F. (1996). Changing the perception of the norm: a strategy to decrease binge drinking among college students. *Journal of American College Health*, 45(3), 134-140.
- Hendriksen, E., Hlubinka, D., Chariyalertsak, S., Chingono, A., Gray, G., Mbwambo, J., . . . Coates, T. (2009). Keep Talking About It: HIV/AIDS-Related Communication and Prior HIV Testing in Tanzania, Zimbabwe, South Africa, and Thailand. *AIDS and Behavior*, 13(6), 1213-1221. doi: 10.1007/s10461-009-9608-0
- Hensen, B., Baggaley, R., Wong, V. J., Grabbe, K. L., Shaffer, N., Lo, Y.-R. J., & Hargreaves, J. (2012). Universal voluntary HIV testing in antenatal care settings: a review of the contribution of provider-initiated testing & counselling. *Tropical Medicine & International Health*, 17(1), 59-70. doi: 10.1111/j.1365-3156.2011.02893.x
- Hensen, B., Taoka, S., Lewis, J. J., Weiss, H. A., & Hargreaves, J. (2014). Systematic review of strategies to increase men's HIV-testing in sub-Saharan Africa. *AIDS*, 28(14), 2133-2145. doi: 10.1097/QAD.0000000000000395.
- Kalichman, S., & Simbayi, L. (2003). HIV testing attitudes, AIDS stigma, and voluntary counselling and testing in a black township in Cape Town, South Africa. *Sexually Transmitted Infections*, 79(6), 442 - 447.
- Kapadia, F., Frye, V., Bonner, S., Emmanuel, P. J., Samples, C. L., & Latka, M. H. (2012). Perceived peer safer sex norms and sexual risk behaviors among substance-using Latino adolescents. *AIDS Education and Prevention*, 24(1), 27-40. doi: 10.1521/aeap.2012.24.1.27
- Kaufman, M. R., Rimal, R. N., Carrasco, M., Fajobi, O., Soko, A., Limaye, R., & Mkandawire, G. (2014). Using social and behavior change communication to increase HIV testing and condom use: the Malawi BRIDGE Project. *AIDS Care*, 26(sup1), S46-S49. doi: 10.1080/09540121.2014.906741

- LaBrie, J. W., Hummer, J. F., Grant, S., & Lac, A. (2010). Immediate reductions in misperceived social norms among high-risk college student groups. *Addictive Behavior, 35*(12), 1094-1101. doi: 10.1016/j.addbeh.2010.08.003
- Lally, P., Bartle, N., & Wardle, J. (2011). Social norms and diet in adolescents. *Appetite, 57*(3), 623-627. doi: 10.1016/j.appet.2011.07.015
- Lankowski, A., Siedner, M., Bangsberg, D., & Tsai, A. (2014). Impact of Geographic and Transportation-Related Barriers on HIV Outcomes in Sub-Saharan Africa: A Systematic Review. *AIDS and Behavior, 18*(7), 1199-1223. doi: 10.1007/s10461-014-0729-8
- Lépine, A., Terris-Prestholt, F., & Vickerman, P. (2014). Determinants of HIV testing among Nigerian couples: a multilevel modelling approach. *Health Policy and Planning*. doi: 10.1093/heapol/czu036
- Lewis, M. A., Litt, D. M., Cronce, J. M., Blayney, J. A., & Gilmore, A. K. (2012). Underestimating Protection and Overestimating Risk: Examining Descriptive Normative Perceptions and Their Association with Drinking and Sexual Behaviors. *The Journal of Sex Research, 51*(1), 86-96. doi: 10.1080/00224499.2012.710664
- Litt, D. M., Lewis, M. A., Linkenbach, J. W., Lande, G., & Neighbors, C. (2014). Normative misperceptions of peer seat belt use among high school students and their relationship to personal seat belt use. *Traffic Injury Prevention, 15*(7), 748-752. doi: 10.1080/15389588.2013.868892
- Mattern, J. L., & Neighbors, C. (2004). Social norms campaigns: examining the relationship between changes in perceived norms and changes in drinking levels. *Journal of Studies on Alcohol and Drugs, 65*(4), 489-493.
- Mills, E. J., Beyrer, C., Birungi, J., & Dybul, M. R. (2012). Engaging Men in Prevention and Care for HIV/AIDS in Africa. *PLoS Med, 9*(2), e1001167. doi: 10.1371/journal.pmed.1001167
- Mills, E. J., Ford, N., & Mugenyi, P. (2009). Expanding HIV care in Africa: making men matter. *The Lancet, 374*(9686), 275-276.
- Musheke, M., Ntalasha, H., Gari, S., Mckenzie, O., Bond, V., Martin-Hilber, A., & Merten, S. (2013). A systematic review of qualitative findings on factors enabling and deterring uptake of HIV testing in Sub-Saharan Africa. *BMC Public Health, 13*(1), 220.
- Neighbors, C., Dillard, A. J., Lewis, M. A., Bergstrom, R. L., & Neil, T. A. (2006). Normative misperceptions and temporal precedence of perceived norms and drinking. *Journal of Studies on Alcohol and Drugs, 67*(2), 290-299.
- Neighbors, C., Larimer, M. E., & Lewis, M. A. (2004). Targeting misperceptions of descriptive drinking norms: efficacy of a computer-delivered personalized normative feedback intervention. *Journal of Consulting and Clinical Psychology, 72*(3), 434-447. doi: 10.1037/0022-006X.72.3.434

- Neighbors, C., Walker, D., Rodriguez, L., Walton, T., Mbilinyi, L., Kaysen, D., & Roffman, R. (2014). Normative Misperceptions of Alcohol Use Among Substance Abusing Army Personnel. *Military Behavioral Health, 2*(2), 203-209. doi: 10.1080/21635781.2014.890883
- Neighbors, C., Walker, D. D., Mbilinyi, L. F., O'Rourke, A., Edleson, J. L., Zegree, J., & Roffman, R. A. (2010). Normative misperceptions of abuse among perpetrators of intimate partner violence. *Violence Against Women, 16*(4), 370-386. doi: 10.1177/1077801210363608
- Pedersen, E. R., LaBrie, J. W., & Hummer, J. F. (2009). Perceived behavioral alcohol norms predict drinking for college students while studying abroad. *Journal of Studies on Alcohol and Drugs, 70*(6), 924-928.
- Perkins, H. W. (2007). Misperceptions of peer drinking norms in Canada: Another look at the "reign of error" and its consequences among college students. *Addictive Behaviors, 32*(11), 2645-2656. doi: 10.1016/j.addbeh.2007.07.007
- Perkins, H. W. (2014). Misperception is reality: The "Reign of Error" about peer risk behaviour norms among youth and young adults. In M. Xenitidou & B. Edmonds (Eds.), *The Complexity of Social Norms* (pp. 11-36): Springer International Publishing.
- Perkins, H. W., & Craig, D. W. (2012). Student-Athletes' Misperceptions of Male and Female Peer Drinking Norms: A Multi-Site Investigation of the "Reign of Error". *Journal of College Student Development, 53*(3), 367-382. doi: DOI: 10.1353/csd.2012.0046
- Perkins, H. W., Craig, D. W., & Perkins, J. M. (2011). Using social norms to reduce bullying: A research intervention among adolescents in five middle schools. *Group Processes & Intergroup Relations, 14*(5), 703-722. doi: 10.1177/1368430210398004
- Perkins, H. W., Haines, M. P., & Rice, R. (2005). Misperceiving the college drinking norm and related problems: A nationwide study of exposure to prevention information, perceived norms and student alcohol misuse. *Journal of Studies on Alcohol and Drugs, 66*(4), 470-478.
- Perkins, H. W., Linkenbach, J. W., Lewis, M. A., & Neighbors, C. (2010). Effectiveness of social norms media marketing in reducing drinking and driving: A statewide campaign. *Addictive Behaviors, 35*(10), 866-874. doi: 10.1016/j.addbeh.2010.05.004
- Perkins, J. M., Perkins, H. W., & Craig, D. W. (2010). Misperceptions of Peer Norms as a Risk Factor for Sugar-Sweetened Beverage Consumption among Secondary School Students. *Journal of the American Dietetic Association, 110*(12), 1916-1921. doi: 10.1016/j.jada.2010.09.008
- Pettifor, A., MacPhail, C., Suchindran, S., & Delany-Moretlwe, S. (2010). Factors Associated with HIV Testing Among Public Sector Clinic Attendees in Johannesburg, South Africa. *AIDS and Behavior, 14*(4), 913-921. doi: 10.1007/s10461-008-9462-5

- Raisamo, S., & Lintonen, T. (2012). Misperceptions of peer gambling norms among adolescents: Analysis of a national sample in Finland. *Open Journal of Preventive Medicine*, 2(2), 131-136.
- Reid, A. E., & Aiken, L. S. (2013). Correcting injunctive norm misperceptions motivates behavior change: a randomized controlled sun protection intervention. *Health Psychology*, 32(5), 551-560. doi: 10.1037/a0028140
- Remien, R. H., Chowdhury, J., Mokhbat, J. E., Soliman, C., Adawy, M. E., & El-Sadr, W. (2009). Gender and Care: Access to HIV Testing, Care and Treatment. *Journal of Acquired Immune Deficiency Syndrome*, 51(Suppl 3), S106-S110. doi: 10.1097/QAI.0b013e3181aafd66
- Rimal, R. N., & Real, K. (2003). Understanding the Influence of Perceived Norms on Behaviors. *Communication Theory*, 13(2), 184-203. doi: 10.1111/j.1468-2885.2003.tb00288.x
- Robinson, E., Fleming, A., & Higgs, S. (2014). Prompting Healthier Eating: Testing the Use of Health and Social Norm Based Messages. *Health Psychology*, 33(9), 1057-1064. doi: <http://dx.doi.org/10.1037/a0034213>
- Sabapathy, K., Van den Bergh, R., Fidler, S., Hayes, R., & Ford, N. (2012). Uptake of Home-Based Voluntary HIV Testing in Sub-Saharan Africa: A Systematic Review and Meta-Analysis. *PLoS Med*, 9(12), e1001351. doi: 10.1371/journal.pmed.1001351
- Sambisa, W., Curtis, S., & Mishra, V. (2010). AIDS stigma as an obstacle to uptake of HIV testing: evidence from a Zimbabwean national population-based survey. *AIDS Care*, 22(2), 170-186. doi: 10.1080/09540120903038374
- Sanders, A., Stogner, J., Seibert, J., & Miller, B. L. (2014). Misperceptions of Peer Pill-Popping: The Prevalence, Correlates, and Effects of Inaccurate Assumptions About Peer Pharmaceutical Misuse. *Substance Use & Misuse*, 49(7), 813-823. doi: 10.3109/10826084.2014.880485
- Sandstrom, M., Makover, H., & Bartini, M. (2012). Social context of bullying: Do misperceptions of group norms influence children's responses to witnessed episodes? *Social Influence*, 8(2-3), 196-215. doi: 10.1080/15534510.2011.651302
- Schultz, P. W. (1999). Changing behavior with normative feedback interventions: A field experiment on curbside recycling. *Basic and Applied Social Psychology*, 21(1), 25-36.
- Shand, T., Thomson-de Boor, H., van den Berg, W., Peacock, D., & Pascoe, L. (2014). The HIV Blind Spot: Men and HIV Testing, Treatment and Care in Sub-Saharan Africa. *IDS Bulletin*, 45(1), 53-60. doi: 10.1111/1759-5436.12068
- Sherif, M. (1936). *The Psychology of Social Norms*. New York: Harper.
- Sherif, M. (1937). An experimental approach to the study of attitudes. *Sociometry*, 1, 90-98.

- Siedner, M., Haberer, J., Bwana, M., Ware, N., & Bangsberg, D. (2012). High acceptability for cell phone text messages to improve communication of laboratory results with HIV-infected patients in rural Uganda: a cross-sectional survey study. *BMC Medical Informatics and Decision Making*, *12*(1), 56.
- Siu, G., Wight, D., & Seeley, J. (2014). Masculinity, social context and HIV testing: an ethnographic study of men in Busia district, rural eastern Uganda. *BMC Public Health*, *14*(1), 33.
- Staveteig, S., Wang, S. F., Head, S. K., Bradley, S. E. K., & Nybro, E. (2013). Demographic patterns of HIV testing uptake in Sub-Saharan Africa. Calverton, Maryland, USA: ICF International.
- Suthar, A. B., Ford, N., Bachanas, P. J., Wong, V. J., Rajan, J. S., Saltzman, A. K., . . . Baggaley, R. C. (2013). Towards Universal Voluntary HIV Testing and Counselling: A Systematic Review and Meta-Analysis of Community-Based Approaches. *PLoS Med*, *10*(8), e1001496. doi: 10.1371/journal.pmed.1001496
- Sweat, M., Morin, S., Celentano, D., Mulawa, M., Singh, B., Mbwambo, J., . . . Coates, T. (2011). Community-based intervention to increase HIV testing and case detection in people aged 16–32 years in Tanzania, Zimbabwe, and Thailand (NIMH Project Accept, HPTN 043): a randomised study. *The Lancet Infectious Diseases*, *11*(7), 525-532. doi: [http://dx.doi.org/10.1016/S1473-3099\(11\)70060-3](http://dx.doi.org/10.1016/S1473-3099(11)70060-3)
- Tomori, C., Risher, K., Limaye, R. J., Van Lith, L. M., Gibbs, S., Smelyanskaya, M., & Celentano, D. D. (2014). A Role for Health Communication in the Continuum of HIV Care, Treatment, and Prevention. *Journal of Acquired Immune Deficiency Syndromes*, *66*, S306-S310 310.1097/QAI.0000000000000239.
- Turner, J., Perkins, H. W., & Bauerle, J. (2008). Declining negative consequences related to alcohol misuse among students exposed to a social norms marketing intervention on a college campus. *Journal of American College Health*, *57*(1), 85-94. doi: 10.3200/JACH.57.1.85-94
- Underwood, C., Hendrickson, Z., Van Lith, L. M., Lengwe Kunda, J. E., & Mallalieu, E. C. (2014). Role of Community-Level Factors Across the Treatment Cascade: A Critical Review. *Journal of Acquired Immune Deficiency Syndromes*, *66*, S311-S318. doi: 10.1097/qai.0000000000000234
- Venkatesh, K. K., Madiba, P., De Bruyn, G., Lurie, M. N., Coates, T. J., & Gray, G. E. (2011). Who Gets Tested for HIV in a South African Urban Township? Implications for Test and Treat and Gender-Based Prevention Interventions. *Journal of Acquired Immune Deficiency Syndromes*, *56*(2), 151-165 110.1097/QAI.1090b1013e318202c318282c.
- Walensky, R. P., & Bassett, I. V. (2011). HIV self-testing and the missing Linkage. *PLoS Med*, *8*(10), e1001101. doi: 10.1371/journal.pmed.1001101

- Walensky, R. P., Wood, R., Fofana, M. O., Martinson, N. A., Losina, E., April, M. D., . . . Paltiel, A. D. (2011). The clinical impact and cost-effectiveness of routine, voluntary HIV screening in South Africa. *Journal of Acquired Immune Deficiency Syndromes*, 56(1), 26-35. doi: 10.1097/QAI.0b013e3181fb8f24
- Young, S. D., Hlavka, Z., Modiba, P., Gray, G., Van Rooyen, H., Richter, L., . . . Coates, T. (2010). HIV-related stigma, social norms, and HIV testing in Soweto and Vulindlela, South Africa: National Institutes of Mental Health Project Accept (HPTN 043). *Journal of Acquired Immune Deficiency Syndromes*, 55(5), 620-624. doi: 10.1097/QAI.0b013e3181fc6429

Appendix

Table A1.1. A catalog of 'Name Generators' (survey questions employed to elicit social ties), which were collected from 59 papers arising from 37 social network studies conducted in more than 26 low- and middle-income countries.

Papers	Text of Name Generators*	Country	Study Design
Adams, Madhavan & Simon, 2002	<ol style="list-style-type: none"> 1. Asked to name people who provide material support. 2. Asked to name people who provide practical support. 3. Asked to name people who provide cognitive support. 4. Asked to name people who provide emotional support. 5. Asked to name husband, mother-in-law or co-wife, if conspicuously absent from the list generated from the first four questions. 6. Asked to name the five most important people among the people already listed from the previous questions. 	Mali	Egocentric
Alatas, Banerjee, Chandrasekhar, Hanna & Olken, 2012	<ol style="list-style-type: none"> 1. Asked to name all other households in the hamlet to whom they were related (either through blood or marriage). 2. Asked to name the formal and informal leaders of the village, and the five poorest and the five richest households in the village, along with all the relatives of each person named. 	Indonesia	Sociocentric
Alvergne, Gibson, Gurmu & Mace, 2011	<ol style="list-style-type: none"> 1. "Name up to five other women/men [same-sex as respondent] with whom you talk most and perceive as among your best friends." 	Ethiopia	Sociocentric

Table A1.1 (Continued)			
Apicella, Marlowe, Fowler & Christakis, 2012	<ol style="list-style-type: none"> 1. "With whom would you like to live after this camp ends?" [choosing from among the entire same-sex adult Hadza population]. 2. Asked to name up to six people to whom they would like to give an actual gift of honey from among members of their particular camp. 	Tanzania	Sociocentric
Avogo & Agadjanian, 2008	<ol style="list-style-type: none"> 1. "With whom do you talk most often (up to four people other than spouse or kin)?" 	Ghana	Egocentric
<p>Banerjee, Chandrasekhar, Duflo & Jackson, 2013;</p> <p>Jackson, Rodriguez-Barraquer & Tan, 2012;</p> <p>Shakya, Christakis & Fowler, 2014a;</p> <p>Shakya, Christakis & Fowler, 2014b</p>	<ol style="list-style-type: none"> 1. "Name the 5 non-relatives whom you speak to the most." 2. "In your free time, whose house do you visit?" 3. "Who visits your house in his or her free time?" 4. "If you need to kerosene or rice, to whom would you go?" 5. "Who would come to you if he or she needed to borrow kerosene or rice"? 6. "If you suddenly needed to borrow Rs. 50 for a day, whom would you ask?" 7. "Whom do you trust enough that if he or she needed to borrow Rs. 50 for a day you would lend it to him or her?" 8. "Who comes to you for advice?" 9. "If you had to make a difficult personal decision, whom would you ask for advice?" 10. "If you had a medical emergency and were alone at home, whom would you ask for help in getting to a hospital?" 	India	Sociocentric

Table A1.1 (Continued)			
	<p>11. "Whom do you go to temple with?"</p> <p>12. "Name any close relatives, aside from those in this household, who also live in this village. Plus people in those same households." *(2-11 limited to 8 nominations)</p>		
<p>Bates, Trostle, Cevallos, Hubbard & Eisenberg, 2007;</p> <p>Trostle, Hubbard, Scott, Cevallos, Bates & Eisenberg, 2008;</p> <p>Zelner, Trostle, Goldstick, Cevallos, House & Eisenberg, 2012</p>	<p>1. "In general, with whom do you spend time [outside your household, but in your community]?"</p> <p>1. "In the past week, outside your household, with whom did you participate in activities having to do with food, like preparing or sharing it?"</p> <p>2. Asked to name to whom outside the household the subject talks about important matters.</p>	Ecuador	Sociocentric
<p>Bignami Van-Assche, 2005;</p> <p>Kohler, Behrman & Watkins, 2007;</p> <p>White & Watkins, 2000</p>	<p>1. "How many people have you chatted with about modern methods of child spacing/family planning? I mean people other than your husband/wife. [If Yes,] Could you please give me the names of (up to) four of these?"</p> <p>2. "How many people have you chatted with about AIDS? I mean people other than your husband/wife. [If Yes,] Could you please give me the names of (up to) four of these?"</p>	Kenya	Egocentric
<p>Cai, De Janvry & Sadoulet, 2012</p>	<p>1. Asked to name five close friends (not including parents or children), either within or outside the village, with whom he/she most frequently discusses rice production or financial related problems.</p>	China	Sociocentric

Table A1.1 (Continued)			
Comola, 2008	1. Asked to name up to five women living in the village with whom the subject had discussed family planning and contraception during the past 6 months.	Nepal	Sociocentric
Comola & Prina, 2013	1. Asked to name people inside or outside the village that a participant could rely on most and with whom the participant or members of the participant's household regularly exchanged gifts and/or loans.	Nepal	Sociocentric
D'Exelle & Riedl, 2010; D'Exelle & Holvoet, 2012	1. Asked whether the interviewed person knew the household [name card displayed] and whether the subject had a social relation of any kind with one of the household members. Then, asked about the content of the relation: friendship, support, social-public, economic, neighbor, or family.	Nicaragua	Sociocentric
De Weerd, 2004; De Weerd & Dercon, 2006; De Weerd & Fafchamps, 2011; Comola, 2012	1. "Can you give a list of people from inside or outside of [this village], who you can personally rely on for help and/or that can rely on you for help in cash, kind or labour?"	Tanzania	Sociocentric
Edmonds, Hruschka, Bernard & Sibley, 2012	1. Asked to name the people to whom respondents had spoken about place of delivery during pregnancy. Probing continued until 20 names were given.	Bangladesh	Egocentric
Ensminger et al, 2011	1. "In this packet, you will find a photograph of all/most of the adults in this village. Pick out the photographs of all the people you usually talk to about any kind of problem in this village." 2. "Are there any other people outside this	15 small-scale societies across the world	Egocentric

Table A1.1 (Continued)			
	village you usually talk to about any kind of problem in this village? Please list all of them."		
Entwisle, Faust, Rindfuss & Kaneda, 2007; Verdery, Entwisle, Faust & Rindfuss, 2012	1. "Does this person have other siblings besides the ones [living in the household] that are still living?" If so, then name and contact's location were recorded. 2. "Did anyone from this village help [the participant] to harvest rice?" If so, then name and contact's location were recorded. 3. "Did anyone from another village come to help [the participant] harvest rice?" If so, then name and contact's location were recorded.	Thailand	Sociocentric
Fonseca-Becker & Valente, 2006	1. Asked to name (up to five) people to whom respondents go for advice or to discuss personal topics.	Bolivia	Egocentric
Fu, He, Duan, Jiang, Ye, Pu, Zhao, Huang & Wong, 2011	1. Asked to name sexual partners within the past five years.	China	Sociocentric
Gayen & Raeside, 2010	1. Asked to name up to five women in the village with whom they talked most and perceived as their best friends.	Bangladesh	Sociocentric
Green, Atuyambe, Ssali, Ryan, & Wagner, 2011	1. Asked to name 20 people with whom they had communicated in the last 6 months by e-mail, phone, person, or any other means, starting with those most important first.	Uganda	Egocentric
Helleringer, Kohler & Chimbiri, 2007; Helleringer & Kohler, 2007; Helleringer, Kohler, Chimbiri, Chatonda & Mkandawire, 2009;	1. Asked to name five most recent sexual partners in the past three years. 2. Asked to name four closest friends on the island. (This was limited to 2 in the second wave.) 3. Asked to name five people to turn to for help in case of unexpected hardship.	Malawi	Sociocentric

Table A1.1 (Continued)			
Helleringer, Mkandawire, Kalilani-Phiri & Kohler, 2013	4. Ties were also assumed through co-membership in the same community groups.		
Henrich & Broesch, 2011	<p>1. "Who would you go to for advice if you had a question about fish or fishing?"</p> <p>2. "Who would you go to for advice if you had a question about planting or growing yams?"</p> <p>3. "Who would you go to for advice if you had a question about using a plant as a medicine?"</p>	Fiji	Egocentric
Hurley, Warren, Doumbia & Winch, 2013	1. "Who are your closest friends in the village?"	Mali	Sociocentric
Jaimovich, 2011	<p>Names were asked as responses to the following questions:</p> <p>1. "Of the land you cultivated last year, did you lend out or borrow in land from other villagers?" [Direction was indicated]</p> <p>2. "Did you, or any members of your household, work for other households during the last year?" [Direction was indicated]</p> <p>3. "Did you lend out or borrow in any means of production (such as tools or fertilizer) from other households in the last year?" [Direction was indicated]</p> <p>4. "Did you lend out or borrow in money from other households in the last year?" [Direction was indicated]</p> <p>5. "Have any of your household members married members of other households?" [Direction was indicated]</p>	Gambia	Sociocentric

Table A1.1 (Continued)			
	6. "With which households do your family members have kinship relationships?"		
Koster, 2011	1. Asked to name the person from whom food was acquired outside the household.	Nicaragua	Egocentric
Mertens Saint-Charles, Lucotte & Mergler, 2008; Mertens, Saint-Charles & Mergler, 2012	1. Asked to name the individuals with whom they usually discussed mercury issues, whether in the context of health, dieting, or fishing.	Brazil	Sociocentric
Miguel & Kremer, 2003	1. Asked to name five friends speaks with most frequently. 2. Asked to name five relatives speaks with most frequently. 3. Asked to name additional social contacts whose children attend local primary schools. 4. Asked to name individuals with whom the respondent speaks specifically about child health issues.	Kenya	Egocentric
Moore, 2014	1. Suppose you suddenly become seriously ill at night, who will you call for help? 2. Suppose you need to borrow a large sum of money, say 250,000 FCFA (about \$500), whom would you ask for help? 3. Who are the people with whom you discuss matters that are important to you? 4. Who are the people that you really enjoy socializing with? 5. Who are the people that you are close to, but did not mention earlier?	Uganda	Egocentric

Table A1.1 (Continued)			
Moser & Mosler, 2008	<p>1. "Who had respondent talked to in the past week (besides family members living in the same household)?"</p> <p>2. "Who had helped respondent the last time they had drinking water or health problems?"</p> <p>3. "Who had respondent talked to about the forthcoming referendum?"</p>	Bolivia	Egocentric
Nolin, 2010; Nolin, 2012	<p>1. Asked to name individuals to whom the subject had given gifts of food, usually more than once, during the preceding hunting season.</p> <p>2. Asked to name individuals from whom the subject had received gifts of food, usually more than once, during the preceding hunting season.</p>	Indonesia	Sociocentric
Ruiz-Casares, 2010	<p>Asked to name all people perceived as available if needed for...</p> <p>1. ...recreation and companionship (e.g. have fun or relax).</p> <p>2. ...advice and information (e.g. useful information on how to care for a sick sibling).</p> <p>3. ...instrumental or tangible aid (e.g. food, transportation, or help thatching a roof)</p> <p>4. ...emotional or affective support (e.g. share secrets and discuss feelings)</p> <p>5. ...validation or positive feedback (e.g. tell good things about yourself)</p> <p>6. Asked to name all people who sometimes make the respondent feel bad or upset.</p>	Namibia	Egocentric

Table A1.1 (Continued)			
Sandberg, 2005; Sandberg, 2006	1. Asked to name up to 22 individuals outside the subject's immediate household to whom the subject had turned for help when sick, whom the subject had helped, or with whom the subject had worked in the previous year. (This was essentially split into three separate name generators.)	Nepal	Sociocentric
Sandberg, 2012	"Can you tell me about people who... 1. ... are closest to your heart?" 2. ... you share your secrets with?" 3. ... ask for help in a crisis?" 4. ... you would ask to be responsible for your family when you travel?" 5. ... are close but don't live in area?" 6. ... are close to you and are kin or faux kin?" 7. ... are in your age grade who you are close to?" 8. ... you gather with regularly in your free time?" 9. ... you talk to in your work or work association?" 10. ... you talk with on the telephone?" 11. ... you talk to in religious group you belong to?" 12. ... you talk to in associations or committees you belong to?" 13. ... you pass your days with in the dry season?" 14. ... have a style of living which pleases you?" 15. ... you may have forgotten among those you have cited?"	Senegal	Egocentric

Stafford, Hughes & Abel, 2010	<ol style="list-style-type: none"> 1. Asked to name best friends. 2. Asked to name siblings. 3. Asked to name spouse (if applicable). 	Honduras	Egocentric
Stoebenau & Valente, 2003	<ol style="list-style-type: none"> 1. "Who do you talk to, here in the village of [name], when you have a big decision to make in your life, or when you need advice about a problem? Can you name four people?" 2. "Have you spoken to anyone here in [name of village] about ways to avoid pregnancy? Can you name four people you have spoken with?" 3. "Have you spoken to anyone about ways to avoid pregnancy outside of the village of X? Can you name four people you have spoken with?" 	Madagascar	Sociocentric
Valente, Watkins, Jato, Van Der Straten, & Tsitsol, 1997	<ol style="list-style-type: none"> 1. "Please tell me the complete names of five people in your [voluntary association] group that you talked to most often in the past six months?" 	Cameroon	Egocentric
Wutich & McCarty, 2008	<ol style="list-style-type: none"> 1. Asked to name 40 people that respondent knew. Knowing was defined as "you know them and they know you by sight or by name, you could contact them, and that there has been some contact (in person, by telephone, by mail or email) in the last two years." 	Mexico	Egocentric

*Exact wording, and the number of responses permitted, are provided if available.

Table A2.1. Social network characteristics of men and women aged 18 years or older across eight villages in one parish in rural Southwestern Uganda.

Variable	Mean	Std Dev	Mean	Std Dev	p-value ^a	Correlation with Depression Symptom Severity Score		Correlation with Food Insecurity Score	
	Women		Men			Women	Men	Women	Men
Total Degree	8.6	4.7	9.1	6.0	p = .04	0.06	-	-0.03	-0.09*
Out-degree	5.1	2.0	5.3	2.3	p = .06	0.04	-0.01	0.02	0.003
Reciprocal Degree	1.6	1.5	1.3	1.4	p < .001	0.02	-0.06	-0.03	-0.09*
Individual Closeness Centrality	0.23	0.02	0.24	0.02	p < .001	0.08	0.003	0.06	0.05
Personal network density	0.19	0.15	0.17	0.15	p = .002	-0.06	-0.01	-0.07*	-0.02
Percent of personal network who are poor	33%	24%	30%	23%	p = .003	0.10	0.007	0.22***	0.13***
Percent of personal network who report moderate or severe food insecurity	56%	23%	48%	22%	p < .001	0.10	0.06	0.24***	0.22***

*p < .05; *** p<.001.

^aFrom test for differences between men and women using nonparametric equality-of-medians test.

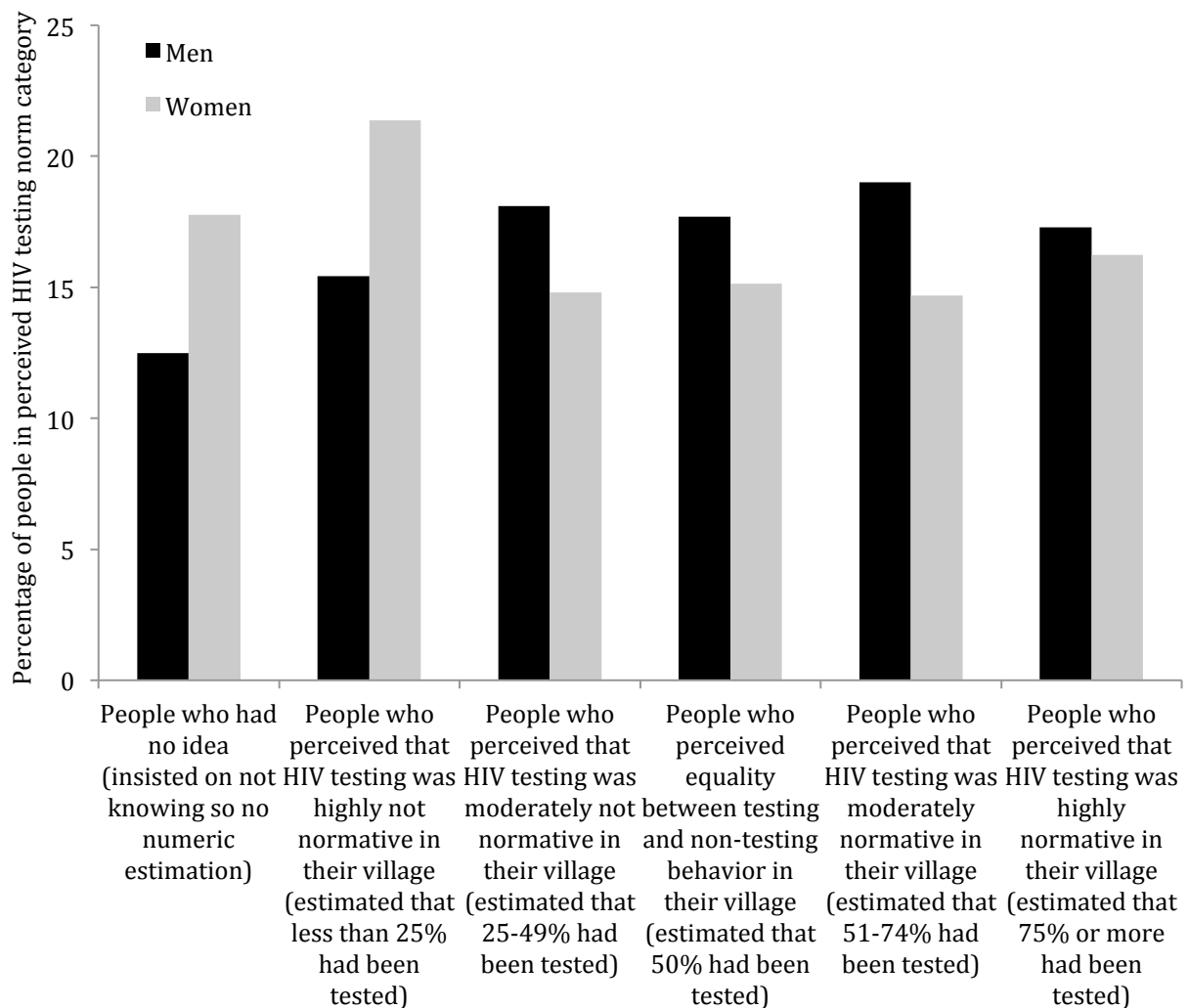


Figure A3.1. Distribution of the estimated prevalence of ever being tested for HIV and perception of testing as normative in one's village among 1,664 men and women (aged 18 years or older) across 8 villages in one parish in rural Southwestern Uganda.

Table A3.1. Perception of ever being tested for HIV as normative in one's village (> 50% prevalence) and the extent of under- or over-estimation of prior HIV testing in one's village (using a cutoff of +/- 20 percentage points to calculate accuracy) by men and women (aged 18 years or older) in eight villages in rural Southwestern Uganda (n = 658 men and n = 750 women).

		Perceived HIV testing as not normative			Perceived HIV testing as normative		
		Under- Estimated the prevalenc e of prior HIV testing	Accurately estimated the prevalenc e of prior HIV testing	Over- estimated the prevalenc e of prior HIV testing	Under- estimated the prevalenc e of prior HIV testing	Accurately estimated the prevalenc e of prior HIV testing	Over- estimated the prevalenc e of prior HIV testing
% in category	Men	55%	4%	0%	0.3%	38%	4%
	Women	58%	4%	0%	0%	34%	4%
Range of % in category across 8 villages	Men	40-66%	18-19%	0%	2%	28-51%	0-14%
	Women	42-66%	0-29%	0%	0%	27-42%	1-11%
Quantity of mis- estimat ion (Q1-Q3 of IQR)	Men	28 to 53 percentag e points less than the norm	-	-	20 to 23 percentag e points less than the norm	-	22 to 27 percentag e points greater than the norm
	Women	29 to 59 percentag e points less than the norm	-	-	-	-	22 to 27 percentag e points greater than the norm

Notes: Prior HIV testing was normative (> 50%) in all 8 villages in the study. Percentages are calculated based on the 85% of participants who gave a numeric estimation of the HIV testing prevalence in their village.

Table A3.2 Multilevel logistic regression odds-ratios for never having been tested for HIV among men and women (aged 18 years or older) in eight villages in one parish in rural Southwestern Uganda.

	Men (n = 707)			Women (n = 882)		
	OR	95% CI		OR	95% CI	
<i>Perception of HIV testing norm in one's village</i>						
Didn't have any idea (no estimation)	4.3***	2.1	8.8	2.8**	1.4	5.5
Testing highly not normative (e.g. estimated 0-24%)	4.1***	2.1	8.0	1.3	0.7	2.5
Testing moderately not normative (e.g. estimated 25-49%)	2.1*	1.1	4.1	0.9	0.4	1.8
Perceived equality between testing and non-testing behavior (e.g. estimated 50%)	2.5**	1.3	4.7	1.0	0.5	2.1
Testing moderately normative (e.g. estimated 51-74%)	1.1	0.5	2.2	1.0	0.5	2.0
Testing highly normative (e.g. estimated 75-100%) [REF]	1.00	-	-	1.00	-	-
<i>Aids-related Stigma</i> (unit change from mean)	1.4	0.9	2.0	0.9	0.6	1.2
<i>Spousal HIV testing status</i>						
Not married	1.9*	1.0	3.5	1.6	1.0	2.7
Unknown spousal status	0.9	0.4	2.3	1.0	0.4	2.4
Spouse not tested	2.3*	1.1	4.6	2.2*	1.1	4.2
Spouse has tested [REF]	1.00	-	-	1.00	-	-
<i>Had children</i>						
No	1.6	0.8	3.2	3.9***	2.1	7.5
Yes [REF]	1.00	-	-	1.00	-	-
<i>Age</i>						
Less than 30 years [REF]	1.00	-	-	1.00	-	-
30-39 years old	1.6	0.8	3.0	1.1	0.6	2.3
40 -49 years old	1.0	0.5	2.0	1.3	0.6	2.6
50-59 years old	0.9	0.4	2.2	3.0**	1.4	6.7
60-69 years old	3.3*	1.3	8.8	3.0**	1.3	6.9
70 years or older	3.4*	1.3	9.1	16.2***	7.0	37.7
<i>Education</i>						
No education	1.3	0.6	2.8	0.5	0.2	1.1
Primary	1.0	0.7	1.6	0.9	0.5	1.6
Secondary [REF]	1.00	-	-	1.00	-	-
Postgraduate	0.5	0.2	1.0	0.6	0.2	1.7

Table A3.2 (Continued)						
<i>Household Wealth Quintile</i>						
Lowest	1.4	0.8	2.8	1.3	0.7	2.7
Second	1.7	0.9	3.1	0.8	0.4	1.5
Third	2.1*	1.2	3.7	1.1	0.6	2.1
Fourth	1.6	0.9	2.7	1.7	0.9	3.1
Highest [REF]	1.00	-	-	1.00	-	-
<i>Village</i>						
1	1.4	0.7	2.9	1.8	0.8	4.1
2	1.1	0.5	2.2	2.3*	1.0	5.1
3	0.9	0.4	1.9	1.3	0.5	3.2
4	1.7	0.8	3.6	2.0	0.9	4.5
5	1.3	0.6	2.9	1.2	0.5	3.3
6	1.5	0.7	3.1	1.2	0.5	2.7
7	1.4	0.6	3.2	3.0*	1.3	7.1
8 [REF]	1.00	-	-	1.00	-	-

* p < .05; ** p < .01; *** p < .001.

Notes: Estimates were obtained using a two-level, random intercepts logistic regression model including fixed effects for age, education, household wealth quintiles, and village, and random effects at the household level.

Data A3.1. Description of control variables.

Stigma was measured using nine items with a four-point response scale (Strongly Disagree, Disagree, Agree, and Strongly Agree).¹ We reverse coded one item and then re-coded all items so that responses to all questions were coded in the same direction where 1 = the least stigma (disagreeing with statements expressing stigma) and 4 = the most stigma (agreeing with statements expressing stigma). We then calculated the mean response across eight items (dropping one entirely uncorrelated item) as long as no more than three items were missing responses across the eight items. (Only 9 participants had more than 3 missing items). The mean was set equal to missing otherwise. Cronbach's alpha was 0.79.

Information on marital status and spousal HIV (available for most couples as study population included all adults and couples data could be linked) was used to create the following categories: a) single, b) married/cohabiting and partner testing history was not available (usually because the partner was not an eligible participant and therefore information on his or her testing status was not available), c) married/cohabiting and partner self-reported as never having been tested, and d) married/cohabiting and partner self-reported as having been tested. Only one respondent had missing information for this variable.

Information on participants' gender, age (missing = 16 responses), whether the participant had any children (missing = 50 responses), educational attainment (missing = 32 responses) and household wealth (zero missing observations) was also collected. Age was categorized as a) less than 30 years old, b) 40-49 years, c) 50-59 years, d) 60-69 years, and e) 70 years or older. Education was categorized as a) none, b) primary, c) secondary, and d) postgraduate. To measure household wealth, we created a household asset index, by conducting a principal components analysis on 26 separate variables representing household assets and housing characteristics (no missing). We retained the first principal component to define the wealth index and then split it into quintiles.²

References for Data A3.1

1. Kalichman SC, Simbayi LC, Jooste S, et al. Development of a Brief Scale to Measure AIDS-Related Stigma in South Africa. *AIDS and Behavior*. 2005/06/01 2005;9(2):135-143.
2. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. *Demography*. Feb 2001;38(1):115-132.