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The social network context of HIV stigma: Population-based, sociocentric network study in rural Uganda

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A B S T R A C T

Rationale: HIV-related stigma profoundly affects the physical and social wellbeing of people living with HIV, as well as the community's engagement with testing, treatment, and prevention. Based on theories of stigma elaborating how it arises from the relationships between the stigmatized and the stigmatizer as well as within the general community, we hypothesized that social networks can shape HIV-related stigma.
Objective: To estimate social network correlates of HIV-related stigma.
Methods: During 2011-2012, we collected complete social network data from a community of 1669 adults ("egos") in Mbarara, Uganda using six culturally-adapted name generators to elicit different types of social ties ("alters"). We measured HIV-related stigma using the 9-item AIDS-Related Stigma Scale. HIV serostatus was based on self-report. We fitted linear regression models that account for network autocorrelation to estimate the association between egos' HIV-related stigma, alters' HIV-related stigma and alters' self-reported HIV serostatus, while adjusting for egos' HIV serostatus, network centrality, village size, perceived HIV prevalence, and sociodemographic characteristics.
Results: The average AIDS-Related Stigma Score was 0.79 (Standard Deviation = 0.50). In the population 116 (7%) egos reported being HIV-positive, and 757 (46%) reported an HIV-positive alter. In the multivariable model, we found that egos' own HIV-related stigma was positively correlated with their alters' average stigma score (b = 0.53; 95% confidence interval [CI] 0.42-0.63) and negatively correlated with having one or more HIV-positive alters (b = -0.05; 95% CI -0.10 to -0.003).
Conclusion: Stigma-reduction interventions should be targeted not only at the level of the individual but also at the level of the network. Directed and meaningful contact with people living with HIV may also reduce HIV-related stigma.

1. Introduction

HIV-related stigma profoundly affects people living with HIV (PLH) as well as the general community. Stigma is an "attribute that is deeply discrediting" that reduces the person "from a whole and usual person to a tainted, discounted one" (p. 3) (Goffman, 1963). Stigma arises from the differential access to social, economic, and political power between the stigmatizer and the stigmatized, and perpetuates social hierarchies by reducing the status of the stigmatized (Gilmore and Somerville, 1994; Link and Phelan, 2001). Power relations are central to how the stigma process unfolds. The manner in which stigma is deployed is historically contingent and varies from setting to setting, and stigma is often layered over pre-existing societal fault lines including those related to gender, race, and class (Gilmore and Somerville, 1994). Stigma manifests in different, overlapping ways: the internalization of negative attitudes and stereotypes by stigmatized individuals (internalized stigma); expectations of rejection by the community were one's stigmatized status to become known (anticipated stigma); and acts of discrimination or hostility towards stigmatized individuals (enacted stigma) (Scambler and Hopkins, 1986; Steward et al., 2008; Turan et al., 2017b). When experienced or internalized by PLH, HIV-related stigma affects their personal and social wellbeing as well as their

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outcomes in the HIV care continuum. Among PLH, HIV-related stigma has been linked to depression (Simbayi et al., 2007; Tsai et al., 2012) and increased HIV transmission risk behavior (Burnham et al., 2016; Siedner et al., 2014), prevents them from disclosing their status to their friends and family (Bogart et al., 2008; Tsai et al., 2013a), compromises their ability to obtain social support (Takada et al., 2014), leads to poor engagement with care (Vanable et al., 2006), and undermines adherence to treatment (Katz et al., 2013; Li et al., 2014). Stigma more generally also affects access to resources that are in turn associated with improved health outcomes, including employment opportunities, housing, and access to medical care (Link and Phelan, 2006).

Among people in the general population, HIV-related stigma has been associated with delays in HIV testing (Genberg et al., 2009; Kelly et al., 2016), HIV transmission risk behavior (Delavande et al., 2014; Kelly et al., 2017), and negative spillover effects on other health behaviors of interest, including maternal and child health (Ng and Tsai, 2017; Turan et al., 2008, 2011, 2012). Stigma has been implicated in delays in response to the global HIV epidemic (Castro and Farmer, 2005), as people continue to present for HIV care and initiate antiretroviral therapy at advanced stages of disease (Siedner et al., 2015). Therefore, reduction or elimination of HIV-related stigma is a critical component of the global response to the HIV epidemic (Turan et al., 2017b; Turan and Nyblade, 2013). However, much remains to be done to develop interventions that effectively eliminate stigma, particularly at the interpersonal and community levels (Stangl et al., 2013).

This study aimed to refine our understanding of the interpersonal aspects of HIV-related stigma through the study of a whole-population social network in rural Uganda. We addressed two fundamental questions about the process of stigma: (1) How do the stigmatizing beliefs of social ties shape one's own stigmatizing beliefs? (2) How does having HIV-positive social ties affect one's own stigmatizing beliefs?

2. Conceptual model

The classic enjoinder of Goffman (1963) was that stigma needs to be discussed in the “language of relationships, not attributes” (p. 3). Stigma is socially constructed: it is specific to the social context in which the stigmatized and the stigmatizer relate to each other, and to the larger context of the community (Farmer, 2006; Major and O'Brien, 2005). Yet few studies have elaborated how social ties help create and shape stigmatizing beliefs.

We hypothesize that social networks can potentially shape HIV-related stigma in two ways. First, peers can shape HIV-related stigma, just as peers shape and spread diverse health-related norms and behaviors (Christakis and Fowler, 2007, 2008; DiMaggio and Garip, 2012; Kuhns et al., 2017; Schneider et al., 2013; Tankard and Paluck, 2016). In resource-limited settings compared with resource-rich settings, social networks may play a more powerful role in the dissemination of information and norms (Perkins et al., 2015). Social networks have been shown to influence latrine use (Shakya et al., 2014) and polio vaccine uptake (Onnela et al., 2016) in India, normative beliefs about intimate partner violence in rural Honduras (Shakya et al., 2016), creation of sanitation infrastructure in rural Ecuador (Zelner et al., 2012), normative beliefs and behaviors regarding HIV transmission behaviors among young Tanzanian men (Mulawa et al., 2016b), and HIV testing behavior (Mulawa et al., 2016a; Perkins et al., 2018a).

Second, PLH might be able to positively influence stigmatizing beliefs among their social ties. Allport (1954) theorized that meaningful communication and collaboration between members of a majority group and a minority group, under appropriate conditions, could lead to decreased prejudice towards the minority group. Empirical studies have since shown that such interactions improve people's attitudes toward stigmatized populations (Broockman and Kalla, 2016; Desforges et al., 1991; Phelan and Link, 2004). Related to this body of work, studies have shown that people living in areas of higher HIV prevalence (Genberg et al., 2009), or those who have personal contact with PLH (Chan and Tsai, 2017), are less likely to endorse negative attitudes toward PLH. One mechanism through which personal contact is expected to operate is by inducing empathy (Batson et al., 1997), or the ability to recognize and understand another's perceptions and feelings. Prior work has shown that the induction of empathy for a member of a stigmatized group has led to improvements in attitudes toward the group as a whole (Batson et al., 2002; Batson et al., 1997).

3. Method

3.1. Ethics statement

All respondents provided written informed consent, either with a signature or with a thumbprint if unable to write. All study procedures were approved by the Committee on the Use of Human Subjects in Research, Harvard University and the Institutional Review Committee, Mbarara University of Science and Technology. Consistent with national guidelines, we also received clearance from the Uganda National Council for Science and Technology and the Research Secretariat in the Office of the President. The institutional review board of the University of California, Los Angeles confirmed that the secondary data analysis described in this manuscript was exempted from review.

3.2. Study setting and population

The study was conducted between 2011 and 2012 in Mbarara, a rural region of southwestern Uganda. The local economy is driven primarily by subsistence agriculture, animal husbandry, and small-scale trading; food and water insecurity are fairly common (Perkins et al., 2018b; Tsai et al., 2011, 2016). At the time of the study, HIV prevalence in the southwestern region of Uganda was 8% (Ministry of Health/Uganda & ICF International, 2012). Nyakabare Parish, composed of 8 villages, was chosen among several candidate study sites because of its history of low migration, long period of settlement, and clear governmental and geographic boundaries. We collected data from all adults aged 18 years and older. People who did not report stable residence in the parish, and people who could not communicate meaningfully with research staff (e.g., due to acute intoxication or cognitive impairment), were excluded. There were a total of 1747 eligible respondents, 1669 (95.5%) of whom were interviewed.

3.3. Data collection

Interview materials were translated from English into Runyankore by trained research assistants, back-translated to ensure fidelity to the original text, and pilot-tested to ensure cultural sensitivity and appropriateness to the local context. Data were collected in two stages. During the first stage, the research team went from household to household to conduct a census of all eligible adults. They collected demographic information and obtained photographs of each eligible respondent. During the second stage, the research team administered confidential, one-on-one, paper-based survey interviews, eliciting each respondent's social networks and using photographs as visual aids to confirm identities. Surveys were also used to elicit self-reported HIV serostatus and other variables of interest, including HIV-related stigma.

3.4. Primary variables of interest

To elicit ties, we administered 6 different name generators. These name generators were modeled after classic name generators such as those used in the General Social Survey (Burt, 1984; Marsden, 1990) and adapted for the local context through focus group studies with key informants. We used multiple role- and behaviorally-specific name generators because we sought to elicit the full range of ties between respondents, and single name generators often do not suffice (Bearman and Parigi, 2004; Shakya et al., 2017). Respondents were asked to name

people with whom they had particular kinds of interactions in the past 12 months: (1) people with whom they spend leisure time; (2) people with whom they discuss financial matters; (3) people with whom they discuss health matters; (4) people who provide emotional support; (5) people with whom they exchange food; and (6) kin/relatives. (The Supplementary Appendix provides the full text of the name generators in their entirety.) For each name generator, except for that eliciting kin networks, the index respondent (subsequently referred to as the "ego") was permitted to identify up to six adults (subsequently referred to as "alters") residing within the parish.

Using these data, we generated a network graph of the parish. In contrast to egocentric network studies that elicit egos' alters and egos' perceptions of the ties between alters (Granovetter, 1973), sociocentric network studies capture ties between all individuals within the community (Moreno, 1953). Sociocentric studies therefore do not rely on egos' *perceptions* of their alters' beliefs, behaviors, and relationships because the alters are also respondents, and these types of studies can more accurately characterize egos' embeddedness within the network because the embeddedness of the egos' alters is also known (Perkins et al., 2015). For example, in our study, we elicited HIV-related stigma and HIV serostatus directly from respondents (egos and alters) rather than rely on egos' potentially inaccurate perceptions of their alters' beliefs and HIV serostatus (Almaatouq et al., 2016; Butts, 2003; Kumbasar et al., 1994; Mulawa et al., 2016a). Many network studies related to health and health behaviors have measured a person's immediate social network, but in resource-limited settings, sociocentric studies are rarely done (Helleringer et al., 2009; Perkins et al., 2015; Schneider et al., 2015).

The outcome of interest was HIV-related stigma, which we measured using the 9-item AIDS-Related Stigma Scale (Kalichman et al., 2005). The scale was administered to all respondents regardless of their self-reported HIV status. The scale consists of 9 statements worded as negative attitudes toward PLH and elicits respondents' endorsement of each item on 4-point Likert-type scale ranging from "strongly disagree" to "strongly agree." Each item is scored from 0 to 3. Egos' total scores were calculated as the average of the 9 items, and we also calculated the mean stigma scale scores of each ego's alters. We reverse coded one item so that a higher number on the total score corresponds to more stigmatizing attitudes towards PLH. The scale showed acceptable internal consistency ($\alpha = 0.78$).

We collected self-reported data on each respondent's self-reported HIV status (HIV positive, HIV negative, or unknown). For each ego, we then used the network data to determine whether he or she had any alters who reported being HIV positive. We did not confirm self-reported HIV serostatus with HIV testing. It is rare for people to report being HIV positive when they are actually seronegative (Macro International and National Statistical Office, 2011). On the other hand, it is possible that some people reported being HIV negative when they were in fact HIV positive. However, our estimate of self-reported HIV prevalence (7%) closely matched the HIV prevalence estimate for the southwestern Uganda region (8%) in the 2011 Uganda AIDS Indicator Survey that was based on unlinked anonymous HIV testing (Ministry of Health/Uganda & ICF International, 2012); therefore we anticipate that any potential bias resulting from misclassification would be minimal.

3.5. Other explanatory variables

We asked respondents what they perceived to be the prevalence of HIV in the community, because prior literature has shown that HIV prevalence is associated with lower levels of stigma (Genberg et al., 2009). The wording of the survey question was as follows: "If there were 100 people in your village, how many of them do you think would actually have HIV/AIDS?" Due to clumping in the data, the perceived HIV prevalence variable was dichotomized at > 50% ("high") vs. 50% or less ("low").

Based on the theory that stigmatization is contingent on differential access to social, political, or economic power between the stigmatizer and the stigmatized (Link and Phelan, 2001), we included in the regression models covariates that represent different forms of power in the community – namely, social embeddedness and socioeconomic status. To measure social embeddedness for each ego, we calculated his or her eigenvector centrality, which is a form of degree centrality that differentially weights each alter by the embeddedness of that alter (Bonacich, 1972, 1987). Egos whose alters are better connected have higher eigenvector centrality compared to egos whose alters are less connected. We also included in the regression models two traditional measures of socioeconomic status: educational attainment and household wealth. Educational attainment was dichotomized at primary school completion vs less than primary school completion. Household wealth was measured using an asset index based on 26 different household items and housing characteristics (Filmer and Pritchett, 2001).

Other sociodemographic variables collected were age, religion, sex, and marital/partnership status, all of which have been shown in prior literature to be associated with HIV-related stigma (Mugoya and Ernst, 2014; Nabukenya and Matovu, 2018; Treves-Kagan et al., 2017; Youssef et al., 2018). We categorized religion into the two most common religions, Protestant or Catholic, and a third category of all other responses. We categorized marital status into single, married, and divorced/separated.

3.6. Statistical analysis

We sought to understand how egos' HIV-related stigma was associated with the HIV serostatus and HIV-related stigma of their alters. We conducted bivariate analyses to estimate the association between HIV-related stigma and the variables described above. We used a nested taxonomy of linear regression models in which the ego's stigma scale score was specified as a function of the ego's own HIV serostatus and the ego's perception of HIV prevalence, the presence of an HIV-positive alter within the ego's network, and the mean HIV-related stigma score among the ego's alters. In the multivariable regression models, we also adjusted for the ego's age, sex, marital status, religion, educational attainment, population of the ego's village, and network centrality. The packages *Igraph* version 2.0 and *sna* version 2.4 were used to conduct social network analyses in R (version 3.4.1). We graphed the network using the Kamada-Kawai algorithm.

Because egos and alters may share unmeasured influences that affect their joint distribution of HIV-related stigma, a simple linear regression model could potentially overestimate the association between egos' own stigmatizing beliefs and the stigmatizing beliefs of their alters. Therefore, we specified an autoregressive model using the linear network autocorrelation model (*lnam*) function in the *sna* package that allowed us to simultaneously model both individual- and network-level effects by taking into account the correlations between the residuals of egos and alters (Leenders, 2002; O'Malley and Marsden, 2008).

The extent of missing data differed by variable: 88 respondents were missing one or more responses for the HIV-related stigma scale, while only 15 were missing age. Eighty-four (5.4%) people without HIV were missing the stigma scale, while 4 (3.4%) people with HIV were missing the stigma scale ($\chi^2 = 0.50$, $p = 0.48$). We used standard multiple imputation in R to create 10 multiply imputed datasets. Multiple imputation proceeded under the assumption of missingness at random, allowing missingness to depend on observed variables and to take full advantage of all observed correlations when generating imputations. The resulting datasets contained 1648 observations, and the remaining 21 observations missing social network information were not included in the regression analyses. The unadjusted bivariate analyses and the nested taxonomy of regression analyses were conducted with each of the imputed datasets, and the parameter estimates and standard errors were adjusted for variability among imputations based on Rubin's combination rules (Little and Rubin, 2002).

We conducted two types of sensitivity analyses. First, we evaluated the robustness of the association between exposure and outcome using the *E*-value, defined as the minimum strength of association that an unmeasured confounder would need to have with both the exposure and outcome, conditional on the measured covariates, to explain away any observed exposure-outcome association. We calculated the *E*-value using an approximated risk ratio based on the standardized effect size ($RR \approx \exp(0.91 \times d)$, as recommended by VanderWeele and Ding (2017). Second, we fitted the final model using the average stigma score only of alters who did not report being HIV positive (i.e., they reported being HIV-negative or did not know their serostatus), to account for the possibility that HIV-positive alters may have lower levels of HIV-related stigma compared with HIV-negative alters or alters of unknown serostatus.

4. Results

4.1. Descriptive statistics

We interviewed 1669 of 1747 (95.5%) eligible respondents. The mean age of respondents was 37 years (standard deviation [*SD*] 18.1), and most respondents were women (926 [54%]), married (939 [58%]), Protestant (1135 [69%]), and did not complete primary school (1127 [69%]) (Table 1). Seven percent (113) of respondents reported being HIV-positive. More than a quarter (497 [30%]) of the respondents believed that the HIV prevalence of the community was greater than 50%. The average AIDS-Related Stigma Score was 0.79 (*SD* 0.50). Most respondents (97%) had stigma scores less than 2.

In response to the name generators, respondents nominated an average of 5.35 (*SD* 2.99, range 0–19) non-overlapping alters (outdegree). When including both alters nominated by the ego and alters who nominated the ego (total degree), the mean number of alters was 9.77 (*SD* 5.52, range 0–55). The mean outdegree and total degree are comparable to those reported in social network studies conducted in a variety of settings worldwide (Chami et al., 2017; Marsden, 1987; Shakya et al., 2017; Yamanis et al., 2016). Almost half (757 [45%]) of the egos had at least one alter who reported being HIV positive. In total, 1870 people were included in the social network of the community, with the network graph shown in Fig. 1.

Table 1
Summary statistics ($N = 1669$).

		Mean or *N*	*SD* or Percent
Individual Variables			
Age	Less Than 30 Years	694	42%
	30–39 Years	330	20%
	40–49 Years	266	16%
	50–59 Years	134	8%
	60 Years or More	230	14%
Sex	Female	913	58%
	Male	707	42%
Marital Status	Married	935	57%
	Divorced/Separated	269	16%
	Single	436	27%
Religion	Catholic	407	24%
	Protestant	1148	69%
	Other	79	5%
Household Asset Quintile	Poorest	273	16%
	Less Poor	316	19%
	Middle	327	20%
	Richer	383	23%
	Richest	370	22%
Education	Less than Primary School Completion	1143	68%
	Completed Primary School	508	30%
HIV-Positive		116	7%
Perceives HIV Prevalence as > 50%		503	30%
AIDS-Related Stigma Scale		0.79	0.50
Network Variables			
Number of Alters		9.77	5.52
Eigenvector Centrality		0.040	0.074
Presence of an HIV-Positive Alter		757	46%
Mean Stigma Score of Alters		0.76	0.25

Column percentages within categories may not add to 100% due to missing data.

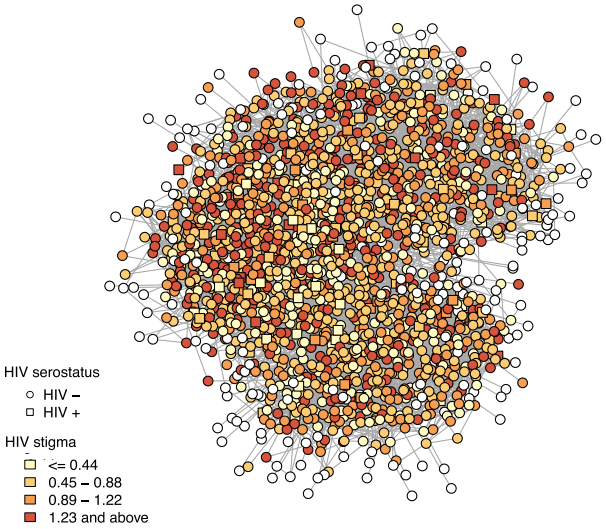

Fig. 1. Social network graph of the Nyakabare Parish population.

4.2. Correlates of HIV-related stigma

In bivariate analyses (Table 2, first column), egos' HIV-related stigma scale scores were significantly correlated with the average stigma score of their alters ($b = 1.03$ per point on the stigma scale; 95% confidence interval [*CI*] 1.01 to 1.04, $p < 0.001$). In addition, self-reported HIV seropositivity ($b = 0.14$; 95% *CI* 0.014 to 0.27, $p = 0.03$) and thinking that HIV is highly prevalent in the community (b = 0.34; 95% *CI* 0.04 to 0.30, $p < 0.001$) were associated with higher levels of HIV-related stigma.

Columns 2 and 3 of Table 2 show a nested taxonomy of multivariable linear regression models. Model 1 includes the ego's individual characteristics. Model 2 includes additional individual characteristics (HIV serostatus, perception of HIV prevalence in the community, village size) and network characteristics (eigenvector centrality, whether he or she has alters with HIV, and the average stigma score of the ego's alters). In this model, we found that egos' HIV-related stigma scale scores were significantly correlated with the average stigma score of their alters ($b = 0.53$ per point on the stigma scale; 95% *CI* 0.42 to 0.63, $p < 0.001$). In terms of the magnitude of this estimate, the estimated regression coefficient was slightly larger than the sample standard deviation (0.53/0.50 = 1.05). In relative terms, the estimated regression coefficient was approximately two-thirds of the sample mean (0.53/0.79 = 0.67). Both of these calculations imply an estimate that is substantively and statistically significant.

Of note, egos with an HIV-positive alter had higher HIV-related stigma scores on bivariate analysis ($b = 0.26$; 95% *CI* 0.016 to 0.314, $p < 0.001$) but lower HIV-related stigma scores in the final multivariable regression model (b =-0.053; 95% *CI* −0.104 to −0.003, $p = 0.040$). This result was largely driven by the inclusion of two covariates in the multivariable regression model: age and alters' average stigma score. When either covariate was added to the bivariate model, the positive association between egos' HIV-related stigma score and having an HIV-positive alter flipped and became negative.

Sensitivity analysis for unmeasured confounding showed that only

Table 2
Correlates of egos' HIV-related stigma (N = 1648).

	Unadjusted	Model 1	Model 2
	b (95% *CI*)	*b* (95% *CI*)	*b* (95% *CI*)
Intercept		0.034 (0.024, 0.044)***	-0.004 (-0.015, 0.008)
Individual Variables			
Age	0.016 (0.014, 0.017)***	0.004 (0.002, 0.006)**	0.001 (-0.001, 0.003)
Sex			
Female	Ref	Ref	Ref
Male	0.564 (0.493, 0.635)***	0.071 (0.007, 0.134)*	0.014 (-0.039, 0.066)
Marital Status			
Single	0.488 (0.416, 0.559)***	0.085 (0.014, 0.156)*	0.000 (-0.067, 0.066)
Divorced/Separated	0.347 (0.209, 0.486)***	0.007 (-0.075, 0.090)	0.007 (-0.072, 0.087)
Married	Ref	Ref	Ref
Religion			
Catholic	0.782 (0.719, 0.844)***	0.485 (0.389, 0.582)***	0.155 (0.053, 0.256)**
Protestant	0.774 (0.732, 0.816)***	0.489 (0.409, 0.570)***	0.166 (0.076, 0.257)***
Other	Ref	Ref	Ref
Household Asset Index	0.180 (0.166, 0.193)***	0.038 (0.018, 0.057)***	0.003 (-0.015, 0.022)
Education			
Less than Primary School Completion	Ref	Ref	Ref
Completed Primary School	0.288 (0.220, 0.356)***	-0.049 (-0.110, 0.013)	-0.072 (-0.130, -0.014)*
HIV Positive	0.142 (0.014, 0.270)*		-0.065 (-0.162, 0.032)
Perceives HIV Prevalence as > 50%	0.335 (0.272, 0.397)***		0.054 (0.002, 0.106)*
Population of village	0.004 (0.003, 0.004)***		0.001 (0.000, 0.001)*
Network Variables			
Eigenvector Centrality	5.297 (0.670, 9.923)*		0.134 (-0.204, 0.472)
Presence of an HIV-Positive Alter	0.258 (0.016, 0.314)***		-0.053 (-0.104, -0.003) *
Mean Stigma Score of Alters	0.977 (0.946, 1.008)***		0.527 (0.423, 0.630)***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

an unmeasured confounder that was strongly associated with the egos' and their alters' average stigma scores, above and beyond the measured covariates included in the regression models, could explain away the estimated association. Using the conversion formula provided by VanderWeele and Ding (2017), we obtained an approximate relative risk of 2.61 (95% *CI* 2.16 to 3.15) and an *E*-value of 4.66. Thus, strong confounding from an unmeasured confounder would be required to explain away the estimated association. The *E*-value analysis showed a less robust association between egos' stigma scores and having an alter with HIV, with an approximate *E*-value of 1.44.

Sensitivity analysis for the final model conducted using the average stigma score of alters without HIV showed estimated coefficients that were similar in terms of magnitude and direction (Supplementary Table).

5. Discussion

In this population-based, sociocentric social network study from rural Uganda, we found important evidence of peer associations in HIV-related stigma. We found that an ego's HIV-related stigma score was higher if his or her alters' stigma scores were higher, and an ego's HIV-related stigma score was lower if he or she had one or more alters with HIV. The estimated associations were statistically significant, robust to the inclusion of multiple covariates including HIV serostatus and perceived HIV prevalence, and were also robust to adjustment for unmeasured network confounders with the autocorrelation model.

Consistent with our hypothesis, an ego's HIV-related stigma score was positively correlated with the average stigma score of his or her alters. Similar findings in the clustering of health-related attitudes among social network peers have been found in studies of other health behaviors, including polio vaccine hesitancy (Onnela et al., 2016), latrine ownership (Shakya et al., 2015), and HIV risk and preventive behaviors (Kuhns et al., 2017; Mulawa et al., 2016a, 2016b; Perkins et al., 2018a). Several mechanisms could link social ties to HIV-related stigma. First, alters can directly influence an ego's attitudes toward PLH. Second, alters can indirectly influence an ego's attitudes toward PLH by shaping his or her underlying knowledge about HIV (Kalichman et al., 2005), perceived access to HIV treatment (Castro and Farmer, 2005; Chan and Tsai, 2016; Chan et al., 2015; Perkins et al., 2018a; Wolfe et al., 2008), and HIV prevalence (Genberg et al., 2009), all of which have been associated with lower levels of HIV-related stigma. Third, alters can shape cultural beliefs that create hierarchies of physical or behavioral characteristics that are considered desirable or undesirable (Link and Phelan, 2001). Fourth, alters can also shape the norms of reciprocity in the community; when a person is unable to engage in the norms of reciprocity, they become targets of stigma (Neuberg et al., 2000). For example, when a person with mental illness violates norms of social exchange, he or she generates feelings of danger, uncertainty, and defensiveness in others, and thereby loses moral standing in the community (Yang and Kleinman, 2008). Similarly, when PLH are perceived to lack the ability to participate in reciprocal economic exchange because of HIV-associated illness, this circumstance can lead to stigmatization of PLH in resource-limited settings (Tsai et al., 2013b).

We also found that an ego who has one or more HIV-positive alters reported lower levels of HIV-related stigma, providing evidence potentially consistent with the contact hypothesis (Allport, 1954). Prior literature has shown that people who live in higher-prevalence communities tend to have less stigmatizing attitudes toward PLH (Genberg et al., 2009). Subsequent studies have shown that personal contact with PLH is negatively correlated with stigmatizing attitudes toward PLH, and that the inverse association is stronger when the PLH is a family member or a friend (Chan and Tsai, 2017; Mall et al., 2013). Our regression models adjusted for perceived HIV prevalence, and showed that being connected to a PLH, rather than the belief that having HIV is normative in the community, is associated with less stigma. This finding is consistent with Allport's original theory that superficial contact does not decrease negative attitudes, and that stigma reduction requires contact between people of equal status in pursuit of common interests (Allport, 1954). The finding is particularly notable because thirty percent of the respondents stated that they believed more than half of their community was HIV positive – an order of magnitude higher than the actual prevalence of HIV in the community.

Consistent with the theory that stigmatization requires differential

access to power (Link and Phelan, 2001), eigenvector centrality, a measure of how well-connected an ego is to other well-connected alters, was positively correlated with stigma. However, educational attainment was negatively correlated with stigma. In prior studies, the association between educational attainment and stigma has been mixed, (Chiao et al., 2009; Stuber et al., 2009; Tsai and Venkataramani, 2015; Wolfe et al., 2008), while knowledge specifically about the disease condition has been associated with lower levels of stigma (Bogart et al., 2008; Girma et al., 2014; Mugoya and Ernst, 2014; Yang et al., 2006; Youssef et al., 2018). We further found that those who identified with Protestant or Catholic faith had higher levels of HIV-related stigma compared to those who identified as neither. While prior studies have shown associations between Judeo-Christian religious beliefs and higher levels of HIV-related stigma primarily through the stigmatization of behaviors associated with HIV transmission (Bluthenthal et al., 2012; Diaz and Ayala, 1999; Quinn and Dickson-Gomez, 2016; Quinn et al., 2018; Varas-Diaz et al., 2010; Zou et al., 2009), these studies also show that religious beliefs and organizations serve as sources of support for PLH (Quinn et al., 2018) and provide motivation to care for PLH (Bluthenthal et al., 2012; Varas-Diaz et al., 2010).

Egos' self-reported HIV serostatus was positively correlated with stigma in bivariate analyses (but the association did not persist as statistically significant after the inclusion of demographic and network variables). Research assistants were not blinded to respondents' self-reported HIV serostatus, but the two sections of the lengthy questionnaire were not placed adjacent to each other, so it is unlikely that research assistants' administration of these questions differed systematically for PLH compared with respondents who reported that their serostatus was unknown or HIV-negative. For PLH who endorsed any of the stigma items, their responses may reflect internalized stigma, which occurs when PLH accept their discredited status as valid and develop self-defacing internal representations of themselves along with guilt, shame, and other negative self-perceptions (Ashaba et al., 2018; Pantelic et al., 2015; Pantelic et al., 2019; Steward et al., 2008; Tsai et al., 2013c; Turan et al., 2017a). Prior work has proceeded similarly in studying how PLH may or may not endorse negatively worded items like those contained in the AIDS-Related Stigma Scale, also interpreting such responses as potentially being consistent with internalized stigma (Tsai, 2015). This approach is also consistent with studies in which parallel scale items—nearly identical in scope but phrased differently—are administered to PLH vs. respondents in the general population in order to measure internalized stigma among PLH and negative attitudes toward PLH among people in the general population (Visser et al., 2008).

5.1. Limitations

Interpretation of our findings is subject to limitations. First, the data are cross-sectional, which limits our ability to make causal inferences. While our network autocorrelation model (Leenders, 2002) attempts to account for exogenous, unmeasured influences that affect people who are connected to each other, our associational findings cannot distinguish between peer influence vs. homophily (McPherson et al., 2001). The e-value sensitivity analysis suggests that the observed association between egos' HIV-related stigma and stima among their alters is robust to unobserved confounding. However, the observed association between egos' HIV-related stigma and having HIV-positive social ties was less robust; namely, it is possible that somewhat weaker confounding could explain away the observed association. Second, the data are all self-reported and therefore subject to the limitations inherent to all studies based on self-report data. Even though the study was conducted in a confidential manner, respondents may have chosen to hide their HIV serostatus due to fear of stigmatization, or hide their stigmatizing attitudes towards HIV due to social desirability (i.e., if they think others do not share this view), leading to underestimation of those variables. Third, while egos were instructed to name alters who resided within the parish, some egos named alters who resided outside of the parish, and this may have affected the calculated centralities for the egos. Finally, questions to elicit social ties can be interpreted differently by different respondents (Bearman and Parigi, 2004). However, we formulated name generators that were tailored for the local context and that were concretely phrased to reduce variability in interpretation (Brewer et al., 1999).

6. Conclusions

In this cross-sectional, population-based sociocentric social network study conducted in rural Uganda, we report two main findings. First, egos' HIV-related stigma was correlated with that of their alters. Second, an ego who had HIV-positive alters reported lower levels of HIV-related stigma, even after adjusting for perceived HIV prevalence. Our findings have important implications for policy makers. First, the clustering of negative attitudes towards HIV suggests that changing attitudes toward HIV and PLH may require intervention not only at the level of the individual but also at the level of the network. Such an intervention may (for example) ask a person to recruit members of his or her social network peers to participate in an intervention together, or encourage peer-to-peer communication to create cascades in the diffusion of attitudes (Bouris et al., 2017; Morgan et al., 2019; Schneider et al., 2012; Valente, 2012). Second, our findings suggest that stigma reduction interventions should encourage community members to engage with PLH. Public health campaigns and policies that support judicious disclosure of HIV status, such as Uganda's couples HIV testing and counseling campaign (Knowledge for Health Project, 2012), might have benefits not only for PLH but also for peers, who may be influenced to develop more positive attitudes toward HIV.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2019.05.012.

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