Published in final edited form as:

Med Care. 2017 February ; 55(2): 102–110. doi:10.1097/MLR.0000000000000595.

Multiplex competition, collaboration, and funding networks among health and social organizations: Towards organization-based HIV interventions for young men who have sex with men

Kayo Fujimoto^a, Peng Wang^b, Lisa Kuhns^c, Michael W Ross^d, Mark L. Williams^e, Robert Garofalo^c, Alden S. Klovdahl^a, Edward O. Laumann^f, and John A. Schneider^g

^aDepartment of Health Promotion & Behavioral Sciences, School of Public Health, The University of Texas Health Science Center at Houston 7000 Fannin Street, UCT 2514, Houston, TX 77030-5401

^bCentre for Transformative Innovation, Faculty of Business and Law, Swinburne University of Technology, Hawthorn, Victoria 3122, Australia

^cDivision of Adolescent Medicine, Ann & Robert H. Lurie Children's Hospital, Chicago, IL, and Northwestern University, Feinberg School of Medicine, Department of Pediatrics, Chicago, IL, 225 E. Chicago Avenue, #161, Chicago, IL 60611

^dDepartment of Family Medicine and Community Health, University of Minnesota, Minneapolis 180 West Bank Office Building, 1300 S Second St., Minneapolis, MN 55454

^eDepartment of Health Policy and Management, College of Public Health & Sciences, Florida International University 11200 SW 8th Street, Miami, FL 33199-2516

^fDepartment of Sociology, University of Chicago, 1126 East 59th Street, Chicago, IL 60637

^gDepartments of Medicine and Public Health Sciences and the Chicago Center for HIV Elimination, University of Chicago, Chicago, IL 5837 South Maryland Avenue MC 5065, Chicago, IL 60637

Abstract

Background—Young men who have sex with men (YMSM) have the highest rates of HIV infection in the United States. Decades into the HIV epidemic, the relationships that YMSM-serving health and social organizations have with one another has not been studied in depth.

Objectives—The aim of this study was to examine the competition, collaboration and funding source structures of multiplex organization networks and the mechanisms that promote fruitful relationships among these organizations.

Corresponding authors: John Schneider, 5837 South Maryland Avenue MC 5065, Chicago, IL 60637; (773) 702-8349; jschnei1@medicine.bsd.uchicago.edu.

There is no potential conflicts exist for all authors.

This was presented at Sunbelt XXXVI, International Sunbelt Social Network Conference, New Port Beach, CA, April 2016.

Disclosure of funding:

This study acknowledges and was supported by the National Institutes of Health/NIMH 1R01MH100021 and the National Institutes of Health/NIDA 1R01DA039934, and NIH/NIGMS 1R21GM113694.

Research Design—The study data collection method was a survey of health and social organizations from 2013–2014 in two cities, Chicago IL, and Houston TX.

Subjects—Study participants were representatives from 138 health and social organizations.

Measures—Responses to survey questions were used to reconstruct competition, collaboration and combined competition-collaboration networks.

Results—While taking into consideration the collaborative relationships among organizations, we provide solid statistical evidence that organizations of similar type, similar social media use patterns, comparable patterns of funding, and similar network contexts tended to compete with one another. This competition was less likely to be accompanied by any sort of collaboration if the organizations shared common funding sources.

Conclusions—Competition that excludes potential collaboration may be detrimental to mobilizing the collective efforts that serve local YMSM communities. System-level interventions may provide promising approaches to scaling-up HIV prevention and treatment efforts so as to encourage organizations to form partnerships with otherwise competing providers.

Keywords

social network analysis (SNA); young MSM (YMSM); organizational networks; organizational ecology

INTRODUCTION

Young men who have sex with men (YMSM) have a disproportionately high prevalence and incidence of human immunodeficiency virus (HIV) infection in the United States (1, 2). Organizations where YMSM congregate, socialize, obtain HIV health related services and find romantic partners—physical and virtual settings—are locations where HIV disease transmission may be facilitated, prevented or treated. The organization attendance patterns of YMSM are complex, increasing the challenges of ascertaining risk or protection in various settings. YMSM are likely to be influenced by complex “inter-organization networks” at the macro level, formed through varying relationships among different types of organizations in gay enclaves and in other communities where YMSM reside. Hence, our study uses a social network approach to examine structures of networks among organizations that serve YMSM.

Social network analysis has been used in numerous studies to examine collaboration networks in public health and human services settings as applied to various health issues (3–7). In the HIV service sector, network analysis has demonstrated utility as a tool for analyzing the influence of inter-organizational networks on integration and service coordination among care systems in the United States (8–11). In these studies, collaboration networks were conceptualized as sending and receiving client referrals, as well as exchanging care-related information and/or funds.

However, previous network studies of HIV/AIDS service organizations have been limited in many respects. First, they have been largely restricted to health-related organizations, such as health providers or community-based health centers, as the key players that form (inter-

organizational) networks. These studies seldom considered the wide array of potential other players, such as organizations, businesses, or other venues where risk occurs and protection may fostered. These other venues are also relevant to disease transmission and control in YMSM populations. Second, previous network studies have analyzed only one type of relationship, i.e., uniplex (“single-stranded tie”) networks, based on collaboration among health providers and HIV service organizations. Studies have paid little attention to multiplex (“multi-stranded tie”) networks that may include competition. HIV/STD service organizations, such as the local health department, the offices of private physicians, and community clinics, can be competitors when they depend on similar resources to survive (9) and, if so, may fight to “protect their turf” (12).

This study takes advantage of a network paradigm as applied to organizational studies (13) to investigate the relational structures of competition and possible collaboration between YMSM-serving organizations of various types, with a focus on multiplex organizational networks. From the perspective of local mobilization to improve community health, it is important to examine the social mechanisms that drive competition among organizations, but that also may foster collaboration. In our study, “competition” means contesting for revenue, clientele or membership, employees, or other resources. “Collaboration” means cooperation by working together, formally or informally, on any activity, project, or event for a common benefit.

Increased collaboration within local communities may be important for progress, particularly with regard to complex, seemingly intractable social problems in which stakeholder organizations are, or might be, contending. With regard to the relevance of the present research, it has been suggested that a key prerequisite of effective collaboration is an understanding of the structural relationships among organizations, as well as the distribution of power and resources in inter-organizational networks (14). It follows that a structural analysis of multiplex networks, which comprise both competition and possible collaboration, could inform YMSM network interventions at the organizational level.

This study aims to identify social mechanisms that promote competition within inter-organization networks, as well as concurrent competition and collaboration within these same networks. There are two main objectives. The first objective is to identify organizational and network contexts (15) associated with competition among organizations. We rely on two theoretical frameworks of population ecology (16, 17) and social network perspectives to derive our hypotheses regarding competition. The second objective is to examine circumstances that might influence organizations to collaborate as well as compete by relying on organizational evolution theory (18).

From the perspective of population ecology (16, 17), competition among organizations tends to occur when organizations rely on the same resources, i.e., share the same resource space. This is known as “niche overlap” (17). Functionally similar organizations compete more intensely with one another as they tend to rely on the same resources, i.e., there is more niche overlap (19–24). We conceptualize niche overlap of YMSM-relevant organizations by reference to “niche dimensions” (25): a) organization-type overlap, b) geographic proximity, c) overlap in marketing strategy of social media use in terms of shared uses of social

networking sites and geo-meeting applications, and d) overlap in funding sources (in terms of shared funding type and shared funder). Our first set of hypotheses is that the more similar in niche dimensions two organizations are, the more likely they are to compete with one another (*Hypothesis 1a–1d*).

From the social network perspective, being similarly positioned in an organizational environment by having the same patterns of relationships to the same resources or to other organizations—“structurally equivalence” (15)—drives competition as a result of being easily replaceable in the organizational networks. We define network contexts of structural equivalence in terms of two types of relationships: a) competition, and b) collaboration. Our second set of hypotheses is that more structurally equivalent two organizations are, the more likely they are to compete with one another (*Hypothesis 2a, 2b*).

According to organizational evolution theory (18), members of organizational populations are interdependent and form relationships based on commensalism (18, 26) by which functionally similar populations compete for scarce resources while cooperating to grow their shared resources. This is termed “growth commensalism” (19). It is expected that competing YMSM-relevant organizations also collaborate with one another as a means to increase shared resources by pursuing common interests in securing financial resources from other sources. This is motivated by their common goal of improving health outcomes for YMSM. Based on “growth commensalism,” our third hypothesis is that under the circumstances of sharing common financial sources (i.e., shared funding type and shared funder), it is more likely that competition co-occurs with collaboration between any two organizations (*Hypothesis 3*). Note that *Hypothesis 3* is essentially the extension of *Hypothesis 1d*.

METHODS

Research Design

The current study is a part of a large multisite longitudinal network study known as YMAP (Young Men’s Affiliation Project), conducted in Chicago and Houston. The YMAP aims to harness locational and social network analysis to better target YMSM (aged 16–29) at risk of HIV and other infections. The present analyses provide results from the baseline Phase I organization survey, using data collected in 2013–2014. All study procedures and data collection instruments were approved by the Committees for the Protection of Human Subjects at the University of Texas Health Science Center at Houston, the University of Chicago, and the Ann & Robert H. Lurie Children’s Hospital of Chicago.

Organization Sampling and Data Collection

We sampled 58 organizations in Chicago and 80 organizations in Houston using an informant-driven sampling method based on perceived importance to and/or frequency of attendance by YMSM from a frame of 161 organizations in Chicago and 168 organizations in Houston. The sampling frame was created by compiling a list of organizations from public sources, which advertised to, served, or were frequented by YMSM. These organizations include both physical organizations and organizations without a fixed physical

address and classified as: (1) Risk (e.g., bars, sex establishments, circuit parties); (2) Social (religious or sporting organizations, homeless shelters); (3) Health (clinics, HIV testing centers); and (4) Others (non-fixed-address organizations, such as student or gaming groups). We then sampled organizations from within this frame based on their large size, perceived popularity among YMSM, or perceived salience in the community (i.e., prestige, reputation) with a consensus established among the study team members in each city.

We expected that these interviewed organizations would play an important role in forming/maintaining the inter-organizational networked system, and that many of the non-interviewed organizations would be connected to these interviewed organizations. In both cities, the average numbers of nominations received for collaboration were higher for the interviewed organizations compared to those for the non-interviewed groups (3.9 for Chicago and 4.9 for Houston for interviewed organizations vs 1.2 for Chicago and 3.0 for Houston for non-interviewed organizations). Similarly for competition relation (2.4 for Chicago and 2.9 for Houston for interviewed organizations, vs 1.1 for Chicago and 1.6 for Houston for non-interviewed organizations). That is, the organizations selected for study were more active players in these organizational networks.

We conducted two-three semi-structured interviews with representatives identified at each sampled organization. Inclusion criteria for organization representatives were: (1) having been affiliated with the organization for at least six months; (2) not planning to leave the organization within the next two years; (3) legally able to access the organization (age; e.g., bars, clubs serving alcohol); (4) not intoxicated, mentally or emotionally unstable, or otherwise unable to participate in the interview. Semi-structured questionnaire items were programmed into a computer-assisted personal interviewing (CAPI) format, using Qualtrics software (27). More detailed descriptions of the YMAP, organization selection procedures and organization survey data can be found in the Supporting Information addendum.

Measures

Dependent network variables—This study used relational information: (1) “Competition” was measured by asking representatives whether or not they regarded each organization as a competitor for revenue, clientele or membership, employees, or other resources; (2) “Collaboration” (i.e., cooperation), by asking whether they had worked together on any activity, project, or event with a common goal, formally or informally.

Explanatory organization and relational covariates—Organization types were classified into categories of Health (H), Social (S), Risk (R), or Other (O), and three dummy variables were created for the first three categories. Relational covariates included geo-coded distances (28) in kilometers between organizations; the number of shared social networking sites used (e.g., Facebook, Twitter, Tumblr) and shared use of geo-meeting applications (“apps,” e.g., Grindr); the number of shared funders (based on sponsorship); and a marker for sharing at least one funding type (sales revenue, allocation of monies from a parent company, private grants, public grants, and charity).

Other controlled variables—Our analysis also controlled for organizational characteristics, such as organization size, operating budgets (in USD), years of organization

existence, number of organizational levels (hierarchy), estimated proportion of Black clientele, number of geo-meeting applications/social networking sites used, number of social networking sites used, and conflict between pairs of organizations.

Multivariate Exponential Random Graph Models (ERGMs)

We used multivariate Exponential Random Graph Models (ERGMs) (29, 30) to model the structures of both the collaboration and competition networks and their interactions; that is, how the structures of collaboration and competition networks may affect each other. The models take into account various attributes of the organizations, such as the types and sizes of the organizations. The impacts of other types of networks and the metrics for pairs of organizations, such as the geographical distances, are also built into our modelling framework. The attributes of organizations and metrics for pairs of organizations, hence the potential network ties, are represented in Figure 1.

Our study statistically tested whether our specification of seven ERGM configurations that represent “niche overlap” (*Hypothesis 1a–1d*), “structural equivalence” (*Hypothesis 2a, 2b*) and “growth commensalism” (*Hypothesis 3*) are more likely to be observed when compared to those expected by chance. We used the software XPNNet to estimate model parameters and assess model goodness of fit (31). More detailed descriptions of ERGMs, including a brief review and mathematical expressions can be found in the Supporting Information addendum.

RESULTS

Descriptive Statistics

The organizational and relational characteristics of organizations for each city are provided in Table 1.

Visualization of Multiplex Organization Networks

Figure 2 provides illustrations of the multiplex organization networks for each city (left side for Houston, right for Chicago). The first organization network (upper graphs) includes combined competition (red) and collaboration ties (green) in relation to organization types (by colored nodes). The second set of graphs (lower graphs) adds funding relationships (shared funder, type of funder) on top of competition ties. To draw both networks, we used NetworkX (32).

Among Houston’s organizations (top-left graph), competition tends to be clustered mainly within risk organizations (brown nodes) and social organizations (yellow nodes). Competition tends to co-occur with collaboration among health venues (green nodes). In contrast, among Chicago’s organizations (right-top graph), competition network tends to be less dense among risk organizations (brown nodes) compared to the counterpart in Houston. Competition tends to co-occur with collaboration among health organizations (green nodes) more densely than in Houston. As for shared-funder networks (orange ties), Houston’s organizations (bottom-left graph) display much denser networks compared to Chicago’s organizations (bottom-right graph).

Multivariate ERGMs

Table 2 presents the estimated multivariate ERGM parameter and standard errors estimates for structural effects for competition (labeled as B), collaboration (labeled as A), and combined networks. We consider a parameter to be statistically significant at the $\alpha = .05$ level for two-sided tests. Empty cells indicate zero effects. Our final models provide adequate fit to all network statistics for both cities. Additional information, including results and interpretations of other controlled variables, is available upon request. [Insert Table 2] *Basic structural effects for competition.* In Chicago, a few organizations competed more with other organizations than we would expect from random networks. Additionally, results indicate a hierarchical competition structure in the sense that organizations tended not to compete with a competitor's competitor except as part of a triadic competition closure (or competition triangles) in Chicago. For Houston organizations, however, competitions tended to be more reciprocal and not as hierarchical.

Basic structural effects for competition-collaboration networks—Both Chicago and Houston organizations that were seen as competitors by others also tended to be regarded as collaborators. Chicago organizations were less active in seeking collaboration and in competing with others. As well, in Chicago, organizations viewed as competitors tended not to name others as collaborators. On the other hand, the Houston organizations that were seen as collaborators by other organizations tended not to name others as competitors.

“Niche overlap” for competition networks—Only Houston organizations tended to compete with other organizations of the same type. This result supports our *Hypothesis 1a* only for Houston. In both cities, geographic distance was not associated with competition, which does not support our *Hypothesis 1b*. For Chicago organizations, however, being geographically closer was associated with collaboration, while being geographically more distant was associated with the co-occurrence of collaboration and competition. As for sharing the same (social media) networking sites, only in Chicago was this associated with competition. There was no evidence of shared geo-applications that led to competition in either city. These results partially support our *Hypothesis 1c*. Results regarding funding sources, that is, funding type and shared funders, demonstrated that organizations tended to compete with each other when they shared one or more common funding types in both Chicago and Houston, and when they shared more common funders in Houston only. This result partially supports our *Hypothesis 1d*.

“Structural equivalence” for competition networks—Competition was more likely to take place among organizations that occupy similar patterns of competition with other organizations only in Houston. This result supports our *Hypothesis 2a* for Houston only. In both cities, competition was more likely to occur among organizations that occupy similar patterns of collaboration with other organizations. This result supports our *Hypothesis 2b*.

“Growth commensalism” for competition-collaboration networks—In both Chicago and Houston, competition was less likely to be accompanied by any collaboration if organizations shared at least one common funding type. This trend of co-occurrence

between competition and collaboration was observed if organizations shared more common funders only in Chicago. These results do not support our *Hypothesis 3* about growth commensalism.

DISCUSSION

Previous public health research has suggested that similar organizations often work together to coordinate services, develop joint programs, and send/receive client referrals where appropriate (7). Our study provides strong evidence of common resources as generators of competition, rather than collaboration among organizations (33). Specifically, organizations of similar types, social media use patterns, and funding patterns tended to compete. These results indicate that niche overlap in these dimensions drives competition among organizations in local communities. Additionally, our study indicates that structural equivalence, occupying similar network contexts, is associated with competition.

There were some differences in niche dimensions of competition found in the two cities. For instance, similarity in organization type was linked to competition in Houston only. In Chicago, shared use of online networking sites was associated with more competition. It was not in Houston. A greater proportion of organizations were health organizations for which a few large organizations dominated the market in Chicago. This may have suppressed competition. The widespread availability and use of online networking sites, however, may have “leveled the playing field” to some degree, facilitating competition among organizations.

Concerning the niche dimension of financial resources, in both Chicago and Houston, sharing common funding types was associated with competition. This kind of competition, however, tended not to be accompanied by collaboration; i.e., organizations engaged in both competition and collaboration were less likely to share common funding types than would be expected by chance. Given a strong tendency for competition and collaboration to co-occur in both cities, shared funding types did not appear to be a relevant factor. Instead, we found geographic proximity as a strong factor related to co-occurrence of competition and collaboration in Chicago. One potential explanation for this finding is that organizations that compete across multiple geographic markets (spatial multipoint competitors) see each other as collaborators in some areas. This is consistent with research on inter-hospital collaboration networks (34).

With regard to shared funders, our findings indicate potential cultural differences in the two cities. In Houston, having more shared funders was associated with more competition, yet this tendency was not observed in Chicago. This may reflect more competition for scarce resource space in Houston, as our data indicate that the average number of shared funders for Houston is higher than that for Chicago (10 for Houston and 6 for Chicago). Additionally, Chicago may have a relatively more stable and generous public/private funding environment compared to Houston. There are also political differences between the two states with regard to same-sex laws. Illinois was the first state to repeal its same-sex laws, and same-sex sexual activity has been legal since 1962, when Illinois became the first U.S. state to repeal its sodomy laws. In contrast, such a repeal did not happen in Texas until 2003,

over 40 years later, when the Supreme Court ruled the state's sodomy law unconstitutional. Having a more permissive or welcoming environment may create more funding opportunities for organization serving YMSM, providing organizations with fewer overlapped common funders.

The findings of our study have certain limitations. First, our network data are cross-sectional, which makes it difficult to infer causal relationships. For instance, we are not certain whether structural equivalence drives competition or whether competition results in structural equivalence. Similarly, our results are limited in inferring any causal relation between funding sources and the co-occurrence of competition and collaboration.

Second, our study was not designed to take into account exogenous economic variables, such as the size of relevant funding pools relative to need. When/where more funds are available to control and prevent the spread of HIV and other infectious diseases relative to need, cooperation, and coordination among providers of health services may be greater and competition less, as anecdotal accounts from Chicago suggest.

Despite these limitations, our study demonstrates that a better understanding of coterminous networks of competition and cooperation is essential for accurately comprehending a variety of empirical phenomena (19). Our study found that shared (and limited) funding sources can drive competition and that such competition is likely to discourage collaboration. Competition that excludes potential collaboration is detrimental to mobilizing communities for collective efforts to better serve health populations, including local MSM communities. One possible solution is to encourage health service provider grantees to form partnerships with the otherwise competing providers. This might be achieved by implementing common funding programs to achieve shared goals of better serving local communities. Such a funding program has been implemented on at least one previous occasion and has provided evidence of enhanced collaboration among organizations (35).

There are few effective HIV intervention programs targeting YMSM (36, 37). Some have suggested an urgent need for novel HIV interventions that engage YMSM which addresses socio-demographic, structural, and biological determinants of HIV risk and infection (1, 38, 39). Few studies, however, have attempted to address these issues, and they have been limited to clinical needs and have focused exclusively on health service interventions (40–42).

Our findings demonstrate the importance of a systems model for HIV prevention by shifting the focus from individuals to structural factors at multiple levels (43, 44). System-level interventions may provide promising approaches to strengthening, disseminating, and scaling-up HIV and other infection prevention and treatment efforts by focusing on programs aimed at improving the functioning of local organizations that deliver services and provide resources to communities (45). Our study provides valuable information that can help guide design, implementation, and delivery of effective organization-level HIV interventions (46–50) tailored to young MSM in the United States.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We acknowledge Dennis Li, Ju Yeong Kim, Kimberly Fisher, Kaitlyn Jaffe, and Erik Lindsley. We also acknowledge Houston Health Department and Chicago Health Department for providing us with HIV incidence data, and contributions of YMAP staff in both Houston and Chicago to this study.

References

1. Oster AM, Johnson CH, Le BC, et al. Trends in HIV prevalence and HIV testing among young MSM: five United States cities, 1994–2011. *AIDS Behav.* 2014; 18:S237–S247. [PubMed: 23955658]
2. Torian LV, Forgione LA. Young MSM at the leading edge of HIV in New York City: back to the future? *JAIDS.* 2015; 68(4):e63–e68. [PubMed: 25559598]
3. Fujimoto K, Valente TW, Pentz MA. Network structural influences on the adoption of evidence-based prevention in communities. *J Community Psychol.* 2009; 37(7):830–845.
4. Mercken L, Saul JE, Lemaire RH, et al. Coevolution of information sharing and implementation of evidence-based practices among North American Tobacco Cessation Quitlines. *Am J Public Health.* 2005; 105(9):1814–22.
5. Shoham DA, Mundt MP, Gamelli RL, et al. The social network of a burn unit team. *J Burn Care Res.* 2015; 36(5):551–557. [PubMed: 25501788]
6. Valente TW, Chou CP, Pentz MA. Community coalitions as a system: effects of network change on adoption of evidence-based substance abuse prevention. *Am J Public Health.* 2007; 97(5):880–886. [PubMed: 17329667]
7. Wickizer TM, Von KM, Cheadle A, et al. Activating communities for health promotion: a process evaluation method. *Am J Public Health.* 1993; 83:561–567. [PubMed: 8460735]
8. Kwait J, Valente TW. Interorganizational relationships among HIV/AIDS service organizations in Baltimore: a network analysis. *J Urban Health.* 2001; 78(3):468–487. [PubMed: 11564850]
9. Thomas JC, Carter C, Torrone E, et al. Pulling together: interagency coordination and HIV/STD prevention. *J Public Health Man.* 2008; 14(1):E1–E6.
10. Thomas JC, Isler MR, Carter C, et al. An interagency network perspective on HIV prevention. *Sex Transm Dis.* 2007; 34(2):71–75. [PubMed: 16778741]
11. Wright ER, Shuff IM. Specifying the integration of mental health and primary health care services for persons with HIV/AIDS: the Indiana integration of care project. *Soc Networks.* 1995; 17:319–340.
12. Thomas JC, Clark M, Robinson J, Monnett M, et al. The social ecology of syphilis. *Soc Sci Med.* 1999; 48(8):1081–1094. [PubMed: 10390046]
13. Borgatti SP, Foster PC. The network paradigm in organizational research: a review and typology. *J Manage.* 2003; 29(6):991–1013.
14. London, S. On collaboration. *TATE*; 2012. Building collaborative communities; p. 74-83.
15. Burt RS, Talmud I. Market niche. *Soc Networks.* 1993; 15:133–149.
16. Hannah MT, Freeman J. The population ecology of organizations. *Am J Sociol.* 1977; 82:929–984.
17. Hannan, MT.; Freeman, J. *Organizational Ecology*. Cambridge, MA: Harvard University Press; 1989.
18. Aldrich, HE.; Ruef, M. *Organizations Evolving*. 2. London: Sage Publications; 2006.
19. Ingram P, Yue LQ. Structure, affect and identity as bases of organizational competition and cooperation. *Acad Manag Ann.* 2008; 2(1):275–303.
20. McPherson M. An ecology of affiliation. *Acad Manag Ann.* 1983; 48:519–532.
21. Sørensen JB. Recruitment-based competition between industries: a community ecology. *Ind Corp Change.* 2004; 13(1):149–170.

22. Housman M, Al-Amin M. Dynamics of ambulatory surgery centers and hospitals market entry. *Health Serv Manage Res.* 2013; 26(2–3):54–64. [PubMed: 25595002]
23. Baum JAC, Mezas SJ. Localized competition and organizational failure in the Manhattan hotel industry 1898–1990. *Admin Sci Quart.* 1992; 36:187–218.
24. Popielarz PA, Neal ZP. The niche as a theoretical tool. *Annu Rev Sociol.* 2007; 33:65–78.
25. Sohn M-W. A relational approach to measuring competition among hospitals. *Health Serv Res.* 2002; 37(2):457–482. [PubMed: 12036003]
26. Monge, P.; Contractor, NS. *Theories of Communication Networks.* New York: Oxford University Press; 2003.
27. Qualtrics. Provo; Utah, USA: 2005.
28. Vincenty T. Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations. *Survey Review.* 1975; XXII:176.
29. Pattison PE, Wasserman S. Logit models and logistic regressions for social networks. II. Multivariate relationships. *Bri J Math Stat Psy.* 1999; 52:169–193.
30. Wang, P. ERGM extensions: models for multiple networks and bipartite networks. In: Lusher, D.; Koskinen, J.; Robins, GL., editors. *Exponential Random Graph Models for Social Networks: Theories, Methods and Applications.* Cambridge: Cambridge University Press; 2013. p. 115-129.
31. Wang, P.; Robins, G.; Pattison, P. *PNet: A program for the simulation and estimation of exponential random graph models.* Australia: University of Melbourne; 2009.
32. Hagberg, AA.; Schult, DA.; Swart, PJ. Exploring network structure, dynamics, and function using NetworkX. In: Varoquaux, G.; Vaught, T.; Millman, J., editors. *Proceedings of the 7th Python in Science Conference (SciPy2008);* Pasadena, CA. 2008. p. 11-15.
33. Monge P, Heiss B, Margolin DB. Communication network evolution in organizational communities. *Communication Theory.* 2008; 18:449–477.
34. Lomi A, Pallotti F. Relational collaboration among spatial multipoint competitors. *Soc Networks.* 2012; 34:101–111.
35. Schoen MW, Moreland-Russell S, Prewitt K, Carothers BJ. Social network analysis of public health programs to measure partnership. *Soc Sci Med.* 2014; 123:90–95. [PubMed: 25462609]
36. Mustanski BS, Newcomb ME, Du Bois SN, Garcia SC, Grov C. HIV in young men who have sex with men: A review of epidemiology, risk and protective factors, and interventions. *J Sex Res.* 2011; 48:218–253. [PubMed: 21409715]
37. Hemmige V, McFadden R, Cook S, Tang H, Schneider JA. HIV prevention interventions to reduce racial disparities in the United States: A systematic review. *J Gen Intern Med.* 2012; 27(8):1047–1067. [PubMed: 22798215]
38. Pingel ES, Thomas L, Harmell C, Bauermeister JA. Creating comprehensive, youth centered, culturally appropriate sex education: what do young gay, bisexual, and questioning men want? *Sex Res Social Policy.* 2013; 10(4):293–301.
39. Balaji AB, Bowles KE, Le BC, Paz-Bailey G, Oster AM. for the NHBS Study Group. High HIV incidence and prevalence and associated factors among young MSM, 2008. *AIDS.* 2013; 27:269–278. [PubMed: 23079807]
40. Maulsby C, Millett G, Lindsey K, et al. A systematic review of HIV interventions for black men who have sex with men (MSM). *BMC Public Health.* 2013; 13(6):625. [PubMed: 23819660]
41. Magnus M, Jones K, Phillips G 2nd, et al. Characteristics associated with retention among African American and Latino adolescent HIV-positive men: results from the outreach, care, and prevention to engage HIV-seropositive young MSM of color special project of national significance initiative. *JAIDS.* 2010; 53:529–536. [PubMed: 19755914]
42. Hightow-Weidman LB, Smith JC, et al. Keeping them in “STYLE”: finding, linking, and retaining young HIV-positive black and Latino men who have sex with men in car. *AIDS Patient Care St.* 2011; 25:37–45.
43. Sullivan PS, Peterson J, Rosenberg ES, Kelley CF, Cooper H, Vaughan A, et al. Understanding Racial HIV/STI Disparities in Black and white men who have sex with men: a multilevel approach. *PLOS ONE.* 2014; 9(3):e90514. [PubMed: 24608176]

44. Latkin CA, Weeks MR, Glasman L, et al. A dynamic social systems model for considering structural factors in HIV prevention and detection. *AIDS Behav.* 2010; 14:S222–S238.
45. Bauermeister JA, Tross S, Ehrhardt AA. A review of HIV/AIDS system-level interventions. *AIDS Behav.* 2009; 13(3):430–448. [PubMed: 18369722]
46. Fujimoto K, Wang P, Ross MW, et al. Venue-mediated weak ties in multiplex HIV risk transmission networks among drug-using male sex workers and associates. *Am J Public Health.* 2015; 105(6):1128–1135. [PubMed: 25880956]
47. Fujimoto K, Williams ML, Ross MW. Venue-based affiliation network and HIV risk behavior among male sex workers. *Sex Transm Dis.* 2013; 40(6):453–458. [PubMed: 23677019]
48. Holloway IW, Rice E, Kipke MD. Venue-based network analysis to inform HIV prevention efforts among young gay, bisexual, and other men who have sex with men. *Prev Sci.* 2014; 15:419–427. [PubMed: 24464324]
49. Schneider JA. Sociostructural 2-mode network analysis: critical connections for HIV transmission elimination. *Sex Transm Dis.* 2013; 40(6):459–461. [PubMed: 23677020]
50. Schneider JA, Walsh T, Cornwell B, et al. HIV health center affiliation networks of black men who have sex with men: disentangling fragmented patterns of HIV prevention. *Sex Transm Dis.* 2012; 39(8):598–604. [PubMed: 22801341]

Figure 1.
Model specifications of network configurations for multivariate exponential random graph models (ERGMs)

Figure 2.
Multiplex venue networks of competition and collaboration (upper graphs), and shared funders and funding types (lower graphs)

Table 1

Descriptive statistics for our organization sample: Percentages with size *n* or means with standard deviations and min and max values for organizational characteristics and relational information

		Chicago (<i>N</i> = 58)	Houston (<i>N</i> = 80)
	Category	Percentage (<i>n</i>) or Mean (<i>SD</i> ; <i>Min</i> , <i>Max</i>)	
Organization type	Health	35% (20)	13% (10)
	Risk	29% (17)	25% (20)
	Social	29% (17)	36% (29)
	Others	7% (4)	26% (21)
Organization size	0 th –50 th percentile	50% (29) [0, 39)	50% (40) [0, 35.5)
	50 th –75 th percentile	24% (14) [39, 505.25)	22.5% (18) [35.5, 125)
	75 th –90 th percentile	16% (9) [505.25, 2571.20)	17.5% (14) [124, 464.8)
	90 th –100 th percentile	10% (6) [2571.20, 500040)	10% (8) [464.8, 1840)
Organization age in years		21.63 (20.14, 1, 114)	18.96 (19.74, 0, 96)
Number of org. levels		4.19 (1.89, 1, 10)	3.72 (1.64, 1, 11)
Operating budgets in dollars	0 th –25 th percentile	19% (5) [3750, 10000)	26% (14) [0, 6250)
	25 th –50 th percentile	31% (8) [10000, 310000)	22% (12) [6250, 84000)
	50 th –75 th percentile	23% (6) [310000, 1750000)	26% (14) [84000, 668750)
	75 th –100 th percentile	27% (7) [1750000, 40000000)	26% (14) [668750, 60000000)
Number of social networking site used		1.48 (1.22, 0, 5)	1.54 (1.36, 0, 6)
Number of geo-meeting applications used		0.38 (1.14, 0, 6)	0.5 (1.34, 0, 7)
Perceived % of Black clientele		44 (34, 5, 99)	23 (24, 0, 99)
Number of shared funders		6.07 (6.90, 0, 25)	10.18 (11.24, 0, 39)
Number of funders		2.12 (2.77, 0, 12)	3.19 (5.39, 0, 25)
Number of funded types		1.91 (1.27, 0, 5)	1.48 (1.07, 0, 5)
Funding type (multiple types can be chosen)	Revenue	57% (33)	59% (47)
	Allocation money	22% (13)	19% (15)
	Private grants	33% (19)	18% (14)
	Public grants	47% (27)	14% (11)
	Charity	33% (19)	39% (31)
Km of pair-wise geographic distances		8.68 (5.92, 0, 26.89)	4.48 (4.17, 0, 22.51)
Number of collaboration ties		3.86 (3.32, 0, 12)	4.89 (5.56, 0, 37)
Number of competition ties		2.43 (3.50, 0, 17)	2.9 (3.79, 0, 14)
Number of conflict ties		0.47 (0.96, 0, 4)	0.63 (1.29, 0, 7)

Note: In Chicago, there were 1.7% missing cases for Organization age in years variable, 8.6% for Number of org. levels variable, 55.2 % for Operating budgets in dollars variable, and 14.9% for Km of Pair-wise geo-distances variable. In Houston, there were 1.3% missing cases for Organization type variable, 1.3% for Number of org. hierarchy variable, 32.5 % for Operating budgets in dollars variable, and 46.5% for Km of pair-wise geographic distances variable. In Organization size and Operating budgets, [.) denotes an interval where [means greater than or equal to whereas) means less than.

Table 2

Multivariate ERGM effects, parameter estimates, and standard errors for the multiplex organizational networks of competition and collaboration, with corresponding hypotheses in parentheses

Graph configurations	Chicago						Houston					
	Competition (B)			Collaboration (A)			Competition (B)			Collaboration (A)		
	Est.	S.E.		Est.	S.E.		Est.	S.E.		Est.	S.E.	
<i>Basic structural effects</i>												
Reciprocity	0.298	0.477		1.144 *	0.306		2.239 *	0.344		1.172 *	0.233	
Sending-receiving ties (Two-path)	-0.120 *	0.041					-0.047	0.040				
Popularity spread (Alt-in-star)	-0.491	0.265					-0.274	0.262				
Activity spread (Alt-out-star)	0.695 *	0.227		0.353	0.235		0.405	0.222		0.436 *	0.178	
Multiple two-path (Alt-two-paths)							-0.172 *	0.050				
Multiple transitivity closure (Alt-triangle-transitivity)	1.050 *	0.162		0.603 *	0.124					0.640 *	0.100	
Structural equivalence (Alt-triangle-D-closure) (H2a)							0.943 *	0.139				
<i>Organizational attributes effects</i>												
Same_org_Health (H1a)							1.817 *	0.423		1.144 *	0.334	
Same_org_Social (H1a)							2.108 *	0.312				
Same_org_Risk (H1a)							1.915 *	0.345				
<i>Relational covariates effects</i>												
Geographic distance (H1b)				-0.054 *	0.014		-0.037	0.019				
Shared social networking sites (H1c)	0.247 *	0.099		-0.242 *	0.087							
Shared geo-meeting applications (H1c)				-0.833 *	0.388							
Shared funding types (H1d)	1.865 *	0.474		0.400 *	0.160		0.733 *	0.261		-0.232	0.121	
Shared funders (H1d)	0.245	0.169					0.199 *	0.066				
<i>Competition-collaboration structural effects</i>												
Co-occurrence_AB												
Reciprocity_AB				2.669 *	0.802					1.536 *	0.495	
In-two-star_AB				0.331	0.287					-0.017	0.350	
Out-two-star_AB				0.084 *	0.012					0.073 *	0.019	
				-0.066 *	0.024							

Graph configurations	Chicago		Houston	
	Competition (B)	Collaboration (A)	Competition (B)	Collaboration (A)
Mixed-sending-receiving ties (Mixed-two-path_AB)	-0.020	0.025	-0.061 *	0.019
Mixed-sending-receiving ties (Mixed-two-path_BA)	-0.073 *	0.026	-0.037	0.022
Structural equivalence (Alt-triangle-D_ABA) (H2b)	0.351 *	0.144	0.346 *	0.084
<i>Relational covariates effects</i>				
Shared funded types_AB (H3)	-1.701 *	0.766	-1.082 *	0.458
Shared funders_AB (H3)	-0.610 *	0.301		
Geographic distance_AB	0.084 *	0.029		

Note:

* Significant parameter estimates ($p < .05$).

Empty cells indicate zero effects. These models control for sender and receiver effects interacted with organizational attributes effects when testing same/similar attributes effects, as listed in Table 1, and other controlled variables described in the manuscript.