Modeling Social Capital as Dynamic Networks to Promote Health Equity

Hua Wang, Mary E. Northridge, Carol Kunzel, Qiuyi Zhang,
Susan S. Kum, Jessica L. Gilbert, Zhu Jin, Sara S. Metcalf

Abstract. Social capital, as comprised of human connections in social networks and their associated benefits, is closely related to the health of individuals, communities, and societies at large. For disadvantaged population groups such as racial/ethnic minorities and older adults, social capital may play a particularly critical role in mitigating the negative effects and reinforcing the positive effects on health. In this project, we model social capital as both cause and effect by simulating dynamic networks. Informed in part by a community-based health promotion program, an agent-based model is contextualized in a GIS environment to explore the complexity of social disparities in oral and general health as experienced at the individual, interpersonal, and community scales. This study provides the foundation for future work investigating how health and healthcare accessibility may be influenced by social networks.

Keywords: social capital, social networks, agent-based modeling, health equity

Acknowledgements. Work on this study was supported by NIH (NIDCR/OBSSR) R01 award DE023072, "Integrating Social and Systems Science Approaches to Promote Oral Health Equity."

1 Introduction

Gaps in access to healthcare services, experiences, and outcomes persist in the United States [30]. Health disparities result from a range of economic, social, cultural, and behavioral factors at multiple levels, resulting in persistent and egregious effects on individual and population health. For example, people with fewer resources may suffer from chronic diseases and systemic inflammation, and lose their teeth as they age, compromising their nutrition and social interactions. Racial and ethnic minorities and people living in poor neighborhoods may lack access to healthy food, community-based amenities, and quality oral and general healthcare. The result is often delayed treatment until oral pain becomes untenable or complications arise. Diabetes and hypertension are more prevalent in disadvantaged and older populations than in wealthier and younger populations, which can negatively affect both oral health and dental treatment. What is detrimental to the oral and general health of older adults is also financially burdensome to the entire healthcare system [20].

The complexity of such phenomena and the importance of studying the healthcare system as a whole involves breaking through the traditional disciplinary boundaries of medicine, dentistry, and public health [20], and requires more than reductionist scientific approaches such as randomized controlled trials [7]. Systems science is especially useful in understanding complex public health issues [13], studying the dynamic interplays underlying health disparities [9], and informing health policy research [14]. In this collaborative project, we apply multiple systems science approaches, including social network, system dynamics, and agent-based modeling, to understand the mechanisms through which social capital may promote health equity.

The study context is the ElderSmile community outreach program of the Columbia University College of Dental Medicine. Since 2006, ElderSmile has conducted health events at senior centers that serve predominantly racial and ethnic minority older adults who live in northern Manhattan or nearby communities. ElderSmile offers educational workshops, preventive oral and general health screenings, and referrals for oral healthcare treatment to older adults who frequent the centers. The centers themselves function as "third places" for community gathering

adfa, p. 1, 2011.

and socialization outside the confines of home ("first places") and work ("second places") [19, 21]. This community-based program thereby affords oral healthcare providers with a means of serving older adults' complex social and health needs.

Based on the insights from ElderSmile staff and participants, a system dynamics approach is used to articulate our conceptual framework and also to guide group model-building activities. Social capital is examined as dynamic social networks and simulated using an agent-based model contextualized in a GIS environment to explore the complexity of social disparities in oral and general health as experienced at the individual, interpersonal, and community scales. The model is used to explore the role of community health promotion that leverages "third places" in stimulating social capital formation and subsequent impacts on health and well-being.

2 Social Capital

Apart from tools and machines in physical capital, skills and talents in human capital, or cash and stocks in financial capital, what people generate, consume, exchange, and accumulate in social capital are human connections and their associated benefits [3]. The concept of social capital has been studied for decades with different approaches to its definition, theoretical elaboration, and methodological implementation [3, 4, 5, 10, 12, 25, 32]. However, the vast majority of the literature has focused on framing social capital as either a cause or an effect [10]. When treated as a cause, social capital is viewed as a network with embedded social structures and properties that can serve as resources available to the members of the network [4, 5, 12]. As an effect, social capital is viewed as a form of social consequences based on interactions between and within networks [8, 32], with the notable example introduced by Putnam [24] of bonding social capital among strong ties and bridging social capital among weak ties.

As Parks [22] points out, "[R]elationships live in communication. They are made, unmade, and remade in the communicative practices of their participants" (p. 24). Rather than taking a static view of social capital, it may prove more fruitful to examine social capital as dynamic networks with feedback loops and cyclical processes [17, 18]. Social capital can thus be conceived of as social agents and structural conditions for community building and mobilization [25] and encompass communication networks, cultural norms, and trust in relationships [27]. By acknowledging the evolutionary and emergent capacity of individual actors as well as their social interactions, this approach to social capital as dynamic networks can also better connect the micro factors at the personal level with the macro factors at the societal level, providing useful insights into often intricate and complex phenomena such as oral healthcare for older adults and racial and ethnic disparities in health.

Social capital is closely related to the health and well-being of individuals, communities, and societies at large [12, 24, 28, 31]. It may exert positive impacts on physical and mental health through multiple mechanisms, including by helping people to navigate healthcare systems, providing buffers against stressors, and offering instrumental and emotional support. But conversely, social capital may also exert excessive demands, expectations of conformity, and social exclusion on individuals and groups that present debilitating barriers to health-seeking behaviors and exacerbate healthcare costs [10, 11, 23]. For disadvantaged population groups such as racial and ethnic minorities and older adults, social capital may play a particularly critical role in mitigating the negative effects and reinforcing the positive effects of factors at multiple levels on health and well-being [29].

3 Conceptual Framework

The diagram in Figure 1 illustrates a dynamic hypothesis of how social factors affect health equity. The relationships in Figure 1 are interconnected as a causal map (a map of causes and effects) in the tradition of system dynamics such that solid arrows indicate direct causal relationships (positive polarity) whereas the dotted arrows indicate inverse causal relationships (negative polarity). In the modeling tradition of system dynamics, reinforcing (positive) feedback loops can be traced when an even number (including zero) of inverse relationships are encountered in a complete cycle of cause and effect. Balancing (negative) feedback loops are traced when there are an odd number of inverse relationships. These structural relationships lead to amplification of a change in direction for a reinforcing feedback loop, and mitigation of such a change for a balancing feedback loop [26].

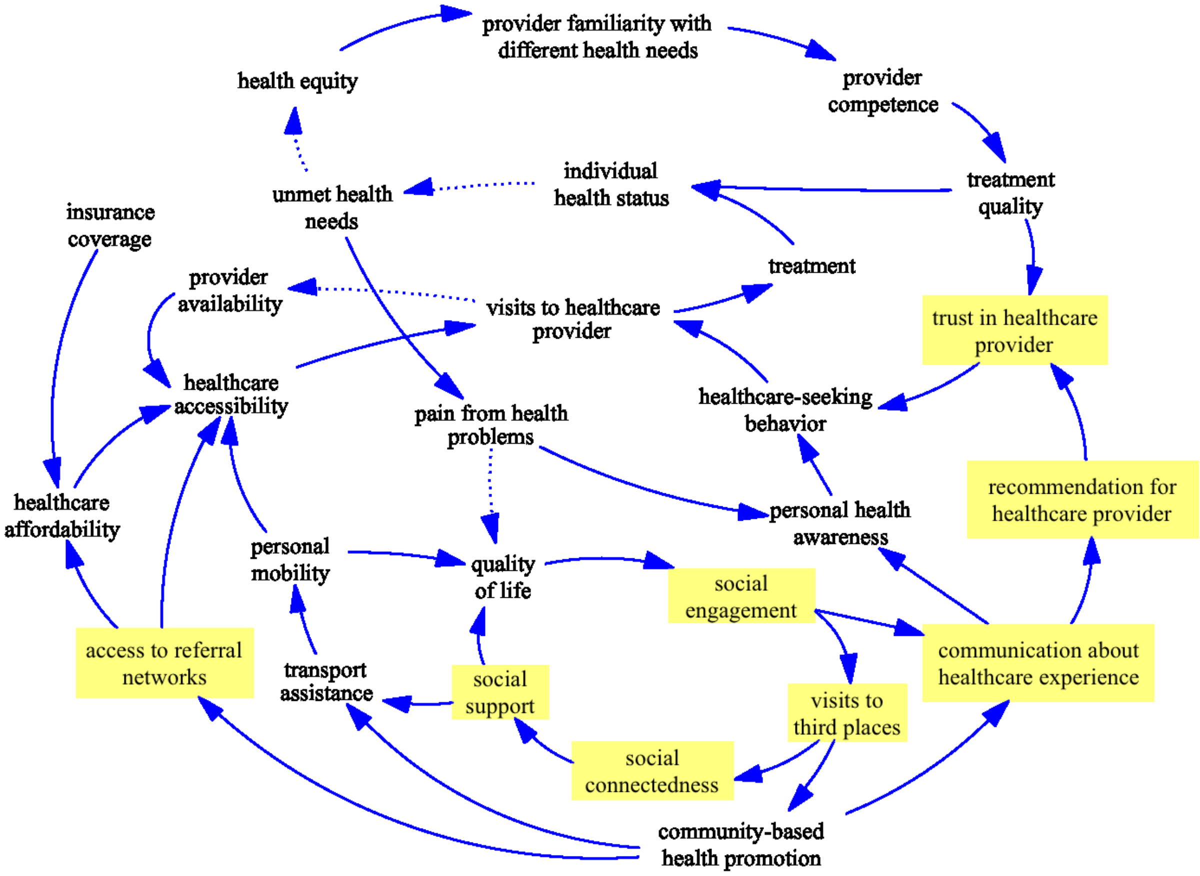

Fig. 1. Social Capital Formation and Impacts in the Context of Health Promotion

The elements of Figure 1 that are highlighted in yellow reflect aspects of social capital. These include social connectedness, social support, social engagement, visits to third places, communication about healthcare experience, recommendation for healthcare provider, and trust in healthcare provider. These factors are interrelated with potential leverage points for health promotion that can steer the system toward greater health equity.

As the foundation for pathways toward health equity, we situate health promotion at the base of Figure 1. Specifically, *community-based health promotion* activities through programs such as *ElderSmile* provide a novel means of intervention by making healthcare services available at third places such as senior centers. The health education component of community-based health promotion may serve to influence *communication about healthcare experience* and *personal health awareness*. Health promotion may also provide mechanisms for *transport assistance. Access to referral networks* results from *community-based health promotion*. Such access is a critical outcome of older adult participation in the *ElderSmile* preventive screenings: it directly improves both *healthcare affordability* and *healthcare accessibility*. *Healthcare accessibility* and *healthcare-seeking behavior* combine to influence *visits to provider* for *treatment*.

Insurance coverage is an important leverage point for health promotion at the societal scale, as evidenced by Medicaid expansion under the Affordable Care Act [1]. *Insurance coverage* is a broad term that belies the array of benefits and limitations that arise under different forms of coverage. Although it is shown as an exogenous policy lever in Figure 1, *insurance coverage* is also influenced by awareness of what services are covered. Limited compensation from Medicaid to healthcare providers for services adversely impacts the effective provider availability and potentially the range of treatment options that are discussed with the patient. Complications of reimbursement processes for Medicaid patients deter utilization of needed healthcare. Metcalf and colleagues [15] discuss Medicaid as it relates to opportunities to promote oral health equity. *Community-based health promotion* programs such as *ElderSmile*, through their outreach and health education arms, help to clarify which providers are available who would accept Medicaid insurance. The relationships drawn in Figure 1 indicate that the expansion of *insurance coverage* increases *healthcare affordability* by lowering out-of-pocket costs.

Contingent upon sufficient *treatment quality*, *visits to healthcare provider* are presumed to improve a person's *individual health status*, reducing *unmet health needs*. We then move conceptually from the scale of the individual to the scale of society at large, so that *unmet health needs* at the individual scale aggregate to reveal disparities that obstruct *health equity*.

A path from health equity to provider competence is hypothesized via provider familiarity with different health needs. Provider competence then improves the treatment quality experienced by the patient. As the treatment quality delivered improves, individual health status also improves. Treatment quality also produces trust in healthcare provider, which then leads to healthcare-seeking behavior, influencing visits to provider for treatment.

At the individual scale, *pain from health problems*, such as dental caries and other oral infections, impinges upon one's *quality of life* and may thereby deter the *social engagement* needed to foster social capital formation. On the other hand, symptomatic pain may also have the beneficial effect of increasing the salience of health issues to promote one's *personal health awareness*, a mechanism for stimulating *health-seeking behavior*. Other symptoms of *unmet health needs*, such as loose teeth and difficulty chewing, may also interfere with *quality of life*.

Older adults' attendance at senior centers, characterized as *visits to third places,* is significant not only because it offers an opportunity to be exposed to *community-based health promotion* through preventive screenings, but also because it offers an opportunity for social interaction and a means of social network formation, thereby enhancing *social connectedness*. *Social engagement* provides opportunities for conversations about relevant matters that may include *communication about healthcare experience*. We consider *communication about healthcare experience* to be an aspect of social capital, as well as a particular consequence of such communication, which is a *recommendation for healthcare provider*. Such a recommendation can serve to instill a sense of *trust in provider*.

Social connectedness is an outcome of *visits to third places* that is explored further in the model described below. This connectedness, in terms of the network structure and the density of social ties, improves the capacity for *social support* that arises from the network. This support may confer practical advantages such as *transport assistance*. Importantly, *social support* enhances *quality of life* for older adults, making daily challenges easier to manage and reducing social isolation. This effect completes a reinforcing feedback mechanism for maintaining *social engagement*.

We constructed the causal hypothesis in Figure 1 to explore the complex feedback mechanisms involved in the way that social capital influences health equity through healthcare-seeking behavior at the individual scale, and health promotion at the community scale. These hypothesized relationships have emerged iteratively as a product of dialogues and group model-building activities with the research team. While our approach is broadly in line with the tradition of system dynamics, instead of implementing our model using the stocks (integrals) and flows (rates of change) associated with that tradition, at this juncture we shift our structural orientation toward the behavior of individual agents. In this way, our causal map is a conceptual framework used to guide the design of agent-based models with which we perform experiments that involve heterogeneous individuals and their cross-scalar interactions with each other and the environment.

4 Agent-Based Model

This model consists of two agent classes that represent people (i.e., older adult senior center attendees and oral healthcare providers) and two agent classes that represent facilities (i.e., senior centers and dental clinics). In addition to these agents there is a Main class that incorporates all of the other classes in the model, as required in the Java-based AnyLogic software platform used for the model [2]. The Main class contains a GIS environment as the landscape in which people agents can move around and interact with each other. This interactive model has a user interface for customizing parameter settings that establish the conditions for each simulation run.

This agent-based model was initially developed without the GIS environment to facilitate discussion and exploration of agents as modeling structures in a group model-building exercise conducted with the research team. The model was intended to simulate small numbers of older adult and provider agents in a dental landscape of limited size. Because the model was also used to set the stage for a cooperative game played by members of the research team in small breakout groups, parameters of the demonstration model were set so that referral delay times were reduced and screening events were held more frequently than in the actual operation of the *ElderSmile* program.

4.1 Model Operation

Upon startup of the simulation, a customizable population of older adult agents is created. Each of these agents has a home location assigned randomly (i.e., with a uniform probability distribution) within the GIS landscape of the northern Manhattan study area. Senior centers are located according to the addresses of centers that are affiliated with the *ElderSmile* program. Dental clinics may be located using information about actual clinic locations [6] or assigned a synthetic location based upon user-specified coordinates to ensure that clinics are in physical proximity to the simulated agents. For the model described here, both empirical and synthetic locations are assigned to simulated clinics.

Each oral healthcare provider is assigned to a dental clinic and also given a random home location in the study area. One of these providers is affiliated with a health promotion program and performs preventive health screenings when not working at the clinic. Screening events occur at one of the senior centers every three days. When attending a screening event, the provider's corresponding dental clinic will be closed for the day. During the screening event, if their actual oral health status is below a diagnostic threshold, participating older adults will receive a referral for treatment at the affiliated provider's dental clinic. The referral is scheduled for the following day.

In the model, we differentiate between perceived and actual oral health status. These are both operationalized as continuous values that can vary between 0 and 1, where 1 implies healthy and 0 implies unhealthy, and are randomly assigned initial values between these bounds. Akin to the notion of personal health awareness in our causal map (see Figure 1 above), perceived oral health status is contingent upon the experience of symptoms, so that poor perceived oral health induces healthcare-seeking behavior to treat health problems. Actual oral health status is recognized by the provider at preventive screenings and used as a criterion for scheduling follow-up referrals. Although they are initialized differently, both actual and perceived oral health status decline without treatment at the same rate (reduced by 0.1 per 10 days) and are assumed to be exacerbated by the presence of another chronic illness (reduced by 0.15 per 10 days).

Boolean parameters are assigned at random upon initialization to establish whether agents trust oral healthcare providers (i.e., are more disposed to go to oral healthcare providers on their own), whether they can afford treatment, or whether they live with a related chronic illness.

As part of their simulated daily routine, older adult agents either attend their nearest senior center or visit one of the dental clinics. The latter case, in which older adult agents proceed directly to a dental clinic, occurs if they have a need for urgent care (i.e., their perceived oral health status declines below a symptomatic threshold, set to default value of 0.4), or if they have scheduled a referral appointment with an oral healthcare provider. Referral appointments are scheduled with a time lag of one day, and are held with the same provider that the agent encountered at the preventive screening.

Agents who can afford care will search for dental clinics within a user-specified distance (default value of 1 km) from the home location to identify an affordable dental clinic, e.g. accepts Medicaid insurance or offer sliding scale fees. If an affordable dental clinic is available, the agent will go to that clinic. Otherwise, they will go to the nearest clinic. Agents who cannot afford care will not visit a dental clinic unless they have a need for urgent care. The outcome of treatment is an improvement in oral health status, encoded in a return to the state of healthy teeth.

If a senior center hosts a preventive health screening event, each older adult at the center is as likely to participate as not (set by a 50% probability). If a participating older adult agent's actual oral health value is lower than a diagnostic threshold, s/he will be referred to the provider's dental clinic. If the person agent can afford to pay for treatment and also trusts an oral healthcare provider, s/he will bypass the referral process and seek treatment directly, undertaking the same decision process as agents who have an urgent need for care in seeking proximate dental clinics.

After each potential activity away from home, older adults then return to their home location.

4.2 Social Networks

Two types of social networks are simulated for agent interactions: 1) the peer social network among older adult senior center attendees; and 2) the patient-provider network between older adults and their oral healthcare providers. The peer social network forms from encounters made at the senior center (under the default assumption, one encounter is sufficient to form a tie) and is attenuated if an older adult no longer frequents the center on a daily basis (ties fade after 3 days). The patient-provider network forms from dental visits.

The visualization of these dynamic networks is facilitated by a user interface enabling selection of either network type for display during simulation. Figure 2 illustrates how the peer network is visualized (at left, with black lines connecting older adults) in contrast to the patient-provider network (at right, with red lines connecting older adults with oral healthcare providers).

The snapshots of the peer and patient-provider social networks shown in Figure 2 were taken at the same point in the simulation run. All embedded agent classes are visible in Figure 2: older adults are shown in black, providers are green, the green buildings represent dental clinics, and the blue buildings represent senior centers where screenings may be held. In the panel at right in Figure 2, the providers are shown working in their clinics and connected through social ties to older adults who are their patients in the study area.

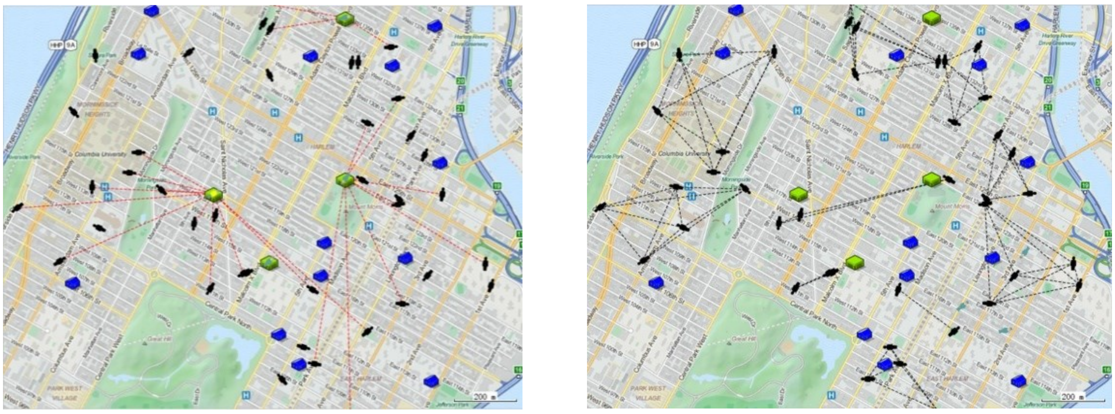

Fig. 2. Simulated Peer Social Network (left) and Patient-Provider Network (right)

Social connectedness in the agent-based model is represented by the degree or number of social ties that each person maintains. In aggregating from the individual level to the community of older adults simulated, we can examine the degree distribution of these connections. Figure 3 depicts the resulting social network degree distribution with a population size of 40 (at left) and 80 (at right) older adults at the end of the simulation run (on the 100th day). For each plot, the horizontal (x) axis delineates the degree or number of connections per person, and the vertical (y) axis depicts the percentage of the population with the given degree as the frequency of the degree in the population.

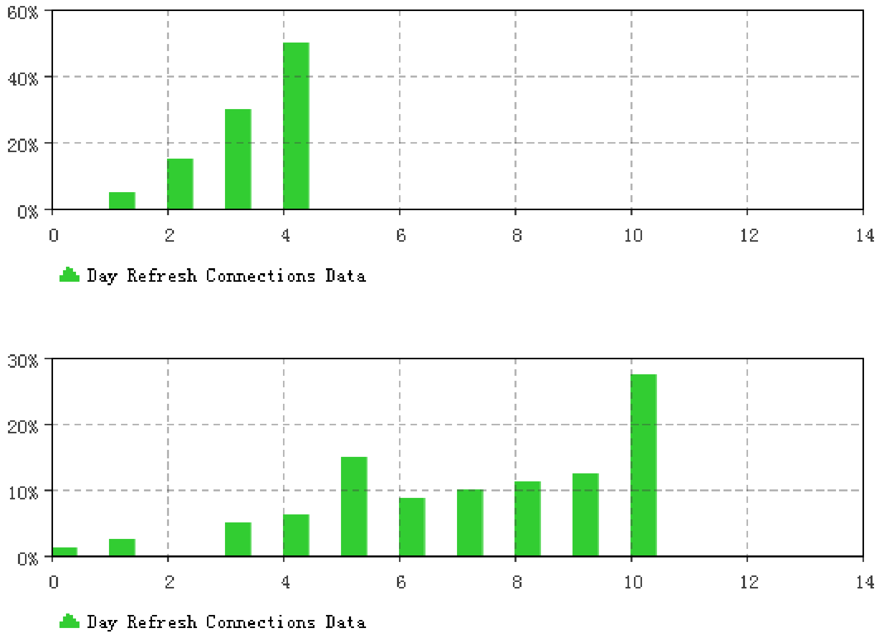

Fig. 3. Emergent Degree Distributions for 40 People (top) and 80 People (bottom)

The degree distributions of both experiments stabilized around the 40th day of simulation as social clusters form from activity at the senior centers. The mode is 4 connections for a population of 40 versus 10 connections for a population of 80. This comparison of social network structure for these different population sizes indicates that a larger population in the same geographic area leads to a greater density of older adults who therefore have more chances to encounter each other at third places such as senior centers. These encounters lead to the formation of social ties that provide opportunities for communication.

4.3 Social Influence on Healthcare-Seeking Behavior

For this study we created a set of scenarios to contrast the simulation results for dental visits achieved through mechanisms of *seeking care through a referral* with *seeking care through a trusted health provider*. An older adult agent's trust in oral healthcare providers is spread through the social network as opinion leaders communicate with others in their social network. A threshold parameter is used in the model to designate certain agents as hubs within their peer social networks. Older adult agents whose degree is greater than the threshold will act as opinion leaders and send a "trust" message to connected agents through peer social network, exerting a social influence toward trust of oral healthcare providers. This mechanism functions much as a recommendation for an oral healthcare provider as expressed in the causal map of Figure 1. However, here trust extends beyond a particular provider. After receiving a trust message, the connected older adults are considered to have trust in oral healthcare providers, indicated by a change in their status from "no trust" to "trust." A forgetting time is applied as a balancing mechanism, with a default value of 30 days, after which the status returns to "no trust." Because it can be lost through this "forgetting," trust functions much like an awareness of or inclination toward care, and similarly be socially influenced. Trust thereby emerges from the peer network to influence the construction of the provider-patient network. If an agent trusts oral healthcare providers, they may seek treatment on their own, without waiting for an appointment by referral.

The dynamics of dental visits are illustrated in Figure 4 for the clinic that accommodates referrals made during the preventive screenings offered by the oral healthcare provider who works there. The left-hand side of Figure 4 indicates the number of visits under the scenario of no social influence. In this scenario, no agents can function as opinion leaders, which is achieved by setting the parameter for hub degree threshold to 100% of the population size. In contrast, the right-hand side of Figure 4 indicates the number of dental visits attained in a scenario of social influence, in which the hub degree threshold is set to 10% of the population size. For the default population of 40 older adults, opinion leaders are those agents who have more than 4 peer connections.

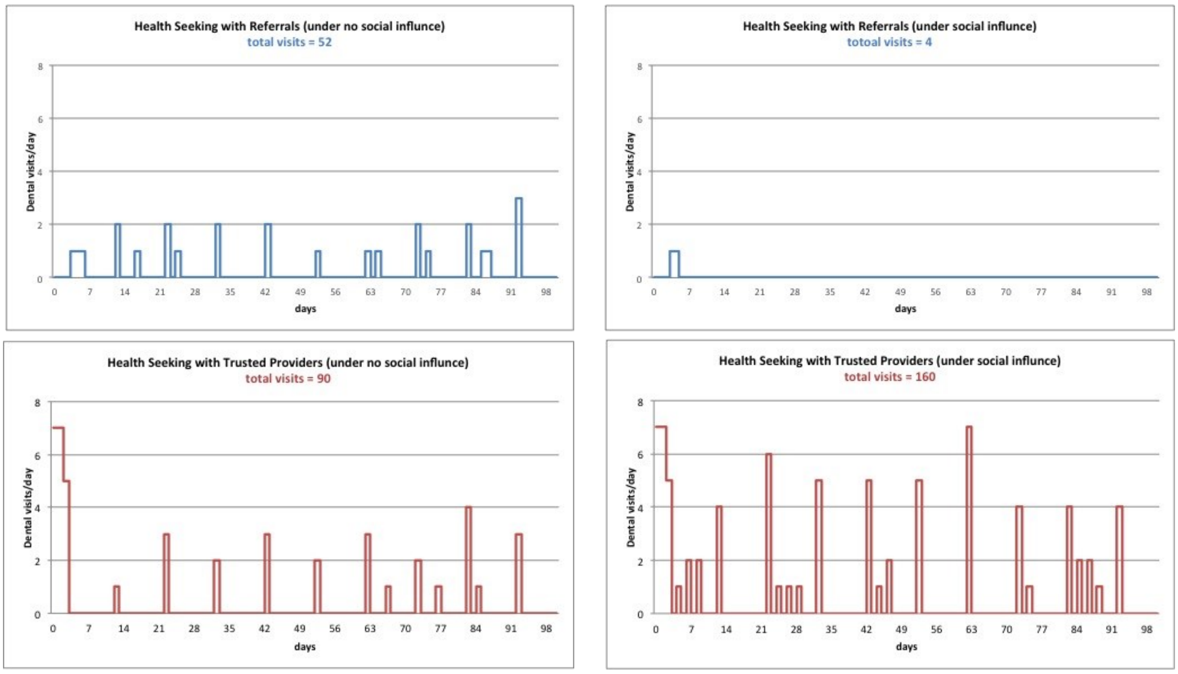

Fig. 4. Social Influence (right) on Dental Visits with Referrals (top) vs. Trusted Providers (bottom)

The dynamics of dental visits for the experiments charted in Figure 4 are arrayed so that the dental visits resulting from referrals established during a preventive screening event appear in the top row, while visits resulting from an older adult agent's own initiative to seek healthcare with trusted providers. The upper right scenario highlights that as social influence takes effect through opinion leader dynamics in the social network, all agents elect to go directly to a trusted oral healthcare provider (shown at bottom right) instead of waiting for a referral appointment to be arranged.

Under the social influence scenario, the simulated results indicate an increase in overall dental visits to the referral clinic as well as the other clinics, demonstrating the potential influence of social networks on healthcare behaviors. Because treatment improves oral health, these visits translate to improved oral health outcomes. In the absence of social influence, cumulative dental visits to the referral clinic are less than visits to other clinics. This gap has been explored in the social influence simulation where hubs have more social influence than others via word of mouth communication.

5 Discussion

This modeling effort was designed to explore how social capital might help mobilize older adults to utilize community-based health promotion and healthcare services. A conceptual framework was first developed as a causal map in the tradition of system dynamics highlighting how elements associated with social capital function endogenously as both cause and effect in a system linking health promotion to health equity. We then demonstrated the design and operation of an agent-based model contextualized in a GIS environment corresponding to the location-based community health program in this study. By simulating the dynamics of two networks (i.e., peer social network and patient-provider network), we experimented with different scenarios to see how social factors at the interpersonal scale might enhance healthcare-seeking behaviors and thereby improve oral health outcomes at the individual and population scales.

For further experimentation around health equity, different population subgroups can be specified that could influence network dynamics according to differences such as racial and ethnic identity, language, and gender. We also hope to draw upon previous models in our portfolio to layer in other elements of network dynamics such as communication about health promotion, healthcare affordability, and transport accessibility as a mediator of healthcare accessibility [16]. Alternative mechanisms for the formation of trust can be designed to consider factors such as treatment quality as well as the recommendation for a particular healthcare provider. This study expanded our portfolio and can help inform future modeling efforts as well as policy research on community-based oral public health to promote health equity.

References

1. Affordable Care Act: The Patient Protection and Affordable Care Act (PPACA), Pub. L. No. 111-148, 124 Stat. 119 (2010)
2. AnyLogic: Multimethod Simulation Software. Version 7.2.0. XJ Technologies, St. Petersburg (2016)
3. Bourdieu, P.: The Forms of Social Capital. Handbook of Theory and Research for the Sociology of Education, Greenwood, New York (1986)
4. Burt, R. S.: Brokerage and closure: An introduction to social capital. Oxford University Press, Oxford, New York (2005)
5. Coleman, J. S.: Social capital in the creation of human capital. American Journal of Sociology 94, S95-S121 (1988)
6. DFTA: Oral care provider directory: A resource directory for use by New York City Department for the Aging partner agencies to help older adults access dental care providers. NYC Department for the Aging (DFTA) and Columbia University College of Dental Medicine, New York (2014)
7. Diez Roux A. V.: Complex systems thinking and current impasses in health disparities research. American Journal of Public Health 101(9): 1627–1634 (2011)
8. Ellison, N., Steinfield, C., Lampe, C.: The benefits of Facebook "friends:" Social capital and college students' use of online social network sites. Journal of Computer-Mediated Communication 12(3), article 1 (2007)
9. Frerichs, L., Lich, K. H., Dave, G., Corbie-Smith, G.: Integrating systems science and community-based participatory research to achieve health equity. American Journal of Public Health, 106, 215-222 (2016)
10. Kawachi, I.: Social capital and health - Making the connections one step at a time. International Journal of Epidemiology 35(4), 989-993 (2006)
11. Kawachi, I., Subramanian, S. V., Kim, D.: Social capital and health: A decade of progress and beyond. In I. Kawachi, S. V. Subramanian & D. Kim (Eds.), Social capital and health. Springer, New York (2008)
12. Lin, N.: Social capital: A theory of social structure and action. Cambridge University Press, New York (2001)
13. Monge, P. S., Contractor, N. S.: Theories of communication networks. Oxford University Press, Oxford (2003)
14. Mabry, P. L., Marcus, S. E., Clark, P. I., Leischow, S. J., Mendez, D.: Systems science: A revolution in public health policy research. American Journal of Public Health, 100(7), 1161-1163 (2010)
15. Metcalf, S. S., Birenz, S. S., Kunzel, C., Wang, H., Schrimshaw, E. W., Marshall, S. E., Northridge, M. E.: The impact of Medicaid expansion on oral health equity for older adults: A systems perspective. Journal of California Dental Association, 43, 369-377 (2015)
16. Metcalf, S., Northridge, M., Widener, M., Chakraborty, B., Marshall, S., Lamster, I.: Modeling social dimensions of oral health among older adults in urban environments. Health Education and Behavior 40(1S): 63S-73S (2013)
17. Monge, P. S., Contractor, N. S.: Theories of communication networks. Oxford University Press, Oxford (2003)
18. Newton, K.: Social capital and democracy. American Behavioral Scientist 40(5), 575-586 (1997)
19. Northridge, M. E., Nye, A., Zhang, Y., Jack G., Cohall, A.T.: ‘‘Third places’’ for healthy aging: Online opportunities for health promotion and disease management in adults in Harlem. Journal of the American Geriatrics Society 59(1): 175-176 (2011)

20. Northridge, M. E., Yu, C. C., Chakraborty, B., GreenBlatt, A. P., Mark, J., Golembeski, C., Cheng, B., Kunzel, C., Metcalf, S. S., Marshall, S. E., & Lamster, I. B.: A community-based oral public health approach to promote health equity. American Journal of Public Health 105(S3): S459-S465 (2015)
21. Oldenburg, R.: Celebrating the third place: Inspiring stories about the "great good places" at the heart of our communities. Da Capo Press, Boston (2000)
22. Parks, M. R.: Personal relationships and personal networks. Routledge, New York (2006)
23. Portes, A.: Social capital: Its origins and application in modern sociology. Annual Review of Sociology 24, 1-24 (1998)
24. Putnam, R.: Bowling alone: The collapse and revival and American community. Simon & Schuster, New York (2000)
25. Putnam, R., Feldstein, L. M., Cohen, D.: Better together: Restoring the American community. Simon & Schuster, New York (2003)
26. Richardson, G. (1991). Feedback thought in social science and systems theory. Pegasus, Waltham (1991)
27. Singhal, A., Papa, M. J., Sharma, D., Pant, S., Worrell, T., Muthuswamy, N., et al.: Entertainment-education and social change: The communication dynamics of social capital. Journal of Creative Communication 1(1), 1-18 (2006)
28. Song, L., Son, J., Lin, N.: Social capital and health. In W. Cockerham (Ed.), The new companion to medical sociology. Wiley-Blackwell, Oxford (2010)
29. Uphoff, E. P., Pickett, K. E., Cabieses, B., Small, N., Wright, J.: A systematic review of the relationships between social capital and socioeconomic inequalities in health: A contribution to understanding the psychosocial pathway of health inequalities. International Journal for Equity in Health 12, 54 (2013)
30. Valente, T. W.: Social networks and health: Models, methods, and applications. Oxford University Press, New York (2010)
31. Wellman, B., & Leighton, B.: Networks, Neighborhoods and Communities. Urban Affairs Quarterly 14, 363-390 (1979)
32. Williams, D.: On and off the 'net: Scales for social capital in an online era. Journal of Computer-Mediated Communication 11(2) (2006)