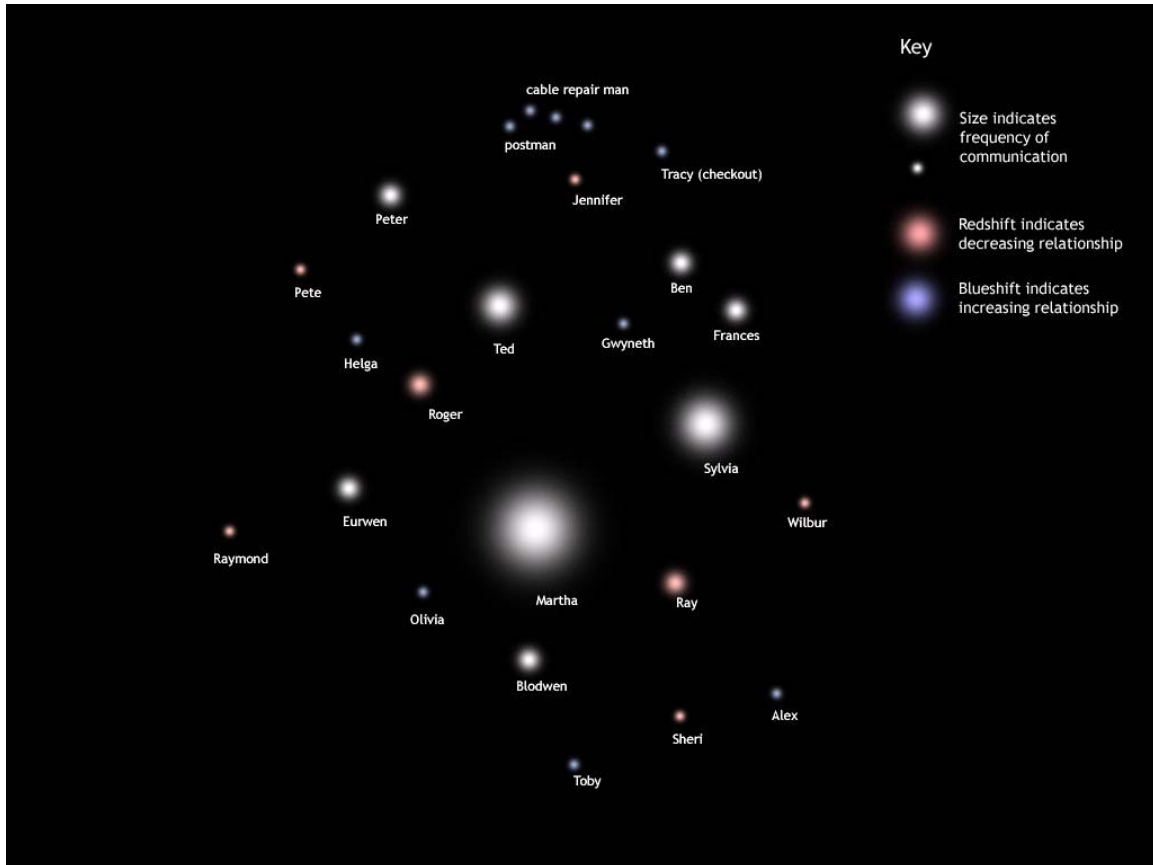


Social networks as health feedback displays

Margaret Morris, Intel



“Loneliness is a part of old age and there ain’t a damn thing you can do about it.” These words of an 82-year-old research participant express the social helplessness felt by many elders who are coping with age related changes such as retirement, death of a spouse, and a diminishing network of surviving peers and relatives. These changes often bring about social disengagement – withdrawal from the relational stimulation and support that can protect against a spectrum of illnesses. Throughout life, many people inaccurately perceive social circumstances as beyond their control, exaggeratedly stable, and generally unchangeable. These perceptual tendencies, combined with the importance of social ties to our health and self-concept, invite new tools to enhance awareness and control of one’s social engagement. This paper describes social network visualizations continuously updated with sensor and journal data that were developed for this purpose. These visualizations and the underlying technology platform of sensor networks, online journals and algorithms, were developed and tested in three month in-home trials as part of ongoing program of multidisciplinary health technology research at Intel. This article focuses primarily on the rationale for these social network displays. Subsequent reports will detail methods and findings.

Can social network models serve not just as analytic tools for social scientists, but also as motivating health displays?

Social networks have long been used in anthropology, sociology, and industrial-organizational psychology to model communication pathways in groups. Scaling algorithms and other mathematical modeling tools allow researchers to analyze current dynamics in social structures and predict patterns of social change. Like cognitive psychologists studying schematic networks, social network researchers examine relatedness in terms of the centrality and clusters of nodes, and the density of the links that connect them (1). Social network modeling is beginning to influence real life practices; for example, the social transparency afforded by tools such as LinkedIn have drastically changed dating and job searching.

This paper explores a simpler, more colloquial understanding of social networks – their reflection of individuals' relatedness and social health. This work examines the capacity of egocentric social networks, empirically derived from a combination of sensor and self-report data, to reflect social wellness. In addition to describing social states, the network visualizations described here were intended to motivate social engagement among people at risk of social isolation, specifically older adults living alone. The goal was to help elders become more aware of their ability to spark interaction and to help their caregivers become more effective, and less overwhelmed, social liaisons. Ultimately, this research is aimed at enhancing elders' quality of life and general health, increasing their autonomy, and helping protect against illnesses with a demonstrated social link such as dementia.

Why should we think of social networks as health feedback displays?

Social engagement is an important indicator and predictor of health status. Longitudinal studies have demonstrated the protective and sometimes even remediative value of social engagement for illness ranging from the common cold to cancer (3). This protective value is suspected to stem from a combination of instrumental and emotional support from others. Influence is another key dimension of social engagement (4). Ethnographic studies that led up to the trials described in this paper highlighted the desire of elders to feel helpful – by teaching, parenting, making people laugh, fixing things, and providing emotional support. Identities crumble when opportunities to play these roles are taken away due to physical or cognitive decline. Often the symptoms of illness, such as forgetting names and difficulty tracking conversation in the case of cognitive aging, remove people from the very sources of social support and stimulation that could help protect them from further health decline. In our ongoing research with older adults and their caregivers, it became clear that health technologies should support individuals' networked sense of self as well as their independent functioning in daily activities. Mirrors of social activity, mapped according to one's network of friends and family, are an exciting and appropriately non-prescriptive way to motivate social engagement. The goal of a nonprescriptive display is to invite self-reflection and self-directed plan for change. Pervasive computing, which enables continuous collection and trending of behavioral data via wireless sensor networks, allows us to develop such feedback displays from the contexts of daily life.

How health displays motivate change: Why some work and others fail

Feedback displays of physiology and behavior have long been a component of medical treatment. Biofeedback of muscle tension, for example, can help migraine sufferers evaluate their attempts to voluntarily relax and tighten muscles associated with their pain. The goal is to increase control over muscles and subtle behaviors that typically lie beneath awareness. The concept of biofeedback has migrated into a variety of consumer-oriented applications for physical health. For example, predictive games have been developed to help diabetic children understand patterns in their glucose levels (5). Behavioral feedback can be another effective another tool for health change. The recently marketed SportBrain, for example, allows users to view pedometer readings over time and evaluate their progress towards fitness goals. Another inspiring feedback example is Frost's (6) use of digital imaging to help diabetic patients capture meals and examine their physiological effect. This approach has recently been commercialized in a variety of mobile

phone services that enrich communication with dietitians. The tools above share key qualities: they reflect contextually rich data, they empower individuals to investigate their health, and they highlight opportunities for healthful change.

Significantly less compelling feedback tools are unfortunately still the only choice presented to most patients. For example, clinicians commonly encourage patients to log behaviors such as diet, sleep, exercise, mood or energy and sometimes to them against variables such as mood or energy. These logs can be informative, but few patients can tolerate the burden and tedium of consistently documenting their behavior. Additional barriers include the difficulty of tracking multivariate environment-behavior-health relationships, disconnects between an individual's experience and clinical metrics, and the challenges of recalling and capturing hourly variability in symptoms, mood, cravings, or energy levels. In addition to such self-charting, some health displays that are notoriously poor at motivating behavioral change persist as poor choices for consumers and clinicians. The bathroom scale, for example, accurately reflects an important health indicator (weight) and its behavioral determinants (eating, exercise), but is a tool that many avoid – sometimes even on the advice of weight-loss coaches. The scale is often experienced as a slap on the wrist rather than a helpful nudge. Another reason some displays can fail to motivate is that they reflect only snapshot in time, with no historical trending and no actionable feedback.

A new area of research, “embedded assessment,” integrates health monitoring with motivating feedback that is relevant to individuals' short and long-term health goals (7). In this approach, long-term health vulnerabilities are matched with individuals' current concerns, even if these concerns are not explicitly health related. If monitoring risk factors for cardiovascular disease among 30 and 40 year olds, feedback is framed in the concerns that are most salient to this cohort such as life balance, performance and appearance. For example, risk factors such as hostility and weight gain could be addressed in terms of strategies to improve interpersonal effectiveness and physical appearance. Another key feature of embedded assessment is the integration of monitoring into individuals' compensatory and preventative health strategies. Feedback is framed in terms of strategies to either work around an impairment (e.g., rehearsing names to compensate for poor memory) or to ward off a potential problem (e.g., exercising to prevent weight gain). Advances in ubiquitous computing are leveraged for continuous and contextually sensitive data collection. As a result, embedded assessment applications can illustrate health variability and its relationship to contextual factors.

Therapeutic value of displaying variability

A key feature of the social displays that we developed is the reflection of behavioral variability and opportunities for change. This technology addresses psychological research on the therapeutic value in highlighting the impermanence of psychosocial states and related circumstances. Seligman's extensive research on attributional style indicates that people can improve their physical health, psychological well-being and even their professional success by recognizing the temporary state of negative situations (8). Another source of guidance comes from studies on mindfulness: A meta-awareness of physical and mental patterns can help individuals cope with and recover from a variety of emotional and physical health challenges (9). Cognitive behavioral therapy and mindfulness practices could be constructively applied to measuring and treating social isolation in later life. Advanced technologies, such as ubiquitous computing and affective displays, holds promise not only for conveying the dynamic qualities of social networks but also for expanding the reach of this support to a far wider audience than that which currently has access to psychotherapy.

Why we need dynamic visualizations of social networks

Social connectedness has generally been treated as a stable construct or trait. We often describe people as loners or joiners, or in Gladwell's more nuanced terms as “connectors, mavens and salesmen” (10). Like these personality characterizations, measurements of social engagement levels imply more stability to social tendencies than may be warranted. Even those questionnaires designed to assess recent social behaviors and feelings of isolation are unlikely to reveal change over brief intervals. Although some of the personality characteristics that influence

the extensiveness of individuals' social networks are stable, there may be more fluctuation in the composition and configuration of these networks than can be accommodated by current measurement tools. With the exclusion of some exciting recent work (11-13) there has been little effort to capture change in individuals' social networks, particularly over short periods of time.

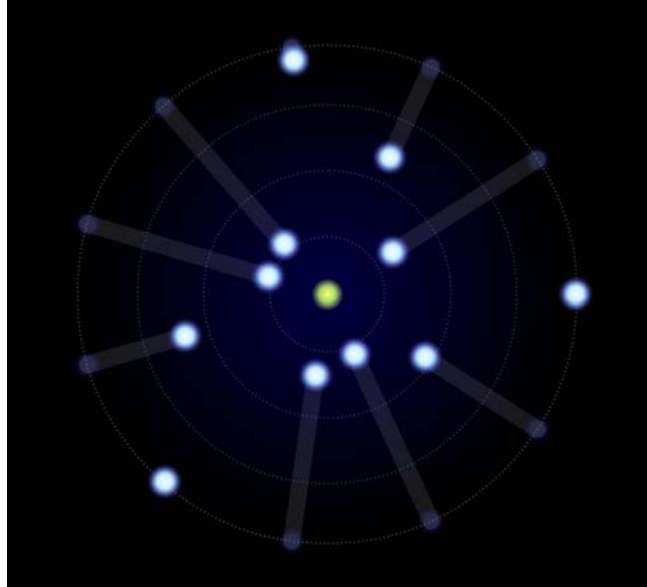
In contrast to this stable characterization, research suggests significant shifts in social networks over the lifespan. The gerontology literature indicates change in social network structure over the lifespan. Most research suggests relational pruning and network simplification with age, although there are some discrepancies about whether this change is desirable to the elder (14). In our ethnographic studies, we encountered people who were very socially active in midlife but became reclusive due to increased social barriers and decreased opportunities for interaction, particularly spontaneous gatherings. These changes sometimes result from the death of a spouse, relocation in later life towards family caregivers and away from friends, deterioration in eyesight that prevents driving, or symptoms of stigmatizing illness such as dementia.

Our household interviews suggest that many elders do crave the spontaneous peer contact that was available to them in previous phases of their lives, but become resigned to living a more solitary life because of the tremendous effort now required to see friends. Many elders resolve dissonant feelings about such losses by re-orienting all their energy around their families. Sometimes isolation is expressed reluctantly by elders or indirectly by a caregiver who may feel overwhelmed or ineffective as the elder's primary social liaison. It should be noted that these challenges may be more strongly experienced by women, who are more likely to live alone in late life, and more likely to find themselves sandwiched between multiple caregiving responsibilities. In addition to changes over the lifespan, variability in social connectedness was evident over very short periods of time. One woman we interviewed enjoys a great deal of social contact during the week, dreads the loneliness she experiences on weekends. Her weekend routine is not so different than her weekly schedule, but it feels emptier because she suspects that on the weekend other people are busy with their families. Other participants in our study despise the evening hours: "This place is a morgue after 7pm" bemoaned one woman about her retirement community. There is most likely also a seasonal variability, in which people experience more loneliness during winter months.

Periodic assessments of social health may not capture these episodic feelings of isolation or even the shifts that take place over longer periods of time. Pervasive computing, because it allows for continuous and contextually sensitive data collection, may be more effective than clinical assessment in identifying the time periods in which solitude is most painful for any particular individual. Behavioral feedback of the data collected from these systems may help people recognize their social patterns, and then develop and evaluate new strategies for initiating social interaction.

Identifying a design metaphor

There were several criteria guiding our choice of a social network display: We wanted an organic symbol of social life that held emotional resonance and visual appeal. It was necessary for this symbol of vitality and connectedness to resonate with people across age, race, gender, educational, and socioeconomic lines. We wanted a symbol that had a recognizable structure, but intrinsically involved movement. These criteria led us to select a solar system.



The solar model of social activity

Configuring the display to motivate change

Why an egocentric model?

A primary goal of this project was to put elders in control of their social activity and to help them envision possibilities for greater social connectedness. Loneliness would then be perceived not as “an inevitable consequence of old age,” but as a temporary state that could shift through behavioral strategies. Our intent was not to present the elder as a speck in the universe, but rather to present compelling opportunities to draw others into the centers of *their* worlds. For that reason, the elder is positioned at the center of the display – as the sun. Family and friends rotate around the elder as planets. Their proximity is determined by the extent of their contact, and updated on an hourly basis. The duration of contact is weighted by the modality of interaction and the emotional closeness of the other person to the elder. Inward movement of planets was anticipated to reinforce the elders’ social efforts.

This egocentric model was designed as a tool for both elders and their caregivers. Without an effective social liaison (typically a family member or close friend), many elders lose the support of weaker social ties that are known to be sustaining. For this reason, the elder’s social network visualization was placed in the homes of both elders and their primary caregivers as an ambient display. The primary caregiver, typically an adult daughter, could monitor her own contact as well as that of other family members and friends. It was expected that, for some caregivers the display would prompt contact and for others it would invite strategy about redistributing contact and responsibilities among a larger set of caregivers.

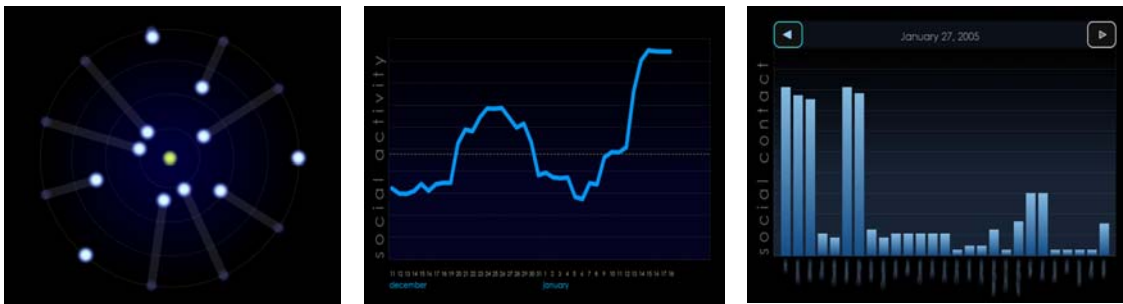
Inviting but not prescribing change:

Another major design goal was to invite change without prescribing specific actions. This design intention is in keeping with persuasive computing (2) and clinical practices of motivational interviewing in which change is invited through the presentation of personalized health information. Additional reasons to avoid explicit social directives relate to the margin of error in exploratory technologies and the cognitive benefits of social planning. Given the rough inferences allowed by sensor technologies and the nuances of social engagement, suggestive mirroring was deemed a more appropriate goal than prescribing. With regard to the second point, cognitive stimulation, the protective benefits of socializing against cognitive decline may stem in part from the mental choreography required to plan an interaction. Such social planning (e.g., picking three compatible friends to take a walk or planning rounds of invitees for a dinner party) provides

cognitive exercise similar to the challenging puzzles that many undertake to ward off dementia. The protective benefit of this cognitive stimulation would be undermined by a prescriptive prompting system. In short, the goal was not only to increase the raw amount of social contact but to encourage reflection and self-efficacy. These goals were at odds with explicit directives or features that would automatically connect the elder with others but aligned with tools that would invite self-reflection and intentional planning.

Views on the social network: display modalities

Our primary lens on the elder's social network is the solar display, a simplified version of the image at the top of the article. In this display and others, we wanted to provide support in a style that differed from most "assistive technologies." Given our goals of fostering social engagement, it seemed particularly important to avoid socially stigmatizing tools. Also, we wanted to create prototypes that would appeal to middle aged caregivers as well as elders; we were interested in how caregivers would use the tools not only to check in on their parents but also to reflect upon own lives. The solar display is minimal in the information it conveys to the casual viewer and could be mistaken for a screen saver. To avoid stigmatizing the elder and to preserve a simple design, the photo and name of the contact appear only when the respective planet is scrolled over. Another feature on the solar display is a historical trace: a line between each person's initial and current level of contact with the elder. Uses toggle between the solar display and several other views. The second view is a line graph – a longitudinal indication of that the elder's aggregate contact with everyone in the social network. We also included a bar graph that shows level of contact with each person on a given day; the user could scroll back and forward in time to see changes in the bar graph over time. Finally, we included a text summary of social activity levels. The three image modalities are depicted below.



From left to right: the solar display, the line graph and bar graph

Implementation and Testing

These displays and a platform of proactive health technologies to support social engagement were tested in three-month in-home trials with six dyads of elders and their primary caregivers. Trials were conducted as case studies with a baseline-intervention design. During the baseline phase, sensor and self-report data were gathered to characterize average the participants' social activity levels. During the intervention phase, the social health displays were introduced. Two other applications (bi-directional presence lamps for the elder-caregiver dyad and a contextual prompt for the phone that showed the caller's image, name, relationship, and gist of last conversation with elder) were also tested in this phase, but are outside the focus of this paper. Collection of sensor and self report continued during the intervention and were used to continually update the social health displays. In-depth interviews that included discussion and mapping of relationships were conducted at key junctures throughout the study (intake, end of baseline, and end of intervention). Although this paper is concentrated on themes from interviews rather than quantitative analyses of sensor data, I briefly summarize our sensor based index of social activity and sensor platform below.

To quantify social activity and compare levels of interaction before and during the display phase of the study, we relied on measurable indicators that could be detected by home sensors: duration of visits and phone calls. Although these measures do not capture the nuances of social engagement, we suspected that they would provide a preliminary benchmark, similar to the way that pedometer readings offer an estimate of physical activity. The social index used for our visualizations is a summary of interactions weighted by a) the closeness of the other person to the elder, b) the modality (e.g., in-person visits were weighted more heavily than phone calls) and c) the duration of each interaction. To this predominantly sensor-based index we added self-reported interactions that took place outside the home. The social index was updated hourly and the displays recalibrated accordingly. Self-reported interactions, entered in an online journal that was personalized with photos and names of contacts, were also used to validate sensor data.

Our system included the following components: Wireless sensors adapted from commercial products; infrared badges and beacons; a phone sensor board linked with a caller ID service; mote radios to relay sensor data to an in-home laptop server; and a laptop for the social health displays. Detailed descriptions of tools and methods will be reported in a more comprehensive report (15).

Preliminary observations from the field

Following are several high level observations from interviews. A more comprehensive analysis of interview and sensor data is in progress. Subsequent reports will detail findings.

- **Adoption and preferences:** Participants were generally fond of the displays and interacted with them frequently. Some people who questioned the depictions of their social activity nonetheless expressed attachment to the displays and disappointment when they were removed at the end of the study. Most elders preferred the solar display and used it as their default setting. They appreciated its circularity and movement, and reported using it as a game-like stimulus for family conversation. Several caregivers expressed a preference for the line graph; one explained "the solar display tells me more about how much *other* people are interacting with my mom, but the line graph is what really tells me what *she's* doing." The text adaptation of the visual displays was generally disliked.
- **Elder reactions:** Interview responses echoed preliminary quantitative findings that elders were more socially active when they were exposed to the social network visualizations (15). This increase most likely relates to the increased self-awareness about variability in social functioning, consequent social motivation, and improved communication with caregivers about social interaction. These themes are briefly described below:

- Elders were surprised by the ups and downs in their social activity levels depicted in the displays. They expressed interest in spotting downward trends early on, and intervening to avoid isolation and depression.
- Displays drew concern to deficits in peer contact. By the end of the study, one elder formed a list of old friends with whom she was going to reconnect, another started intensifying interactions with acquaintances, and another became significantly more socially involved in her retirement community.
- Dialogue between elders and caregivers about social isolation was facilitated. As explained by one caregiver, the displays provided a vocabulary and permission to discuss concerns about social issues, particularly her mother's lack of peer relationships.
- Social journaling increased markedly with the introduction of the social displays. The online social journal was designed as a validation of sensor data, but was typically experienced as a therapeutic tool once the feedback was provided. Elders' increased enthusiasm for self-monitoring provides compelling support for the principle of embedding feedback into health assessment technologies.
- **Caregiver reactions:** The displays appeared to help adult children modulate their caregiving responsibilities. They generated awareness, and in some cases outreach, among children who were not terribly active in their parents' care, provided additional information to the caregivers who were content with their level of involvement but wanted more reassurance about their parent's wellbeing, and for the overburdened caregiver, motivated strategies for distributing responsibility.
 - The displays were most helpful for the adult children who were very actively involved as caregivers. Validation of their caregiving activities was appreciated, and some wanted to catalyze involvement from other relatives by sharing the displays.
 - Most caregivers shared the displays with siblings and enjoyed a playful competition about who could be the closest planet (i.e., best child). Family members made a point of checking their position in the elders' social network when visiting either the elder or the primary caregiver. Some conducted informal tests to see how much contact was needed to make a perceptible difference in the display. Any failures of the system to register phone calls or visits these relatives made to the elder elicited strong complaints.
 - The displays sparked new insight among some participants about the significant time and energy they devote to caregiving. One woman explained that seeing her central position in her mom's network made her realize how many other areas of her life she had been neglecting. Consequently, she initiated several strategies to bring other people into her mom's daily life and started scheduling time for her own hobbies and interests. Another woman, who at the beginning of the study insisted that her father was entirely self-sufficient and that she was "by no means a caregiver," began to see how much she was doing for her father: "I now realize that I kind of am a caregiver and I feel OK about pushing him to see other people." This perceptual shift was validating: she felt more confident that she played a valuable family role and more energetic about helping her father maintain social ties.

Future design directions

These preliminary observations suggest value in applying social network modeling for health feedback. The reactions of participants indicate several directions for future design research. A general direction is to model more complex dimensions of social interaction and to capture data in a wider array of environments. Several logical extensions of this research, some of which are underway, include mobile systems to measure and support interaction outside the home, extending access to social displays and journal applications by wider set of family members and friends, and trending of social engagement as a health indicator. Also, models should reflect additional aspects of engagement such as extent to which the user initiates or responds to social overtures. Although designed to be ambient displays, the visualizations could invite more interaction, allowing users to annotate discrepancies between the displays and their subjective sense of social engagement. To encourage planning, the displays could invite individuals to map out ideal social networks and periodically compare them with the sensor based depictions. Finally, there are compelling opportunities to allow adult children to simultaneously monitor their own life concerns (e.g., relationships, interests, health, activities, responsibilities) on the same applications that permit visibility into their parents' social wellness displays. These are only a few of the many advances that could generate exciting health applications of social network analysis.

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