Investigating Older Adults' Social Networks and Coproduction Activities for Health

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ABSTRACT
In this survey study, we extend previous research by investigating the influence of both whole network and individual ego networks on older adults' perceived well-being from the perspective of salutogenesis. We especially take interest in their coproduction engagement where people actively involve one another in doing different types of activities to maintain health. Participants included 173 older adults aged 60 or older from retirement communities and people who age-in-place. Using social network analysis, we found network characteristics like density, degree centrality, or diameter were not associated with older adults' coproduction engagement and psychological well-being. We further found that coproduction activities may be an important mediator because our CCRC and AiP participants had similar level of coproductions and psychological well-being. Based on the results, we suggest that technological designs should facilitate older adults' coproduction by supporting diversity, expanding coproduction networks, and having customizations for different community structures in order to promote smart and connected health.

Author Keywords
Coproduction; Older adults; Salutogenesis; Health; Social networks; Social network analysis

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INTRODUCTION
Engaging in active life and having connected networks help older adults maintain their physical and mental health. Research has investigated both societal and individual factors that complementarily contribute to older adults' health and quality of life, including better access to networks of social support [15], active engagement in community or different kinds of activities [34], or a capacity to respond effectively to stress and maintain high function over time [43]. Conventionally, policy makers and researchers have addressed aging by focusing on mitigation of issues and declines associated with it, such as social isolation or deteriorating physical health and cognitive capacity [25, 35]. As a result, health promotion programs for or discussions about older adults have often stressed problems and limitations, embracing the *pathogenetic* approach that considers older adults as a social group in need of special care [43]. The pathogenetic view does not consider how older adults evaluate their own aging processes, or what they may desire or need to maintain their health. Instead, measures like sound physical or cognitive functioning and a lack of chronic diseases or disabilities are likely to be recruited as benchmarks to assess the health of older adults [25]. Assistive technologies grounded in the logic of deficit design similarly may fail to recognize their target users' underlying goals and needs but rather deepen the stereotypes of aging [27].

We argue for a construal of aging as a natural process in person's life trajectory and for research on health and aging to thus be approached in a positive, or *salutogenetic* way. Salutogenesis recognizes that people have the capacity and resilience to sustain hardships in spite of difficult conditions: in the case of older adults, dealing with illness or functional declines as people age and pulling personal and social resources to remain positive and active are indicators of salutogenesis [1, 2, 22]. We proposed that novel technological supports for older adults should reflective this salutogenic viewpoint, helping older adults take an active role in maintaining and promoting their own healthy aging.

Previous research using a salutogenesis viewpoint for older people's health has focused primarily on individual factors such as resilience, resourcefulness, self-efficacy, and so on [e.g., 43, 44]. However, we note that socio-structural factors like social networks and interpersonal collaboration may also affect one's psychological health and should be considered alongside the individual factors [15, 38]. We

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complement previous work by investigating how older adults provide support for one another through engaging one another socially and collaboratively in different activities, or called *coproduction*, and how their social networks serve as resources for such types of coproduction activities, which in turn lead to perceived well-being. C*oproduction* is defined as activities done with members in a community, through which collective efforts can be motivated and accumulated for community-based initiatives in health and well-being [8, 29].

Shifting away from a pathogenetic or custodial perspective, this paper argues that older adults can provide social resources to one another and actively contribute to their communities. We propose that technology designs should aim at facilitating coproduction engagement for older adults' smart and connected health. Many countries around the world have already experienced the demographic transition into an aging society. It is important to study how older adults leverage personal and community resources for better health. Building upon research studies of social networks, coproduction, and salutogenesis, our project is examining older adults' community resources, social networks, and coproduction interactions. We look into how these social structures enhance their individual level of health and well-being. We also discuss the design implications for coproduction of connected health.

Coproduction networks and salutogenesis

Individuals are connected with others in different social contexts and those interpersonal connections reflect social networks of many types; the resulting networks offer members a sense of connection, social support, etc. [6, 10]. Strong social support from family ties may reduce mortality rate [40]; interactions with strong ties like friends and neighbors have a positive effect on subjective well-being, which is more prominent for older adults in rural areas than those in urban areas [29].

In addition to the quality of social network ties, researchers have also investigated the impacts of social network structures on older adults' health. These characteristics include network size, network density (the degree of dyadic connection in a network), and network transitivity (a measure of connectedness that investigates the likelihood that two people will be liked to one another, given their common link to a third person) [3, 18]. For example, older adults' social networks tend to shrink after retirement and as they age [45]; the availability of fewer social connections may lead to inferior physical health. A lack of social support is also associated with deteriorating mental health [12]. In contrast, it appears that social networks of greater density increases access to informal support and associated health benefits [26]. In studies of specific types of network, researchers have found that older adults' *peer* networks (i.e., rather than family networks) significantly influences health and well-being [17, 21]. A broader network in one's *local community* (e.g., ties to neighbors or local organizations) has also been shown to positively predict adaptability with aging: older adults with diverse friend and community networks have lower risks for mortality [29, 27]. On the other hand, research also shows that people with connected *interpersonal networks* tend to be more involved in different types of activities such as volunteering and thus have more opportunities to establish interpersonal relationships [13]. These two domains of social networks, whole network and individual networks, are structurally interdependent. We argue that incorporating both ego network analysis and whole network analysis can provide much insight into how these two network structures influence older adults' health.

While empirical work suggests that social connections as evidenced by peer networks in a broad community context facilitates factors related to health, there has been little attention to how older adults engage in interaction through these networks, and what might be the benefits of engaging in various social activities with members of these networks. To complement previous work, we are using a coproduction viewpoint to advance research about how social networks relate to older adults' health and well-being. *Coproduction* refers to collaboration of activities among people to achieve a desired outcome [8]. A key feature of coproduction is empowerment of the engaged members because they have the subjectivity to decide how to accomplish the goal and reciprocate [8, 11]. The coproduction framework strengthens health and well-being based on what is perceived to be good (salutogenesis) by older adults and what they can do to help one another to achieve the goal.

Researchers posit that coproduction can be applied among individuals in a community to promote more interpersonal interactions [3, 8]. Through such interactions, people can actually coproduce health and well-being. For example, in order to treat depression and sense of isolation, doctors and healthcare professionals in the U.K. refer their patients to accompany people in need on shopping trips or assist with their daily living tasks [20, 36]. In this case, coproduction not only fulfills requests of patients in need but enhances their sense of self-esteem from being able to help others [20]. Using coproduction as an approach for improving older adults' health and social connectedness is promising, as it expands their potential social contacts, increases types of potential activity engagement, reinforces the feelings of being needed and valued, and builds a connected community [8, 11, 36]. In our study, we investigate if coproduction activities are associated older adults' perceived well-being.

Much of the previous work focuses on older adults' community engagement through volunteering or providing services to those in need [31]; but how they coproduce *with one another* over a wide range of activities is still unanalyzed. While most daily and social activities are taken for granted by younger adults, it is important to examine how older adults actively initiate activities that contribute to

their health and well-being. In a prior interview study, we learned that there are several common types of activities older adults do with one another, including physical, socialization, interest-based, discussion, and service/volunteering activities. In this study, we further explore which types of activities are mostly coproduced and with whom.

The networks in which older adults are embedded provide them with potential resources in terms of coproduction partners and types of coproduction activities available. For example, it may be that a more inter-connected network leads to more coproduction opportunities. Our study investigates how structural network characteristics like density and transitivity, individual ego networks, and specific coproduction activity networks influence older adults' well-being. We also consider different community structures for comparisons, considering physically co-located retirement communities and people who age in place and are thus in distributed networks, exploring these settings to see if they provide different network resources.

Technology for coproduction

To promote healthy aging among older adults, different technologies can be designed to address different aspects of aging, such as applications that use Kinect to promote physical health [18], social network site prototypes for social connections [12], audio-based interfaces for online communication [6], and so on. Another common technology intervention is to provide healthcare interventions, such as home robots that assist with house maintenance [4, 27] or assistive technologies that monitor accidents [38].

Our salutogenesis viewpoint lead us to focus on technology that supports activity engagement among older adults. Technology that facilitates coproduction should cater to ease of individual use and group collaboration. Researchers have investigated timebanking as a platform for promoting coproduction among people of all ages [5, 8, 9, 11]. Designing systems for older adults requires an understanding of their usability and information-processing needs [15, 27]. Designer specifications and user behavior are often misaligned in the design of new systems of interaction [45]. This becomes problematic in older adults, who have significantly different needs with respect to usability than typical technology users [32, 27, 15]. Studies have shown that while technology usage generally declines with age, the perception that technology can be useful and functional is associated with significantly slower declines [15]. Given the importance of coproduction activities to health and well-being, the present study is exploring design features that may facilitate coproduction activities as part of timebanking or other platforms that support a range of community structures.

METHOD

Procedures and participants

Data for the present study was collected between June and September of 2016 through a mix of physical and digital surveys distributed to residents of a small eastern U.S. town. Participants were recruited from continuing care retirement communities (CCRC; this is a living arrangement for older adults that includes independent living, assisted living, and nursing home care, offering residents a continuum of care; community residents live physically close to one another), the local senior center, a university-affiliated lifelong learning program for older adults, and a local volunteering organization. The survey took less than 30 minutes to complete and was completed by 233 individuals.

Out of the total 223 responses, 173 were valid with no missing data, with the average participant being female (69.4 %), 69.92 years old (*SD* = 12.45), married (66.2%; 15.2% single and 18.6% widowed), and a college graduate (33.1% had a bachelor's degree, 33.8% had a master's and 21.9% had a doctoral or professional degree). Importantly, the survey asked participants to specify a community with which they identified as "community". 37 respondents identified with a retirement community; 117 identified with the broader local community (people who age in place, AiP); 19 did not report to have identified with any community. Table 1 reports participant characteristics by community identity.

	Total	CCRC	AiP	Unidentified
Number (n)	187	37	101	21
Mean Age (*SD*)	69.92 (12.45)	71.56 (17.16)	69.51 (10.39)	68.18 (13.19)
Gender (Male/Female)	M: 36 F: 109	M: 10 F: 23	M: 23 F: 72	M: 3 F: 14
Relationship (Married/Single/ Widowed)	M: 96 S: 22 W: 27	M: 22 S: 1 W: 10	M: 68 S: 16 W: 11	M: 6 S: 5 W: 6

Table 1. Descriptive data for participants classified by identified community.

Measures

Social network characteristics

Social networks are ideally studied by mapping complete networks, often referred to as "whole" networks. Whole networks refer to networks that are delimited geographically or organizationally by common activities. While studying complete community networks is a natural way to explore the community's social structures, whole networks are relatively difficult to obtain. Thus in our study, we use ego (individual participants), ego-alter (participants' friends), and alter-alter networks to construct

whole networks. This approach is frequently used to overcome the challenges to collecting whole network data [7], especially where online networks that connect community members are not pervasive, as is true for many older adults.

On the individual network level, "ego" network analysis allows us to understand opportunities and constraints facing individuals [22]. In an ego network, the focus is on individuals (egos) and their personal connections (alters). We asked our participants to fill out five social network matrices, indicating: 1) up to five people (alters) with whom they interact on a day-to-day basis; 2) for each alter, classifying their relationship as acquaintance, friend, spouse/partner, or family member; 3) the level of each alter's physical proximity (close by, in the same neighborhood, in a different neighborhood, in an external community); 4) if the alters know one another; and 5) the types of coproduction activities they engage in with each alter (socialization, exercise, discussion, service, interest-based activities).

The ego network approach was also used to examine survey participants' connections to one another, including any shared alters. This allowed us to examine whole networks for the communities to which our respondents were connected. In the end, five whole-network characteristics were extracted and analyzed for degree of ties, centralization, density, closure, diameter, and average distance. Three ego-centric network characteristics were also examined, including ego network density, average degree of alters in ego network, and network transitivity.

Psychological well-being: Satisfaction with life

Psychological well-being is considered as an indicator of health [e.g., 14, 21, 35, 36]. Research in positive psychology suggests that the components contributing to psychological well-being consist of concepts like satisfaction with life, self-esteem, and happiness [36]. Among them, satisfaction with life refers to the knowledge and assurance that older adults hold for experiencing a satisfactory quality of life. Thus, we operationalized psychological well-being with a satisfaction of life scale [16]. This 5-item scale was measured on a 5-point Likert scale (M = 3.99; SD = .65; α = .82). The questions include "In most ways my life is close to my ideal; the conditions of my life are excellent; I am satisfied with my life; so far, I have gotten the important things I want in life; if I could live my life over, I would almost change nothing." According to our analysis, people who live in CCRC reported to have a mean of 4.01 (SD = .64), whereas those who age in place had a mean of 4.00 (SD = .65). The t-test did not indicate a difference in the level of satisfaction with life between these two groups of participants (t (60.21) = .09, p = .93).

RESULTS

Comparison of Network Characteristics

We examined the social networks of participants through overlapping ego-alter relationships (to study the whole networks), as well as at the individual level by examining qualities of each respondents' ego-centric network structure. Whole network characteristics were examined first for the entire set of participants, followed by a comparison of the two primary community types for participants (CCRC and AiP; see the network visualizations in Figure 1). We first reported the whole-network measures and then the ego-network measures (see Table 2).

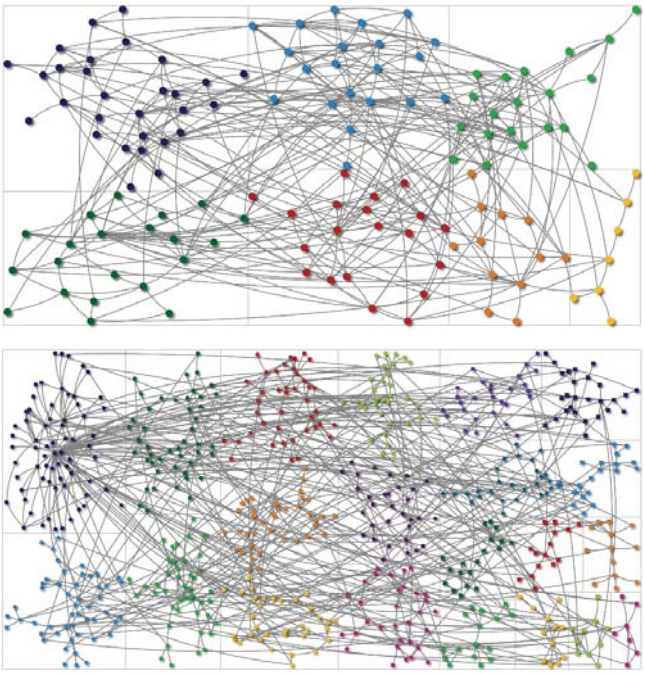

Figure 1. CCRC network (top); AiP network (bottom).

Whole-network measures

The average degree of centrality describes the average number of links for each individual in a network. The average degree of centrality among participants in the whole network was 3.59; as expected, the degree was higher for CCRC participants (5.95), as compared to AiP respondents (3.57).

Density is a ratio measure (ranging from 0 to 1) of the number of ties that are present out of a maximum possible number of such ties in a given network. It is reflective of the interconnectedness of a network, which in the present study was more pronounced in the CCRC community (.046) than in the AiP community (.0058) or the whole network (.0049).

Overall centralization is the degree to which each network is centralized around just a few nodes. This measure is quite similar in both the retirement community network (.103) and the network of older adults who are aging in place (.101). This similarity in centralization score suggests that

despite the seemingly apparent differences in community structure (CCRC vs. AiP), both networks tend to rely on key players to bridge ties.

We identified 15 individuals with a degree centrality of 10 or higher (Min = 10, Max = 17) in the whole network. Among them, we found four individuals from the CCRC community and four from the AiP community (all regulars at the local senior center). Seven of the highly centralized nodes did not complete a survey, but rather were mentioned by our respondents (i.e. emerged as alters). For the eight central individuals corresponding to survey participants (whether CCRC or AiP), they tended to be long-time residents of the local area who participate in multiple local organizations, and/or central community figures such as members of community councils or other key organizations. Most were central only within their respective CCRC or the AiP community; they were not "bridges" connecting different sub-communities, suggesting the interconnection of different communities may not be established.

	Whole	CCRC	AiP
Whole network measures			
Avg Degree	3.586	5.953	3.573
Degree Centralization	.0185	.1027	.1005
Density	.0049	.0461	.0058
Closure	.4026	.0785	.1148
Diameter	21	6	10
Avg Distance	7.5404	3.0415	4.945
Individual network measures			
Number of ties	6.63	6.03	7.02
Avg degree of alters	1.33	1.21	1.40
Transitivity	.59	.69	.57

Table 2. Network measures by community type.

Diameter measures the integration of network components. It is assessed by finding the shortest geodesic distance between the two most distant nodes in the network. In this set of network data we found notable differences in diameter based on type of community: CCRC has a diameter of 6, meaning that the shortest distance between the two most dislocated nodes in the network are connected by six ties. This value increases to 10 in AiP, reflective of the nature of the community in which individuals are more distributed and connected through a variety of local organizations and events. The diameter of the whole network was higher at 21.

Closure can be described as the degree to which every individual in a given network knows everybody else in that network. Two nodes may not be tied to one another, but they may have a weak tie through a mutually connected third node. Closure within CCRC was .078, while the AiP network was .115. The whole network has a higher occurrence of closure (.403).

Individual network measures

Number of ties in an ego network is an individual's total number of connections in the network. Taken together, an average of 6.63 (*SD*=4.76) ties was reported. Respondents who were from CCRC had an average of 6.03 (*SD*=4.42) ties, whereas people from AiP had 7.02 (*SD*=4.75).

Average degree of alters in the ego network refers to the average number of ties incident upon alter nodes in the ego networks (i.e. individuals listed by survey participants. An average degree of 1.33 (*SD*=.95) was reported. For CCRC, the average is 1.21 (*SD*=.88); for AiP, the average is 1.40 (*SD*=.95).

Ego network transitivity is the degree to which ego's alters are connected to one another in any given triad. For example, if person A knows person B, and person A also knows person C, a transitive property exists in this triad if a person's B and C also know one another. This is a measure of local density. An average of .59 (*SD*=.43) was reported. For CCRC, the average is .69 (*SD*=.40); for AiP, the average is .57 (*SD*=.43).

Coproduction Activity Network

Among all types of coproduction activities within ego networks that we investigated, our participants reported most ties for engaging in socialization (M = 3.39, SD = 1.61); followed by interest-based activities (M = 2.52, SD = 1.79); discussion-related activities (M = 2.20, SD = 1.82), service and volunteering (M = 1.5, SD = 1.44); and physical activities (M = 1.22, SD = 1.28). We investigated whether community type was associated with ties available for different coproduction activities. Earlier we reported that the CCRC community had a denser and more centralized network structure than that of AiP, which affords network resources for coproduction partners and activities. However an independent samples t-test found no corresponding difference in number of ties for CCRC versus AiP respondents (t (136) = -.84, n.s.).

Given that whole network structure seemed not to influence the availability of coproduction activity ties, we also tested to see if any ego-centric network measures was correlated with engaging in coproduction at all. We found that average degree of alters in ego network was significantly associated with coproduction engagement (β = .85, p< .000).

Relationship of coproduction ties

We looked into the relationship dimension of these coproduction ties because we hoped to identify the coproduction partners (see Table 3). Overall, respondents reported that 7.65% of their ties were acquaintances

(*M*=.33, *SD*=.85); 54.94% were friends (*M*=2.39, *SD*=1.74); 8.52% (*M*=.37, *SD*=.48) were spouse/partners; and 23.58% (*M*=1.03, *SD*=1.11) were family members. Looking at the communities separately, CCRC respondents reported 11.5% (*M*=.58, *SD*=1.06) acquaintance ties; 48.48% (*M*=2.42, *SD*=1.62) friend ties; 6% (*M*=.30, *SD*=.47) spouse/partner; and 21.8% (*M*=1.09, *SD*=1.10) family members. AiP respondents had 5.7% (*M*=.28, *SD*=.80) acquaintance ties; 47.8% (*M*=2.39, *SD*=1.77) friend ties; 7.8 % (*M*=.39, *SD*=.49) spouse/partner; and 19.87% (*M*=.99, *SD*=1.09) family members.

	Whole	CCRC	AiP
Relationship			
Acquaintance	7.65%	11.5%	5.7%
Friend	54.94%	48.48%	47.8%
Spouse/Partner	8.52%	6%	7.8 %
Family	23.58%	21.8%	19.87%
Physical Proximity			
Near	29.14%	48.48%	25.03%
Same Neighborhood	16.56%	16.4%	16.8%
Different Neighborhood	20.43%	6.1%	23.4%
External Community	7.64%	9.1%	6.9%

Table 3. Relationship and physical proximity of the coproduction ties.

Physical proximity of coproduction ties

We asked the participants to report how far the geographical distance is each of the coproduction ties to them. Because CCRC participants live in a bounded geographic community, we assume that their coproduction partners are people close by, whereas for participants who age in place live in distributed neighborhoods, we assume that coproduction partners may spread across the broader community.

In terms of physical proximity of these coproduction ties (see Table 3), 29.14% of ties (*M*=1.46, *SD*=1.53) were people close by, 16.56% (*M*=.83, *SD*=1.27) were people from the same neighborhood, 20.43% (*M*=1.02, *SD*=1.38) were people in a different neighborhood, and 7.64% (*M*=.38, *SD*=.85) were people from an external community. CCRC respondents had 48.48% ties (*M*=2.42, *SD*=1.80) who lived near, 16.4% (*M*=.82, *SD*=1.33) in the same neighborhood, 6.1% (*M*=.30, *SD*=.64) in a different neighborhood, and 9.1% (*M*=.45, *SD*=.83) in an external community, whereas AiP respondents had 25.03% ties (*M*=1.25, *SD*=1.39) who lived near, 16.8% (*M*=.84, *SD*=1.27) in the same neighborhood, 23.4% (*M*=1.17, *SD*=1.46) in a different neighborhood, and 6.9% (*M*=.34, *SD*=.83) in an external community.

DISCUSSION

Social networks can be viewed as an emergent structure of relationships that develop without any overall top-down initiative or support. Using social network analysis to examine network topology helps us identify basic patterns owing to the way that communities are connected, affecting different features in the network. Our whole network analysis did highlight a number of differences associated with different community types.

Coproduction and Psychological Well-being

Almost all the network measures we examined indicated that CCRC, when compared to AiP or the whole network, was a more connected living arrangement with higher average degree, degree centralization, and density as well as lower diameter and average distance. This is not a surprising result given the community infrastructure enabled by physical proximity among the residents, which facilitates building a dense and centralized network within the community. The interesting and somewhat bewildering result is the low closure value, suggesting that despite living in a retirement community near many other age peers, members may not be related through weak ties. In addition, the highly centralized nodes in both CCRC and AiP were centralized only within that community. It seems these individuals do not bridge *across* social clusters. This points to a technology design opportunity for "building bridges" across relatively isolated community structures. It is also worth looking into their distinct roles within the community and how they influence coproduction practices in a future study.

Drawing from previous studies [e.g., 3, 13, 14, 17], our results tied to network measures were expected to show that participants from CCRC have better psychological well-being than participants who age in place, as CCRC has a more connected network structure. However, the t-test showed no difference on psychological well-being between the two groups. When we further decomposed the coproduction activity network, the gaps between the two community structures are closed. The coproduction practice patterns were similar for CCRC and AiP. Given the result that people's psychological well-being did not differ between these two groups, it suggests coproduction activities may be one mediating activity through which the network structure affect perceived well-being.

Previous research pointed out that social activities, leisure, informal learning, volunteering are positively correlated with physical and mental health [14, 21, 29, 31, 35]. Given the reported ties of each coproduction activity, we learned that these coproductions are not carried out equally: Participants reported most ties for socialization. Around half of the ties were partners for interest-based and discussion activities. With averages of just one tie for service/volunteering and as a exercise partner, our results

imply that the participants may not engage in these activities as much. It may also be these activity types are more likely to be carried out individually, as they do not require any partners. Also, recall that we asked participants to list five ties they interact with on a day-to-day basis; it is not surprising that to see a tendency for listing people who are close to them like spouse [22]. It could be the case that people do not have to rely on close ties to coproduce service/volunteering or physical activities.

Given the results of a regression test on the influence of *network structure* (physically connected retirement communities vs. dispersed aging-in-place networks) on coproduction activities, we concluded that this distinction was not echoed in our data. We further tested to see if the influences were derived from *individuals' social networks* instead. Among all the ego-centric network characteristics, average degree centrality of ego network (average nodes held by actors in ego network), a measure of connectedness, is associated with coproduction engagement. It suggests that people with more social connections have the access to social resources in terms of partners and varieties of coproduction activities in their network, which paves for coproduction participation. When taking relationship into account, we found out that most CCRC and AiP respondents coproduced with their friends and family members. In terms of physical proximity of those ties, CCRC respondents coproduced predominantly with people who lived close by. On the other hand, AiP respondents' coproduction networks were more distributed. Our results indicate that although physical connectedness enabled by living arrangement seemingly provides the infrastructure of constructing a close community or enhancing more coproduction opportunities, coproduction engagement depends more on individuals' social networks.

Last, in the analysis that assessed measures of well-being between respondents from either a CCRC or a aging-in-place community, we did not find any significant difference. Previous studies usually associate health with large, diverse, and connected networks for older adults [e.g., 13, 14, 29, 27]. Having peer networks is also suggested to contribute to older adults' well-being [17, 21]. In this case, AiP networks with low network density and degree centrality, and high diameter and average distance should have fared worse. However, our results showed that the coproduction practices as well as the level of perceived well-being between CCRC and AiP participants were not significantly different. In other words, the potential of using coproduction as a lens to examine older adults' health may be established. In our results, the community network structure did not confine the respondents' coproductions. It is the individuals who took the effort in building their own social networks can benefit from coproduction engagement.

In light of salutogenesis, the distinctions among different types of coproduction activities imply that future studies should weigh these activities differently based on how older adults' actual practices when trying to quantify how different activities are related to older adults' health. Alternatively, a composite of coproduction activities may be established to reflect the diversity of practices. In light of human-centered design and positive design, while it is possible to promote less conducted activities, technological support could also consider what the target users' like to do and do well.

Design Implications

Diversity and flexibility for coproduction

The five common coproduction categories were derived from our interviews with the people in the communities. There were various sub-activities under each category. The current study with quantitative results further showed that they were practiced differently. In order for technology to support older adults' coproductions, we argue the interface design should afford flexibility for users to propose diverse activities. Take hOurworld, one of the largest timebanking platform in the U.S., for example; around 40 higher-level categories with a total of more than 200 sub-types of activities are built in for users to choose. For instance, under "nature/outdoor" category, there are environmental education, birding tours, nature walks, etc. If users cannot find anything suitable, they can propose one. While the attempt of incorporating a wide spectrum of activities does show diversity, another platform grounded in minimal design with features of initiating and joining activities on a mobile timebanking application lifts the predetermined structures that may inhibit users can also promote diverse coproduction [9]. Older adults may have different interests and needs than younger generation in terms of technology use [41]. It may be possible that the structured categories and activities on hOurworld do not pertain to them as much as they do to younger users. In light of salutogenesis, simple designs may allow them to practice in the way they desire. Whether older adults prefer well-structured or free-form interface interaction along with tool choice are among our research interests to pursue in the future studies.

Coproduction networks

Our results indicated that participants coproduced a lot with their friends and family members. Also, connection with weak ties is not common in our sample. Timebanking can support communication and generalized reciprocity among community members who may not know one another before the coproduction activity [5, 11], which may potentially facilitate older adults to expand their coproduced networks, potentially even with the younger generation [11]. However, researchers also pointed out that promoting weak social ties among older adults may reduce their use of social media [23]. Although timebanking is not a type of social media, communicating and interacting with acquaintances or unknown people do take place via timebanking. A possible solution to this is to highlight the values of engaging in coproductions using designs. For example, timebanking allows users to keep track of exchanges with time credits, leaving a record of what are

accomplished with other community members [8]. A more reciprocal contribution could be also highlighted by the metaphor of the design feature. Carroll [9] suggests that in some scenarios like finding a chess match, the activity cannot be achieved were it not for the joiner's participation. So posting an activity invitation and joining one imply that the two people both take initiatives to animate the community. The emphasis of what older adults can contribute and reciprocate should be incorporated into designs.

Customization for community

Introduction of technological interventions may be more successful if they are directed at different communities of older adults with different coproduction needs. Our results already showed that older adults are not a homogenous group, distinct technological support should be taken into consideration. In AiP community, people had more distributed coproduction networks, technological support of connecting partners and finding activities to do may be helpful. However, designing bridging technologies that support needs of various social groups in the broader community should take age-related needs, accessibility, preferences, or cultural practices into account [23]. In CCRC, people mainly coproduced with those close by. Affordances of mobile technology, such as immediacy, mobility, and high social presence can be leveraged to increase interactions and facility communications [5, 9]. Nevertheless, with older adults, usability issues with different tools need to be taken into consideration [32].

Limitations and Future Directions

There are some limitations of our study. First, the survey is cross-sectional, so the results can only be interpreted with associations instead of causations. Network structure is dynamic and changes across time. A longitudinal research is required to holistically unpack the dynamics. In addition, aging-in-place population is consisted of a wide range of diversities in terms of health conditions, socioeconomic status, community engagement, etc. Selection bias in recruitment was present in our data in that we relied on a lifelong learning institute and the local senior center for reaching out potential participants when these groups of people tend to be more active participants in the community. We recognize the difficulty of reaching out those less active/disconnected individuals and they are the specific group who could benefit from forms of coproductions. Future studies should seek to include the underrepresented older population. Third, we purposely limited the number of ties (five) our respondents reported in the survey due to the concerns over increased cognitive overload (especially in the case when they had to report the alter network matrix) and cumbersome process our participants may face. While this decision makes completing the survey easier for the participants, it also faces the downside that they were limited by the number of ties they could include in their network. Future research could expand the number of ties in the network analysis to capture variances in coproduction activities and their associations with perceived well-being. Last, we only investigated the quantity of coproduction activities in this study. The quality of coproduction activity engagement may very well be just as important as the varieties in which people participate. We encourage future study to study this aspect and its influence on older adults' well-being.

CONCLUSION

Using social network analysis, we report a survey study of 173 older adults that examined how their health and well-being is affected by the whole network, their individual social networks, and coproduction activities. Adopting the lens of salutogenesis, we have emphasized the older adults' capacity for actively participating in different activities with one another and helping one another stay healthy. We compared two different community structures, a closely-connected CCRC and a more distributed AiP network, but found that in contrast to previous studies, these network structures did not influence participants' well-being. People with a more connected personal network have resources for coproduction partners and activities irrespective of their community. Coproduction activities may be an important mediator because we found that CCRC and AiP participants had similar level of coproductions. We suggest that technological designs should facilitate coproduction by supporting diversity, expanding coproduction networks, and having customizations for different community structures.

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