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Making visible the invisible: understanding the nuances of computer-supported cooperative work on informal elderly caregiving in Southern Cone families

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Abstract

The design of computer-supported caregiving technology has generally not acknowledged the complexity and heterogeneity of the informal care provision to older adults. For instance, most Latin American older adults have not been capable to broadly embrace digital technology to interact with their family members. This attitude, complemented with a high commitment derived from a strong filial obligation, burdens those family members that are most engaged in caring for their older adults, indirectly producing tension within the family network. In order to better understand this scenario in Southern Cone families (i.e., a particular region within Latin America comprising Chile, Argentina, and Uruguay), we conducted a localized multi-method study involving shadowing, contextual inquiry, and semi-structured interviews with informal elderly caregivers. Our study results highlight design implications and structure the elderly caregiving ecosystem, providing means to support invisible work and its articulation in this highly collaborative scenario. In particular, (1) we define a set of roles that characterize the viewpoints and concerns of the different family members regarding informal elderly caregiving, and therefore sustain the articulation of the process; (2) we draft the main concerns of the involved stakeholders in the form of a caregiving matrix, which can be used for visualizing the current fulfillment of duties within the family network; and (3) we describe a set of typical caregiving scenarios aimed to inform the design of contextualized strategies for mediating the social interaction space of intergenerational families through computer-supported technology. By addressing the identified implications, HCI and CSCW researchers, designers, and practitioners would be able to better understand the complexity of informal elderly caregiving in the South of Latin America, and therefore identify plausible solutions that would improve user experience and the effectiveness of computer-supported mediation strategies this context.

Keywords Latin America · Informal elderly caregiving · Aging in place · Localized study

This manuscript corresponds to a significant extension of the article "It takes at least two to tango: Understanding the cooperative nature of elderly caregiving in Latin America," published by the same authors in: Proceedings of the ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW'17). ACM Press, pp. 1618–1630. https://doi.org/10.1145/2998181.2998314. Regarding the new material presented in this extension, we now present new empirical findings in subsection: 4.5 Structuring the informal elderly caregiving process. As such, this serves as ground for extending section 5 (Discussion) and framing new material in section 6 (Insights into Technology Design), in the form of new layers of analysis and reusable design artifacts.

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1 Introduction

As a person gets older, the size of his/her social network, sense of social connection, and interaction frequency all tend to decrease [18], focusing more on close family members—mainly children and grandchildren [28]. This perceived degradation in social exchanges negatively impacts the physical and mental health of older adults, and therefore, their wellbeing. This stresses the need to improve the social health of older adults as a strategy to enhance their own quality of life, hence reducing the burden that close family members usually suffer as a consequence of assuming informal caregiving duties.

As in any culture, the health, physical, and economic state of Latin American older adults determine many of their needs. As reported in the literature, specific cultural traits also

introduce implicit societal expectations regarding the involvement of older adults and their family members in the context of informal elderly caregiving (e.g., [1, 2, 12, 17, 27, 28, 33, 39]). For example, in a considerable number of Latin American families, which are largely collectivistic, i.e., emphasizing the needs of groups over individuals, adult daughters still dedicate a considerable amount of their available time to care for their parents and own children [2, 16, 43].

Literature recognizes this situation as the assumption of a filial obligation, which is deeply rooted in Latin America. In some cases, it is further considered as a societal expectation [2] in which family members are prompted to promote social engagement and provide affective care to their older adults [2, 32]. Likewise, older adults expect this kind of involvement from their family networks, exposing their needs as caregiving requirements that have to be addressed [16]. Culture also affects the way in which family members deal with this activity. For instance, in Latin America, social interaction with older adults should ideally be conducted in a face-to-face manner, since this has been the traditional way to interact with this cohort. As a result, it is not surprising that a large number of Latin American older adults still prefer to stick to this interaction paradigm [17], acknowledging that aging in place is also a preferred schema by governments and public services for supporting active aging and the overall wellbeing of older adults [31] with the explicit involvement of their family networks. All in all, this shapes the way in which family exchanges should be supported, reinforced, or mediated.

In this manuscript, we refer to informal elderly caregiver as any family member who engages in providing care and assistance to their older adults, even if the latter do not suffer from chronic or disabling conditions. Latin American adult children—mainly women—assume a large part of this process due to both cultural expectations derived from a perceived filial obligation [2] and the Latino parenting style [12]. These caregivers assume several informal roles and have different engagement levels toward the process. The dilemma of simultaneously having to care for their parents and children [2, 17], as well as unbalanced responsibilities when caring for older adults, stress family caregivers and produce tensions with other members in the family network. Therefore, this situation affects the quality of life of the involved family members, and consequently the results of the caregiving process [2, 16].

The design of effective domestic computing solutions requires framing the socio-cultural nuances of the interaction scenario where they will be deployed. In other words, designers in this domain need to deeply understand the contextual viewpoints and concerns of the involved stakeholders that will interact with the conceived social technology support. In that respect, although previous research efforts have been dedicated to conceiving computer-mediated technology to facilitate the social interaction among members within a family network [26], these solutions are not fully transferrable to the case of middle-class Latin American families. Therefore, it turns relevant in this scenario to systematically study how to improve technology acceptance and adoption among older adults, which based on state-of-the-art solutions, can act as a way to help design and introduce computer-based technology for enhancing their social health through mediating their social interaction space.

While related literature in social gerontology and anthropology describes cultural aspects around the informal care provision for older adults in Latin America [1, 24, 27, 28, 32, 39], it does not explore in depth the cooperative nature of the informal elderly caregiving process and does not characterize its structure and dynamics by identifying the involved actors and the relationships among them. In order to deepen the understanding of elderly caregiving in this context, this manuscript complements prior literature and provides ground for socio-technical designers and social computing practitioners to conceive technology-based caregiving services tailored to Latin American families.

The study presented in this manuscript identifies the roles and caregiving activities assumed by family members, as well as their concerns related to the interaction, coordination, articulation, and negotiation necessary to accomplish an effective informal elderly caregiving process, thus favoring the aging in place paradigm. In particular, the study findings indicate that (1) family members assume implicit roles and separation of concerns to participate in the informal elderly caregiving process, (2) the kinship relationship with the older adult and the gender of the caregiver are the main indicators of the willingness of a family member to address caregiving duties, and (3) the lack of visibility of the older adults' needs and caregiving activities is the main source of inefficiency of the process, resulting in tension among family members and imbalance regarding caregiving tasks.

2 Related work

Contrary to most Western countries, in the Southern Cone of Latin America—Chile, Argentina, and Uruguay—there is usually little or no participation of formal caregiving networks or government services to support the informal care provision for older adults [24, 30]. Therefore, informal caregiving becomes more unpredictable in terms of response time, given that the assistance depends on the cooperative, voluntary, and articulated action of family members [15]. These features configure an aging in place scenario that is different to that in most Western countries, where there is increasing governmental funding for home and community-based services with an increasing demand for technology that can improve health and independence of older adults [20, 31]. By understanding the dynamics of this scenario, we could enlarge our breadth of

knowledge by formulating guidelines that would help software designers conceive, develop, and deploy domestic technology effectively.

As a cultural region, Latin America has been largely overlooked in mainstream HCI and CSCW research venues regarding the informal care provision to older adults [16]. In that respect, Gutierrez et al. [17] have identified key factors that reflect the similarities and differences between communication and caregiving practices in Latin America and other Western countries: (1) social configurations, contrasting individualistic and collectivistic preferences; (2) autonomy and independence of family members; (3) privacy concerns regarding digital technology; (4) asymmetric interaction preferences and routines; (5) perceived relevance of regular face-to-face encounters; (6) level of technology adoption; and (7) stress and burden within the intergenerational social care process.

Understanding the role of family members in informal elderly caregiving settings has become an important issue in rapidly aging societies. In fact, given that there are no clear signs of a reduction in disability among older adults, that family ties are loosening, and that there is a growing female labor-market participation [9], there is an increasing need to care for chronically ill, disabled, and partially independent older adults.

According to Procter et al. [31], an effective aging in place strategy should be based upon the social and collaborative contribution of all participants in the caregiving network. Therefore, the nature of informal elderly caregiving is sustained through cooperative work, which resonates with prior research by Consolvo et al. [11], highlighting the distributed and articulated effort required in coordinating the different activities within the family network as a way to sustain informal caregiving.

Schmidt [35] states that cooperative work corresponds to a group of people engaging in a common task, in which they are mutually dependent and need to act together to get the work done. Therefore, this kind of work is sustained by interdependence, where each participant is rendered accountable for accomplishing his or her tasks [36]. Studying the cooperative nature of the informal elderly caregiving process would then enable socio-technical researchers, designers, and practitioners to deepen their understanding of the attitudes, needs, and expectations of the involved stakeholders—older adults, caregivers, and extended family members—to ease the introduction of computer-mediated technology to facilitate the process.

Schorch et al. [38] identified three aspects that characterize the informal care experience at home, highlighting the expertise of caregivers, feelings of social isolation, and burden. Although in a different socio-cultural scenario, informal caregivers in Latin America also feel burdened by having to deal with their duties, often struggling to maintain a sustainable work-life balance [2, 15]. Furthermore, Latin American caregivers currently do not have access to respite care alternatives, which increases the workload and stress related to fulfilling their duties, particularly among the adult children assuming the role of primary caregiver [2]. This situation highlights an opportunity for CSCW designers to conceive contextualized mediating technology to reduce the burden produced by assuming caregiving duties in Latin American families.

Friends and neighbors also help sustain the informal care provision to older adults [19], where adults consider that the main source of informal caregiving for older adults has to be supported by the extended family network, including close friends [16]. Therefore, deepening our understanding of the cooperative nature of informal elderly caregiving needs to go beyond the nuclear family structure and involves extended family members as well as surrounding people who feel close to the older adult and are willing to provide assistance in case of need.

There are also differences attributed to the gender of caregivers regarding the fulfillment of caregiving duties. Related literature states that women provide more hours of care, are more prone to assume the emotional work [6], and are more involved in tasks than men [5]. For instance, daughters are more likely to assist their parents with their daily activities [13], while sons are more proactive and deal with instrumental tasks [10]. In Latin America, one of the adult daughters is usually the primary source of care for older adults [2], whereas male children tend to rely more on their social capital to find assistance for sustaining their caregiving duties [16].

Although in most cultures there are expectations for adult children to care for their older parents, the viewpoints on the importance of societal prospects to this matter usually do not converge [42]. The strength of filial obligation toward caregiving duties is moderated by the influence of the family of procreation, i.e., consisting of the adult child, his/her partner, and their children. On the one hand, according to Gallagher and Gerstel [14], having children is more positively associated with caregiving than is the absence of children. On the other hand, according to Barros et al. [2], in Chilean families, there are asymmetric views on the priority of fulfilling filial obligation duties: older adults expect that their adult children take care of them, while the latter prioritize their own families of procreation.

In the context of informal elderly caregiving, the collective effort for providing care to the older adults is sustained through the involvement of a considerable part of the family network. In that respect, literature reports further contradictory perceptions on the assumption of these tasks in Southern Cone families. For instance, younger family members tend to have asymmetric perceptions on aging and the need to provide informal support and assistance to older adults. While only one in four seniors is dependent, young people usually generalize social stereotypes that do not agree with the present potential

of older adults, thus encouraging resignation and fatalism [1]. This viewpoint, complementing the ruling filial obligation [2], causes informal elderly caregivers to feel burdened, struggling to find an acceptable work-life balance.

Given the distributed and interdependent role of family members when fulfilling caregiving tasks, a major challenge that emerges is articulating the distributed collective effort within the network [37]. This relates to the case of informal elderly caregiving and understanding how to coordinate the actions of family members and allocate resources to improve the efficiency of the process. Indeed, following the discourse proposed by Star and Strauss on the ecology of visible and invisible work [40], there are confronting visions in Southern Cone family networks regarding the informal care provision to their older adults. While duties are mainly assumed by one of the adult children in the family, the work and consequent burden on these informal caregivers are not always assumed as such by society [29].

Technology that supports the process of caring for older adults in Chile and Argentina can be an effective way of balancing the workload of caregivers. It also favors the social integration of older adults, simultaneously bridging the gap in the asymmetric views on aging among family members. However, the adoption of computer-supported home-care systems usually represents a challenge [44]. In this sense, Huber et al. [21] identified that one of the most important factors that limits the adoption of technology by older adults is the fear that these systems might replace human contact with their family caregivers. Similarly, Procter et al. [31] add that informal caregivers and care recipients usually need to reschedule their daily routines around the caregiving tasks, whereas current assisted-living devices usually lack affordances that fit the mental model of older adults. Mynatt et al. [25] also highlight a tension between assistance and autonomy, as well as privacy and independence concerns.

Therefore, one plausible alternative to assist older adults into embracing caregiving technology is to design meaningful experiences that do not limit physical exchanges. In addition, respecting the existing routines and expectations of the different involved stakeholders is required, not only for facilitating the technology adoption and promoting effective and meaningful exchanges, but also to try aligning the implicit and explicit asymmetries existing across generations.

3 Study methods

We conducted a multi-method qualitative study confronting the viewpoints and concerns of adult children acting as informal caregivers with those proposed by the other members in the family network. By combining complementary methods for gathering contextualized data in the wild, we aimed to build a richer picture on how family members co-construct

their elderly caregiving experience. By doing so, we are in position to derive contextualized design guidelines of computer-supported technology conceived to mediate the social interaction space of Latin American family members.

3.1 Participants

Through online notices, email lists, and snowball sampling, we recruited four middle-class adult children acting as informal caregivers for their parents. We focused our recruitment process to match the most representative socio-demographic traits and generational structure of Southern Cone families, as reported in the literature [2]. In particular, all members in the studied families were all born and raised in the cities they are currently living in (namely Santiago, Chile, and San Juan, Argentina), consider themselves as middle-class, and the adult children enacting the role of informal caregivers are professionals are currently active in the job market. In the rest of this manuscript, we refer to the recruited people as "primary informal caregivers."

We centered our sampling strategy on the recruited primary caregivers, extending it then to their wider family networks. We approached the informal caregivers' siblings, children, and nephews. In this latter case, candidates had to be over the age of 14 and explicitly express their intention of being part of the study in order to be considered as a participant. The final study sample was composed of 51 people across 4 family networks ($n = 16, 11, 13, 11$, respectively). Families are distributed across several households living in a same city. Two of them were based in Santiago (Chile), while the other two in San Juan (Argentina). Table 1 details the socio-demographic data of participants.

Table 1 Locations, gender, and ages of participants

Family	Households	Participants	
1	1A	2F (83, 61*)	2M (68, 28)
Chile	1B	1F (36)	1M (37)
	1C	2F (55, 37)	2M (33, 29)
	1D	2F (41, 16)	2M (47, 22)
	1E	1F (32)	1M (31)
2	2A	1F (71)	1M (73)
Chile	2B	2F (58, 29)	1M (31)
	2C	2F (49, 16)	2M (53, 18)
	2D	1F (48)	1M (43*)
3	3A	1F (61)	1M (72)
Argentina	3B	1F (48)	2M (48, 24)
	3C	1F (28)	1M (25)
	3D	2F (44, 18)	1M (45)
	3E	2F (42*, 14)	1M (42)
4	4A	1F (77)	1M (79)
Argentina	4B	1F (48)	2M (48, 24)
	4C	1F (40)	1M (42*)
	4D	3F (32, 16, 14)	1M (49)

The recruited primary caregivers, who are identified with a star (*) in Table 1, have daily 8-h work shifts. None of the studied families had external assistance—except for housekeeping—to care for their older adults.

In summary, the sampling schema for participants was executed in two stages:

1. We initially recruited four informal family caregivers from four independent families, two living in Santiago (Chile) and two in San Juan (Argentina). These people served as our primary informants for the study, identified with a star (*) in Table 1.
2. Then, we expanded the data collection process, individually and independently within each family, covering a subset of the intergenerational network within each family (at least one older adult, one adult child, and one grandchild per family). These subjects are the other family members reported in Table 1.

3.2 Data collection

We gathered the data independently in each family, following a three-stage process: (1) through contextualized interviews and observation with the four primary informal caregivers; (2) by observing the four settings during an informal family meeting using the shadowing technique; and (3) through interviewing the supporting family network of each primary informal caregiver. Next we describe each stage.

- *Contextual inquiry.* Aiming to gather insights into how primary informal elderly caregivers fulfill their duties, we conducted contextualized interviews intertwined with in-place observation. This method explores a group of users by observing and inquiring about what they actually do, why they do it in that way, what their latent needs are, and identifying their core values.

The authors met participants ($n = 4$, one from each studied family) and discussed their experiences and main concerns on being informal elderly caregivers. Some example interview questions were the following: *How do you feel when performing your caregiving tasks?* (to assess the personal expectations and engagement with the caregiving tasks); *How do you rely on other family members to fulfill your caregiving duties?* (to explore the involvement of the family network as well as how the primary caregiver positions him/herself within the group); and *What motivated you to assume this role?* (to understand the reasons that motivate the primary caregiver to achieve his/her duties). Interviews were audio-recorded for later transcription and analysis, and later augmented with contextualized field notes. The process lasted for about 3 h with each participant.

- *Shadowing.* To understand the internal dynamics of families and interaction regarding the care provision to older adults in a natural setting, we observed an informal meeting in each family ($n = 8, 8, 9, 6$ participants, respectively in each observed family). These meetings, deeply grounded in tradition and fairly common in Latin America, are typically organized around lunchtime on weekends and gather together several family members.

While observing this setting, we took detailed handwritten field notes to understand the relation between the primary informal caregiver and the rest of the family network. We were also interested in the actual involvement of family members in terms of care provision for their older adults, as well as their informal interaction with each other. In particular, we observed how different family members related to the older adult receiving care, how these people coordinate the care provision and fulfillment of caregiving tasks, what sources of tension and conflict between participants emerge in the process, and the nature of informal exchanges (e.g., conversations and other ways of social interaction).

- *Semi-structured interviews.* Finally, with the goal of understanding the perception and experiences of the supporting family network in the care provision for the older adult receiving care, the authors conducted individual semi-structured interviews to the members in each family. We interviewed a total of 41 participants ($n = 14, 8, 10, 9$, respectively in each family), covering each family network until reaching data saturation.

Interviews were conducted in Spanish and lasted between 40 and 60 min each. We audio-recorded them with the explicit consent of each participant for later transcription and analysis. The interview script was validated in a pilot study with three people, aiming to resolve wording problems and ambiguous statements.

The main topics covered in the interview were as follows: *How do you participate in the care provision for the older adult in your family?* (to confront the vision of the primary informal caregiver with the rest of the family network); *How do you keep up to date of the doings and whereabouts of the older adult in your family?* (to explore the mechanisms used by the family network to sustain their interaction with their older adults); and *How would you situate yourself in the caring network of the older adult in your family?* (to understand the interaction within the family network and the individual concerns of family members regarding the care provision for their older adults).

3.3 Data analysis

We generated our study dataset by transcribing the collected audio data and extending it with our handwritten field notes. To analyze our dataset, we followed the thematic analysis approach, which consists of generating initial codes from the data, searching for themes, contrasting the identified themes with the data, and iteratively refining the themes and narrative.

We framed our analysis around the idea that family members implicitly or explicitly tend to assume roles in informal caregiving. This is based on previous work by Miller et al. [23] in hospital settings and on an initial proposal on caregiving and intergenerational family communication roles presented by the authors in a previous work [15].

The description of the caregiving roles reported in this paper builds upon our own prior work [16] and we extend our analysis by providing new layers of empirical findings structuring the caregiving ecosystem and reusable design artifacts to support this specific application domain.

Quotes, translated from Spanish by the authors, are provided to illustrate the main topics grouped under each theme. "AC" refers to the adult children in the family network, "AP" to the adult partners of family members belonging to the filial branch of the older adult receiving care, and "GC" represents grandchildren.

3.4 Ethical considerations

Following the American Psychological Association (APA) ethical guidelines for fieldwork research, all participants were compensated for their time and provided their free, explicit, and informed consent. The study design has been approved on ethical grounds by the Research Ethics Board of the Faculty of Physical and Mathematical Sciences of the University of Chile.

Interviewees were informed about the goals of the research, the nature of the data intended to be collected, and our efforts to ensure confidentiality during data collection, treatment, and dissemination. Participants were also offered the right to withdraw from the study at any time. No participants declined to participate in the study nor dropped out.

Regarding the observation of weekend family meetings, we contacted beforehand the participants who confirmed to participate in the study and provided consent. We presented the scope of the study and explained the role that the assigned researcher would take as external observer during the meeting. Given the intimate nature of this setting, we only kept handwritten notes and opted to not use recordings.

Quotes and any kind of information containing personal or identifiable participant data were anonymized, and pseudonyms were used if necessary. Once the quotes were selected to sustain the reported narrative, we returned to the involved participants and offered them the power to veto the publication of their quotes if they considered them a breach of confidentiality. No participants decided to edit or withdraw their quotes for publication.

4 Findings

We identified three core aspects that shape the structure and dynamics of the informal elderly caregiving process: (1) the assumption of implicit roles; (2) the articulation of the work performed by family members for conducting the process; and (3) the sources of tension within the family network. We also identified gender as a transversal issue influencing the three core aspects stated above, which resonates with related literature in social sciences and nursing [5, 6, 10, 13, 29].

4.1 Roles in informal elderly caregiving

The main characteristic of cooperative informal caregiving in Latin America is that the involved stakeholders also share the trait of belonging to the same extended family network, rarely interacting with external service providers, such as professional caregivers or medical services. The derived roles characterize the concerns and viewpoints of informal caregivers. Although by no means the proposed roles intend to be exhaustive, we argue that it is possible to use this characterization for informing the design of social computing technology tailored to the expectations and scope of caregiving duties to be fulfilled by family members.

- *Assistant*. Family members assuming this role share the same roof with the older adult, continuously monitoring and providing care and assistance. In urgent cases, they are in a position to promptly address the situation. The significant other of the older adult receiving care or an adult child usually assumes this role. For instance, one assistant explains how she ended up assuming this role:

My parents lived together in a house close to ours. We visited them quite often, usually on weekends. Unfortunately, when my father passed away some years ago, mom started to feel very sad. She didn't visit her friends like she used to, and started to get sick quite often. I decided to bring her back to my house, to help her with her needs. […] It was difficult in the beginning, but I still think it was for the best. She seems happy now. She plays with my kids, she reads to them, and sometimes she goes for a walk and phones her friends. AC1, family 1A, female, 61 years old.

Strictly speaking, the tasks associated with this role are similar to those that an external, formal caregiver performs, e.g., supporting the activities of daily living (ADLs), the instrumental activities of daily living (IADLs), and indirectly providing information and connecting family members with news about the older adult. Although literature reports design considerations for ambient information systems to assist older adults in accomplishing their ADLs (e.g., [25, 33, 41]), in the studied scenario, family members typically assume this role, particularly adult children, and are aware of the implications of the unwritten social norm of filial obligation. These family caregivers therefore consider that fulfilling these duties is a moral repayment for the care received by their parents. For instance, another of our assistants, who is also the youngest son of the older adult in his family, states:

> I don't see this [assuming caregiving duties] as an obligation, but rather as an honor!. AC5, family 2D, male, 43 years old.

Following on the notion of articulation work proposed by Schmidt and Simone [37], assistants are the family members who are in charge of articulating the distributed collective effort of sustaining the informal caregiving duties within the family network. This implicit leadership within the family is also an expression of invisible work [40], which is particularly stressed in Latin American families given the collectivistic nature of social links and the historic tradition of filial obligation [2]. In some cases, family members inadvertently overlook the invisible nature of this work, thus resulting in burdened assistants due to an unbalanced caregiving workload.

- *Monitor*. They are family members who do not share the same roof with the older adult but are consistently aware of the doings and whereabouts of their older adults. Typically, monitors are in position to provide affective care, social engagement, informal health care, economic and financial support, and to a lesser extent, security and safety.

Most monitors are available to support care recipients when necessary (e.g., for running errands), and they coordinate their activities with the assistant (if any). Typically, one or more of the adult children assume this role.

> My sister and I coordinate with my father's partner to address his needs, but mainly to support the health issues of our dad. AC3, family 2B, female, 58 years old.

Given that monitors do not live with the older adult, they usually establish mechanisms to inform themselves about the older adult's actions. In some cases, the monitors rely on their social capital within the family network and also involve neighbors to reach their older adults.

> I am always concerned about my parents. I tend to call them at least once a day, usually during my lunch break at work. However, when I can't reach them, I worry because I don't know if something bad has happened. In those cases, I usually call their neighbors or my brother who lives nearby to see if they have news about them. AC10, family 4C, male, 42 years old.

Many recurrent tasks of monitors are related to sustaining the social capital within the family network. For instance, they mediate the interaction between two members who cannot smoothly communicate with each other, as well as organize and run weekly reunions with the older adult.

> My children are not willing to interact with my mother because she is always bothering them with religious comments. Therefore, I keep my mom informed about my children's activities. Sometimes, and with the consent of my children, I invite her to have lunch with us on weekends. AC6, family 3B, female, 48 years old.

- *Helper*. They are less-committed family members, who typically contribute in instrumental duties that require low effort and do not represent a long-term commitment. They are usually the siblings of assistants and monitors, and grandchildren who are affectively close to the older adults. People assume this role on-demand, in response to a request typically raised by an assistant or monitor.

> My dad makes a significant effort to care for my grandfather, so I try to help him with these tasks. Sometimes he asks me for help, but other times I take the initiative. GC18, family 4D, female, 16 years old.

Neighbors and close friends of the older adults act as helpers, which resonates with prior literature on the involvement of affectively close external members to the family.

- *Outsider*. We identify as outsiders those family members who are not willing or available to assume caregiving duties. Among typical outsiders, we include teenage grandchildren who do not feel affectively attached to their grandparents, and family members that do not live physically close to the kin.

These people justify their minor involvement indicating that they are not aware of the current needs of the older adult, and that there are others more capable who can conduct the caregiving tasks. However, in some cases, some outsiders are willing to participate if necessary. For instance, GC11 states:

> I would help grandma if she needs me, but I don't know what to do! My parents and uncles already take care of her and keep telling me not to worry. GC11, family 2C, female, 16 years old.

Although outsiders can initially be weak links when articulating the caregiving work, the collectivistic nature of social links in Latin America still sustains strong interpersonal ties, usually built upon affection. Therefore, based on our field observations during family meetings, we claim that these family members can be persuaded to participate in the process during short time periods, under specific conditions, and to perform particular tasks.

4.2 Assumption of family caregiving roles

The set of activities performed by the family members in favor of their older adults is what determines their role in this process. Recognizing that people do not necessarily assume static roles, and that the informal caregiving work is articulated, the study results identify a set of factors that strongly influence the assumption of caregiving roles.

The gender and kinship relationship of caregivers with the older adult seem to transversally influence the assumption of roles and affect the coordination and articulation effort of sustaining the informal caregiving work. Trying to not overgeneralize the structure of every family ecosystem, the study results indicate that there are noticeable differences in how people embrace their duties. In that respect, Table 2 shows the roles that, according to our observations, are usually assumed by family members.

The main difference in the assumption of roles according to gender is that female caregivers are usually more committed

Table 2 Assumption of roles in informal elderly caregiving

Relation	Female	Male
Partner	Assistant	Assistant
Adult child in the same house	Assistant	Monitor
	Monitor	Helper
Adult child in another house	Assistant	Monitor
	Monitor	Helper
Grandchild	Helper	Helper

than male caregivers. As such, adult daughters tend to get involved in roles with more load and responsibility, such as assistants and monitors.

The affective link between the older adult and his/her family members also influences the role that will be implicitly assumed by the latter. We observed that it is not rare that the last adult child leaving the parental home tends to be the most committed in caring for his/her parents.

> I am the youngest one among my siblings, and we all assumed it was kind of 'natural' that I had to be more aware if dad and mom need something. AC8, family 3E, female, 42 years old.

Similarly, as we observed during the family meetings, the number and quality of shared memories shape the grandparent-grandchildren relationship, which in turn depends on the physical distance between these people. Therefore, those grandchildren who consider themselves to be affectively close to their grandparents are more prone to assume more time and resource-consuming tasks in order to care for their older adults.

A third factor that influences the adoption of family caregiving roles is distance. This notion is usually considered in CSCW research as a hurdle to effectively mediate interaction between people [3]. In the case of informal elderly caregiving in family settings, this still holds. When adult children move away, they typically reformulate their caregiving commitments with their parents. However, given the strength of socio-affective links within the family network, distance usually does not deteriorate the link between adult children and their parents, but negatively impacts the relationship between grandparents and grandchildren.

> I switched jobs a couple of months ago and I had to relocate as well. […] We [family members] can't see my mother as often as we'd like to. In any case, I still try to call her quite often and I push my kids to do so as well. I also send her some money every month to help her to buy medicines or cover other personal expenses. AC2, family 1D, male, 47 years old.

In summary, adult children living away tend to proactively assume the role of helper and make an effort to engage their children into maintaining the contact with the older adults. However, the lack of frequent face-to-face interaction deteriorates the relationship between grandchildren and grandparents. This situation is recognized—and assumed—by younger family members, but not always by the older adults.

4.3 Coordination and articulation of the informal elderly caregiving work

Ensuring the assumption of family caregiving roles requires articulating the collective distributed effort of family members. However, this can turn to be demanding due to the complex and dynamic arrangement of the family network with regard to this process. Indeed, in the studied families, promoting articulation work is more an expectation rather than an established practice. Through our field observations, we noted that improvisation and individualism often cause tension in the relationship among family members. However, the expression of collectivistic social links imposes a superior goal of avoiding conflicts inside the family, particularly when they involve the older adults. This latter situation helps maintain a balance among the people engaged in the caregiving process.

Monitors and helpers usually coordinate in a point-to-point way with the assistant. Otherwise, monitors act individually based on the separation of concerns implicitly assumed by family members and eventually ask for the help of their partner and children. As AC10 stated, this attitude is usually assumed because coordinating the caregiving work is sometimes perceived as a source of conflict within the family.

> When dad passed away, we needed to decide who was going to take care of mom. My sister was initially reluctant, but she ended up helping her move to her place. Thank God she did it, so we don't have to fight over it! Not only because she can keep an eye on mom, but also because she loves updating us on how mom's doing or if she needs something. AC10, family 4C, male, 42 years old.

Consequently, given that the articulation work tends to be centralized in the assistant, the caregiving activities conducted or mediated by a monitor are not visible to other monitors or helpers belonging to a different family branch. This limits the capability to coordinate and negotiate activities among those assuming caregiving roles, thus making the process inefficient. For instance, as we observed during family meeting no. 4, it was quite common to see actual needs of the older adult that ended up not being addressed, while others were over fulfilled.

Male caregivers tend to be more willing to ask for help and work cooperatively than female caregivers. Typically, the former convenes people of their same filial branch. For instance, AC5 relies on his siblings when he is unavailable:

> I always try to support my parents. My siblings also take care of them, but to a lesser extent. […] When you ask

them to do something, they're there. We're very united and share responsibilities. AC5, family 2D, male, 43 years old.

Contrarily, female caregivers in our interviews repeatedly claim to address the challenges due to caregiving by themselves. This leads to complaints about the lack of help, particularly toward family members of the same generation.

> Dad is already used to me being the one who drives him to the doctor. […] I have to do it because I live closer (to him). […] I would really like more involvement from my brothers. Although they are aware that they need to do more for our dad, they tend to overload me and avoid their responsibilities. AC8, family 3E, female, 42 years old.

All in all, it turns that female caregivers expect more involvement from other family members, whereas male caregivers actually recognize that they benefit from more support, particularly that offered by members of their same generation. These observations resonate with related research on burdened family caregivers [29].

Female and male adult children tend to look to different concerns when engaging in caregiving duties. On the one hand, women acting as monitors or assistants focus more on emotional expression and values, i.e., in supporting the human being that is cared for. Thus, they are more willing to provide affective and social care than male caregivers.

> Even if they [the older adults in the family] are not my parents, I love them. They are wise and deserve all our respect. I do everything that I can to support them, together with my husband and my children. AP8, family 2D, female, 48 years old.

On the other hand, male monitors focus more on providing comfort, safety, and peace to the older adults. They are more effective than female in this domain and usually do not feel burdened with the responsibilities that they assume. However, they are not always willing to engage in caregiving routines or accomplish the assumed duties.

> Although I love mom and dad, I also have to admit that my wife takes care of them more than I do (laughs)! I mean, we both work together: I am usually more present for assisting with particular tasks, doing shopping, fetching their medicine at the pharmacy, and so on. My wife is always there entertaining them, looking at old photos with our kids, watching TV, and spending

quality time together. AC5, family 2D, male, 43 years old.

Therefore, as suggested by caregivers in family 2D, the effort provided by both genders tends to complement each other in order to sustain an effective informal caregiving plan. This includes not only sharing duties and coordinating the allocation of resources but also individually or jointly assuming responsibilities when providing care. In this family, both visions work coordinately in order to smoothly run the process, which indirectly engages other family members to actively participate in the caregiving process.

This implicit separation of concerns offers some kind of order and stability to the family ecosystem. When adult children are both of the same gender, one of them usually relies on the assistance of his/her partner for fulfilling the caregiving work.

> We are three brothers, and unfortunately there are caring aspects that are more naturally addressed by women, like emotional contention or just spending time listening to the older adult. When these issues arise, I ask my wife for help. AC9, family 4B, male, 48 years old.

4.4 Sources of tension among informal caregivers

The elderly caregiving process in the observed families is unstable and informal, where some participants periodically conduct independent efforts for stabilizing the situation. Through our interviews, we identified several sources of tension that for short-time periods jeopardize the relationship among family caregivers.

Typically, the caregiving process does not provide visibility of the activities conducted by family members in favor of their older adults. This induces an asymmetric perception of the assumed caregiving roles across the family due to an implicit assumption of separation of concerns in the fulfillment of caregiving tasks. In this case, most assistants and monitors feel themselves as those who are the most engaged with the care provision. Therefore, it is not unusual that they consider some family members as free riders, which increases tension in the family network.

> Don't get me wrong. We all do our best to help mom, whenever we can. However, I regret that my brothers don't take the initiative. I frequently need to keep reminding them to have lunch together on Sundays and to go pick mom's medicines. It's the least they can do! […] However, you're not in position to complain, because then the others [siblings] keep telling that it's

my role to keep the family together! AC1, family 1A, female, 61 years old.

> My sister thinks that she's the only one supporting mom and doesn't value the support that we provide her [mom]. This sometimes irritates me and we end up having an argument. AC2, family 1D, male, 47 years old.

In addition, the separation of concerns within the elderly caregiving process imbalances the load assumed by the adult children, since the care activities of female caregivers are usually time consuming and performed more frequently than those assumed by male caregivers. Considering this situation, it is not surprising to observe that female adult children are more engaged in the caregiving process than male caregivers, which resonates with related literature [2, 5, 6, 29]. Furthermore, given that monitors and most helpers are not broadly aware of the needs of the older adults, they usually fail to contribute to the extent expected by the primary caregiver, i.e., the assistant.

As a way to involve younger family members into caregiving duties and also address pending needs of their older adults, some adult children—usually assistants and monitors—try to impose filial obligation duties upon their own children in favor of the grandparents.

> I care a lot about grandma, but sometimes dad asks me a lot to do and I can't manage keeping track of my stuff at the University and all the issues that we have at home. I have no problems with taking on certain tasks, but someone has to be there to help me if I can't do it. I also have to take care of myself and nobody is going to help me there! GC12, family 2C, male, 18 years old.

However, as we observed throughout the study, grandchildren in many cases refuse the parental imposition on participating in the caregiving process. This strains the relationship with their parents, and in some cases, with their grandparents.

> I don't know what's wrong with mom and dad! It's like they get mad if I don't call grandma or I don't go visit her. […] Yes, they're my grandparents but we already see each other once a week, so I don't think I should do more for them. That's what mom and dad are for! GC6, family 1D, female, 16 years old.

Following the formulation of Schmidt and Bannon on the nature of cooperative work [36], younger family members

typically do not feel accountable for taking part in the cooperative process of informal caregiving. This mismatch in the perception of following the filial obligation is a potential source of tension among family members, which according to our field observations, is higher when assistants feel burdened with their caregiving duties. This situation highlights the need to address the expectations of the various family members and conceive means to effectively support an appropriate articulation work within the caregiving network.

4.5 Structuring the informal elderly caregiving ecosystem

We depict in Fig. 1 a conceptual model that structures and characterizes the informal elderly caregiving ecosystem observed in the studied scenario. The components of this model are grounded in the empirical work reported in the previous subsections and related literature discussed in section 2.

This model identifies four interrelated factors—represented as quadrants—that affect the effectiveness of the family caregiving ecosystem: (1) the elderly caregiving needs, (2) the capability of informal caregivers to address these needs, (3) the actions taken to deal with the elderly needs, and (4) the impact that the conducted actions have in the wellbeing of the older adults.

White boxes (e.g., *cultural context* and *roles assumed by the family caregivers*) represent the main components that form the informal family caregiving experience. Finally, arrows represent how these components are interrelated. In the figure, "OA" stands for older adult.

Each of these factors in our model (i.e., a quadrant) defines a particular concern to address in the design of social interaction supporting systems. Next we describe each quadrant.

4.5.1 Elderly caregiving needs

Although the user group of older adults is vastly heterogeneous and diverse [45], there is a common trait in Latin American elderly, consisting on typically having a group of affectively close people that care for them. While these people typically are their partner and adult children, other relatives and friends also participate.

Some of the needs of older adults are due to a fluctuating or declining health and wellbeing status due to aging. Others are a result of the cultural aspects around the caregiving ecosystem, which create expectations not only in the older adults but also in the whole family community. This situation introduces a set of caregiving requirements, which according to the elderly, should be addressed by their family caregivers either due to partnership or as a result of their filial duties [2, 32]. In this respect, the filial obligation is understood as an implicit contract where mainly adult children take care of their parents as a repayment for the care they received during childhood [2].

In order to sustain the wellbeing of older adults, the typical caring activities that informal elderly caregivers are faced to perform as a part of the filial obligation are the following:

- *Affective care*. By promoting affection, older adults feel themselves appreciated and loved by other family members. This also considers the provision of emotional support.
- *Social engagement*. This considers engaging older adults in the activities within their family, e.g., organizing reunions and organizing holiday trips together. It also includes promoting recreation activities.
- *Informal health care*. This considers the assistance to the elderly in addressing their health treatments and medical
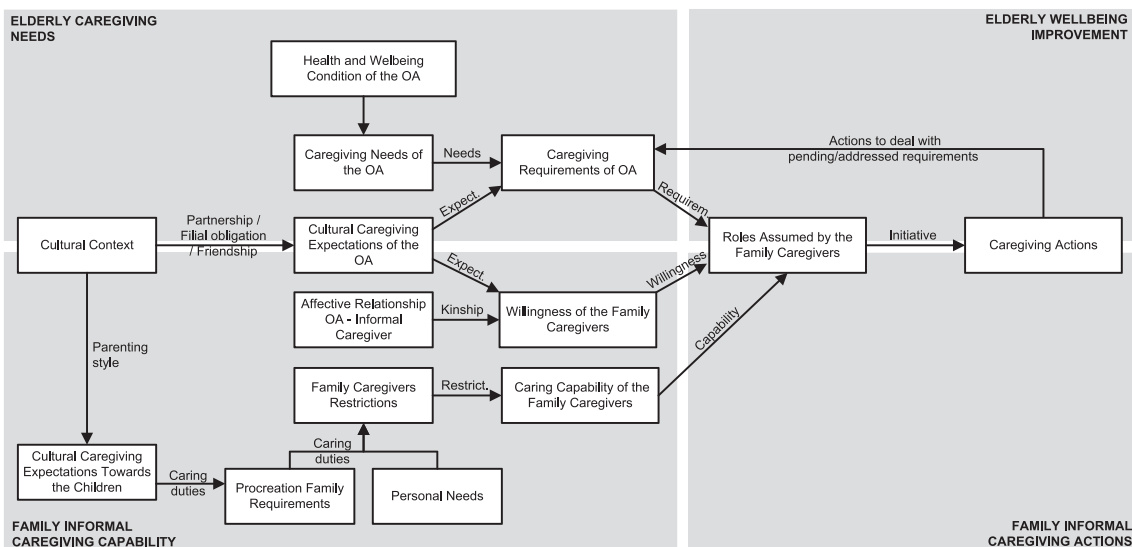

Fig. 1 Informal elderly caregiving ecosystem in Latin American families

issues, as well as performing informal tracking of their health conditions.

- *Economic support*. It represents the provision of money, either directly or indirectly, to address needs of the elderly.
- *Financial support*. It considers helping manage—or explicitly managing—the economic resources of older adults. For instance, this includes paying bills, taxes, and personal expenses.
- *Housekeeping*. It represents activities that allow managing the house of the older adult, e.g., cleaning, shopping, cooking, doing laundry, and providing safety and security.
- *Activities of daily living*. They are personal activities that people tend to do every day without needing assistance, such as eating, bathing, dressing, toileting, transferring (walking), and continence.
- *Sporadic supporting activities*. Represent actions to address unexpected non-critical needs, like repairing or installing electrical appliances. Sometimes family members assist in performing these activities or by finding a provider to complete these actions.

The support for these caring activities has different relevance and frequency of required assistance, which is something clear for the older adults, but not always for the family caregivers. Typically, when the required support is highly frequent, such an activity is perceived by the elderly as highly relevant and creates expectations on them.

Frequently, the priority assigned by older adults to their needs does not match with that assigned by his/her informal caregivers. Therefore, both perceptions should be represented and contrasted to avoid misunderstandings.

4.5.2 Family informal caregiving capability

Family caregivers usually take the responsibility to help older adults address their needs. However, some of them (particularly adult children) have their own commitments and duties, which take a considerable amount of their available free time. Culturally, in Latin American families, it is expected that parents focus on taking care of their family of procreation, which jointly with their personal needs, generate a set of restrictions that jeopardize a full-time commitment to address the elderly caregiving process [2].

Furthermore, the cultural expectations on caring for older adults and the affective relationship between the elderly and the potential caregiver determine the willingness of family members to actively take part in this ecosystem. Considering these restrictions, family caregivers assume roles to sustain their activities, which potentially become a source of conflicts and tension among them.

4.5.3 Family informal caregiving activities

Caregiving roles are informal, voluntarily assumed, and involve different levels of commitment in the caregiving process. It is expected that each role addresses specific activities to assist the elderly. Given the informality of these roles, it is rare that somebody monitors if the activities are actually performed, not even their frequency. Furthermore, family caregivers are reluctant to monitor these activities, as it is usually perceived as a source of conflict within the family network [15, 16]. Consequently, there is little to no visibility about the caregivers' contributions, commitments, planned activities, and pending requirements, which also represents a source of conflict.

4.5.4 Elderly wellbeing improvement

One of the main goals of informal caregivers, when engaging in assisting their seniors, is to reduce the needs of the latter, as well as positively impacting their wellbeing. Given that older adults tend to have recurrent short-term needs, a good way to achieve a good positive impact on their wellbeing is to react promptly and actually address their concerns. As a result, older adults perceive the informal caregiving process as an increased interaction frequency with their families and consequently better social integration.

5 Discussion

There are no one-size-fits-all solutions for taking care of older adults, since such a process would have to address their particular needs, adapt to certain configurations of roles, and consider the commitments of family members. The study results presented in this manuscript provide insights for informing the design of computer-mediated solutions for supporting elderly caregiving and mediating intergenerational communication.

Concerning the way in which the informal caregiving process is articulated, the results indicate that family members voluntarily assume implicit roles that determine their level of engagement and willingness to be aware of the caregiving process. In other words:

> **Design Implication #1**: *Socio-technical designers of informal caregiving technology should consider the potential influence of informal caregiving and intergenerational communication roles. Therefore, they should actively provide particular services for each role. For instance, the activities of assistants and monitors can be supported with technology for easily reporting the pending needs of the older adults, and thus establishing a platform for*

seeking help without being involved in the coordination of the caregiving effort.

The assumption of the proposed roles also implies the design of awareness, notification, and persuasion mechanisms for making the caregiving work visible, since participants expect to receive up-to-date information following their level of engagement. Similarly, the mediation of mechanisms for making the caregiving work visible should limit the imposition of caregiving duties that fall out of the range of responsibilities that family members could assume. This opens various challenges for social computing technology designers, such as providing the means to facilitate their identification within the family caregiving ecosystem, which would allow providing contextualized services to the involved participants. We can state this idea as follows:

Design Implication #2: *Key design considerations to take into account when designing effective domestic computing technology for mediating the social interaction space of family members are as follows: social awareness, activity awareness, persuasive strategies, and up-to-date feedback loop mechanisms.*

Although the findings reported in this manuscript indicate that gender and the kinship relationship of caregivers with the cared for older adult are the main drivers for mediating the assumption of caregiving roles, there are also other factors affecting the involvement of family members that are not easy to automatically identify, such as affection and physical distance. Moreover, the role assumed by a family member can change for several reasons.

Design Implication #3: *Keeping track of the evolution of roles within a family network represents a design challenge that would also help conceive and deploy contextualized services. Similarly, such services should also support the technology adoption of older adults, for instance, by enabling and/or adapting services tailored to the current level of system appropriation. If a computer-supported mediator system intends to persuade people to engage in a more active role (*e.g.*, outsiders becoming helpers), such a change should be detected as a way to increase the available resources for effectively intervening in the caregiving process.*

The findings also indicate that, although it is required, there is little to no coordination among roles, given that this activity requires high availability from family members, is time consuming, and usually generates conflict within the caregiving network. This opens several opportunities for designing coordination services for family members.

According to Schmidt and Simone [37], the articulation of the distributed activities that are part of a cooperative work requires appropriate mechanisms of communication and coordination among the involved participants. In that respect, the study results go a step forward by informing that such mechanisms should consider the roles assumed by family members and respect the loosely coupled nature of the caregiving work.

Design Implication #4: *It seems to be more appropriate that helpers subscribe to particular requests raised by monitors and assistants, rather than the latter send these requests directly to the former. This would reduce the imposition of filial obligation among helpers, which constrains the dedication and involvement of these people.*

Regarding the factors affecting the willingness of family members to engage in caring duties, the study results indicate that the gender of caregivers makes them prone to address particular types of caring activities. Moreover, the concerns of female and male caregivers are complementary.

Related literature in Western countries identifies the distinctive role of the female adult children in the caregiving process [5, 6]. However, it does not clarify what key concerns are usually addressed by each gender in the studied sociocultural context. In that respect, the study findings suggest that the design of specialized services need to consider not only the role assumed by caregivers but also their gender. We can summarize this idea as follows:

Design Implication #5: *Female monitors in Southern Cone families tend to prefer addressing the social and affective needs of the older adults, as well as keeping informed the latter on the whereabouts of the younger members of the family. Conversely, male monitors prefer to ensure instrumental security, safety, and comfort issues by improving the living environment of older adults. These two attitudes toward the fulfillment of caregiving duties need to be aligned with the proposition of contextualized awareness mechanisms and computer-supported mediators.*

Regarding the main sources of tension in the family caregiving process, the study results identify several causes. In that respect, the lack of visibility of both older adults' needs and actual fulfillment of caregiving activities are the main sources of tension within the family network. Classical approaches of CSCW design suggest that using common information spaces, such as shared views or board systems [35, 37], could contribute to make visible these aspects of the caregiving process. Therefore, in order to be effective for articulating the informal caregiving work in Southern Cone families, the study findings suggest that the design of mediating solutions should consider

multiple views that display particular information according to the assumed roles and gender of family members.

> **Design Implication #6**: *Making the older adult needs visible can help identify the most demanding areas of the older adult receiving care and articulate the effort expected to be contributed by family caregivers. This also opens several opportunities for enabling and facilitating the participation of helpers, who could use notification services to be aware of particular caregiving requests in favor of the older adults.*

For instance, helpers may decide what request to address depending on their availability and perceived affective link with the older adult. Therefore, such services help ease the coordination among caregivers, balance the workload on the most engaged people, and address the tension generated by the imposition of filial obligation matters to grandchildren.

Finally, concerning the visibility of the caregiving duties and following the reasoning of Star and Strauss on the parallels of visible and invisible work in CSCW systems [40], the study findings show the need to make the roles and caregiving activities explicit, while visualizing the formal and informal duties of the family members as a way to recognize their contribution in the process and improve the balance of responsibilities among people assuming similar roles.

Making this information explicit also helps align the expectations of primary caregivers, the older adults receiving care, and the other members in the family network. However, the study results indicate that the interviewed family members tend to avoid conflict as much as possible regarding the articulation of caregiving work.

> **Design Implication #7**: *Visualizing the fulfillment of caregiving duties as a way to make people aware of the caregiving activities within the family network should encourage the participation of family members in a fruitful way, for instance following strategies based in positive psychology, rather than exposing them to the rest of the network.*

In particular, by making visible the concerns of primary caregivers and the effective involvement of other family members can provide a sense of activity awareness on the coordination and articulation work in the caregiving experience. However, addressing this concern introduces potential design challenges, such as respecting the privacy of the involved family members, as well as identifying ways to load balance the amount of work requested and/or actually performed by the network members. As future work, we will experiment in this domain, particularly by studying the design of mixed-initiative digital assistants and personalized persuasive triggers to engage family members in the caregiving process.

6 Insights into technology design

Until quite recently, the socio-emotional nuances of the caregiving work have been overlooked by most HCI and CSCW literature [7]. Resonating with the current breadth of literature, through this study, we reaffirm that the work of informal elderly caregivers is typically invisible [8, 40] and lacks support [38]. While several authors have reflected on ways to support the daily life of informal caregivers (e.g., Consolvo et al. [11]; Schinkinger and Tellioğlu [34]; Zárate-Bravo, García-Vásquez, and Rodríguez [46]), the presented study results show an evident lack of visibility about the pending requirements of older adults and also about the caregivers' activities and assumed commitments. This situation represents a source of conflict and tension between family members and the older adults receiving care.

6.1 Visualizing the family caregiving ecosystem

Given that caregivers usually do not want to coordinate the caring activities within their family networks—due to the potential conflict that may arise with other family members— Table 3 represents a matrix we conceived for assisting designers deal with these limitations.

In the representation above, each column represents the dimensions of the typical elderly caregiving needs, as discussed in section 4.5. In order to provide a more accurate representation of the requirements specific to a particular older adult, these dimensions are sorted by priority and grouped by frequency, i.e., whether they are daily, weekly, monthly, or sporadically. Each need also has a particular level of required support: high, medium, and low/not required. These variables are visually mapped by color intensity in every column.

Each row represents a family member participating in the process. Therefore, every cell, i.e., the pair [family member—care dimension] represents how much a particular family member contributes (or is willing to contribute) to address a specific need of the older adult receiving care. This ranges from: actual commitment in fulfilling the task (represented as +), willingness to engage in fulfilling the task (represented as /), and represents burden to the family member (−).

The matrix can be implemented as a serious game in which the members declare an initial set of caregiving commitments. The study results can be used to infer the matrix information when it is not available for a particular person, hence acting as an initial seed for setting up the game. Then, the dynamics of the process updates and adjusts the initial definition of caregivers by providing a picture of the current process. In this respect, game mechanics, and by extension gamification, provide a view on how to persuade people on keeping updated their caregiving actions, to encourage them to support particular activities, and to engage more people in the process.

Table 3 Informal elderly caregiving matrix

Family member	Daily	Weekly			Monthly			Sporadically
	Daily activities	Social	Housekeeping	Affective	Financial support	Economic support	Informal health care	Repairing, installing, securing, etc.
Member 1								
…								
Member N								

As an example, Table 4 depicts an example of the family caregiving ecosystem for a male older adult (family no. 3 in the presented study). "AC" stands for adult child, "AP" for adult partner, and "GC" for grandchild.

The matrix contrasts the elderly needs with the caring commitments and willingness of family members. Any action taken or untaken by them, related to a requirement of the elderly, updates the status of the matrix, thus reflecting the behavior of caregivers.

On the one hand, by analyzing the matrix information, we can identify caregivers that have no backup (e.g., AC7 for economic support or AP10 for home instrumentation), family members acting as outsiders (GC13 and GC14), and helpers (AP10, GC15, GC16). This analysis also indicates that there is an over assistance in social and affective care, and an unnecessary support in informal health care, while there is little financial and economic support. These results can be automatically obtained with simple algorithms that use a computable version of the proposed matrix as input.

The previous analysis can be then used to provide participation awareness, engage more people in the caregiving process, and persuade caregivers to address needs with insufficient support. The study findings represent a key input to identify candidate caregivers to be persuaded, by considering their gender, the relationship with the elderly, their commitments and willingness, the type of need to be addressed, and their caring activity recorded at a certain time.

On the other hand, making visible the matrix information can help family members reorganize, change their willingness toward supporting certain caring activities, and change their caring behavior. Moreover, this information could also allow them implicitly coordinate their activities without being exposed to potential conflicts with other members, to know when to intervene or ask for help to perform a certain caring activity.

6.2 Assisting family members in the caregiving process

Although the matrix allows identifying opportunities to improve the caregiving support (i.e., what to support), the study results indicate key aspects to be considered when designing solutions to address limitations of the caregiving process (i.e., how to support it). For instance, when assistants and monitors are all either male or female, it would be interesting to count on a system that persuades adult partners to help, given the positive influence of counting with the participation of both

Table 4 Example of the informal elderly caregiving matrix for a male older adult

Family member	Daily	Weekly			Monthly			Sporadically
	Daily activities	Social	Housekeeping	Affective	Financial support	Economic support	Informal health care	Repairing, installing, securing, etc.
AC6		++	//	++			++	
AC7		+		+		+	+	
AC8		++		++	+		++	
AP10		/		/	/			+
AP13		+		+				
GC13					/			
GC14				−				
GC15		+		//				
GC16		+		+				

genders in effective informal caregiving schemes we identified in our study.

Considering the fact that the social and affective needs are usually important for Latin American older adults, serious games can be developed to engage them in these activities with their grandchildren, neighbors, or friends. Thus, they address an elderly need and enhance their affective links. This can also be implemented around common routines between older adults and the rest of the family, as suggested by Brereton et al. [4]. Similarly, given that the needs of older adults are usually visible only to assistants and monitors, mobile technology can be designed to keep the helpers aware of them. Some elderly needs are periodic, which allows supporting systems infer the demand for support. The study results can also be used to infer the suitability of systems designed to supporting older adults and caregivers in other cultural scenarios, for instance tele-dining systems [22].

6.3 Scenarios for supporting elderly caregiving

By aggregating the collected empirical data collected from the studied cases, we can identify the main configuration of intergenerational triads regarding the care provision to older adults and the commitment of the involved parties on engaging in informal social interaction. In an initial attempt to describe the communication and coordination practices of caregivers across different family structures, we grouped the interviewed triads under one of three family types as shown in Fig. 2.

We used circles to depict women and triangles for men. "OA" stands for older adult, "AC" for adult child, and "GC" for grandchild. The quality of the affective link is represented with a line between the involved people. The thickness of this link maps the perceived strength of the relationship between each member within the triad. The color of the line indicates who evaluated the quality of each link (i.e., gray for the older adult, black for the adult child, and white for the grandchild).

Family type no. 1 represents structures where one daughter usually acts as caregiver and the care recipient is a female older adult. This family type, which is the most frequent one in our sample, sometimes involves one or more grandchildren

in the caregiving process. Family type no. 2 involves male and female caregivers, where the care recipient is a male older adult. Finally, family type no. 3 represents triads where the adult children and grandchildren live far away from the older adult, e.g., in a different city. This involves male and female caregivers, and the care recipients are mainly female older adults. Naturally, given the complexity of family links, not all families fit under the identified groups, but most of the observed configurations (almost 80%) can be clustered under one of these family types.

Likewise, we identified four caregiving scenarios (Fig. 3), which can be supported in different ways using computer-supported technology. Scenario no. 1 is the most frequent one, where a female family caregiver simultaneously takes care of her mother and own children. The size of the arrows indicates the willingness of a person to support the other party, and the type of line maps if the support is effective (solid lines) or potential (dashed lines). "OA" stands for older adult, "FC" for family caregiver, and "H" for helper.

Regarding scenario no. 1, we observe that grandchildren and some adult children are not available to be caregivers; however, they are willing to contribute as much as possible. Unfortunately, they do not frequently assume such a role since they have little to no understanding of the elderly short-term needs, e.g., buying medicine or groceries. Female older adults receiving help usually do not represent an obstacle for helpers. This opens several opportunities for designing technology to engage and support helpers, thus satisfying the needs of older adults and reducing the workload of caregivers. Nevertheless, designing this kind of technology requires that female caregivers realize that other family members can contribute not only as caregivers but also as helpers.

> **Design Implication #8**: Designing technology that decentralizes (even partially) the control held by female caregivers represents a plausible design opportunity.

Scenario no. 2 is similar to the previous one, with the difference that the older adult is a man. In this case, there is not only a lack of visibility of the elderly short-term needs but also
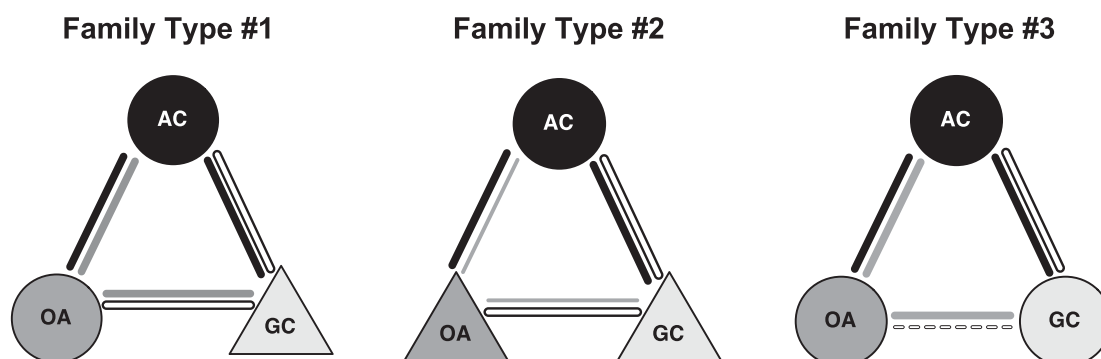

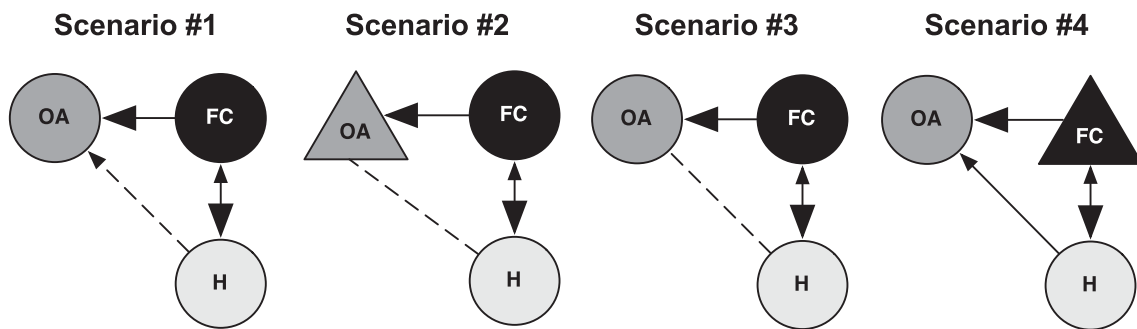**Fig. 2** Representative intergenerational triads

Fig. 3 Scenarios of family caregiving support

a reluctance of older adults to receive external support. Therefore, effective technology to address the caregiving process should probably be aimed at persuading both helpers and older adults using positive computing solutions. For instance, highlighting shared memories can contribute to increasing the willingness of potential helpers to assist older adults, and to the latter for receiving external support. In that respect, there is also an opportunity to assist male older adults using their partner as mediator, i.e., the grandmother can make their shared needs explicit and thus getting external support that benefits both of them.

In scenario no. 3, the caregiver and her children live far away from the older adult. Typically, the older adults keep direct contact with their caregiver, but usually not as much with their grandchildren. Although there is technology specifically targeted at keeping alive and reinforcing the link between distance-separated grandparents and grandchildren, most of these solutions are focused on kids and do not necessarily consider teen or young adult grandchildren as potential actors in the caregiving process. This opens several opportunities to design technology for this scenario.

Finally, in scenario no. 4, the caregivers are male. Although they usually involve other family members as helpers, their coordination is centralized. Therefore, it depends on the active participation of caregivers. Coordinating activities in this scenario can benefit from technology that decentralizes or automates part of this process, given that male caregivers usually receive external support from other family members.

6.4 Linking it all together

Considering the family caregiving model structured in section 4.5 (Fig. 1), the specialized caregiving roles derived in section 4.1, and the matrix visualization on the elderly caregiving ecosystem proposed above (Table 3), we can identify how these formalizations interact with each other as a way to identify opportunities for mediating the informal elderly caregiving process and engaging family members in intergenerational social exchanges. Figure 4 provides an overview of the structured model

grounded in literature with design implications derived from the empirical studies so far.

On the one hand, the color of the matrix columns (Table 4), representing the support required to address the elderly needs, matches with the caregiving requirements presented in the ecosystem conceptual model (label 1 in Fig. 4). Similarly, the willingness and commitment values of a caregiver in the matrix both correspond to the components labeled as 2 and 3 in Fig. 4. The caregiving actions that update the status of the matrix correspond to the component labeled as 4. All these actions are performed following the current viewpoints and concerns of the roles that are assumed by the involved family members within the caregiving network.

Figure 4 also shows in red the main opportunities to make visible the elderly needs as well as the caregiving commitments (roles), willingness, and actions. Moreover, it indicates where social computing designers can take action to increase the participation, involvement, and engagement within the family network. These different concerns to address the asymmetries within the interaction space can be instantiated following one or more computer-supported technology strategies, such as personalized persuasion or awareness mechanisms.

6.5 Study limitations

It is important to understand the context in which computing solutions might support older adults and their family members. In the particular case of the study presented in this manuscript, we limit our analysis to the case of Chile and Argentina, where we did not find any noticeable cultural differences between the sampled families, i.e., the studied families are comparable in terms of how they articulate the informal care provision for their older adults.

However, given the diversity of family settings and the heterogeneity in aging people, we cannot ensure that the study results still hold for larger populations. Certainly, there is space to replicate this study in other groups, and thus identifying similarities and differences on how family networks structure themselves around the informal elderly caregiving process.
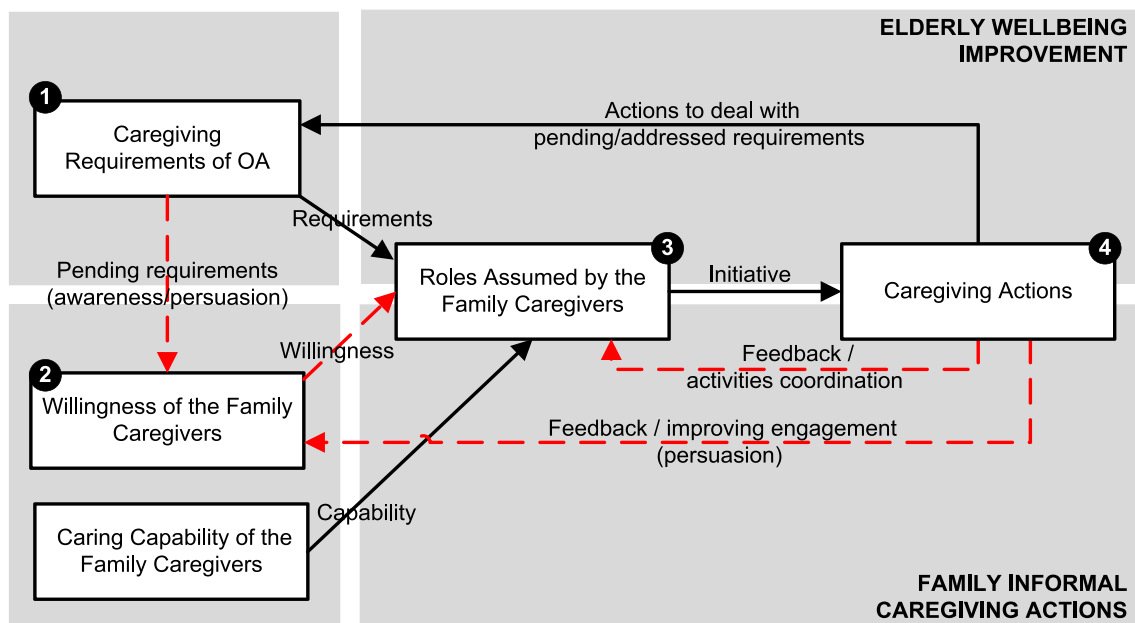
Fig. 4 Opportunities for intervening the informal elderly caregiving process

7 Conclusion

Facilitating aging in place in Southern Cone families requires addressing the cooperative nature of informal caregiving work. In these countries, family members usually assume implicit roles to address the main activities for providing care to their older adults. While literature suggests that this process burdens primary caregivers—usually one of the female adult children in the family—it is not evident how to design technology for improving the articulation of the caregiving work. Understanding these aspects would help social computing designers and practitioners conceive new mechanisms for addressing this situation.

In particular, as a way to bridge this gap, we identified a set of roles that characterize the concerns and viewpoints of the different family members regarding informal elderly caregiving, and therefore sustain the articulation of the process. We also drafted the main concerns of the involved stakeholders in the form of a caregiving matrix, which can be used for visualizing the current fulfillment of duties within the family network. Finally, we described a set of typical caregiving scenarios aimed to inform the design of contextualized strategies for mediating the social interaction space of intergenerational families through computer-supported technology.

In summary, given that most Latin American countries share a similar culture, social, and economical development, and have seen similar historical processes over the years, it is quite possible that the presented findings help explain the cooperative nature of informal elderly caregiving in other countries of the region.

Understanding the dynamics of the cooperative nature of the informal elderly caregiving work drives us to formulate design guidelines of meaningful technology for older adults, particularly respecting the viewpoints, concerns, and expectations of informal caregivers and surrounding members in the family network. Similarly, understanding the informal caregiving work from a design point-of-view helps us specialize the formulation of guidelines for computer-supported technology to mediate family networks in contextualized scenarios.

In particular, this manuscript provides three main contributions:

- It specializes and provides a detailed description of elderly caregiving and intergenerational communication family roles.
- It frames a caregiving matrix, exposing the current availability of resources and engaged people within the family network, as a way to visualize the fulfillment of duties for supporting the articulation of the caregiving work.
- It characterizes a set of typical caregiving scenarios in Southern Cone families, which can be used as a way to inform the design of computer-supported technology to mediate the social interaction space of family networks, thus aiming to ease the coordination and articulation of the elderly caregiving work.

Compliance with ethical standards

The study design has been approved on ethical grounds by the Research Ethics Board of the Faculty of Physical and Mathematical Sciences of the University of Chile.

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