

Overcoming Barriers to the Adoption of Locating Technologies in Dementia Care: A Multi-stakeholder Focus Group Study

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Research Article

Keywords: Alzheimer's disease, assistive technology, adoption, barriers, dementia, focus group, locating technology, services, stakeholders, surveillance

Posted Date: March 15th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-283981/v1>

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Abstract

Background: Locating technologies are a subtype of assistive technology that aim to support persons with dementia by helping manage spatial orientation impairments and provide aid to caregivers by intervening when necessary. Although a variety of locating devices are commercially available, their adoption has remained low in the past years. Several studies have explored barriers to the adoption of assistive technologies from the perspective of professional stakeholders, but in-depth explorations for locating technologies are sparse. Additionally, the inputs of business professionals are lacking. The aim of this study was to expand knowledge on barriers to the adoption of locating technologies from a multi-stakeholder professional perspective, and to explore strategies to optimize adoption.

Methods: In total, 22 professionals working in business (n = 7), healthcare (n = 6) and research (n = 9) fields related to gerontology and gerontechnology participated in our focus group study. Perceptions on the value of using locating technologies for dementia care, barriers to their adoption, as well as salient services and information dissemination strategies were explored. After verbatim transcription, transcripts were analysed following an inductive data-driven content analysis approach in MAXQDA.

Results: Six key adoption barriers centering on: (1) awareness-, (2) technological-, (3) product characteristic- and (4) capital investment-based limitations, (5) unclear benefits, as well as (6) ethical concerns emerged. The interplay between barriers was high. Five core themes on services and information dissemination strategies centering on: (1) digital autonomy support, (2) emergency support, (3) information dissemination actors, (4) product acquisition, and (5) product advertising were extracted.

Conclusions: Our study with interdisciplinary stakeholders expands knowledge on barriers to the adoption of locating technologies for dementia care, and reinforces recommendations that an interdisciplinary strategy is needed to optimize adoption. Also, our findings show that focusing on services to increase digital autonomy and on information dissemination strategies has been largely overlooked and may be particularly effective.

Background

The development and deployment of assistive technologies (ATs) represents an opportunity to reshape dementia care on a global and socioeconomically diverse scale at potentially low costs (1). Several types of ATs exist to compensate for a multitude of cognitive and physical deficits in persons with Alzheimer's disease (AD) and related dementias (PwDs) (2). In the literature, locating, or 'monitoring', 'surveillance', 'tracking', or 'wayfinding' ATs that use satellite-based positioning technology such as global position systems (GPS) have received considerable attention (3, 4). Indeed, spatial orientation impairments in AD develop early (5), are common (6, 7), and can cause significant stress and burden for PwDs and their caregivers (CGs) (8). Prevalence rates of PwDs getting lost even in familiar environments range from 17% (6) to 75% (7) depending on definitions and reporting measures used, which exposes PwDs to risks that can result in life-threatening circumstances (9). To avoid such risks, CGs' often limit PwDs' independent

outdoor ambulation by opting for chaperon, sedative or incarceration-type prevention measures (10) although these measures can negatively impact biopsychosocial health (11). By contrast, locating devices can promote PwDs' independence and safety by helping them manage spatial orientation impairments and by supporting CGs to intervene when necessary (12).

Using insights from focus groups with key stakeholders from business, healthcare and research fields, the current study complements existing research by providing an in-depth exploration of the adoption barriers, and recommendations for salient services and information dissemination strategies for locating technologies for dementia care. The goal was to identify ways to optimize the adoption of locating technologies for end-users.

Methods

Participants and setting

We utilised a convenience sampling technique to recruit professionals working in fields related to gerontology and gerontechnology from our work network. In total, seventy professionals were contacted via personalized e-mail to partake in a half-day focus group study held at the Memory Clinic of the Charité Universitätsmedizin Berlin, Germany, in May 2016. Invitations outlined the study purpose, methodology and organizational details. Specifically, professionals were from business, healthcare and research backgrounds, and were separated into groups based on their professional field to maximize group homogeneity and interaction (28). We estimated that sample sizes per group of approximately ten to fifteen would be sufficient to reach data saturation based on sample homogeneity (28). All professionals who participated provided their written informed consent, and the ethics committee of the medical faculty of the Charité Universitätsmedizin Berlin approved of the study (protocol number EA4/033/16). Participation was voluntary, there were no exclusion criteria, and no incentives for participation were provided. To help ensure that professionals felt comfortable when sharing their thoughts and experiences, discussion moderators indicated that each participant would be given a unique identification number known only to the research team when coding raw data. All methods were carried out in accordance with relevant guidelines and regulations.

Study design

A qualitative study in the form of focus groups to obtain information from various viewpoints (29) was performed. To identify topics and structure the focus group, an interview guide based on a review of the relevant literature was developed. The final guide comprised of three sections detailed below. Each group was led by a discussion moderator (HM, OP, LW) and one or two assistant moderators (SDF, VL, RS, GÖ, FK) who kept notes and audio recorded the discussion. All moderators and assistant moderators were provided with the interview guide prior to the focus groups. Also, a dry run of the interview guide was performed to allow for adjustments in wording or placement of questions, and to ensure familiarity and consistency with the guide between groups. Focus groups lasted approximately three hours, which included the administration of informed consent and filling out of questionnaires.

Section 1: Exploration of perceptions on value of use

Professionals first filled out a standard demographic questionnaire which also assessed years of experience (i.e., professional or personal) with dementia and ATs, as well as one-time and monthly pay willingness for a locating device from the perspective of end-users (i.e., proxy measurement). Also, technological affinity was assessed with the Technological Affinity for Electronic Products questionnaire (TA-EG; Likert scale 19-95, scores proportional to affinity) (30). The TA-EG assesses key aspects of the technology acceptance model which provides information on technology acceptance and use (31). Then, professionals' perceptions on the value of using locating technologies for dementia care were explored by having them write down and discuss at least two keywords or phrases they associate with their use. Exploring perceptions served as an icebreaker (32) to allow professionals to acclimatise to their group before moving onto the next sections.

Section 2: Exploration of adoption barriers

Thereafter, obstacles to the adoption of locating technologies by end-users were explored by examining views on personal experience, product characteristics, and clinical needs and expectations. To supplement the discussion, a GPS watch marketed for persons with orientation impairments and a smartphone with a pre-installed native android application to locate the watch were presented. These products were available due to our concurrent UX study with PwDs and CGs (12) and are displayed in more detail [see Additional file 1].

Section 3: Exploration of services and information dissemination strategies

Lastly, views on salient services and information dissemination strategies, including recommendations for customer services, service provision methods, and promotional methods such as product advertising were discussed. To supplement the discussion, the flyers of two commercially available GPS watches marketed for persons with orientation impairments (12), which included the GPS watch shown in the previous section, were presented.

Data analysis

Results

Participant characteristics

In total, 22 professionals out of the 70 contacted participated (n = 35, no response; n = 8, unavailable; n = 5, no-show). The final groups were: (i) business (n = 7, company executives or associates with current gerontechnology focus), (ii) healthcare (n = 6, representatives of AD organizations and healthcare management professionals), and (iii) research (n = 9, researchers with current gerontechnology focus). No significant group membership differences were found, and one significant difference between gender and dementia experience was found, Mann-Whitney $U = 20.500$, $z = -2.681$, $P = .007$, with a mean rank of 7.55 for males and 14.79 for females. Participant demographics are presented in Table 1.

Perceptions of value of use

We identified three recurrent themes on perceptions on value of use and nine subthemes, displayed in Table 2, Section 1. The shared perception was that using locating technologies could result in increasing end-users' quality of life on psychological, social, and physical levels by: (i) promoting PwDs' personal security and (ii) independence, and by (iii) reducing CGs' stress and burden. These benefits could be achieved due to location finding, risk reduction, supporting autonomous mobility as well as social engagement, by offering peace of mind for CGs by assisting with remote location, and by improving caregiving resource utilization. Still, professionals expressed mixed feelings for each perceived benefit. In particular, products could represent a sense of false security due to inaccurate location. Also, PwDs might view product use as reducing their independence due to feelings of being tracked. Similarly, CGs could feel uneasy when using products due to their tracking nature. However, professionals pointed out that most CGs feel morally responsible to monitor and that devices offer more ethical forms of monitoring compared to alternative methods such as restricting ambulation. No theme density differences between groups were found.

Adoption barriers

We identified six recurrent adoption barriers themes and 22 subthemes, displayed in Table 2, Section 2.

(i) Awareness limitations. A key theme centered on the low awareness of the existence of

locating technologies by end-users. This could be attributed in part to poor knowledge transfers between end-users and professional stakeholders. Business professionals indicated product marketing issues leading to low awareness, such as products being released "way too early". Also, the lack of a readily available overview of commercial products, and limited retail access to products leading to complex purchasing processes for end-users were highlighted. Furthermore, the low technological affinity of most end-users was expressed by research and healthcare professionals.

(ii) Technological limitations. Technological limitations causing usage-related difficulties

also lead to low adoption by not satisfying the expectation that use could help increase quality of life. Research professionals in particular reported on their experience with products that do not provide reliable and accurate location based on poor network communication issues, frequent hiccups, and product maintenance updates. Furthermore, poor battery performance was a central technological barrier for all groups.

(iii) Product characteristic limitations. Regarding the presented locating device, all groups

showed high approval for a watch design. However, professionals emphasized that discrepancies between end-users' needs and available products would discourage adoption. They expressed the concept of "less is more", the lack of individual configurations that can adapt to changing healthcare needs with advancing disease severity, as well as unsatisfactory and stigmatizing aesthetics due to

developing products for heterogeneous populations using a one-size-fits-all design approach or due to technological limitations. Moreover, product affordability and insufficient information on additional costs upon purchase were pivotal barriers.

(iv) Capital investment limitations. Business professionals were the only group to express

that capital investment limitations impacted the successful development and deployment of high-quality products. They criticized the collection of viewpoints on optimal product characteristics without also advocating for higher capital investments to successfully translate viewpoints to product development. Moreover, they argued for a better follow-through from research and development phases to product commercialization.

(v) Unclear benefits. Several unclear benefits on the value of using locating technologies

were discussed. These included end-users not recognizing the need to use products that can aid with spatial orientation deficits, utilizing more trusted locating methods such as involving social network members, and the limited number of studies using a user-centered design to better understand end-users' needs and preferences with unclear information on clinical effectiveness. Also, previous negative experiences with devices could yield persistent negative perceptions and hinder adoption in spite of rapidly improving technological innovations.

(vi) Ethical concerns. The balance between products being able to both heighten PwDs'

autonomous mobility and infringe on their personal privacy via ubiquitous location control by CGs was at the core of the discussion. Professionals mentioned that CGs' sense of moral responsibility to provide security for PwDs might encourage the adoption of a security-at-all-costs viewpoint even if information on how PwDs' movement data are collected by third parties is unclear due to unclear data security and privacy aspects. In addition, research and business professionals added that unclear laws pertaining to legal rights on the location of others hinder adoption via slow product development and commercialization.

Services and information dissemination strategies

We identified five recurrent themes on salient services and information dissemination strategies and 23 subthemes, displayed in Table 2, Section 2.

(i) Digital autonomy support. Efforts to support end-users' digital autonomy upon product

purchase was a key theme. Discussed ways to support digital autonomy included offering installation and product training support. Specific examples included providing at-home installments, product education, web-based automated technical support to allow end-users to search for answers to frequently asked questions and customer support telephone numbers, as well as offering case-management support, where a case manager develops and coordinates a comprehensive plan of services based on

end-users' needs. However, professionals questioned how the suggested services could be cost-effectively financed.

(ii) Emergency support. A second type of service that was discussed centered on support

in emergency situations. Professionals in all groups agreed that round-the-clock, external emergency call centers should be available to provide real-time assistance in the event that a PwD goes missing or if end-users have more pressing questions. Still, professionals made it clear that providing quality call centers is fraught with challenges. In particular, they cautioned that such services are notoriously expensive to manage and that they require a large personnel base.

(iii) Information dissemination actors. Professionals also discussed the role of several

key actors who could help increase product awareness. Proposed actors included memory clinics, medical supply stores, general practitioners, governments, and healthcare insurance companies. However, healthcare and research professionals cautioned about the lack of regular follow-ups at memory clinics, as well as time limitations of general practitioners and potentially harming patient–doctor trust relationships.

(iv) Product acquisition. Furthermore, professionals discussed which product acquisition

methods would allow to best reach end-users, increase product familiarity and facilitate product financing. Main ideas included promoting retail versus online sales, offering trial periods at low or no cost, and exploring the role of government subsidies in product financing.

(v) Product advertising. Lastly, the role of promotional activities centering on product

advertising were highlighted. Key recommendations included ensuring that advertising messaging and visuals utilize a end-user focus. For example, this could be achieved by emphasizing the value of using products to help with PwDs' autonomous mobility rather than focusing on tracking features. Other suggestions included displaying a seal of quality from respected research institutions on product advertisements, as well as transparently addressing key product characteristics and services such as battery life, assistance with emergency situations, and data security. Furthermore, several examples of advertising platforms that were viewed as being able to more effectively reach end-users were mentioned. Identified platforms were television, magazines, and pharmacies. However, business professionals commented on the lack of financial resources to promote products on platforms that might better reach end-users.

Discussion

This qualitative, focus group study reports on key barriers to the adoption of locating technologies for use in dementia care, as well as on services and information dissemination strategies to increase adoption. Results are relevant for researchers, healthcare and business professionals, including product designers

and developers as they highlight that adoption involves more than the technology and products themselves.

Overall, the professionals in our sample held positive views on the use of locating technologies as a way to increase end-users' quality of life. However, these technologies also raised ethical concerns since they could be seen as restricting PwDs' independence. In particular, professionals wished for clear and transparent information on how PwDs' data and movement profiles are saved. These findings resonate with previous publications (14, 22, 37). The mention of these ethical concerns from business professionals is encouraging as others have argued that ATs developers pay too little attention to the needs of end-users or the "human factor" (p. 77) (38). Also, participants believed that PwDs' need for independence and CGs' need to locate PwDs might outweigh data security concerns, a sentiment expressed by end-users themselves (39). This finding reinforces the importance of creating opportunities for collaborations between business professionals and end-users to ensure that data security and end-user perspectives are integral to product development.

The discussion of adoption barriers revealed that the interplay between barriers is high. For example, low awareness of the existence of locating technologies by end-users could in part be attributed to unsuccessful communication across relevant stakeholders, with limited research on clinical and cost-effectiveness as a driving factor behind this association. In turn, limited research-validated studies on clinical effectiveness discourages healthcare professionals from recommending locating technologies, and hampers larger societal discourses on their value. Regarding product characteristics, the role of technological innovations to maximize individualization and reduce the risk of stigmatization were stressed. Although not explicitly mentioned by professionals, we add that technological innovations that incorporate prominent patterns of AD-related spatial orientation deficits, such as "dimensions of pattern (lapping, random, or pacing), frequency, [and] boundary transgressions" (p. 99) (8) could help ensure that locating technologies better respond to end-users' needs, desires, and capabilities.

When discussing services, professionals highlighted that supporting the digital autonomy of end-users to help counteract low technological affinity, as well as building trusting relationships with service providers are essential for adoption. Efforts to support digital autonomy to help PwDs age-in-place is a timely topic (40), and several examples on ways to optimize digital autonomy were provided. We maintain that services can address end-users' low technological experience in real-world scenarios by mimicking clinical study environments where products are typically explained and shortly tested before being used for longer periods of time. Furthermore, while discussing information dissemination strategies, professionals provided several recommendations for promotional activities to increase product awareness. Taken together, they indicated that a multi-stakeholder approach is key and advocated the concept of "meeting consumers where they are" by using traditional sources of information dissemination. Also, they mentioned that offering trial periods could help end-users gain experience with a product and enable UX feedback. Indeed, studies show that end-users are more satisfied with the acquisition of ATs when their opinions are factored into device recommendations (41). Feedback on the presented advertisement flyers indicated that product marketing has a large room for improvement in

terms of content and visuals. Similar to recent studies (42, 43), professionals' stressed the importance of placing end-users at the center of marketing activities to reduce stigmatizing keywords and visuals, as well as to ensure that information on functionality and data security are transparently and adequately addressed.

This study has some limitations. First, although asking professionals about their views on the use of locating technologies for dementia care might have resulted in findings reported elsewhere (20, 44), the perspectives of business professionals are largely lacking in the literature. Second, the use of a convenience sampling technique, which was used to ensure that professionals have sufficient knowledge on the use of locating technologies for dementia care, might have resulted in the collection of viewpoints from persons more positively biased toward the use of these technologies. However, other professional stakeholders (14, 20) similarly report high openness toward the use of ATs in dementia care. Still, the possibility of a positive bias cannot be conclusively ruled out, particularly since 22 out of the 70 professionals contacted agreed to participate. However, as previously mentioned, the focus groups generated rich and diverse viewpoints and low recruitment rates using e-mail is typical (45). Third, the finding that recommendations regarding product pricing were not explicitly discussed in the third section although purchase cost was mentioned as a pivotal barrier for product adoption can be seen as a limitation. This limitation is not unique to our work, and past research with end-users also generally reports a high range of acceptable purchase costs which typically range from 20 to 100 dollars (42). Finally, the fact that the discussion took place a few years ago may be seen as a limitation to the present findings. Yet, from what could be found from the scientific literature, no significant changes in the uptake of locating technologies by end-users has occurred since the study was performed, suggesting that adoption barriers have not been adequately addressed.

The strengths of the present study include its qualitative nature to allow for an in-depth exploration of a complex and multifaceted topic (29), as well as its interdisciplinary nature by bringing together stakeholders with different areas of expertise. While others have argued that "multiple stakeholders with differing philosophical viewpoints slow the development, commercialization and deployment of geriatric technologies" (p. 80) (46), our results do not support this view. A key recommendation based on the results of the current study is to provide opportunities for collaborations between end-users and interdisciplinary stakeholders to support the development and commercialization of scientifically-validated, clinically effective locating technologies for dementia care (47). Also, and to our knowledge, the inclusion of business professionals is new. Business professionals proved to be particularly helpful in understanding business-related topics and hurdles since they provided more examples of service recommendations, were the only group to mention the role of government subsidies in product financing, as well as capital investment limitations impacting the development and deployment of high-quality products. studies addressing marketing strategies for locating technologies for dementia care are rare (42) even though marketing aspects play a central role in product adoption (25, 26). Lastly, the focus on locating technologies can be viewed as a strength as viable solutions to increase adoption are still largely limited to extrapolating findings from a broad range of ATs with various applications.

Conclusions

In conclusion, this paper resonates with past findings on adoption barriers, and identifies services and information dissemination factors that remain to be addressed before the implementation of locating technologies can truly make a difference in dementia care. The need to improve locating solutions and their adoption has been highlighted by the recent creation of international and interdisciplinary consortiums and networks (48, 49). Moving forward, collaborations between end-users and professional stakeholders that examine what services end-users find appropriate to increase digital autonomy, and what information dissemination strategies to utilize to effectively reach end-users are steps in the right direction.

Abbreviations

AD: Alzheimer's disease; ATs: Assistive technologies; CGs: Caregivers; GPS: Global Positioning System; PwDs: Persons with dementia; UX: user experience

Declarations

Acknowledgements

The authors would like to thank Valentina Lüdtke, Robert Sonnenschein, Gökhan Özer and Florian Konwischer for their role as assistant moderators.

Author's contributions

All authors contributed to the preparation of the manuscript. SDF, HM, LW, and OP designed the study. HM, LW, and OP moderated one focus group each. SDF, HM, and CH transcribed, coded, and analyzed the data. SDF drafted the manuscript. All authors have read and approved the final version of the manuscript.

Funding

This work was supported by the Focus Area DynAge of the Freie Universität Berlin and the Charité – Universitätsmedizin Berlin [grant number 50000003]. The funders had no role in the study design, data collection and analysis, decision to publish, nor in manuscript preparation and final submission.

Availability of data and materials

The authors confirm that the data supporting the findings of this article are available within the article.

Ethics approval and consent to participate

This study obtained the ethical approval of the ethics committee of the medical faculty of the Charité– Universitätsmedizin Berlin (protocol number EA4/033/16). A written informed consent was obtained from

all participants before taking part in the focus group. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Descriptive characteristics of the participants.				
Variables	Business (n = 7)	Healthcare (n = 6)	Research (n = 9)	All (n = 22)
Age	44.3 ± 10 [32-55]	46.7 ± 12.9 [28-62]	37.1 ± 11.1 [27-62]	42 ± 11.5 [27-62]
Gender, m/f (% female)	5/2 (29)	2/4 (67)	3/6 (67)	10/12 (55)
Education, n (%)				
High school	1 (14)	1 (17)	-	2 (9)
College	1 (14)	1 (17)	-	2 (9)
Any university*	5 (71)	4 (67)	9 (100)	18 (82)
Dementia exp. yrs, n (%)				
<2 yrs	1 (14)	-	4 (44)	5 (23%)
2-5 yrs	4 (57)	1 (17)	-	5 (23%)
5-10 yrs	2 (29)	2 (33)	2 (22)	6 (27%)
>10 yrs	-	3 (50)	3 (33)	6 (27%)
ATs exp. yrs, n (%)				
<2 yrs	1 (14)	1 (17)	4 (44)	6 (27%)
2-5 yrs	3 (43)	2 (33)	1 (11)	6 (27%)
5-10 yrs	3 (43)	2 (33)	4 (44)	9 (41%)
>10 yrs	-	1 (17)	-	1 (5%)
Pay willingness, once	235.6 ± 134.6 [99-500]	255 ± 193.8 [100-600]	211.7 ± 176.6 [20-500]	231.1 ± 162.3 [20-600]
Pay willingness, monthly	16.3 ± 8.2 [5-30]	20.5 ± 8.1 [10-30]	17.9 ± 17.6 [0-50]	18.1 ± 12.5 [0-50]
TA-EG (range 19-95)	76.6 ± 8.7 [59-83]	64.7 ± 6.7 [58-74]	68 ± 9.9 [57-83]	69.7 ± 9.7 [54-83]
Abbreviations: ATs, assistive technologies; exp., experience; m/f, male/female; n, number; TA-EG, Technological Affinity for Electronic Products; yrs, years.				
NOTES. Continuous and discrete variables are displayed as mean ± standard deviation [range]. Standard deviations are rounded to nearest decimal point. Percentages are rounded to nearest whole number. TA-EG scores are proportional to technological affinity. Pay willingness in Euros.				
* For education, "any university": one business, healthcare and research professional, respectively, obtained a Master's degree, and four business, three healthcare and eight research professionals				

obtained a PhD degree.

Table 2 to be placed immediately following Results, i.e., immediately before Discussion

Table 2. Overview of themes and subthemes illustrated with quotes per focus group section.			
Section 1: Exploration of perceptions on value of use			
Themes	Subthemes	Illustrative quotes	Theme density (%) [*]
Promote security for PwDs	· Location finding	P2, Business: <i>“Security is guaranteed by the product since for example, when PwDs do not come home at a specific time, they can be located.”</i>	$n_b = 5$ (71) $n_h = 3$ (50) $n_r = 6$ (67)
Counterargument	· Risk reduction	P2, Business: <i>“A lot of people have been saved with these products from freezing, drowning, etc.”</i>	$n_b = 0$ (0)
	· False sense of security	P15, Research: <i>“I can see with the app where a PwD is, on which street corner, but I can’t see whether s/he is crossing at a red light or not.”</i>	$n_h = 0$ (0) $n_r = 1$ (11)
Promote independence for PwDs	· Autonomous mobility	P15, Research: <i>“These products can also help maintain or increase the freedom of movement and independence of PwDs.”</i> P6, Business: <i>“If you don’t have such a system, then you have someone telling PwDs: “Stop” Stay put! Where are you going again?”</i>	$n_b = 3$ (43) $n_h = 4$ (67) $n_r = 6$ (67)
Counterargument	· Social engagement	P15, Research: <i>“Yeah I mean like when you can see a daily profile of PwDs—where one likes to go, spend their time, what they find interesting in their neighbourhood.”</i>	$n_b = 2$ (29)
	· Feeling tracked	P5, Business: <i>“The persons that wears the product can feel like they are being tracked, and that’s not a good feeling.”</i>	$n_h = 2$ (33) $n_r = 2$ (22)

Reduce stress and burden for CGs	· Assistance with remote location	P2, Business: <i>"It makes me feel more secure because I'm worried that my [fictitious] dad might not find his way back home although he might be able to... We have clients come up to us and say: 'Thank you, thank you, thank you! We can let our father, uncle, etc. walk alone again.'"</i>	$n_b = 2$ (29)
		P6, Business: <i>I see monitoring also positively. There are a lot of people in professional care settings or CGs who feel responsible in providing this monitoring."</i>	$n_h = 2$ (33)
			$n_r = 5$ (56)
	· Efficient resource utilization	P22, Research: <i>"To make it easier to care for PwDs... It might be more comfortable for formal care settings because they can save on personnel or invest less time in these [locating] task."</i>	
Counterargument	· Uneasiness about tracking	P5, Business: <i>"But also CGs that use the product can feel uneasy because they are tracking PwDs."</i>	$n_b = 1$ (14)
			$n_h = 0$ (0)
			$n_r = 0$ (0)

Abbreviations: n, number; n_b , = business; n_h , = healthcare; n_r = research.

NOTE. Percentages in parentheses rounded to nearest whole number.

* Theme density calculated based on professionals' written keywords or phrases and supplemented by contributions in the open discussion.

Table 2 (continued)

Section 2: Exploration of adoption barriers

Themes	Subthemes	Illustrative quotes
Awareness limitations	· Low knowledge transfers between stakeholders	P14, Research: <i>"I can't use what I don't know exists. That's the main problem I learned after conducting 105 interviews [with PwDs and CGs]."</i> P11, Healthcare: <i>"From the perspective of end-users, this is a product that I don't know, that is unfamiliar... Product awareness is still largely inadequate."</i>

P2, Business: *"My personal opinion: Way too early. End-users don't know that these products exist."*

· Lack of overview of available products

P21, Research: *"General practitioners don't have an overview of all commercially available products. The same goes for nursing facilities."*

· Limited retail access to products

P4, Business: *"If CGs need it [GPS technology], where do they go? Where can you buy it? You won't find it in a supermarket or media store! You first have to research it and if you're not from this line of work, it's hard [to find information]."*

P14, Research: *"Some [PwDs and CGs] say: 'I've read or heard about this, but I don't know where I can buy these products. I guess online.'"*

· Low technological affinity of end-users

P18, Research: *"There are certainly older adults that are good with technologies, which have smartphones. But there are some older adults that have no experience—that are technology skeptic."*

P13, Healthcare: *"We are talking about the age group 70 plus, right? The next generation will be more familiar with these technologies."*

Technological limitations

· Unsatisfactory reliability of location function

P16, Research: *"If it's in the name, it has to work!"*

P14, Research: *"If it [location] doesn't work reliably, it won't reduce CGs stress and burden."*

P22, Research: *"When one enters an underground parking lot or a building, then you can often pretty much forget about location. The product has to be more than 150% reliable. If not, you can forget it!"*

· Unsatisfactory accuracy of location function

P22, Research: *"It should be low maintenance... You should be able to locate immediately, without having to wait for updates. And if there's a discrepancy of a few meters and I'm in the pedestrian zone and there are a lot of people around, it could be that I don't find someone who is two meters away."*

P16, Research: *"The location of two minutes ago might not be valid."*

· Poor battery performance

P3, Business: *"If I need a GPS product all day, maybe it won't last all day. And cellphones [for CGs] either."*

P1, Business: *"How long does the battery last? Since our latest update, max two days..."* [P4, Business: *"Max? Yeah, that's a problem."*]

	<ul style="list-style-type: none"> · Limited functionality 	<p>P1, Business: <i>"Some products have security straps. But no one wants to walk around with such a thing!"</i></p> <p>P11, Healthcare: <i>"For the battery, there's a signal notifying you when you are running low on power. Of course, the question is when you receive a notification. Because it's totally annoying if the product starts to beep when you are alone. This might lead to more disorientation."</i></p> <p>P5, Business: <i>"Geofencing is one aspect. I would program other intelligent functions, such as integrated temperature recognition. There are maybe other things at PwDs' location that could active an alarm. So I would program intelligent systems."</i></p> <p>P7, Business: <i>"I would like a product that notifies me when my [fictitious] mom leaves her home without the product."</i></p> <p>P22, Research: <i>"And then an emergency recognition, so that when PwDs fall down or stumble on something, that the system recognizes this."</i></p>
	<ul style="list-style-type: none"> · Product costs 	<p>P1, Business: <i>"The biggest barrier is always the price."</i></p> <p>P10, Healthcare: <i>"There's a cost problem at the moment. Can I afford this? Are there any additional costs once I use it? Products are simply too expensive."</i></p> <p>P5, Healthcare: <i>"Cost is a big factor. Do I purchase it or not for the last phase of my life?"</i></p>
<p>Unclear benefits</p>	<ul style="list-style-type: none"> · Unclear perceived need by end-users 	<p>P11, Healthcare: <i>"PwDs do not see that they need it [locating device]. At most, CGs recognize a need."</i></p> <p>P6, Business: <i>"I can imagine that my fictitious father might need such a product. But whether he sees a need? There might be no recognized need."</i></p> <p>P2, Business: <i>"No end-user purchases it out of prevention. All buy it because something has already happened."</i></p> <p>P8, Healthcare: <i>"It [using a locating technology] of course depends on dementia severity."</i></p>
<p>Table 2 (continued)</p>		
	<ul style="list-style-type: none"> · Reliance on other trusted locating methods 	<p>P5, Business: <i>"I [CGs] might pragmatically get more involved with the [local] community."</i></p>

	<ul style="list-style-type: none"> · Lack of studies and unclear clinical effectiveness · Previous negative user experience 	<p>P21, Research: <i>“End-users should be more involved [in research and development]. They should test products and then we will better understand what needs to be improved.”</i></p> <p>P1, Business: <i>“We need the Charité and the German Alzheimer Society to come out with studies. Then there will be a bigger discussion.”</i></p> <p>P2, Business: <i>“There are dementia severities, and then it’s always the question: ‘How long can I [CGs] let PwDs move about and use the product [without studies with PwDs with different AD severities]?”</i></p> <p>P19, Research: <i>“I can’t evaluate products as a lay person. Do I need it? Does it work?”</i></p> <p>P1, Business: <i>“The technology is constantly changing. And those [end-users] who did test it three-four years ago... they had bad experiences. And if it doesn’t work on the first attempt: Next! Forget it!”</i></p>
Ethical concerns	<ul style="list-style-type: none"> · Balance between autonomous mobility of PwDs and control by CGs · Unclear information on data privacy and security · Unclear legal rights on location of others 	<p>P19, Research: <i>“As a PwD, I have my autonomy, I have my rights. I might not know that I am being located at a particular time. But for CGs, that’s really not a problem because they have a sense of security. There’s a big difference between medical professionals and CGs, where medical professionals say: ‘That’s an infringement on personal freedom’, and CGs say: ‘I don’t care. I have to know where [PwD] is!’”</i></p> <p>P13, Healthcare: <i>“There are also data security aspects, so basically the fear of being watched or controlled.”</i></p> <p>P3, Business: <i>“I think of tracking firms that collect large amounts of data, secretly collecting information on movement profiles... Do we reduce independence or increase security?”</i></p> <p>P6, Business: <i>“We are very involved with this at the moment. How many movement profiles can be programmed and saved, under which conditions, etc.? This is a very difficult situation at the moment for all businesses involved.”</i></p> <p>P15, Research: <i>“There are a lot of decisions at the moment on what is allowed regarding locating others.”</i></p> <p>P2, Business: <i>“Ultimately, it’s a legal problem with too many unknowns. Are we allowed to do this, to do that? This hinders commercialization. First get approval from a court of law. The external framework could be better. This is one of the main reasons why it [GPS technologies] has not spread so quickly.”</i></p>
Capital	<ul style="list-style-type: none"> · Lack of 	<p>P1, Business: <i>“There’s no one here [in the other groups] that I</i></p>

investment limitations	funding	<i>know was involved in product development, right? There's a big discrepancy. We could all say how products should be and what could be done. But you have to have the money to do this...you first have to have the money to invest."</i>
	· Low product development follow-through	P1, Business: <i>"There are too many products that are not developed to the end."</i>

Section 3: Exploration of services and information dissemination strategies

Themes	Subthemes	Illustrative quotes
Digital autonomy support	· Installation and product training support	P15, Research: <i>"A support that's really tailored to end-users. Particularly to help set up and configure the product."</i>

Table 2 (continued)

		P3, Business: <i>"If I use it for the first time, I would like to have an installation assistance on how to use the app that I can maybe turn on and off."</i>
		P17, Research: <i>"That you really have an on-location support that also makes house calls to help one get started with the product."</i>

	· Automated technical support	P6, Business: <i>"...for example, that telephone numbers are listed on a website, that frequent questions such as 'How to install the program', etc. are provided."</i>
	· Case-management support	P5, Business: <i>"Case-management service support... If I have a person with deficits, with a certain problem severity, then I can also offer other attractive service support features."</i>
<i>Counterargument</i>	· Unclear affordability of services for end-users	P2, Business: <i>"But these services have to be affordable and there are simply too many older adults that do not have the financial capacity."</i>

Emergency support	· Emergency call centers	P10, Healthcare: <i>"At a minimum [for emergency situations], there has to be a hotline."</i>
		P17, Research: <i>"It's important to have an emergency support call service that answers whatever question you might have."</i>

Counterargument	<ul style="list-style-type: none"> · Lack of personnel and financial resources 	<p>P6, Business: "When an alarm is set out, because you have personnel changes every 24 hours, you have to have a lot of people that do this [job]. Who does it on the weekends?"</p> <p>P22, Research: "support that is available 24/7...but this has to be financed. That's also really expensive!"</p>
Information dissemination actors	<ul style="list-style-type: none"> · Memory clinics · Medical supply stores · General practitioners · Government-based local promotional activities · Healthcare insurance companies · Financial, time and lack of follow-up limitations of proposed actors 	<p>P9, Healthcare: "You could involve memory clinics."</p> <p>P?, Healthcare: "It would be really easy to involve medical supply stores."</p> <p>P17, Research: "I think that general practitioners should be involved because they are typically the starting point. There's a trust-based relationship there."</p> <p>P19, Research: "There's a pilot project in [German city], where the government has set up a counselling center also for technology for older adults... They can advise you there... You can go to them, but they can also go to you."</p> <p>P5, Business: "What we need is support from an established healthcare insurance company that creates a 'service-support platform'."</p> <p>P9, Healthcare: "But PwDs come here [memory clinic] at max every six months..."</p> <p>P22, Research: "If my general practitioner talks to me about such products, I'd feel like they are trying to sell me something. I don't go to my general practitioner for that."</p> <p>P19, Research: "GPs are saying: 'What else are we also supposed to do?' Who pays for this extra work?"</p>
Product acquisition	<ul style="list-style-type: none"> · Retail options 	<p>P19, Research: "At the moment, most products can be bought online. So there's a lack of vendors with whom older adults can talk to. I think personal talks are extremely important."</p>
	<ul style="list-style-type: none"> · Trial periods 	<p>P8, Healthcare: "I might see an ad for such a product and think: 'Oh, that's cool!' But I still have no</p>

**Table 2
(continued)**

experience with the product. Experience is elementary. If I don't have experience, I won't use the product."

P12, Healthcare: *"For me, it would be a requirement that I can test the product first for two to three weeks without having to pay a big amount for this. Maybe a little fee, but not the entire amount."*

P16, Research: *"For many, it's important to be able to experience the product, to touch it, feel it. Maybe offer a trial purchase."*

· Government subsidies

P5, Business: *"In nursing care, there are a lot of government care grants...different financial plans, how you can use these various services..."*

Product advertising

· Promotion of independence and autonomy

P2, Business: *"We are trying to erase the word tracking."*

P3, Business: *"We've replaced the word tracking with guardian angel."*

P10, Healthcare, flyer-feedback: *"And particularly in old age, the importance of remaining independent without sacrificing comfort and safety."*

· Need-based information targeted toward end-users

P11, Healthcare, flyer-feedback: *"I prefer the description on this flyer. It's simple and contains all you need to know... I see security, quality of life, liberty. The visual presentation is good and the font size is nice and large. This other flyer is not directed toward PwDs, but rather only toward CGs."*

· Seal of quality from trusted organisations

P1, Business: *"There have to be institutions. That's why I'm here today... In the end, the Charité or similar is missing. The stamp from ISO does not suffice. When Charité or German Healthcare Ministry is visible, then there's a completely different quality level that is achieved."*

· Addressing data security concerns

P20, Research: *"It could be a marketing problem... for example, that it's not clear that it can be avoided that everyone sees my data and locate me. If I don't know that, I don't buy it."*

P10, Healthcare: *"This aspect [data security] has to be covered in product advertising."*

P16, Research: *"I really think that there is a general lack of clear information on data security. It's really important that data security is communicated and mentioned and that it's theoretically possible for a third party to access data sensitive information. So that people know what to do in such situations."*

	<ul style="list-style-type: none"> · Addressing key product and service details 	<p>P5, Business, flyer feedback: <i>“What I still don’t know is whether I have to take the watch off every day and charge it.”</i></p> <p>P6, Business: <i>“Let’s say I receive a message at 4am about my mother and this happens three nights in a row. I’ll be woken up and I can’t really help... What happens then?”</i></p>
	<ul style="list-style-type: none"> · Stigmatizing visuals 	<p>P19, Research, flyer feedback: <i>“This picture is a no-no for the current generation of older adults.”</i></p>
<p>Counterargument</p>	<ul style="list-style-type: none"> · Conventional advertising platforms: television, magazines, pharmacies · Financial limitations 	<p>P14, Research: <i>“There are probably people that don’t check online for this [GPS product], but rather watch TV. So maybe use TV ads to multiply information.”</i></p> <p>P22, Research: <i>“I saw an ad in [free magazine with large older adult readership] about a high blood pressure product. I thought that was really good. A magazine that a lot of older adults read—not just PwDs and CGs. And the magazines are free. You can just take one.”</i></p> <p>P14, Research: <i>“Maybe there should just be ads placed in pharmacy windows.”</i></p> <p>P1, Business: <i>“I don’t produce million-dollar TV ads.”</i></p>

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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