Health professionals' and researchers' views on Intelligent Assistive Technology for psychogeriatric care

Marcello Ienca[a,b,*]

Mirjam Lipps[b]

Tenzin Wangmo[b]

Fabrice Jotterand[b,c]

Bernice Elger[b,d]

Reto W Kressig[e]

[a]Health Ethics and Policy Lab, Department of Health Sciences and Technology, ETH Zurich, Switzerland; [b]Institute for Biomedical Ethics, University of Basel, Switzerland; [c]Center of Bioethics and Medical Humanities, Institute Health and Equity, Medical College of Wisconsin, USA; [d]University Center for Legal Medicine, Univerisity of Geneva, Switzerland; [e]University Center for Medicine of Aging Basel, Felix PlatterHospital and University of Basel, Switzerland; *Corresponding author: marcello.ienca@hest.ethz.ch

M. Ienca, M. Lipps, T. Wangmo, F. Jotterand, B. Elger, R.W. Kressig. Health professionals' and researchers' views on Intelligent Assistive Technology for psychogeriatric care. Gerontechnology 2018;17(3):139-150; https://doi.org/10.4017/gt.2018.17.3.002.00 Intelligent Assistive Technologies (IATs) open the prospects of alleviating the global burden of population aging and dementia. However, their translation from designing labs to the clinical setting appears suboptimal. This study aims at obtaining more detailed knowledge on the clinical translation of IATs by exploring the views and attitudes of key health professionals involved in dementia and older adults care. Qualitative data were gathered in three among the countries with the highest and lowest birthrate (Switzerland, Germany, and Italy), hence particularly exposed to aging-related health burden. Our findings provide a qualitatively rich picture of the current opportunities and challenges of using IATs in the clinical setting. In addition, we identify a number of possible barriers to the adequate translation of IATs into the clinics and delineate possible solutions to overcome these barriers.

Keywords: Intelligent Assistive Technology (IAT), dementia, gerontechnology, health professionals, translational medicine, adoption, doctor-patient relationship

Introduction

Today over 900 million people worldwide are aged 60 years and over[1]. In many countries increased longevity is accompanied by declining fertility rates causing a rapid increase in the proportion of older people to the total population. This trend is particularly recognizable in Western European countries such as Italy, Germany and Switzerland, which have high life expectancy (Switzerland 83.4; Italy 82.7; Germany: 81.0) and low fertility rates (Italy 1.43; Germany: 1.44; Switzerland: 1.55)[2]. In these countries, people aged 60 years and over constituted around one fourth of the total population in 2015 (Italy: 28.6; Germany: 27.6; Switzerland: 23.6%), a number that is expected to increase by an additional 8-9% by 2030[3]. These demographic trends pose a major challenge to public health since older age is associated with rising incidence of non-communicable chronic diseases, increased disability and higher healthcare costs. A major component of health burden among older population in those countries includes Alzheimer's disease (AD) and other age-dependent dementias. People with dementia experience major cognitive and physical disabilities, hence need constant care during basic activities of daily living[1]. This is reported to create a heavy economic and social burden[4], primarily as a consequence of the high financial and social costs of long-term medical care, informal care provided by families, and social

care provided by community care professionals.

Gerontechnologies that can help older adults and people with dementia remain mobile and independent, hold the promise of mitigating this global health challenge by decreasing the costs for long-term care to families and society, alleviating caregiving burden, facilitating the delivery of medical care, and increasing the quality of life of this vulnerable population[5,6]. Intelligent Assistive Technology (IAT) is the umbrella term often used to comprehensively describe the broad spectrum of gerontechnological solutions (both hardware and software) with own computing capabilities designed to assist older adults and people with dementia in homecare and institutional setting[6]. A recent review has shown that the number of IATs with application to psychogeriatric care has nearly tripled in the last 5 years and even increased by a factor of 15 compared to beginning of the new millennium[7]. The same review shows that the IAT spectrum encompasses a large variety of computing solutions. These include distributed systems such as ambient assisted living technologies, care robots, mobility and rehabilitation aids, handheld devices, apps, wearables and human-machine interfaces[7]. The common denominator of these otherwise different technologies is their capacity to use intelligent computation to support psychogeriatric care. IATs are being developed for a variety of clinical and social-care purposes including assistance during the completion of activities of daily living, health and behavioral monitoring, physical and cognitive assistance, facilitated interaction and engagement, care delivery and rehabilitation, as well as emotional support[7].

While technology is developing fast, studies assessing the clinical and social effectiveness of IATs remain scarce and significantly vary in number and level of generalizability depending on the specific IAT type. Bemelmans et al. have shown that socially assistive robots such as Paro can have a positive effect on mitigating the mood scores of patients in various stages of dementia[8]. This positive effect is particularly recognizable in long-term care setting[9]. However, large-scale cohort studies are rare for this IAT type. Other IAT types such as ambient assisted living (AAL) technology have been investigated more extensively. For example, the UP-TECH project involved a randomized control trial with 438 patient-caregiver dyads to validate an integrated package of AAL solutions in Italy. Nonetheless, experts have emphasized the need for improved evaluation methods, "particularly feature-focused scenario-based evaluations"[10]. Furthermore, cross-national and cross-cultural studies appear still rare.

Besides validation, one further challenge is adoption. Research shows that adoption rates of IATs in dementia and older adults care are still low[11]. Investigating the views of key stakeholders involved in dementia and older adults care is gaining momentum as an effective strategy for acquiring valuable insights about possible barriers to the successful adoption of IATs in the institutional and home-care setting. In 2014, a German interview-study investigated the views of dementia caregivers and identified a lack of awareness and unsuccessful information transfer across relevant stakeholders[11]. A UK study involving people with dementia and their caregivers suggested that lack of information and cost-related considerations might play a role in determining adoption rates[12]. To date, researchers have indicated a number of possible barriers and obstacles to IAT adoption including lack of robust evidence for the cost-effectiveness of IAT solutions[13], low-prevalence of user-centered approaches to technology design[7], information gaps at the cross-section of technology development and healthcare[11], high costs of IATs and absence of viable reimbursement plans[12,13], as well as unaddressed ethical considerations, privacy in particular[14,15]. A few studies investigated the perspective of health professionals on the use of IATs for dementia and older adults care. A recent study in the UK explored the views on IATs of GPs, people with dementia and their caregivers[16]. Their results indicate moderately high awareness among GPs about IAT solutions but show persistent obstacles in the dissemination of adequate information and support[16]. As health professionals are critical decision-makers for the adoption of new medical technologies, more research is needed to investigate their views and attitudes towards IATs, especially in light of current trends in population aging.

To this purpose, our study aims at obtaining more detailed knowledge on the views and attitudes towards IATs of health professionals and researchers involved in psychogeriatric care and/or research. Qualitative data were gathered in three European countries with the highest longevity and lowest birthrate (Switzerland, Germany, and Italy), hence particularly exposed to aging-related health burden. Furthermore, it aims at producing qualitative, experience-based and clinically-oriented knowledge that can be used by gerontechnologists to inform future development and implementation studies involving IATs in psychogeriatric care. As IATs compose a numerically considerable[7] and ethically challenging[17] component of gerontechnology, cross-national expert assessments of IAT can provide useful information not only for IAT designers and developers but also for ethicists, health professionals, policy makers and gerontechnologists.

Methods

Study sampling and recruitment

We conducted and analyzed open-ended qualitative interviews with health professionals and researchers working in Switzerland, Germany, and Italy. Interviewees were conducting research and/or actively working within the fields of geriatrics, psychiatry, neurology, neuropsychology, gerontology, nursing, and healthcare management. They had direct research experience in the field of gerontechnology and/or in the professional care for psychogeriatric patients including people with dementia and other age-dependent disability. Purposive sampling was adopted according to positions, expertise, research background and years of experience to obtain a diverse selection of stakeholders from both private and public health institutions with varying disciplinary affiliation and professional experience. A total of 21 stakeholders were purposively selected from the homepages of the research institutions according to their professional profile or recruited through subsequent snowballing. The initial sample was adopted based on previous qualitative studies assessing IAT use among caregivers of persons with dementia whose sample sizes were comprised between 10 and 25[18-20]. Snowball was interrupted once theoretical saturation was achieved. Participants were contacted via e-mail outlining the research and invited to participate in the study. Three respondents declined the invitation due to conflicting commitments while one respondent dropped out from the study after initial acceptance due to health issues. A total of 17 interviews were completed (*Table 1*). The overall response rate was 85%. The invitation message contained the following information:
(i) title of the study: "*Health professionals' views on Intelligent Assistive Technology for Dementia and Elderly Care*";
(ii) study rationale, design, and purpose;
(iii) interview methodology and approximate length;
(iv) safeguards employed for the protection of confidentiality and anonymization of the collected data;
(v) contact details of the research team; as well the (vi) informed consent form. Prior to recruitment, the study obtained a waiver from the Ethics Committee Northwest/Central Switzerland (EKNZ).

Table 1. Interviewees' distribution (N=17)

Country	**n (%)**
Switzerland	10 (59)
Germany	4 (23)
Italy	3 (18)
Professional experience	**n (%)**
Gerontology	1 (6)
Geriatrics	2 (13)
GP	1 (6)
Neurology	2 (13)
Neuropsychology	3 (19)
Nursing	1 (6)
Nursing home management	1 (6)
Psychiatry	5 (31)
Gender	**n (%)**
Male	10 (59)
Female	7 (41)

Data collection

Semi-structured interviews were carried out and the research team designed an interview guide involving fifteen open-ended questions. Using the interview guide, we sought to first explore healthcare professionals' (a) expectations, needs and perceptions regarding the clinical application of IATs, and (b) practical experiences with the clinical use of these technologies. Other questions included issues of effectiveness, clinical evaluation, care needs, interactions with designers, developers and other stakeholders, as well as issues related to the governance and management of IATs. Finally, interviewees were invited to provide recommendations for gerontechnologists, IAT designers and developers based on their clinical experience and perceived clinical needs with the purpose of improving IAT use for the benefit of end-users. The interview guide was pilot-tested and adapted during the first few interviews. Whenever useful to orient the conversation or provide tangible technological examples, participants were presented with the latest comprehensive index of IATs for dementia and older adults care known to the interviewer, encompassing the following IAT types: distributed systems, robots, mobility and rehabilitation aids, handheld/multimedia, software/apps, wearables, and human-machine interfaces[7].

Fifteen interviews were conducted face-to-face at the interviewees' institutions or at a location of their choice. Two interviews were conducted via video-call upon request from the participants. The first author conducted all the interviews in the time period between October 2016 and April 2017 and they were digitally recorded. The interviews lasted approximately between 21 and 55 minutes, with an average duration of 33 minutes. The recorded audio files were transcribed verbatim in the original language of the interviewees (English, German, or Italian) using the F4transkript software.

Data checking and data analysis

To ensure respondent validation[21], the study participants were given the opportunity to review their interview transcripts. Two participants made use of this option. Thereafter, thematic

Table 2. Overview of themes and subthemes

Themes	(1) IAT-use in response to current challenges in dementia and older adults care	(2) Personal experience and clinical implementation	(3) Expected benefits of IAT-use	(4) Barriers to adoption of IATs	(5) Recommendations for designers and developers	(6) The future of DEC in the digital era
Subtheme 1	Lack of resources: technological, financial, and human	Awareness	Improving QoC	Mismatch between patients' needs and IATs	Clinical validation	Holistic approaches-IAT in conjunction with: Pharma. therapy, early diagnosis, and human care
Subtheme 2	Caregiver burden	Actual utilization of IATs	Reducing caregiver burden	Technical limitations	Technical requirements: portability, reliability, and user-friendliness	Personalized care
Subtheme 3	Communication	Need for open-minded and evidence-based approaches	Improving communication and social interaction	Translational problems	User-centeredness	
Subtheme 4	AD diagnostics		Improving HRQoL of patients			

analysis[22] was used for systematically identifying, organizing, and offering insight into, patterns of meaning (themes) across a dataset. All data were read thoroughly by two researchers (MI, ML) in the language of the interview, and thereafter coded with the support of the data analysis software MAXQDA 12. Data analysis included three sequential steps. First, a code system was developed based on thematic relations using both inductive and deductive reasoning. Second, major themes were identified and categorized independently by two researchers. Finally, emerging themes were analyzed and compared within the code system, and adaptations were made to increase logical consistency. Discrepancies in interpretation were discussed and revised at various phases until a consensus was reached among all members of the research team.

Results

Our analysis identified six main recurrent themes. Each of these core themes was further analyzed in detailed. An overview of themes and subthemes is presented in *Table 2*.

(1) IAT-use in response to current challenges in older adults and dementia care;
(2) Personal experience and clinical implementation;
(3) Expected benefits of IAT use;
(4) Barriers to adoption of IATs;
(5) Recommendations for IAT designers and developers;
(6) The future of dementia and older adults care in the digital era.

IAT-use in response to current challenges in older adults and dementia care

Interviewees repeatedly discussed IATs in the context of current challenges in psychogeriatric care. In particular, they identified the lack of technological support, together with the scarcity of financial and human resources, as a major obstacle towards the successful delivery of older adults and dementia care services at their institutions. The lack of adequate technological equipment and digital infrastructures was perceived as a possible cause of sub-optimal care delivery jointly with the shortage of skilled healthcare workers, especially skilled nurses with specific training in the care of older people with dementia.

P15, Neurologist, Female, Italy: "*In our hospital we don't have much technological support. Often it happens that a patient wanders away and this creates problems, even though there are guardians. But it still happens that patients wander away.*"

P4, Psychiatrist, Male, Switzerland: "*The main problem, in my view, is the lack of trained healthcare professionals, and financially viable… and, of course, also of (technological) instruments, individual devices… of course… we are better off but this is a big problem in nursing homes and other institutions… we receive more and more questions about this*."

IATs were also presented in relation to the problem of limited therapeutic opportunities for various forms of dementia, especially AD, and the

rapid erosion of the caregiver-to-patient ratio. Caregiver burden among formal caregivers was perceived as a major source of problem at the interviewees' institutions.

P3, Nursing Home Manager, Female, Switzerland: "*Yes, they (caregivers) are always overburdened. So, we always have to check that they are still here, that they don't get sick*."

In light of unmet expectations with pharmacological therapy and in view of caregiver shortage and budget limitations at healthcare institutions, interviewees hypothesized that IAT support could mitigate the burden of disease and its associated financial problems before adequate therapeutic solutions are developed. The increasing need for skilled caregivers and persistent budget limitations at care institutions appeared hardly reconcilable unless smart technology-mediated solutions are deployed.

P6, GP, Male, Switzerland: "*I think that in the future (IATs) are the only way to overcome the dilemma between the lack of caregivers and the lack of money*."

Some interviewees identified a special challenge in their communication with patients with dementia, which was thought to be an important component of the doctor-patient relationship. Consequently, strategies that could facilitate or improve communication between patients and health professionals were perceived of primary importance.

P7, Geriatrician, Female, Switzerland: "*This is the greatest challenge: approaching patients and communicating with them*."

Finally, in the specific context of AD, interviewees addressed the problem of late diagnosis and the lack of adequate tools and strategies for the early and accurate diagnosis of the disease. In this respect, health professionals expressed hopes that advances in personalized mHealth such as wearable health monitoring or portable brain and eye imaging could lead to better diagnostic outcomes, especially in the form of self-assessment.

P2, Neuropsychologist, Male, Switzerland: "*The big challenge, I think, is that we should become able to tell what it is as early as possible and as reliably as possible. […]. We should get to a point where we can develop various examinations that patients can perform autonomously because the features of the device are so easy to grasp that they become self-explanatory*."

Personal experience and clinical implementation

Reference to personal experience in relation to the clinical utilization of IATs was a common thematic pattern. Our findings show that most health professionals were aware of the existence and clinical availability of various types of IATs for older adults and dementia care including ambient assisted living technologies (AALs), personal care robots, handheld devices and activity trackers.

P8, Geriatrician, Female, Switzerland: "*I know many GPS systems, alarm systems, and all these types of wearables, and then I know these intelligent beds (…) and security systems, sensors…*"

P13, Gerontologist, Male, Germany: "*We have been working on projects involving assistive devices, smartphone based, and glasses… smart glasses for people with mild cognitive impairment*" P16, Psychiatrist, Female, Italy: "*Yes, I've heard about these (social robots)*"

However, only less than one third of them reported having actually used such technologies at their institutions to enhance care. Concurrently, interactions between health professionals and technology producers appeared rare, with less than one in four healthcare professionals reporting active interactions with designers, developers or marketers of assistive technologies for clinical purposes even though such interaction was often perceived as necessary to enable clinical translation.

P15, Neurologist, Female, Italy: "*No, nobody ever came here to show or propose some products to us… maybe because we are just ambulant clinics… but at regional level either… nothing*."

P14, Psychiatrist, Female, Germany: "*Having a look at what's technologically possible. And in the help-desk kind of study, clinicians would not refer to that, they would not feel like "oh let's have a look at what is available nowadays"... clinicians wouldn't do that. So it really has to be presented to them. There are some people who are more interested and they, on conferences for example, would go to stands and see what's new... but most clinicians wouldn't. So if it's not presented to them, they wouldn't get in touch with it*."

Results show that interviewees had mixed but mostly positive views about the use of IATs in psychogeriatric care. Such positive attitudes were often associated with the idea that the assessment of new medical technologies should require open-minded attitudes to technological novelty and evidence-based approaches to technology evaluation. Most interviewees argued that prejudices against technological innovation could harm medical progress and delay the delivery of better healthcare services for patients. At the same time, interviewees felt that the efficacy of technology-mediated interventions should be carefully assessed and that the risks of hype or

unintended effects should be prevented. As multiple interviewees reported:
P5, Psychiatrist, Male, Switzerland: "*Of course, you need to have a critical mindset but you shouldn't be anti-technology. I think there is a lot of hostility towards new technologies, I was affected by it myself. When I first saw this robot seal I said: "please, spare me this crap!" but then I realized this was a stupid attitude. You shouldn't be hostile. You should first try and then judge*".

P6, Neuropsychologist, Female, Switzerland: "*I don't have anything against them (IATs). I think they are a 'must' in the future.*"

P17, Psychiatrist, Male, Italy: "*I am absolutely in favor of any therapeutic-technological device that can benefit the patient. Our hospital is full, completely full of geriatric patients, so are the emergency wards, so any tool that can help prevent hospitalization would be good.*"

Expected benefits of IAT use
Positive attitudes towards IATs were largely dependent on optimistic expectations regarding the potential of these technologies to improve care delivery and ultimately benefit older adults patients. These attitudes appeared associated with recurring subthemes:
First, improving the Quality of Care (QoC) was perceived as a major opportunity enabled by IATs as these technologies were perceived as able to gather more and better information about patients, especially patients with dementia, hence to deliver more personalized care solutions;

P10, Psychiatrist, Male, Switzerland: "*I think the environment and the type of dementia care… an individualized care closely dependent on the stage of the disease and as adapted as possible to the personal needs (of the user)…*"

Second, participants expected that IATs will reduce the burden on formal and informal caregivers, which was often reported by interviewees as a major challenge in current psychogeriatric care;

P4, Psychiatrist, Male, Switzerland: "I *see these technologies especially useful among patients with advanced dementia as a relief for caregivers… as they can undertake certain mechanical functions…*"

P14, Psychiatrist, Female, Germany: "*I think where I see a potential is in assistive functions, so apps that can, for example, monitor motivation and the general psychological condition of relatives, support it and maybe even automates first aids or starts a conversation*"

P6, Neuropsychologist, Female, Switzerland: "*Of course they can reduce the burden on caregivers if they are adequately implemented*"

Besides caregivers, psychogeriatric patients, especially people with dementia, were also considered primary beneficiaries of the clinical application of IATs. In fact, participants perceived that IATs have the potential to improving the health-related quality of life (HRQoL) of patients and increase their safety and security;

P10, Psychiatrist, Male, Switzerland: "*Through technology you can obtain targeted alleviation of burden and workload or, under certain circumstances, increase the safety of patients, or in other circumstances… where you can transfer care tasks to technology.*"

P14, Psychiatrist, Female, Germany: "I *think the issue of safety/security is the one that is best addressed through IATs*"

P15, Neurologist, Female, Italy: "*I think that the priority is to care about the safety of people. Precisely because care is so hard, so hard. So, I would welcome those (IATs)*"

Fourth, IATs were perceived as enablers of novel opportunities for patient-caregiver communication, hence capable of digitally enhancing the patient-health professional and patient-relative relationships. This possibility appeared particularly useful in the context of multilingual communities.

P14, Psychiatrist, Female, Germany: "*I have tested tracking devices and telephone hotlines and I had a positive experience with them. Even though the devices sometimes weren't so good, but my impression was that the care workers were well sensitized. Of course, there are always barriers with such media tools. But if I have somebody over the phone and through such devices… when a relative asks for support, in such circumstances having the chance to rely on devices that can process information, or navigate… videoconferences, videochats, videos that can give me an understanding of the situation, or that you can have a consultation with…*"

P6, Neuropsychologist, Female, Switzerland: "*In Switzerland we have so many foreign care workers and they are not able to converse with patients with dementia in their native language. So, I would envision conversational robots that can say something or translate sentences.*"

Finally, IATs were expected to maintain or even improve the social relations of patients. This expected benefit was often perceived in conjunction with the capacity of these technologies to reduce loneliness and social isolation;

P16, Psychiatrist, Male, Italy: "*It could be a success. Because robots can talk, relate, interact, so patients maybe don't feel lonely… maybe patients, from this point of view, don't feel abandoned. Especially because these patients are very fragile. Every small thing can (help). It may sound silly but I have experienced many times that some patients have pets and that these pets can make them feel much better. So, this can improve their quality of life.*"

Barriers to adoption of IATs

Barriers to adoption from the perspective of health professionals and researchers appeared strongly associated with both (i) current limitations in the design, development clinical implementation of IATs, and (ii) perceived collateral risks and obstacles in the translation of research results into the clinics. Three subthemes could be identified:

First, low technology acceptance among older patients was often attributed to a mismatch between patients' needs or abilities and design characteristics of currently available products. According to the interviewees, the specific cognitive and physical limitations of older adults, especially those of people with AD, are not adequately addressed by current IATs, resulting in a number of usage-related difficulties from the perspective of patients. These difficulties included: low familiarity among older users with advanced computing technology, the problem of adapting to unintuitive interfaces, excessive cognitive workload required by the IAT during everyday use, long training times required or the presence of visible features that can lead to social stigma;

P13, Gerontologist, Female, Germany: "*These are people that no longer use any technology in their daily life, except for a light switch…very few can use a coffee machine, so it's very difficult to approach...*"

P11, Nurse, Male, Germany : "*Sometimes you have one button and many lights, and that makes it difficult even for a technology-savvy man like me to unambiguously understand which lights correspond to which alarm or what kind of signal…*"

P1, Neuropsychologist, Male, Switzerland: "*Programming a reminder is way too complicated… the cognitive impairments of these patients do not allow them to do that… so patients can't benefit from it (app-based cognitive assistant).*"

P12, Gerontologist, Female, Germany: *"Ahm… acceptance is influenced by… you know, products are too big, or not adapted to their target population, or too clunky, or not enough unobtrusive and not enough user-friendly.*"

P11, Nurse, Male, Germany: "*I think that many technologies, as they are today, are still made in a manner that can generate visual stigma.*"

Second, technical limitations and low efficacy of certain IATs were also widely reported. Interviewees identified technical challenges in the IATs they used at their institutions. These challenges included poor quality of hardware and software, unoptimized interfaces, low reliability, low accuracy and others. These issues were perceived to negatively affect the utilizability of these technologies among end-users and even jeopardize the entire IAT market. In fact, the presence in the IAT market of numerous poorly designed, clinically ineffective and insufficiently validated devices was often presented as a risk factor that could harm the reputation and credibility of the entire market.

P12, Gerontologist, F- Germany: "*In most cases we're talking about devices that are not so valuable. The specifications and materials are awful.*"

P6, Neuropsychologist, F- Switzerland: "*Once you have a negative image, this will negatively affect the future production of truly helpful robots*"

P1, Neuropsychologist, M- Switzerland: "*A really, truly helpful assistive technology… I've experienced that rarely…*"

Besides technical considerations, critical problems in the successful translation of research prototypes from the designing labs to the clinical setting were identified. These translational problems included a knowledge gap between technology producers and clinicians due to insufficient interaction among these stakeholders groups, lack of time or absence of mediators that can enable information transfer across these groups, and difficulties associated with interdisciplinary collaborations between engineers and clinicians;

P14, Psychiatrist, Female, Germany: "*There was only once a research project... proposed... but it was really difficult to imagine how that could, in the very end, translate into clinical relevance so we didn't follow up on that.*"

P13, Gerontologist, Male, Germany: "*I have experienced this myself with security sensorics that worked very well theoretically, still worked well in the lab but then in reality didn't work properly anymore.*"

P11, Nurse, Male, Germany: "*There are language barriers between medicine and engineering.*"

P11, Nurse, Male, Germany: "*This is of course a big problem. How can a clinics, how can a health professional, how can patient associations transfer knowledge to the engineers that are responsible for creating a new device?*"

P8, Geriatrician, Male, Switzerland: "I *can't meet with all (IAT) companies. I just don't have the time!*"

These considerations led many interviewees to advocate the creation of intermediary platforms that could bridge the gap and facilitate information transfer across relevant stakeholders.

P9, Psychiatrist, Male, Switzerland: "*People in the clinics have just a general idea of what can be done, but very few ideas, not so much understanding of what that technologically means. I am sure that a mediation (between clinicians and tech-producers) is very important.*"

Recommendations for IAT designers and developers

Based on their clinical experience, interviewees provided recommendations for IAT producers on how to adapt technological designs and development strategies to their clinical needs with the purpose of increasing clinical effectiveness and acceptance among end-users. One major subtheme in this respect was clinical validation. Most interviewees argued that a cause of reluctance towards the introduction of IATs in their clinical praxis was the insufficient clinical validation of current products and the lack of sufficient and generalizable data about their safety and effectiveness.

P10, Psychiatrist, Male, Switzerland: "*So I looked into the studies and saw that the evidence is very poor. (…) There are studies that say "it works" and others that say "it doesn't work". But evidence is currently small. Until there is a lack of evidence any discussion with industrial partners is difficult.*"

Concurrently, interviewees argued that studies conducted in designing labs and other experimental settings should be complemented with studies in real-world scenarios: P12, Gerontologist, Female, Germany: "*You should definitely get out from the lab and back into reality! There should be more every-day studies… there is certainly not enough.*"

This recommendation appeared strongly linked with the theme of persistent translational barriers as interviewees reported the difficulty of replicating in the field research results previously obtained in controlled laboratory settings: P13, Gerontologist, Male, Germany: "*I have experienced this myself with security sensorics that worked very well theoretically, still worked well in the lab but then in reality didn't work properly anymore.*"

Other interviewees, however, proposed to distinguish minimally invasive IATs such as activity trackers and monitoring technologies from other devices and argued that the former might be entitled to faster clinical validation given their low invasiveness and risk. In such circumstance, a conflict appeared between the physician's need for clinical validation and the need for accelerating the development of new products for the benefit of patients.

P14, Psychiatrist, Female, Germany: "*Actually with devices that only show that they are (…) helpful and they are not invasive, I wouldn't mind too much about it going quicker to the market. Because that's the thing: in this field the consumer will then very easily show if a product is good or not by using it, buying it, or especially using them or not. So, I would not insist on a big dataset beforehand.*"

Frequently associated with the theme of clinical validation was the problem of identifying "signal-from-noise" in the IAT market. Interviewees largely shared the view that it is hard for them to detect truly effective tools in the large and ever-evolving IAT market, hence recommended to divert more efforts from the design of new prototypes to the clinical implementation of existing ones.

P12, Gerontologist, Female, Germany: "*The money shouldn't be invested for even more new hyper-high prototypes, in contrast we should place more research funds in the implementation.*"

In order to increase technology acceptance among end-users, interviewees recommended ameliorating the technical specifications of current IATs and prioritizing the principles of reliability, portability and user-friendliness. Reliable functioning was perceived as a necessary requirement to guarantee that users can trust and safely rely on and their assistive tools in their daily activities.

P14, Psychiatrist, Female, Germany: "*Reliability is key. So, this is an experience we made with GPS systems: very frequently they are just not working. And that's not helpful for the patients or the caregivers if the devices frequently have issues with the battery or no signal or something like that. That leads to frustration and then they don't use it at all. So, reliability is very important.*"

The importance of portability (i.e. the ability to be easily carried, worn or moved) was associated with the problem of forgetfulness, which is particularly prominent among older people with AD and other dementias.

P14, Psychiatrist, Female, Germany: "*So, it would be a device that can be carried on the body, and would not have to be remembered to take with you. So, it can be a watch on the wrist or around your neck. So probably it would be a good kind of device for cognitive assistance.*"

Virtually all interviewees highlighted the importance of user-friendly, cognitively easy and

behaviorally effortless interfaces to increase acceptance and efficacy among end-users. This theme appeared strongly linked with consideration of unintuitive and cognitively demanding interfaces as a major barrier to adoption and acceptance among older users.

P14, Psychiatrist, Female, Germany: *"One thing that's really important is that the device should not have too many buttons or too many functions because patients wouldn't be able to use them anyway in most cases and it would be confusing for them. So, where there is like one button to record something and one button to play probably it would be the easiest way and most likely to be used then."*

Finally, a general consensus could be identified among interviewees regarding the importance of pursuing user-centered approaches to technology design. In addition to patient-centered approaches, inclusive approaches favoring the involvement of caregivers were also positively evaluated.

P10, Psychiatrist, Male, Switzerland: *"It's absolutely important that engineers closely work together with clinicians as well as patients and their relatives, and that these can tell engineers what dementia is and what the needs of these patients are."*

P4, Psychiatrist, Male, Switzerland: *"It's not sufficient to simply involve patients in the process. You also have to involve their caregivers, relatives etc…. because sometimes their needs might be different."*

The future of older adults and dementia care in the digital era

A significant subset of coded themes was associated with views, expectations and predictions about the future of psychogeriatric in the digital era. Interviewees expected that with advances in robotics and the progressive digitalization and automation of healthcare, IATs will become increasingly ubiquitous.

P7, GP, Male, Germany: *"I cannot foresee if in 20 years robots will be regularly utilized, but I'm very confident that they will."*

However, all interviewees agreed that IATs should integrate and complement human-delivered care but not replace it altogether.

P3, Nuring Home Manager, Female, Switzerland: *"Technology is an added value, a support, but I don't think that it can replace human care."*

P4, Psychiatrist, Male, Switzerland: *"I think that these instruments should remain assistive tools and shouldn't replace medical examinations, diagnoses or therapies. I find this a risky trend: if doctor-patient contact is abolished and everything runs via apps… I think this is dangerous…"*

This consensus about the integrative but not substitutive nature of technology-mediated care was often associated with the idea that assistive robots and other IATs cannot adequately support the social dimension of the patient-caregiver dynamic and replicate eminently human abilities such as empathy, companionship and human contact.

P5, Psychiatrist, Male, Switzerland: *"This (IAT) is a support but if it ends up replacing human care entirely then we will be deprived of this… human contact, humanity… this empathy and emotional exchange."*

Interviewees indicated IATs as one of the strategies that should be pursued to tackle "the grand challenge" of global aging and dementia. Additionally, they called for holistic approaches consisting of coordinated strategies including prevention, early diagnosis, better pharmacological therapies, personalized care and IATs.

P16, Psychiatrist, Male, Italy: *"Raising awareness and investing more resources and funds for the establishment of interdisciplinary teams that can support the patient not only clinically but also socially."*

From their perspective, various parallel approaches will be required to mitigate the global burden of population aging and dementia and IATs are likely to become part of a multi-strategic roadmap for dementia and older adults care in the upcoming decades.

Limitations

This study has several limitations. While the use of a qualitative method allowed exploring a multifaceted topic in depth, such qualitative design prevents representative and generalizable conclusions. The study sample may not have represented the full range of experts' views from the field of dementia and older adults care in the three target countries, since it was limited in regards to sample size, recruitment strategy as well as geographical and cultural variation. However, since the interviewees came from three countries characterized by large proportions of psychogeriatric population and worked at internationally renowned healthcare institutions with direct experience with gerontechnology development and testing, we believe that their views and perspectives provided valuable insights on IAT use in light of current trends in population aging.

In addition, there may be selection biases due to the recruitment process. In order to provide participants with adequate information, a brief summary of the project description was included in

the invitation email (see methods section). This could have stimulated participants to reflect on the topic before the actual interview. Despite these limitations, the obtained findings show a variety of well-differentiated attitudes which add significant knowledge about how health professionals' and researchers' attitudes towards IATs for older adults and dementia care. Further research is required to provide (i) quantitative data on health professionals' awareness, views and attitudes regarding IATs, (ii) qualitative insights from different cultural settings, and (iii) a more detailed assessment of the ethical issues at stake from a clinical perspective.

Discussion

Awareness, clinical utilization, and translational issues

Although participants appeared very familiar with the current trends in IAT and gerontechnology, only a small number (less than one third) of experts reported having actually used IATs in the clinical setting. This denotes insufficient transfer at the cross-section between technology development and clinical implementation. This finding is confirmed by the recurrent report of unresolved challenges in the translation of prototypes into clinically viable products[23]. In contrast, the general open-mindedness and positive attitude about IATs of interviewees seems to challenge the elsewhere reported hypothesis[24] that lower-than-expected adoption might be caused by conservative attitudes towards technology among stakeholders.

This insufficient information transfer may be due to the fact that interactions between health professionals and technology producers are reportedly rare, with only few interviewees reporting active interactions with designers, developers or marketers of assistive technologies for clinical purposes. Interviewees indicated as possible causes of such missing interaction the lack of time and interest of health professionals (especially physicians) in engaging with IAT producers, and the absence of mediators that can enable information transfer across these groups. Based on this evidence, increasing investments and strengthening efforts for the adequate implementation of IATs, as many interviewees suggested, seem to be an urgent priority. To facilitate such implementation, there is a need for creating new intermediary and consulting services at the cross-section between the lab and the clinics. These intermediary entities can spin off from existing organizations and services including consulting, patient advocacy, digital incubators, caregiver networks, industry organizations and others. While all interviewees acknowledged such need, and called for the creation of intermediary and consulting services, there was disagreement and uncertainty about which stakeholders should be involved in such intermediation. In particular, the direct involvement of health professionals was questioned by many respondents due to their limited expertise and time constrains.

Strictly linked to the problem of insufficient transfer at the cross-section between technology development and clinical use is the frequently reported presence of unresolved problems in the translation of research prototypes into viable clinical tools. Translation is a fundamental mechanism for leveraging the benefits of IATs for psychogeriatric care[25]. In light of our findings, three main translational challenges need to be addressed. First, producers should improve the technical reliability of their products in order to provide health professionals with more reliable tools. Second, the clinical validity of current IATs needs to be increased through larger and better designed studies, especially studies involving (i) larger population samples of, (ii) older adults with specific forms/stages of cognitive impairment, and (iii) in real-world settings (e.g. homecare). As hypothesized in previous studies[7,26], our results show that technical reliability and clinical validity are predictors of trust in IAT among health professionals, hence might positively influence final adoption into clinical practice. Large-scale randomized control trials were often perceived as a privileged method of clinical validation. Furthermore, our results support the claim by Kearns et al. (2016) that proof of concept studies in gerontechnology are useful but not sufficient[28].

Promises and challenges

Overall our findings indicate a positive match, from the health professionals' and researchers' perspective, between the perceived challenges in older adults and dementia care and the perceived capacity of IATs to address such challenges. In fact, our participants believe that assistive technologies can (i) alleviate caregiving burden, (ii) provide new tools for self-assessment and early diagnosis, (iii) optimize financial expenditures by providing more targeted and cost-effective interventions, (iv) facilitate doctor-patient communication, and (v) supply for the imminent shortage of human caregivers.

At the same time, however, results indicate a general wish to inscribe IATs into a broader and multistrategic roadmap for tackling the grand challenge of population aging and dementia. Our findings show a strong consensus that IATs should not replace human-delivered psychogeriatric care, diagnostics and therapy but should complement these human activities by providing mechanical and informational support for the benefit of patients and their caregivers. Particularly, interviewees hypothesized the impossibility of replicating via IATs (e.g.: through care robots) putatively human

aspects of care such as empathy, human contact and emotional intelligence. While it remains an open empirical question whether advances in emotional intelligence can achieve such human-like features[28], the results from our study suggest that preserving (aspects of) human care will increase the likelihood of IAT-interventions to be accepted by health professionals. Furthermore, interviewees observed, in line with previous analyses[29], that entirely IAT-mediated care might have negative consequences on social relationships, including the patient-health professional relationship. Concurrently, our results indicate a need for harmonizing efforts in IAT development and implementation with other long-term strategies for enhancing older adults and dementia care, including prevention, pharmacological therapy, diagnosis and end-of-life support.

Validation and Assessment

The open and positive attitude of interviewees towards IATs denotes an incentive for future technological development in this field. These results strengthen previous findings corroborating the positive potential of IATs for improving older adults and dementia care[5]. However, our interviewees recommended that the focus in IAT-research should be shifted from the development of new prototypes to their validation and successful implementation. This is consistent with recent review results[7] showing that the IAT market is rapidly expanding in size and variety but is still affected by inadequate clinical validation, slow implementation and outdated models of technology design. There is also a need for supporting physicians in the process of filtering signal from noise in the IAT market. That is, there is a need to identify safe, clinically effective, adequately validated and socially beneficial devices and distinguishing them from devices that do not meet these requirements to improve clinical use. While consumer preferences and market dynamics could, on the long term, enable such filtering process, proactive designs and calibrated regulatory interventions could help accelerate and maximize the benefits of IATs in the short-to-medium term. In addition, even though there is general agreement that "adequate implementation" is pivotal (see P6), it remains open what kind of implementation qualifies as "adequate", i.e. which criteria and methods are required. It is worth observing that calibrated regulatory interventions and adequate implementation strategies can contribute not only to accurately identifying safe and effective products within the chaotic IAT domain, but also, and most importantly, to accelerate responsible innovation and the sharing of clinical benefits among psychogeriatric patients.

User-centered design

To this respect, our findings reveal health professionals' preference for user-centered approaches to technology design and indicate room for cross-disciplinary collaboration among designers, developers and healthcare professionals with the aim of involving end-users in the process and better adapting future products to their specific needs. Since review results show the almost half IATs for dementia and older adults care are developed in absence of user-centered approaches to product design[7,17], more efforts are needed to better root such approaches in technology development. In addition, interviewees often associated the lack of user-centered approaches with higher risk of technical limitations such as unintuitive, demanding or inflexible interfaces, which were identified as major barriers towards adoption. Consequently, a shift to user-centered approaches might have the potential to initiate a virtuous circle where the early involvement of end-users in the design phase results in better products that obtain higher adoption rates among end-users. This is consistent with a plethora of studies advocating the importance of user-centered design and development in healthcare technology[17,23,30,31]. User-centered models of design developed in contiguous health technology areas such as assistive and rehabilitation technology[23] might offer a useful starting point for IAT research. Furthermore, given the vulnerability of psychogeriatric patients, ethically-aligned[32] and value-sensitive[33] approaches to technology development are highly encouraged.

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