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The future of the provision process for mobility assistive technology: a survey of providers

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Abstract

Purpose: The purpose of this study was to evaluate the opinions of providers of mobility assistive technologies to help inform a research agenda and set priorities.

Materials and Methods: This survey study was anonymous and gathered opinions of individuals who participate in the process to provide wheelchairs and other assistive technologies to clients. Participants were asked to rank the importance of developing various technologies and rank items against each other in terms of order of importance. Participants were also asked to respond to several open-ended questions or statements.

Results: A total of 161 providers from 35 states within the USA consented to participation and completed the survey.

Conclusions: This survey revealed themes of advanced wheelchair design, assistive robotics and intelligent systems, human machine interfaces, and smart device applications. It also outlined priorities for researchers to provide continuing education to clients and providers. These themes will be used to develop research and development priorities.

Keywords

disability; mobility; rehabilitation; robotics; therapy; wheelchair

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Introduction

Fifty-three million adults, or 22% of the US population, have a disability which can affect their daily activities or participation in the community.[1] Mobility limitations are the most common functional disability, affecting about 1 in 8 Americans.[1] Assistive technologies to improve mobility can increase independence with activities and participation[2] and are commonly utilized; 3.6 million Americans[3] and over 250,000 Veterans use a wheelchair. [4] Wheelchairs have the capability of improving function, independence, home and community integration, activity, and participation;[5, 6, 7, 8] comfort;[9, 10] and quality of life.[9, 11] However, wheelchairs do not overcome all barriers to mobility.

Revolutionary mobility assistive technologies have the potential to overcome some of these barriers. Artificial intelligence robotics, robotic arms that attach to wheelchairs, adaptive sports and recreation equipment, devices that assist standing and transfers, smart technology for monitoring and coaching, power add-on devices for manual wheelchairs, and power mobility devices that operate in extreme terrain are just some examples of technologies that have great potential to greatly enhance mobility in ways wheelchairs cannot. Moreover, innovations in device design and alternative power sources may advance the capabilities of wheelchairs and scooters currently on the market.

To more fully examine how assistive technologies may overcome barriers through mitigating the effects of impairments, The National Academies of Sciences, Engineering, and Medicine (NAS), with support from the Social Security Administration, released report in 2017 that provides an analysis of the use of selected assistive products and technologies currently on the market and calls for research priorities.[12] The President's Council of Advisors on Science and Technology (PCAST) also released a report in 2016 emphasizing the need for user-centered design and outcomes research on mobility assistive technologies.[13] The PCAST report also called for the VA and Centers for Medicare and Medicaid Services to generate a "road map" for mobility assistive technology research and for federal support of research in this area. Yet, this roadmap has yet to be developed.

In order to begin to inform a user-centered research agenda for mobility assistive technologies, we conducted a pilot study of 112 clients who use mobility assistive technologies to understand more fully their needs and wants.[14] Several themes emerged as priority strategic areas for future research: (1) assistive robotics, (2) smart home technologies, and (3) alternative power sources for mobility devices. However, healthcare professionals and technical experts involved in the provision of mobility assistive technologies were not part of that survey.

The opinions of providers intimately involved in provision of mobility assistive technologies are critical to obtain, since the procurement process is known to be related to device acceptance or abandonment,[15] is inherently interdisciplinary, and involves multiple steps. [16] The Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) Wheelchair Service Provision Guide[17] outlines a complex patient-centered process spanning from client evaluation to the final custom fitting and training for wheeled mobility devices. The process for providing other mobility assistive technology such as

prostheses or orthoses is similarly complex. Key stakeholders in this process have critical knowledge about the gaps between client needs and device performance, as well as the complex interplay among product translation, policy, and funding that are important considerations in driving research and development. The purpose of the present study, therefore, was to evaluate the opinions of providers of mobility assistive technologies to help inform a research agenda and set priorities.

Methods

The survey (see appendix 1) was developed by experts in the field of assistive technology at the Human Engineering Research Laboratories (HERL) in Pittsburgh, PA. The survey was designed to take less than 10 minutes to complete. Questions were based on results from on a previously conducted survey.[14] Further content validity was established through consultation with the VA Pittsburgh Healthcare System Veterans Engineering Resource Center (VERC). The study was conducted as an exempt study approved by the Institutional Review Board of the University of Pittsburgh. The survey was administered through the Research Electronic Data Capture (REDCap) system, a secure, web-based software system sponsored by the Clinical Translational and Science Institute at the University of Pittsburgh. The questionnaire was anonymous, and therefore no identifiable personal information was collected.

The home page provided a brief description of the project and an overview of informed consent, asking the participant to answer whether they consented to taking the survey. Participants were asked how important it would be for their clients to carry out certain activities if technology could accommodate them. The next set of questions were structured to allow participants to provide individual rankings of importance of developing various technologies that were ranked highly in our prior survey.[14] The survey also required participants to rank these items against each other in terms of order of importance. Participants were asked how often people with disabilities play an active role in the decision-making process when getting new mobility equipment and how often clients get adequate support to be able to maintain their assistive technology long term. Participants were also asked to respond to several open-ended questions or statements.

Inclusion criteria were: age 18 years or older, consents to participate in the survey, U.S. Citizen, and an individual who participates in the process to provide wheelchairs and other assistive technology to those who use it. There were no exclusion criteria.

Participants were recruited in person at various events and professional conferences including the 2016 Paralyzed Veterans of America Summit, the 2017 International Seating Symposium, the 2017 National Disabled Veterans Winter Sports Clinic and the 2017 National Veterans Wheelchair Games. Flyers were shared through personal contacts, professional listservs, agency newsletters and magazines, our organization's website, and through social media postings. Potential participants were directed to access the web link directly or to contact a study coordinator.

Descriptive statistics for each multiple-choice item were reported using frequency counts and percentages. Average rankings were examined for sets of items that were placed in order by participants. All descriptive statistics were performed using SPSS v24.0 (IBM Corp.) Open-ended responses were examined in detail to identify overall patterns and themes, as well as unique, creative solutions to the issues of mobility.

Results

From the 165 individuals who were recruited, a total of 161 (97.6%) consented to participation and completed the survey. Table 1 displays characteristics of the sample. Participants practiced or worked in 35 different states within the U.S. and came from diverse backgrounds; providing care through clinical, technical and financial roles. Thirty-four percent of providers were certified Assistive Technology Professionals (n = 55). About half of the sample reported providing care through the US Department of Veterans Affairs (n = 82) and about 14% were Veterans themselves. Although not explicitly asked of all participants, two providers also specified that they had a disability.

When asked about how important it would be for clients to carry out certain activities if technology could accommodate them, the majority of providers identified all four categories of activities as critical/important (table 2). Participants were also asked how important it would be to develop specific technologies. While most technologies were rated as critical or important, wheelchairs and components that could self-adjust or could assist in overcoming obstacles gained the most critical ratings (table 2). A total of 64% (n = 103) of providers think it will be commonplace in the future for people who use assistive technology to have a robot to perform activities of daily living.

When asked to rank five “futuristic inventions” and four “futuristic mobility/ transportation inventions” from least to most important using a 5-point or 4-point scale, respectively (tables 3 & 4), devices to assist with transfers and new power sources for wheelchairs were consistently ranked as most important.

The majority of providers (n = 127, 78.9%) felt that people with disabilities often (n = 98, 60.9%) or always (n = 29, 18%) play an active role in the decision-making process when getting new mobility equipment. However, the majority (n = 110, 68.3%) also said that people with disabilities rarely (n = 105, 65.2 %) or never (n = 5, 3.1%) get adequate support to be able to maintain their assistive technology long term.

Answers to open ended questions are listed in Table 5. Several barriers and facilitators to clients obtaining new technologies were identified. The most commonly cited barrier was the intensive process to get insurance approval for the device. This included the cost of the device itself, the availability of funding, and the time it takes to obtain authorization and ultimately procure the equipment. Other barriers cited commonly included lack of client knowledge that technology exists or how to access or use it, lack of provider knowledge about technology or the provision process, and lack of support for proper maintenance. The majority of participants did not report any facilitators. However, programs that provide

funding and expertise of suppliers and providers were listed frequently as facilitators by those who did respond.

Comments were also elicited on the provision process itself. The most common examples cited of ways that the provision process could be improved were to decrease the time required for clients to acquire devices and any means that streamlines the overall provision process. Providers felt that research could help their practice by developing new or better technologies, comparing devices or demonstrating efficacy of the use of devices on client outcomes, and generating evidence that can be used to support best practice or justify clients' need for technology in their documentation. Providers most wanted to receive additional training on environmental control devices, human machine interfaces, and new and emerging technologies. Several providers also provided open-ended comments that there should be more government funding for research on assistive technologies and streamlining of the process to obtain Food and Drug Administration approval for devices.

Finally, providers were asked to suggest research on other devices that could benefit clients or ways that new technology could benefit them. Participants named devices that promote portability, environmental access, or travel with wheelchairs (e.g., wheelchairs suitable for travel, devices that help load wheelchairs, alternative power sources), assistive robotics including exoskeletons, human machine interfaces, and tissue regeneration. Further, high priority was placed on devices that improve safety, activities and participation.

Discussion

This survey of providers of mobility assistive technologies can be used to inform the research "road map" described by PCAST and NAS, and develop research and development priorities. Overall, providers felt that technology is important for mobility in all aspects of a person's life and to reduce need for caregiver support. Overall the qualitative results suggest that providers want researchers to develop new and better technology that can be acquired at lower cost. They also felt that research should be conducted to demonstrate impact of device use on client outcomes, and that positive outcomes from such research will guide best practice and help providers justify the medical necessity of the devices in their documentation. They also pointed to a gap in knowledge of clients and providers, which presents an opportunity for researchers to provide continuing education opportunities for clients and providers on what technology is already available, how to use and maintain it, what new technology is emerging, and how to apply best practice in the provision process.

Results of this study identify four important research and development thrusts. All four are specifically mentioned as key rehabilitation research opportunities in a report by experts in the US Department of Veterans Affairs Office of Research and Development.[18]

One major thrust is **advanced wheelchair design**. Survey participants placed emphasis on alternative power sources for wheelchairs and mobility technology that improves activity, participation, and safety, especially during travel. Our own research has always been focused on demonstrating how client outcomes and safety can be maximized by optimizing wheelchair components and setup, rigorous wheelchair standards testing, and evidence-

based training and assessment protocols.[19, 20] The call for alternatives to conventional batteries is consistent with research showing that batteries and electrical components are the most common components of power mobility devices to fail and need replacement.[21, 22]. Interestingly, only one participant highlighted the need for research into adaptive sports technologies. This is surprising since some of the providers were recruited at sporting events. Our own emphasis on the need for research in adaptive sports technology [23] may not have been echoed by providers due to concerns with reimbursement for such technologies outside of the VA.

A second thrust is **robotics and intelligent systems**. Participants highlighted the need for obstacle avoidance, wheelchairs that self-adjust, navigation assistance, and self-driving or robotic power wheelchairs. Most participants felt it inevitable that robots will be used in everyday life to aid daily activities. Our own perspective has been that navigation, sensing and control systems, especially those that adapt to client needs or learn from client behavior, are top priorities for advanced wheelchair design research.[20, 23] Likewise, we have argued for the need for more research on desktop robots or those that attach to wheelchairs, semi-autonomous robots, and more studies that compare performance of different robots in terms of efficacy, safety and reliability.[20, 24, 25] Providers rated devices to assist transfers as highly important. This was expected from providers given that many may be intimately involved in assessing and training clients to transfer and may therefore recognize the importance of transfers for both the client and the caregiver. This focus on transfers is consistent with our own priorities for developing robotic devices that assist with transfers to and from wheelchairs and beds[26] and improving transfer biomechanics of clients and caregivers.[19, 20]

A third thrust is **human machine interfaces for manipulation and mobility**. Participants emphasized the need for interfaces that allow control of mobility devices and robots with the brain, eyes, face, or other body systems and for more training in this area. This is consistent with recent trends in assistive technology development which emphasizes improving the human machine interface, improving the hardware and software of the technologies, and improving shared control strategies between the user and the device.[27] We have also previously emphasized the need for more research in interfaces between the user and the wheelchair, as well as universal control interfaces and software algorithms that afford better control of many devices. [20, 28]

Fourth, **smart device applications**, includes participant priorities of smart technology to control the home and other environments, and mobile health technology or wearable devices that can be used to monitor activity or promote healthy behaviors. Indeed, it has been our own perspective that monitoring and coaching technologies will become more robust and prevalent as research advances in these areas.[19]

It is interesting to note that while providers perceived that clients get the opportunity to play an active role in obtaining their assistive technologies, they also felt that clients rarely or never get adequate support to maintain their equipment. This finding speaks to a mismatch between the services that professionals feel that they should be providing and the resources available in their settings. It is important for providers and healthcare systems as a whole to

take more measures to ensure that clients are provided with appropriate follow-up and maintenance. Otherwise, clients may be dissatisfied with the technology provided, the technology may not fully optimize their function or participation in the community, or the technology could be abandoned.[15] Training programs[29] to teach clients how to perform basic maintenance on their assistive technologies and access to rehabilitation technicians and engineers should also be prioritized.

A few limitations to this research study deserve discussion. First, this study involved completion of an online survey. Those who are not technologically savvy or those who do not have internet access may therefore be under-represented in our sample. Second, we sampled a small proportion of the professionals providing technologies in the U.S. However, the participants had a wide variety of professional backgrounds, represented 70% of the states in the U.S. and were generally experienced in the field, the majority having been in practice for more than 11 years. Third, survey participants can sometimes over-express enthusiasm about specific topics or the survey. We therefore asked participants to rank items against each other in terms of order of importance in order to identify emergent themes that were more ranked as important than others. Fourth, we did not define some terms in the survey for participants. For example, we asked whether participants felt that clients get adequate “support” to maintain their equipment without defining the term “support.” This was done intentionally to elicit open-ended feedback. Thus, it is important to interpret responses from some particular questions in the context of the broader feedback provided. Open-ended comments related to this particular survey question indicated that a need exists for maintenance training programs for clients and also for repair services in a clinical or home setting (e.g., availability of a rehabilitation technician or rehabilitation engineer). Finally, surveys can be inherently biased toward the organization’s mission, especially if participants feel strongly about the cause. We therefore based our survey content on responses provided by participants in our prior work[14], consulted with the VERC to establish content validity, and provided ample opportunity for participants to provide unstructured feedback and ideas besides those presented in the survey. The qualitative feedback was helpful in expanding the themes that emerged from the survey.

Future work will be conducted to obtain a larger and more representative sample of users of mobility assistive technology. The current and future surveys will be used along with this study to inform a research agenda that will drive innovation in the field and develop and translate novel assistive technologies.

Conclusion

This survey of providers of mobility assistive technologies will be used to set research and development priorities for advanced wheelchair design, assistive robotics and intelligent systems, human machine interfaces, and smart device applications. It also outlined priorities for researchers to provide continuing education to clients and providers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Biography

Biographical notes

Brad Dicianno, MD is the Medical Director and Chief Operating Officer of the Human Engineering Research Laboratories (HERL) and the Medical Director of the VA Center of Excellence on Wheelchairs and Associated Rehabilitation Engineering (WARE). He is a rehabilitation physician (physiatrist), bioengineer, and Associate Professor in the Department of Physical Medicine and Rehabilitation (PM&R) at the University of Pittsburgh School of Medicine. His research interests are in the area of assistive technology interventions for people with disabilities including advanced wheelchair technology and mobile health. He serves as the Medical Director of the Center for Assistive Technology and the Director of the UPMC Adult Spina Bifida Clinic at the University of Pittsburgh Medical Center.

James Joseph, Gunnery Sergeant USMC (ret.), MS is a Research Associate and Peer Mentor of the HERL. He is a rehabilitation and clinical mental health counselor and information technology specialist. His areas of interest are rehabilitation science aimed at improving the quality of life for individuals living with disability, especially Veterans. GySgt. Joseph spent twenty-two years on active duty in the United States Marine Corps serving as an electro-optics technician in multiple worldwide assignments.

Stacy Eckstein, BS, MT (ASCP) is the Assistant Director for Clinical and Regulatory Affairs for the HERL. She is responsible for managing the clinical coordinator team, assisting in the development and implementation of research protocols and overseeing data management and security.

Christina K. Zigler, PhD, MEd is a biostatistician with the Department of PM&R at the University of Pittsburgh. She has a multidisciplinary background in statistics, measurement, psychology, and medical research with over ten years of experience working on diverse projects, including those at the University of Miami, the University of Pittsburgh, the Children's Hospital of Pittsburgh of UPMC, and within the VA Pittsburgh Healthcare System. She obtained her doctorate in research methodology from the University of Pittsburgh with a concentration in applied statistics and psychometrics. Her current and past research focuses on best practices for modeling with multilevel data structures and improving the measurement of physician- and patient-reported outcomes. She has published in journals such as The British Journal of Dermatology, The Journal of the American Academy of Dermatology, and Arthritis Care & Research, and presented at multiple American Educational Research Association annual meetings.

Eleanor J. Quinby, BS is a research technician in the Department of PM&R at the University of Pittsburgh. Her background is in natural science, with a focus in psychology. She has

assisted with research focused on assistive technology interventions involving mobile health and the assessment of community-based care programs for people with disabilities.

Mark R. Schmeler, PhD, OTR/L, ATP is an Associate Professor and Director of the Continuing Education Program in the Department of Rehabilitation Science & Technology (RST) at the University of Pittsburgh. He is the course director for the International Seating Symposium and directs several other continuing education venues including web-based post-professional education and training. He directs a national contract to develop assistive technology clinics within the Veterans Administration's Polytrauma and Spinal Cord Injury Rehabilitation Systems of Care. He is a co-developer of the Functional Mobility Assessment and manages a registry of large data related to mobility outcomes that investigates the effectiveness of various mobility assistive equipment. He has over 27 years of clinical practice experience and continues to practice as an occupational therapist and assistive technology professional in the Center for Assistive Technology at the University of Pittsburgh Medical Center.

Richard M. Schein, PhD, MPH is a research health scientist within the Department of RST at the University of Pittsburgh. He received his Master of Science in Rehabilitation Science and Technology, a Master of Public Health in Health Policy and Healthcare Management, and Doctorate of Philosophy in Rehabilitation Science all from the University of Pittsburgh. He is serving as the Operations Officer to develop assistive technology clinics within the Veterans Administration's Polytrauma and Spinal Cord Injury Rehabilitation Systems of Care. He has also assisted with the development and deployment of an information infrastructure for healthcare and rehabilitation service including telerehabilitation, a database for measuring health outcomes, and online portal system organization. He blends together his diverse background with research and clinical education, as well as project management. His areas of research include wheeled mobility and seating, funding and policy, outcome measures, continuing education and telerehabilitation.

Jon Pearlman, PhD is the Associate Director of Product Innovation and Translation at the HERL and an Associate Professor in the Department of RST at the University of Pittsburgh. His research centers on assistive technology product development and quality control. Related to these topics, Dr. Pearlman has several assistive technology design and development projects in collaboration with clinician and commercialization. Dr. Pearlman is also the director of the International Society of Wheelchair Professionals, which aims to coordinate the global wheelchair sector, set and advocate for high quality product and service standards, and increase awareness of the global need for improved wheelchair products and services.

Rory A. Cooper, PhD is the Founder, Director and Chief Executive Officer of HERL and the Director of the VA Center of Excellence on WARE. He is a bioengineer and an electrical and computer engineer. He is a FISA-PVA Chair of Rehabilitation Engineering and Distinguished Professor in the Department of RST, and Professor of Bioengineering, PM&R, and Orthopedic Surgery at the University of. He has been an author on over 350 peer-reviewed journal publications, and an inventor on over 20 patents on assistive technologies issued or pending.

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Table 1.

Demographic information for 161 providers who completed the survey.

Gender	n	%
Male	73	54.7
Female	88	45.3
Age Group		
18–29	8	5.0
30–49	75	46.6
50–64	62	38.5
65+	15	9.3
Missing	1	<1.0
Race		
White or Caucasian	137	85.1
Other	8	5.0
Black or African American	5	3.1
Two or more races	5	3.1
Asian	4	2.5
American Indian or Alaska Native	1	<1.0
Missing	1	<1.0
Ethnicity		
Unknown	2	1.2
Hispanic or Latino	8	5.0
Not Hispanic or Latino	151	93.8
Highest level of education		
Associate's degree	10	6.2
Bachelor's degree	33	20.5
Doctorate - MD, DO, PhD, DPT, DOT, ScD	48	29.8
High school diploma or equivalent (GED)	6	3.7
Master's degree	60	37.3
Other advanced degree	4	2.5
Years working in profession		
11+ years	106	65.8
7–10 years	29	18.0
3–6 years	16	9.9
2 years or less	10	6.2
Academic or Professional Training (participants could choose more than one training)		

Gender	n	%
Clinical Training	120	74.5
Technical Training	32	19.9
Both clinical and technical	5	3.1
Unknown or Business/Corporate	14	8.7
Specific Technical Training (participants could choose more than one training)		
Rehabilitation engineer	19	11.8
Technician	10	6.2
Biomedical engineer	10	6.2
Mechanical engineer	4	2.5
Electrical engineer	3	1.9
Industrial engineer	2	1.2
Ergonomist	1	<1.0
Specific Clinical Training (participants could choose more than one training)		
Occupational Therapist	36	22.4
Physical Therapist	35	21.7
Nurse or Advanced Practice Provider	18	11.1
Physician	13	8.1
Counselor/Therapist/Psychologist	10	6.2
Social worker	9	5.6
Speech Language Pathologist	3	1.9
Physical Therapy Assistant	2	1.2
Orthotist	1	<1.0
Prosthetist	1	<1.0
Specific Business/Corporate Training (participants could choose more than one training)		
Financial/Business	3	1.9
Product Developer	1	<1.0
Indicated 'Other' Training	10	6.2
Primary professional setting (participants could choose more than one setting)		
Rehabilitation facility	36	22.3
Academic institution	22	13.7
Outpatient Facility or Clinic	20	12.4
Acute care hospital	19	11.8
Durable medical equipment supplier/provider	17	10.6
Community-based center, i.e., independent living center, AT specialty center	10	6.2
Assistive technology manufacturer	6	3.7
Governmental Agency/VA Administration/ Vocational Rehabilitation	6	3.7
Home health agency	5	3.1
Private outpatient office or private practice	4	2.5

Gender	n	%
Research center	3	1.9
Skilled nursing facility/long-term care facility	3	1.9
Association or Foundation	3	1.9
Unknown	6	3.7

AT= assistive technology

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Table 2:

Importance of client activities and areas of technology and development; n (%)

Client activities “if technology could accommodate”	Critical	Important	Minor Importance	Not important
To live without a caregiver or with less assistance	66 (41.0)	81 (50.3)	13 (8.1)	1 (<1.0)
To go to work or school or be more productive at work/school	75 (46.6)	74 (46.0)	12 (7.5)	-
To meet all of their personal mobility needs (e.g. home, work, neighborhood)	108 (67.1)	50 (31.1)	2 (1.2)	-
To travel freely (e.g. vacation, cruise, airline, bus, taxi, train)	58 (36.0)	94 (58.4)	8 (5.0)	1 (<1.0)
Areas of technology and development	Critical	Important	Minor Importance	Not important
Portable powered transfer devices that a person with a disability could use independently	68 (42.2)	86 (53.4)	7 (4.3)	-
Ways to decrease the amount of time it takes to provide customized wheelchair components (e.g. 3D printing on site)	37 (23.0)	88 (54.7)	31 (19.3)	5 (3.1)
Virtual reality programs used for evaluation and training purposes	9 (5.6)	72 (44.7)	70 (43.5)	10 (6.2)
Wearable or mobile technologies that can provide health or other information to AT users or their clinicians	32 (19.9)	101 (62.7)	27 (16.8)	1 (<1)
Human-machine interfaces for people with disabilities to improve their function	51 (31.7)	86 (53.4)	22 (13.7)	2 (1.2)
Wheelchairs and components that can self-adjust or can assist in overcoming obstacles	81 (50.3)	70 (43.5)	9 (5.6)	1 (<1)
Alternative power sources for wheelchairs	47 (29.2)	78 (48.4)	29 (18.0)	7 (4.3)

Table 3.

Ranking of futuristic inventions from 1 (least important) to 5 (most important); n (%)

	Missing response	Most important	Important	Neutral	Somewhat important	Least important
Personal robot/Robot servant	6 (3.7)	6 (3.7)	21 (13.0)	28 (17.4)	60 (37.3)	40 (24.8)
Brain implant to control assistive devices (e.g. wheelchairs, robots, home controls, etc.)	4 (2.5)	22 (13.7)	24 (14.9)	50 (31.1)	40 (24.8)	21 (13.0)
Smart home technology to control lights, doors, windows, shades, etc. with voice commands or online	6 (3.7)	43 (26.7)	70 (43.5)	26 (16.1)	14 (8.7)	2 (1.2)
Devices to make transfers to and from a wheelchair simple, safe, and pain free	2 (1.2)	84 (52.2)	38 (23.6)	20 (12.4)	15 (9.3)	2 (1.2)
Virtual reality or video game that provides training	3 (1.9)	1 (<1)	8 (5.0)	32 (19.9)	26 (16.1)	91 (56.5)

Table 4.

Ranking of futuristic mobility/transportation inventions from 1 (least important) to 4 (most important); n (%)

	Missing response	Most important	Important	Somewhat important	Least important
Self-driving or robotic powered wheelchair	5 (3.1)	41 (25.5)	52 (32.3)	33 (20.5)	30 (18.6)
New power sources for wheelchairs (e.g. longer-lasting batteries, fuel cells, compressed air)	6 (3.7)	54 (33.5)	37 (23.0)	37 (23.0)	27 (16.8)
Manual wheelchair that would fold or disassemble to fit in a suitcase	1 (<1)	21 (13.0)	37 (23.0)	48 (29.8)	54 (33.5)
Exoskeleton for daily mobility	-	42 (26.1)	32 (19.9)	43 (26.7)	44 (27.3)

Table 5.

Qualitative feedback from open ended questions

Please identify 3 potential barriers that people with disabilities or rehabilitation professionals encounter when obtaining new assistive technology		
Cost of Equipment, funding or procurement	128	79.5%
Client knowledge about how to use technology	66	41.0%
Knowledge of what is available, or access to the equipment itself	52	32.3%
Provider knowledge of how to use technology, train clients, or obtain equipment	27	16.8%
Availability of maintenance or repair processes	26	16.1%
Access to providers	25	15.5%
Policies or government regulations	4	2.5%
Identify 2 topic areas on which you would like to have additional training related to assistive technology		
Not specified/ No response	29	18.0%
Environmental control devices	17	10.6%
New or emerging assistive technology	17	10.6%
Human machine interface/ Brain computer interface	16	9.9%
New technology specific to wheelchairs	15	9.3%
Smartphone apps/wearables	14	8.7%
Devices for positioning and stability	13	8.1%
Integration of multiple technologies	13	8.1%
Smart home technology for safety or environmental control	12	7.5%
Knowledge of approval/ funding process	12	7.5%
New technology to promote power mobility	11	6.8%
Knowledge of existing technology	10	6.2%
Training for users and providers	10	6.2%
Exoskeleton technology	9	5.6%
Electronic cognition devices	8	5.0%
Communication devices	7	4.3%
Programming of power wheelchairs	6	3.7%
Assistive robotics	6	3.7%
Alternate power sources	5	3.1%
Maintenance and repair	4	2.5%
Outcome measures, effectiveness research	4	2.5%
Virtual reality	4	2.5%
In your experience, have you encountered any facilitators that have made the process of obtaining new assistive technology easier or faster for people with disabilities?		
No Facilitators	40	24.8%
No Response/ Not Specified	20	12.4%
State/ federal programs and outside organizations	17	10.6%
Suppliers with expertise who have a streamlined process and wide selection of equipment	17	10.6%

Clinicians with expertise	15	9.3%
VA Specific resources	14	8.7%
Communication between clients and providers	13	8.1%
Funding	10	6.2%
Streamlined authorization process	7	4.3%
Access to providers	5	3.1%
Equipment trial and loan programs	4	2.5%
Online ordering	3	1.9%
Onsite Fabrication abilities (3D Printing)	2	1.2%
Motivation of providers	2	1.2%
DIY Options for equipment	1	0.6%
How can your current service delivery process be improved?		
Decreased time to acquire technology	31	19.3%
Streamline process for evaluations/authorizations	26	16.1%
No Response/ Not specified	26	16.1%
Better communication/ coordination between clients and providers	17	10.6%
Training of providers	17	10.6%
Funding	16	9.9%
Staffing	11	6.8%
Access to providers	10	6.2%
Reducing government funding regulations and barriers	10	6.2%
Client training	7	4.3%
Better processes for follow-up/ maintenance	6	3.7%
More equipment available for demo/ trials	6	3.7%
Better outcome measures	4	2.5%
Cannot be improved	2	1.2%
Onsite Fabrication abilities (3D Printing)	1	0.6%
More family involvement	1	0.6%
How could future research help you in your practice?		
Develop better or new assistive technology	46	28.6%
Compare or assess effectiveness of technology, especially effects on quality of life	40	24.8%
Generate evidence to support best practice and approval/ funding	35	21.7%
No response/ Not specified	29	18.0%
Demonstrate ways to improve access to technology	12	7.5%
Create more affordable technologies	10	6.2%
Develop training program to educate providers	8	5.0%
Create mobile health/wearable devices to improve social integration or ADLs	6	3.7%
Create more options/variety of devices	4	2.5%
Create device that captures data on technology use	1	0.6%
Research in adaptive sports	1	0.6%
Develop new Human machine interfaces for educational and vocational environments	1	0.6%

Develop new Algorithms	1	0.6%
Are there any other futuristic inventions that you feel could benefit your clients? Are there any other futuristic mobility inventions that you feel could benefit your clients?		
No response/ Not specified	278	
Portable mobility options (Travel power chair, portable ramp, chair loading)	9	5.6%
Assistive Robotics	7	4.3%
Obstacle climbing wheelchairs	6	3.7%
Exoskeletons	6	3.7%
Alternative power sources	4	2.5%
Human machine interfaces including Brain computer interfaces	3	1.9%
Tissue regeneration/ Synthetic tissues	2	1.2%
Are there any other areas where you feel technology could benefit your clients?		
No response/ Not specified	112	69.6%
Increase participation/social integration	19	11.8%
Improve activities/ADLS/ Independence/Safety	19	11.8%
Improve quality of care (care management, decreased caregiver burnout, support for family members)	4	2.5%
Increase options for various technologies	4	2.5%
No way for it to benefit clients	2	1.2%
Improve access to various environments	2	1.2%
Improve options to integrate multiple technologies	1	0.6%
Assist with care of the aging	1	0.6%
Improve internet access	1	0.6%

ADLS=Activities of Daily Living, DIY= "do it yourself"