Consumer Feedback to Steer the Future of Assistive Technology Research and Development: A Pilot Study

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Objective: The overall objective of this project was to identify consumers' opinions of their needs and wants related to assistive technology (AT) in a systematic and quantitative manner via a questionnaire that can be used to validate existing and establish new research priorities. **Methods:** This pilot study describes questionnaire development, online implementation, and revisions considered to the questionnaire in preparation for conducting a nationwide survey. Data from a sample ($N = 112$) are presented. The pilot study was critical to refine the questions and ensure that meaningful information was being collected. **Results:** It was identified that revisions were warranted to provide more structure and allow for consumers to prioritize AT research efforts. **Conclusion:** The questionnaire results, although positively in favor of many of the technologies presented, are inconclusive to identify generalizable research priorities, thus expansion to a nationwide population is warranted. **Key words:** assistive technology, disability, rehabilitation, spinal cord injury

According to the Centers for Disease Control and Prevention, 53 million adults – or 22% of the United States population – have a disability.¹ The most common functional disability type, reported by 1 in 8 adults (13%),¹ is a mobility limitation, defined as serious difficulty walking or climbing stairs. The use of assistive technology (AT) has the potential to compensate for a mobility impairment and improve overall function with activities and participation.² An AT device is defined as any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.³ Wheelchairs, walkers, and scooters are vital technologies that can compensate for mobility loss and are a critical part of maintaining or restoring a person's ability to move around.⁴ The wheelchair has been considered the most important therapeutic device used in rehabilitation.⁵ Approximately 2 million people in the United States currently depend on a wheelchair for day-to-day tasks.⁶ Veterans with

disabilities who use mobility assistive equipment such as wheelchairs or scooters exceed 250,000 in number, and this number continues to increase.⁷

AT, which includes advanced wheelchair design, a new generation of prosthetic devices, and voice recognition systems, provides more capabilities and allows for more independence for individuals with disabilities than was available in the past.⁸ Wheelchairs and scooters have the capability of improving function, independence, home and community integration, activity and participation,⁹⁻¹² comfort,^{13,14} and quality of life.^{13,15}

Despite the progress made with research on individual stages of disability and AT, there continues to be a need to evaluate the broader interaction of people and rehabilitation in the context of the environment.^{16,17} An editorial published in the *Journal of Rehabilitation Research & Development* identified advanced wheelchairs as an important theme in rehabilitation research, as there continues to be technical, social, and behavioral barriers to overcome.¹⁸ The US General Accounting Office has found that scientific

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advancement of AT, such as advances in wheelchair design, enhances the potential for people with disabilities to work.¹⁹

The 2016 President's Council of Advisors on Science and Technology (PCAST) Report discusses advances in wheelchair technology and calls for the VA and the Centers for Medicare & Medicaid Services to create a "road map" for wheelchair technology for the next decade.⁴ This report discusses the importance of gearing technology solutions to function, so that the technologies are relevant to a heterogeneous population, and recognizing that users have different needs and capabilities. Several themes emerged in the report, including the need for user-centered design, technology standards, and interdisciplinary and translational research into technologies that can support an aging population, such as home robotics, wheelchairs, technology for training and coaching, and home monitoring technologies. The report recommends that federal agencies support interdisciplinary and translational research in these areas.

Each year, the National Council on Disability provides a mandated report to the White House and Congress to offer recommendations on new and emerging issues affecting the lives of people with disabilities; in 2016, the report focused on technology.¹⁶ This report recognizes that our society has not evolved to the point where people with disabilities use technology to the extent needed to enjoy the rights of full citizenship, as recognized by the Constitution. There is an emphasis on how technology can contribute to the lives of people with disabilities in the areas of education, employment, health and well-being, and independent living and the need for emerging and innovative technologies to maximize daily functioning. Smith summarizes the different perspectives of stakeholders involved in the provision of AT^{20(p20)}:

Basic researchers want to understand foundational factors explaining why AT works and the related causes and effects. People with disabilities and service providers want to know which AT devices work and under what real-life conditions. Manufacturers and developers want to demonstrate that their products work. Funders want to know what functional improvements are made with which devices and services and at what costs. . . . People with disabilities want products that work.

Although numerous reports and publications describe the importance and scope of the need to continue to develop AT, a comprehensive means for researchers to identify consumer-driven research opportunities at a national level does not exist. The overall objective of this project is to identify consumers' opinions of their needs and wants related to AT in a systematic manner, which can be used to validate existing and establish new research priorities. A needs assessment has the potential to improve AT research and development, thus leading to the advancement of AT desired most by consumers. The specific aim of this subproject was to pilot the survey itself and modify any of the questions and/or available responses prior to conducting a large-scale nationwide assessment.

Methods

The pilot survey was developed by AT experts affiliated with the Human Engineering Research Laboratories (HERL) in Pittsburgh, Pennsylvania, and contributions were made by the VA Pittsburgh Healthcare System Veterans Engineering Resource Center (VERC) regarding content and format, thus establishing content validity. The survey was designed to collect basic demographics and information on AT usage and respond to 10 dichotomous (yes/no) questions regarding whether consumers felt various technologies would be useful. The technologies presented were focused on strategic areas currently under development at HERL or in the pipeline. Three additional questions asked participants to choose one of the options provided. One question asked, "If there were a technology to change one aspect of your life what would you change?" The other 2 questions asked participants to identify their preferred "futuristic invention" and "transportation or mobility related futuristic invention" that they would like to own. The last question was an open-ended text field to provide the opportunity for participants to share their ideas for technology development. This survey is intended to ascertain people's opinions of AT, and rigorous qualitative methods to further establish the reliability and validity of the questionnaire itself is therefore not warranted.

HERL conducted an exempt pilot study approved by the University of Pittsburgh's Human Research Protection's Office. The questionnaire was administered in REDCap (Research Electronic Data Capture), which is a secure, web-based application designed to optimize clinical trial data collection via an account sponsored by the Clinical Translational & Science Institute at the University of Pittsburgh. The questionnaire was designed to take less than 10 minutes to complete, and some questions were not asked based on prior responses (conditional branching). Participants had the option to complete the study via the web independently or contact a study coordinator to complete the questionnaire by phone. The landing page provided a brief description of the project and addressed the required elements of informed consent. The questionnaire was anonymous, and therefore no identifiable personal health information was collected. Eligibility criteria were age 18 years or older and use of mobility-related assistive technology.

The active recruitment period for this study was a 3-month period (June-August 2016) with a target goal of 100 participants. A convenience sample was recruited via the Assistive Technology Research Registry developed by the Department of Rehabilitation Sciences & Technology of the University of Pittsburgh. The registry research coordinator distributed the approved study recruitment materials to registry participants, all of whom had previously consented to be contacted about research opportunities related to AT. Potential participants were directed to access the web link directly or to contact a study coordinator.

Results

Of the 244 registry participants who were sent the flyer, 113 people responded and 112 people were enrolled into this research study between June and August of 2016. One person declined to participate (reason unknown) and did not answer any of the questions asked. Forty-two females (37.5%) and 70 males (62.5%) responded, representing 25 unique states in suburban ($n = 59$; 52.7%), urban ($n = 37$; 33%), and rural ($n = 16$; 14.3%) environments. Most participants ($n = 82$; 73.2%) were over 50 years of age. Thirty-three (29.5%) were Veterans, 30 of whom reported receiving AT from the VA.

The cohort was comprised primarily of Caucasians ($n = 95$; 84.8%) and African Americans ($n = 12$; 10.7%).

In this convenience sample, a large majority of participants ($n = 61$; 54.5%) were diagnosed with a spinal cord injury (SCI). Other medical conditions represented were multiple sclerosis ($n = 13$; 11.6%), muscular dystrophy ($n = 5$; 4.5%), spina bifida ($n = 5$; 4.5%), traumatic brain injury ($n = 4$; 3.6%), and upper or lower extremity amputation ($n = 4$; 3.6%). Four people reported dual diagnosis of SCI and TBI ($n = 2$), MS ($n = 1$), and amputation ($n = 1$). An additional 21.4% ($n = 24$) fell into other categories with an $n \leq 3$ or the disability was not specified (**Figure 1**).

Most participants (82%; $n = 93$) reported that they had used AT for more than 5 years. Participants had the option to "check all that apply" and reported using the following mobility-related technologies: manual wheelchairs ($n = 67$; 60%), power wheelchairs ($n = 60$; 54%), scooters ($n = 11$; 10%), cane/crutch/walkers ($n = 20$, 17.9%), lower extremity orthoses ($n = 10$; 8.9%), lower extremity prostheses ($n = 2$), and other ($n = 13$; 11.6%).

Figure 1. The types of disabilities reported by consumers surveyed. SCI = spinal cord injury; MS = multiple sclerosis; MD = muscular dystrophy; TBI = traumatic brain injury; SB = spinal bifida; AMP = amputation.

Table 1 demonstrates the survey responses for all participants (ALL), manual wheelchair users (MWC), and powered mobility device users (PMD), which includes both power wheelchair and scooter users. Many participants reported using more than one device, and 27 of the total ($N = 112$) participants reported using both an MWC and a PMD and therefore were included in both of these groups. Within the PMD ($n = 67$) group, 4 participants reported using both a PWC and a scooter, and their information was only included once. For 8 out of the 10 dichotomous questions, the responses were positive, ranging from 67% to 96.4% among all participants. Among the 67 power wheelchair and scooter users surveyed, 23.9% of participants were interested in brain implants for improving their driving ability, and 49.3% of participants were interested in self-driving power wheelchairs.

The ability to live without the need for a caregiver or with less assistance was the top choice at 42% ($n = 47$). When participants were asked to select one aspect of their life they would like to change with the use of technology, the ability to meet all personal mobility needs and the ability to travel freely were chosen by 25.0% ($n = 28$) and 23.2% ($n = 26$), respectively. Smart home technology with the integration of a voice control interface was chosen by 39.3% ($n = 44$), and new wheelchair power sources (eg, longer lasting batteries, fuel cells, combustibles, pressurized gases) was chosen by 33.9% ($n = 38$); these were both leading choices when consumers were asked what futuristic inventions they would like to own (**Figures 2-4**).

A myriad of responses were received when people were asked what they would like to see improved on their assistive devices. An overview of the

Table 1. Survey responses all participants (ALL), manual wheelchair users (MWC), and powered mobility device users (PMD)

Questions	Yes <i>n</i> (%)			No <i>n</i> (%)		
	ALL	MWC	PMD	ALL	MWC	PMD
In the future, do you think robots will be commonplace for people who use AT to perform activities of daily living?	85 (75.9)	51 (76.1)	53 (79.1)	27 (24.1)	16 (23.9)	14 (20.9)
Do you think people who need a custom part or component for their assistive device should be able to have it made for them in the clinic or laboratory (ie, 3D printed) within a few days?	108 (96.4)	64 (95.5)	64 (95.5)	4 (3.6)	3 (4.5)	3 (4.5)
Do you think that people who use wheelchairs should be able to take a wheelchair test drive using virtual reality, which would be like a wheelchair driving game?	88 (78.6)	49 (73.1)	53 (79.1)	24 (21.4)	18 (26.9)	14 (20.9)
If you needed an electric powered wheelchair, would you be willing to get a brain implant to be able to improve your driving ability?	28 (25.0)	17 (25.3)	16 (23.9)	84 (75.0)	50 (74.6)	51 (76.1)
If you needed an electric powered wheelchair, would you use one that was capable of driving itself?	51 (45.5)	31 (46.3)	33 (49.3)	61 (54.5)	36 (53.7)	34 (50.7)
Would you use a robot or automated device to prepare your meals, clean your home, brush your teeth, or bathe?	76 (67.9)	42 (62.7)	52 (77.6)	36 (32.1)	25 (37.3)	15 (22.4)
Would you wear a device or devices that constantly show you information about your health that you could share with your healthcare team?	75 (67.0)	49 (73.1)	45 (67.2)	37 (33.0)	18 (26.9)	22 (32.8)
Would you use a device or devices that told you when to have your assistive device maintained?	93 (83.0)	54 (80.6)	50 (74.6)	19 (17.0)	13 (19.4)	10 (14.9)
If you needed a wheelchair, would you use powered seating functions and/or cushions that adjusted automatically to reduce your risk of injury or illness?	104 (92.9)	63 (94.0)	62 (92.5)	8 (7.1)	4 (6.0)	5 (7.5)
If you used a wheelchair, would you use a device to allow you to transfer yourself to and from your wheelchair without assistance from another person?	103 (92.0)	61 (91.0)	64 (95.5)	9 (8.0)	6 (9.0)	3 (4.5)

Note: AT = assistive technology; 3D = three-dimensional.

Figure 2. Respondents responses to the question: If there were a technology to change one aspect of your life what would you change?

Figure 3. Respondents responses to the question: If there were one futuristic invention that you could own, what would it be?

Figure 4. Respondents responses to the question: If there were one futuristic transportation or mobility invention that you could own, what would it be?

themes identified from the open-ended responses included (1) new technologies not commercially available, (2) modifications to the design and/or function of commercially available technologies, (3) suggestions for improvements in the provision of and maintenance of technology, (4) improved comfort, and (5) affordability and/or access to AT.

Discussion

HERL's research routinely includes consumers in the evaluation of prototype AT devices in all phases of development.²¹⁻²⁴ These evaluations generally include in-person focus groups to generate ideas about how to improve future prototype iterations. The consumer feedback received on specific technologies has proven valuable in advancing the development of those products. We believe a broader, nationwide survey allows us the opportunity to learn more about the needs of people who use AT to help direct HERL's research and the research of others by focusing on user-stated needs and goals. Surveying a nationwide sample of people who use AT will provide an avenue

for consumers to provide feedback on whether the technologies we perceive as important are aligned with consumers' priorities for AT devices.

Most responses were positive and in favor of using technologies for improving mobility-related activities at home, work/school, and in the community. Technology to reduce the need for caregiver assistance was identified as a potential priority. This concept is supported by prior work in developing assistive robots and robotic tools that address both mobility and manipulation of objects. Such work identified that individuals with disabilities prefer an option to perform an activity independently with the use of technology, even if the task at hand takes increased time and/or effort.²⁵ Smart home technology with a voice-control interface was also well received, which is unsurprising given the global trend toward voice-controlled technologies and home automation systems.²⁶ Alternative power sources were also among the futuristic technologies chosen by consumers. Battery maintenance and reliability are critical to the operation of an electric-powered wheelchair, and frequent failures limit mobility resulting in a reduced quality of life.²⁷

The open-ended questionnaire responses were diverse, but they mostly related to existing technologies. AT development is often built upon existing AT rather than representing completely novel technologies. In 2012, Cowan et al reported trends in AT were based on 3 categories that demonstrate this point: (1) improving AT mechanics, (2) improving the user-technology physical interface, and (3) sharing control between the user and the technology.²⁸ We anticipate building upon this framework to prioritize our research efforts to enhance existing and establish new technology development important to consumers and to reduce the incidence of abandonment. Mobility devices have been reported to be abandoned more than any other devices. Factors associated with AT abandonment include lack of client-centered care in the provision process, ease of device procurement, poor device performance, and a change in the user needs or priorities.²⁹ In addition to the technology advancement itself, consideration will be given to the AT service delivery process as established by RESNA.³⁰

Implementation of the pilot study was necessary to identify revisions to the survey before expansion to a large-scale evaluation. For example, it was found that more information was needed on type of disability, as the level of SCI is inversely associated with a person's functional capability. This may significantly impact a respondent's vision of what technology is important. For example, it is expected that only those with higher level lesions would be interested in brain computer interfaces. We plan to collect more discrete disability information to further understand the implications of our results.

In addition to minor changes to improve clarity and remove technical jargon, the survey has been modified to provide more structure with the intent to ascertain more meaningful responses from participants. For example, the dichotomous questions do not provide a means to prioritize topics and future research efforts. Therefore, the survey to be used to collect a nationwide data sample has been structured and categorized based on 4 strategic areas: (1) wearable or smart technologies, (2) human machine interfaces, (3) smart wheelchair design, and (4) alternative power sources. These questions now utilize a Likert scale for participants to rank each technology's importance and how each ranks in comparison to other technologies.

There are a few limitations to this research study. A key limitation of any survey is that it polls on what the organization's perception of value to the consumer is, rather than what the consumer actually values.³¹ Our approach to address this concern is to have an open field for individuals to share their ideas and opinions on technology development. Given the nature of a pilot study, another limitation is the small sample size ($N = 112$). When recruiting a nationwide sample, greater emphasis will be placed on enrolling a diverse population (ie, age, race, gender, Veteran status, etc). Although there are provisions (ie, paper/pencil, telephone) for enrolling people who are not technologically savvy and/or do not have internet access, a plan needs to be developed to effectively disseminate this information to this subset of the population. A second parallel initiative is to survey rehabilitation professionals involved in the AT service delivery process to better understand potential opportunity for improvement to the provision of AT.

Conclusions

Rehabilitation research continues to be competitive with limited allocation of federal funds in the field of disability research.¹⁶ It is critical that AT research and development have a pathway to prioritize efforts and continue to be proactive and constantly innovative to capture the changing requirements of consumer needs and wants over time. The pilot questionnaire results, although positively in favor of many of the technologies presented, are inconclusive to identify generalizable research priorities, thus expansion to a nationwide population is warranted. We expect this national survey of consumers will greatly assist in determining consumer opinions and serve as a valuable tool for AT stakeholders. Specifically, we anticipate that this feedback will be invaluable to steer research and to facilitate translational research directly impacting clinical practice and stimulate further research and development among the rehabilitation research community at large.

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