BARRIERS AND FACILITATORS TO ADOPTING A CLINICIAN DASHBOARD SUPPORTING UPPER LIMB MYOELECTRIC-CONTROLLED PROSTHESES

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ABSTRACT

Integrating the use of myoelectric-controlled upper limb prostheses into daily life can be complex. A dashboard reporting data and insights on real-world prosthetic use and performance could improve information available for clinicians to inform care, as well as communication among end-users (prosthesis wearers) and their clinical care providers. The purpose of this project is to blend implementation science and user-centered design methodology to inform the development and refinement of a dashboard that improves efficiency and supports clinical decision-making related to prosthesis training and clinical support. We used a mixed methods approach with a stakeholder advisory panel, semi-structured interviews, and surveys from occupational therapists, prosthetists, end-users, and other technology stakeholders. Interviews reveal clinician and end-user concern related to design, adaptability of the platform to meet the needs, capability, and opportunity of the clinicians, as well as to address motivation of end-users. The dashboard may improve communication but also could create work infrastructure challenges that make the dashboard have a relative disadvantage over other forms of communication. Surveys suggest good usability, acceptability, appropriateness, and feasibility. However, occupational therapists, the primary target population, have the lowest perceived usability and feasibility scores at the current point of dashboard design and conceptualization. In summary, mixed methods data from clinicians and prosthesis wearers provides valuable information that can drive improved development of a dashboard.

INTRODUCTION

Upper limb loss/absence is a significant cause of disability that limits the ability to perform routine daily activities. While prosthetic devices can help restore function of the lost limb, learning to fully incorporate the prosthesis into daily life is a substantial hurdle for many wearers [1]. There are many barriers experienced by people with limb loss/absence, as well as the clinicians (occupational therapists and prosthetists) who help them train to use new prostheses effectively. Improving the quality of prosthesis training is crucial for wearers to achieve optimal function and long-term use.

Unfortunately, insufficient tools exist to inform clinicians about daily prosthesis use and performance outside the clinic. This lack of information makes it difficult for clinicians to make informed decisions to be able to administer effective treatments to improve real-world performance. Consequently, clinicians are “flying blind” once wearers leave the clinic. A clinician-facing dashboard (i.e., a web-based software application) that provides them access to objective, real-world measures and actionable data insights and suggestions could support their intuition and facilitate their decision-making to improve clinical efficiency, and ultimately, rehabilitation outcomes.

Myoelectric-controlled prostheses add technical and clinical complexity [2], which can be a barrier to rehabilitation technology uptake [3]. Many technology developers are comfortable with technology including sensors and software, but prosthesis wearers and clinicians may be less comfortable with these technological advancements. Creating systems, such as a clinician dashboard, that could improve the comfort and competence of clinical and community end-users is essential for the sustained success and uptake of myoelectric controlled devices.

This mixed method study uses implementation science and user-centered design methodology to better understand and address barriers to myoelectric-controlled upper limb prostheses, as well as to develop a clinician dashboard for occupational therapists treating individuals with upper limb loss. First, we engaged a multidisciplinary advisory board to enable partnership between the industry sponsor, clinical and community advisors. Second, we conducted qualitative interviews with occupational therapists, prosthetists, upper limb myoelectric prosthesis wearers, and other

technology stakeholders. Third, we administered a survey to better understand features that would be valued by interview participants, as well as key pre-implementation metrics of usability, feasibility, acceptability, and appropriateness of the dashboard prototype . Our overall hypothesis is that acceptability and future uptake of the dashboard will be enhanced by our application of these user-centered methods.

METHODS

Mixed Methods Design and Multidisciplinary Advisory Board

A convergent parallel mixed methods approach is used including insight from a multidisciplinary advisory board, interviews, and surveys. The advisory board includes five industry representatives, two upper limb myoelectric control wearers, as well as one occupational therapist and one prosthetist on the research team. Key advisory board roles are to provide input on recruitment, interview guides, and data interpretation to ensure that the data is integrated through the lens of practical user experience (clinician and community member). As the results are shared with the advisory board, the co-investigators (MR, ZW) lead collaborative discussions to triangulate data using a convergent parallel approach. Forthcoming think-aloud sessions will guide dashboard refinements.

Interviews

Qualitative research methods include interviewing occupational therapists, prosthetists, upper limb myoelectric control wearers, and other technology stakeholders. Other technology stakeholders could be individuals that work for industry in research and development, sales, or health policy. The goal was at least 12 clinicians and 12 other end-users (prosthesis wearers), as 12 has been shown to be sufficient to reach saturation of themes [4]. Participants are interviewed by someone trained in semi-structured interview techniques who has the same background (*e.g.* occupational therapist (KT), prosthetist (LM), a non-clinician interviews lay/end-user participants (PA)). Informed consent was obtained from each participant under the guidelines and approval of Northwestern University IRB (ID#: STU00219595) prior to study participation.

Semi-structured interviews take 20-40 minutes. They include an initial series of questions about themselves (demographics), their relevant experiences with prostheses, as well as barriers and facilitators to prosthetics rehabilitation. Then all participants watch an approximately 7-minute-long video describing the purpose of the Clinician Dashboard with some visuals suggesting at features that may be included in the Dashboard. Then participants answer another series of semi-structured questions about how they could use the Dashboard, as well as features they would want to see. Probes are used to ask for clarification and additional information when needed.

Interviews are conducted over Zoom. They are audio recorded, transcribed professionally, de-identified, and uploaded into qualitative analysis software (Dedoose, 9.2.005, Los Angeles, CA, USA). Transcripts are coded using a combination of deductive and inductive codes. Coders first use directed content analysis [5] to assign codes related to barriers and facilitators of future implementation based on the constructs defined in the Consolidated Framework for Implementation Research version 2.0 (CFIR), thereby maximizing generalizability for future studies [6]. Each coder (MR, PA, KT, LM) brings unique experience based on their research and clinical backgrounds to share during coding discussions. Each transcript is coded by two raters, blind to the other's codes. Codes are then compared. An additional coder assists with developing consensus as needed when there are discrepancies between coders.

Surveys

Surveys were sent to each interview participants following completion of the interview. Surveys include items selected from previously validated surveys of usability, feasibility, acceptability, and appropriateness. Open ended questions are available but not required to be completed soliciting additional feedback or information. Usability is measured using the System Usability Scale (SUS) [7]. Research indicate that scores over 68% indicates good usability [8]. Participants also complete the Feasibility of Intervention Measure (FIM), Acceptability of Intervention Measure (AIM), and Intervention Appropriateness Measure (IAM) [9]. During survey pretesting with the Advisory Board, surveys were modified to reduce the number of questions and overall study burden. The usability survey was modified to include 6 of 10 questions (scored 0-4). Two of four possible questions were asked about acceptability and feasibility, and only one of four questions on appropriateness was asked (scored 1-5). Survey data is described with sum or means scores based on the convention for that survey, using descriptive statistics.

RESULTS

Multidisciplinary Advisory Board

The advisory board has met 7 times an average of 4 ± 1 weeks apart. Key insights added by the advisory board include the importance of gaining insight from other non-clinician technology stakeholders, recruitment input, and advice on interpretation of suggestions for clinician dashboard design and features.

Interviews and Surveys

At approximately 80% of our recruitment goal, 29 interviews have been completed, including 18 clinicians and 11 non-clinicians (8 individuals with upper limb loss). Table 1 describes the participant demographics and experience within their role and myoelectric control use. 100% of current participants are white and nonhispanic.

Table 1: Participant characteristics

	Occupational Therapist	**Prosthetist**	**End-User**	**Technology Stakeholder**
Number of participants	9	9	8	3
Age (years ± std)	47.6 ± 12.17	46.5 ± 16.8	43.8 ± 12.6	42.3 ± 8.6
Male, n (%) Female, n (%)	0 (0%) 9 (100%)	8 (89%) 1 (11%)	4 (50%) 4 (50%)	1 (33%) 2 (67%)
Experience (# of years as a clinician or with upper-limb loss)	23.4 ± 12.3	26.0 ± 7.4	15.7 ± 13.3	
Congenital limb loss, n (%) Traumatic/Acquired, n (%)			2 (25%) 6 (75%)	
Duration of time training people with upper extremity limb-loss (years)	11.3 ± 7.1	23.3 ± 8.2		
Duration of time working with pattern recognition myoelectric prostheses (years)	6.2 ± 3.3	9.6 ± 3.4	4.4 ± 3.3	8.3 ± 2.4

Barriers and facilitators related to novel technologies were coded to CFIR. Related to the dashboard itself, simple design, adaptability for different patients, and providing relative advantage over other means of data sharing and communication were key considerations. Interviewees commented on the needs, capabilities, and opportunities of the occupational therapists who would be using the dashboard. In contrast, the needs of the end-users were less commonly discussed. Instead, end-user motivators, capability, and opportunity were considered important related to potential barriers to the adoption. Related to organizations that would be adopting the Dashboard (inner setting and processes), interviews indicated the importance of considering communication, engaging users, as well as work infrastructure. Outside of a single organization (outer setting), the dashboard was perceived as potentially facilitating partnerships and connections. However, financing myoelectric controlled devices, health policy and legal ramifications were perceived to be barriers. Clinicians suggested improvements to adaptability and data presentation, while end-users suggested a variety of games and forums to increase communication and connection.

The survey results are described in Table 2. All acceptability and appropriateness values were greater than 80% of the possible score, indicating good pre-implementation potential. However, occupational therapists provided relatively lower scores for usability and feasibility. For this clinician dashboard target population, the average usability score of 40.0 of 60 represents 66.7% of the total possible available score, which is currently below the 68% usability target set by the developers of the System Usability Scale.

Table 2: Pre-implementation scores for the Clinician Dashboard

Construct (Score Type, Range)	**Usability (sum, 0-60)**	**Acceptability (average, 1-5)**	**Feasibility (average, 1-5)**	**Appropriateness (average, 1-5)**
Occupational Therapists (n=9)	40.0 ± 5.0	4.4 ± 0.6	3.9 ± 0.5	4.4 ± 0.5
Prosthetists (n=9)	44.7 ± 8.0	4.2 ± 0.5	4.2 ± 0.6	4.2 ± 0.4
End-Users (n=8)	45.9 ± 7.1	4.4 ± 0.6	4.6 ± 0.4	4.1 ± 0.4
Tech Stakeholders (n=3)	45.8 ± 8.2	5.0 ± 0	5.0 ± 0	5.0 ± 0

DISCUSSION

This work emphasizes the importance of clinical and end-user engagement in the research and development process for novel technologies. We use an innovative approach to combine implementation research methodology and user-centered design. The data highlights the use of pre-implementation outcomes such as usability, feasibility, acceptability, and adoption. Achieving high scores in these domains is thought to facilitate future adoption of technology.

First, our qualitative pre-implementation data corroborate prior research on uptake of novel technologies. Our past research indicates that ease of use, time to set up, and relative advantage are some of the most important barriers [3]. Similarly, we heard in our interviews that simple design was valued and clinicians expressed concern related to the relative advantage of information in the dashboard compared to their current clinical techniques and workflows [3]. The importance of adapting the dashboard to different clinical needs and patient motivators, such as communication preferences, are novel.

Limitations of this research thus far includes the lack of heterogeneity of participants. High proportions of white prosthesis wearers may be indicative of barriers to technology access and cost-related barriers for myoelectric control in underrepresented populations. Additionally, high proportions of end-users with traumatic limb loss may reflect greater prosthesis coverage of myoelectric controlled devices by workers compensation insurance. We are actively recruiting additional interview participants in underrepresented groups.

The interviews and surveys with key stakeholders are the first stage of this research which are being conducted in parallel with development of a dashboard prototype. Occupational therapists who participate in the interviews will be invited back to participate in think-aloud sessions. Think-aloud sessions are a key component of user-centered design that allow the participant to interact with a prototype of the new tool [10]. In these sessions, participants are typically asked to “think-aloud” everything that comes to mind as they navigate through the dashboard prototype and to complete a series of tasks simulating how they might use the dashboard in the real-world. Participants will be asked open-ended questions to reflect on their experience and provide feedback. We plan to complete 3-4 think-aloud sessions between iterative rounds of dashboard refinement and will gather usability, feasibility, acceptability, and appropriateness measures with a goal of reaching 68% usability. The final stage of this work will be real-world implementation where clinicians will use the dashboard in a clinical setting with new myoelectric prosthesis wearers.

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