Evaluate the usability and barriers to use of WheelTrak technology for preventative wheelchair maintenance

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INTRODUCTION

According to the World Health Organization, older adults will be using two or more assistive devices by 2030 to overcome barriers and enable full and equal participation in society [1]. Wheelchairs are assistive devices that serve as a primary means of mobility and independence for the elderly and are linked to improved well-being and delaying the need for long-term care. Unfortunately, while wheelchairs play a significant role in the lives of older adults, they are known to break down frequently. More than 50% community-dwelling wheelchair users experience breakdowns with wheelchair casters, rear wheels, brakes, frames and seating systems within 6 months of wheelchair use [2–7]. Overall, breakdowns are associated with physical, psychological, social, and economic ramifications for elderly wheelchair users, increasing public health and personal burden.

Research evidence and the World Health Organization's (WHO) Guidelines on the provision of manual wheelchairs recommend routine wheelchair maintenance to avoid breakdowns [8]–[10]. For instance, in aircrafts, maintenance is scheduled based on onboard condition monitoring systems and in automobiles, the odometer mileage reading directs the change of engine oil and oil filter. Unfortunately, no such usage or condition monitoring applications exist for wheelchairs that can inform users, caregivers, and service providers of preventative maintenance. Fortunately, the widespread availability of low-cost activity monitoring tools, such as sensors included in smartphones, offer an opportunity to track real-time wheelchair usage characteristics and guide maintenance. We are developing a smartphone application called WheelTrak (see Figure 1) that pairs with a wheelchair datalogger for measuring wheelchair travel distance and shocks and alerts users when maintenance is due.

To further support the design of WheelTrak technology, participatory action research was utilized through interviewing several stakeholders, including wheelchair users (n=21), providers (n=5), a technician trainer (n=1), testing personnel (n=1), manufacturers (n=2), and insurance providers (n=2) through the University of Pittsburgh Innovation Institute's technology transfer programs. Key findings related to the translational potential of WheelTrak were positive. Users consistently stated they would like to maintain their quality of life and avoid breakdowns and subsequent hassles with provider repairs. Users appreciated the development of preventative maintenance technology. They would like to see usage parameters for weekly and monthly periods and report wheelchair failures to providers. Users would like to inform providers of upcoming maintenance or service repairs once the app sends a notification. We developed the fully functional prototype (see Figure 1) of the smartphone app that connects with the datalogger based on user feedback. This study aims to gather qualitative and quantitative data on older adult's interaction experience with WheelTrak application and perceived difficulties and potential compliance with maintenance practices.

METHODS

Design

Semi-structured interviews were conducted with elderly wheelchair and scooter users to perform interaction testing with the WheelTrak app. Through these interviews, qualitative data on user experience with WheelTrak application and perceived difficulties and potential compliance with WheelTrak-enabled preventative maintenance practices were explored. In addition, a validated tool was administered to collect quantitative data during the interviews.

Participants

Inclusion criteria for participants were as follows: 1) 60 years or older and 2) had a manual wheelchair, power wheelchair, or scooter. Participants living in the Pittsburgh area were recruited through the University of Pittsburgh Pepper Center Registry.

Procedure

The authors developed a set of interview questions for older adults based on earlier user interaction experiences related to wheelchair breakdowns, repairs and technology choices. Before the interview took place, recruitment, screening, interview availability, and location were determined. All but one interview took place at the older adult's place of residence. During the interviews participants were asked about their experiences with wheelchair failure,

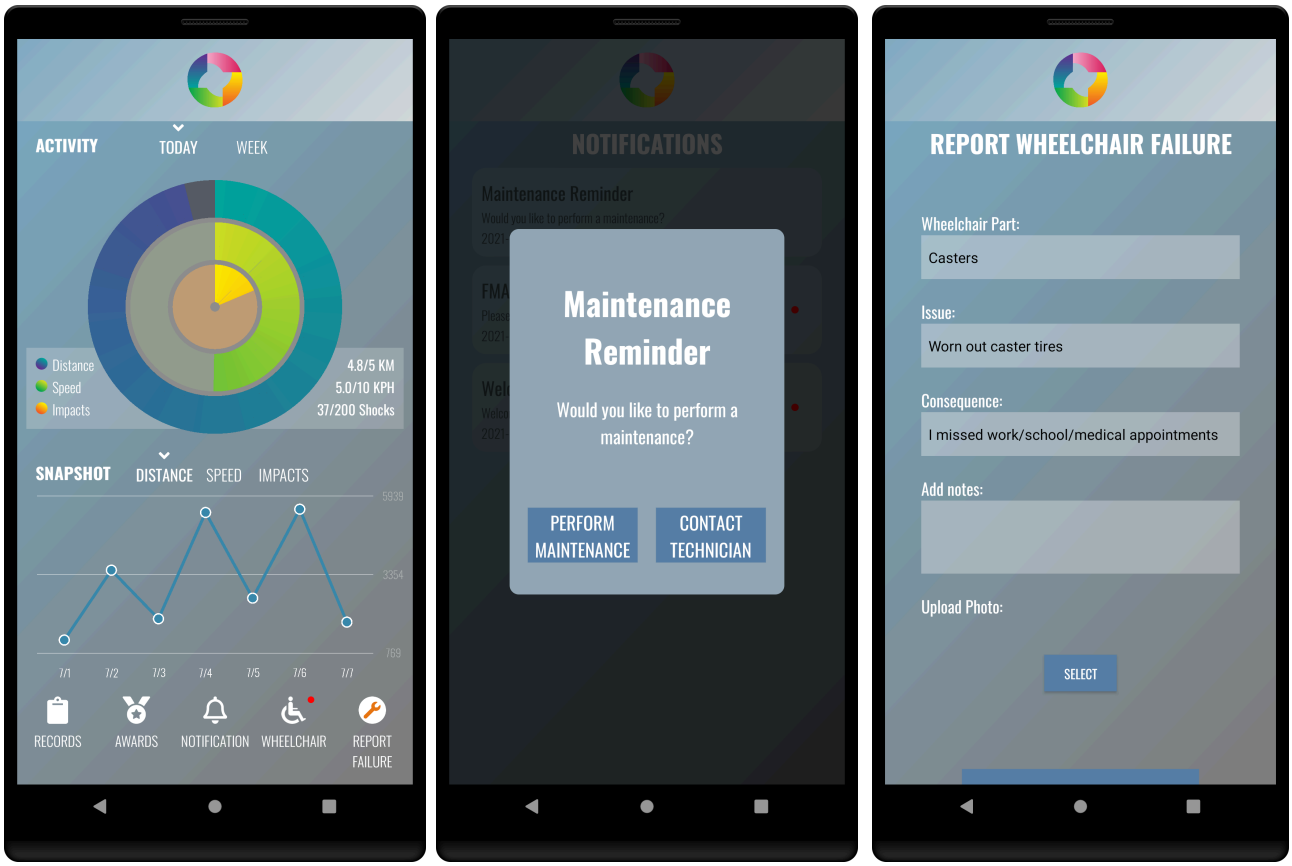

Figure 1. WheelTrak main screen (left), maintenance notification (center), and failure report screen (right)

repairing their wheelchair, performing wheelchair maintenance, restrictions to maintenance, and technology use. Then the interviewer demonstrated the WheelTrak application and/or allowed the participant to use the app. Participants were asked questions regarding their impressions of the application, if it would fit into their lifestyle, how often they use it, and other questions related to specific application pages. Lastly, participants completed the System Usability Scale (SUS), which is a self-report instrument widely used to assess users' satisfaction of use, internal beliefs, motivation, attitudes and intentions towards technology [11]–[13].

Analysis

To ensure accurate interpretation of qualitative data, interviews were audio-recorded and then transcribed verbatim. Transcripts were de-identified. A systematic approach to qualitative thematic analysis was used to analyze interview data and identify and develop codes and themes using NVivio 12 Plus. Open, axial, and selective coding strategies were used which enabled the researchers to constantly interact with and compare and reduce the data [14]. Common concepts and themes expressed were given a descriptive code [15].

Participants' total SUS score was calculated along with the average SUS score of all participants. A SUS score of 80 out of 100 means users are impressed with the application and would recommend it to others. A SUS score around 68 is an average usability rating indicating room for improvement and below 51 means a lack of usability and need for improvement [13].

RESULTS

Ten older adults were interviewed in this study. Six overarching themes were identified through the qualitative data analysis as follows:

1) Barriers to maintenance: 100% of the participants in the study stated they were not trained in wheelchair or scooter maintenance, alluding to a collective lack of knowledge in this area. Also, participants stated low confidence in this area and were fearful of carrying out maintenance. Additional barriers noted were participants' health issues, including vision problems and lack of strength and dexterity in their hands, making manipulating objects difficult. Three participants stated they would ask someone to do maintenance for them.

2) Facilitators to maintenance: 100% of the participants stated the importance of routine maintenance. Furthermore, 40% of participants stated they routinely clean their wheelchairs and check for any problems. Participants expressed the desire to be educated on this maintenance, as their mobility device is a key piece of equipment that enables them to carry out daily activities. Participants suggested using YouTube videos, in-person training, and other educational methods to facilitate this learning.

3) Hassles with failures and repairs: The most common parts that failed and were replaced include brakes, wheels, and tires. Other failures participants experienced were with the armrests, connection/battery, grip handles, back of the wheelchair, front struts, and their cushion. Some participants suffered consequences due to these failures. P02 could not go grocery shopping that day since their scooter would not move off the transportation bus. P03 and P10 stated no consequences due to failure but they are aware that their brakes are not secure and may slip, causing them to be more cautious when standing up. Most repairs were completed by participants' wheelchair service provider or the Veteran Affairs. They were timely, although P06 and P07 stated the longest repair time between two weeks to two months.

4) Technology use: 80% of the participants stated the use of a smartphone and or iPad. The most significant barrier noted regarding charging these devices was remembering to charge them. There were minimum challenges stated with using this technology. All participants indicated that they keep their phones on them or close by. These places include their bag, wheelchair pocket, pants pocket, rollator basket, and kitchen or bedroom. Two participants indicated they kept their phones on them if they were to fall.

5) Facilitators of WheelTrak: 50% of the participants stated they would use the application once every day. All participants indicated the importance of wheelchair maintenance and stated the app "…serves it purpose". Additionally, four participants stated the application was helpful and well designed, and five participants stated WheelTrak was easy to use. Lastly, the majority of participants stated the application would fit into their lifestyle except for three participants who stated they are not active enough to use WheelTrak.

6) WheelTrak app improvements: The interaction testing assisted us in locating the avenues for design improvements in the app. These changes include:

    a. Make text easy to read: increasing the text size, changing the contrast and font.

    b. Increasing icon sizes at the bottom of the main page enables easier navigation, especially for someone with shaky hands.

    c. Participants stated the report failure page, wheelchair page, and notifications page to be most important. Convenience was a common code amongst these pages, due to provider information being accessible.

    d. When asked how participants would be like to be notified that maintenance was upcoming or due, there were a variety of preferences across the board. These included a phone call, text message, or email. The majority of participants did not want their children or spouses to be notified of maintenance, increasing care burden. The majority of participants liked the idea of sending the maintenance notification directly to the service provider.

    e. Lastly, participants stated the maintenance awards page to be unnecessary. The graphs and charts on the home page were challenging to read and understand. However, they may appeal to younger wheelchair users as per the participants.

The average SUS score was 60.25, indicating room for improvement of WheelTrak usability. The highest total SUS score was 90, and the lowest score was 35. This participant was unfamiliar with using a smartphone, causing extreme difficulty using WheelTrak, contributing to this low score.

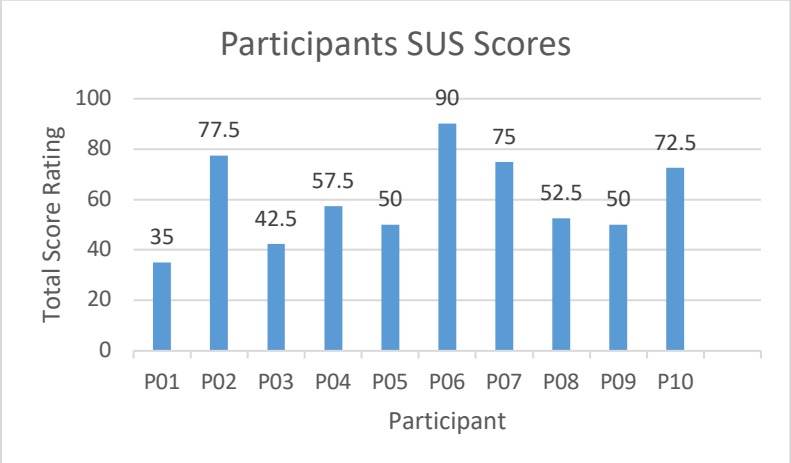

Figure 2. SUS Scores for WheelTrak app

DISCUSSION

Most wheelchair users are unable to perform maintenance due to lack of knowledge, training and ability. There is a need to educate the elderly population on wheelchair maintenance as well alert them when maintenance is upcoming or due. WheelTrak aims to empower the wheelchair user population and take charge of maintenance. Most elderly individuals are capable of using their smartphone and were able to use the WheelTrak app. In this study, older adult wheelchair and scooter users identified the importance of carrying out preventative wheelchair maintenance and indicated they would utilize the application at least once a week. The barriers and facilitators found in this study indicate the need for capacity building for wheelchair maintenance training. We hope using a low-cost tool like WheelTrak can assist in training adoption. Qualitative and quantitative feedback collected in the study provides directions to the authors to redesign the WheelTrak app for better functionality and display. Some design changes were unique to the older population owing to reduced ability. The authors plan to revise the app and conduct additional usability testing. This study was limited to older adults, and future app testing should include other adults using wheelchairs and other assistive devices. The app features will be evaluated in another study conducted by the authors on development of the preventative maintenance model with wheelchair usage data.

CONCLUSIONS

The WheelTrak preventative maintenance application has been identified as a tool that the elderly would use to report wheelchair failures, contract their service provider, and notify them if maintenance was upcoming or due. This study informed the research team of improvements to the application, making it easier to use and adopt by elderly wheelchair users.

REFERENCES

[1] World Health Organization. Assistive technology. https://www.who.int/news-room/fact-sheets/detail/assistive-technology. Published 2018.

[2] Kirby RL, Ackroyd-Stolarz SA, Brown MG, Kirkland SA, MacLeod DA. Wheelchair-related accidents caused by tips and falls among noninstitutionalized users of manually propelled wheelchairs in Nova Scotia. Am J Phys Med Rehabil. 1994;73(5):319-330. doi:10.1097/00002060-199409000-00004.

[3] Gaal RP, Rebholtz N, Hotchkiss RD, Pfaelzer PF. Wheelchair rider injuries: causes and consequences for wheelchair design and selection. *J Rehabil Res Dev*. 1997;34(1):58-71.

[4] Toro M, Worobey L, Boninger ML, Cooper RA, Pearlman J. Type and Frequency of Reported Wheelchair Repairs and Related Adverse Consequences Among People With Spinal Cord Injury. *Arch Phys Med Rehabil*. 2016;97(10):1753-1760. doi:10.1016/J.APMR.2016.03.032.

[5] Calder CJ, Kirby RL. Fatal wheelchair-related accidents in the United States. *Am J Phys Med Rehabil*. 1990;69(4):184-190

[6] Kirby RL, Ackroyd-Stolarz SA. Wheelchair safety--adverse reports to the United States Food and Drug Administration. *Am J Phys Med Rehabil*. 1995;74(4):308-312.

[7] Hogaboom NS, Worobey LA, Houlihan B V, Heinemann AW, Boninger ML. Wheelchair breakdowns are associated with pain, pressure injuries, rehospitalization, and self-perceived health in full-time wheelchair users with spinal cord injury. *Arch Phys Med Rehabil*. 2018. doi:10.1016/j.apmr.2018.04.002.

[8] Borg J, Khasnabis C. *Guidelines on the Provision of Manual Wheelchairs in Less-Resourced Settings*. World Health Organization; 2008.

[9] Chen W-Y, Jang Y, Wang J-D, et al. Wheelchair-Related Accidents: Relationship With Wheelchair-Using Behavior in Active Community Wheelchair Users. *Arch Phys Med Rehabil*. 2011;92(6):892-898. doi:10.1016/j.apmr.2011.01.008.

[10] Fitzgerald SG, Collins DM, Cooper RA, et al. Issues in maintenance and repairs of wheelchairs: A pilot study. *J Rehabil Res Dev*. 2005;42(6):853-862. http://www.ncbi.nlm.nih.gov/pubmed/16680622.

[11] Dianat I, Ghanbari Z, AsghariJafarabadi M. Psychometric properties of the persian language version of the system usability scale. *Heal Promot Perspect*. 2014;4(1):82.

[12] Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: a new tool for assessing the quality of health mobile apps. *JMIR mHealth uHealth*. 2015;3(1):e27.

[13] Brooke J. SUS-A quick and dirty usability scale. *Usability Eval Ind*. 1996;189(194):4-7.

[14] Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. International Management Review, 15 (1), 45-55.

[15] Herlache-Pretzer, E., Winkle, M. Y., Csatari, R., Kolanowski, A., Londry, A., & Dawson, R. (2017). The impact of service dogs on engagement in occupation among females with mobility impairments: A qualitative descriptive study. International Journal of Environmental Research and Public Health, 14(6), 649.