Correlating wheelchair usage and failure measures for developing a wheelchair maintenance technology

Sarah Marsh[1,2], Carmen DiGiovine[1,2], Muyun Zhao[1,2], Alyssa Boccardi[3], Aaron Wu[3], Bryan Hess[3], Anand Mhatre[1,2]

[1]*Rehabilitation Engineering Design Laboratory, The Ohio State University*, [2]*Assistive Technology Center, The Ohio State University Wexner Medical Center,* [3]*University of Pittsburgh*

ABSTRACT

Around 75 million people with locomotor disabilities experience moderate to severe disability and profound limitations with mobility, daily activities, and social participation. Wheelchairs are assistive devices that serve as a primary means of mobility and independence however, wheelchair parts break regularly. More than 50% of community-dwelling wheelchair users experience failures with wheelchair parts within six months of use, leading to physical, psychological, social, and economic ramifications.

Prior research supports the development of preventative maintenance measures for manual wheelchair users. Accordingly, maintenance training programs designed to combat wheelchair failure have been developed. These tools are formulated based on expert consensus and have yet to demonstrate the efficacy of failure prevention. Additionally, these tools cannot monitor wheelchair use and inform maintenance routines.

In response to the need for more robust, active maintenance measures, we are developing Wheeltrak, a wheelchair maintenance technology that comprises a sensor and smartphone app. The sensor collects road shock measurements, travel distance, and other usage-related parameters and alerts users when maintenance is due based on a algorithm..

This pilot study aims to model the algorithm and investigate the relationship between wheelchair usage and failure measures. The study hypothesis is road shocks and wheelchair failure frequency are highly correlated (R2>=0.8).

Eight ultralight manual wheelchair users were studied utilizing a mixed-methods approach for data collection. A usage monitoring sensor was mounted to the wheelchair frame and collected data for a week. Failures and demographic data was collected using surveys at t=0 and 8 months.

Participants experienced 2.28±2.21 high-risk failures and 6.86±4.18 low-risk failures over the study period of 20 months. High-risk failures included fractured axle lock, caster wheel, caster fork, axle bearings, brakes, and push rims. Worn-out tires, seat, cushions and loose brakes were some low-risk failures. Regression analyses yielded two models that linked wheelchair failure measures with usage measures. The first model indicated that wheelchair failure frequency is significantly associated with the number of road shocks per unit distance and magnitude of road shocks ($F(3,6)=28.2$, $p=.01$, $R^2=.95$). The second model showed that the occurrence of a wheelchair caster failure is significantly associated with age, skills training status, and weight distribution on rear wheels and casters ($X^2(2,6)=536$, $p<.01$).

The study findings support Wheeltrak technology-led maintenance and development of the technology for providing maintenance knowledge and enabling compliance, which could prevent wheelchair failures based on research evidence.

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