SMART ACCESSIBILITY 2022

The Seventh International Conference on Universal Accessibility in the Internet of Things and Smart Environments

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SMART ACCESSIBILITY 2022

Forward

The Seventh International Conference on Universal Accessibility in the Internet of Things and Smart Environments (SMART ACCESIBILITY 2022) was held in Porto, Portugal, June 26 - 30, 2022..

There are several similar definitions for universal accessibility, such as design for all, universal design, inclusive design, accessible design, and barrier free design. These and similar approaches are relevant to this conference. The focus will be on methods, tools, techniques and applications for human diversity, social inclusion and equality, enabling all people to have equal opportunities and to participate in the information society.

The accepted papers covered topics such as accessibility by design, digital inclusion, accessibility devices and applications. We believe that the SMART ACCESIBILITY 2022 contributions offered a large panel of solutions to key problems in areas of accessibility.

We take here the opportunity to warmly thank all the members of the SMART ACCESIBILITY 2022 technical program committee as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and efforts to contribute to the SMART ACCESIBILITY 2022. We truly believe that thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations and sponsors. In addition, we also gratefully thank the members of the SMART ACCESIBILITY 2022 organizing committee for their help in handling the logistics and for their work that is making this professional meeting a success.

We hope the SMART ACCESIBILITY 2022 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the universal accessibility field. We also hope that Porto provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city

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Economic Impact of Adopting Assistive Technologies on Quality Adjusted Life Years and Work Productivity

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***Abstract*—This paper discusses the development of a novel survey instrument to measure the impact of adopting assistive technologies. The goal is to determine the quality of life improvements and increase in work productivity for people with disabilities with the use of assistive technologies. The task of Wayfinding is presented as a case study to evaluate the benefit to people with disabilities. This paper contributes to the Accessibility Devices and Applications track of the conference.**

Keywords-accessibility; assisitve technology; quality adjusted life years; work productivity.

I. INTRODUCTION

Assistive Technologies (AT) are a concept of an item or piece of equipment that enables individuals with disabilities to enjoy full inclusion and integration in society. While accessibility focuses on giving "similar" access capabilities to a specific device or service, AT is broader, with a focus on enabling core human tasks.

Technological advances in health and social care have led to a plethora of ATs that enable people with impairments or disabilities to ameliorate their impact to varying extents. There is an increasing awareness that there are many barriers, physical or otherwise, that impede opportunities for work, education, and participation by people with disabilities. Technology has tremendous potential for removing accessibility barriers. For example, mapping and localization systems deployed in public spaces support orientation and wayfinding, or to identify safe paths to traverse for wheelchair users [1], [2], [3].

Often ATs are developed with the claim it is useful and has potential to ameliorate the life of people with disabilities [4], [5]. Quantifying the benefits of ATs is an important consideration towards its development and adoptability. Central to quantifying these benefits is the use of survey instruments. Common survey instruments adopted for measuring health utility are EQ-5D-3L developed by the EuroQol Group, Health Utilities Index Mark 3 scale (HUI3), SF-6D scale developed from SF-36. Questionnaires to evaluate at-work disability and productivity loss are Work Limitations Questionnaire (WLQ-25) and Workplace Activity Limitation Scale (WALS). The most common questionnaire to measure Quality-Adjusted Life Years (QALY) is EQ-5D-3L, where three levels of severity are assigned to five dimensions of quality of life, namely, mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Similarly, HUI3 considers eight attributes of 5 to 6 levels.

There are no survey instruments developed that standardizes aspects related to both QALY and work productivity jointly. Most health utility capturing instruments (such as EQ-5D-3L and SF-36) address quality of life, while other instruments such as WALS and WALQ-25 measure the work dimension. Primarily these instruments evaluate the impact of interventions such as a drug or medical treatments and in some cases commonly used ATs (hearing aids, rollators) [6]. QALY could serve as a proxy for work productivity but it lacks explicit work-related metrics, making it an abstract measure of work productivity. The impact of ATs on QALY and work productivity can be separately measured by different instruments designed for this purpose. However, it is beneficial, meaningful, and efficient to have an instrument that measures both dimensions, especially when an AT such as a wayfinding tool cuts across dimensions. Measuring the impact for people with disabilities using a single instrument embodying both QALY and work productivity, allows for robust analysis of the AT.

Thus, the objective of this work is to develop a unique standardized survey instrument that measures both health utility and work productivity as it applies to adopting ATs by people with disabilities. The questionnaire developed will assess utility weights for quality of work-life and quality of life, and will be deployed widely to gather statistics from individuals with a wide range of disabilities, namely impairments related to visual, hearing, motor, cognitive and elderly.

The rest of this paper is organized as follows. Section II describes the methodology. Section III provides a description of the evaluation tasks and the framework on which future work will be accomplished. The acknowledgement and conclusions close the article.

II. METHODOLOGY

The unique questionnaire designed to address health and work productivity follows the construct to calculate Quality-Adjusted Life Years (QALY). QALY is a well-known measure that attempts to show the extent to which a particular treatment or system extends life and improves the quality of life at the same time [6], [7], [8], [9]. It is a tool aimed at incorporating all the essential dimensions of health,

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ability, and length of life. It combines the effects of health interventions on morbidity (quality of life) and mortality (quantity of life) into a single index. QALY has been largely used by insurance providers to weigh the benefits of a drug or medical treatment for patients [8], [10], [11].

QALY determines *by how much* not being in health impacts a person's quality of life. QALY's do this by assigning a number between 0 and 1, called a health utility, to the various conditions a person's health could be in. A 0 would represent the lowest possible quality of life, while a 1 would represent the highest possible quality of life. Health utilities are typically derived from surveys (EQ-5D-3L, SF-36), which attempt to determine how much survey participants would prefer to be in one health state as compared to another. Health states do not correspond directly to specific disabilities- they instead represent the degree of impairment a person has in specific, limited categories of functioning (such as mobility, ability to perform tasks, etc.). However, most disabilities share some or all characteristics of a health state. Goal of a health utility as measured by the instrument is to measure the degree to which a particular disability negatively impacts quality of life as compared to a state of perfect health. After determining the health utility, the decimal is multiplied by the number of years (quantity of life) that the AT is expected to cover. The quantity can be the number of years by which the system extends their life or enhances productivity at work, i.e., the number of years a person expects to use AT over their lifetime in being able to maintain a certain standard of living and work [12] effectively. Similarly, some states are identified that relate to quality of work-life [13], [14], [15]. These states help explain impact on work productivity. Figure 1 breaks down health and quality of work-life dimensions from which health and work utilities are calculated. Adoption of ATs are expected to change the utilities, thereby aiding in measuring changes in QALY and work productivity. This would further help in determining the cost-effectiveness of adopting AT.

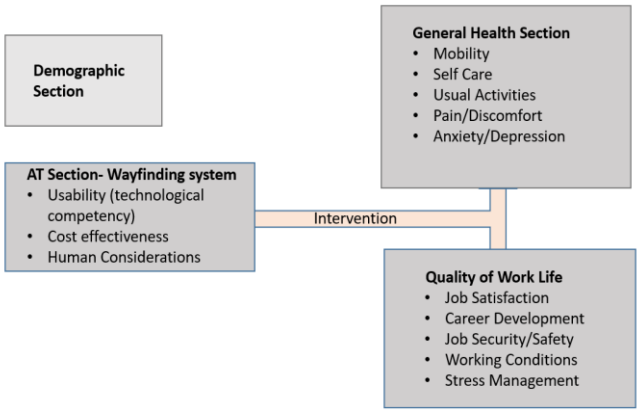

Figure 1. Design of the survey instrument

III. DESCRIPTION

To evaluate the economic impact of adopting an assistive technology in alleviating health and work productivity of a person with disability, the following is undertaken in this research work:

A. *Use of Instruments for AT applications:*

A feasibility study of popularly used and industry accepted survey instruments (EQ-5D-3L, SF-36, WALS and WLQ) is conducted to measure the impact of ATs in quality of life and work productivity for people with disabilities. This scoping literature review across various domains (healthcare, information technology, transportation etc.) shows despite the wide-spread use of the survey instruments, there is not much analysis of AT adoptability. The landscape is dominated by instruments gauging the impact of drugs or medical treatments. Table 1 provides a snapshot of limited work published in literature applying instruments to measure the impact of AT on people with disabilities. While there are some evidences of using EQ-5D-3L and SF-36 in measuring AT adoptability, there is hardly any of WALS and WLQ use.

B. *Comparative study of Instruments:*

A comparative study of the four instruments listed above is conducted on various criteria to gauge its degree of suitability in measuring both aspects of life and work productivity together with AT interventions. The study finds that these instruments are typically used in a mutually exclusive form i.e., measures either quality of life or work productivity. However, ATs can be instrumental in improving both aspects. The comparative study provides a benchmark to develop a unique standardized instrument that accomplishes the objective outlined in this research. Table 2 evaluates the four survey instruments on the following criteria, a) the nature of questions the survey seeks to evaluate, b) format of the questions, c) the prevalent applicability of the instrument, d) accessibility of the instrument, e) strengths, and weaknesses of the instrument. This evaluation of commonly used survey instruments that serve as the industry standard guides the development of the novel instrument proposed in this paper.

C. *Case Study of Wayfinding systems:*

A unique standardized instrument is developed that measures the joint impact of ATs in both quality of life and quality of work-life. A smartphone-based indoor/outdoor wayfinding application for persons with disabilities is used as a case study for applying this instrument. This instrument is calibrated against established instruments (EQ-5D-3L, SF-36, WALS and WLQ) and provides a detailed framework to measure both QALY and work productivity.

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Figure 1 provides the structure of the instrument and its design. Similar to the EQ-5D-3L instrument, 5 health states are defined and responses will be gathered at 5 levels spanning no problems at all to extreme problems. To measure work productivity, 5 more states are defined specific to work experience and these follow the same construct of measuring responses at 5 levels. The unique instrument with standardized 10 dimensions and 5 levels of responses to each dimension will allow for determining utility values or index values. The index values will be used to calculate QALY and work productivity aspects jointly for different groups of people with disabilities. Additionally, the developed instrument will also be administered to people with no disabilities to serve as a benchmark. The instrument will allow for evaluating the changes in index values based on adoption of the wayfinding system. Further, the cost-effectiveness of adopting wayfinding system can be computed from QALY and Work Productivity calculations.

Future work will involve gathering data by administering the designed instrument to persons with disabilities related to impairments such as cognitive, visual, hearing, motor, and elderly and also to persons with no disabilities.

IV. CONCLUSION

In this paper we introduce a unique survey instrument in the context of established separate questionnaires for health and work-life that contributes to the literature in two ways. A survey instrument that evaluates both the health and work-life domains jointly, and secondly, analyses the use of assistive technologies on quality of life and work productivity in the targeted population. This work addresses the gap in the literature where studies focus on the impact of interventions such as a drug or medical treatment and in some cases AT, either on the quality of life or work productivity.

ACKNOWLEDGMENT

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TABLE 1: SURVEY INSTRUMENTS MEASURING AT ADOPTIONS

Authors	Year	Title of Paper	Instrument Used	AT Used
[6]	2012	Can we rely on QALYs for assistive technologies?	EQ-5D	Various
[16]	2020	Self-management and cognitive rehabilitation in early stage dementia – merging methods to promote coping and adoption of assistive technology. A pilot study.	EQ-5D	ReACT app
[17]	2015	Hearing aid and hearing assistance technology use in Aotearoa/New Zealand.	SF-36	Hearing Aid
[18]	2011	Health-Related Quality of Life Among Older Adults With and Without Functional Limitations.	SF-36	Various
[19]	2015	The effect of powered scooters on activity, participation and quality of life in elderly users.	SF-36	Powered Mobility Devices
[20]	2017	Pain, fatigue, function and participation among long-term manual wheelchair users partnered with a mobility service dog.	SF-36	Mobility Service Dogs
[21]	2019	Rehabilitation evaluation of the newly developed polymeric based passive polycentric knee joint.	SF-36	Polycentric Knee Joint
[22]	2017	Comparing the Chinese versions of two knee-specific questionnaires (IKDC and KOOS): reliability, validity, and responsiveness.	SF-36	Comparing 2 AT Surveys
[23]	2008	Tracking mobility-related assistive technology in an outcomes study.	SF-36	Mobility Assistive Technology Devices
[24]	2021	The effectiveness and cost-effectiveness of assistive technology and telecare for independent living in dementia: a randomized controlled trial.	EQ-5D	Assistive Technology and Telecare (dementia)
[25]	2012	Effect of hearing aids on hearing disability and quality of life in the elderly.	EQ-5D	Hearing Aid
[26]	2016	Assistive Technology for Cognition and Health-related Quality of Life in Huntington's Disease.	EQ-5D	Assistive Technology for Cognition to improve HRQoL (health related quality of life)
[27]	2018	Pragmatic randomized controlled trial of a trauma-focused guided self-help Program versus Individual trauma-focused cognitive behavioral therapy for post-traumatic stress disorder (RAPID): trial protocol.	EQ-5D	Online Guided Self Help Program
[28]	2022	Adverse events in the treatment of motorcycle-related isolated limb injuries at a regional hospital in Uganda: a prospective clinical analysis.	EQ-5D	Addressing Clinical Adverse Events in regards to limbs

[29]	2019	Perceptions of the impact of disability and impairment on health, quality of life and capability.	EQ-5D	Various
[30]	2017	Job retention vocational rehabilitation for employed people with inflammatory arthritis (WORK-IA): a feasibility randomized controlled trial.	WLQ	VR/AR

TABLE 2: COMPARISON OF SURVEY INSTRUMENTS

Instrument Features	**SF-36**	**EQ-5D-3L**	**WALS**	**WLQ**
Questions	Focused on Health General health, emotional and social activities question.	Focused on Health Specific disability questions, and the severity of that disability based on the scale presented.	Focused on Work	Focused on Work Focused on symptoms/impacts from the past 2 weeks Each question asks about a different aspect of work.
Format	36 questions, divided into 8 different domains	5 domains, with three different levels of responses	12 questions, 4 levels of answers	25 questions divided into 4 subscales, rating scale from 1-6
Intent	Intended for use with arthritis	Intended for use with arthritis	Intended for use with arthritis	Intended to assess various states of workplace disabilities
Accessibility	Given the simplicity of the questions, it is very accessible	Very accessible because of the ease of answer choices regarding the scale	Very accessible given the short length of the survey	Semi-accessible a bit of a longer survey but goes more in depth
Strengths	Simple answer choices to questions makes it easier for people to fill out. Covers a lot of ground regarding limitations of activities, and it dives into the specifics of what one has trouble with.	More responsive to improvement/decline in people's condition in terms of mobility The scale has "states" which are worse than death. This helps people understand the seriousness of the diseases these people have and helps professionals assist them appropriately.	No recall period Does not go into depth on each individual thing making it easy to understand and fill out	Very easy to complete Goes in depth into the areas it covers Higher work limitation numbers, which means this survey is more sensitive
Weaknesses	Missing values estimated through the mean of answered data in the same scale for patients with responses for at least half of the domain questions. Given the above is true, the results may not be accurate in those cases.	Not effective for use with hearing impaired individuals Patient excluded of specific analysis if any question is left unanswered.	If 2 questions are left unanswered the patient is left out of special analysis Does not go in depth into the problems	With only 5 questions, it does not cover everything in which someone might need. Uses reverse instructions which can be confusing for individuals Not very intuitive for blind people, they may be confused with all of the different choices.

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