RESEARCH ARTICLE

Evaluation of a Tele-assistance Technological Tool in Activities of Daily Life of People with Visual Disabilities

Camilo Barrera Valencia[1], Consuelo Vélez Álvarez[2,*], Héctor Darío Escobar Góme[3] and Paola Tatiana Henao Chic[4]

[1]*University Official, Telehealth Leader, Universidad de Caldas, Carrera 21 No. 65 A 48 - Manizales, Caldas, Colombia*
[2]*Public Health Department, Universidad de Caldas, Carrera 21 No. 65 A 48 - Manizales, Caldas, Colombia*
[3]*Health Sciences Department, Universidad de Caldas, Carrera 21 No. 65 A 48 - Manizales, Caldas, Colombia*
[4]*Specialist in International Business Management, People Contact Project Director Carrera 21 No. 65 A 48 - Manizales, Caldas, Colombia*

Abstract:

Introduction:

Blind people lose an important degree of independence, which makes it difficult to carry out different activities of daily life.

Objective:

To develop and evaluate a telecare model that consisted of guiding a person with visual disability through a video conference to carry out activities of daily life.

Methods:

The telecare model is based on the guidance through voice commands. Telecare begins when a blind person, through a mobile device, transmits images, video and voice (video conference) in real-time to a person with normal vision in a different place that works as a guide, so that the guide knows the details of the blind person. The environment of the person that can solve immediate information needs, location or selection of objects requires visual support. It was evaluated with 37 people with visual disabilities through the Lawton & Brody scale.

Results:

It is an improved progressive evolution in the level of independence of the Lawton and Brody scale, which presents an advance of just over 2 points in the scale thanks to the tele-assistance application (p = 0.000).

Conclusion:

The participants were at a moderate level of dependence and, after the tele-assistance tests, their level was mild. The highest score was obtained in activities related to money management and purchases. In contrast, participants had less value activities within the home. The results allowed us to verify the effectiveness of telecare to improve the independence and well-being of people with visual disabilities.

Keywords: Health, Blindness, Visually impaired persons, Video conference, Orthosis, Mobile health (MeSH terms).

1. INTRODUCTION

There are approximately 285 million visually impaired people in the world, of whom about 14% are blind, 86% have low vision (moderate and severe visual impairment), and approximately 90% of the global burden of visual disability concentrates in developing countries [1, 2]. The most frequent causes of low vision and blindness [3] include age-related macular degeneration, glaucoma, diabetic retinopathy, retinitis pigmentosa [4], retinal detachment, ocular toxoplasmosis and ocular trauma [5, 6]. Although there are different aids to improve vision in people with mild to moderate visual impairment [7.8], they do not solve the problem in people with severe visual impairment or blindness [9, 10], who need technologies that replace vision such as Braille, "talking books," the use of walking sticks for the blind and guide dogs [11] to improve their independence in basic activities.

* Address correspondence to this author at the Public Health Department, Universidad de Caldas, Carrera 21 No. 65 A 48 - Manizales, Caldas, Colombia; Tel: +57 3155411897; E-mail: Consuelo.velez@ucaldas.edu.co

Tele-assistance, in its shortest and most specific definition, means, "To help at a distance": the prefix tele is a Greek word meaning at a distance, and the word "assistance" in the dictionary of the Real Academia de la Lengua Española is defined as the act of assisting or helping [12]. Tele-assistance is a part of a broad field of Information and Communication Technologies (ICT) applied to health, including telemedicine, electronic medical records and mobile health. The World Health Organization (WHO) defined this general framework as Cyber health or e-Health in 2005 [13].

Specifically, tele-assistance allows the carrying out of distance assistance activities in which, a more experienced health worker accompanies or guides a health worker with less experience or expertise through ICT [14] to care for people who need help in their home or environment, becoming essentially a social attention service [15].

The research project "Tele-assistance to improve the functionality of people with severe visual impairment or blindness" aimed to develop and evaluate the effectiveness of a tele-assistance model, which consisted in remotely guiding people with visual impairment through a video conference for the accomplishment of activities of the daily living.

The objectives of this study were: (1) to determine a provision of service model to support the functionality of people with severe visual impairment or blindness, and (2) to evaluate the tele-assistance model as a support to the functionality of people with severe visual impairment or blindness.

2. METHODS

2.1. Study Setting and Population

To determine the effectiveness of the tele-assistance model developed in the project "Tele-assistance to improve the functionality of people with severe visual impairment or blindness", 43 people with severe visual impairment or blindness who met the inclusion criteria and accepted to participate in the project, were included in the study. Inclusion criteria were: (1) Of legal age to participate in research and signature of informed consent; (2) Having a companion to support them during the tests (guarantor of activities performed during the sessions); (3) Permanent resident of the city of Manizales; and (4) Visual impairment in both eyes according to the International Classification of Diseases, Tenth Revision, ICD-10 (severe visual impairment, profound visual impairment, close to blindness, blindness).

On the other hand, the exclusion criteria of the study were: (1) Auditory and cognitive problems that limit the ability to listen and follow commands; (2) People with physical or motor disabilities that prevent them to carry out daily living activities without assistance of a caregiver; and (3) Use of an electronic device to improve functionality (electronic stick, infrared glasses, *etc*.).

The research was developed in 3 stages. The first stage consisted of: (1) Invitation and socialization of the research project to blind people interested in participating in the study; (2) Application of inclusion and exclusion criteria; (3)

Signature of informed consent; (4) Clinical evaluation by the ophthalmologist to confirm compliance with inclusion requirements and the degree of visual impairment. In the second stage, a complete pilot test was conducted with 4 participants in the study, with the purpose of adjusting research protocols, instruments and the technological component. Finally, the third stage was the execution of the investigation with 43 people and the application of the instruments described below.

2.2. Instruments

In total, 9 instruments were applied for the execution of the research as follows: informed consent, inclusion criteria, exclusion criteria, participants' satisfaction survey, guide person's satisfaction survey, evaluation of the technological component - electronic device, internet and software -, sociodemographic instrument, ophthalmologic medical assessment, and Lawton & Brody scale.

The Lawton & Brody index for instrumental daily living activities, which evaluates 8 fundamental aspects of independence in daily living activities, was applied to each person. The test was carried out with and without telehealth (test - posttest) for the following variables: using the telephone, shopping, preparing food, doing housework, doing the laundry, using public transport, handling medications and handling money. The Lawton & Brody scale is developed through 31 activities and each block of instrumental activities gives a score of one and zero, respectively. The degree of dependence is classified as follows: 0 to 1 points total dependence; 2 to 3 points severe dependence; 4 to 5 points moderate dependence; 6 to 7 points light dependence; and 8 points, independence.

2.3. Procedure and Model Description

The tests were carried out in 3 phases as well: Test 1: Using the phone and handling the medications. Test 2: Preparing food, doing housework and doing laundry. Test 3: Using public transportation, shopping and handling money.

Prior to the Lawton & Brody tests, the study participants were trained in the management of the mobile device and video conference interaction with the guide person.

The tele-assistance model developed is based on guidance through voice commands. Tele-assistance begins when the blind person, through a mobile device (electronic glasses), transmits images, video and voice in real-time (video conference) to a guide with normal vision that is in a different place, so that it knows the details of the blind person environment and solve their immediate needs for information, location or objects selection that require visual support. The glasses that were used in the different tests were Optinvent ORA 1 Smart Glasses; Epson Moverio BT 200 Smart Glasses and M100 Smart Glasses Enterprise.

It is worth mentioning that the tests were carried out in a controlled environment and with the support of a face-to-face assistant who ensured the safety of the study participants during the different tests. In total, each participant carried out 8 tests in the scenarios described above.

The equipment used to carry out the tests were: mobile device with video conference for the blind person, computer

for the guide person, internet platform with minimum connectivity of 1 megabit, tele-assistance software, battery or support UPS for connection longer than 2 hours.

2.4. Data Analysis

Reliability of 95% and a p-value for the contrast of 0.05 were considered for the analysis. Statistical analysis consisted of establishing the relationship between the different variables proposed. Parametric tests (Student t and ANOVA, as appropriate) were applied to the normal distribution variables, and non-parametric tests (Mann-Whitney, W de Wilcoxon, Kolmogórov-Smirnov, and Kruskal-Wallis) were applied to the variables that were not normally distributed.

Study hypothesis 1: The tele-assistance model developed in the research is not effective to improve the functionality of daily living activities in people with severe visual impairment or blindness.

Study hypothesis 2: The tele-assistance model developed in the research is effective to improve the functionality of daily living activities in people with severe visual impairment or blindness.

3. RESULTS

3.1. Characterization of the Population

The study counted on the participation of 43 people who fulfilled all the inclusion criteria. Eighty-six percent of them, that is to say, 37 people, successfully completed all activities around the project, and the results for the analysis come from this group.

37.8% of the participants were female (14 people), compared to 67.2% of male participants (23 people). Most of them belong to a low socioeconomic level (83.7%), compared to 16.2% of participants who are part of a medium-high socioeconomic level. 30 years was the minimum age of the participants and 50 years was the maximum age. The main diagnoses of the patients under study were Retinitis Pigmentosa (the majority), absolute glaucoma, Diabetic Retinopathy sequelae, ocular trauma sequelae, cerebrovascular disease sequelae.

From the characterization variable related to economic dependence, it was established that 67.6% depend economically on someone else while, in contrast, 32.4% are independent in their capacity to generate income.

The education level of the participants was 18.9% with a university education, 5.4% with technical education, 27% with elementary education (5 years of study) and 45.9% with secondary education (12 years of study). Only 2.7% of participants reported having no educational background. The highest rate of disability in the study is the "acquired" disability with 56.8%, followed by "congenital" disability with 35.1%. Regarding the health regime, 64.9% of the participants belong to the contributory regime (pay their health directly) followed by the subsidized regime (the state subsidizes health) with 27%, the rest 5.4% belong to regime special. Braille use by the participants occurred in 37.8% of the cases. The use of orthoses in the participants of the test was present in 89.2% of the cases.

Once the general characterization aspects of the sample were considered, the effectiveness of tele-assistance was determined by means of statistical tests in relation to the contribution to the independence of people through the measurement in the evolution in the of Lawton & Brody scale.

3.2. Efficiency of Technology

A highly significant evolution was demonstrated in the level of independence of the Lawton & Brody scale applied to the study for the 37 people, presenting an advance of slightly more than 2 points in the scale thanks to the application of tele-assistance using Wilcoxon statistic test for non-parametric distributions and related samples ($p = 0.000$).

It was possible to establish that the participants, before using the tele-assistance model developed in the study, were in a level of moderate dependence and after the tests with tele-assistance their level changed to light dependence. This confirms the efficiency of the implementation of the project for the improvement of conditions related to independence in performing basic daily activities that affect the perception of quality of life and well-being of people with visual impairment who participated in the study.

To determine if there are differences associated with the different characterization variables that affect the effectiveness of the tests and, therefore affect the evolution of the Lawton & Brody scale, statistical analyses were performed for each component, which are presented below. It is worth noting that after a Shapiro Wilk test the variable "evolution" yielded a non-normal distribution ($p = 0.000$) which indicates that the statistical tests to be used were non-parametric. Therefore, Mann-Whitney tests were used for variables with two independent samples and Kruskal-Wallis tests were used for variables with more than two independent samples.

The "male/female" variable presented statistically significant differences with the average evolution in the Lawton & Brody scale ($p = 0.007$), being the average evolution of 2.4 levels in males, in contrast to the evolution in females which averaged 1.5 levels (Table **1**).

Table 1. Analysis of differences in evolution associated with characterization variables.

Variables	p-value	Variable	p-value
Male/female	0,007	Social stratum	0,874
Economic dependency	0,902	Education level	0,897
Type of disability	0,222	Health regime	0,737
Use of Braille	0,255	Use of orthoses	0,157

Table **2** presents the summary in which the results of the study can be seen for three different status, as follows:

- **Before**: Corresponds to people who are not in Lawton & Brody scale levels and therefore their independence level is 0 (dependent).
- **After**: Corresponds to the proportion of participants who evolve from Lawton & Brody non-score levels to score levels (independence).
- **No change**: It is the proportion of participants who remain at non-score levels.

Table 2. Proportions of different status at the Lawton & Brody levels for the research.

	Daily Living Activities Evaluated	Before (Dependence)	After (Independence)	Did not Change
1	Using the Phone	2.7%	35.1%	64.9%
2	Shopping	62.1%	43.2%	37.8%
3	Preparing Food	43.2%	16.2%	56.7%
4	Doing Housekeeping	32.4%	32.4%	67.5%
5	Doing the Laundry	10.8%	10.8%	89.1%
6	Using Public Transportation	24.3%	24.3%	75.7%
7	Handling Medicines	43.2%	43.2%	56.8%
8	Handling Money	100%	94.6%	2.7%

Table 3. Lawton & Brody dimensions according to the "male/female" variable.

Evaluated Activities	Description
Using the Phone	• Use the telephone on own initiative: there are no differences between men and women. • Can dial well some family numbers: women present in the status "before" a 7.1% compared to a proportion of 8.7% of men who had this status as initial level. • Can answer the phone, but cannot dial: there are no significant differences in the proportion associated with the male/female variable. • Are not able to use the phone: only 4.3% of men are found. There are no women in this status.
Shopping	• Independently perform all necessary purchases: there are no significant differences in the status in relation to the male/female variable. In both cases, it approximates a 43.2% in the evolution of independence when making the necessary purchases, being a great proportion of gained independence. • Independently perform small purchases: there is a higher concentration of initial status for men with 39.1% compared to women with 28.6%. • Need to be accompanied to make any purchase: in the status "before" women have a greater presence on this level with 35.7%, compared to 21.7% of men. • Totally unable to shop no people at this level within the test.
Preparing Food	• Organize, prepare and serve the meals on their own adequately: men present evolution of 21.7% compared to 7.1% of women. • Properly prepare meals if ingredients are provided: women do not present changes compared to 8.7% improvement for men. • Prepare, warm and serve meals, but does not follow a proper diet: 4.3% of men show an evolution in this area compared to 7.1% of women. • Need to have meals prepared and served: a large proportion of men (30.4%) contrast in their initial status in this variable "before" compared to 7.1% of women. Therefore, men in the test are much less independent for this component.
Doing Housekeeping	• Do housekeeping by themselves or with occasional help for heavy work: 57.1% of women do not present changes compared to 34.8% of men who do have changes at this level, being this one of the variables generating the lowest impact with tele-assistance for the case of men. • Perform light tasks, such as washing dishes and making beds: men had better results in relation to evolution with 13%. Women did not evolve at this level. • Perform slight tasks, but cannot maintain an adequate level of cleanliness: women did not have a presence in this level, while men evolved to this status in 21.7%, again showing greater initial capacities among women for independence for the case of this dimension. • Need help in all housework: 21.7% of men registered this level as their initial state. No woman had this state in the housekeeping dimension. • Do not participate in any housekeeping activity: there is no data for this level in the variable.
Doing the Laundry	• Wash all their clothes on their own: 71% of women were in this status and did not change, compared to 34.8% of men. Regarding the evolution of this variable status, 7.1% of the women obtained results compared to 4.3% of the men. • Wash small garments on their own: most women with 21.4% and men with 39.1% do not present changes in this condition of the component. • All laundry should be done by another person: no woman has any status in this variable. 13.0% of the men started in this status and 13.0% of them did not change status during the study.
Using Public Transportation	• Travel alone on public transport or drive their own car: women had a greater evolution in their status facing this variable with 21.4%, compared to 13% of men. • Can take a taxi, but does not use another means of transport: in this level of the component, women evolved their status in 7.1% against the 8.7% of men. All participants experienced changes for this level. • Travel by public transport when accompanied by another person: there is no change in this variable, 57.1% of the women do not show any change while 73.9% of the men register a change. • Only use a taxi or car with the help of others: 7.1% of women started in this status of the transport and mobility component, while there are no men in this status. • Do not travel: no data exist at this level, neither for men nor for women.

(Table 3) contd.....

Evaluated Activities	Description
Handling Medicines	• Can take their medication on time and with the correct dose: in 71.4% of the women, there is no evolution; 43.5% of men do not present change in this status. • Take their medication if the dose is previously prepared: men have a higher proportion of initial status with 56.5% compared to women with 21.4%. • Not able to administer their medication: There are no values for this condition.
Handling Money	• Handle their economic affairs by themselves: 92.9% of women and 95.7% of men present changes in independence for this money management component. This is the variable with the greatest changes for participants throughout the study. • Perform day-to-day purchases, but need help in large purchases, banks, among others: 28.6% of women and 17.4% of men are in their initial status in this variable of the independence component In the handling of money • Unable to handle money: In 64.3%, women are characterized in an initial status in this variable, while men are in 78.3%.

There are components in which the test presented better results in relation to the change of status, such as the handling money activity (94% of participants switched to scoring zones in independence on the scale after using telehealth), and independence when shopping (43.2% showed change to areas of independence in this component after the use of remote assistance). The component of independence in doing the laundry was in general terms the component with the least change (89.1% of participants did not experience changes in this component after using telehealth). It is necessary to understand the existence of correlations that allow explaining the performance of Lawton & Brody variables with the characterization variables.

3.3. Analysis of Each Dimension

Given the existence of a correlation between the evolution of results and the "male/female" variable, the difference in the measure of central tendency for both male and female in relation to evolution was determined. It was established that there are significant differences, showing that in males there is an average evolution of 2.39 levels against female of 1.5 levels on the Lawton & Brody scale with $p = 0.011$ when applying the Mann-Whitney test.

The situation of the "male/female" variable in the different dimensions of Lawton & Brody is described below to establish in which dimensions the study shows better results (Table **3**).

3.4. Perception of Quality and Satisfaction

Table **4** shows the results of the satisfaction survey conducted among 37 participants of the study, which evaluated the care received by the team during the investigation and the perception of the use of telehealth. The measurement scale was as follows: 1: Poor, 2: Fair, 3: Good, 4: Excellent.

All the items on the quality and satisfaction of the research project were rated between "good" and" excellent" by the participants.

The variables with the highest scores in relation to quality in the test were: "explanations given in the tests carried out" (4 points and ds = 0); "work of the project team" (4 points and ds = 0), "Help from the person in charge of the orientation "(4 points and ds = 0). Of great importance is the high rating given by the study participants to the use of tele-assistance to improve the functionality in activities of daily living, especially in environments outside their home with a score of 3.89. However, it was not the same when the use of telehealth is applied to activities in their home with a score of 3.14.

When faced to the questions: "Would you recommend to other visually impaired people this type of aids to improve their functionality?", and "Would you pay to get the benefits of this service?", people recommend 100% of the time they help to improve the functionality and independence in the daily activities for the visually impaired. Even when faced to the question whether they would pay for benefits, 83.8% of the participants said they would do so.

To determine if there were differences in quality perception and test satisfaction associated with the "male/female" variable, analyses for non-parametric tests (KS $p = 0.001$) were carried out. After applying the Mann-Whitney test, it was possible to establish that there are no differences between the quality perception average ratings associated with the participants' gender (p between 1,000 and 0,394).

Table 4. Quality and satisfaction survey conducted among the study participants.

Variables	Average Score
How do you rate the explanations given in the tests performed?	4.0
How do you rate the work team that was with you in the project?	4.0
How do you rate the help given by the person who gave you the orientation?	4.0
How do you rate the personal experience of the project?	3.92
How do you rate the benefits received with the use of telehealth?	3.92
How do you rate this type of help to improve your activities outside your home?	3.89
How do you rate the time devoted to you during the tests?	3.89
How do you rate the fulfillment of what you expected in relation to what you experienced in the project?	3.78
How do you rate the ophthalmologic care received?	3.73
How do you rate the call process to participate in the project?	3.57
How do you rate this type of help to improve your activities in your home?	3.14

Tests of correlations through the Spearman statistic show that there is a relationship between the variables "type of disability", "years of diagnosis" and "use of orthotics" with 4 quality variables, which makes it possible to establish that the satisfaction generated in people participating in the study is independent of crucial aspects such as age, gender and other characterization variables that could imply errors in the design of the experience of the test.

In the case of the "type of disability" contrast variable, the Kruskal-Wallis test was applied in such a way that it was possible to establish significant differences in the scoring values of the variables related to satisfaction and quality of the test. It was found that there are no significant differences, neither for the variable that measures the personal experience lived through the project (p = 0.053), nor for the variable that evaluates the benefits received with the use of tele-assistance (p = 0.053). Therefore, although there is some degree of correlation between the quality variables, it was not possible to establish differences associated with the type of disability.

4. DISCUSSION

The research results confirm that the tele-assistance model developed, aimed at people with blindness or a severe visual impairment, brings important benefits to improve the functionality of people when they perform activities of daily living such as handling money, shopping or using the phone. The result obtained confirms the study hypothesis 2, which indicates that tele-assistance is effective in improving the functionality of daily living activities in people with severe visual impairment or blindness. The statistical analysis showed a greater benefit in the daily living instrumental activities presented below, with number 1 being the highest benefit and number 8 being the lowest benefit: (1) Handling money, (2) Shopping, (3) Handling medications, (4) Using the telephone, (5) Doing housekeeping, (6) Using public transportation, (7) Preparing food, (8) Doing the laundry.

Likewise, these results are consistent with the satisfaction survey applied to the participants of the research, who valued tele-assistance better in activities outside their home (*e.g.* shopping), as opposed to activities within their house (doing the laundry) that, although the contribution of tele-assistance was recognized, they consider it smaller.

The results of the study indicate that there are statistically significant differences between the "use of tele-assistance" and "male/female" variables (Spearman's statistic p = 0.005 - Mann-Whitney statistic p = 0.007), but there are no significant differences in the other sociodemographic and clinical variables (P = 0.160) and the years of diagnosis of the disability (p = 0.987). Regarding the "male/female" variable, there is more independence in the male participants, possibly because males had a lower overall score in the degree of independence compared to the initial degree of independence of the female participants.

On the other hand, the general results obtained in the study, contrasted with the solutions available for people with blindness or a severe visual impairment, show an important advance for a more inclusive and egalitarian society. Currently, there is a wide range of aids that are being developed for

mobile devices such as smartphones [16 - 19] that allow people with blindness or severe visual impairment to solve daily activities and improve their quality of life. Some of these technologies are used to obtain information from the phone through voice [20] or gestures (head movement) [21], with the purpose of getting help in moving from one place to another [22 - 24], avoiding obstacles at an intermediate distance [25], achieving a perception of the space around them [26] accessing information on public transport schedules [27], handling devices at home such as the microwave [28], handling the smartphone [29], or going shopping [30].

Despite the immense potential of technologies embedded in smartphones, previous research has concluded that people will only use assistive devices that meet their specific needs [31], and this may not occur in the technologies described as long as they present restrictions, combined with the fact that "*Any blind or visually impaired person has different specific mobility, orientation and navigation capabilities that need to be complemented in a number of ways*" [32], reason why support models based on a single-way to carry out a task could result in low potential solutions to be used by most people.

The tele-assistance model implemented in this study, in contrast to the previous solutions, far surpasses the obstacles of stigmatization and shame often felt by people with blindness [33] as it is presented with the use of aesthetically discreet glasses (mobile device), which capture and transmit audio and video from the environment of the person with visual impairment to a guiding center where an agent acts as a mediator and can respond to the specific needs of the user. In this way, it is presented as a tele-assistance model flexible to the requirements of the person remotely, not limited to specific technologies, adaptable to any smartphone and, therefore, in line with the tendency to consider mobile phones as solutions capable of equipping users with a ubiquitous capacity [33, 34]. Other types of help have recently been created for people with blindness or visual impairment, including devices that increase depth perception [35] and magnification of images, use of epiretinal prostheses [36], vibration alarms and electronic components in walking canes for the blind [37] video cameras with audio integrated in glasses that recognize letters and objects [38], and training with virtual reality to develop skills in risk situations [39].

The tele-assistance solution developed and evaluated in the present study uses remote guidance that frees the independence of the user and gives him greater autonomy and capacity for the accomplishment of the daily living activities like shopping, handling money, searching an address, knowing the surrounding environment and overcoming obstacles, among others. Undoubtedly, guidance by people with normal vision is an effective and affordable way for people suffering from this type of clinical condition. The different information and communication technologies solutions respond to the challenges of the 21st century, bringing people closer to a more inclusive and egalitarian society.

Finally, no references of this type were found in the literature research. Most telehealth applications are focused on home care for older adults. The authors recognize as one of the limitations of the study the number of participants, which could

directly influence the analysis.

CONCLUSION

The participants were at a moderate level of dependence and, after the tele-assistance tests, their level was mild. The highest score was obtained in activities related to money management and purchases. In contrast, participants performed less value activities within the home. The results allowed us to verify the effectiveness of telecare to improve the independence and well-being of people with visual disabilities.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Informed consent was granted by the Bioethics Committee of Universidad de Caldas, Minutes No. 011 of 2015, consecutive # CBCS -025-15 of September 09, 2015, based on Resolution 008430 of 1993 of the Ministry of Health on scientific, technical and administrative standards for health research.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Each participant signed an informed consent to participate in the study.

FUNDING

CONFLICT OF INTEREST

The authors state that they do not have any conflict of interest regarding this manuscript.

ACKNOWLEDGEMENTS

REFERENCES

[1]   Hicks SL, Wilson I, Muhammed L, Worsfold J, Downes SM, Kennard C. A depth-based head-mounted visual display to aid navigation in partially sighted individuals. PLoS One 2013; 8(7)e67695
        [http://dx.doi.org/10.1371/journal.pone.0067695] [PMID: 23844067]

[2]   WHO. Global data on visual impairment. WHO 2017.

[3]   Furtado JM, Lansingh VC, Carter MJ, *et al*. Causes of blindness and visual impairment in Latin America. Surv Ophthalmol 2012; 57(2): 149-77.

[4]   Linares M, Ramos EA, Rodríguez S, Rosello A, Lázaro Y, Cuéllar R. Retinosis pigmentaria en baja visión. Rev Cuba Oftalmol 2011; 24: 279-86.

[5]   Quintero M, Perea CA, Padilla CM, Rojas I, Rodríguez S, Luis I. Capacidad funcional y calidad de vida en los ancianos con degeneración macular y baja visión. Rev Cuba Oftalmol 2014; 27. [A].

[6]   Hong T, Mitchell P, Burlutsky G, Fong CS-U, Rochtchina E, Wang JJ. Visual impairment and subsequent use of support services among older people: longitudinal findings from the Blue Mountains Eye Study. Am J Ophthalmol 2013; 156(2): 393-399.e1.
        [http://dx.doi.org/10.1016/j.ajo.2013.04.002] [PMID: 23688709]

[7]   Thomas R, Barker L, Rubin G, Dahlmann-Noor A. Assistive technology for children and young people with low vision. Cochrane Database Syst Rev 2015; (6): CD011350
        [http://dx.doi.org/10.1002/14651858.CD011350.pub2] [PMID: 26086876]

[8]   Haji SA, Sambhav K, Grover S, Chalam KV. Evaluation of the iPad as a low vision aid for improving reading ability. Clin Ophthalmol 2014; 9: 17-20.
        [http://dx.doi.org/10.2147/OPTH.S73193] [PMID: 25552897]

[9]   Monteiro MM, Montilha RdeC, Carvalho KM, Gasparetto ME. Optical and nonoptical aids for reading and writing in individuals with acquired low vision. Arq Bras Oftalmol 2014; 77(2): 91-4.
        [http://dx.doi.org/10.5935/0004-2749.20140023] [PMID: 25076472]

[10]   Pearce E, Crossland MD, Rubin GS. The efficacy of low vision device training in a hospital-based low vision clinic. Br J Ophthalmol 2011; 95(1): 105-8.
        [http://dx.doi.org/10.1136/bjo.2009.175703] [PMID: 20837788]

[11]   O'Brien EE, Mohtar AA, Diment LE, Reynolds KJ. A detachable electronic device for use with a long white cane to assist with mobility. Assist Technol 2014; 26(4): 219-26.
        [http://dx.doi.org/10.1080/10400435.2014.926468] [PMID: 25771607]

[12]   Valero MA, Sánchez JA, Bermejo AB. Servicios y tecnologías de teleasistencia: Tendencias y retos en el hogar digital. CEIM 2007.

[13]   Resolución WHA58. eSalud Actas oficiales de la 58a Asamblea Mundial de la Salud 2005. Available from: http://apps.who. int/ gb/ or/ s/s_wha58r1.html

[14]   De Toledo P. Propuesta de un modelo de sistema de telemedicina para la atención sanitaria domiciliaria 2003.http://oa.upm.es/362/

[15]   Giraldo-Rodríguez L, Torres-Castro S, Martínez-Ramírez D, Gutiérrez-Robledo LM, Pérez-Cuevas R. Tele-asistencia y tele-alarma para adultos mayores: experiencias preliminares en Mexico. Rev Saude Publica 2013; 47: 711-7.
        [http://dx.doi.org/10.1590/S0034-8910.2013047004574] [PMID: 24346662]

[16]   Hakobyan L, Lumsden J, O'Sullivan D, Bartlett H. Mobile assistive technologies for the visually impaired. Surv Ophthalmol 2013; 58(6): 513-28.
        [http://dx.doi.org/10.1016/j.survophthal.2012.10.004] [PMID: 24054999]

[17]   Fruchterman JR. In the Palm of Your Hand: A Vision of the Future of Technology for People with Visual Impairments. J Vis Impair Blind 2003; 97: 1-15. (accessed August 10, 2017) Available from: https://eric.ed.gov/?id=EJ678663

[18]   Escobar-Gómez HD, Vélez-Álvarez C, Barrera-Valencia C. External aids for improving the Independence of persons with visual impairment. Rev Cuba Oftalmol 2016; 30.

[19]   Kientz JA, Patel SN, Tyebkhan AZ, Gane B, Wiley J, Abowd GD. Where's my stuff? Design and evaluation of a mobile system for locating lost items for the visually impaired. Proc 8th Int ACM SIGACCESS Conf Comput Access. 103.

[20]   Dicke C, Wolf K, Tal Y. Foogue: eyes-free interaction for smartphones.
        [http://dx.doi.org/10.1145/1851600.1851705]

[21]   Brewster S, Lumsden J, Bell M, Hall M, Tasker S. Multimodal "eyes-free" interaction techniques for wearable devices.
        [http://dx.doi.org/10.1145/642611.642694]

[22]   Sabra S. Mobile-embedded smart guide for the blind. In: communications in computer and information science. Berlin, Heidelberg: Springer 2011; pp. 571-8.

[23]   Coughlan J, Manduchi R. Functional assessment of a camera phone-based wayfinding system operated by blind andvisually impaired users. Int J Artif Intell Tools 2009; 18(3): 379-97.
        [http://dx.doi.org/10.1142/S0218213009000196] [PMID: 19960101]

[24]   Deegan P, Grupen R, Hanson A, *et al*. Mobile manipulators for

[http://dx.doi.org/10.1016/j.survophthal.2011.07.002] [PMID: 22137039]

assisted living in residential settings. Auton Robots 2008; 24: 179-92.
[http://dx.doi.org/10.1007/s10514-007-9061-8]

[25] Zhang J, Lip CW, Ong SK, Nee AYC. A multiple sensor-based shoe-mounted user interface designed for navigation systems for the visually impaired.
[http://dx.doi.org/10.4108/ICST.WICON2010.8516]

[26] Shen H, Chan K-Y, Coughlan J, Brabyn J. A mobile phone system to find crosswalks for visually impaired pedestrians. Technol Disabil 2008; 20(3): 217-24.
[http://dx.doi.org/10.3233/TAD-2008-20304] [PMID: 20411035]

[27] Azenkot S, Fortuna E. Improving public transit usability for blind and deaf-blind people by connecting a braille display to a smartphone. Proc 12th Int ACM SIGACCESS Conf Comput Access. 317.
[http://dx.doi.org/10.1145/1878803.1878890]

[28] Nicolau H, Nunes R, Jorge J. Personal mobile controller for blind people. Proc 12th Int Conf Hum Comput Interact with Mob Devices Serv. 371.
[http://dx.doi.org/10.1145/1851600.1851670]

[29] Bujacz M, Baranski P, Morański M, Strumillo P. Remote mobility and navigation aid for the visually disabled. Proceedings of the 7th International Conference on Disability 2008. Available from: https://www.researchgate.net/publication/228642487_Remote_mobility_and_navigation_aid_for_the_visually_disabled

[30] Kulyukin VA. From ShopTalk to ShopMobile: vision-based barcode scanning with mobile phones for independent blind grocery shopping 2010. Available from: https://www.researchgate.net/ publication/ 228813287_ From_ ShopTalk_ to_ ShopMobile_ vision- based_ barcode_ scanning_ with_ mobile_ phones_ for_ independent_ blind_ grocery_ shopping

[31] Hersh MA. he design and evaluation of assistive technology products and devices part 3: Outcomes of assistive product use 2010. Available from: http://eprints.gla.ac.uk/46407/

[32] Strumillo P. Electronic interfaces aiding the visually impaired in environmental access, mobility and navigation. 3rd Int Conf Hum Syst Interact IEEE. 17-24.
[http://dx.doi.org/10.1109/HSI.2010.5514595]

[33] Connelly KH, Faber AM, Rogers Y, Siek KA, Toscos T. Mobile applications that empower people to monitor their personal health. E&I Elektrotech Inf Tech 2006; 123: 124-8.
[http://dx.doi.org/10.1007/s00502-006-0326]

[34] Crabtree A, Hemmings T, Rodden T, *et al.* Designing with care: Adapting cultural probes to inform design in sensitive settings. Ergon Soc Aust 2003; 4-13. Available from: http://citeseerx. ist. psu. edu/ viewdoc/ summary?doi=10.1.1.67.9650

[35] van Rheede JJ, Wilson IR, Qian RI, Downes SM, Kennard C, Hicks SL. Improving mobility performance in low vision with a distance-based representation of the visual scene. Invest Ophthalmol Vis Sci 2015; 56(8): 4802-9.
[http://dx.doi.org/10.1167/iovs.14-16311] [PMID: 26218908]

[36] Weiland JD, Cho AK, Humayun MS. Retinal prostheses: Current clinical results and future needs. Ophthalmology 2011; 118(11): 2227-37.
[http://dx.doi.org/10.1016/j.ophtha.2011.08.042] [PMID: 22047893]

[37] Pundlik S, Tomasi M, Luo G. Evaluation of a portable collision warning device for patients with peripheral vision loss in an obstacle course. Invest Ophthalmol Vis Sci 2015; 56(4): 2571-9.
[http://dx.doi.org/10.1167/iovs.14-15935] [PMID: 25788655]

[38] Katz LJ. Does using a low vision aid device improve quality of life in glaucoma patients? 2015. Available from: https://clinicaltrials.gov/ ct2/ show/ NCT02526680

[39] Liu L. Efficacy of Enhancing Low Vision Mobility Thru Visual Training in Virtual World Full Text View - ClinicalTrialsgov, Univ 2015. Available from: https://clinicaltrials.gov/ ct2/ show/ NCT02310880