Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 67 (2015) 57 – 66

Procedia Computer Science

6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2015)

A Study of Universal Design in Everyday Life of Elderly Adults

Moyen M. Mustaquim*

Department of Informatics and Media,Uppsala University, Box 513, 751 20 Uppsala, Sweden

Abstract

The longevity of the aging populations resulting in a demographic gap is an emergent problem in present society. Universal design philosophy is a transfer towards inclusion promising improved solutions for people with diverse abilities. Nevertheless, often in practice it becomes a mere conception. Existing theoretical guidelines as design principles often fail to result in factual universal design. This is particularly worrying for the lifestyle-improvement of disabled older adults, since no standard ways to evaluate the impacts of universal design principles exist. This paper presents the results of a study on the effect of universal design and its practice involving 31 elderly adults from an elderly home. The study revealed that it would be desirable to explain universal design principles in operational terms to measure and relate them in facilitating the improvement of life quality for older adults. Furthermore, this result is anticipated to stress the importance of further assays concerning the modifying of universal design principles.

Peer-review under responsibility of organizing committee of the 6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2015)

Keywords: Universal Design; Design for All; Inclusive Design; Universal Design Principles Assessment; Accessibility

1. Introduction

Since the world is undergoing a major process of demographic alteration, involving the aging of the population, an age gap between young and elderly adults is clearly noticeable. Individuals aged 65 and over in Organization for Economic Cooperation and Development (OECD) countries are 15% of the total working population and this is

* Corresponding with author: Tel.: +46 (0) 703 33 51 46.
E-mail address: moyen.mustaquim@im.uu.se, aunney@gmail.com

Peer-review under responsibility of organizing committee of the 6th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2015)
doi:10.1016/j.procs.2015.09.249

expected to increase by 30% in number by the year 2030.[1] This aging of the population has diverse consequences for society, including issues like pensions and healthcare, and for the general facilities of consumer products and services. However, one of the many alarming concerns in this respect is an aggregate rise of age-associated disabilities. One in every ten people in their fifties has serious impairment in mobility, and this becomes one in every two for people in their eighties.[2,3] Although the status of older people's health makes it ambiguous to predict different age-related disabilities in the future,[4] there is an alarming chance for the growth in the number of people with impaired mobility and disability due to their age. The rise of disability is usual with age for other external causes, which older adults tend to deny for social shame, despite its being a typical part of human life.[10] Besides, a large number of people have some kinds of functionalities that are lesser than the traditional norm apart from the fact that people also may be temporarily or situationally handicapped.[11] This is one of the main reasons why age-related accessibility issues are a growing interest in human-computer interaction research. For example, the approach and case of an EU-funded innovative project, SOPRANO, is worth mentioning here, which is focused on a move away 'from technology-push and problem-focused approach' to the 'user-driven approaches' for benefiting practically the users in everyday life by involving them in the research process.[13] While for elderly adults the 'future of physiological anthropology' is expected to gain more attention by the practice of universal design,[8] many of them at present are still excluded from being able to lead a normal everyday life, due to the lack of proper accessibility convenience. There could be several reasons involved with this, but one important concern that is often overlooked is the misapplication of the term 'universal design' in improving the everyday life of people with different types of disabilities. Many organizational policymakers often use the universal design terminology for commercial success and claim its positive impact on accessibility causes, leaving the true outcome to be achieved. Often in a certain design phase policymakers introduce some new properties in design and later claim them to be universally designed, which in practice is not the case. Therefore, regardless of different guidelines and design principles addressing many different needs for aging populations, it is important that they are well understood by different organizations or developers serving for the aging community[14] so that incorrect policymaking does not occur. Identification of a proper framework is therefore needed for the successful implication of universal design for all and not just the disabled people.[9] But for this to happen, it is important to evaluate present universal design principles to see what is needed for the improving and then translating their outcomes into successful frameworks. This was the underlying rationale behind this research in which the existing principles of universal designs were considered to analyze and see how they would influence the everyday life of elderly adults. The research question here is therefore: 'How do existing universal design principles influence the defining of accessibility issues for elderly adults in their everyday life?' Thus the general research resolution was to find a rationale behind motivating the addressed debate about universal design, predominantly as it applies to the everyday life of elderly adults. As an attempt at answering the research question, an empirical study was conducted (see Method in Section 3) as reported in this paper, when universal design principles were measured for a focused closed group of elderly adults. Section 4 also presents the results and necessary statistical operations that were performed on the collected data set. Section 5 gives an extensive discussion with future work possibilities, followed by the conclusion in Section 6.

2. Universal Design and its Principles

The design of products or environments to be used and experienced by people of different ages and abilities without adaptation is reflected as the primary concept of the universal design.[5] No doubt the concept of universal design is growing around the world and this idea has expanded towards the scope of inclusive design, which specifically extends the definition of universal design by including users who have been excluded by rapidly changing technology, particularly the elderly and aging populations. This, in the long run, prioritizes the role and value of extreme user groups in innovation and in new products and service development. The British Standards Institute[6] defines inclusive design as "the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialized design." Different physical and psychological contexts of use concerning the interactions between products, services, and interfaces are also prioritized by the practice of universal design.[7] The design principles set for universal design described below were developed by a group of U.S. designers and design educators from five research organizations in 1997.[5]

- Equitable Use: The design does not neglect, exclude, or stigmatize any group of users.
- Flexibility in Use: The design should present a wide range of personal choices and their abilities.
- Simple, Intuitive Use: The design should be easy to understand, regardless of the user's experience, acquaintance, language skills, or their present level of focusing.
- Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- Tolerance for Error: The design minimizes hazards and the negative costs of unintentional or unintended events.
- Low Physical Effort: The design should be used proficiently and with comfort, with the smallest amount of tiredness.
- Size and Space for Approach and Use: The design is done in such a way that the appropriate size and space is provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

However, it is difficult to see the implication of these design principles, since they are more used as guidelines. It is not evident that these design principles are followed whenever accessibility issues are dealt with the older adults or people with disabilities. Instead, different focused problems for people with disabilities deal with customized guidelines and design principles in which the universal design principles are merely reflected. For example, researches involving web accessibility guidelines[14–16] could be referred. In this way universal design becomes a concept instead of a practice, which is alarming. Academic research on universal design (UD) itself is therefore needed to overcome this problem.

3. Methods

To discover how the existing UD principles would explain the abilities of elderly adults in their daily life was the aim of this study, which was conducted by a quantitative field experiment for a period of 4 weeks, in Autumn 2011 at Montgomery County's Arcola Health and Rehab Center, located in Maryland, U.S.A. Based on the average household income, this is the richest county in Maryland province and the addressed rehab center has around 200 employees. During the study, the number of patients living at Arcola was 157, out of which 40% were female. The financial levels for the patients were fixed and the money for aiding them comes from Medicare A or B and the Medicaid insurance package of the U.S. healthcare system. A total of 31 patients participated in this study. The patients were selected based on their cognitive ability so that they were capable enough to understand and answer the questionnaires. None of the participants had any kind of mental disability that could affect their understanding of the questionnaires to any extreme extent and their disability was limited within the scope of functional and mobility issues. All participants could hear and see without any major difficulty. At first the basic demographic information was collected from the patients. Around 77% of the participants were female and 33% of the participants were male, with their age ranging from 67 to 93. Most of the participants were not skilled at using the computer and internet but they were familiar with using mobile phones and other assistive technology devices for communication. The basis for our analysis was our questionnaire responses in ranking, based on a scale of 1 to 9. The questionnaire items were designed to understand the different variables that make up the UD principles. The scales used in the research were qualitatively tested with respondents who were demographically similar to the final field work respondents.

The test bed was set up by allowing each patient to answer specific questions that would reflect the principles of UD and their act in the participant's everyday life in Arcola. The subjects were requested to understand the questions properly. When they failed to do so, they were helped by their nurse to understand and answer the questions. The researcher was given permission to have access to the participants during the day at specific times. Usually the evening coffee-break time or during the dinner TV time was when the researcher was able to talk with the participants. The researcher was introduced to the patients by the working nurses who informed them together with the researcher of the purpose of this study. During the process of collecting answers, some participants showed anxiety and even after initial agreement to participate in the survey, they denied answering any questions in the given form. The researcher made an attempt to talk with the nurse and if, after discussing the matter with the nurse, a patient still denied to participate they were by no means forced to and therefore not included in the survey. Thus even though initially the process expected to have 60 patients, in the end the total number of potential participants

resulted at 31. The results from the questionnaires were coded into SPSS V.22 and statistical operations were then run to come up with different conclusions, which are described in the following sections.

4. Results

The 15 questions asked of the participants were classified for reflecting four groups of variables to be an abstract representation of the 7 UD principles, namely: perception (4 questions), design (5 questions), socialenv (3 questions) and learning (3 questions). Statistical operations were then performed on the data set, which is presented here followed by a summary of the results.

4.1. Reliability analysis

The Cronbach alpha coefficient was reported to be .795, in a reliability analysis performed in this research. Therefore the scale used in the analysis could be considered as reliable with the sample of the research. Even though values of some items presented in 'item total statistics table' (not shown here) for the 'correlated item-total correlation column' showed values below .3 and some values under the 'Cronbach's alpha if item deleted column' showed higher than the final Cronbach's value, then there was no need to remove these items since the Cronbach's alpha coefficient was already above .7, indicating the sample data set to be reliable enough with 15 total numbers of items. Table 1 shows the Cronbach's alpha in reliability analysis.

Table 1. Cronbach's alpha in reliability analysis

Reliability Statistics

Cronbach's Alpha	Num. of Items
.795	15

4.2. Correlation matrix

A correlation matrix analysis was made to see how the three independent variables—perception, design, and socioenv—would act in a regression with learning as a dependent variable. From Table 2 it is obvious that all values of p are smaller than .05, which indicates that there could be a true relationship. For learning variables the value of r is highest, indicating the existence of a correlation. So for a regression, learning could clearly be a dependent variable. With $p \leq 0.5$, the degrees of freedom (D_f) could thus be calculated as $D_f = n-2 = 31-2=29$.

Table 2. A correlation matrix for the four variables

Correlations

		Perception	Design	SocioEnv	Learning
Perceiption	Pearson Correlation	1	.349	.267	.444*
	Sig. (2-tailed)		.054	.147	.012
	N	31	31	31	31
Design	Pearson Correlation	.349	1	.255	.345
	Sig. (2-tailed)	.054		.167	.057
	N	31	31	31	31
SocioEnv	Pearson Correlation	.267	.255	1	.656**
	Sig. (2-tailed)	.147	.167		.000
	N	31	31	31	31
Learning	Pearson Correlation	.444*	.345	.656**	1
	Sig. (2-tailed)	.012	.057	.000	
	N	31	31	31	31

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.3. Multiple regressions

Table 3 shows the value of r square to be .519, meaning 51.9% of the variance in the dependent variable learning was explained by the model including perception, design, and socioenv. However, for a small sample size (31) involved in this research, it was often more practical to choose the value of the adjusted r square (Table 3) instead of r square, for better estimating the population. Therefore, we can conclude that at least 46.5% (adjusted r square = .465) of the variance in the model is explained by the independent variables.

Table 3. Model summary table from the multiple regressions

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.720[a]	.519	.465	4.833

a. Predictors: (Constant), SocioEnv, Design, Perception

b. Dependent Variable: Learning

Table 4 shows the correlations between the four variables of the model. Here the independent variables showed a satisfying relationship with the dependent variable learning (more than .3). At the same time, the value of each independent variable is less than .7, which is a support for retaining them all in describing the model.

Table 4. Correlations table from the multiple regressions

Correlations

		Learning	Perception	Design	SocioEnv
Pearson Correlation	Learning	1.000	.444	.345	.656
	Perception	.444	1.000	.349	.267
	Design	.345	.349	1.000	.255
	SocioEnv	.656	.267	.255	1.000
Sig. (1-tailed)	Learning	.	.006	.029	.000
	Perception	.006	.	.027	.073
	Design	.029	.027	.	.084
	SocioEnv	.000	.073	.084	.
N	Learning	31	31	31	31
	Perception	31	31	31	31
	Design	31	31	31	31
	SocioEnv	31	31	31	31

Table 5 indicates the beta values under the standardized coefficients column for each independent variable, indicating that socioenv makes the largest unique contribution among the three independent variables for describing the model. Also the sig values from Table 5 indicate statistical significance in predicting the dependent variable. Socioenv, having the sig value .000 (less than 0.5), thus made a unique and statistically significant contribution to the prediction of learning. The collinearity statistic diagnostics also showed the values of tolerances (Table 5) high above 0, indicating no risk of multicollinearity in our assumptions.

Table 5. Coefficient table from the multiple regressions

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.146	4.284		-.034	.973		
	Perception	.210	.119	.255	1.754	.091	.844	1.184
	Design	.110	.140	.114	.789	.437	.850	1.176
	SocioEnv	.557	.140	.559	3.969	.000	.899	1.112

Finally, Table 6 presents the validity of the statistical significance of the result. The sig value in Table 6 is .000 indicating the meaning of $p \leq .0005$, which confirms the values of multiple r in population equal to 0 and thus can reject the null hypothesis.

Table 6. ANOVA table from multiple regressions

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	680.237	3	226.746	9.708	.000[b]
	Residual	630.601	27	23.356		
	Total	1310.839	30			

a. Dependent Variable: Learning, b. Predictors: (Constant), SocioEnv, Design, Perception

4.4. T-test

A paired sample t-test was conducted to see if there is any significant difference between the scores of learning and perception. While Table 7 shows a decrease in learning (mean value 17.81) with perception (mean value 25.42), Table 8 shows the 2-tailed sig value to be .000 (value less than .0005) indicating that there is a significant difference between these two scores with a degree of freedom 30 and a t-value of 5.419. The effect size statistic was calculated by measuring 'Eta squared' using the formula, Eta squared $=t^2/t^2+N-1= (5.419)^2/ (5.419)^2+31-1= 29.36/29.36+31-1=0.49$. Given that the eta squared value being .14 reflects a large effect, it can be concluded that there was a large effect with substantial differences in the learning and perception.

Table 7. Paired sample statistics table from the T-test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Perception	25.42	31	8.041	1.444
	Learning	17.81	31	6.610	1.187

Table 8. Paired samples test table from the T-test

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 Perception - Learning	7.613	7.822	1.405	4.744	10.482	5.419	30	.000

The scatter plots of three independent variables with the dependent variable learning are shown in Fig. 1.

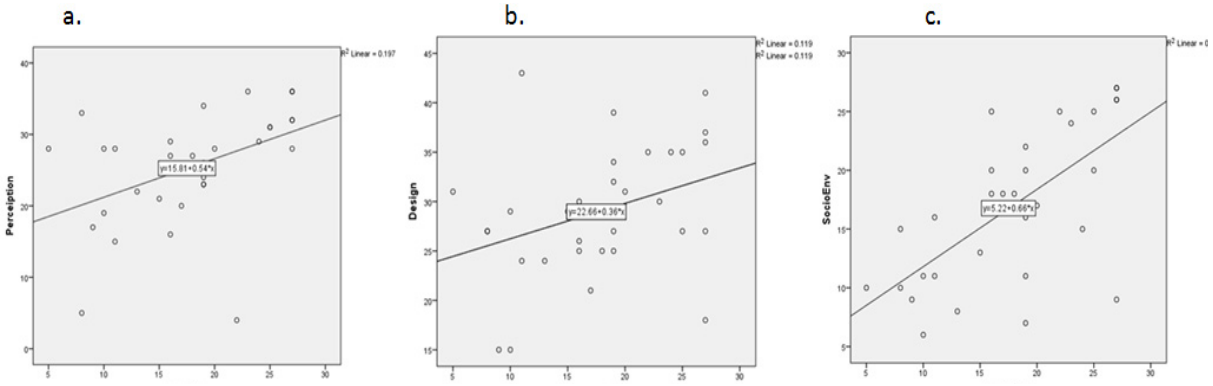

Fig. 1. (a) Scatter plot of Learning and Perception; (b) Scatter plot of Learning and Design (c) Scatter plot of Learning and SocioEnv

4.5. Summary of the results

The result showed that UD parameters defining the learning present a significant difference in describing itself, through the variables that define perceptions. Even though in a regression it showed that learning could be in a regression with other independent variables, the associated scatter plots from Fig. 1 showed there were no close correlations between the respective two variables in each plot. More clearly, this could be interpreted by stating that the way participants learn to use a system was not related to the way different information was presented for them to perceive for the ease of learning. Perceptible information, simplicity in use, and flexibility in use therefore were not properly reflected from the answers of the participants. Considering the effect on design variables, similar conclusions could be drawn for the low physical effort and simple intuitive use of design principles. On the other hand, multiple regressions suggested that it is not possible to omit any of the variables deflecting these design principles, but it was important to retain them. Therefore, it would be practical to point out the underlying cause of this result towards the failure of the appropriate application of UD in the everyday life of elderly adults from this study. One interesting point to note here is that the patients reflected about social features that could be improved by the concept of UD and its principles. The socioenv variable showed significance as an independent variable in defining the learning of the participants, but no such parameters have been addressed in UD principles to date. In a

multiple regression the social variable showed the highest unique significance in defining learning in the model, which also supports the importance of this parameter to be included in UD principles. These findings also reflect that it is important to understand the existing UD principles, which at present do not really suffice for the design of proper inclusiveness and accessible everyday life for elderly adults.

5. Discussions and Future Research

The core argument behind this research was that it would be desirable to develop an operational concept of physical disabilities and mobility. This would allow the measurements of a group for benefits associated with individual measures. More generally, measures to enhance the mobility and disability of elderly people may help them live independently in their own homes or in elderly care centers for longer, which generally would both meet their desires and reduce the cost of long-term care for the society. This approach would be particularly valuable, while UD principles could potentially fit into working in the everyday life of this focused user group, since, as discussed earlier, the loss of mobility and disability of different types increases with age. In the long run, this in turn would make it possible to assess the impact of measures aimed at enhancing the mobility and disability of older people. One interesting finding from this study worth mentioning here is that regardless of the participants' suffering from different types of disabilities and living in a system that was not inclusively designed following the UD principles, they still did not feel the need of different features in their daily life promised by UD. Instead, they showed interest on a new issue, like social factors. Adding new parameters for extending UD principles is thus appropriate for designing proper accessible systems and surroundings for elderly adults.

While mainstreaming 'UD in the everyday life of the elderly adult' has been one of the prime aims of accessibility research, the possibility of achieving this could be made higher if 'universal design' itself could be mainstreamed. Newell and Gregor in this respect stated that the ambition of designing for 'everyone' could actually discourage designers from taking the first step towards inclusive design and thus the UD concept might work as a 'barrier' for increasing accessibility.[11] Therefore the research in HCI should consider the diversity of users, since disabled people are not a smaller population group[11] to not be included in this diversity. Still, the use of improper design principles may result in accessible designs that might not be suitable for a larger population group with diverse user requirements and disabilities. This is why restructuring the UD principles is required. In this respect the example of the WAI-AGE project could be referred as a support to this research. In this project a deep understanding of the elderly and disabled people's needs were highly focused within the context of web accessibility for formulating a set of specific actions.[14] This paper's core idea can thus be mapped within the similar concept of deep understanding of the focused user's needs through the modification of UD principles.

Often guidelines are classified into two major categories, namely the academic and industrial, which overlap with each other highlighting the same problem in different phrasing.[15] This particularly is important in the context of this paper. It seems that the UD principles (guidelines) were not academically researched, and instead were derived and standardized from practical experiences. A lack of in-depth academic research on UD principles has left a room open for initiating different misunderstanding and misinterpretation of what UD is, how it should be practiced for the older users, and how the users' needs should be discovered properly for the successful practice of UD. This probably has created a lot of wrong policy alterations by the different decision-makers in organizations. UD is identified to be a vital research area for which more action research studies are needed for further knowledge development.[18] The attempt that was taken in this paper thus could also be seen as a motivation towards mixing the practical experience and academic research on the topic of UD principles for overcoming different misunderstanding of UD for furthering its knowledge. In this respect, International Classification of Functioning (ICF)[17] by WHO is worth mentioning, which could be great guidelines for planning in different levels of the system, since the individual's functional problems were taken into consideration as a societal responsibility in the ICF disability index.

Regarding the scope of HCI and UD research, a few words are important to mention here that have originated from the results of this research. It is important to remember that participants' association with no technological system was exclusively measured through the survey questionnaires. The objective here was to see how UD was being practiced in an environment in which it is supposed to be optimally reflected in the everyday life of elderly adults in a caregiving home that claims to follow UD in the settings, which definitely consisted of the use of basic

technological systems like the mobile phone and television. However, HCI is now not only about direct human and machine interaction anymore, and has a broader multidisciplinary possibility. Considering that UD is a design philosophy practiced widely in HCI, the scope of HCI research could surely be extended by the addition of new knowledge into the design principles. Thus the extended design principles could be seen as an extension tool for an existing design that needs to be improved where accessibility may or may not be an issue. Because it is often a misunderstood common opinion that UD is the design for accessibility only is given and practiced for numerous reasons, namely money and clients' backing.[18] The traditional concept of UD could be extended and practiced for the enhancing of the usability of a design.

However, elderly adults in their daily life were one of the fields in which UD principles were evaluated in a very small-scale setup in this research. One important next step for this research could thus be the assessing of UD principles in other research scopes of interest. For example, video games and the use of UD were assessed in one study when the reported results indicated a non-stability of UD principles[12] and thus could be compared with the results of this research. Identifying the universal accessibility design principles is another research that could be initiated from this study's results. The findings here can help in order to identify, edit, and formulate new design principles that would not only be appropriate as general design principles, but could also be included in bigger accessibility problem domains under the reflection of using the same design principles.

6. Conclusion

The purpose of this study was to understand how well the different parameters from the UD principles are perceived by the elderly adults in their everyday life in a setup at which they use assistive technologies and are users of other systems and designs that are meant to be designed for them. A quantitative study result here indicated that UD principles were barely reflected as a cause for supporting this purpose. Statistical analysis performed on the collected data set showed that in the study setup the elderly peoples with disability were not concerned about the UD practice, and neither were they aware of what to expect in a setup at which they spend their daily life. The result also showed that participants subconsciously demand other factors to be important and be included in their system (social factor) which at present is not reflected through UD or its principles and practice. It was concluded in this research by arguing that the factors of UD principles are therefore in need of improvement through modification so that they could be successfully used to improve users' experiences. UD principles have been now established for nearly two decades and they act as a foundation for measuring and evaluating accessible designs. The findings from this study have shown that existing design principles were not completely appropriate for defining the accessibility for the elderly adults. Thus, this result also stresses the overtures of further empirical evidence to push forwards the arguments of refining the UD principles in effect.

Acknowledgments

The author would like to express his heartiest gratitude to the occupational therapist, Mary Modderman, who helped him get involved with the Arcola Health and Rehab Center. The author would also like to thank different working nurses in the Arcola Health and Rehab Center for their help during the data collection for this research. The author's deep respect and gratitude goes to the different involved patients who actually made this study happen.

References

1. Organization for Economic Cooperation and Development (OECD). *Fostering Entrepreneurship*. Paris: OECD; 1998.
2. Krettzman, L. Licensed to Drive at 85? A Report on the Mobility Needs of Older People in the Next 25 Years. London: Help the Aged; 1996.
3. Martin, J., Mbltzbr, H., Elliot, D. The Prevalence of Disability among Adults, London: HMSO for Office of Populations, Censuses and Surveys; 1998.
4. Metz, D. Can the impact of ageing on health care costs be avoided? *Journal of Health Services Research and Policy*, 1999; **4**:249-52.
5. Center for Accessible Housing. Accessible environments: Toward universal design. Raleigh: North Carolina State University; 1995.
6. British Standard 7000-6:2005. Design management systems - Managing inclusive design – Guide; 2005.
7. Langdon, P., Clarkson, J. and Robinson, P. Designing accessible technology. *Universal Access in the Information Society*, 2007; **6:**117-8.

8. Crews, D.E., Zavotka, S. Aging, disability, and frailty: implications for universal design. *Journal of Physiological Anthropology*, 2006; **25:**113-8.
9. Marcus, A. Universal, ubiquitous, user-interface design for the disabled and elderly. *Interactions*, 2003; **10**: 23-7.
10. Story, M.F., Mueller, J.L., and Mace, R.L. The Universal Design File: Designing for people of all ages and abilities, 1998.
11. Newell, A.F., Gregor, P. Design for older and disabled people–where do we go from here? *Universal Access in the Information Society, 2002*; **2:**3-7.
12. Mustaquim, M.M. Assessment of universal design principles for analyzing computer games' accessibility. *Springer Berlin Heidelberg*, 2012; 428-35
13. Sixsmith, A.et al. SOPRANO–an ambient assisted living system for supporting older people at home. Ambient Assistive Health and Wellness Management in the Heart of the City. *Springer Berlin Heidelberg*, 2009; 233-6.
14. Arch, A., and Shadi, A.. How web accessibility guidelines apply to design for the ageing population. *Proceedings of Accessible Design in a Digital World Conference*, York, UK, 2008.
15. Zaphiris, P., Kurniawan, S. and Ghiawadwala, M. A systematic approach to the development of research-based web design guidelines for older people. *Universal Access in the Information Society*, 2007; **6**: 59-65.
16. Arch, A. Web accessibility for older users: successes and opportunities (keynote). *Proceedings of the 2009 International Cross-Disciplinary Conference on Web Accessibility* (W4A). ACM; 2009.
17. World Health Organization. How to use the ICF: A practical manual for using the International Classification of Functioning, Disability and Health (ICF), 2013.
18. Björk, E. Many become losers when the universal design perspective is neglected: exploring the true cost of ignoring universal design principles. *Technology and Disability*, 2009, **21.4**: 117-25.