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Decision Support System for Evaluating Accessibility of Facilities

Judith Bendel

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Abstract

This article describes an information system for analysis and decision support for the evaluation of facilities' accessibility for the elderly and for people with disabilities. The system is used to provide consistent, updated, reliable and objective information for accessibility audits of home and public facilities, based on the specifications of the official guideline requirements. With the existing knowledge it is adaptable and applicable as an audit tool in areas other than physical accessibility in any country.

People with disabilities are a significant segment of the population. Depending on the definition used, about 10%-21% of the world's population are disabled individuals. The elderly population consists of an additional 10% (Kostanjsek, 2005; Xingyan, 2003; U.S. Census Bureau, 2004). This population has special access needs for performing activities of daily living.

Accessibility in all types of environments, including public facilities and homes, enables the integration of people with disabilities into society, increasing their independence and improving their quality of life. Inaccessible public facilities violate the motto "access for all". Disabled individuals may be unable to consume services of such facilities, which, in turn, lose the business of this sizable population.

Over the past two decades there has been a gradual paradigm shift for disability measures from the medical model to one focusing on the interaction between a person

Judith Bendel, PhD, Access Unlimited, Director of programs and information center, 17 Bilu St., Kfar Sava, Israel. bendelj@hotmail.com

and multiple factors in his environment (Stein, 2004). Whereas the medical model measures the individual's degree of impairment and dysfunction (Law, Baum & Dunn, 2000), proposing to "fix the person" in order to overcome his disability, (Jette & Badley, 2002), the current model "focuses on the dynamic interplay of the person and environment rather than the individual or environment alone" (Thapar, et al., 2004 p. 280). This paradigm of disability has been advanced by various national and international groups, including the World Health Organization (WHO, 2002).

Iwarsson & Stahl (2003) suggested an instrumental, three-step definition of accessibility, emphasizing the need to integrate environmental and personal components when analyzing accessibility: 1. Assessment of functional limitations and dependence on mobility aids; 2**.** Assessment of environmental barriers; and 3. Calculation of a total score, that is, a predictive measure of the degree of accessibility problems.

Many countries have laws, regulations and guidelines for barrier-free design. These guidelines, although often similar in nature, vary from country to country. It should be noted that in many countries, including Israel and the US, the standards refer to minimum requirements (ADAAG, 2002, The Standards Institution of Israel, 1998). There are many cases in which enforcement of the guidelines is problematic, and there are buildings that do not fully comply with the requirements. For example, a study of 120 restaurants in three U.S Midwestern states (McClain, et al., 2003) revealed only partial compliance with regulations. For example, only 53% of the restaurants surveyed provide handicapped parking and only 66% of the restaurants that required a ramp, provided them.

In Israel, as in the U.S., full compliance with the standards is required only for construction of new buildings and alteration of existing buildings. Structural barriers must be removed from the latter on the condition that this may be easily accomplished. If complying with the Standards is not readily achievable, modification that does not fully comply, may be performed on the condition that it poses no health or safety risk. The regulations do not define what changes would be accomplished easily and what expense is required for a facility to meet its obligation to remove barriers. The judgment is made on a case-by-case basis by the planner (architect or engineer) of the facility. Should a private individual bring lawsuits to enforce their rights or file complaints with federal

agencies, the decision will be made in court. Since the degree of difficulty in removing barriers changes over time, accessibility issues should be re-evaluated annually (Adaptive Environments, 1995)

Evaluations for Facility Accessibility

There are guidelines but no official audit tools to assess compliance. The existing data collection tools are not supported by data analysis tools. Several authors focused on identifying instruments that measure the built environment. The Enabler (Steinfeld & Danford, 1997), for example, assesses private homes. Its premise is that accessibility problems arise in the relation between the individual and the environment.

Enabler users first assess their "functional profile", choosing from 15 possible functional deficits (such as severe loss of sight, difficulty in moving head, etc.). The "problem identification matrix" indicates whether each of the design characteristics constitutes a potential problem, a problem, a severe problem or an impossibility for persons characterized by the 15 physical, sensory and cognitive deficits noted on the Enabler. This matrix requires interpretation and substantive knowledge of the functional impact of each deficit/impairment to determine a potential problem for a user. It clarifies the unique situation of each user and emphasizes the implications of design decisions. Although The Enabler is not an instrument for quantifying accessibility of buildings or other aspects of the environment, assessment sections for public places are currently being developed and tested for the use of public transport by people with functional deficits.

Iwarsson (1999) modified the Enabler matrix to include items referring to the immediate surroundings of the residence, entrances, the indoor spaces, and communication. To improve validity and reliability of measurement, these items correlated with norms for accessible housing promulgated by a Swedish organization (Iwarsson & Isacsson, 1996). Adherence to each individual norm is relevant to potential users' impairments. For example: "No telephone with amplified sound" creates a communication impossibility for persons with severe loss of hearing, however is not a potential problem for other types of disabilities. Scoring is judgment-dependent and therefore training in administering the tool is recommended in order to ensure inter-rater reliability (The Enabler website, 2005).

Other tools attempt to assess hazards that persons with physical or cognitive deficits face in their homes, with the ultimate purpose of predicting and preventing falls and other injuries. Most of them have taken a familiar road to quantification: develop a bank of items that each constitutes a risk (i.e., loose rugs, dangling power cords, lack of grab bars, etc.), assign points for presence or absence, and add up to obtain a residence hazard score (Clemson, Fitzgerald, Heard & Cumming, 1999). Two such instrument are the HEAP (Home Environmental Assessment Protocol) and the Safer Tool. The HEAP (Gitlin, et al., 2002) addresses an individual's functioning in one section. Unlike the scoring of accessibility checklists, absolute standards often are not used in home risk assessments, which rely on observation of the individual in his or her residence and are largely subjective. (Reliability scores using the Kappa test showed poor results; <0.60 on 35 out of 63 items which were tested in 22 houses)

The Safer Assessment of Function and the Environment (Letts & Marshall, 1995) is based on the assumption that falls or other negative outcomes result from an interaction between the environment and the individual. Reliability scores using the Kappa test showed very good results; 0.80-1.00, on 53 out of 97 items which were tested in 23 houses. (Letts, Scott, Burtney, Marshall, & McKean, 1998).

Accessibility checklists

Accessibility checklists are used to assess the degree to which both existing and new buildings satisfy legal criteria for access. The purpose of the Americans with Disabilities Act (ADA) checklist for Readily Achievable Barrier Removal (Adaptive Environments, 1995), for example, is to "help you identify accessibility problems and solutions in existing facilities, in order to meet your obligations under the ADA" (Adaptive Environments, 1995, p. 2). This tool checks for compliance with the ADA Accessibility Guidelines (ADAAG, 2002) and has been widely used in the U.S. since the passage of the ADA. However, in his review, Dijkers (2003) found no reliability data for most of studies that used the checklist.

Some items in most standard checklists are measurable, and others require yes/no answers. As no data analysis tools are available, analysis is limited to summing the number of non-compliance items. Most access guides and websites, especially in the tourism industry, include descriptive information as well. Some (i.e., Accessible San

Diego - www.accessandiego.com) specify accessibility for people with specific disabilities or needs, such as wheelchair users, the hearing impaired, etc. Tourist facilities are usually evaluated by a professional visitor who uses a checklist, adding his own personal impression. This person could be a professional (architect/accessibility expert, occupational therapist, or rehabilitation expert) or a non-professional user or surveyor. Sometimes the checklist is completed by a client or by the owner of the facility. This type of analysis may result in subjective and biased information.

The definition of accessibility is complicated and many details are needed to begin to meet the needs of people with a wide range of disabilities. Each detail does not stand alone; therefore, the sum of the non-compliant items is not always an indication of accessibility. For example, if access to all rooms and services in the building fully comply with the standards, but the entrance door is too narrow, a simple count will show that only one item does not comply with standards. The surveyor may mistakenly conclude that the building is accessible, when in fact it is totally inaccessible to a wheelchair user, who cannot enter the facility. Dijkers (2003) found that at this point no objective characterization of the barrier/support was available and therefore suggested that researchers use actual measurements of slopes for example as an independent quantification barriers/supports tool.

Very few attempts have been made to construct data analysis tools. An accessibility assessment model was developed in Korea to calculate an accessibility index for public information kiosks. The model consists of eight terms to be considered in kiosk design and operation. The index was organized such that it quantitatively and objectively assesses the accessibility of such kiosks (Seongil & Cho, 2004).

The first step in addressing the demand to provide accessibility is to share consistent, reliable and objective access information. Adaptation of facilities must be in accordance with standards required by law as well as with the personal needs of the consumer. In order to provide such information, there is need for a valid and reliable accessibility evaluation tool (Dijkers, 2003).

Objectives

This article aims to present a computerized audit tool and a decision support system

model for evaluating accessibility of existing public facilities, to be used by architects/accessibility experts, occupational therapists, and/or rehabilitation experts. The result of the audit enables public, private and non-profit organizations to estimate the amount of work and cost required to adapt a facility so that it may be used by all consumers. The decision support system, developed by the Access Unlimited [*] expert team, focuses on the interplay between the individual and the built environment. This system highlights items in the facility requiring adaptation or upgrading to better meet the user's needs, and prioritizes items for implementation.

Description of the Decision Support system

The decision support and grading system is a unique, reliable and bias-free tool, based on mathematical equations (detailed below). The equations are defined to grade accessibility of specific elements and spaces separately (i.e. parking, entrance, restrooms, food services etc.), by type of disability. Other equations are defined for an overall weighted grade of the whole facility. The grades are type of facility and type of disability specific, as described below.

Grades are given on a scale from 1-4, i.e. 4 = inaccessible; 3= requires assistance; 2= accessible but does not meet all specifications of the standards; and 1 = accessible according to national standards.

The system is flexible – the individual guidelines and requirements of any country can be applied, allowing this grading system to be applied worldwide (only grade 4 requires adjustment to national standards). So far the Israeli standards and the ADA guidelines were applied. It can therefore be used as a universal grading system, presented to the customer by universal symbols. The analyzed information can be displayed in many different forms, ranging from a full detailed report of the findings through customized reports for different users, reports that may aid in decision-making for occupational

Note. [*] "Access Unlimited" is a non-profit organization. Its main goal is to promote accessibility to public environments, tourist and recreation activities, and to provide information for people with various disabilities. Staff members (rehabilitation advisor and rehabilitation experts) consult on adapting buildings and sites, carry out research on tools for assessing accessibility and Design for All, and provide tools for evaluating the accessibility of existing facilities with the goal of eliminating barriers. They also provide counseling, promote awareness of the needs of people with disabilities, and develop empowerment programs for these individuals.

therapists and architects, as well as other professionals, regarding priorities of implementation.

Population. People with physical or sensory disabilities which may influence their ability to use public facilities during the performance of typical daily activities were referred to use this system. There are four major disability groups: wheelchair users, users of crutches or walkers, individuals with visual impairments and individuals with auditory impairments. Analyses of the access needs of people with mental disabilities are in testing stage.

Methodology

The data collection tool

A questionnaire based on the Israeli standards for accessible design (Israel Ministry of Housing, 2004) was created in cooperation with individuals with various disabilities. Some questions require a measurable answer and others, a yes/no answer. To avoid subjective responses, no questions require personal judgment. The questionnaire is comprised of items pertaining to the required standards (in terms of size, design etc.). For example: Restrooms: width of clear opening of door, type of door knob: lever/turning, what is the distance between the center line of the toilet seat to the side wall, etc. In addition the reactions of individuals with disabilities to the accessibility of various facilities was added (for example, distance of service location from entrance or availability of rest areas)

At each site/building visited, information is collected regarding its suitability for individuals using wheelchairs, crutches or walkers, and for those with visual or auditory impairments.

The questionnaire was pilot-tested in several types of facilities by the Access Unlimited team together with people with mobility, visual, or auditory impairments, during the first half of year 2000. The facilities visited included three museums of varying sizes, three types of accommodation facilities (hotel, youth hostel and bed and breakfast), a promenade, three community centers with sports facilities, three municipality/local authority buildings, three school buildings and two banks. At least two people audited each facility.

The activities of the individuals with disabilities were observed, and their comments were used to improve the questionnaire. Inconsistent responses to two questionnaire items ("approach path to the building" and "the entrance") were found. Some respondents included steps close to the entrance as part of the information regarding the entrance, others considered them to be part of the path, and yet others noted the same information on both items). Some respondents suggested adding items (i.e., providing a special key to operate an elevator no operated by an attendant) not included in the standards to the questionnaire for a more comprehensive audit.

The questionnaire is continuously being tested and revised. Surveyors (professionals and students) of studies by Access Unlimited are trained to present the questionnaire and learn how to take measurements. Data on the first 10 buildings in each survey (out of 8 surveys of 30 - 150 buildings each) are collected by at least two people, to confirm reliability. Formal reliability testing is planned for the questionnaire, however none has been performed yet.

Data analysis model and equations

Formulae based on mathematical equations were developed for data analysis to provide the accessibility grades. The equations consist of Boolean operators ("and" & "or" & "not") combining the questionnaire components.

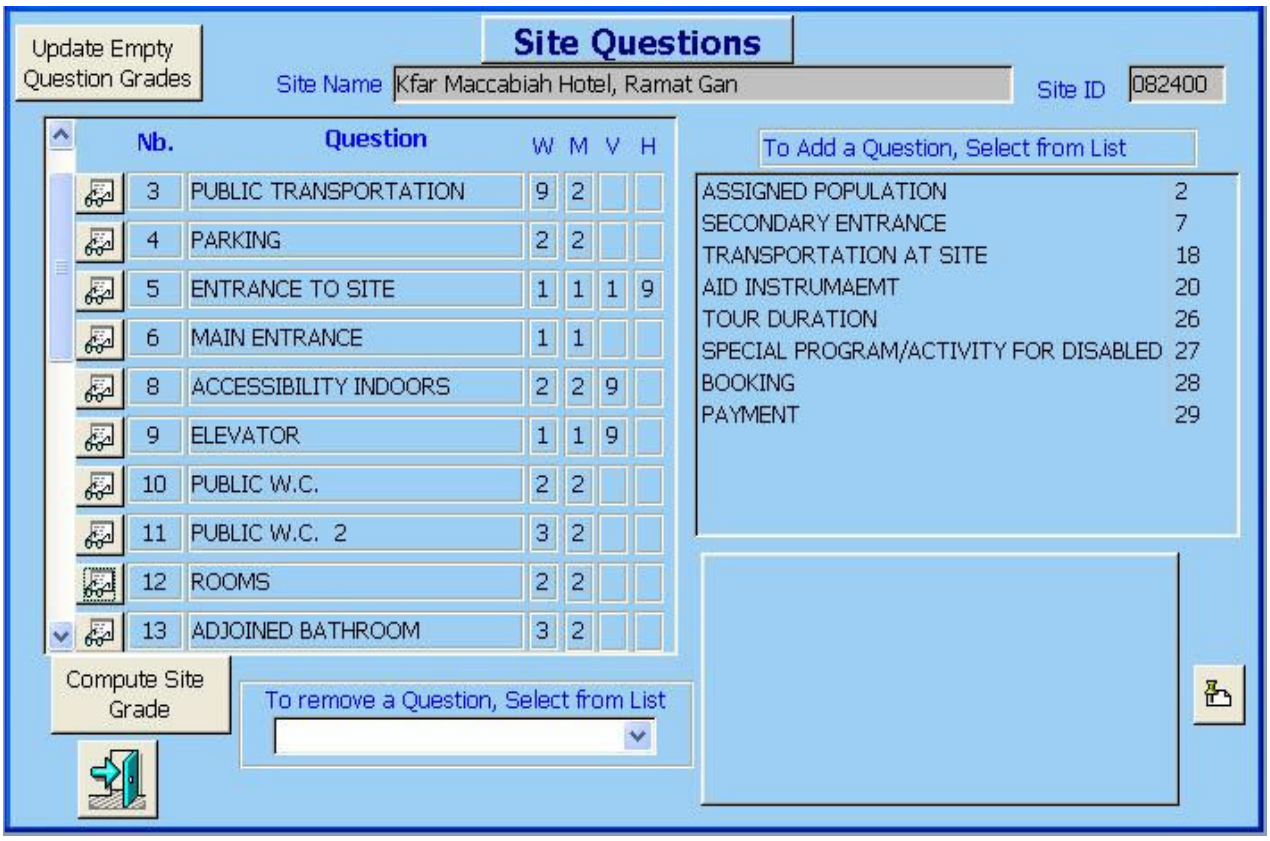
The formulae were defined by a multidisciplinary team of experts (rehabilitation and accessibility experts, including a rehabilitation advisor and an architect who are also disabled). They were also discussed with researchers in the U.S. (in a rehabilitation center, in a center for universal design and in a university Occupational Therapy department) as well as with architects, with experts in accessible tourism in Europe, and with accessibility expert at the Standards Institution of Israel. The standards are based on the multidisciplinary expert consensus rather than on rigorous scientific evidence.

There are two sets of formulae. The first set consists of 104 formulae, each one defining the accessibility of 26 specific elements in the building and its surrounding (parking lot, entrance, etc.), each element relating to each of the four major types of disabilities mentioned above. For example, the formula for an accessible elevator for the visually impaired is:

availability of visual directional signage on pathway & signage is mounted with centreline 150 cm. from the floor & size of the letters is at least 22 mm. & availability of tactical directional signage on pathway & availability of tactile stripe in front of the entrance door & (raised characters **or** Braille on control buttons) & (verbal **or** audible door opening and floor indicators).

In other words, if the specific element in the building complies with all requirements for wheelchair users according to standards and behaviours (as defined in the questionnaire), the element will receive a score of 1 in the wheelchair category. However it will receive a score of 2 if it is wheelchair users can access it, even if some of the components do not fully comply with the guidelines (for example, the toilet will receive a score of 2 if all components comply with the standards except, for example, that the length of the grab bar near the toilet is shorter than required, but is usable). Figure 1 illustrates the scores for each item for each disability category printed from the database screen upon data entry.

Figure 1



This approach considers the interaction between the individual and the environment, as well as possible combinations between the different elements of design. Variations in design are considered in the definition of the formulae. For example, a bathroom will be considered accessible by wheelchair if the door opens inward (according to standards it should open outward) but the size of the cubicle allows for adequate manoeuvring space when the door is open.

The second set of formulae defines the overall accessibility according to type of buildings/site and to type of disability. The buildings/sites were grouped into eight major categories (such as accommodations, sports facilities, cultural centers, and open sites, including parks, promenades, etc.). There are a total of 32 formulae in this group. The overall weighted grade of the building's accessibility is computed base on all the services available and the building environment, using the grades of each element (determined by the first set of formulae): access from public transportation, parking lot, and pedestrian path, vertical and horizontal circulation, availability of aid devices and technologies as well as additional information which is not included in the standards or guidelines (for example: availability of alternative services to compensate for insufficient or difficult access, such as valet parking, alternative space for receiving service etc., or location of the key for locked rest rooms). The relative importance of each element and the connection between elements are considered in the definition of the formulae

As behaviour of people in public buildings is related to the type of service given in the building, the usability of the building is analyzed accordingly. Therefore, the formulae for a bank, for example, will differ from those of a sports facility. Gym, swimming pool, changing rooms and toilets are elements with high relative importance for people who visit a sports facility. However in a bank, elements with a high level of importance include service desks, automatic teller machines, etc., with the relative importance of adapted toilet for clients with disabilities (not employees) being low, as a person usually spends just a short period of time in the bank while doing business.

If all the elements at the site/building comply with all requirements (as defined in the questionnaire), the building will receive a score of 1 in the wheelchair category. However it will receive a score of 2 (functional) for wheelchair users if all the relevant elements

received a score of 1 or 2 (for example, if the entrance and various elements of vertical and horizontal circulation score 1 but the parking lot and the toilet score 2, then the total score will be 2).

Data processing and reports

A database was created to accommodate the information collected with the mathematical equations integrated into it for a built-in scoring system. Site-specific information is collected and coded based on the questionnaire described above, in a user-friendly input system. Scores are automatically generated upon data input. In this way no bias related to the data collector's perspective or personal impression is involved. The scoring system helps avoid mistakes that may occur by analyzing the data manually and facilitates presentation of the analyzed information in a variety of forms.

Reports generated automatically by the system include detailed access information, highlighting for the reader the accessibility level of the site, for an easy first screening of the building/site, followed by some further details describing relevant information within the site. Special reports designed for planners or site owners, present specific relevant items in the facility which were found non-compliant with the guidelines and need renovation or upgrading. These reports highlight the relative importance of the item with a pointer to the relevant requirement, for decision making purpose. Furthermore, selected information and grades of building/site can be extracted from the system and used as input to other media, such as website application, city maps or tour guides.

Applicability to other countries

The highest grade (1 = accessible according to standards) is country-specific. (As mentioned above, the standards differ from one country to another). However, all other grades are applicable universally. For example, grade 2 (accessible but does not meet the standards) can be viewed as a universal usable accessibility grade/score. Even though the site does not meet the standards of one country (and therefore not totally accessible), the facility is usable. The system is designed to allow flexibility for changes in standards and guidelines, as well as for progress and technical innovations. The model can be applied to other types of disabilities as well.

Advantages of the system

- The decision support system integrates many details and combinations, according to local guidelines.
- The results of the information analysis are consistent and bias-free.
- No personal judgment is required.
- It accounts for a wide range of access needs for each type of disability.
- The system is flexible to allow for updates, changes of standards and technical innovations.
- The grading system is adaptable to any country's standards.
- The analyzed information can be presented in many different forms.
- This accessibility audit tool is appropriate for different users: policy makers, designers, professionals, services, organizations and consumers.
- The use of the system saves time as data analysis is done instantly upon data input and does not require manual analysis on the many details involved.
- The system is adaptable to any language written horizontally (Right /Left).

Currently the system is on a stand-alone computer and is not yet available for use on the internet. Only authorised users can process the system's data. Occupational therapists and other users could use the system by submitting data they collected according to specific guidelines given by Access Unlimited and have it processed within hours. The system was initially created for the use of public building evaluators, namely accessibility advisors, architects and heath-related professionals such as occupational therapists. It is flexible and adaptable, fulfilling different functions. With minor modification, occupational therapists may apply this system when performing home evaluations and when assisting individuals in adapting their home environment to their needs.

Implementation

The DSS was implemented in surveys of various types of public facilities, including in approximately 150 health care facilities. Reports focusing specifically on the items found to be non-compliant with the guidelines, emphasizing the requirement, were used to plan renovations. To date, no formal validity test was performed however facility owners and

the architects responsible for planning the renovations reviewed all buildings, finding the reports to be reliable. The reports were helpful in making decisions regarding the action needed and in calculating the cost involved (for example, the decision regarding one building was to move to another location, as adaptation was technically complicated or too costly) and by architects to plan renovations for the audited facilities.

Several surveys done by the cities of Tel Aviv and Ashkelon implemented the DSS and its results were used by city planners. Other surveys were carried out on university campuses (the Hebrew University of Jerusalem, Rehovot campus, Bar IlanUniversity, Kiryat Ono College,) to plan renovations to improve accessibility. Approximately 2500 public buildings were audited to date. The tool was also used in a national survey (for the Commissioner of Equal Rights Office) of approximately 600 facilities including health clinics, banks and schools, to create statistical data on accessibility of various types of facilities. It is currently being used in an exercise of a public building evaluation project of students in the department of Occupational Therapy department at a U.S. university.

DSS for Tourism

Information for disabled tourists may be found on the internet (www.access-unlimited.co.il) and in tour guidebooks (Bendel, 2002; Bendel, Gur & Kalkuda, 2004). Although no formal reliability test was performed, consumer satisfaction (regarding the accuracy of sites evaluated, usefulness of information for planning vacations, etc.) was expressed in writing by many to Access Unlimited as well as to the State of Israel Ministry of Tourism. The guidebooks (including approximately 1,000 sites) enable visitors to choose sites (including, museums, holy sites, accommodations, restaurants, theaters, etc.) based on their individual needs.

The grading system facilitated highlighting the accessibility level of each site, providing relevant information about it. The grading system was also used for presentation of data in a guidebook for the general population, (Carta Guide, 2003), in a city map (Survey of Israel, 2004), and in an audio guide (Tour-Man, 2005).

Conclusion and recommendations

This article clarified the need for an audit tool that provides consistent, reliable and objective access information for planning according to universal design. The DSS consists of an objective data collection tool, supported by a data analysis tool. The

mathematical equations used to assess accessibility are defined based on the interaction between disability and environment, as well as on possible variations of accessible design. The automated data analysis tool provides for consistent and unbiased results.

The DSS is based on universal values. The technology can be adapted to industries such as home design and to private homes and can be used by public municipalities and public, private or non-profit organizations striving toward the inclusion of individuals with disabilities.

Research is recommended to obtain reliability and validity data (including validating the system's usefulness in countries other than Israel). The system is slated to be adapted for use by occupational therapists in home evaluation and its internet application is being developed as well.

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