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A Comparative Study of Standardised Tools for Assessment of Environmental Fall-Hazards

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Abstract: The purpose of the current study is to identify a tool for assessment of environmental fall-hazards in residential spaces of elderly persons that is reliable for application in empirical studies for building and environmental design.

Six standardized tools that were designed for the assessment of environmental fall-hazards were recruited for the current study. A comparative study of the tools was conducted to identify criteria for reliable assessment.

Eight criteria of environmental fall-hazard assessment tools were identified. The study could not identify any tools that satisfied all eight criteria. The Housing Enabler tool was found to be the most versatile tool among the six tools selected for the study. However, the tool requires slight modifications for reliable applications in countries other than Sweden. It was observed that the majority of the tools did not consider the effect of perceived environmental fall-hazards, user opinions, the intensity of risk imposed, and the functional ability of the user as criteria for assessment.

Key Words: Elderly, Falls, Environmental fall-hazards, Hazard-perception, falls-prevention, Assessment tools.

I. Introduction:

Nine percent of the global population was above 65 years of age in the year 2019. It is estimated that 15.9% of the world population will be above 65 years of age by the year 2050 (United Nations report on World Population Ageing report, 2019). This indicates that every, one in six persons will be above the age of 65 years by 2050. The recent research trends have focused momentously in the area of health, safety, and better living conditions for the elderly persons.

Falls are a major concern in the elderly and fall incidents are mostly fatal in old age and could hinder the health and well-being of the person to a great extent. A home environment should ensure safety against accidents and prevention of falls to help the elders live without physical and psychological barriers. Interventions to prevent falls by home modifications have proved to improve the situation (Stevens et al, 2001; Lord et al, 2006; Clemson et al, 2008). Research in this area is largely dependent on the reliable assessment of home environments for identifying environmental fall-hazards to propose solutions for fall-prevention interventions.

There are many standard and reliable home-safety assessment tools developed majorly by occupational therapists for clinical and research purposes. However, the reliability of the available standardised tools for empirical studies related to building and environmental design has to be explored. The purpose of the current study is to identify a reliable tool for assessment of environmental fall-hazards for application in empirical studies.

II. The Methodology of Study:

A systematic review of the literature was conducted using web search engines to identify scientific papers based on the key-words of the study. Fifty-one papers were identified. Thirteen papers were excluded based on their relevance to the topic and one unpublished paper was excluded. Thirty-seven published research papers were selected for the final literature review. In the first phase of the study, six standardised tools for assessment of environmental fall-hazards were selected after the exclusion of three tools. The criteria for exclusion were based on relevance to the current study, validity, and reliability of the tools.

In the next phase of the study, the literature was reviewed to identify types of environmental-fall hazards in residential spaces of the elderly to analyse the tools for their range of assessment (Table II). A total of fifty-five environmental fall-hazards were identified from the available sources and were categorised into eleven types of fall-hazards (Table I) for ease of application. The six standardised tools were reviewed for a comparative study to identify the criteria for reliable application in empirical studies.

III. The environmental fall-hazard assessment tools

1. West mead Home Safety Assessment (WeHSA) Tool:

The West mead Home safety Assessment (WeHSA) tool was designed to identify environmental hazards in homes of elderly persons. The first version of the WeHSA was developed by Clemson et al (1992) as a preliminary step to a major research project (Clemson, 1996) on environmental hazards in homes of elderly persons who have fallen and suffered hip fractures. The checklist consisted of 72 items, which were selected based on the literature review and the advice of an expert committee of occupational therapists.

Each item was coded as a potential hazard, not a potential hazard or not relevant. Potential hazards identified were defined with the details of the particular hazard. 'Not relevant' were items that were not present or never used by the subject. The study presented acceptable levels of inter-rater reliability for most items and 19 items needed further development. The checklist was further modified into 35 items (Clemson et al, 1996). Further revisions were made to make the tool a criterion-referenced tool (Clemson, 1997a), which gives categories of hazards in the home and also provides the opportunity for the researcher to determine if the hazard category is relevant for the particular client. Inter-rater reliability (Clemson, 1996) and content validity (Clemson, 1999) was established for the tool. Operational definitions of key variables were developed to be included in the manual. The manual and the tool together provided a valid way of identifying home fall hazards. (Clemson, 1997a)

2. The SAFER HOME tool:

Oliver et al (1993) developed the Safety Assessment of Function and the Environment for rehabilitation (SAFER) tool. The tool was based on a Canadian in-home psycho-geriatric assessment tool, pioneered by community occupational therapists and association (COTA). The tool consisted of 128 items, divided into 15 areas of concern. The tool assesses the house and immediate surroundings and the assessment was made examining each item in a combination of the environmental situation of the home and the functional ability of the client.

The client was involved with the therapist in identifying the problems and the assessment took approximately 1hour time and then the therapist had to address each hazard identified with one or more suggestions to overcome the problem. Content validity, inter-rater reliability, test-retest reliability, and internal consistency were established for the tool (Letts et al., 1995). Chiu et al (2001) presented a 100-page manual for the SAFER tool which has 97 items and 14 areas of concern.

SAFER was not designed to measure changes post-intervention, its rating scale was not sensitive enough to detect changes in living situations. The Safety Assessment of Function and the Environment for Rehab – Health Outcome Measurement and Evaluation (SAFER-HOME) was developed to address the outcome measures of the effectiveness of home safety assessment and intervention which was not addressed earlier (Letts et al., 1995).

SAFER-HOME is established on the theoretical model of Person-Environment-Occupation (Law et al, 1996) and on the belief that home safety must be interpreted in the context of one's natural environment (Letts et al, 1995). The 97 items of the SAFER-HOME were the same as the SAFER tool grouped into 14 domains. The original SAFER tool was a binary scale (presence or absence of a hazard). The rating scale of the SAFER-HOME follows a 4-point Likert scale based on the severity of the problem, ranging from 'No identified concern' to 'severe problem'. Factor analysis, reliability and construct validity of SAFER-HOME were established (Chiu & Oliver, 2006).

3. The Home Environment Survey Tool:

The Home Environment Survey (HES) tool assesses hazards for falls in the living environments of the elderly (Rodriguez, 1994). The tool was developed after reviewing existing tools and was presented to Architects and environmental engineers, who were experts in the field of older persons and their home environments.

The checklist consists of 73 items. 41 items are related to observable environmental factors in the living room, bedroom, kitchen, and bathroom. 12 questions were about the front yard, backyard and inside stairs, 9 questions were about behavioural factors associated with falls, like balance and vision, etc.

The process of assessment involved clients for identifying aspects of the environment that are easy to modify like clutter, loose rugs, etc and the trained home inspectors took note of more persistent hazards that require professional help for modification. The time for each assessment was 15 minutes and the staircase was not included in the study. Pre-determined definitions and field application rules make the tool more reliable and consistent for evaluating Environmental hazards.

Good to excellent reliability was established for the tool with a kappa equal to 0.87, except for the tripping hazards which did not have good reliability (Morgana et al, 2005).

4. The Housing Enabler:

The original tool 'Enabler', was the first version of the tool developed with a purpose to assess architectural barriers in the homes of elderly persons to enable accessibility (Iwarsson & Isacsson, 1996). The tool was based on Steinfeld's (1979) theory of the relationship between the capacities of the individual and the demands of the surrounding environment. Swedish building regulations were considered as threshold measurements for the initially developed 144 items with 4 sub-parts of the tool. The tool was comprised of 33 items related to the outdoor environment, 49 items related to entrances, 100 items related to the indoor environment, and 6 items related to communication features. The home assessment procedure was performed in three steps. First, the client's functional limitations were assessed with the help of 15 items. Second, 188 items related to environmental barriers in the home and immediate surroundings were assessed. The third step was the calculation of the accessibility score, which was performed by a combination of the individual's functional limitations and physical environmental barriers.

The items were scored on a 4-point Likert scale that was marked on basis of the severity of the problems predicted to arise in the combination of functional limitations of the individual and the barriers in the physical environment. Higher the score, the greater the accessibility problems. The entire process may take 2 hours to complete the process.

A self-administered version of the tool was developed by Fange & Iwarsson (1999) useful for studying the client's perception of accessibility and usability in their housing environment in combination with the housing enabler. Contains 31 questions about different aspects of the house environment. Carlsson et al (2004) developed the computerised tool of the Housing Enabler. A reduced version of the Housing Enabler was developed with 61 items instead of the original 188 by Carlsson et al (2009). The inter-rater reliability (Iwarsson & Isacsson, 1996), Construct validity (Iwarsson and Slaug, 2001), construct validity (Fange & Iwarsson, 2009), cross-national and multi-professional inter-rater reliability (Iwarsson et al, 2005) have been established for the Housing Enabler tool.

5. Home Falls and Accidents Screening Tool (HOME FAST):

The Home Falls and Accidents Screening Tool (HOME FAST) was developed by Mackenzie et al (2000). The tool consists of 25 items used for screening the hazards rather than for assessment. Each item is scored dichotomously to identify a hazard and No hazard. Not Applicable (NA) was marked if the feature does not exist. If the feature is present and the person does not use it, it cannot be a NA. If a person is unable to use a feature present in the house, this may point a hazard in the house.

Cross-National validity (Mackenzie et al, 2002), predictive validity and responsiveness (Mackenzie et al, 2009), inter-rater, and test-retest reliability (Vu & Mackenzie, 2012) were established for the tool. A manual would assist in the consistent application of the HOME FAST. (Mackenzie et al, 2016). One study proved that HOME FAST was a feasible tool for research and clinical purpose in Malaysia (Romli et al, 2016).

6. Home Safety Self-Assessment Tool:

The Home Safety Self-Assessment tool (HSSAT) was designed to use by older individuals to promote home safety and ageing in place (Horowitz et al, 2013). The prototype of the HSSAT included a home safety checklist, potential solutions for identified problems, and a listing of home modification service providers and other locally available resources. Content analysis for the checklist was based on the literature review. 3 focus groups were conducted to get feedback on the HSSAT tool. The HSSAT was proven to be a tool that may assist elderly persons in identifying environmental hazards to promote ageing in place.

Table I: List of environmental fall-hazard categories in the home environments of elderly persons.

S.No	Categories of fall-hazards	Description of environmental fall-hazards
1	Poor Quality of Lighting	• Non-Uniform Lighting that casts shadows on the floor • Sharp difference in illumination levels in transition spaces • Low illumination in walkways (Less than 107 Lux)*
2	Cluttered circulation spaces	• Presence of obstacles or permanent installations in circulation spaces. • Presence of cords in circulation spaces. • Cluttered furniture/ accessories in functional spaces.
3	Absence of preventive measures like grab bar installations	• Absence of grab bars where there is a level difference or a transition required. • Absence of grab bars where tasks require a person to stand up from sitting or lying down posture or vice versa. • Absence of grab bars along the length of the wall in toilets, corridors, staircase, ramp, and dampness prone areas. (850 mm from floor level).* • Wrong installation and unsteady grab bars (recommended diameter and clearance from the wall are 40mm and 88 mm respectively).*
4	Unsecured floor coverings and mats	• Presence of loose foot mats or other floor coverings that are not secured with a safety tape to the floor.
5	Hazards related to the Door design	• Difficult to operate the door. • The threshold is higher than 25mm – 50mm and not flush with the floor. * • Difficult to use door accessories. • Presence of doors where not necessary. • Doors opening in the wrong direction.
6	Low-efficacy of flooring to withstand slips, trips, and falls	• Presence of sharp and unmarked level differences in flooring. • Steep slopes for curb ramps. • Slippery flooring with Dynamic coefficient of friction (DCOF) less than 0.42 in both dry and wet conditions between underfoot and flooring surface. • Uneven, ill-maintained flooring surface.
7	Insufficient space clearance	• Space clearance less than 1000 mm for door openings and circulation spaces, 720 mm to 770 mm between furniture, 1200 mm width of the staircase, 1000 mm for the ramp for a single person, and 1800 mm for more than one person.* • Insufficient space clearance for knee under the kitchen sink, while cooking, while seated on a dining table or a study table or in similar circumstances.

		• Insufficient space clearance for tasks performed in standing postures like taking bath, dishwashing, opening a cupboard, cooking, etc. • Space clearance less than recommended for wheelchair users.
8	Reach that requires exaggerated body postures	• Vertical reach outside the range of 990 mm – 1100 mm from floor level for switchboards, higher than 1550 mm from floor level for tower bolts of doors, shelves, racks, or hanger rods, planters in the garden or balcony, etc. that may require exaggerated body postures.* • Obstructions for horizontal reach like window controls, reaching shelves in the prayer room while in a seated posture, soap dispensers in the bathroom and utility spaces, reaching the coffee table in the living room while in a seated posture, etc. that requires a person to stretch in exaggerated postures.
9	Hazards due to furniture design & arrangement	• Absence of seating in places like the primary entrance, at intervals of 10M in long walkways, places like the kitchen, toilet, and utility where tasks may cause fatigue in the elderly.* • Chairs and other seating arrangements that do not provide support for the elderly while a transition from sitting to standing postures and vice versa. In case of no such support, an additional support system should be provided next to the chair. • Recliners that are operated with levers, which require body strength and an ability to grip firmly or require leg strength to push the footrest down. • Seating lower than 520 mm from floor level.* • Furniture arrangement that obstructs circulations within the room and to the connecting spaces • Furniture that is not sturdy. • Hardware that is difficult to operate or does not offer easy grip for opening and closing cupboards and wardrobes. • All floor level cabinets, counters, and cupboards that do not have adequate space for toe kicks. • Countertops and preparation tables that allow spills on the floor • Sharp corners and edges for countertops • Absence of visual or tactile indicators for countertops and furniture placed beside major circulation spaces for people with poor vision.
10	Hazards related to design aspects like spatial organization and wrong placement of fixtures	• Uncovered circulation spaces connecting the outdoor to indoor spaces. • Long and indirect circulation spaces or those with abrupt changes. • The landing near the main door should be covered to avoid rainwater • Placement of stairs or level differences adjacent to the door openings. • Longer than 5 to 6 meters distance between spaces like kitchen and dining or bedroom and toilet.* • Wrong placement of fixtures like a washbasin adjoining a circulation space. • The clash between circulation spaces and task areas like general circulation into and out of the Kitchen should not obstruct the work triangle. • The work triangle connecting the three work areas, sink, refrigerator, and cooking surface should not be more than 7.9 M. Each side of the triangle should not be less than 1200mm and more than 2700 mm.*

		• No segregation between wet and dry spaces in toilets and utility spaces. • Staircases with protruding nosing, varying sizes of treads and risers, risers higher than the recommended 120 mm – 150 mm, Treads less than 300 mm.* • Slopes that are steeper than 1:20 for walking ramps without grab bars and ramps steeper than 1:12 for ramps with grab bars on either side.* • The height of the railing should be 950 mm – 1000 mm for balconies, staircases, and ramps.*
11	Sensory attributes of the environment which induce confusion in elderly people like colour, texture, surface contrast, materials used and finishes.	• Colours of adjoining surfaces that are similar in shades and cause confusion in identifying the difference between the horizontal and vertical surfaces or level differences. • Shiny and glossy finishes for flooring, furniture finishes, wall surfaces, etc. • Mirrors and reflective glass that confuse especially if placed adjacent to major circulation spaces. • Patterns cause a sense of movement and confusion.
***References for threshold values: American National Standards Institute, ICC A117.1-2017 Standard for Accessible and Usable Buildings and Facilities; Americans with Disabilities Act (ADA) Accessibility Guidelines (ADAAG); American National Standard Specifications for Ceramic Tile (2012)**		

IV. Discussion:

The current study is an attempt to identify a standard tool for in-depth assessment of residential spaces of the elderly to assess environmental fall-hazards through scientific inquiry. The study was conducted with a premise to find a tool that is reliable for empirical studies related to building and environment design parameters for elderly people. A comparative study of the six standardised tools was conducted and the results were reported on basis of the following criteria, identified in the review of the literature.

1. In-Depth Survey of the Space:

A review of the available tools revealed that most of the standard tools were designed for clinical applications for Occupational therapy. The HOME FAST was more a relevant tool for clinical application which has only 25 items and can be administered in 20 to 30 minutes with a visual inspection of the home environment. The tool provides a quick assessment and an overview of the number of possible fall-hazards in the environment for a clinical purpose only. Hence the tool may not be reliable for empirical studies. WeHSA (72 items), Housing Enabler (203 items), and SAFER HOME (97 items) have been designed for an in-depth survey of the house but the tools assess the environment with visual inspection or by involving the user for assessment. Much of the data collected depends upon the researcher's perception rather than using scientific instruments to measure the parameters. Hence the scope of applicability of the tools for empirical studies is narrow. HES/HC and HSSAT are tools designed for self-assessment of the home environment for identifying potential fall-hazards and hence their application for empirical studies is limited.

2. Relevance to environmental fall-hazards:

It was observed that four out of the six tools reviewed were designed to identify environmental fall-hazards in the residential spaces of the elderly people. The Housing Enabler, a tool designed to identify barriers in residential spaces of elderly persons, has exhibited reliable results in predicting falls in the elderly (Iwarsson et al, 2009). The SAFER HOME is a tool more focused on examining the general safety of an elderly person rather than being specific about environmental fall hazards. Hence, the tool may not be applicable for identifying environmental fall-hazards in particular.

3. Range of assessment:

A checklist was prepared from the review of literature for the types of environmental fall hazards in the residential spaces of the elderly persons. The study identified fifty-five types of environmental fall hazards that are related to building and environmental design. These were grouped into eleven categories for ease of application (Table I). The six standardised tools were reviewed and the items were compared with the checklist

(Table II). It was observed that two tools, the WeHSA and the Housing Enabler were designed to assess all the eleven categories of environmental fall-hazards identified.

Table II: Review of items assessed in the standardised fall-hazards assessment tools.

S.No	Categories of environmental fall-hazards	WeHSA	SAFER HOME	HES/HC	Housing Enabler	HOME FAST	HSSAT
1	Poor quality of lighting	✓	✗	✓	✓	✓	✓
2	Cluttered circulation spaces	✓	✓	✓	✓	✓	✓
3	Absence of Grab Bars	✓	✓	✓	✓	✓	✓
4	Unsafe floor coverings/mats	✓	✓	✓	✓	✓	✓
5	Door design flaws	✓	✓	✗	✓	✗	✗
6	Low-Efficacy of flooring to withstand falls	✓	✓	✗	✓	✓	✓
7	Insufficient Space clearance	✓	✗	✗	✓	✓	✓
8	Reach difficulty	✓	✓	✓	✓	✓	✓
9	Furniture design & arrangement	✓	✗	✓	✓	✓	✓
10	Design flaws	✓	✗	✗	✓	✓	✓
11	Sensory attributes of the environment	✓	✗	✗	✓	✗	✗

4. Functional Ability of the User:

The majority of fall incidents occur due to a combination of the intrinsic capacity of a person that occurs due to ageing or disease and the extrinsic features of the environment he functions in (Iwarsson et al, 2009). On contrary, it was observed that most of the home assessment tools assessed environmental hazards only, and the role of the functional ability of a person related to the environmental stressors was not considered. Iwarsson et al's (2009) study stated that the person-environment fit in the home environment is a stronger predictor of indoor falls among older adults than the assessment of environmental barriers only, and that perceived aspects of the home play a role as predictors for falls. Hence, studies regarding the assessment of environmental fall hazards related to falls prediction shall consider the functional ability of the user to yield reliable results.

5. Administration of the tool:

An important criterion in this research was to understand about who administers the tool. It was observed that the majority of the tools were made for clinical applications by occupational therapists or for self-assessment of the house to identify potential environmental hazards. The majority of the tools studied were designed for application by occupational therapists who may not be consistent with the assessment of built-environment parameters. (Iwarsson and Isacsson, 1996). On the other hand, Architects, Building Engineers, and Designers may lack the knowledge about the physical abilities of the elderly, and in turn, may be challenged to assess the user interaction with the environment. Hence the data collected may not yield reliable results in both cases. Most of the tools studied adopted one or more of the three strategies mentioned below to yield reliable results.

i) Training the Assessor for conducting the study
ii) A Manual with detailed descriptions of the fall hazards
iii) Recruiting a diverse team of experts from the building industry, as well as healthcare to conduct the study.

The Housing Enabler was observed to be a versatile tool for application in various fields as the tool can only be administered after a mandatory period of training. Other tools had manuals or descriptions for each item for reliable data collection. HSSAT adopted graphical representations of typical fall-hazards to guide the user in self-assessment. However, empirical studies may consider all the three strategies identified in the current study for reliable data collection.

6. Calculation of levels of risk:

Assessment of a house for environmental fall hazards may not be consistent if every hazard identified is treated as an equal contributor to falls and accidents. For example, a wet and slippery flooring may pose a much greater risk to an individual compared to a dry flooring close to the threshold dynamic coefficient of friction level. The latter may be a lower level of risk to a person who is healthy and has a good balance ability compared to a frail individual with impaired balance ability. In certain circumstances, a combination of environmental hazards may cause a higher level of risk. For instance, a slippery flooring and absence of a grab-bar for support, cluttered circulation space and poor quality of lighting, etc. Hence it is important to assign a level of risk to each environmental hazard on basis of the severity of risk it imposes.

It was observed that SAFER HOME and Housing Enabler were designed to assess the levels of risk imposed by each item being assessed on a 4-point Likert scale. On the other hand, WeHSA, HES, HES/HC, HOME FAST, and HSSAT were designed to assess the environmental hazards on a dichotomous scale on basis of the presence or absence of a hazard. An in-depth assessment of a house for empirical studies or home modification interventions may call for a reliable tool that can assess the severity of a particular environmental feature.

7. International Validity

The challenges that arise for the international validity of a tool are two-fold. First, the tool should have a translated version in the regional language of the place and secondly, the tool being used for building assessments should address the regional building regulations. The housing enabler is available in multiple languages like Swedish, German, Hungarian, Latina, Icelandic, and Portuguese apart from English (Iwarsson et al, 2012). This makes the tool more adaptable in various countries. However, the tool is based on the Swedish building regulations, which may be a challenge for international validity. The other tools like HOME FAST, HSSAT, HES/HC are reliable screening tools for the identification of environmental hazards and hence are not affected by building regulations (Table III). Though most of the tools are internationally valid, their application for in-depth scientific studies is limited.

8. User Opinion and Perceived fall-hazards:

Environmental hazards alone do not contribute to the falls and rather it is important to involve the user in the assessment of the house for potential hazards Romli et al (2017). User opinions play a crucial role in understanding the needs of the user when considering home modifications. It was observed that most of the tools were not designed for acquiring user opinions about the performance of the building. One tool, the HSSAT involves the user's opinions in the assessment. However, this is limited to opinions related to the safety aspects of the house and the physical ability of the user to overcome the barriers if any.

Perceived aspects of the house may also play a significant role as predictors for falls (Iwarsson et al, 2009). Physical and psychological aspects of a person may influence his perception of a fall hazard. A Person can anticipate a fall hazard in a safe environment and on the other hand, a more confident person may tend to ignore potential fall hazards in their environments. Northridge et al (1995) studied the role of the health and functional status of people on the risk of falls. It was observed that the frail elderly people were most prone to

Table III: Comparison of standardised fall-hazards assessment tools.

Scale	WeHSA	SAFER HOME	HES	HES/HC	Housing Enabler	HOME FAST	HSSAT
Author	Clemson (1997)	Chiu et al (2006)	Rodriguez (1994)	Morgana et al. (2005)	Iwarsson (1999)	Mackenzie et al. (2000)	Horowitz et al (2013)
Purpose of the tool	To identify home hazards for elderly persons who experienced a fall and fractured their hip.	The tool examines a person's ability to function safely in home environment.	To identify fall hazards of the home environment of elderly in a standard and quantitative manner	A self- assessment tool to identify home falls hazards.	Designed to assess physical barriers in the home environment of elderly population.	To assess fall related environmental hazards	The tool is used for self-assessment to identify fall hazards of the home environment of elderly.
Number of items	72 items	97 items with 14 areas of concern	Variable	73 items	15 items of functional ability, Step 2: 188 items of environment barriers	25 items	66 environmental hazards can be assessed
Theoritical background	Derived from literature review	Theoritical model of Person - Environment - Occupation (Law et al, 1995).	Based on review of existing tools	Based on the HES tool Rodriguez (1994)	The tool is based on the Person-Environment fit theory.	Derived from literature review	The tool is based on the Person-Environment fit theory.
Assessed by	Occupatioanl Therapists	Occupatioanl Therapist and the client.	Occupational therapists and the client	Self-assessment tool.	Trained Occupational therapists, Physiotherapists, Architects, Interior designers.	Occupatioanl Therapists	Self-assessment tool.
Time required	60 minutes	1 to 1.5 hours	15 minutes	1 to 1.5 hours	2 hours	20 - 30 minutes	Not specified
Score Calculation	Dichotomous scale (presence or absence of hazard)	4-pont likert scale based on severity of problem.	Dichotomous scale (presence or absence of hazard)	Dichotomous scale (presence or absence of hazard)	4-pont likert scale based on severity of problem.	Dichotomous scale (presence or absence of hazard)	Dichotomous scale
Reliability	Inter-rater reliability was established Clemson et al (1999).	Good inter-rater and test - retest reliabilities were established Letts & Marshall (1995).	Reliability for self-report items, k = 0.65 - 0.92 and for persistant items, k = 0.18 - 0.35	k = 0.87 fair to excellent agreement. Tripping hazards did not have a good reliability.	1st part, k = 0.87, 2nd part, k = 0.68	Descriptions were included to optimise inter-rater reliability	Inter-rater correlation coefficient = 0.89. intraclass correlation coefficient for test-retest reliability = 0.97 Tomita et al (2014).
Validity	Content validity was established Clemson (1999).	Lettes & Marshal (1995) justified the content validity and internal consistancy of the scale.	The tool was reviewd by Architects and environmental designers	None	Content validity was established for the tool	Content validity was established for the tool	Content validity index = 0.98

falls due to intrinsic reasons based on health and functional ability but vigorous elderly persons were most prone to falls due to extrinsic features of the environment. The reason being that the functionally able people tend to ignore or underrate potential fall hazards in their environment.

Some studies have established a relation between the anticipation of fall hazard and the occurrence of falls. In anticipation of a fall hazard, people tend to pitch their heads down to focus on their step rather than on a possible potential hazard. (Avineri et al, 2012). Most people adopt a stiffening strategy increasing the possibility of postural sway which may lead to loss of balance and fall (Young, 2014). Another study stated that, on anticipating a fall hazard, study participants changed their gait speed and walked with a wide gait and flat foot resulting in loss of balance (Chippendale & Boltz, 2015). Hence there is a strong basis to state that perception of fall hazards in an environment could influence the risk of falls and a person's perceived aspects of the house could have a strong intent for inclusion in hazard assessment interventions. Two tools in the current study, the HSSAT, and the HES were designed for self-assessment of the house but the assessment was based on the instruction manual provided rather than rating the user perception of the space.

V. Conclusions:

The current study was instrumental in identifying eight criteria for the design of environmental fall-hazard assessment tools and fifty-five types of environmental fall hazards in the residential spaces of elderly people through a review of the literature. The fifty-five types of environmental fall hazards were categorised into eleven types of fall-hazards for ease of application (Table I). The eight criteria of assessment tools identified from the literature review are,

i) The tool should have competence for conducting an in-depth survey of the space rather than a quick screening of the space for environmental fall-hazards. Standard instruments shall be used for measurement rather than relying on the assessor's visual inspection for reliable data collection.
ii) The tool shall focus on the assessment of environmental fall-hazards rather than including all types of environmental hazards like fire, security or crime, etc.
iii) The tool shall comprehensively assess all the possible types of environmental fall hazards. The current study identified eleven categories of fall hazards and only two of the six tools reviewed, measured all the eleven categories of fall-hazards.
iv) The tool shall assess fall-hazards with relation to the functional ability of the user. Ignoring the functional ability of the user and considering only the environmental factors may not yield reliable results in empirical studies.
v) Three strategies were identified in the current study for the reliable administration of tools used for identifying environmental fall hazards.
    - Training the Assessor for conducting the study.
    - A Manual with detailed descriptions of the fall hazards.
    - Recruiting a diverse team of experts from the building industry, as well as healthcare to conduct the study.
vi) The tool shall be able to assess the intensity of a fall-hazard as all fall hazards may not impose the same levels of risk to the user. The intensity of fall-hazards in the environment is very variable depending on various parameters related to the environment and the individual.
vii) The international validity of the tool plays an important role if the tool has to be administered for larger sample size in different geographical regions. On the other hand, the tool may be tested for reliability and validity in the context of the region under study.
viii) It is important to acquire the user's opinion in the assessment of potential environmental fall-hazards. Perceived aspects of the house may play a significant role in the assessment of environmental fall-hazards. This aspect cannot be ignored as a healthy and more vigorous person may perceive a potentially hazardous environment as safe and on the contrary, a frail person may feel vulnerable in a safe environment. Their behaviour in such circumstances was observed to impact the incidence of falls (Northridge et al, 1995; Avineri et al, 2012; Young, 2014; Chippendale & Boltz, 2015).

The six standardised tools were compared to identify if the tools can be readily adapted for empirical studies. It was observed that the Housing Enabler was the most versatile tool concerning its reliability in the assessment of hazards in residential environments. However, the tool does not consider user perceptions and it is a more generalised tool for assessment of barriers rather than for the fall-hazards. The tool is based on Swedish building regulations and this calls for considering regional bylaws if the tool has to be used in other countries. Hence, it can be concluded that the tool can be applied in empirical studies with slight modifications to include the regional aspects. However, future studies shall focus on understanding the role of perceived fall-hazards and their inclusion in tools used for assessment of environmental fall-hazards.

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