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## Avoiding accidental falls in residences for dementia persons

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### Abstract

The homes are designed and constructed such as to protect the residents from the weather and environmental hazards, malicious actions of evildoers and provide a comfort living environment. Houses should provide security in all house residents' dependless on their age or health condition. The present article refers to the influence of the home environment on the accidental falls of dementia persons and focus on the particular residence characteristics that increases the risk of falls in dementia persons. It suggests prevention strategies, home assessment, and necessary modifications in house accommodation. The role of the engineer and of physician can be decisive in predicting and avoiding falls and eliminating the home accidents consequences. Firstly it is identified the potential hazards in all house areas, and analyzed the points, activities, and substances that may contribute to accidents. Subsequently, are ranked and sorted them. Finally, are determined the necessary amendments. Through this procedure, it is achieved risk control.

**Keywords:** Accidental falls, aging, dementia, injuries, residence characteristics

### 1. Introduction

Dementia is a syndrome, with a chronic or progressive character. The cognitive function is being deteriorated progressively more than normal aging. It influences memory, thinking, and judgment, orientation, understanding, learning capability, language, calculation, comprehension. Consciousness is not influenced. The deterioration in emotional control, modification in social control, or motivation appears at the beginning of the disease, while the cognitive function is being affected progressively. The prevalent cause worldwide, of disability and dependency for older people, is dementia. It is a devastating disease in patients, their caregivers and their families <sup>[1]</sup>.

It is said that long-term geriatric care depends on the quantity and quality of education and training of specialists in institutional resources <sup>[2]</sup>. In the same way, geriatric care in residents is being affected by the education and training of caregivers and from the living environment. Elderly persons, and especially persons with dementia, spend most of their time in the domestic environment. The living environment affects the quality of human lives. The design, facilities, accommodation, home area, dimensions, and arrangement of the furniture should be selected after much thought and should be considered the basic guidelines for accident prevention strategy and the particularities that people with dementia have. As far as the place where the accidents happen more frequently, other surveys have shown that the most commonplace is in the residents and mainly in living rooms, bedrooms, and bathrooms <sup>[3-4]</sup>, with accidental falls were observed more often early in morning (between 4:00 and 7:00 am) <sup>[5]</sup>.

Fractures in dementia persons may affect their mobility permanent, even after their recovery. Lower limb or pelvis fractures may cease their ability to walk <sup>[6]</sup>. The scope of this paper is to create awareness of the prevention of falls in residents living with dementia and highlight that it is better to prevent a disease than to cure according to the Greek ancient father of Medicine Hippocrates. A prevention strategy has many benefits for saving lives, keeping steady the quality of life of patients, reduction of economic cost in hospitals and care units, and eliminating the lost hours which are needed to run for help to the patients in families. Engineers have a dominant role to play in achieving this goal <sup>[7]</sup>. However, for an effective accident prevention strategy, it should be taken into consideration the habits and behaviour of dementia persons.

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## 2. Fall Prevention from an engineering perspective

A person falls during his effort to move or during his movement. Friction opposes the mass movement. According to physics, two kinds of friction exist, static and dynamic (or kinetic) friction. Static friction develops when the body (the human feet) is starting to move relative to another material that it is contacting and remaining static (the floor). The value of static friction varies from zero up to the lower force which is necessary for starting the motion. The value of static friction is higher of the lower force required to keep moving. The static friction depends on the coefficient of friction (COF), the weight of the body (the weight of the human body), and on the angle of the flat surface (floor inclination) regarding the weight of the human body which is always perpendicular to the horizontal surface. The coefficient of friction is a dimensionless quantity, which indicates the roughness between the two surfaces. A body is starting to move if the static friction is being exceeded. In a hasty manner, dynamic friction or kinetic friction develops when a body is moving and inhibit the conservation of movement. Similarly, dynamic or kinetic friction depends on the coefficient of kinetic friction, the weight of the human body, and the angle of the floor inclination regarding the bodyweight.

A slip may occur when the force that puts a man on his feet, exceeds the static friction (when he starts to move) or exceed the dynamic friction (when he is already moving). The coefficient of static and dynamic friction depends on the smoothness of the surfaces (of the surface of the floor and shoes that a human is wearing). The presence of water, liquids, oil, powder, dirt or other lubricants affects this coefficient and makes it lower. In studies of healthy adults, normally, the coefficient of friction is a function of the step length<sup>[8]</sup> and of gait speed<sup>[9]</sup>. According to another survey, which compares healthy young and older adults, older adults had shorter step lengths and a lower coefficient of friction when they were walking. The coefficient of friction (COF) was lower in older adults, walking at controlled velocity and random step length. In both age groups, the coefficient of friction was the same when the speed and step length are defined. The step length and required COF are directly correlated, although the speed affects step length in weaker and negative ways<sup>[9]</sup>.

But the falls among people with dementia do not obey only the rules of Physics. Persons with dementia often have also balanced problems, walking difficulties in addition to diminishing strength and loss of muscle mass. The angle of their feet regarding the floor surface may be declined from normal, and therefore static and kinetic friction is altered and the falls are more likely to happen. In addition to this, people with dementia lose progressively their ability to coordinate their hands, throw materials on the floor, an action that increases the slipperiness of a surface. Thus, the choice of the floor material should be thoughtful with the main scope of preventing falls from slipping and evaluating by an educated person.

## 3. Choosing floor materials

There are many test methods examining the slip risk walking on the tiles. Tests measure static and dynamic friction factors or surface roughness. The test measures or the dynamic coefficient of friction of a floor are “the pendulum test”, “the slip alert test” and “the friction test”.

The “pendulum test” is conducted by a proper test apparatus manufactured and calibrated according to standards<sup>[10]</sup>. The device has a swinging arm that simulates a pedestrian heel and the way it makes contact with a floor. It left it to strike the floor from a horizontal to a horizontal position. The friction only decelerates the arm and diminishes the width of oscillation. The presence of even a small amount of water on the floor alters the coefficient of friction. Values between 0-24 indicate a high slip potential, 25-35 moderate, and above 36 low, for walking on a flat surface and in a straight line. The test may be contacted at the point on the floor at which a slip occurs<sup>[11]</sup>.

The “slip alert test”, uses a wheelbase trolley and a special aluminium ramp applied on the floor under examination. The trolley is placed manually on the upper side of the ramp and then left to roll by gravity. The distance which crosses over the ramp, on the floor, before stops moving, is counting. The coefficient of friction of the floor is connected with this measured distance and can be evaluated exactly using graphs supplied with the device. Other test instruments for evaluating the coefficient of friction are FSC2000, Tortus, etc.

Health and Safety Executive (HSE) reports the advantages or disadvantages of some test instruments<sup>[11]</sup>. Apart from the coefficient of friction tests are micro-roughness tests which measure the surface micro-roughness. The slip properties of a flat surface are changing with pollutants. Contaminates that exist on a floor fills the intervals between the surface of the floor and the heel and alters slip potential. For keeping a low slip potential the floor must have enough micro-roughness to break through a thick pollutant. There are instruments available in the markets<sup>[12]</sup>.

Furthermore, there are ramps tests. In a ramp test, the tiles are glued and seated normally on a ramp (platform) and lubricated. A person is walking on the ramp while the tilt of the ramp is being increased gradually. The angle at which the person slides is being noted. The standards that are considered are DIN 51097, and DIN 51130<sup>[13-14]</sup>.

## 4. Checking list

This article proposes a non-profit organization for giving advice in families for reducing the risk of accidental falls and slips in the residents. For that purpose, the organization would occupy engineers and physicians to conduct home inspections. Inspections in houses are mandatory, in environmental, constructions, issues in Greece, but not in the field of accident prevention in residents. However, home inspections could be carried out at the family’s request. There are no agreements, regulations, protocols, or legal laws, for that scope. The home inspections maybe are conducted by two-person engineering to propose technical aspects and give solutions and a physician to conduct a psychiatric evaluation. An officer will note the citizens’ requests for home inspections. When the home inspection is ended, a written report should be delivered, with the points that need improvements and technical interventions. The report should be structured with hierarchical classification. The first points should be the most dangerous for elderly persons. In general, the methodology of house inspection should follow the principles of risk analysis.

At the beginning of risk analysis, some significant data are gathered, which depict the existing conditions in the house. Subsequently, a detailed inspection report should be

prepared based on the detailed list. The detailed list contains the environmental interventions that are suggested for possible applications. The list should take into consideration the economic budget of the family and the solutions should

adapt to the family’s financial funds and their willingness to spend money on innovation. Collaboration with the rest members of the family during the inspection is also essential to reveal the invisible problems that may exist in a home.

**Table 1:** Dominate key points, for a first stage house evaluation.

	<b>Note</b>
Floor condition	<ul style="list-style-type: none"> <li>-the slipperiness of the floor material in every place,</li> <li>-the presence of rugs in each room,</li> <li>-the floor abnormalities, or worn floors or discontinuities on the floors,</li> <li>-the presence of stairs and inclined surfaces,</li> <li>-the presence of loose wires,</li> <li>- The degree of the floor purity at various times of the day.</li> </ul>
Fall and near fall incidents	The fall and near fall incidents would be noted, as well as their occurring frequency and location, the hour of the day that happened. Further details such as a possible explanation or fault analysis, could be included. The testimony of attendants and the evaluation of data as recorded by a camera may be valuable assistance.
	<b>Note</b>
House accommodation	<ul style="list-style-type: none"> <li>-sharp surfaces</li> <li>-furniture stability</li> <li>-is it enough space for free movements</li> <li>-transparent surfaces</li> <li>- Frequent used items and if they are inaccessible places.</li> <li>- Is flammable materials and other dangerous products are in a locked position.</li> <li>- Is the rubbish bins fixed in a way that they cannot be moved or Overturned.</li> </ul>
Medication	Note the medication and particular the psychotropic drugs, which are one of the main causes of falls in people with dementia.
Noise, temperature, humidity	An environment, with multiple stimuli, could be stressful for dementia persons. These persons have limited ability to understand and interpret noises and what is happening in the environment. Their reaction may be problematic in an attempt to protect themselves, their space, or their personal belongings. Apart from noise levels and other physical parameters such as the air temperature and humidity should be recorded for reducing unwanted stimulation. Most people are feeling comfortable when the air temperature ranges from 20 °C – 27 °C and humidity is between 35% -60%. Practical rules such as closing the patient’s room door could be a solution, but not for a long time for avoiding feeling loneliness and isolation.
The procedure of house evaluation should be repeated periodically for examining if it is required further action.	

**5. Indicated Measures**

The philosophy of taking measures is to replace the dangerous with a less dangerous or a non-dangerous. Aging is accompanied by degeneration in many organs and brings vision changes. Vision is considered an important contributing factor affecting the frequency and severity of falls. The process of vision is complicated and analyzed in multi-stages. The information through the eyes reaches into the brain, where it is interpreted accompanied by other senses. Often, people with dementia have problems with the brain processes of visual signals resulting in misperceptions or misidentifications. Existing eye diseases (cataracts, glaucoma etc.) strokes or certain medications may contribute to these perception problems which are often described with the term “visuoperceptual difficulties”. House adaptations are mandatory for supporting these persons and avoid accidents. Materials that decrease their perception ability like transparent glass should be removed and replaced by others. The glass surfaces (vertical, horizontal, or other objects made by glass) should be avoided.

Good illumination (300 Lux) improves their vertical vision. Older people also need increased light levels. Particularly, natural light has many scientifically proven benefits. Choose as a bedroom a place with sufficient natural lighting. Maximize the benefits of natural light by arranging the furniture in a way to minimize shadows. Shadows make things to be mistaken or in some cases increase their confusion (mainly, those who are suffering from delirium). Direct artificial light may produce shadows and reflections. A good solution for artificial light is the illumination of the

ceiling, which produces diffuse light. The illumination is uniform and the objects are clearly visible. Non-gradual changes in light level. Eye light adaptation functions are aggravated by age. Minimize glare reflectance. Choose surface materials and floor surfaces without reflection. Persons with dementia may get the wrong impression that the floor is wet and avoid walking on it. On totally flat surfaces, should be avoided color changes for not misinterpreted as having altitude differences. The floor should not have the same hue as the wall. It makes it difficult for persons with dementia to perceive where the floor is ending and the wall is beginning. Some house accommodations trigger anguish or agitation of people having dementia. Although some surveys used mirrors as a therapeutic tool [15, 16], some others show a decrease in agitation by covering mirrors [17]. The explanation given was that dementia persons did not identify their own reflection. They may be scared that a stranger is near them or in their room and watches them. It seems also that mirrors increase the confusion of dementia persons. Limit their number and size and consider thoughtfully where are placed. Persons in the later stages of dementia become progressively frail and may have accidents when they are trying to go to the bathroom at night. A bed railing is used often to prevent droppings. In more burden situations a hospital bed may be recommended. However, before placing movement restrictions must be considered thoroughly moral and ethical rules. The patient's will be taken into account. In order to overcome this problem, consider the floor material near the bed; make it by rubber or polyurethane.

The presence of water on the floor is another cause of falling. Insufficient drainage or inappropriate tilt, (e.g. in bathrooms), increases the risk of falling. Extremely slippery liquids (liquid soap, oil, etc.) may be placed at fixed points with dispensers and overflow basins. Lock the selves that contain flour, rice, detergents, and other products which make a surface extremely slippery when they are spilled. Place the food and the water, in an easily seen place, for being reached without effort.

The usage of staircases is a complex task that requires coordination of vision and of the movement of the lower limbs; however, dementia persons gradually lose these abilities. Therefore the stairs should be avoided. Nevertheless, if are present, marked them using color differences to make more clear the different levels or being made of dissimilar materials. The stairs should have the appropriate dimensions to remain on it the whole foot. Light switches should be present at the beginning and at the end of the stairwell. Handrails fixed in the walls are very helpful. Keep a sufficient place for moving. Remove every item that obstructs their route. The portable ladders should also be avoided. However, if their use is necessary, another person must be in close. The ladders should be inspected periodically for signs of wear, or other defects and complies with the regulations related to their construction characteristics. Most ladders used in houses are light-duty ladders (Type III). The stability is also affected by the ladder's supporting surface.

Arrange the furniture near the walls for keeping enough free space. Remove the furniture with wheels. Have in mind that, these persons may become a handicap and need the use of a wheelchair or other walking aids (crutches, canes, walkers, etc.), in the future. Do not use furniture with sharp edges. Choose furniture having bright colours, different from the colour of the floor. The term "ergonomics" is usually referred on workers. However, examining ergonomic factors may help minimize the risk of an accident. Choose furniture and appliances taking into consideration the body and shape, posture, and particularly the mental, vision, hearing, abilities of the person with dementia. Consider the proper kitchen and garden tools, too. Locate grips, and furniture, and other accommodations taking into consideration if they are left or right-hand persons or are having mobility disorders on one side of the body. Keep in mind that people with dementia have reduced muscle strength; therefore the shutters, windows, taps, etc., should not demand extreme physical strength. When a person with dementia cannot do something, may become nervous. The furniture should have good arm and back supports and be comfortable. Anxiety and unreasonable movements may also be triggered by musculoskeletal pains.

Dailey activities such as clothing may need to be adapted depending upon the dementia stages. Do not encourage these persons to wear long, and very loose clothing. The dressing would be made easy to increase their autonomy and self-confidence. Choose shoes without shoelaces. Dementia persons should not walk in socks, should wear the right number of shoes, avoid using loose slippers, or slippers with high heels, and be adapted on their special needs.

Every medication may have positive benefits and side effects. Scientific surveys have found a significant correlation between the medication for dementia diseases and hazard of fall <sup>[18]</sup>. Despite the promise of no side effects

the risk of falls and particular of hip fractures is not reduced <sup>[19]</sup>.

## 6. Usefulness of assistive technology for fall prevention

Assistive Technology (AT) according the legislation of Unites States and as amending by WHO (2004), are items, pieces of equipment which produced commercially for an individual or for mass production and are used to improve, increase, or maintain, the functional capabilities of a person with a disability <sup>[20]</sup>. Many appliances are invented for remote monitoring of vital signs as well as others indicates the location and movement of patients <sup>[21-23]</sup>. Different kinds of appliances can improve a dementia person's safety and remain secure at home (as of fall detectors, video monitoring, remote health monitoring, smoke and heat alarms, etc.).

Many accidents happened when the person is trying to get out of bed. The caregivers are not possible to maintain optical contact with the patient continuously and an alarm gadget may help. In markets are available bed and chair alarms, which are activated on changes of the pressure and produce an alarm as a warning sound for caregivers. These pressure sensors or pressure switches can measure alterations on static forces (local sensing). They can be placed usually under the pillow or under the sitting surface, or underneath a mat.

The electronic motion detector senses the moving object (area sensing). A transmitter emits waves (infrared, microwave, ultrasound) which are detected by a sensor. Due to human motion, these waves between transmitter and sensor (receiver) are interrupted or altered. This triggers an appropriate circuit to produce a specific task (sound a buzzer; open the door of the bathroom, etc.). Motion sensors are an inexpensive solution for open lights to illuminate the path to the bathroom during the night. The two above circuits may be combined (pressure sensor and a motion detector). When the pressure sensor detects weight changes, a relay may be activated to open lights at a specific path (e.g. into bathroom). People with dementia have a greater risk of disorientation inside the home. Opening the lights in a dark house helps them to guide at the right direction. Also, it may be beneficial to a recorded repetitive voice giving instructions. For further assistance, the bathroom door may also open in the same way as are opening the lights. In markets are also available products that may be placed at the entrance door or at windows to alert the caregiver when the person with dementia attempts to leave the home. All these devices are easily installed and can help to prevent wandering in dementia patients.

Studies were shown that slower walking speed may depict that the person is tired or may indicate that the person has altered cerebral blood flow a situation that is combined with health conditions such as cognitive impairment and disability. Infrared sensors used by Hayes and colleagues have measured the daily activities and the changes in walking speed <sup>[24]</sup>. However, this observation may be done also by caregivers. Inside the house, the distance between any points is known and simply divided by the required time for people with dementia to cross over, which can be used as a rough index for the person's physical or mental state.

When patients try to get dressed is a common source of falling. During their effort to getting dressed lose their balance, or may trap their hands or feet in the garment. A

contact sensor (reed switch) placed on the door of the wardrobe may alert the caregivers in case that the person with dementia is trying to get dressed.

### 7. Limitations

A home inspection reflects the visible condition which presents in the apartment at the time of the inspection. The conditions that exist in a home can change. The conditions could deteriorate after the time of the inspection. A visual home inspection report is limited it is describing the conditions in the parts of the house that the inspector can see. Obviously, maybe be presented in the house rooms or other points that are permanently hidden by ceiling, wall, or floor. These are maybe excluded, but are remaining as parts of the home. Normally, these dangerous places may be blocked by locking, but in some cases, the locking ceases to exist, leading to dangerous or unsanitary conditions. Another limitation is the right to privacy in households. The inspectors should be very careful with issues that relate to privacy and comply with all laws concerning it.

### 8. Conclusions

Environmental hazards consider as a significant contributory factor for falls among older people. House hazards and older persons' diminished physical capabilities have resulted in a large proportion of falls. Home assessments could help to eliminate environmental hazards. In Greece, there is not such an action yet. The ultimate target is the experience of inspection to be transferred to the families that have dementia person to avoid falls. Dementia persons cannot fight for their rights therefore we must protect them, preserve their rights, and implement a dementia-friendly community.

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