

**Application of Domino Theory to Analyze Hazard Suppression in the Elderly Housing  
in Rural Areas of Thailand: A Case Study of Phichit Province**

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**Abstract**

This study seeks to collect and analyze data for the purpose of creating concrete guidelines for the reduction of accidents caused by the physical environments in homes occupied by elderly people. The study utilizes the Domino Theory developed by H.W.Heinrich to analyze industrial accidents in the workplace. Qualitative data was collected for the study using purposive sampling method together with a survey of homes occupied by seniors and in-depth interviews of the senior occupants and their relatives. The sample consists of 20 households selected from households with elderly persons in three districts in Phichit Province. Domino Theory is applied by representing simulated accident causes and hazards with an arrangement of five falling dominoes. If one domino falls, next dominoes will also fall. However, if one of dominoes is eliminated, so is its effect. The First Domino—Ancestry and Social Environment—has 14 risk factors such as eyesight and mobility problems suffered by many seniors. The Second Domino—Fault of Person —has 16 risk factors such as carelessness, existence of and failure to remove physical hazards and lack of safety inspections. The Third Domino—Unsafe Act/Unsafe Condition—has 14 risk factors such as no safety equipment for the elderly, inappropriate use of materials and dilapidated houses in need of repair. The Fourth Domino—Accident—has 16 risk factors such as slipping and falling. The Fifth Domino involves—Injury—with 11 risk factors such as broken bones and severe physical pain. Therefore, Domino Theory can be effective in eliminating the factors causing accidents, especially those included in the second and third dominoes. There are three practice methods for hazard suppression, including 1) awareness, 2) home inspections, and 3) home maintenance and management of the physical environment in the homes of older persons. This study is explained by the Domino Theory to communicate with the elderly and their relatives who stayed in the studied houses. The result is that they begin to realize the chance accidents occurring in their residences.

**Keywords:** Accidents Elderly Housing in Rural Area Physical Environment Domino Theory the Abilities of the Elderly

## 1. Introduction

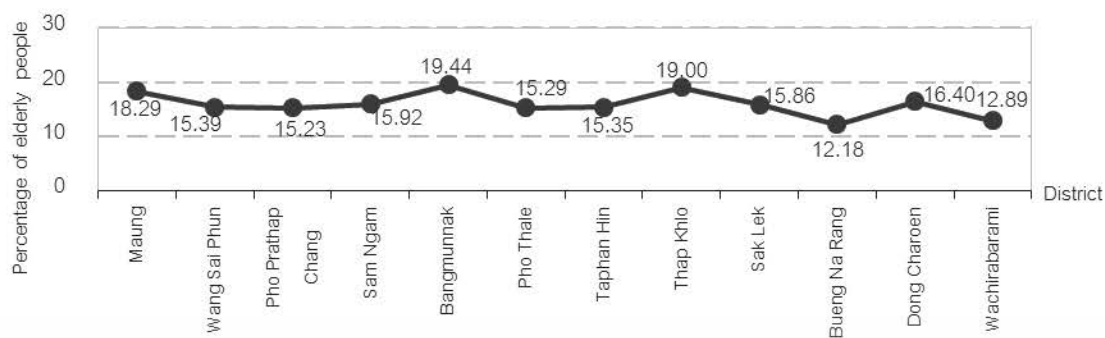
Over the next twenty years, the ratio of people over 60 in the world's population will increase from 10% in 2000 to 13.6% in 2020. This trend is even more evident in Thailand where the ratio will increase from 9.4% in 2000 to 16.8% in 2020 (National Economic and Social Advisory Council, 2004). The 2007 census taken by the Thai National Statistical Office, which published age ratio distribution by province, revealed the highest over-60 ratios to be in Phichit with 14.93%, Lamphun with 14.53%, Phrae with 14.50%, Sukhothai with 14.40% and Lampang with 14.07%, respectively. These data show that Thailand is becoming an "Aging Society." Some of the causes of the increased age ratio are economic problems and changing Thai values, such as fewer weddings, fewer babies, and an increase in single-person households. Thus, the trend is toward a higher ratio of elderly people than in the past. Moreover, the elderly are often neglected, especially in rural areas. Many relatives of the elderly must work in urban areas because there are no jobs in the rural areas. In light of these facts, this study was conducted to determine how to increase accident awareness and hazard suppression for elderly housing in rural areas. There are many factors causing hazards and accident risks to the aging. Domino Theory suggests a method for hazard suppression that will reduce the causes of these accidents (Dan Petisen, 1971). H. W. Heinrich simulates five dominoes: the first domino-Ancestry and Social Environment; the second domino-Fault of Person; the third domino-Unsafe Acts or Physical Hazards; the fourth domino-Accident; and the fifth domino-Injury. As elderly households differ from the average in terms of social surroundings, physical environments, physical conditions and economic situations; hazard suppression for elderly houses is also different. Accident suppression through Domino Theory analysis provides benefits for all events and conditions.

## 2. Materials and methods

This study of elderly risk behavior in their homes utilizes seven processes to evaluate the causes of accidents. **The first process**, the research project are prepared by literature review, including concepts and theories about hazard suppression and by review of the data previously collected from case study areas. **The second process** involves study area selection, identification of purposive sampling and basic data gathering methods. Review of data collected by the National Statistical Office Thailand revealed that Phichit Province has the highest concentration of elderly people in Thailand, with 14.93% in 2007 rising to 16.42% in 2011 (Ministry of Social Development and Human Security, 2011). Those ratios make Phichit Province a significant area for study. Moreover, Phichit Province has supporting data, including: (1) a significant number of residents that are or soon will be part of the "Aging Society" living in typical elderly physical environments; (2) diverse surroundings and geographies which affect people such as flood zones, dry zones and a lot of open space; and (3) diverse types of housing representative of residential housing in the Lower Northern Region of Thailand. The pilot area selection process involved consideration of three rural areas in Phichit Province that were considered based upon different ratios of elderly population. (Figure 1) Moreover, selection utilized criteria including: (1) diverse geography and habitation, (2) typical housing in each area and (3) populations in study areas with prevalent aging societies. The three research areas selected are: (1) Pa Makhap Sub-District, Mueang District (2) Thap Man Sub-District, TaphanHin District and (3) BuengBua Sub-District, Wachirabarami District in Phichit Province.

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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา หรืออ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้



**Figure 1** Percentage of the elderly in district areas of Phichit Province in 2011

**The Third process** involves population and sample. This research focuses on the buildings resided by the elderly in Phichit Province. The independent variables are 20 residential buildings and they are chosen by means of purposive sampling. The residential buildings for the elderly are divided into 3 categories. It is expected that the chance of having accidents for them will vary. The first sample group includes single-story homes that are raised from the ground no more than 150 centimetres, such that the under-areas cannot be conveniently utilized. The second sample group includes single-story homes, raised from the ground more than 150 centimetres, such that the under-areas can be conveniently utilized by the residents for such things as storage and relaxation. Third sample group includes two story residential homes. In addition, this research investigates further other factors causing the accidents in the residential buildings for the elderly. The 3 studied locations are identified. Types of the elderly can be classified as 3 groups including the Society-Bound, the Home-Bound and the Bed-Bound. These are the extraneous variables. **The fourth process** involves research instruments that reviewed through the application of safety concepts and Domino Theory. Two instruments were constructed. The first instrument was a structured survey that collected data about elderly homes regarding such things as the functional areas and accident risks imposed by the physical environment. The second data collection instrument employed in-depth interviews of the subject elderly people, their relatives and other occupants living in the sample houses. Interviewees were asked for details and opinions about the physical environment, behaviors of the elderly people and accident risks they perceived in the elderly houses. Pilot studies were conducted. Using the collected data, the survey and interview documents were adjusted by expert reviewers.

**The fifth process** involves working directly in the field to gather data. Three methodologies were used: (1) direct observation of elderly risk behaviors in their homes; (2) direct surveys of the physical environment of the elderly homes included in the study; and (3) in-depth interviews of the elderly and their relatives or other dwellers that occupied the homes. Elderly people were selected for in-depth interviews based upon the suggestions and recommendations of specialist people from each of the three study areas. The aforementioned purposive sampling technique was employed to select elderly people and houses and for testing in the pilot study. Data collection in the field was aided by the opinions and suggestions of knowledgeable people in the sampling study areas.

**The sixth process** involves compilation of the report and the formulation of appropriate conclusions. Data was analyzed through the focus of Domino Theory to formulate elderly residential management guidelines to ensure safety.

**Finally**, researcher and team returned to study areas with a draft report that was reviewed for a period by the subject seniors, their relatives and co-dwellers. The report was appropriately adjusted based on their feedback. The completed research delineates the causes of accidents in aging residents and provides management guidelines to improve residential safety for the elderly in the rural areas of the lower northern region.

### 3. Results and discussion

Results of the study were analyzed through the lens of Domino Theory, focusing on the physical ability data collected directly from the elderly who reside in the selected homes; the general physical environments, including both functional and surrounding areas; senior risk behaviors; and actual accidents and their causes. Detail follows.

#### 3.1 Findings of the study factors or variables which were expected to influence the accident.

3.1.1 The ability levels of elderly people who reside in study houses. There are three elderly groups of people in this study which were classified according to their ambulatory abilities and daily practices and routines. The three group classifications are society-bound, home-bound and bed-bound. There were six seniors in society-bound group. These six were able to independently go up and down the stairs, walk over smooth surfaces, eat, use toilet facilities, and take care of their own personal hygiene. Their average ages ranged from 62-76 years old. There were 13 seniors in the home-bound group. These 13 were able to walk on smooth surfaces with the aid of equipment such as canes and walkers; they were able to eat with assistance, but often spilled their food; they were only able to manage toilet facilities with assistance; and also required assistance with personal hygiene. Their average ages ranged from 64-85 years old. Finally, there was only one senior in the bed-bound group, aged 82 years old. This bed-bound individual was able to eat only with the assistance of special equipment and a caretaker; the caretaker assists toilet activities on the bed; and the caretaker manages personal hygiene.

3.1.2 General environment of studied locations. Pa Makhap is geographically a plateau and rice field. It experiences flooding; however, this does not last very long. The buildings are mostly designed with single-story which has a space under living floor. The upper floor also has a bathroom. This is different from the buildings constructed in the rural areas in the Northern Province. This is the case for Thap Man where Phichit River is located near the buildings. It is also a plateau with irrigation. The land is best for agriculture including lemon and fruit farms. Residential space is with gardens and big trees to provide a shade for those residing there. BuengBua is the large topography with no great rivers running through it. There is reported drought and lack of water during a dry season. The buildings, therefore, are not situated on a high land for there is no case of flooding.

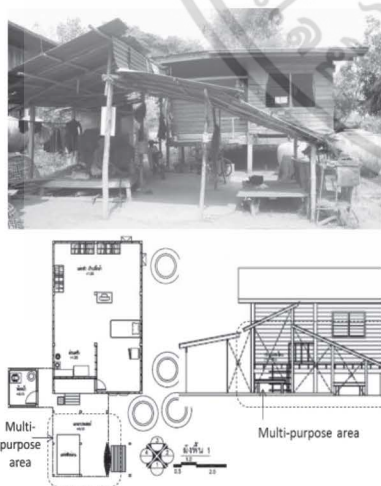
เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า  
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3.1.3 General physical environments of elderly houses. Sampling of elderly houses took place in study areas. Sample data concerning materials and facility problems were studied to explore the effects of the physical environments. Wall materials used included wood only, wood integrated with brick, brick only, gypsum board only, and adobe block only. Structural materials used included wood only, wood integrated with ferro-concrete, ferro-concrete only and adobe block only. Floor materials used included wood only, wood integrated with ferro-concrete and ferro-concrete only. Roof materials studied used zinc sheeting, concrete or ceramic roof-tile, and metal sheeting. Roof materials are critical considering the effects of weather on the sampled houses. In evaluating the physical environments in the elderly homes the study considered interior obstructions and barriers impeding movement around the internal areas, as well as such barriers in the outdoor and surrounding areas. The study also considered the lack of standardized housing components, such as stairs, whose treads and risers were often of variable size and often failed to comply with accepted standards which require a minimum tread depth of 28 centimeters and a maximum riser height of 15 centimeters (Ministry of Interior, 2005)

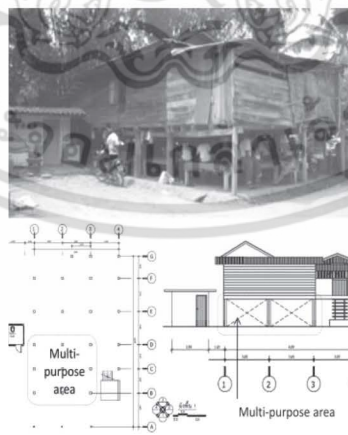
**3.2 Findings of the correlations of factors influencing the accidents**

3.2.1 Public area using of the elderly. The study also investigates the correlations between the study areas and the ability of the elderly from in-depth interviews. The richness of study areas, i.e. Thap Man Sub-District and Pa Makarb Sub-District, affect society-bound elderly that they used public spaces for sword dancing and did useful activities e.g. temple court sweeping. However, the elderly of home-bound group and bed-bound group in all study areas did not come out of the houses and surrounding areas because they undergo trouble to movement.

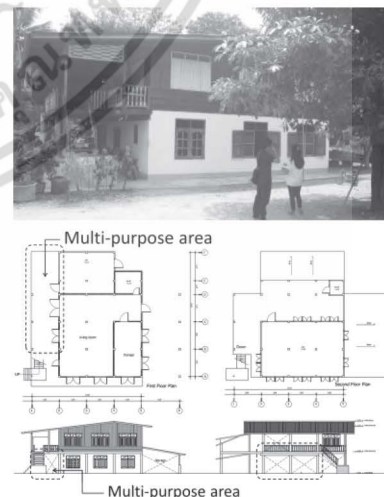
3.2.2 Functional and surrounding areas and elderly behaviors. The study also investigates the correlations between the ability of the elderly and various space utilizations. There are three elderly groups that used functional and surrounding areas in and around their homes. (Figure 2, Figure 3 and Figure 4)



**Figure 2** multi-purpose area of single-story house



**Figure 3** multi-purpose area of single-story house that have a high-space under the living floor



**Figure 4** multi-purpose area of double-story house

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**The first group, Society-Bound,** consists of seniors in good health who are able to use surrounding areas for working in occupations such as weaving baskets, making brooms and throwing handmade pottery.

**The second group, Home-Bound,** consists of seniors whose behaviors varied with the type of housing. The first type of housing considered was single-story Thai houses in rural areas that often have a low-space under the living floor. Even though the overhead clearances in those low spaces are limited, seniors and their relatives utilize them anyway. These low spaces carry significant risk of injury such as a severe blow to the head upon contact with an unseen low beam or floor joist. The second type of housing considered was single-story Thai houses in rural areas that often have high-space under the living floor. Seniors and their relatives favor these cool areas for daytime rest. The third type of houses considered was double-story Thai houses. Seniors tend to favor the cooler ventilated areas on the ground floor of the houses for living and multipurpose use. Nonetheless, the study seeks to evaluate all areas used by seniors for living, eating, toilet hygiene and sleeping. The most significant areas are the spaces used for rest and dining. These "multi-purpose areas" are the most heavily used areas in the rural Thai houses of the Lower Northern Region of Thailand. Also significant are the toilet facilities as they often have functional limitations resulting in the greatest numbers of elderly accidents and injuries.

**The third group, Bed-Bound,** consists of seniors who use only one space for living, eating, toilet activities and sleeping. These seniors need assistance with virtually everything they have to do. The study found that this group favors ventilated rest areas that offer greater accessibility and more open space to keep elderly aid appliances.

3.2.3 Risk and accidents of seniors. The study also seeks to explain the correlations between sample locations their space utilization and accident. Based on the study of the residential buildings resided by the three groups of the elderly, the result discovers the pattern of how they live their lives and the functions and space of the buildings in the studied areas. It signifies correlations between the building structure and chance of having accidents. There are three important issues in this topic, including consideration of the areas of the home where most accidents actually occur, the areas of the home where seniors are most aware of the potential for accident and areas of the home where accidents are typically caused by mistakenly designed or poorly maintained facilities and housing components. First, the number one accident areas of senior homes are the outdoor areas (55.56%), kitchen areas (19.45%), stairs (11.11%), toilet facilities and basements (9.72%). (Figure 5) Second, the accident areas about which seniors have the most visceral concern about danger in their houses and surroundings are the outdoor areas (44.44%), stairs (25%), toilet facilities (20.83%), basement or space under Thai homes (5.56%) and kitchen areas/ dining areas (5.56%). (Figure 6)

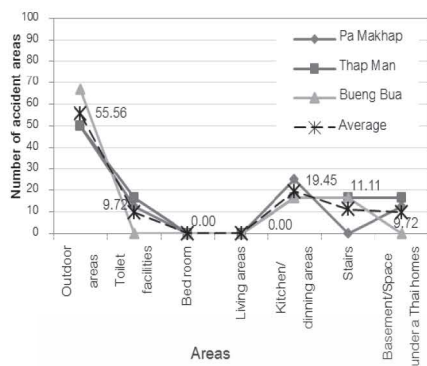


Figure 5 Accident occurrence areas of senior homes

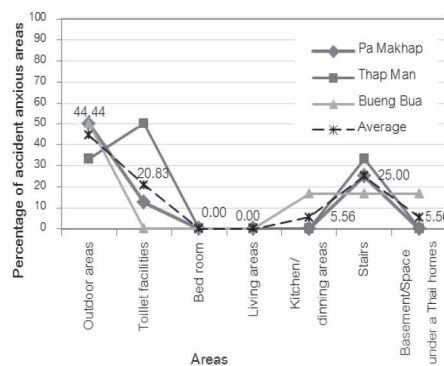


Figure 6 Accident areas where seniors were anxious

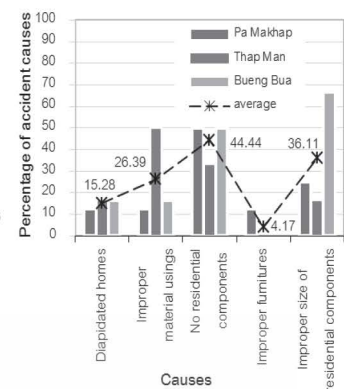


Figure 7 Accident causes from residential environments

However, seniors do not mention any risks associated with open basements—the open space under Thai houses because they are used to spending so much time there in the daytime. They are also more likely to have accidents in the kitchen/dining areas because they are not concerned about the safety of those areas and become careless.

Third, the many accidents caused by the poor physical facilities and residential components are rooted in the fact that there is insufficient elderly equipment available and residential components lack standardization. (Figure 7)

- **Improper materials, no residential components and improper size of residential components:** If the residential buildings are located in the flooding prone area, the stairs are mostly built with cement or tiles. The newly built one does not have a handrail and it is also steep. Each riser is 19-22 centimeters high. Handrail is installed only on one side and this easily leads to accidents. The standard practice normally would have the elderly stair's risers of 15 centimeters high with handrails installed on both sides.

- **Dilapidated houses:** It normally happens with the kitchen. This is because the kitchen needs to support great dead load at all times. Some kitchens are used as a cleaning area. The detergents have eroded the floor leading to the collapse.

- **Improper Furniture:** This shows the case of imbalanced sizes of furniture. For example, wooden sofas have the height of 65-73 centimeters. Some are built 35-38 centimeters high. The standard height recommendation for the elderly normally is 45-50 centimeters.

Accidents can happen and these can be seen. (Figure 8) Simple statistics obtained from the study can be used to support how to alleviate accidents by applying the Domino Theory as described in the next part. (Figure 9)



Figure 8 Residential components which made accident risk.

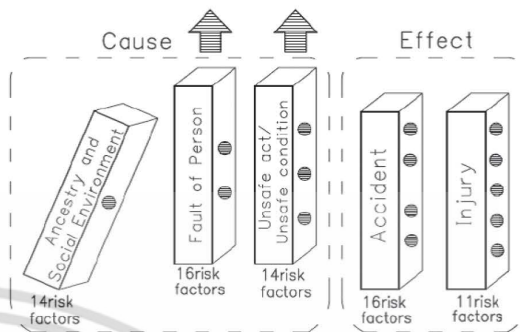


Figure 9 The considered method of Hazard suppression

### 3.3 Domino Theory analysis to determine accident causes and results

Accident causes are considered through Domino Theory analysis that simulates accident causes and results as a scenario of the fifth domino, injury. If one domino falls, the next will fall too. The first, second and third dominoes are the causes leading to the fourth and fifth dominoes, which are accidents and injury. (Figure 9) The first domino, Ancestry and Social Environment, has 14 risk factors, the second domino, Fault of Person, has 16 risk factors, the third domino, Unsafe Act/Unsafe Condition, has 14 risk factors. These causes bring us to the fourth domino, Accident, which has 16 factors, and the fifth domino, Injury which has 11 factors.

The first domino, ancestry and social environment: The two of the groups of seniors in this study, including society-bound and home-bound seniors, are able to carry out housework and daily routines independently. For example, they are able to go from a multi-purpose area to the toilet and are able to cook. The bed-bound seniors are not able to do anything independently. From the data gathered on 20 elderly of the three groups, it was found that 14 elderly (70%) who fell had declining health. However, accident causes from the first domino conditions normally occur because physical deteriorations are natural and cannot be eliminated by facility improvements, but can be improved by public health intervention. Thus, the first domino cannot be completely eliminated.

The second domino, fault of person: Elderly risk behaviours can be eliminated as risk factors. The study isolated preventable risk factors, including such things as placing a slippery doormat in front of the stairs, leaving obstructions in pathways, and failure to make residential repairs. For example, broken floor structures, such as floor tiles, in the kitchen and dining areas often caused senior injuries. The third domino, unsafe act/unsafe condition: This is a major cause of accidents, including failure to provide proper equipment such as canes and walkers; failure to provide proper building components such as handrails; failure to properly size and standardize components such as stairs, toilets, tables and chairs and failure to use appropriate materials such as non-slippery floor tiles in areas that often become wet from rain or oily from cooking. These factors are often the cause of the fourth domino, Accident: The study revealed that seniors often suffer preventable accidents, including tripping, slipping, falling down stairs and falling in dilapidated kitchens. The fifth domino, Injury: The study revealed that seniors suffering these accidents often sustain bleeding head injuries and painful joint and bone injuries. However, if seniors, their relatives or other residents eliminated these risk factors, many of these accidents and injuries would not occur.

## 4. Conclusion

The research results regarding society-bound elderly conform to data set forth in the literature reviews, which find a relationship between age and mobility in the context of senior homes (Hester, JR., 1975). Therefore, hazard suppression for elderly home management should apply to areas and behaviors related to daily living activities such as eating, cooking, toilet use and sleeping. The Domino Theory of H.W. Heinrich is significant because the elderly are usually physically declining in a manner that affects independent ability and efficiency. Moreover, most accident causes in Domino Theory can be traced to the fault of persons that are most responsible for the factors affecting accidents and injury to elderly. These effects are not high level. However, there are two issues for relevant problem solving, including adjusting the safety environment for elderly homes and building awareness about accidents which occur from omission.

Seniors and the people responsible for them easily could understand explanations that follow from Domino Theory. Accident risk problem solving can be illustrated by using the domino order, especially the second domino, fault of person, such as omission, no interest in safety and unsafe behaviors, and the third domino, failure to make repairs or install appropriate residential components. These dominoes can be eliminated simply by adjusting the physical environment and providing appropriate equipment to conform with universal design theory and ergonomic principles that relate to the elderly.

### 4.1 Guidelines for Hazard Suppression in Elderly Homes in Rural Areas that relates to Domino Theory:

#### 4.1.1 Fault of person – Solution for Second Domino Factors

1) To construct knowledge and experience: Construct a knowledge and experience base for accident prevention that can be used to train the occupants of senior houses by passing on knowledge, experience and suggestions to eliminate ignorance.

2) To train: Train the occupants of senior houses to be aware of safety and the potential for accidents occurring in their homes.

3) To construct awareness: The occupants of senior houses should actively manage risk factors through such actions as cleaning, picking up slippery mats and eliminating unnecessary obstructions in travel areas.

4) To check residential structure: The occupants of senior houses should habitually check residential structures for defects resulting from both poor design and wear that need to be rectified or repaired.

#### 4.1.2 Unsafe Act/Unsafe Condition – Solution for Third Domino Factors

1) To provide appropriate building components and equipment to aid the elderly: Elderly houses should have appropriate building components such as handrails in the bathrooms, on stairways, and in areas of travel, as needed.

2) To set appropriate component sizing: Improperly designed, built or sized components in elderly houses are major causes of accidents. Standardized sizing that follows universal design theory is necessary for elderly dwellings. For example, stairways should have risers no more than 15 centimeters high

and treads at least 28 centimeters deep. Handrails should measure 80 centimeters high from the floor or stair steps. At some point, a handicapped senior that is able to move by using a slide board should have specific components such as windows put at a lower than normal level so the senior is able to open and close them. Moreover, lowering windows will improve quality of life by enabling the elderly to see outdoor views.

3) To set appropriate materials: There is a large variety of building and construction materials now on the market. If the occupants of senior houses choose inappropriate materials, such as slippery tiles for the kitchen or bathroom floors, the elderly will have accidents. Thus, people living in senior houses should be more concerned with the appropriate suitability of their choices rather than with beauty.

4) To renovate dilapidated housing: Residents of senior houses should carefully monitor the condition of their homes, especially such things as broken railings, missing floor tiles or decaying floor structures. Heavy loads, such as water jars, should not be placed on structures that may not support them.

5) To select appropriate furniture sizing: Selecting appropriately sized furniture will significantly reduce accidents. There are special universal design and ergonomic considerations that should be followed for the elderly. Sometimes an individual may have specific ergonomic needs that a caretaker should provide.

However, often correction of deficiencies in the physical environment and house renovation can be difficult or impossible because of family economic situations and attitudes. For example, family members may often feel anxious about cost, construction time and the reliability of builders. Hence, the research team went back into some elderly houses in the rural areas to analyze the physical environments through Domino Theory to find an appropriate solution.

#### 4.1.3 To suggest appropriate hazard suppression for elderly housing in rural area.

1) Houses should have appropriate components and equipment for elderly safety that can be made inexpensively with local materials such as handrails from bamboo.

2) Slippery tiles can be made less slippery without the need to change them by the application of inexpensive textured stickers or a rough texture, such a special paints that are available for this purpose.

3) Elderly houses in rural areas which house only one senior can share certain appliances. Thus, the community should take part in solving these problems.

4) Kitchen and dining areas in rural homes commonly become dilapidated over time, but these problem areas are often overlooked. For example, many residents put too much weight, such as water jars and appliances, over worn out floor structures. These loads are the causes of many accidents and injuries. Simple education of the occupants of these houses can provide the know-how to prevent these risk factors.

The Domino Theory of H. W. Heinrich was studied and utilized in this research to explain methods of hazard suppression for elderly houses in rural areas of the Lower Northern. Using the five dominoes, placed in order, the study showed that Domino Theory relates well to real practice. The effect of the fourth domino, accidents, on the fifth domino, injury, will not occur if the second domino, fault of person, or the third domino, เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่นอนุญาตให้นำไปใช้ประโยชน์ด้านการค้า

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unsafe act/unsafe condition, is eliminated from the hazard process. Nonetheless, the first domino, ancestry and social environment is not easily eliminated given the barrier of undesirable personal traits, such a stubbornness, and entrenched social attitudes that are unlikely to change. On the pro side, Domino Theory can provide people with the knowledge base necessary to recognize risk factors, understand construction and make changes necessary for the safety of seniors. On the con side, these solutions will solve nothing if people will not embrace them and apply them in practice.

#### 4.2 Benefit of Domino Theory for presenting to people in rural areas

This study applies the Domino Theory to share the findings to the elderly and their relatives. This makes the explanation simple and understandable. Participants are involved in the process leading to their awareness to mitigate the chance of having accidents as a result of building structures.

### Acknowledgment

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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา อย่างไรก็ดีเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้  
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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา หรืออ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้