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RESEARCH ARTICLE

Association Between Awareness of Informal Caregivers and Falls in Elderly Patients with Uncontrolled Diabetes Mellitus

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Abstract:

Background:

Elderly people with uncontrolled diabetes mellitus (DM) are at risk of falls, which can lead to injury and disability. Not much is known of informal caregivers' awareness of falls in elderly patients with DM.

Objective:

This study aims to identify an association between caregiver's awareness and falls in elderly patients with DM.

Methods:

A total of 136 pairs of DM patients and their respective family caregivers were recruited from a clinical service center at Chiang Mai University, Thailand. The questionnaire regarding the caregiver's awareness of the risk of falls in elderly patients was given *via* a face-to-face interview. Each elderly patient was asked about their history of falls in the prior year, and the risk of falls was assessed by Time Up & Go (TUG) test. Logistic regression analysis was performed to determine association.

Results:

The mean age of the DM patients was 65.7 years. Sixty-two patients (45.6%) had fallen at least once in the prior year. The mean TUG test result was 12.67±1.83 second. Most caregivers demonstrated a high level of awareness regarding the risk of falls in elderly patients. The results of the multivariable analysis showed that three variables – balance problems, risk of falls assessed by TUG test, and scores of caregiver's awareness of risk of falls – were significantly related to falls in the previous year among elderly patients with DM (p-value<0.05).

Conclusion:

The caregivers' awareness of fall risk may influence fall occurrence among older adults with DM. An intervention program to improve awareness among informal caregivers should be considered for fall prevention in elderly people.

Keywords: Fall, Caregiver, Awareness, Elderly, Diabetes, TUG.

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1. INTRODUCTION

Nowadays, the number of diabetic patients is dramatically increasing worldwide. According to the International Diabetes Federation report, in 2019, there were a total of 463 million diabetic patients. It was further predicted that 628 million people would be diagnosed with diabetes by 2045. Unfortunately, 4 million people have died from diabetes [1]. In Thailand, the Ministry of public health reported that there were 2.81 million diabetic patients in 2019. Of these, 1.65 million people with diabetes were elderly. Diabetes Mellitus (DM) causes high plasma glucose levels and causes many complications in multiple organs, such as vision, the neurological system, the cardiovascular system, and the musculoskeletal system. Moreover, elderly people with diabetes have a high risk of falling and untimely death [2].

Falling can lead to injury and disability in the elderly. The most common injury is a bone fracture and traumatic brain injury [3], which can result in immobility, loss of activities of daily living, and death [4]. Falling not only requires significant treatment and rehabilitation but also more assistance from caregivers for activities of daily life [5, 6]. Worldwide, more than 37 million falls must be treated, and have killed more than 646,000 patients, mostly older people [7]. In 2017, the Ministry

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of Public Health of Thailand reported approximately 3 million cases of elderly people falling, with the risk of falls increasing with age, and with 1,046 cases per hundred thousand people resulting in death [8]. Medical conditions, such as diabetes, contributed to increased rates of falling in the elderly [7, 9].

Prior studies revealed a higher incidence of falls in older persons with diabetes who use insulin for controlling blood sugar, when compared to older persons without diabetes [10]. Approximately 39% of falls in one year were reported to be elderly diabetic individuals [11]. Therefore, elderly patients with DM need family or informal caregivers to provide care and pay close attention in order to prevent falls. The caregivers play an important role in caring for patients in multiple ways [12], including providing first aid, treating minor illnesses, managing medication, administering drug regimens, and providing physical and psychological support [13]. A family caregiver then is a protector who can help prevent falls and fall-related injuries.

According to a number of studies, awareness and concern in both seniors and their caregivers regarding falls may be an important factor for fall prevention among elderly people [15 - 17]. However, little is known about the influence of the caregiver's awareness on falling in older adults with uncontrolled diabetes, who are at high risk. This study aimed to identify an association between the level of fall awareness of family caregivers and fall occurrence in elderly patients with DM, and to determine risk factors associated with falling.

2. MATERIALS AND METHODS

2.1. Study Site and Population

This cross-sectional study conveniently sampled 136 pairs of senior DM patients with their respective caregivers who lived in urban areas in Chiang Mai, Thailand, and came to the AMS Clinical Service Center (AMS CSC), Faculty of Associated Medical Sciences, Chiang Mai University. The inclusion criteria for patients were (a) male or female aged 60 years and older; (b) a haemoglobin A1C level of 6.5% or higher for two consecutive tests during health check-ups for diagnosing "uncontrolled DM" [1]; and (c) no diabetes complications (*e.g.* retinopathy, nephropathy, neuropathy), disabilities, or chronic diseases that affect mobility or gait patterns. The eligible criteria for the patients' caregivers were family members or relatives who stayed with the patient at least 3 hours a day, with at least one year of care experience. This study was approved by the Institutional Ethical Committee of the Faculty of Associated Medical Sciences, Chiang Mai University, Thailand (approval number AMSEC-63EX-004). Participants gave informed consent prior to data collection.

2.2. Data Collection

Face-to-face interviews and functional assessments were conducted at the AMS CSC by a researcher. The questionnaire consisted of 2 parts, one part for the elderly patient and one part for the family caregiver. Data from the part for the elderly patient with uncontrolled DM included demographic characteristics, self-reported medical history, living environment, and fall history during the prior year. For the caregiver's part, data collection included demographic characteristics, care characteristics, and an awareness questionnaire regarding fall risk in elderly patients, which was developed by the researchers. The awareness questionnaire comprised eighteen items that were assessed using a five-point rating scale from strongly disagree to strongly agree. Possible scores ranged from 18 to 90 points. For positive statements, strongly disagree was scored 1 and strongly agree was scored 5. For negative statements, strongly disagree was scored 5 and strongly agree was scored 1. The validity of the questionnaire was examined by three experts in family medicine, physical therapy, and public health, resulting in an index of item objective congruence of 0.96. The reliability of the awareness questionnaire had a Cronbach's alpha coefficient of 0.96.

In addition, the risk of falls for elderly patients was assessed by a standardized tool called the "Timed Up & Go (TUG) test" [18]. Briefly, the patients were asked to sit in a seat with a height of about 46 centimeters. The patients were asked to walk normally on the floor for about 3 meters, turn and walk back to the seat and sit down. The time, from the moment the patient stood up from the seat until they returned to the seat, was recorded. For familiarity, the patients were allowed to walk through the test once before the time was taken.

2.3. Statistical Analysis

We performed data analysis using SPSS version 17, licensed from Chiang Mai University (SPSS Inc., Chicago, IL, USA). Frequency, percentage, mean, and Standard Deviation (SD) were used to describe the general characteristics of the information. Binary logistic regression was analyzed to test the association between caregivers' fall awareness, other fall-related factors, and elderly patients' falls in the prior year. Univariable analysis was performed to investigate factors with p-values of less than 0.15. The significant factors were then put through multivariable analysis to examine the variables that were still related to fall occurrence with levels of significance of $p<0.05$. The predictors with a p-value < 0.05 were put into the final regression model.

3. RESULTS

3.1. Descriptive Characteristics of Elderly Patients with DM and Caregivers

Descriptive characteristics of the 136 pairs of DM patients and their respective family caregivers are shown in Table **1**. All family caregivers who participated in this study were the primary caregivers of elderly patients. Most patients (69.9%) were female, whereas the majority of the caregivers (52.9%) were male. The average age among elderly patients was 65.65±3.45, with a range of 60–76 years old, and the average age of their caregivers was 59.95±11.96, with a range of 25–75 years. Half (52.2%) of the patients were obese, with a body mass index of more than 23.0 kilograms/meter^2. Walking is the most popular form of exercise among elderly patients. Only 5.1% of elderly patients used gait aids. All elderly patients slept in a low bed with a height of 40 – 60 centimetres. Almost all of them (99.3%) had no handrails in their bedroom. The risk

factors in the bathroom included having no handrail around the flush toilet (90.4%), using a squat toilet (0.7%), and slippery floors (2.9%). In the kitchen, the risk factors were disorganization (31.6%) and wet floors (5.1%). The risk factors on the floor included carpeted walkways (58.1%), objects or obstacles in walkways (27.9%), and slippery or uneven floors (21.3%).

Table 1. Descriptive characteristics of 136 pairs of DM patients and their family caregivers.

Characteristics	Elderly with DM	Caregiver
	N (%)	N (%)
Personal characteristics		
Relationship to the elderly patient Spouse Son Daughter Brother or sister	-	 104 (76.5) 13 (9.6) 8 (5.9) 11 (8.1)
Gender Male Female	 41(30.1) 95 (69.9)	 72 (52.9) 64 (47.1)
Age (years) [mean±SD]	65.65±3.45	59.95±11.96
Body mass index (kg/m^2) [mean±SD]	25.27±3.17	
Marital Status Married Single Divorced/Widowed/Separated	 104 (75.7) 16 (11.8) 17 (12.5)	 118 (86.8) 12 (8.8) 6 (4.4)
Education Senior high/Diploma Bachelor	 39 (28.7) 97 (71.3)	 19 (14.0) 117 (86.0)
Currently working	5 (3.7)	30 (22.1)
Health care provider	25 (18.4)	19 (14.0)
Duration of DM diagnosis (years) [mean±SD]	4.47±1.89	-
Other underlying diseases	80 (58.8)	-
Other drug history besides DM drugs Antihypertensives Diuretics Dyslipidemia Anticoagulant Psychotropics More than 4 types of drug	75 (55.1) 45 (33.1) 6 (4.4) 31 (22.8) 2 (1.5) 0 (0.0) 6 (4.4)	-
Drink alcohol	53 (39.0)	-
Exercise None < 3 times per week ≥ 3 times per week	 25 (18.4) 64 (47.1) 47 (34.6)	-
Sleep problems None Slightly Moderate	 40 (29.4) 77 (56.6) 19 (14.0)	-
Balance problems	67 (49.3)	-
Incontinence or constipation problems	17 (12.5)	-
Use of progressive lenses	45 (33.1)	-
Wears slippers at home	69 (50.7)	-
Wears socks at home	12 (8.8)	-
Uses stairs	75 (55.1)	-
Care characteristics		
Days dedicated to provide care for the elderly 5 6 7	-	 8 (5.9) 15 (11.0) 113 (83.1)
Period of time spent as a caregiver Daytime Nighttime Daytime & Nighttime	-	 3 (2.2) 27 (19.9) 106 (77.9)

(Table 1) contd.....

Characteristics	Elderly with DM	Caregiver
Previous experience caring for the elderly	-	31 (22.8)
Environmental characteristics		
Home design One-story house Two-story house	 73 (53.7) 63 (46.3)	-
Type of floors Wood Tile	 34 (25.0) 102 (75.0)	-
Poor lighting in the bedroom	22 (16.2)	-
Risk factors in the bathroom	124 (91.2)	-
Risk factors in the kitchen	45 (33.1)	-
Risk factors on the floor	96 (70.6)	-

3.2. TUG Test and Fall History Among Elderly Patients with DM

The TUG test was performed to assess the risk of falling among elderly patients and resulted in a range of duration from 9.08 to 16.72 seconds, with a mean duration of 12.67±1.83 seconds. Average walking duration for patients classified as fallers was 14.04±1.35 seconds and the average for non-fallers was 11.53±1.33 seconds. Regarding fall occurrence, 62 patients (45.6%) had fallen in the prior 12 months and 11.3% had experienced recurrent falls, including indoor falls or falls around the house (93.6%), and outdoor falls (6.5%). Falling sometimes resulted in injury, including bruises and abrasions (45.2%), pain and swelling (27.4%), and open wounds (11.3%). Most patients did not receive treatment after falling. Some treated themselves and went to hospitals or clinics, but no one had to be admitted to a hospital. The causes of falling were tripping over objects (48.8%), slipping (25.8%), poor balance while changing position (22.6%), dizziness (16.1%), faintness (4.8%), walking down the stairs (4.8%), stumbling over uneven ground (3.2%), and being pushed by other persons (3.2%).

3.3. Caregiver's Awareness of Risk of Falls in Elderly Patients with DM

Caregiver's awareness of the risk of falls in elderly patients with uncontrollable diabetes is presented in Table **2**. The average fall awareness score for informal caregivers was 77.24±9.75, with a range of 63–90 points, indicating a good level of awareness. The mean fall awareness score for caregivers of patients classified as fallers was 69.45±6.45, and the average for caregivers of non-fallers was 83.77±6.81 points. The questionnaire item with the highest awareness score (mean = 4.49) was the question, "The caregiver will be careful when traveling with the patient such as going out to see a doctor" with 50% answering strongly agree. Whereas, the item with the lowest score (mean = 3.71) was the question "If the caregiver sees a wet floor, the caregiver will leave it to dry by itself" with 48.5% answering disagree.

Table 2. Caregiver's awareness of risk of fall in elderly patients with uncontrollable diabetes (N = 136).

Awareness item	Mean±SD (score)
1. As the patient becomes older, the caregiver will increase caregiving provided to the patient to avoid falls.	4.48±0.56
2. The caregiver must pay more attention to the care of elderly diabetic patients than they would the care of healthy elderly people as regards falling.	3.84±0.76
3. If the elderly patient has vision, balance, or joint and muscle problems, the caregiver will help the patient while doing activities.	4.35±0.65
4. The caregiver will help the elderly do activities as requested in order to reduce the risk of falls from doing activities by himself/herself.	4.32±0.63
5. If the elderly patient falls, the caregiver will increase care provided to prevent falls in the future.	4.37±0.59
6. The caregiver has good conversations with the elderly patient about mental help, which may reduce risk of falls.	4.20±0.79
7. The caregiver will provide much more care to prevent falls if the elderly patient takes any drugs with side effects affecting balance, e.g., sleeping pills or antihypertensives.	4.27±0.73
8. The caregiver will provide sufficient light in the areas where the elderly patient resides.	4.38±0.60
9. The caregiver will arrange the items that the elderly patient uses regularly so that they will be able to use or pick up them easily.	4.36±0.59
10. If there are objects on the floor or materials blocking the way, the caregiver will wait for others to remove or pick them up.[a]	4.22±0.70
11. The caregiver will organize electrical cables that clutter walkways to reduce the risk of stumbling.	4.33±0.73
12. If the caregiver sees a wet floor, the caregiver will leave it to dry by itself.[a]	3.71±1.00
13. The caregiver will warn the elderly patient to be careful when they are going up and down the stairs or they will provide extra care to the patient if the patient has difficulties doing so on his/her own.	4.43±0.55
14. The caregiver will warn the elderly patient to be careful when they are walking on rough or uneven surfaces.	4.45±0.53
15. The caregiver pays attention when choosing shoes that are suitable for the elderly patient.	4.29±0.69

(Table 2) contd.....

16. The caregiver will encourage the patient to do exercise based on his/her physical condition in order to strengthen muscles and joints.	4.35±0.61
17. The caregiver will encourage the elderly patient to eat healthy food in order to increase their physical strength.	4.40±0.56
18. The caregiver will be careful when traveling with the patient, e.g., going to see a doctor.	4.49±0.52
Total	77.24±9.75

[a]Negative statement.

3.4. Association Between Awareness of Informal Caregivers and Falls in Elderly Patients with DM

Logistic regression analysis was used to investigate how awareness of informal caregivers was associated with falls in the past year among elderly patients with DM. According to univariable analysis, non-significant factors at p-value=0.15 included (a) six variables of the patients' characteristics – gender, education, work as a healthcare provider, alcohol consumption, wearing socks at home, and use of stairs; (b) two variables of the caregivers' characteristics – gender, and marital status; (c) all variables of care characteristics – number of days providing care to the elderly, time for care, and experience with elderly care; and (d) one variable of environmental characteristics – risk factors in the bathroom (data not shown). However, there was an inversely significant relationship between fall awareness score of informal caregivers and falls in the past year among elderly patients with DM (OR=0.80, p-value<0.001). Factors associated with falls in elderly patients with uncontrolled diabetes by binary logistic regression are shown in Table **3**.

For multiple logistic regression, all variables with p-values of less than 0.15 were entered into the analysis. The results from the last model showed that three factors – balance problems, risk of falls, and caregiver's awareness – were statistically significantly related to falls in the prior year among elderly patients with DM (Table **4**).

4. DISCUSSION

A total of 136 pairs of elderly patients with uncontrollable DM and their respective informal caregivers participated in the study. The findings revealed a 1-year prevalence of falls of 45.6%, quite a high prevalence considering an estimated 30–40% of patients aged 65 and older will fall at least once yearly [19]. This may be because older people with DM, especially insulin-treated patients, have a greater risk of falling [9 - 11, 20]. Additionally, elderly DM patients with complications, including neuropathy or retinopathy, which cause a decline in sensory function, may have an increased risk of falls [21]. However, this study excluded patients with DM complications due to possible effects on many organ systems as well as on physical function and mobility. Almost all (93.6%) falls among elderly patients were indoor falls, or falls around the house. This is consistent with the previous study, which reported a greater chance of indoor falls in patients with diabetes [22]. These findings emphasized that falls are a concern for elderly adults with diabetes mellitus; therefore, a program for fall prevention should be promoted.

Table 3. Factors associated with falls in elderly patients with uncontrolled diabetes by univariable analysis, logistic regression (N=136).

Factors	B	S.E.	OR (95% CI)	p-value
Elderly patient factors				
Age (years)	0.14	0.05	1.15 (1.04, 1.28)	0.008*
BMI (kg/m^2)	0.12	0.06	1.13 (1.01, 1.26)	0.039*
Marital status				
Married	Ref.			
Single	-0.81	0.57	0.45 (0.14, 1.37)	0.159
Divorced/Widowed/Separated	-0.89	0.57	0.41 (0.13, 1.24)	0.115
Duration of DM diagnosis (years)	0.60	0.13	1.82 (1.41, 2.34)	<0.001*
Other underlying diseases	1.81	0.40	6.11 (2.79, 13.37)	<0.001*
Other drug history besides DM drugs	1.50	0.38	4.46 (2.14, 9.31)	<0.001*
Exercise				
≥ 3 times per week	Ref.			
< 3 times per week	1.21	0.60	3.37 (1.03, 10.97)	0.044*
None	2.52	0.63	12.38 (3.59, 42.70)	<0.001*
Sleep problems				
None	Ref.			
Slightly	0.92	0.43	2.50 (1.07, 5.82)	0.033*
Moderate	3.24	0.83	25.50 (4.99, 130.23)	<0.001*
Balance problems	2.82	0.44	16.81 (7.15, 39.52)	<0.001*
Incontinence/constipation problems	3.23	1.05	25.39 (3.26,197.97)	0.002*
Use of progressive lenses	1.77	0.41	5.88 (2.66, 13.01)	<0.001*

(Table 3) contd.....

Wears slippers at home	0.79	0.35	2.20 (1.10, 4.37)	0.025*
Environmental factors				
Home design	0.76	0.35	2.13 (1.07, 4.24)	0.031*
Type of floors	0.92	0.43	2.50 (1.08, 5.75)	0.032*
Poor lighting in the bedroom	1.03	0.50	2.79 (1.05, 7.44)	0.040*
Risk factors in the kitchen	1.02	0.38	2.76 (1.32, 5.77)	0.007*
Risk factors on the floor	1.27	0.42	3.55 (1.56, 8.06)	0.003*
Time Up & Go Test (sec)	1.16	0.18	3.18 (2.23, 4.55)	<0.001*
Informal caregiver's factors				
Relationship to the elderly patient				
Spouse	Ref.			
Son	-0.15	0.59	0.86 (0.27, 2.72)	0.794
Daughter	-0.41	0.93	0.67 (0.11, 4.16)	0.664
Brother or sister	-1.50	0.81	0.22 (0.05, 1.08)	0.062
Age (years)	0.03	0.02	1.03 (0.99, 1.06)	0.091
Education	-1.72	0.59	0.18 (0.06, 0.57)	0.004*
Currently working	-0.85	0.44	0.43 (0.18, 1.02)	0.056
Health care provider	-1.69	0.66	0.18 (0.51, 0.67)	0.010*
Caregiver's awareness (scores)	-0.22	0.03	0.80 (0.76, 0.86)	<0.001*

Abbreviations: B = regression coefficient, S.E. = standard error, OR = odds ratio, CI = confidence interval, Ref. = reference group.

Note: Variables: other underlying diseases (no = 0, yes = 1); drug history besides DM drugs (no = 0, yes = 1); balance problems (no = 0, yes = 1); incontinence problems (no = 0, yes = 1); use of progressive lenses (no = 0, yes = 1); wears slippers at home (no = 0, yes = 1); home design (one-story house = 0, two-story house = 1); type of floor (wood = 0, tile = 1); poor lighting in the bedroom (no = 0, yes = 1); risk factors in the kitchen (no = 0, yes = 1); risk factors on the floor (no = 0, yes = 1); education (senior high/diploma = 0, bachelor = 1); currently working (no = 0, yes = 1); health care provider (no = 0, yes = 1); age (years), BMI (kg/m^2), duration of DM diagnosis (years), Time Up & Go Test, and caregiver's awareness = continuous data.

*Significant at the 0.05 level (2-tailed).

Table 4. Predictors influencing falls in elderly patients with uncontrolled diabetes by multiple logistic regression (N=136).

Factors	B	S.E.	OR (95% CI)	p-value
Balance problems (no = 0, yes = 1)	1.36	0.60	3.90 (1.20,12.64)	0.023*
Time Up & Go Test (sec)	0.63	0.21	1.87 (1.23, 2.85)	0.003*
Caregiver's awareness (scores)	-0.12	0.04	0.90 (0.83, 0.97)	0.009*

*Significant at the 0.05 level (2-tailed).

In the present study, fall risk was assessed by TUG test, which requires both static and dynamic balance, resulting in a mean of 12.7 seconds (means of 14.0 and 11.5 seconds for fallers and non-fallers, respectively). This is similar to the walking speed test used for elderly diabetic patients in the study of Chiba *et al*. [20], which reported a mean of 12.0 seconds (means of 13.6 and 11.0 seconds for fallers and non-fallers, respectively). In addition, the DM patients in the current study had, on average, a higher fall risk when compared to the general population of Thai community-dwelling elderly people, who have reported means of 11.7 seconds for fallers and 10.4 seconds for non-fallers [23]. According to another study of community-dwelling elderly people in Japan, the faller group had a mean score of 10.5 seconds, and the non-faller group had a mean of 8.3 seconds [24]. However, many factors influence walking speed, such as participants' physical factors (height, age), shoes, surface textures, and height of the chair [18, 25].

In terms of fall awareness, it was found that informal caregivers had high scores of awareness regarding fall risk in elderly patients. This may be due to caregivers' levels of education [26], as most had a bachelor's degree. The present study is similar to a previous study of family caregivers of patients with cancer, in which most caregivers were a spouse or partner of the patients and were well-educated [17]. In addition, the study of Potter *et al.* [17] revealed that caregivers' fall risk awareness improved after receiving standard education and a fall-prevention DVD program. Our findings show that family caregivers were aware of the risk of falls among DM patients in many dimensions, including daily activity support, psychological support, home environment organization, elderly health promotion, and warning and surveillance both indoors and outdoors. The low prevalence of outdoor falls among patients may reflect caregivers' careful observance of the elderly patients when they travel outside, as this question had the highest score of awareness in this study. Likewise, the low prevalence of falls from stumbling over uneven ground (3.2%) may reflect caregivers' high awareness about cautioning the elderly to be careful while walking on rough surfaces or in areas with uneven ground, which can increase fall rate [27, 28]. However, the lowest score, regarding caregivers' awareness about floor care, may indicate one reason that slipping was so common among elderly patients, at 25.8%. This is also supported by a prior study that found that wet and slippery floors resulted in an increased risk of falling [27, 29]. Based on these findings, the awareness of caregivers may impact the risk of falls in elderly patients.

Both univariable and multivariable analysis revealed that family caregivers' fall awareness was inversely related to fall occurrence among elderly patients with uncontrollable diabetes in the prior year, indicating a main influencing factor. This is supported by concepts and theories of awareness of situations, which is a preventative skill that reduces human error and environmental risk factors, solving problems before unwanted

events occur [30]. When one has awareness, that awareness will cause a behavioral change [31]. It can be concluded, then, that if family caregivers have high awareness regarding the risk of falling, that awareness will lead to greater fall prevention, reducing occurrence of falls in elderly patients with DM. However, a previous study also found a relationship between older adults' awareness and their own fall rate [32]. Therefore, elderly patients' own fall awareness should be included in future studies. Regarding caregiver factors, education level and work in the health science field were both negatively associated with falls among the patients. This suggests that higher education level and occupational background related to health may influence knowledge and understanding about risk of falling, including risk factor elimination and prevention, which can affect severity in case of falls and reduce risk of falls in elderly patients. On the other hand, care characteristics, comprising number of days providing care, time providing care, and experience with elderly care, were not related to falls. The findings suggest that caregivers' awareness about fall risk is a main protective factor for both indoor and outdoor falls among elderly patients.

Multivariable modelling revealed that balance problems and fall risk (tested by speed walking) were factors related to falls in the prior year among elderly patients with DM. Similarly, the study of Osoba *et al*. [33] found that visual system, posture balance control, and slower walking style among older adults can lead to falling, and the study of Shaw *et al*. [34] revealed a particularly high risk of falling among older adults with impaired orthostatic blood pressure control or who experienced loss of balance while changing positions. In addition, the elderly patients in the current study reported falling due to loss of balance when changing position at 22.6%. This is commonly found in the elderly due to age-related impairment of compensatory reflexes to the upright position. Age increase can cause degeneration of physiological systems, movement, balance and equilibrium, and the ability to do activities, resulting in a greater chance of falls [35]. Moreover, the age of elderly patients in this study was positively related to falls, which is consistent with a previous study, which found that fall rate increases with age [36]. Additionally, BMI was another personal factor of the elderly patients that was positively related to their falls. This is similar to previous research, which found that obesity affected fall risk [37].

Exercise is a key factor in promoting many aspects of body efficiency, including rehabilitation from non-communicable diseases. Specifically, it promoted efficient type 2 diabetes control and prevention, including possible combinations thereof [38]. Exercise also reduced the risk of falls among patients in this study. This is consistent with the study of Sherrington *et al*. [39], which found different types of exercise influenced fall risk reduction in older adults. Duration of DM diagnosis was associated with falls in the elderly patients because long-term diabetes may affect physiological systems, leading to higher fall risk [40]. Having other underlying diseases and taking other drugs in addition to DM drugs were also related to falls. Numerous studies revealed an increased risk of falls in older adults related to intake of medication such as polypharmacy, antihypertensive medications, and cardiac or analgesic drugs (digoxin, type IA antiarrhythmic, and diuretic use) [41 - 45]. This may be due to side effects of the drugs which include dizziness and orthostatic hypotension.

Other health problems of the elderly patients such as sleep problems, especially at the moderate level, urinary incontinence or constipation problems, and use of progressive lenses, were positively related to increased risk of falls in elderly patients. According to a prior study, sleep disturbance was associated with falls in older adults [46]. Also, the study of Soliman *et al*. [47] found that problems of urinary system control are related to falls and bone fractures. One possible explanation is that this may be caused by older adults' hurrying and carelessness when walking into toilets [48]. Visual changes in older adults cause a decreased ability to adjust visual equilibrium. Wearing eyeglasses can improve vision, and progressive lenses, in particular, can help in various situations. However, elderly people who wear multifocal glasses may have a greater chance of falling due to misestimating surface textures, obstacles, uneven floors, or stairs while walking. This is consistent with the study of Lord *et al*. [49], which found that multifocal lenses increased fall risk in older adults.

Wearing shoes in the house was also related to falls in older adults in this study. A previous study found that elderly people wearing slippers had a higher risk of falling than those with bare feet [50]. Environmental factors such as home design and type of floor contributed to falls among elderly patients in this study. Having a bedroom on the ground floor can help patients avoid walking up and downstairs. As a result, a duplex or multi-story house increased the chance of fall risk. The findings showed that tile floors increased the risk of falls when compared to wood floors. This may be due to the decreased frictional force on smoother, more slippery tile floors. Therefore, types of tile should be investigated in further research to identify more slip-resistant flooring. Furthermore, some characteristics in different rooms of the participants' houses were identified as risk factors related to falls, such as poor lighting in the bedroom, no handrail around a flush toilet, use of a squat toilet, a disorganized kitchen, carpeted walkways, objects or obstacles in the walkway, wet or slippery floors, and uneven areas. This is supported by previous studies, which found that insufficient lighting, objects such as rugs around the house, and lack of grab bars in the toilet may increase the risk of falls [19, 28, 48]. In particular, the main cause of falling among elderly patients was stumbling (48.8%). This suggests that designing, caring for, and organizing the home are important factors for indoor fall prevention.

Limitations of our study include i) potential for recall bias in the interviews regarding falls in the prior 12 months may have affected the results; ii) the participants chosen by convenience sampling had higher education levels and were younger elderly people, and may not be generalizable to the whole population; and iii) cross-sectional study design does not provide information about causal relationships, especially because caregivers' current fall risk awareness may have changed overtime. However, this initial study highlighted that fall awareness of informal caregivers affects falls among elderly patients. For further research, a longitudinal study with random sampling to investigate the relationship between caregivers' awareness and fall rate among elderly patients is

recommended. Also, several factors not included in this study, such as other factors of the elderly patients (cognitive status, fall knowledge, fall awareness, *etc*.) and of the family caregivers (fall knowledge, health history, *etc*.), should be investigated.

CONCLUSION

In conclusion, there is a relationship between caregiver awareness and falls in older adults with uncontrollable diabetes. Personal factors of both caregivers and elderly patients, as well as environmental factors in the home, were related to falls. An intervention program to improve family caregiver awareness designed around daily activity and psychological support, home environment organization, elderly health promotion, and surveillance while traveling should be considered for fall prevention and reduction in elderly people.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Ethical Committee of Faculty of Associated Medical Sciences, Chiang Mai University, Thailand (approval number AMSEC-63EX-004).

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Written informed consent was obtained from each participant prior to the study.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available on request from the corresponding author [J.W].

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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