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ORIGINAL ARTICLE

Association between physical capacity and occupational falls among middle-aged and older farmers in Thailand: Using the self-check risk assessment tool in Japan

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Abstract

Objectives: Declining physical capacity caused by aging increases the risk of occupational falls on the same level and to lower levels. In emerging countries in Asia, the development of a program for older farmers to assess their risk of occupational falls is valuable. The current study aimed to evaluate the relationship between physical capacity and experience of occupational falls among middle-aged and older Thai farmers.

Methods: We conducted a cross-sectional survey of 419 Thai farmers aged 40 years and over during March and April, 2021. For the assessment of physical capacity, we used the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool developed in Japan, consisting of five physical test components. Multiple logistic regression and receiver operating characteristic curves were used to analyze the data.

Results: The results revealed that 25.5% of participants had experienced occupational falls in the past 12 months. For each of the five physical test components, there was no significant association between physical capacity and experience of occupational falls. The area under the receiver operating characteristic curve was less than 0.60 for each of the five physical test components. A similar trend was observed when the analysis was limited to participants aged 50 years and over.

Conclusions: The current study did not reveal any associations between physical capacity in each test and experience of occupational falls among middle-aged and older Thai farmers. Because the mechanisms underlying occupational falls are complex, multiple intervention approaches may be important for preventing accidents.

KEYWORDS

aging, agriculture, fall, farmer, occupational safety

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1 | INTRODUCTION

Aging of the agricultural workforce is a growing concern in emerging countries in Asia.[1] In Thailand, agriculture is the industry with the largest number of workers, accounting for 29.5% of the working population.[2] Thailand is an emerging country with a rapidly aging population, and the percentage of the population aged 65 and over is estimated to increase from 13.0% in 2020 to 26.2% in 2040.[3] Because agriculture belongs to the informal sector in Thailand, farmers do not have access to social security systems such as pensions, workers' compensation, or unemployment insurance.[4] Therefore, it is important for farmers to maintain their health and ability to work over a long period.

Declining physical capacity caused by aging, including muscle weakness and loss of balance, increases the risk of falling.[5] A fall is defined as "an unexpected event in which the participant comes to rest on the ground, floor, or lower level".[6] In the United States, occupational falls are categorized into "falls on same level" and "falls to lower levels".[7] It is estimated that 28–35% of older individuals aged 65 years and over experience a fall-related accident annually, sometimes resulting in fracture, disuse syndrome, or death.[8] In developed countries, the incidence of occupational falls is increasing because of the aging workforce.[9,10] Older workers are reported to be at a higher risk of serious or fatal occupational injuries than younger workers.[11] To prevent occupational falls, companies have taken various measures, such as education, training, and work environment improvements.[12]

A variety of physical capacity measurements have been developed to assess the risk of fall-related injuries in older individuals.[13-15] In Japan, the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool was developed by the Japan Industrial Safety and Health Association in 2010.[16] This tool consists of five physical measurement items and can assess lower limb strength, agility, and balance among middle-aged and older workers. After the measurement, employers can arrange tasks for the workers to match their physical capacity, and the workers can maintain and improve their physical capacity. The use of this tool is currently increasing in the Japanese manufacturing industry because it can safely measure the physical capabilities of older workers without the use of specialized measurement instruments.[17,18]

The development of a program for middle-aged and older farmers to assess their risk of occupational falls would be valuable in Thailand. However, the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool was developed on the basis of a survey of workers in secondary and tertiary industries,[16] and its validity for farmers has not been assessed. Because farmers work in outdoor environments, with heavy use of their feet and legs, they may differ from other study populations.[17,18] Therefore, the purpose of the current study was to evaluate the relationship between physical capacity and experiences of occupational falls among middle-aged and older Thai farmers using the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool.

2 | SUBJECTS AND METHODS

2.1 | Study design and participants

We conducted a cross-sectional survey of farmers in Nan Province, Thailand from March 22–April 5, 2021. The survey consisted of a questionnaire and physical tests. Certified Thai safety officers with expertise in ergonomics measured the physical tests (SA, TL, KK, CT, and AM). A certified senior occupational physician (TI) from Japan with experience in this field provided oversight with translating the protocol procedure[16] and providing training prior to the study. Farmer–producer groups and health centers in four districts (Mueang Nan, Trung Trang, Phu Pian, and Wiang Sa) of Nan Province collaborated with the study. The group leaders contacted the member farmers and invited them to health centers or related facilities in each district of the data collection sites. The inclusion criteria were used to select individuals who (a) were aged 40 years and over, and (b) had been engaged in the same agricultural work for at least 1 year. The exclusion criteria were used to screen out individuals who (a) were not engaged full-time in agriculture, (b) had limitations that could affect physical testing (e.g., lower limb dysfunction due to hemiplegia), and (c) returned incomplete questionnaires or physical tests.

2.2 | Ethics

Participation was voluntary, and all participants provided written informed consent prior to the survey. Participants received 300 THB (approximately 9.6 USD) as financial compensation. This study was approved by the Ethical Review Committee for Human Research of Mahidol University (MUPH2021-023) and the Ethics Committee of the University of Occupational and Environmental Health, Japan (R2-067).

2.3 | Outcome

The outcome of this study was experience of occupational falls on the same level or lower levels.[7] We asked the following question in the questionnaire: "Have you

been injured at work by a fall on the same level or lower levels in the past 12 months?" Responses were selected from "yes, one time," "yes, two times or more," and "no".

2.4 | Explanatory variables

The Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool was used to assess participants' physical capacity.[16] This tool consists of five physical measurement items: (a) two-step test, (b) stepping test in a seated position, (c) functional reach test, (d) standing on one leg with eyes closed, and (e) standing on one leg with eyes open. We measured each of the four tests twice, except for the stepping test, and used the better of the two results.[16] A brief description of each measurement method is given below.

a. Two-step test

The two-step test evaluates walking ability and muscle strength of the lower limbs. This test measures the maximum two strides without losing balance (cm) divided by self-reported body height (cm).

b. Stepping test in a seated position

The stepping test in a seated position evaluates the agility of the lower limbs. This test counts the number of steps performed by seated participants while they move their toes left and right between the floor outside and inside a 30 cm wide line in 20 s.

c. Functional reach test

The functional reach test evaluates dynamic balance. This test measures the distance reached with fingertips extended (cm) as far forward as possible while participants maintain their balance without moving their feet.

d. Standing on one leg with eyes closed

Standing on one leg with eyes closed evaluates static balance. This test was conducted while standing on one leg with eyes closed, and measures maximum holding time until both feet touch the ground (sec). The measurement was stopped at 120 s.

e. Standing on one leg with eyes open

Standing on one leg with eyes open also evaluates static balance. This test was conducted using the same procedure described above but with eyes open. The measurement was stopped at 180 s.

2.5 | Covariates

The covariates were selected on the basis of relevant studies of farmers or older community-dwelling adults.[19-21] The questionnaire collected information about participants' sex,[19] age,[19,20] marital status,[19] education,[19,20] agricultural product,[20] working hours,[20] height and weight,[21] and underlying diseases with medication use.[20] Information about agricultural products was obtained in descriptive form, and then categorized into rice, vegetables, flowers, fruit, and rubber trees. Body mass index was calculated by self-reported height and weight.

2.6 | Statistical analysis

To dichotomize the outcome variable of experience of occupational falls, we combined responses of "yes, one time" and "yes, two times or more" into "yes". Measured values were categorized into "good," "normal," and "bad," based on the tertile distribution of the sample for each item of physical tests. Chi-square tests (univariate model) and multiple logistic regression (adjusted model) were conducted to assess the association between each physical capacity of the five physical tests and experience of occupational falls. The multivariate model was adjusted for sex, age, marital status, education, agricultural product, working hours, body mass index, and underlying diseases with medication use. Goodness of fit was assessed using the Hosmer–Lemeshow test. Receiver operating characteristic (ROC) curves were calculated to assess the relationship between continuous values of the five physical tests and experience of occupational falls. Area under the ROC curves (AUCs) were also calculated. We also performed the same analyses for participants aged 50 years and over to evaluate the results in older individuals separately. Statistical significance was defined as p value <0.05. Stata/SE 16.1 (StataCorp) was used for the statistical analysis.

3 | RESULTS

Table 1 presents the characteristics of the study participants. A total of 442 participants volunteered to take part in the present study. Because 23 participants met the exclusion criteria, 419 were eligible for analysis. Participants' average age was 58.0 years (range: 40–80 years); 224 participants (53.5%) were women and 271 (64.1%) had no educational background or had only graduated from

TABLE 1 General characteristics of the study participants.

	Total	Occupational falls	
		Yes	No
	$n = 419$	$n = 107$	$n = 312$
Sex, *n* (%)			
Women	224 (53.5)	43 (40.2)	181 (58.0)
Men	195 (46.5)	64 (59.8)	131 (42.0)
Age (years), *n* (%)			
40–49	69 (16.4)	24 (22.4)	45 (14.4)
50–59	175 (41.8)	44 (41.2)	131 (42.0)
60–69	140 (33.4)	32 (29.9)	108 (34.6)
70–80	35 (8.4)	7 (6.5)	28 (9.0)
Marital status, *n* (%)			
Marriage	344 (82.5)	95 (88.8)	249 (80.3)
Single/Divorced/ Widowed	73 (17.5)	12 (11.2)	61 (19.7)
Education, *n* (%)			
None, or elementary school	271 (64.7)	67 (62.6)	204 (65.4)
Junior high school or above	148 (35.3)	40 (37.4)	108 (34.6)
Agricultural product (multiple selections allowed), *n* (%)			
Rice	293 (69.9)	69 (64.5)	224 (71.8)
Vegetables	125 (29.8)	38 (35.5)	87 (27.9)
Flowers	57 (13.6)	10 (9.3)	47 (15.1)
Fruit	52 (12.4)	22 (20.6)	30 (9.6)
Rubber trees	44 (10.5)	9 (8.4)	35 (11.2)
Working hours (hours/day), *n* (%)			
6.0–7.9	146 (35.0)	30 (28.3)	116 (37.3)
8.0–8.9	218 (52.3)	60 (56.6)	158 (50.8)
≥9.0	53 (12.7)	16 (15.1)	37 (11.9)
Body mass index (kg/ m^2), mean (SD)	23.7 (3.7)	24.4 (3.8)	23.5 (3.7)
Underlying disease with medication use, *n* (%)	147 (35.5)	34 (31.8)	113 (36.8)
Two-step test (widest two-step stride [cm]/ body height [cm]), mean (SD)	1.27 (0.16)	1.28 (0.16)	1.26 (0.16)
Stepping test in a seated position (steps/20 s), mean (SD)	22.0 (5.2)	22.3 (4.7)	21.9 (5.4)
Functional reach test (cm), mean (SD)	25.9 (7.3)	27.4 (7.3)	25.4 (7.2)
Standing on one leg with eyes closed (sec), mean (SD)	10.5 (16.1)	9.7 (13.7)	10.9 (16.8)
Standing on one leg with eyes open (sec), mean (SD)	82.1 (69.1)	81.5 (68.1)	82.4 (69.5)

elementary school. The most common agricultural product was rice (69.9%), followed by vegetables (29.8%) and flowers (13.6%). The average score of the stepping test was 22.0 steps per 20 s. The average score of the standing on one leg test was 10.5 s with eyes closed, and 82.1 s with eyes open. In addition, 25.5% of participants had experienced occupational falls in the past 12 months.

Table 2 shows the associations between physical capacity and occupational falls. In each of the five physical test components, there were no significant associations between normal or bad physical capacity and experience of occupational falls compared with good physical capacity for participants aged 40 years and over. The Hosmer–Lemeshow test confirmed the goodness of fit of the adjusted model: the lowest p value was 0.397 for the "standing on one leg with eyes open" and the highest p value was 0.792 for the "two-step test." When the analysis was limited to participants aged 50 years and over ($n = 350$), no significant differences were observed (data not shown).

Figure 1 shows the ROC curves for each of the five physical test components to assess the experience of occupational falls. All AUCs were less than 0.60, with a maximum value of 0.57 for the functional reach test. A similar trend was observed when the analysis was limited to participants aged 50 years and over (data not shown).

4 | DISCUSSION

The present study evaluated the relationship between physical capacity and the experience of occupational falls among middle-aged and older farmers using the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace. The results revealed that 25.5% of farmers had experienced occupational falls in the past 12 months. We found no significant associations between physical capacity at each physical test component of this tool and experience of occupational falls. The trend was not changed at different cut-off age points and categorical or continuous assessment. These findings suggest that this tool may not be useful for a program to assess occupational fall risk among older farmers.

There are several possible reasons for the lack of association between physical capacity and experience of occupational falls. The current findings are in agreement with two replication studies of the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace.[17,18] These two replication studies were conducted among manufacturing workers under the age of 65, suggesting that the relatively younger age and work environment safety may have attenuated the results.[17,18] In contrast, the current study included workers up to 80 years old and working in an outdoor

TABLE 2 Associations between physical capacity and occupational falls using the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool

	Participants	Occupational falls	Univariate			Adjusted[a]		
	n	*n* (%)	OR	95% CI	*p* value	OR	(95% CI)	*p* value
Two-step test (widest two-step stride [cm]/body height [cm])								
Good (1.33–1.82)	139	43 (30.9)	1.00	—	—	1.00	—	—
Normal (1.21–1.32)	140	32 (22.9)	0.66	0.39–1.13	0.128	0.67	0.38–1.21	0.184
Bad (0.66–1.20)	140	32 (22.9)	0.66	0.39–1.13	0.128	0.90	0.49–1.65	0.737
Stepping test in the seated position (steps/20 s)								
Good (24–43)	151	40 (26.5)	1.00	—	—	1.00	—	—
Normal (20–23)	143	36 (25.2)	0.93	0.55–1.58	0.797	1.10	0.61–1.96	0.758
Bad (10–19)	125	31 (24.8)	0.92	0.53–1.58	0.749	1.14	0.62–2.13	0.672
Functional reach test (cm)								
Good (30–49)	140	42 (30.0)	1.00	—	—	1.00	—	—
Normal (24–29)	123	29 (23.6)	0.72	0.42–1.25	0.242	0.78	0.43–1.44	0.426
Bad (7–23)	156	36 (23.1)	0.70	0.42–1.18	0.177	0.97	0.54–1.74	0.909
Standing on one leg with eyes closed (seconds)								
Good (8.7–120.0)	140	37 (26.4)	1.00	—	—	1.00	—	—
Normal (3.4–8.6)	139	31 (22.3)	0.80	0.46–1.38	0.422	0.67	0.37–1.24	0.200
Bad (0.0–3.3)	140	39 (27.9)	1.08	0.64–1.82	0.788	1.26	0.69–2.33	0.452
Standing on one leg with eyes open (seconds)								
Good (114–180)	140	34 (24.3)	1.00	—	—	1.00	—	—
Normal (30–113)	140	39 (27.9)	1.20	0.71–2.06	0.496	1.22	0.68–2.19	0.497
Bad (0–29)	139	34 (24.5)	1.01	0.58–1.74	0.973	1.19	0.63–2.26	0.597

Note: Abbreviations: CI, confidence intervalOR, odds ratio.

[a]Adjusted for sex, age, marital status, education, agricultural product, working hours, body mass index, and underlying diseases with medication use.

environment but still found no association. Therefore, we considered that the relationship between physical capacity and occupational falls among older workers may be complex. First, the "healthy worker effect" should be considered, because the prediction accuracy of physical capacity for future fall injuries may differ between older workers and community-dwelling older individuals.[22-24] Second, employers may have arranged work with a low risk of occupational injuries for older farmers in the current study population.[25] Third, occupational falls may be strongly influenced by factors other than physical function, such as work content and the work environment.[26] Therefore, we believe that multiple intervention approaches may be necessary for preventing occupational falls among older farmers.

Importantly, the current study revealed the present status of occupational falls in middle-aged and older farmers. The results revealed that 25.5% of older farmers had experienced occupational falls, which is a relatively high proportion compared with similar studies in the manufacturing industry (6.2–14.2%).[16,17] The agricultural sector involves a high risk of injury,[4] such as slipping because of rain or tripping in the dark. For example, because rice cultivation involves running water, work environments typically contain many slippery surfaces.[27] Another study in Nepal reported that 35.1% of farmers experienced occupational injuries three times a year, particularly during the rainy season.[28] In contrast, a study in United States reported that agriculture did not involve a higher frequency of occupational falls than other industries.[9] As agriculture becomes more automated in developed countries, the number of occupational accidents tends to decrease.[29] These findings suggest that the high frequency of occupational falls in the agricultural sector depends on a variety of factors, including the type of agricultural product, climate, and automation. Because farming is included in the informal sector in emerging countries, there are no national statistics regarding workers' compensation. The current results suggest the importance of fall prevention in Asian agriculture.

Importantly, the current study also provided information about the basic physical capabilities of Thai

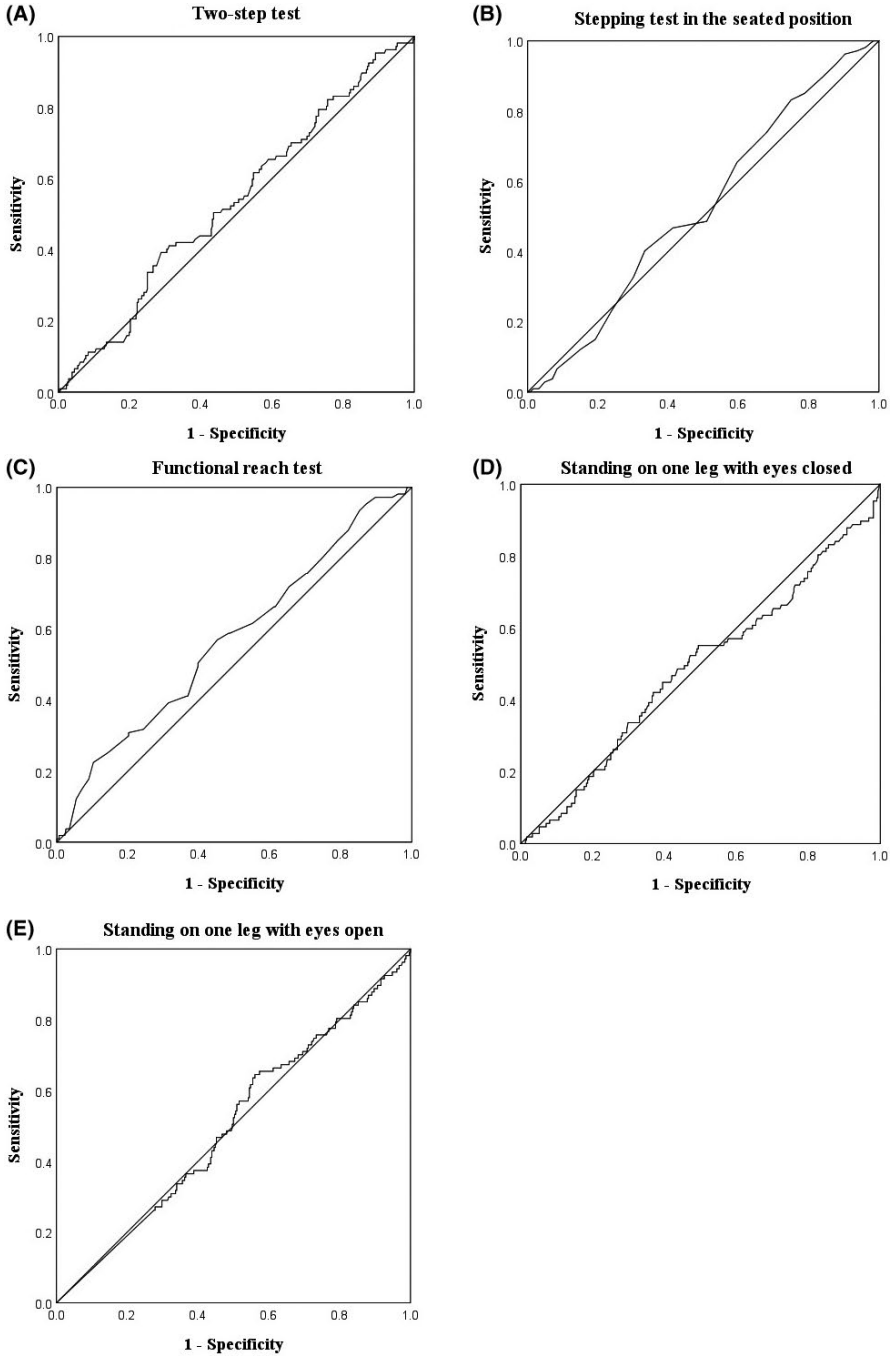

FIGURE 1 Receiver operating characteristic (ROC) curves of five physical tests to assess experience of occupational falls in the past 12 months: (a) two-step test, (b) stepping test in a seated position, (c) functional reach test, (d) standing on one leg with eyes closed, and (e) standing on one leg with eyes open.

farmers. We observed a gap between standard evaluation values and the measurements in the current study.[16] For example, the average score on the stepping test was 22.0 steps in the current study, which is lower than the normal range of 29–43 steps in the original rating chart. Similarly, the average score for standing on one leg with eyes open was 10.5 s, which was also relatively low (normal range in the original rating chart: 17.1–55.0 s). This trend was consistent with a previous study using other physical tests among older Thai adults.[30] In that study, Thaweewannakij et al. proposed that one reason for this result is that older Thai adults tend to be relatively small in stature, indicating little muscle mass compared with populations in other countries.[30] These results suggest that agility and balance in older Thai farmers are relatively poor, potentially affecting their risk of health issues beyond occupational falls.[31]

The current study involved several limitations. Because of the cross-sectional design, it was difficult to derive causal relationships between physical capacity and experience of occupational falls. For example, participants who had experienced severe occupational falls may not have been able to join the study. Future studies should be conducted using a cohort design. However, a history of falls in the past year is known to act as a strong predictor of future fall risk; the evidence supports our

findings.[32] Second, selection bias may have affected the current study. For example, it is possible that participants who were concerned about their health were more likely to participate in this study, potentially influencing the results. To overcome this limitation, participants should be selected randomly. Third, the relationship between the physical examination and occupational falls may not have been clarified because of the relatively low and narrow range of physical capacity of the participants in this study. Therefore, the development of a physical examination with a wider range of values for the older population in Thailand may yield different results. Further research is warranted in this field.

In conclusion, the present study revealed the current status of occupational falls and physical capacity among middle-aged and older Thai farmers using the Self-Check Risk Assessment of Falls and Other Accidents in the Workplace tool. However, the results revealed no associations between physical capacity and experiences of occupational falls. Because the mechanisms underlying occupational falls are complex, multiple intervention approaches may be valuable for preventing accidents.

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DISCLOSURE

Approval of the research protocol: This study was approved by the Ethical Review Committee for Human Research of Mahidol University (MUPH2021-023) and the Ethics Committee of the University of Occupational and Environmental Health, Japan (R2-067). *Informed Consent*: All participants provided written informed consent prior to the survey. *Registry and the Registration No. of the study/trial*: N/A. *Animal Studies*: N/A. *Conflict of Interest*: N/A.

AUTHOR CONTRIBUTIONS

S.A. conceived the ideas. S.A, T.L, C.T., K.K., and A.M. collected the data. T.L. contributed data entry. T.I. contributed data analysis. T.I. drafted the initial manuscript with S.A. and K.H. All the authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

No additional data are available.

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REFERENCES

1. Rigg J, Phongsiri M, Promphakping B, Salamanca A, Sripun M. Who will tend the farm? Interrogating the ageing Asian farmer. *J Peasant Stud*. 2020;47:306-325.
2. Thailand Office of National Economic and Social Development Council. Thai Economic Performance in Q1 and Outlook for 2021. Published 2021. https://www.nesdc.go.th/nesdb_en/article_attach/article_file_20210528141639.pdf. Accessed July 1, 2021.
3. statista. Share of population older than 65 in Thailand from 2015 to 2020 with a forecast to 2100. Published 2021. https://www.statista.com/statistics/713667/thailand-forecast-aging-population/. Accessed July 1, 2021.
4. Yogyorn D, Slatin C, Siriruttanapruk S, et al. Estimating of the costs of nonfatal occupational injuries and illnesses in agricultural works in Thailand. *J Public Health Policy*. 2021;42:71-85.
5. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. *Age Ageing*. 2006;35(suppl_2):ii37-ii41.
6. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. 2012;2012:CD007146.
7. United States Department of Labor Bureau of Labor Statistics. Occupational Injury and Illness Classification Manual Version 2.01. Published 2012. https://www.bls.gov/iif/oiics_manual_2010.pdf. Accessed 1 July, 2021.
8. World Health Organization. *WHO global report on falls prevention in older age*. World Health Organization; 2007.
9. Yeoh HT, Lockhart TE, Wu X. Non-fatal occupational falls on the same level. *Ergonomics*. 2013;56:153-165.
10. Japan Industrial Safety and Health Association. Industrial Accidents Statistics in Japan (2020). Published 2020. https://www.jisha.or.jp/english/statistics/accidents_in_detail_2020.html. Accessed July 1, 2021.
11. Peng L, Chan AHS. A meta-analysis of the relationship between ageing and occupational safety and health. *Saf Sci*. 2019;112:162-172.
12. Hsiao H. Fall prevention research and practice: a total worker safety approach. *Ind Health*. 2014;52:381-392.
13. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol*. 1990;45:M192-197.
14. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*. 1991;39:142-148.
15. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc*. 1986;34:119-126.
16. Japan Industrial Safety and Health Association. Study Report on promotion program for prevention of hazard risks associated with reduced physical capacity in old workers. Published

2010 (in Japanese). https://www.mhlw.go.jp/new-info/kobetu/roudou/gyousei/anzen/101006-1.html. Accessed July 1, 2021.
17. Nakamura T, Oyama I, Fujino Y, et al. Evaluation and simplification of the occupational slip, trip and fall risk-assessment test. *Ind Health*. 2016;54:354-360.
18. Tsukada T, Sakakibara H. Risk assessment of fall-related occupational accidents in the workplace. *J Occup Health*. 2016;58:612-621.
19. Kim T, Choi SD, Xiong S. Epidemiology of fall and its socioeconomic risk factors in community-dwelling Korean elderly. *PLoS One*. 2020;15:e0234787.
20. Sprince NL, Zwerling C, Lynch CF, et al. Risk factors for agricultural injury: a case-control analysis of Iowa farmers in the agricultural health study. *J Agric Saf Health*. 2003;9:5-18.
21. Fjeldstad C, Fjeldstad AS, Acree LS, Nickel KJ, Gardner AW. The influence of obesity on falls and quality of life. *Dyn Med*. 2008;7:4.
22. Buchner DM, Cress ME, de Lateur BJ, et al. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *J Gerontol Ser A Biol Sci Med Sci*. 1997;52:M218-224.
23. Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. *J Gerontol*. 1989;44:M112-117.
24. Lord SR, McLean D, Stathers G. Physiological factors associated with injurious falls in older people living in the community. *Gerontology*. 1992;38:338-346.
25. FitzGerald D, Keane RA, Reid A, O'Neill D. Ageing, cognitive disorders and professional practice. *Age Ageing*. 2013;42:608-614.
26. Chang WR, Leclercq S, Lockhart TE, Haslam R. State of science: occupational slips, trips and falls on the same level. *Ergonomics*. 2016;59:861-883.
27. Kongtip P, Nankongnab N, Mahaboonpeeti R, et al. Differences among Thai agricultural workers' Health, working conditions, and pesticide use by farm type. *Ann Work Expo Health*. 2018;62:167-181.
28. Bhattarai D, Singh SB, Baral D, Sah RB, Budhathoki SS, Pokharel PK. Work-related injuries among farmers: a cross-sectional study from rural Nepal. *J Occup Med Toxicol*. 2016;11:48.
29. Bellamy LJ, Manuel HJ, Oh JI. Investigated serious occupational accidents in the Netherlands, 1998–2009. *Int J Occup Saf Ergon*. 2014;20:19-32.
30. Thaweewannakij T, Wilaichit S, Chuchot R, et al. Reference values of physical performance in Thai elderly people who are functioning well and dwelling in the community. *Phys Ther*. 2013;93:1312-1320.
31. Pérès K, Matharan F, Allard M, et al. Health and aging in elderly farmers: the AMI cohort. *BMC Public Health*. 2012;12:558.
32. American Geriatrics Society, British Geriatrics Society, American Academy of Orthopaedic Surgeons Panel. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. *J Am Geriatr Soc*. 2001;49:664-672.

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