

# Farm operations and slips, trips, and falls among corn farm workers in Thailand

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**Abstract:** Slips, trips, and falls (STFs) represent a main source of injury among farm workers. The purpose of this study was to evaluate the association between farm operations and STFs among corn farm workers. We conducted a cross-sectional study using a self-administered questionnaire among corn farm workers in Nan and Saraburi provinces, Thailand from July 5 to 23, 2022. Poisson regression analysis was used. Among 338 participants, 122 (36.1%) had experienced an STF in the previous 6 months. Conducting very frequent, frequent, or occasional pest management was associated with a higher incidence rate ratio (IRR) of STFs than never or rarely pest management (adjusted IRR 1.93, 95% confidence interval [CI]=1.23 to 3.04,  $p=0.004$ ). People with marginal or unsatisfactory work break lengths had a higher incidence rate of STFs than those with satisfactory work breaks (adjusted IRR 1.40, 95% CI=1.03 to 1.89,  $p=0.030$ ). We found that corn farm workers in our study often experienced STFs, which was associated with a high frequency of pest management practices and inadequate work breaks. Reducing the physical burden of pest management may be effective as an STF prevention strategy.

**Key words:** Agriculture, Fall, Farm worker, Occupational injury, Occupational safety

## Introduction

Slips, trips, and falls (STFs) are a main source of injury among farm workers<sup>1, 2)</sup>. In the United States, falls account for a quarter of all occupational injuries among farm workers, with 0.75 injuries per 100 person-years<sup>1)</sup>.

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STFs lead to more lost workdays than other occupational injuries<sup>2</sup>). Aging of the workforce in developed countries is accelerating deaths from STFs<sup>3</sup>). Similar trends can be expected in developing countries; however, it is difficult to grasp the actual situation in these countries because farm workers belong to an informal sector that is not required to report occupational injuries<sup>4</sup>). A previous study in Thailand reported that 25.1% of middle-aged and older farm workers had experienced a fall injury in the past year<sup>5</sup>).

It is difficult to prevent STFs in agriculture owing to the nature of agricultural operations. Farm operations change daily in the management of crops and animals. For example, corn farming involves multiple processes such as planting, irrigation, pest management, harvesting, and storage. In each process, different equipment is used and different knowledge is required. Additionally, farm operations are affected easily by weather and land conditions. Therefore, farm workers experience fall injuries more frequently at work than at home<sup>6</sup>).

Farm workers themselves must understand the risk of STFs in each type of farm operation, especially in the informal sector where meeting occupational health and safety requirements is not mandatory. A previous study identified factors associated with occupational falls, which included age, sex, obesity, and agricultural production<sup>7</sup>). Physical fitness is not associated with falls in agriculture, however<sup>5</sup>). This suggests that falls in agriculture could be attributed more to the type of work and work environment than to physical fitness. However, it is unclear which farm operations pose the greatest STF risks for different farm workers. The purpose of this study was to evaluate the association between farm operations and STFs among corn farm workers in Thailand.

## Subjects and Methods

### *Participants and procedure*

We conducted a cross-sectional study among corn farm workers in Nan and Saraburi provinces, Thailand, from July 5 to 23, 2022. Self-administered questionnaire data were extracted from a farmer health survey project that included interviews and physical fitness measurements. Corn has recently become the fastest growing exported agricultural product in Thailand<sup>8</sup>). Corn cultivation in Thailand mainly involves a two-season crop, but it can be grown year-round if irrigation facilities are available. The first seeding season is from April to June and the second is from September to October. The cultivation period is approximately 90 d (depending on the season and type of

corn).

We selected four districts in Nan Province (Pua, Na Muan, Na Noi, and Thawangpha) and one district in Saraburi Province (Wang Muang) as study sites. Nan and Saraburi provinces are located in northern and central Thailand, respectively, and both are major corn-producing areas. Nan Province had a population of 476,727 people in 2021, with approximately half the population engaged in agriculture<sup>9</sup>). The total area is approximately 19,713 km<sup>2</sup>, and the area planted with corn is 661,367 rai (a unit of land area in Thailand, equivalent to 1,600 m<sup>2</sup>)<sup>8</sup>). Saraburi province had a population of 643,963 people in 2021, with most residents also engaged in agriculture<sup>10</sup>). The total area is approximately 3,576,486 km<sup>2</sup>, with 195,855 rai planted with corn. Corn is harvested at 731 kg per rai<sup>8</sup>).

Participants were recruited using a purposive sampling technique, with each farmers' cooperative leader calling on workers to visit their office. A self-administered questionnaire was distributed to participants after their written informed consent was obtained. The inclusion criteria were farm workers engaged in agriculture for at least one year. The exclusion criteria were farm workers who were not engaged in corn production or who did not report the outcome variables on the questionnaire regarding STFs. Each participant received approximately 200 Thai baht (approximately 5.60 USD) as a financial incentive. This study was approved by the Ethical Review Committee for Human Research of Mahidol University (MUPH2022-046).

### *Outcome*

The outcome was having experienced an STF in the previous 6 months<sup>6</sup>). The survey questions were according to a previous study among home care aides<sup>11</sup>). First, we asked about their experiences of STFs as follows: "In the past 6 months, have you ever slipped, tripped, or fallen at work (including any minor slips, trips, or falls)?" Participants reported the number of times that they had experienced an STF. For those who had experienced an STF, additional questions were asked about the location, type of farm operation involved, contact with the ground, and injuries. The response options for location included on agricultural land, on a vehicle (e.g., truck, tractor, or all-terrain vehicle), on a trafficked road, indoors, or on the stairs.

### *Exposure*

Exposure variables were farm operations, including the frequency of performing each farm operation, and work hours and work breaks, which were directly associated

with the quantity of farm operations. We included five types of farm operation: planting, irrigation, pest management, harvesting, and storage. Participants selected a single option for the frequency of performing each farm operation during the previous 6 months from among the following: never, rarely, occasionally, frequently, and very frequently. We asked about work hours per day as a continuous variable, and the length of work breaks was reported on a 3-point Likert-type scale as satisfactory, marginal, and unsatisfactory. These questions were developed based on a previous study of potato farm workers in the United States<sup>12</sup>.

### Covariates

Information on sex, age, educational attainment, height, weight, regular alcohol intake, exercise, and underlying diseases (hypertension and diabetes) was extracted from the questionnaire data as covariates<sup>7</sup>. Body mass index was calculated using height and weight values reported on the questionnaire.

### Statistics

Descriptive statistics were used to summarize the occurrence of STFs in the previous 6 months. This included the number and percentage of cases, location, farm operation involved, contact with the ground, and injuries. Poisson regression analysis was conducted to evaluate the association between farm operations and number of STFs experienced. Working hours and work breaks were also included as exposure variables. Working hours were categorized into three categories: <8.0, 8.0–8.9, and ≥9.0 h. Other exposure variables were dichotomized in the analysis. In multivariate analysis, we adjusted for sex, age, educational attainment, body mass index, regular alcohol intake, exercise, and underlying diseases (hypertension and diabetes). The results are presented as incidence rate ratios (IRRs), 95% confidence intervals (CIs), and two-sided *p*-values. *P*<0.05 was set to indicate statistical significance. Stata/SE 16.1 (StataCorp LLC, College Station, TX, USA) was used for statistical analysis.

## Results

A total of 389 corn farm workers were enrolled in this study and 338 were included in the analysis (44 were not engaged in corn farming and 7 did not provide responses for the outcome). Table 1 shows the general characteristics of the survey participants. Most participants were women (64.2%) and had no education or an elementary school

**Table 1. General characteristics of survey participants**

Variable (missing data, n)	N=338
Female sex (4)	217 (64.2)
Age, yr (6)	
17–39	53 (15.7)
40–49	65 (19.2)
50–59	122 (36.1)
60–83	92 (27.2)
Educational attainment (6)	
None or elementary school	193 (57.1)
Junior high school or above	139 (41.1)
Body mass index ≥30 kg/m <sup>2</sup> (5)	48 (14.2)
Regular alcohol intake (2)	95 (28.1)
Exercise ≥3 d/week	121 (35.8)
Underlying disease	
Hypertension	75 (22.2)
Diabetes	28 (8.3)
Planting (6)	
Never/rarely	84 (24.9)
Occasionally/frequently/very frequently	248 (73.4)
Irrigation (8)	
Never/rarely	185 (54.7)
Occasionally/frequently/very frequently	145 (42.9)
Pest management (6)	
Never/rarely	101 (29.9)
Occasionally/frequently/very frequently	231 (68.3)
Harvesting (6)	
Never/rarely	146 (43.2)
Occasionally/frequently/very frequently	186 (55.0)
Storage (6)	
Never/rarely	149 (44.1)
Occasionally/frequently/very frequently	183 (54.1)
Working hours, hours/day (5)	
<8.0	138 (40.8)
8.0–8.9	156 (46.2)
≥9.0	39 (11.5)
Length of work breaks (9)	
Satisfactory	214 (63.3)
Marginal/unsatisfactory	115 (34.0)

Values are n (%).

education (57.1%). Most participants were in their 50s (36.1%), followed by those in their 60s and older (27.2%). In total, 14.2% of participants had body mass index ≥30 kg/m<sup>2</sup>, and 22.2% were being treated for hypertension. As for the frequency of farm operations, planting (73.4%) and pest management (68.3%) were the most frequently performed, and irrigation (42.9%) was performed least frequently. Approximately two-thirds (63.3%) of respondents were satisfied with the length of their work breaks.

Table 2 describes STFs among corn farm workers dur-

**Table 2. Incidence of slips, trips, and falls (STFs) in agriculture during the previous 6 months**

Variable (missing data, n)	N=338
Any STFs in the previous 6 months	122 (36.1)
Number of STFs among those with any STFs	
1	59 (17.5)
2	35 (10.4)
3+	28 (8.3)
Location of STFs among those with any STFs (9)	
Agricultural land	98 (29.0)
On a vehicle (e.g., truck, tractor, all-terrain vehicle)	1 (0.3)
Trafficked road	4 (1.2)
Indoor	9 (2.7)
Stairs	1 (0.3)
Farm operations among those with any STFs (16)	
Planting	46 (13.6)
Irrigation	15 (4.4)
Pest management	19 (5.6)
Harvesting	16 (4.7)
Storage	10 (3.0)
Fall to the ground (6)	42 (12.4)
Injury owing to any STFs	13 (3.8)

Values are n (%).

ing the previous 6 months. STFs were experienced by 122 (36.1%) of respondents, among whom 59 (17.5%) had experienced an STF once, 35 (10.4%) had an STF twice, and 28 (8.3%) had experienced an STF three or more times. Agricultural land (n=98, 29.0%) was the most common location where STFs occurred. Planting (n=46, 13.6%) was the most common farm operation during which STFs occurred, followed by pest management (n=19, 5.6%). Contact with the ground was reported by 42 (12.4%) participants and 13 (3.8%) said the STF resulted in injury.

Table 3 presents the association between farm operations and STFs. The IRR was increased among those engaged very frequently, frequently, or occasionally in pest management operation, as compared with never or rarely in this operation (adjusted IRR 1.93, 95% CI=1.23 to 3.04, *p*=0.004). Higher frequency of planting tended to increase the IRR in the univariate model (IRR 1.37, 95% CI=0.98 to 1.92, *p*=0.067), but no such trend was observed in the multivariate model. People who had marginal or unsatisfactory work break lengths had a higher incidence rate of STFs than those with satisfactory work breaks (adjusted IRR 1.40, 95% CI=1.03 to 1.89, *p*=0.030).

**Table 3. Association between farm operations and slips, trips, and falls (STFs)**

	STFs		Univariate			Multivariate*		
	n (%)	IRR	(95% CI)	<i>p</i> -value	IRR	(95% CI)	<i>p</i> -value	
Planting								
Never/rarely	21 (25.0)	1.00	-	-	1.00	-	-	
Occasionally/frequently/very frequently	100 (40.3)	1.37	(0.98–1.92)	0.067	0.96	(0.61–1.53)	0.869	
Irrigation								
Never/rarely	63 (34.1)	1.00	-	-	1.00	-	-	
Occasionally/frequently/very frequently	57 (39.3)	1.11	(0.84–1.45)	0.463	1.10	(0.79–1.55)	0.572	
Pest management								
Never/rarely	25 (24.8)	1.00	-	-	1.00	-	-	
Occasionally/frequently/very frequently	96 (41.6)	1.58	(1.14–2.19)	0.006	1.93	(1.23–3.04)	0.004	
Harvesting								
Never/rarely	45 (30.8)	1.00	-	-	1.00	-	-	
Occasionally/frequently/very frequently	76 (40.9)	1.20	(0.91–1.58)	0.202	0.97	(0.62–1.51)	0.875	
Storage								
Never/rarely	48 (32.2)	1.00	-	-	1.00	-	-	
Occasionally/frequently/very frequently	73 (39.9)	1.10	(0.84–1.45)	0.478	0.87	(0.58–1.31)	0.506	
Working hours								
<8.0	53 (38.4)	1.00	-	-	1.00	-	-	
8.0–8.9	54 (34.6)	0.85	(0.63–1.15)	0.282	1.22	(0.88–1.70)	0.231	
≥9.0	12 (30.8)	0.89	(0.55–1.43)	0.626	1.43	(0.90–2.26)	0.133	
Length of work breaks								
Satisfactory	69 (32.2)	1.00	-	-	1.00	-	-	
Marginal/unsatisfactory	51 (44.3)	1.28	(0.97–1.69)	0.078	1.40	(1.03–1.89)	0.030	

IRR: incidence rate ratio; CI: confidence interval.

\*Adjusted for sex, age (continuous), educational attainment, body mass index (continuous), regular alcohol intake, exercise, underlying diseases (hypertension and diabetes), frequency of tasks (planting, irrigation, pest management, harvesting, and storage), working hours, and length of work breaks.

## Discussion

In the current study, we evaluated the association between farm operations and STFs among corn farm workers in Thailand. STFs were common events, with 36.1% of corn farmers experiencing an STF in the previous 6 months. Planting and farm operations on agricultural land were the most frequent situations under which STFs occurred. A high frequency of planting tended to increase the incidence of STF in univariate analysis, but this trend disappeared in multivariate analysis. We conducted a post-hoc analysis and found that the frequency of other farm operations acted as a confounding factor (data not shown). Therefore, multiple tasks performed during the planting period were considered to exacerbate the occurrence of STFs during planting. We found that STFs were more likely to occur under working conditions in which more frequent pest management was conducted and with inadequate work breaks. These findings are important for the development of intervention programs to prevent STFs among agricultural workers.

The current study identified that corn farm workers experienced a high frequency of STFs (36.1%), which often occurred on agricultural land and during planting operations. This finding is consistent with those of a previous study among potato growers, reporting that planting involved the greatest fall risk<sup>12</sup>). Agriculture has a higher incidence of occupational injuries than other industries<sup>13</sup>). For example, the incidence rate of STFs is only 8.9% among health care workers in Thailand<sup>14</sup>). There are several possible reasons for the gap between agriculture and other industries. First, hazardous working environments, such as wet ground, slopes, and darkness, may contribute to STFs<sup>15</sup>). Second, occupational safety practices are not well implemented in agriculture<sup>16</sup>). Farm workers often do not receive safety training and tend to underestimate the risks and consequences of STFs<sup>15</sup>). Hence, the use of personal protective equipment for STFs, such as non-slip boots, is also inadequate<sup>17</sup>).

We found that frequent pest management and inadequate work breaks were risk factors for STFs. The result regarding pest management can be explained by the work characteristics of this type of farm operation<sup>18</sup>). Pest management is performed intermittently between planting and harvest to protect corn from insects, weeds, and diseases<sup>19</sup>). Carrying pesticide tanks on the back and spraying movements cause musculoskeletal disorders<sup>20</sup>). Personal protective equipment such as layered clothing are required when conducting pest management, which contribute to

heat stroke and fatigue<sup>21</sup>). These symptoms persist after pest management procedures are completed and may accelerate the occurrence of STFs. This is in line with reports that fall injuries in agriculture are more common in the afternoon when fatigue sets in<sup>22</sup>). Our results suggest that adequate work breaks, especially for workers engaged in pest management, can reduce the incidence of STFs.

There are several limitations in the current study. First, recall bias should be considered because we assessed experiences of STF using a self-administered questionnaire. To deal with this, we asked about STFs experienced during the previous 6 months, which is relatively shorter than the recall period in previous studies<sup>11, 23</sup>). Second, we did not differentiate between slips, trips, and falls because of concerns about recall bias. However, separating these categories would provide valuable insights for targeted countermeasures. Third, the findings of this study should be interpreted with caution as we limited our focus to corn cultivation and the study was only conducted in Thailand. For example, climate and agricultural mechanization vary from country to country, which could affect the results obtained.

In this study, we found that corn farm workers in Thailand often experienced STFs, which was associated with a higher frequency of pest management operations and inadequately long work breaks. Reducing the physical burden of pest management may help to not only prevent musculoskeletal disorders<sup>20</sup>) and heat stroke<sup>21</sup>), this may also serve as an effective fall prevention strategy. The risk factors identified in this study provide insight for developing a comprehensive intervention approach for corn farm workers. For example, the International Labour Office has provided a participatory ergonomic intervention tool for agriculture<sup>24</sup>). By identifying good practices in pest management that have a low physical burden, such tools may help to effectively prevent STFs.

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## Conflict of Interest

The authors declare no conflicts of interest.

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