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LOW WAGES AND LONG WORKING HOURS ARE RISK FACTORS FOR WORKPLACE INJURY IN THAI COHORT STUDY PARTICIPANTS

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Abstract

Objectives:

To explore individual determinants of workplace injury among Thai workers.

Design:

Cross-sectional analysis of a large national cohort.

Setting:

Thailand.

Participants:

Thai Cohort Study participants who responded to the 2009 follow-up survey were included if they reported doing paid work or being self-employed (n=51,751).

Outcome measures:

Self-reported injury incidence over the past 12 months was calculated. Gender-stratified multivariate logistic regression models were used to test associations between individual determinants and self-reported workplace injury.

Results:

Workplace injuries were reported by 1317 study participants (2.5%); the incidence was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. Multivariate modelling showed that those working 40+ hours per week and working for a low income, particularly low-earning self-employed workers, were at increased risk of workplace injury.

Conclusions:

Reductions in occupational injury rates could be achieved by limiting working hours to 40 per week. Particularly for Thai low wage earners and those with longer workdays, there is a need for effective injury preventive programs.

Article Summary

Article focus

- Research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level
- The aim of the present study was to investigate individual determinants of workplace injury among Thai workers participating in a large national Thai Cohort Study (TCS)
- The objectives were to determine the impact of working hours and level of income on workplace injury risk

Key messages

- Of the study participants that were doing paid work or were self-employed, 3.4% of the men and 1.8% of the women reported a workplace injury that occurred over the past 12 months
- Those working more than 40 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk.
- Part-time workers were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers

Strengths and limitations of this study

- The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels
- A study limitation was the self-report nature of the data, which relies on accurate recall and reporting

Introduction

Thailand is a newly industrialised country. The transition to a modern consumer economy is accompanied by a shift in birth and death rates, disease patterns and injury risks [1]. Until recently, 46% of employed Thais were working in the agricultural sector, but the proportion of industrial workers is rapidly increasing [2]. Occupational Health and Safety is being increasingly recognised in Thailand as an important component of population health and wellbeing. While the role of individual level risk factors such as working hours and resulting fatigue is not well studied in Thailand, there is evidence from other countries that extended work hours increase the risk of injury [3] independent of industry and occupation [4]. Actions underway in Thailand to improve occupational health and safety include the implementation of an occupational health and safety surveillance system, a 'healthy workplace program' to promote safety [2], and a large scale pilot program integrating occupational and environmental health services into existing public health systems [5]. Another area recently targeted in policy is pesticide poisoning among farmers.

The research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level. Much of the occupational health and safety research has focussed on formal employment, which accounts for only a third of the Thai workforce [6]. Among Thais working in the non-formal sector, the safety of working conditions has deteriorated over recent years [7]. This is especially so for chemical injuries among informal agricultural workers. Also, informal workers are more likely to work longer hours than formal workers and this would be expected to increase injury risks.

Occupational injury risks arising from high working hours and other individual level determinants can potentially be addressed in injury preventative measures across sectors and industries in Thailand. Therefore, the aim of the present study is to investigate individual determinants of workplace injury among Thai workers participating in a large national Thai Cohort Study (TCS). The objectives are to determine the impact of working hours and level of income on workplace injury risk.

Methods

In this cross-sectional analysis of the Thai Cohort Study, self-reported workplace injury was determined among those respondents of the second survey (in 2009) who were doing paid work or self employed.

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The 2005 baseline characteristics of cohort participants [8] and comparisons with the population of Thailand [1 9] have been reported previously: the STOU cohort has a higher proportion of females than the general Thai population (54.7 vs. 50.5%); more young adults (51.5 vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0 vs. 24.7%) [9]. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort [9].

Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students already have established jobs and because of their work and family responsibilities and modest economic circumstances are unable to leave their locations to attend an on-campus university fulltime. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocols 2004344 and 2009570). Informed written consent was obtained from all participants.

Sample

The sample inclusions and exclusions are shown in Figure 1. In the survey of 2009, study participants were asked "What is your current work status? (You can choose more than one option)" with possible answers: Doing paid work/ Self employed/ Help family business but no wage/ Doing unpaid work/ Look after home (homemaker)/ Student/ Retired (do not work for income)/ Seeking work for the first time/ Unemployed/ Cannot work due to temporary sickness or disability/ Cannot work due to permanent sickness or disability/ Other. Those who indicated they were doing paid work and/or self employed were included in this study. Participants were also asked to report "How many hours per week do you work in all paid jobs?" Those who did not provide this information were excluded.

Participants who reported having had a workplace injury leading to limited activity, and who also indicated that they could not work due to a temporary or permanent sickness or disability, were included in the analyses. Their working hours (prior to injury) were imputed by the sample median. The final sample consists of 51,751 participants.

Hours of paid work

The median number of working hours per week was 40, inter-quartile range [10 to 48]. The distribution was multimodal. There were three spikes in the distribution: 18% of participants reported working 8 hours per week; 21% reported working 40 hours and 11% reported working 48 hours. The working hours were therefore categorised as follows: ≤10; 11-39; 40; 41-48; ≥49 hours

per week. The Thai Cohort Study survey of 2009 did not include questions about working in agriculture or farming, or about working multiple jobs.

Other exposure variables

The 2009 TCS survey included questions about marital status, area of residence, working hours, monthly personal wages and alcohol consumption. Self-employment was used as a proxy for informal employment [10]. Study participants who indicated 'Self employed' in response to the question about current work status were therefore considered to be informally employed.

Workplace injury

The core questions asked were: (1) "In the last 12 months how many times did you have a NON-TRAFFIC injury?" with possible answers never/one/two/three/four or more; (2) "What was the location at which your most serious non-traffic related injury occurred?" with possible answers home/sports facility/workplace (agricultural)/workplace (non-agricultural)/other; and (3) "When you experienced your most serious non-traffic related injury did you receive medical care?" with possible answers yes/no. Workplace injury was defined as non-traffic related injury that occurred in the workplace, agricultural or non-agricultural, and for which medical care was received.

Analysis

To gain insight into risk factors for workplace injury, injury incidence was calculated per 1000 worker-years (self-reported workplace injury in the last year in the numerator and the 51,751 study participants engaged in paid work in the denominator). To explore gender differences, for example, workplace injury incidence was calculated for men and women separately. However, possible gender differences could be attributed to men working more hours per year than women. To account for differences in work exposure duration, workplace injury incidence was also calculated per hours worked expressed per 1,000,000 hours. The results can be converted to American full time equivalents (FTE): assuming a 40 hour work week and 52 work weeks per year equates 2080 hours;

to convert the injury rates to 100 FTE-years, they should be multiplied by a factor 0.2080. The results of this study are presented per 1,000,000 hours to avoid confusion about the 'standard' number of hours worked per year, which may differ substantially per country.

To calculate the workplace injury incidence per 1000 worker-years, the number of persons with a workplace injury sustained in the last 12 months was divided by the total number of workers, and multiplied by 1000. To calculate the incidence per 1,000,000 hours worked, the number of persons with a workplace injury was divided by the sum of weekly hours worked by all workers (multiplied by 52 to obtain the hours worked per year), and multiplied by 1,000,000. Confidence intervals for the incidence rates were calculated by first assuming injury occurrence to have a Poisson distribution, and finding its related confidence interval[11].

A count model (Poisson or negative binomial) of injury incidence with hours worked as off set was considered, but while this approach would fully take into account the work exposure duration, the potential non-linear impacts of working hours on injury rates could not be explored. For example, working more than 48 hours per week may lead to increased injury rates due to prolonged exposure but there may be an additional effect due to fatigue. A 10 hour work-week may be associated with reduced injury rates due to limited exposure, but the slower rate of gaining experience on the job may increase injury rates. These non-linear effects of working hours on injury rates cannot be captured in a count model with an offset.

A multiple logistic regression model was therefore used. Factors that were likely to be associated with workplace injuries were tested in the model, which was stratified by gender. Covariates were individual-level work-related factors (income, hours of paid work, and self-employment) and demographics that could confound the association between work-related factors and risk of injury (age, gender, marital status, area of residence and alcohol intake). The association between exposure variables and the outcome, i.e. workplace injury for which medical help was sought, could

be confounded by access to health services. The multivariate logistic regression model was therefore repeated for a modified outcome: workplace injury, regardless of medical help sought.

Results

Workplace injury

Workplace injuries for which medical help was sought were reported by 1317 study participants (2.5%); 3.4% of the men and 1.8% of the women reported a workplace injury. The types of injury are summarised in Table 1. The most commonly reported workplace injuries were cuts, bites or open wounds (35%) and sprains, strains or dislocations (33%). Bruising or superficial injury was more common among participants with injuries sustained in agricultural work; cuts, bites or open wounds also tended to be more common among agricultural work injuries.

The incidence of workplace injury was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. The incidence per 1000 worker-years as well as the incidence per 1,000,000 hours worked is summarised in Table 2. Incidence was greatest in the age group 30-39 years, men, participants who were never married, live in rural areas, are in the lowest wage category, work the most hours, are self-employed and regularly drink alcohol.

Self-employment and workplace injury

Self-employment was reported by 17% or workers. Compared with other paid workers, self-employed workers were more likely to work over 49 hours per week (30% vs. 21%). They were more likely to have a low income of <7000 Baht (25% vs. 11%), but they were also more likely to have a high income of >30,000 Baht (16% vs. 9%). The injury incidence of workplace injury per worker-years, as well as per hours worked, was greater among the self-employed (Table 2). This held true for low earners (self-employed workers had 30 [25-37] and other paid workers had 22[19-25] injuries per 10^6 worked hours) and for mid-range earners (17 [15-20] vs. 12 [11-13]) but not for high

earners (>30,000 Baht) who had 9 [6-13] vs. 9 [7-11] injuries per 10^6 worked hours for self-employed vs. other workers, respectively.

Determinants of workplace injury

The high incidence of workplace injury among low earners was more pronounced among men than women (Figure 2). Men with low income and ≥41 working hours per week had the highest incidence of workplace injury (Table 3). The association between weekly working hours and injury differed for injury incidence expressed per worker-years (Figure 3, top) and incidence expressed per worked hours (Figure 3, bottom). The incidence per worker-years increased with hours worked, whereas the incidence per worked hour is greatest in the group with the least hours worked per week.

The results of the multivariate logistic regression model stratified by sex shows that working hours and income are associated with workplace injury (Table 4). In women but not in men, first marriage was negatively associated with workplace injury. In men but not in women, age above 50 years was negatively associated, and self-employment and alcohol consumption were positively associated with workplace injury.

The multivariate logistic regression was repeated for a modified outcome: workplace injury, regardless of medical help sought. Although this outcome may include very minor injuries, any potential confounding by access to health services is removed. Any workplace injury, regardless of whether medical help was sought, was reported by 6275 participants; 14% of men and 11% of women reported a workplace injury. Women reported having had any workplace injury 5.8 as often as they reported a workplace injury for which medical help was sought, among men this was 4.1 times. The pattern of association between exposure variables and outcome was similar to that shown in Table 4, with one noteworthy exception. For women, increasing age was statistically significantly associated with less workplace injury (age 30-39: OR 0.9 [95%CI 0.8-1.0]; age 40-49: 0.7 [0.6-0.8], age ≥50: 0.6 [0.4-0.8]; reference ages <30 years).

Discussion

Among Thai Cohort Study participants, workplace injury resulting in medical care was common, particularly among men. Those working more than 40 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk. Part-time workers were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers.

The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels. Informal work was partially captured by distinguishing self-employed workers from other workers. Potential injury reporting bias related to health service access, i.e. under-reporting of serious injuries because of limitations in health service access, were addressed by repeating the analysis for all reported injuries, regardless of seeking medical attention. A study limitation was the self-report nature of the data, which relies on accurate recall and reporting. Occupational injury incidence studies are limited in their generalisability by the methodology used and the study sample: Thai Cohort Study participants are undergoing long-distance education and they are a little younger and better educated than the Thai population. Really poor and uneducated workers are not in the cohort, and this may be reflected in the occupational injury rates. This should be taken into account when comparing the overall annual incidence of workplace injuries reported in this study with national statistics reported in other studies.

Comparison of incidence across studies becomes more complex when study methodologies differ. For example, workplace injury rates reported in this study were considerably higher than those reported in a study of non-fatal occupational injuries in employees in Malaysia: 34 and 18 injuries per 1000 worker years for men and women respectively in the Thai Cohort Study participants, compared with 10.7 and 3.6 reported for Malaysia [12]. In the study by Abas et al. Social Security Organisation claims for workplace injury and disease were analysed. Arguably not every

occupational injury for which help was sought will result in a benefit claim, and Abas et al are therefore analysing a more severe workplace injury selection. Emergency department visits for occupational afflictions are 60% greater than the rate of accepted lost-time compensation claims, according to a Canadian study comparing incidence determined from emergency department visits to incidence determined from workers' compensation claims[13]. In another example, a study conducted in a commune in Vietnam that is transitioning from agriculture to new industries, occupational injury incidence was reported based on face-to-face household surveys [14-15]. The reported rates were more than 30-fold the findings for the Thai Cohort Study, with an annualised incidence rate of 1001 per 1000 full time employee equivalents. Although this may reflect a discrepancy in injury rates in the Thai and Vietnamese populations, the results also highlight the difficulties in occupational injury comparisons between countries.

In developing and newly industrialised countries, surveys provide an alternative to workers' compensation claims analysis for deriving injury rates, but the results are highly dependent on the study sample (e.g. an agricultural commune compared to a nation-wide sample of working long-distance Open University students). Results also reflect the wording and translation of the survey and other methodological choices such as whether to include injuries arising from unpaid work, self-employment and work in the family business. The present study demonstrates the association between individual determinants and workplace injury; it is not the purpose of this study to present overall Thai occupational injury rates suitable for comparison to other national statistics.

Working more than 40 hours per week and working for low wages were independent risk factors for workplace injury in the Thai Cohort Study participants. A US survey-based study has reported a similar trend; however, this was observed in women but not in men [16], possibly due to the higher burden of household activities for women and decreased time for rest and recovery. Other US survey-based studies have shown a similar correlation between increased working hours and work-related injury; results were not shown separately for men and women [4 17]. Decreased self-reported

sleep was also found to be correlated with increased injury [4]. A US study among workers in manufacturing showed that long hours of work increase the risk for an injury in a dose-response manner, and the case cross-over study design contributed to the evidence for a causal relationship between working hours and injury [3]. In the present study the association between working hours and injury rates was confirmed for the Thai study participants. Interestingly, this trend was not seen when the injury incidence was expressed per 10^6 hours worked. If the injury incidence associated with overwork exceeds that expected based on increased 'expose duration'[17], one would expect the incidence per hours worked to increase with >40 working hours per week; however, this was not the case. Working less than 40 hours, however, and in particular working 10 hours or less was associated with the greatest injury risk per hour worked. This may be due to relative job inexperience.

Occupational injury incidence varied by gender and age in our study. Injury rates in previous studies are mostly reported to be greatest around the ages 20-25, and to decline with increasing age [18-20]. In a Canadian study, the types of jobs of young workers were found to play an important role in the high injury risk: adjusting for job characteristics substantially reduced the increased injury risk of young workers [21]. In other words, not youth itself but the jobs and work circumstances of youth contribute to the risk of injury. The peak injury incidence at age 30-39 among Thai men, therefore, might partly be explained by the continued participation in heavy physical work and high risk jobs by Thai men, beyond the age of 25.

Self-employed workers, representing a substantial proportion of the informal workforce, were at increased risk of injury. Unionisation rates in the informal workforce are generally low, and informal workers are not protected by existing workplace laws and regulations [22]. Improvement of wages, working hours and workplace safety for these workers may require a gradual transition to formalised employment, and more wide-spread formation of labour unions.

In conclusion, among Thai workers represented in the Thai Cohort Study, occupational injury incidence was greater for men than for women and injury rates peaked at ages 30 to 39. Injury rates

were increased among the self-employed, suggesting that statistics based on the formal workforce only may underestimate the injury rates in the combined (formal and informal) working population. The highest injury rates were recorded for those working more than 40 hours per week and for low wage earners; this did not appear to exceed the risk expected from increased exposure. Overall reductions in occupational injury rates might therefore be achieved by limiting working hours to 40 per week, particularly among low wage earners. The population of Thailand is growing, as is the Thai working population, including low wage earners and those with longer workdays. Particularly for these groups, there is an increasing need for effective injury preventive programs.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JBG and RM analysed that data and conceptualized and drafted the manuscript. BT provided background information on the Thai labour force. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

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Table 1. Workplace injury types for agricultural and non-agricultural injuries for which medical care was sought*.

	Agricultural workplace injury (n=347)		Non-agricultural workplace injury (n=970)		Chi-square, DF, P-value		
	N	(%)	N	(%)	X^2	DF	p
Nature of the injury							
Fracture	32	(9%)	96	(10%)	0.1	1	0.7
Sprain, strain or dislocation	127	(37%)	313	(32%)	2.2	1	0.1
Cut, bite or open wound	136	(39%)	324	(33%)	3.8	1	0.05
Bruise or superficial injury	109	(31%)	234	(24%)	7.0	1	0.008
Burn/scald	19	(5%)	47	(5%)	0.2	1	0.6
Concussion	61	(18%)	137	(14%)	2.4	1	0.1
Organ system (internal) injury	42	(12%)	104	(11%)	0.5	1	0.5
Other	41	(12%)	130	(13%)	0.6	1	0.5
Injury types reported							
None	5	(1%)	18	(2%)	7	2	0.03
One	218	(63%)	678	(70%)			
Two or more	124	(36%)	274	(28%)			

* Participants can report more than one injury.

Table 2. Incidence of workplace injury from the second Thai Cohort Study survey*.

Variable	Paid workers	Hours worked	Injured at the work-place	Incidence (events per 1000 workers years)			Incidence (events per 10^6 hours worked)		
					95% CI			95% CI	
Age (years)									
<30	13466	484352	338	25	[22	28]	13	[12	15]
30 to 39	22609	818742	639	28	[26	31]	15	[14	16]
40 to 49	12392	430020	284	23	[20	26]	13	[11	14]
≥50	3284	105121	56	17	[13	22]	10	[8	13]
Gender									
Women	28428	976250	524	18	[17	20]	10	[9	11]
Men	23323	861985	793	34	[32	36]	18	[16	19]
Marital status									
First marriage	24924	883648	570	23	[21	25]	12	[11	13]
Never married	17229	619014	490	28	[26	31]	15	[14	17]
Other	5182	184475	141	27	[23	32]	15	[12	17]
Missing data	4416	151098	116	26	[22	32]	15	[12	18]
Area									
Rural	22104	773206	597	27	[25	29]	15	[14	16]
Urban	29077	1044702	706	24	[23	26]	13	[12	14]

Monthly income (Baht)									
≤7000	7005	226603	285	41	[36	46]	24	[21	27]
7001 to 10,000	12168	418784	350	29	[26	32]	16	[14	18]
10,001 to 20,000	19595	711783	426	22	[20	24]	11	[10	13]
20,001 to 30,000	7660	278719	159	21	[18	24]	11	[9	13]
≥30,001	5233	199328	94	18	[15	22]	9	[7	11]
Weekly hours of paid work									
≤10	14561	116813	304	21	[19	23]	50	[44	56]
11 to 39	6360	155600	148	23	[20	27]	18	[15	21]
40	10921	436840	240	22	[19	25]	11	[9	12]
40 to 48	8088	379064	224	28	[24	32]	11	[10	13]
≥49	11821	749918	401	34	[31	37]	10	[9	11]
Self employment									
Yes	8863	311580	301	34	[30	38]	19	[16	21]
No	42888	1526655	1016	24	[22	25]	13	[12	14]
Alcohol									
None	35149	1236917	755	21	[20	23]	12	[11	13]
1-5 per week	7086	257715	236	33	[29	38]	18	[15	20]
6 or more per week	7407	275276	264	36	[31	40]	18	[16	21]

* The most serious non-traffic injury that occurred in the last 12 months was included if it occurred in the workplace, and if medical care was received for the injury. To take differences in exposure duration into account, incidence was also reported per 1,000,000 hours of paid work.

Table 3. Incidence of workplace injury (injuries per 1000 worker-years) by hours worked and monthly income, for men and women. Darker shades correspond with higher workplace injury incidence.

MEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	47 [38-58]	46 [37-57]	62 [53-73]
10,001-20,000 Baht	24 [18-31]	23 [19-29]	35 [30-42]
≥20,001 Baht	15 [10-23]	23 [18-30]	28 [22-35]

WOMEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	19 [15-23]	21 [16-26]	27 [23-32]
10,001-20,000 Baht	10 [7-15]	14 [10-19]	20 [16-25]
≥20,001 Baht	16 [10-24]	11 [7-17]	19 [13-25]

Table 4. Multiple logistic regression model of workplace injuries requiring medical care; the model is stratified by gender*.

	Women			Men		
	492/26858			746/22070		p-value
	OR	[95% CI]		OR	[95% CI]	
Age (years)						
<30	1	[REF]	0.07	1	[REF]	0.007
30 to 39	1.3	[1.1 -1.7]		1.1	[0.9 -1.4]	
40 to 49	1.2	[1.0 -1.8]		0.9	[0.7 -1.1]	
≥50	1.3	[0.7 -2.2]		0.6	[0.4 -0.9]	
Marital status						
First marriage	0.6	[0.5 -0.8]	0.0005	1.0	[0.8 -1.2]	0.59
Never married	1	[REF]		1	[REF]	
Other	0.8	[0.6 -1.1]		1.2	[0.9 -1.6]	
Area						
Rural	0.9	[0.8 -1.1]	0.42	1.0	[0.8 -1.1]	0.85
Urban	1	[REF]		1	[REF]	
Weekly hours of paid work						
≤10	0.8	[0.6 -1.1]	0.0002	0.9	[0.7 -1.1]	0.001
11 to 39	0.9	[0.7 -1.3]		0.9	[0.7 -1.2]	
40	1	[REF]		1	[REF]	
41 to 48	1.2	[0.9 -1.6]		1.2	[0.9 -1.5]	
≥49	1.4	[1.1 -1.9]		1.3	[1.0 -1.6]	
Monthly personal income (Baht)						

≤7000	2.0	[1.5 -2.6]	<0.0001	2.5	[2.0 -3.1]	<0.0001
7001 to 10,000	1.4	[1.1 -1.8]		1.6	[1.3 -1.9]	
10,001 to 20,000	1	[REF]		1	[REF]	
20,001 to 30,000	1.0	[0.7 -1.3]		1.0	[0.8 -1.2]	
≥30,001	1.1	[0.8 -1.7]		0.8	[0.6 -1.0]	
Self employment						
Yes	1.1	[0.8 -1.4]	0.52	1.4	[1.2 -1.7]	0.0003
No	1	[REF]		1	[REF]	
Alcohol						
None	1	[REF]	0.35	1	[REF]	0.002
1-5 per week	1.0	[0.7 -1.4]		1.3	[1.1 -1.6]	
6 or more per week	1.4	[0.9 -2.4]		1.3	[1.1 -1.5]	

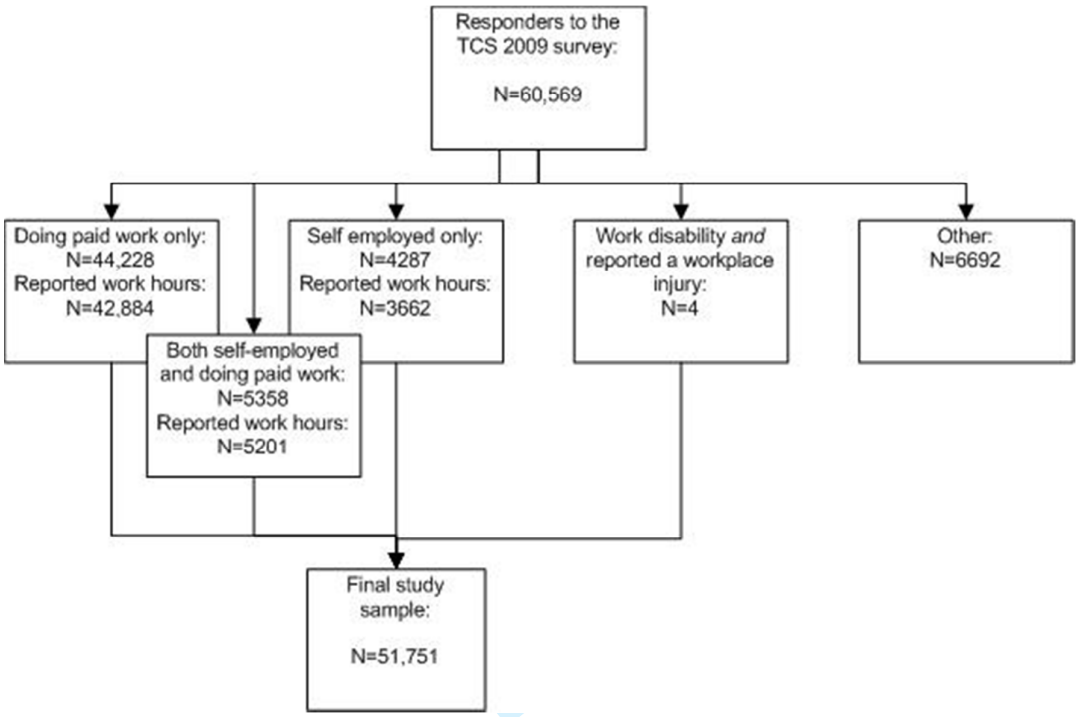

Figure 1. Inclusions and exclusions of study sample

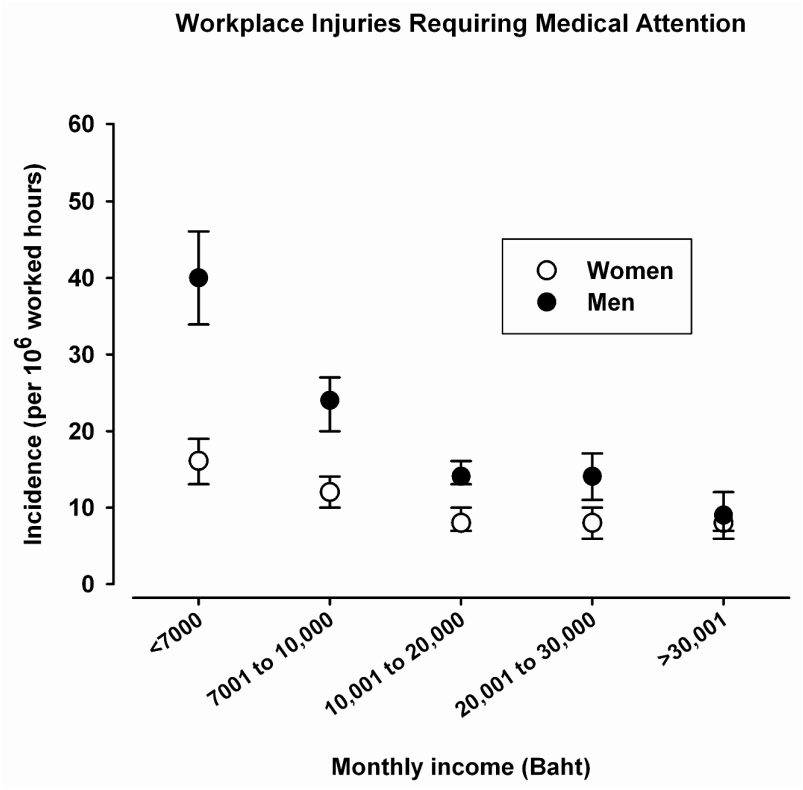

Figure 2. Incidence of workplace injury by monthly income

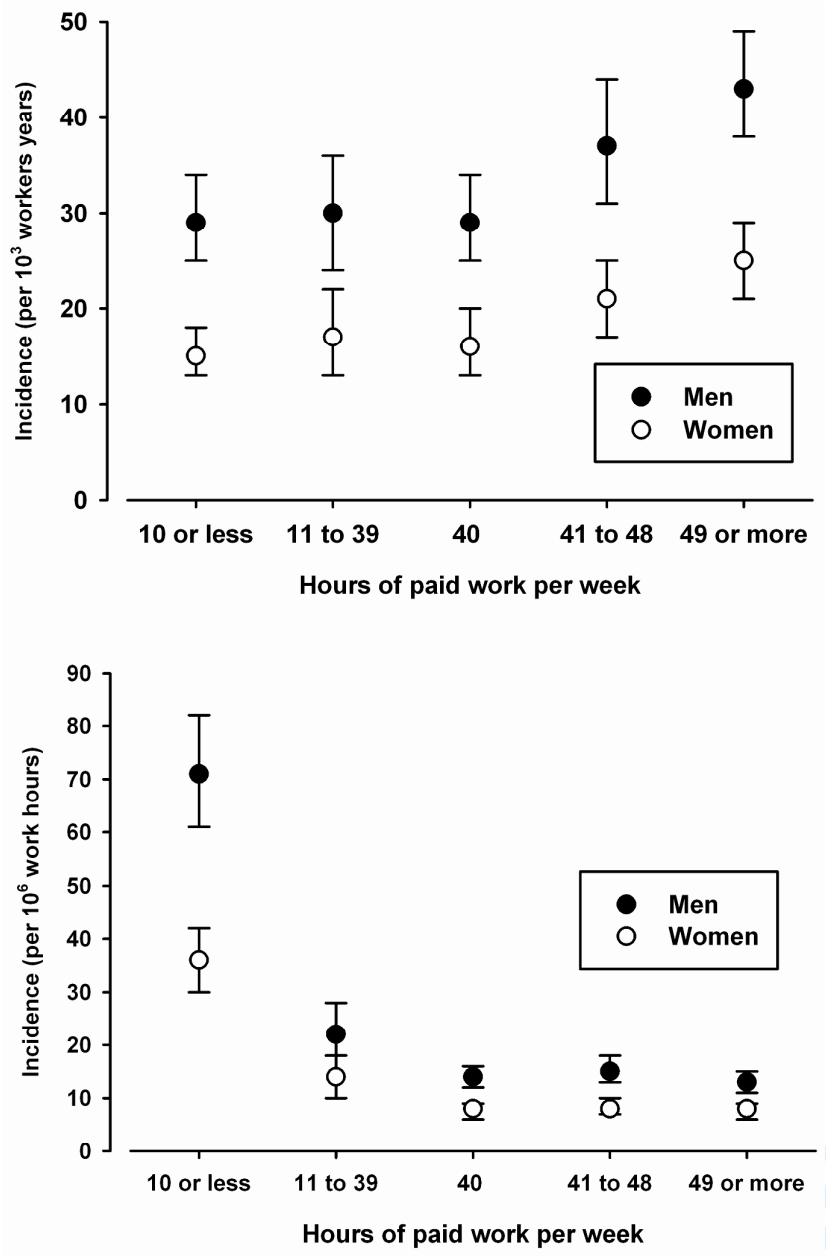

Figure 3. Incidence of workplace injury by weekly working hours

Funding

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Competing Interests

None

Contributorship

JBG and RM analysed that data and conceptualized and drafted the manuscript. BT provided background information on the Thai labour force. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

Data sharing

Data are available through a data access agreement which includes guarantees regarding ethical conduct and scientific quality of any proposed analyses and publications. Anyone wanting access should contact Adrian Sleigh or Sam-ang Seubsman (study Principal Investigators).

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7,8*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	22
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8,9
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	22
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	22
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6, 10
		(b) Indicate number of participants with missing data for each variable of interest	22
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	10, 16, 17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17-18, 20-21
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

DETERMINANTS OF WORKPLACE INJURY AMONG THAI COHORT STUDY PARTICIPANTS

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DETERMINANTS OF WORKPLACE INJURY AMONG THAI COHORT STUDY PARTICIPANTS

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Figures: 3

Tables: 4

Abstract

Objectives:

To explore individual determinants of workplace injury among Thai workers.

Design:

Cross-sectional analysis of a large national cohort.

Setting:

Thailand.

Participants:

Thai Cohort Study participants who responded to the 2009 follow-up survey were included if they reported doing paid work or being self-employed (n=51,751).

Outcome measures:

Self-reported injury incidence over the past 12 months was calculated. Multivariate logistic regression models were used to test associations between individual determinants and self-reported workplace injury.

Results:

Workplace injuries were reported by 1317 study participants (2.5%); the incidence was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. Among men working ≥41 hours and earning <10,000 Baht, the injury rate was four times higher compared to men working <11 hours and earning ≥ 20,001 Baht; differences in injury rates were less pronounced in women. Multivariate modelling showed that working ≥49 hours per week (23%) and working for ≤10,000 Bath/month (37%) were associated with workplace injury. The increase in injury risk with increased working hours did not exceed the risk expected from increased exposure.

Conclusions:

Reductions in occupational injury rates could be achieved by limiting working hours to 48 per week. Particularly for Thai low wage earners and those with longer workdays, there is a need for effective injury preventive programs.

Article Summary

Article focus

- Research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level
- The aim of the present study was to investigate individual determinants of workplace injury among Thai workers participating in a large national Thai Cohort Study (TCS)
- The objectives were to determine the impact of working hours and level of income on workplace injury risk

Key messages

- Of the study participants that were doing paid work or were self-employed, 3.4% of the men and 1.8% of the women reported a workplace injury that occurred over the past 12 months
- Those working more than 48 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk.
- Part-time workers were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers

Strengths and limitations of this study

- The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels
- A study limitation was the self-report nature of the data, which relies on accurate recall and reporting

Introduction

Thailand is a newly industrialised country. The transition to a modern consumer economy is accompanied by a shift in birth and death rates, disease patterns and injury risks [1]. Until recently, 46% of employed Thais were working in the agricultural sector, but the proportion of industrial workers is rapidly increasing [2]. Occupational Health and Safety is being increasingly recognised in Thailand as an important component of population health and wellbeing. At the transitioning stage, Thailand is facing both old and new occupational health problems: many traditional hazards in workplaces, such as silica, lead and unsafe work practice, still exist while new hazards related to changing working environments are emerging[2]. An example is increasing levels of stress at work, which may trigger deterioration of workplace safety. Actions underway in Thailand to improve occupational health and safety include the implementation of an occupational health and safety surveillance system, a 'healthy workplace program' to promote safety [2], and a large scale pilot program integrating occupational and environmental health services into existing public health systems [3]. Another area recently targeted in policy is pesticide poisoning among farmers.

While the role of individual level risk factors such as working hours and resulting fatigue is not well studied in Thailand, there is evidence from other countries that extended work hours increase the risk of injury [4] independent of industry and occupation [5]. In Ethiopia, a developing country, working 48 hours or less per week was found to be negatively associated with occupational injury in small and medium-scale industries[6]. The impact of working hours on workplace injury risk has not been investigated in the Thai context.

Individual-level determinants, such as working hours, are not specific to a workplace, industry or sector. Occupational injury risks arising from modifiable individual level determinants can potentially be addressed in injury preventive measures across Thailand. Therefore, the aim of the present study is to investigate individual determinants of workplace injury among Thai workers participating in a

large national Thai Cohort Study (TCS). In particular, this study will address the impact of working hours and level of income on workplace injury risk.

The research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level. Much of the occupational health and safety research has focussed on formal employment, which accounts for only a third of the Thai workforce [7]. Among Thais working in the non-formal sector, the safety of working conditions has deteriorated over recent years [8]. This is especially so for chemical injuries among informal agricultural workers. Also, informal workers are more likely to work longer hours than formal workers and this would be expected to increase injury risks. Informal workers are therefore not excluded from this study: TCS participants who engaged in paid employment or were self-employed in 2009 are included.

Methods

In this cross-sectional analysis of the Thai Cohort Study, self-reported workplace injury was determined among those respondents of the second survey (in 2009) who were doing paid work or self employed. Although both the first (2005) and second (2009) surveys contained detailed questions about injury, the 2009 survey questions were designed to fully capture traffic and non-traffic injury, also among those who had both a traffic and a non-traffic accident in the previous year. This analysis is therefore focussed on the second survey only. Work status information is not derived from the 2005 survey because it is likely to have changed over the four years between the surveys.

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The 2005 baseline characteristics of cohort participants [9] and comparisons with the population of Thailand [1 10] have been reported previously: the STOU cohort has a higher proportion of females than the general Thai population (54.7% vs. 50.5%); more young adults (51.5% vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0% vs. 24.7%) [10]. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort [10].

Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students already have established jobs and because of their work and family responsibilities and modest economic circumstances are unable to leave their locations to attend an on-campus university fulltime. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocols 2004344 and 2009570). Informed written consent was obtained from all participants.

Sample

The sample inclusions and exclusions are shown in Figure 1. In the survey of 2009, study participants were asked "What is your current work status? (You can choose more than one option)" with possible answers: Doing paid work/ Self employed/ Help family business but no wage/ Doing unpaid work/ Look after home (homemaker)/ Student/ Retired (do not work for income)/ Seeking work for the first time/ Unemployed/ Cannot work due to temporary sickness or disability/ Cannot work due to permanent sickness or disability/ Other. Those who indicated they were doing paid work and/or self employed were included in this study. Participants were also asked to report "How many hours per week do you work in all paid jobs?" Those who did not provide this information were excluded. Inclusion was based entirely on response to the 2009 survey; responses to the 2005 survey were not considered.

Participants who reported having had a workplace injury leading to limited activity, and who also indicated that they could not work due to a temporary or permanent sickness or disability, were included in the analyses. Their working hours (prior to injury) were imputed by the sample median. The final sample consists of 51,751 participants.

Workplace injury

The core questions asked were: (1) "In the last 12 months how many times did you have a NON-TRAFFIC injury?" with possible answers never/one/two/three/four or more; (2) "What was the location at which your most serious non-traffic related injury occurred?" with possible answers home/sports facility/workplace (agricultural)/workplace (non-agricultural)/other; and (3) "When you experienced your most serious non-traffic related injury did you receive medical care?" with possible answers yes/no. Workplace injury was defined as non-traffic related injury that occurred in the workplace, agricultural or non-agricultural, and for which medical care was received. Non-traffic injuries that occurred outside the workplace were not considered in this study.

Self-employment

Self-employment was used as a proxy for informal employment [11]. Study participants who indicated 'Self employed' in response to the question about current work status were therefore considered to be informally employed.

Determinants of workplace injury

The median number of working hours per week was 40, inter-quartile range [10 to 48]. The distribution was multimodal. There were three spikes in the distribution: 18% of participants reported working 8 hours per week; 21% reported working 40 hours and 11% reported working 48 hours. The working hours were therefore categorised as follows: ≤10; 11-39; 40; 41-48; ≥49 hours per week. The Thai Cohort Study survey of 2009 did not include questions about working in agriculture or farming, or about working multiple jobs.

The 2009 TCS survey included questions about marital status, area of residence, working hours, monthly personal wages and alcohol consumption.

Analysis

Analyses were performed in SAS 9.2 (SAS Institute, Cary NC). To gain insight into risk factors for workplace injury, injury incidence was calculated per 1000 worker-years (self-reported workplace injury in the last year in the numerator and the 51,751 study participants engaged in paid work in the denominator). To explore gender differences, for example, workplace injury incidence was calculated for men and women separately. However, possible gender differences could be attributed to men working more hours per year than women. To account for differences in work exposure duration, workplace injury incidence was also calculated per hours worked expressed per 1,000,000 hours. The results can be converted to American full time equivalents (FTE): assuming a 40 hour work week and 52 work weeks per year equates 2080 hours; to convert the injury rates to 100 FTE-years, they should be multiplied by a factor 0.2080. The results of this study are presented per

1,000,000 hours to avoid confusion about the 'standard' number of hours worked per year, which may differ substantially per country.

To calculate the workplace injury incidence per 1000 worker-years, the number of persons with a workplace injury sustained in the last 12 months was divided by the total number of workers, and multiplied by 1000. To calculate the incidence per 1,000,000 hours worked, the number of persons with a workplace injury was divided by the sum of weekly hours worked by all workers (multiplied by 52 to obtain the hours worked per year), and multiplied by 1,000,000. Confidence intervals for the incidence rates were calculated by first assuming injury occurrence to have a Poisson distribution, and finding its related confidence interval[12].

A multiple logistic regression model was used to test factors that were likely to be associated with workplace injuries. The model was gender-stratified. Covariates were individual-level work-related factors (income, hours of paid work, and self-employment) and demographics that could confound the association between work-related factors and risk of injury (age, gender, marital status, area of residence and alcohol intake).

The association between exposure variables and the outcome, i.e. workplace injury for which medical help was sought, could be confounded by access to health services. The multivariate logistic regression model was therefore repeated for a modified outcome: workplace injury, regardless of medical help sought.

Results

Workplace injury

Workplace injuries for which medical help was sought were reported by 1317 study participants (2.5%); 3.4% of the men and 1.8% of the women reported a workplace injury. The types of injury are summarised in Table 1. The most commonly reported workplace injuries were cuts, bites or open

wounds (35%) and sprains, strains or dislocations (33%). Bruising or superficial injury was more common among participants with injuries sustained in agricultural work; cuts, bites or open wounds also tended to be more common among agricultural work injuries.

The incidence of workplace injury was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. The incidence per 1000 worker-years as well as the incidence per 1,000,000 hours worked is summarised in Table 2. Incidence was greatest in the age group 30-39 years, men, participants who were never married, live in rural areas, are in the lowest wage category, work the most hours, are self-employed and regularly drink alcohol.

Self-employment and workplace injury

Self-employment was reported by 17% or workers. Compared with other paid workers, self-employed workers were more likely to work over 49 hours per week (30% vs. 21%). They were more likely to have a low income of <7000 Baht (25% vs. 11%), but they were also more likely to have a high income of >30,000 Baht (16% vs. 9%). The injury incidence of workplace injury per worker-years, as well as per hours worked, was greater among the self-employed (Table 2). This held true for low earners (self-employed workers had 30 [25-37] and other paid workers had 22[19-25] injuries per 10^6 worked hours) and for mid-range earners (17 [15-20] vs. 12 [11-13]) but not for high earners (>30,000 Baht) who had 9 [6-13] vs. 9 [7-11] injuries per 10^6 worked hours for self-employed vs. other workers, respectively.

Determinants of workplace injury

The high incidence of workplace injury among low earners was more pronounced among men than women (Figure 2). Among men working ≥41 hours and earning <10,000 Baht, the injury rate was four times higher compared to men working <11 hours and earning ≥ 20,001 Baht; differences in injury rates were less pronounced in women (Table 3). The association between weekly working hours and injury differed for injury incidence expressed per worker-years (Figure 3, top) and

incidence expressed per worked hours (Figure 3, bottom). The incidence per worker-years increased with hours worked, whereas the incidence per worked hour is greatest in the group with the least hours worked per week.

The results of the multivariate logistic regression model stratified by sex shows that working hours and income were independently associated with workplace injury (Table 4). Working ≥49 hours per week was associated with workplace injury in both men and women. Among both men and women earning a monthly personal income of ≤10,000 Baht was also associated with workplace injury. Among those earning >10,000 Baht per month, increase in income was not associated with a further reduction in injury. In women but not in men, first marriage was negatively associated with workplace injury. In men but not in women, age above 50 years was negatively associated, and self-employment and alcohol consumption were positively associated with workplace injury.

The multivariate logistic regression was repeated for a modified outcome: workplace injury, regardless of medical help sought. Although this outcome may include very minor injuries, any potential confounding by access to health services is removed. Any workplace injury, regardless of whether medical help was sought, was reported by 6275 participants; 14% of men and 11% of women reported a workplace injury. Women reported having had any workplace injury 5.8 as often as they reported a workplace injury for which medical help was sought, among men this was 4.1 times. The pattern of association between exposure variables and outcome was similar to that shown in Table 4, with one noteworthy exception. For women, increasing age was statistically significantly associated with less workplace injury (age 30-39: OR 0.9 [95%CI 0.8-1.0]; age 40-49: 0.7 [0.6-0.8], age ≥50: 0.6 [0.4-0.8]; reference ages <30 years).

Discussion

Among Thai Cohort Study participants, workplace injury resulting in medical care was common, particularly among men. Those working more than 48 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk. Study participants working ≥10 hours per week were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers.

The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels. Informal work was partially captured by distinguishing self-employed workers from other workers. Potential injury reporting bias related to health service access, i.e. under-reporting of serious injuries because of limitations in health service access, were addressed by repeating the analysis for all reported injuries, regardless of seeking medical attention. A study limitation was the self-report nature of the data, which relies on accurate recall and reporting. This was a cross-sectional analysis. Not only was the data accuracy dependent on recall of exposure and injury, but it was assumed that exposure lead to injury and not vice-versa. Potentially, factors such as working hours, income and alcohol use may have been modified as a result of the injury. Although it seems unlikely that working hours would be increased as a result of an injury, workplace injury may have affected income and alcohol intake. Causality in the association between these factors and workplace injury cannot be established in this study.

Occupational injury incidence studies are limited in their generalisability by the methodology used and the study sample: Thai Cohort Study participants are undergoing long-distance education and they are a little younger and better educated than the Thai population. Really poor and uneducated workers are not in the cohort, and this may be reflected in the occupational injury rates. Because injury rates were increased in the low income group, the workplace injury rate in the Thai population is therefore likely to be greater than that of Thai Cohort Study participants. This should be taken into

account when comparing the overall annual incidence of workplace injuries reported in this study with national statistics reported in other studies.

Comparison of incidence across studies becomes more complex when study methodologies differ. For example, workplace injury rates reported in this study were considerably higher than those reported in a study of non-fatal occupational injuries in employees in Malaysia: 34 and 18 injuries per 1000 worker years for men and women respectively in the Thai Cohort Study participants, compared with 10.7 and 3.6 reported for Malaysia [13]. In the study by Abas et al. Social Security Organisation claims for workplace injury and disease were analysed. Arguably not every occupational injury for which help was sought will result in a benefit claim, and Abas et al are therefore analysing a more severe workplace injury selection. Emergency department visits for occupational afflictions are 60% greater than the rate of accepted lost-time compensation claims, according to a Canadian study comparing incidence determined from emergency department visits to incidence determined from workers' compensation claims[14]. In another example, a study conducted in a commune in Vietnam that is transitioning from agriculture to new industries, occupational injury incidence was reported based on face-to-face household surveys [15-16]. The reported rates were more than 30-fold the findings for the Thai Cohort Study, with an annualised incidence rate of 1001 per 1000 full time employee equivalents. Although this may reflect a discrepancy in injury rates in the Thai and Vietnamese populations, the results also highlight the difficulties in occupational injury comparisons between countries.

In developing and newly industrialised countries, surveys provide an alternative to workers' compensation claims analysis for deriving injury rates, but the results are highly dependent on the study sample (e.g. an agricultural commune compared to a nation-wide sample of working long-distance Open University students). Results also reflect the wording and translation of the survey and other methodological choices such as whether to include injuries arising from unpaid work, self-employment and work in the family business. The present study demonstrates the association

between individual determinants and workplace injury; it is not the purpose of this study to present overall Thai occupational injury rates suitable for comparison to other national statistics.

Working more than 48 hours per week and working for low wages were independent risk factors for workplace injury in the Thai Cohort Study participants. A US survey-based study has reported a similar trend; however, this was observed in women but not in men [17], possibly due to the higher burden of household activities for women and decreased time for rest and recovery. Other US survey-based studies have shown a similar correlation between increased working hours and work-related injury; results were not shown separately for men and women [5 18]. Decreased self-reported sleep was also found to be correlated with increased injury [5]. A US study among workers in manufacturing showed that long hours of work increase the risk for an injury in a dose-response manner, and the case cross-over study design contributed to the evidence for a causal relationship between working hours and injury [4]. In the present study the association between working hours and injury rates was confirmed for the Thai study participants. Interestingly, this trend was not seen when the injury incidence was expressed per 10^6 hours worked. If the injury incidence associated with overwork exceeds that expected based on increased 'expose duration'[18], one would expect the incidence per hours worked to increase with >40 working hours per week; however, this was not the case. Working less than 40 hours, however, and in particular working 10 hours or less was associated with the greatest injury risk per hour worked. This may be due to relative job inexperience.

Thailand has recently introduced a minimum wage of 300 Baht per day for all employees. Although the current study cannot establish causality in the relationship between income and workplace injury (and the minimum wage of 300 baht per day is still in the lowest income category of <7000 Baht as categorised in this study), the introduction of the minimum wage may reduce need to work multiple jobs. This could lead to a decrease in the number of workers working more than 48 hours per week, which is likely to directly reduce the incidence of workplace injury.

Occupational injury incidence varied by gender and age in our study. Injury rates in previous studies are mostly reported to be greatest around the ages 20-25, and to decline with increasing age [19-21]. In a Canadian study, the types of jobs of young workers were found to play an important role in the high injury risk: adjusting for job characteristics substantially reduced the increased injury risk of young workers [22]. In other words, not youth itself but the jobs and work circumstances of youth contribute to the risk of injury. The peak injury incidence at age 30-39 among Thai workers, therefore, might partly be explained by the continued participation in heavy physical work and high risk jobs by Thai workers (particularly by men), beyond the age of 25.

Self-employed workers, representing a substantial proportion of the informal workforce, were at increased risk of injury. Unionisation rates in the informal workforce are generally low, and informal workers are not protected by existing workplace laws and regulations [23]. Improvement of wages, working hours and workplace safety for these workers may require a gradual transition to formalised employment, and more wide-spread formation of labour unions.

In conclusion, among Thai workers represented in the Thai Cohort Study, occupational injury incidence was greater for men than for women and injury rates peaked at ages 30 to 39. Injury rates were increased among the self-employed, suggesting that statistics based on the formal workforce only may underestimate the injury rates in the combined (formal and informal) working population. The highest injury rates were recorded for those working more than 48 hours per week and for low wage earners; this did not appear to exceed the risk expected from increased exposure. Overall reductions in occupational injury rates might therefore be achieved by limiting working hours to 48 per week, particularly among low wage earners. The population of Thailand is growing, as is the Thai working population, including low wage earners and those with longer workdays. Particularly for these groups, there is an increasing need for effective injury preventive programs.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JBG and RM analysed that data and conceptualized and drafted the manuscript. BT provided background information on the Thai labour force. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

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Data sharing

Data are available through a data access agreement which includes guarantees regarding ethical conduct and scientific quality of any proposed analyses and publications. Anyone wanting access should contact Adrian Sleigh or Sam-ang Seubsman (study Principal Investigators).

Table 1. Workplace injury types for agricultural and non-agricultural injuries for which medical care was sought*.

	Agricultural workplace injury (n=347)		Non-agricultural workplace injury (n=970)		Chi-square, DF, P-value		
	N	(%)	N	(%)	X^2	DF	p
Nature of the injury							
Fracture	32	(9%)	96	(10%)	0.1	1	0.7
Sprain, strain or dislocation	127	(37%)	313	(32%)	2.2	1	0.1
Cut, bite or open wound	136	(39%)	324	(33%)	3.8	1	0.05
Bruise or superficial injury	109	(31%)	234	(24%)	7.0	1	0.008
Burn/scald	19	(5%)	47	(5%)	0.2	1	0.6
Concussion	61	(18%)	137	(14%)	2.4	1	0.1
Organ system (internal) injury	42	(12%)	104	(11%)	0.5	1	0.5
Other	41	(12%)	130	(13%)	0.6	1	0.5
Injury types reported							
None	5	(1%)	18	(2%)	7	2	0.03
One	218	(63%)	678	(70%)			
Two or more	124	(36%)	274	(28%)			

* Participants can report more than one injury.

Table 2. Incidence of workplace injury from the second Thai Cohort Study survey*.

Variable	Paid workers	Hours worked	Injured at the work-place	Incidence (events per 1000 workers years)		Incidence (events per 10^6 hours worked)	
					95% CI		95% CI
Age (years)							
<30	13,466	484,352	338	25	[22 28]	13	[12 15]
30 to 39	22,609	818,742	639	28	[26 31]	15	[14 16]
40 to 49	12,392	430,020	284	23	[20 26]	13	[11 14]
≥50	3284	105,121	56	17	[13 22]	10	[8 13]
Gender							
Women	28,428	976,250	524	18	[17 20]	10	[9 11]
Men	23,323	861,985	793	34	[32 36]	18	[16 19]
Marital status							
First marriage	24,924	883,648	570	23	[21 25]	12	[11 13]
Never married	17,229	619,014	490	28	[26 31]	15	[14 17]
Other	5182	184,475	141	27	[23 32]	15	[12 17]
Missing data	4416	151,098	116	26	[22 32]	15	[12 18]
Area							
Rural	22,104	773,206	597	27	[25 29]	15	[14 16]
Urban	29,077	1,044,702	706	24	[23 26]	13	[12 14]
Monthly income (Baht)							

≤7000	7005	226,603	285	41	[36 46]	24	[21 27]
7001 to 10,000	12,168	418,784	350	29	[26 32]	16	[14 18]
10,001 to 20,000	19,595	711,783	426	22	[20 24]	11	[10 13]
20,001 to 30,000	7660	278,719	159	21	[18 24]	11	[9 13]
≥30,001	5233	199,328	94	18	[15 22]	9	[7 11]
Weekly hours of paid work							
≤10	14,561	116,813	304	21	[19 23]	50	[44 56]
11 to 39	6360	155,600	148	23	[20 27]	18	[15 21]
40	10,921	436,840	240	22	[19 25]	11	[9 12]
41 to 48	8088	379,064	224	28	[24 32]	11	[10 13]
≥49	11,821	749,918	401	34	[31 37]	10	[9 11]
Self employment							
Yes	8863	311,580	301	34	[30 38]	19	[16 21]
No	42,888	1,526,655	1016	24	[22 25]	13	[12 14]
Alcohol							
None	35,149	1,236,917	755	21	[20 23]	12	[11 13]
1-5 per week	7086	257,715	236	33	[29 38]	18	[15 20]
6 or more per week	7407	275,276	264	36	[31 40]	18	[16 21]

* The most serious non-traffic injury that occurred in the last 12 months was included if it occurred in the workplace, and if medical care was received for the injury. To take differences in exposure duration into account, incidence was also reported per 1,000,000 hours of paid work.

Table 3. Incidence of workplace injury (injuries per 1000 worker-years) by hours worked and monthly income, for men and women. Darker shades correspond with higher workplace injury incidence.

MEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	47 [38-58]	46 [37-57]	62 [53-73]
10,001-20,000 Baht	24 [18-31]	23 [19-29]	35 [30-42]
≥20,001 Baht	15 [10-23]	23 [18-30]	28 [22-35]

WOMEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	19 [15-23]	21 [16-26]	27 [23-32]
10,001-20,000 Baht	10 [7-15]	14 [10-19]	20 [16-25]
≥20,001 Baht	16 [10-24]	11 [7-17]	19 [13-25]

Table 4. Multiple logistic regression model of workplace injuries requiring medical care; the model is stratified by gender*.

	Women 492/26,858			Men 746/22,070		
	OR	[95% CI]		OR	[95% CI]	
Age (years)						
<30	1	[REF]	0.07	1	[REF]	0.007
30 to 39	1.3	[1.1 -1.7]		1.1	[0.9 -1.4]	
40 to 49	1.2	[1.0 -1.8]		0.9	[0.7 -1.1]	
≥50	1.3	[0.7 -2.2]		0.6	[0.4 -0.9]	
Marital status						
First marriage	0.6	[0.5 -0.8]	0.0005	1.0	[0.8 -1.2]	0.59
Never married	1	[REF]		1	[REF]	
Other	0.8	[0.6 -1.1]		1.2	[0.9 -1.6]	
Area						
Rural	0.9	[0.8 -1.1]	0.42	1.0	[0.8 -1.1]	0.85
Urban	1	[REF]		1	[REF]	
Weekly hours of paid work						
≤10	0.8	[0.6 -1.1]	0.0002	0.9	[0.7 -1.1]	0.001
11 to 39	0.9	[0.7 -1.3]		0.9	[0.7 -1.2]	
40	1	[REF]		1	[REF]	
41 to 48	1.2	[0.9 -1.6]		1.2	[0.9 -1.5]	
≥49	1.4	[1.1 -1.9]		1.3	[1.0 -1.6]	
Monthly personal income (Baht)						

≤7000	2.0	[1.5 -2.6]	<0.0001	2.5	[2.0 -3.1]	<0.0001
7001 to 10,000	1.4	[1.1 -1.8]		1.6	[1.3 -1.9]	
10,001 to 20,000	1	[REF]		1	[REF]	
20,001 to 30,000	1.0	[0.7 -1.3]		1.0	[0.8 -1.2]	
≥30,001	1.1	[0.8 -1.7]		0.8	[0.6 -1.0]	
Self employment						
Yes	1.1	[0.8 -1.4]	0.52	1.4	[1.2 -1.7]	0.0003
No	1	[REF]		1	[REF]	
Alcohol						
None	1	[REF]	0.35	1	[REF]	0.002
1-5 per week	1.0	[0.7 -1.4]		1.3	[1.1 -1.6]	
6 or more per week	1.4	[0.9 -2.4]		1.3	[1.1 -1.5]	

Figure legends:

Figure 1. Inclusions and exclusions of study sample.

Only those reporting work hours were included: 42,884 were doing paid work only; 3662 were self-employed, 5201 were both self-employed and doing paid work and 4 reported a work disability as well as a recent workplace injury.

Figure 2. Incidence of workplace injury by monthly income

Figure 3. Incidence of workplace injury by weekly working hours

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DETERMINANTS OF WORKPLACE INJURY AMONG THAI COHORT STUDY PARTICIPANTS

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Abstract

Objectives:

To explore individual determinants of workplace injury among Thai workers.

Design:

Cross-sectional analysis of a large national cohort.

Setting:

Thailand.

Participants:

Thai Cohort Study participants who responded to the 2009 follow-up survey were included if they reported doing paid work or being self-employed (n=51,751).

Outcome measures:

Self-reported injury incidence over the past 12 months was calculated. Multivariate logistic regression models were used to test associations between individual determinants and self-reported workplace injury.

Results:

Workplace injuries were reported by 1317 study participants (2.5%); the incidence was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. Among men working ≥41 hours and earning <10,000 Baht, the injury rate was four times higher compared to men working <11 hours and earning ≥ 20,001 Baht; differences in injury rates were less pronounced in women. Multivariate modelling showed that working ≥49 hours per week (23%) and working for ≤10,000 Bath/month (37%) were associated with workplace injury. The increase in injury risk with increased working hours did not exceed the risk expected from increased exposure.

Conclusions:

Reductions in occupational injury rates could be achieved by limiting working hours to 48 per week. Particularly for Thai low wage earners and those with longer workdays, there is a need for effective injury preventive programs.

Article Summary

Article focus

- Research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level
- The aim of the present study was to investigate individual determinants of workplace injury among Thai workers participating in a large national Thai Cohort Study (TCS)
- The objectives were to determine the impact of working hours and level of income on workplace injury risk

Key messages

- Of the study participants that were doing paid work or were self-employed, 3.4% of the men and 1.8% of the women reported a workplace injury that occurred over the past 12 months
- Those working more than 48 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk.
- Part-time workers were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers

Strengths and limitations of this study

- The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels
- A study limitation was the self-report nature of the data, which relies on accurate recall and reporting

Introduction

Thailand is a newly industrialised country. The transition to a modern consumer economy is accompanied by a shift in birth and death rates, disease patterns and injury risks [1]. Until recently, 46% of employed Thais were working in the agricultural sector, but the proportion of industrial workers is rapidly increasing [2]. Occupational Health and Safety is being increasingly recognised in Thailand as an important component of population health and wellbeing. At the transitioning stage, Thailand is facing both old and new occupational health problems: many traditional hazards in workplaces, such as silica, lead and unsafe work practice, still exist while new hazards related to changing working environments are emerging[2]. An example is increasing levels of stress at work, which may trigger deterioration of workplace safety. Actions underway in Thailand to improve occupational health and safety include the implementation of an occupational health and safety surveillance system, a 'healthy workplace program' to promote safety [2], and a large scale pilot program integrating occupational and environmental health services into existing public health systems [3]. Another area recently targeted in policy is pesticide poisoning among farmers.

While the role of individual level risk factors such as working hours and resulting fatigue is not well studied in Thailand, there is evidence from other countries that extended work hours increase the risk of injury [4] independent of industry and occupation [5]. In Ethiopia, a developing country, working 48 hours or less per week was found to be negatively associated with occupational injury in small and medium-scale industries[6]. The impact of working hours on workplace injury risk has not been investigated in the Thai context.

Individual-level determinants, such as working hours, are not specific to a workplace, industry or sector. Occupational injury risks arising from modifiable individual level determinants can potentially be addressed in injury preventive measures across Thailand. Therefore, the aim of the present study is to investigate individual determinants of workplace injury among Thai workers participating in a

large national Thai Cohort Study (TCS). In particular, this study will address the impact of working hours and level of income on workplace injury risk.

The research informing occupational health and safety policy in Thailand has been largely at the employer, the community and the primary health care level. Much of the occupational health and safety research has focussed on formal employment, which accounts for only a third of the Thai workforce [7]. Among Thais working in the non-formal sector, the safety of working conditions has deteriorated over recent years [8]. This is especially so for chemical injuries among informal agricultural workers. Also, informal workers are more likely to work longer hours than formal workers and this would be expected to increase injury risks. Informal workers are therefore not excluded from this study: TCS participants who engaged in paid employment or were self-employed in 2009 are included.

Methods

In this cross-sectional analysis of the Thai Cohort Study, self-reported workplace injury was determined among those respondents of the second survey (in 2009) who were doing paid work or self employed. Although both the first (2005) and second (2009) surveys contained detailed questions about injury, the 2009 survey questions were designed to fully capture traffic and non-traffic injury, also among those who had both a traffic and a non-traffic accident in the previous year. This analysis is therefore focussed on the second survey only. Work status information is not derived from the 2005 survey because it is likely to have changed over the four years between the surveys.

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The 2005 baseline characteristics of cohort participants [9] and comparisons with the population of Thailand [1 10] have been reported previously: the STOU cohort has a higher proportion of females than the general Thai population (54.7% vs. 50.5%); more young adults (51.5% vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0% vs. 24.7%) [10]. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort [10].

Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students already have established jobs and because of their work and family responsibilities and modest economic circumstances are unable to leave their locations to attend an on-campus university fulltime. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocols 2004344 and 2009570). Informed written consent was obtained from all participants.

Sample

The sample inclusions and exclusions are shown in Figure 1. In the survey of 2009, study participants were asked "What is your current work status? (You can choose more than one option)" with possible answers: Doing paid work/ Self employed/ Help family business but no wage/ Doing unpaid work/ Look after home (homemaker)/ Student/ Retired (do not work for income)/ Seeking work for the first time/ Unemployed/ Cannot work due to temporary sickness or disability/ Cannot work due to permanent sickness or disability/ Other. Those who indicated they were doing paid work and/or self employed were included in this study. Participants were also asked to report "How many hours per week do you work in all paid jobs?" Those who did not provide this information were excluded. Inclusion was based entirely on response to the 2009 survey; responses to the 2005 survey were not considered.

Participants who reported having had a workplace injury leading to limited activity, and who also indicated that they could not work due to a temporary or permanent sickness or disability, were included in the analyses. Their working hours (prior to injury) were imputed by the sample median. The final sample consists of 51,751 participants.

Workplace injury

The core questions asked were: (1) "In the last 12 months how many times did you have a NON-TRAFFIC injury?" with possible answers never/one/two/three/four or more; (2) "What was the location at which your most serious non-traffic related injury occurred?" with possible answers home/sports facility/workplace (agricultural)/workplace (non-agricultural)/other; and (3) "When you experienced your most serious non-traffic related injury did you receive medical care?" with possible answers yes/no. Workplace injury was defined as non-traffic related injury that occurred in the workplace, agricultural or non-agricultural, and for which medical care was received. Non-traffic injuries that occurred outside the workplace were not considered in this study.

Self-employment

Self-employment was used as a proxy for informal employment [11]. Study participants who indicated 'Self employed' in response to the question about current work status were therefore considered to be informally employed.

Determinants of workplace injury

The median number of working hours per week was 40, inter-quartile range [10 to 48]. The distribution was multimodal. There were three spikes in the distribution: 18% of participants reported working 8 hours per week; 21% reported working 40 hours and 11% reported working 48 hours. The working hours were therefore categorised as follows: ≤10; 11-39; 40; 41-48; ≥49 hours per week. The Thai Cohort Study survey of 2009 did not include questions about working in agriculture or farming, or about working multiple jobs.

The 2009 TCS survey included questions about marital status, area of residence, working hours, monthly personal wages and alcohol consumption.

Analysis

Analyses were performed in SAS 9.2 (SAS Institute, Cary NC). To gain insight into risk factors for workplace injury, injury incidence was calculated per 1000 worker-years (self-reported workplace injury in the last year in the numerator and the 51,751 study participants engaged in paid work in the denominator). To explore gender differences, for example, workplace injury incidence was calculated for men and women separately. However, possible gender differences could be attributed to men working more hours per year than women. To account for differences in work exposure duration, workplace injury incidence was also calculated per hours worked expressed per 1,000,000 hours. The results can be converted to American full time equivalents (FTE): assuming a 40 hour work week and 52 work weeks per year equates 2080 hours; to convert the injury rates to 100 FTE-years, they should be multiplied by a factor 0.2080. The results of this study are presented per

1,000,000 hours to avoid confusion about the 'standard' number of hours worked per year, which may differ substantially per country.

To calculate the workplace injury incidence per 1000 worker-years, the number of persons with a workplace injury sustained in the last 12 months was divided by the total number of workers, and multiplied by 1000. To calculate the incidence per 1,000,000 hours worked, the number of persons with a workplace injury was divided by the sum of weekly hours worked by all workers (multiplied by 52 to obtain the hours worked per year), and multiplied by 1,000,000. Confidence intervals for the incidence rates were calculated by first assuming injury occurrence to have a Poisson distribution, and finding its related confidence interval[12].

A multiple logistic regression model was used to test factors that were likely to be associated with workplace injuries. The model was gender-stratified. Covariates were individual-level work-related factors (income, hours of paid work, and self-employment) and demographics that could confound the association between work-related factors and risk of injury (age, gender, marital status, area of residence and alcohol intake).

The association between exposure variables and the outcome, i.e. workplace injury for which medical help was sought, could be confounded by access to health services. The multivariate logistic regression model was therefore repeated for a modified outcome: workplace injury, regardless of medical help sought.

Results

Workplace injury

Workplace injuries for which medical help was sought were reported by 1317 study participants (2.5%); 3.4% of the men and 1.8% of the women reported a workplace injury. The types of injury are summarised in Table 1. The most commonly reported workplace injuries were cuts, bites or open

wounds (35%) and sprains, strains or dislocations (33%). Bruising or superficial injury was more common among participants with injuries sustained in agricultural work; cuts, bites or open wounds also tended to be more common among agricultural work injuries.

The incidence of workplace injury was 34 [95%CI 32-36] per 1000 worker years for men, and 18 [17-20] for women. The incidence per 1000 worker-years as well as the incidence per 1,000,000 hours worked is summarised in Table 2. Incidence was greatest in the age group 30-39 years, men, participants who were never married, live in rural areas, are in the lowest wage category, work the most hours, are self-employed and regularly drink alcohol.

Self-employment and workplace injury

Self-employment was reported by 17% or workers. Compared with other paid workers, self-employed workers were more likely to work over 49 hours per week (30% vs. 21%). They were more likely to have a low income of <7000 Baht (25% vs. 11%), but they were also more likely to have a high income of >30,000 Baht (16% vs. 9%). The injury incidence of workplace injury per worker-years, as well as per hours worked, was greater among the self-employed (Table 2). This held true for low earners (self-employed workers had 30 [25-37] and other paid workers had 22[19-25] injuries per 10^6 worked hours) and for mid-range earners (17 [15-20] vs. 12 [11-13]) but not for high earners (>30,000 Baht) who had 9 [6-13] vs. 9 [7-11] injuries per 10^6 worked hours for self-employed vs. other workers, respectively.

Determinants of workplace injury

The high incidence of workplace injury among low earners was more pronounced among men than women (Figure 2). Among men working ≥41 hours and earning <10,000 Baht, the injury rate was four times higher compared to men working <11 hours and earning ≥ 20,001 Baht; differences in injury rates were less pronounced in women (Table 3). The association between weekly working hours and injury differed for injury incidence expressed per worker-years (Figure 3, top) and

incidence expressed per worked hours (Figure 3, bottom). The incidence per worker-years increased with hours worked, whereas the incidence per worked hour is greatest in the group with the least hours worked per week.

The results of the multivariate logistic regression model stratified by sex shows that working hours and income were independently associated with workplace injury (Table 4). Working ≥49 hours per week was associated with workplace injury in both men and women. Among both men and women earning a monthly personal income of ≤10,000 Baht was also associated with workplace injury. Among those earning >10,000 Baht per month, increase in income was not associated with a further reduction in injury. In women but not in men, first marriage was negatively associated with workplace injury. In men but not in women, age above 50 years was negatively associated, and self-employment and alcohol consumption were positively associated with workplace injury.

The multivariate logistic regression was repeated for a modified outcome: workplace injury, regardless of medical help sought. Although this outcome may include very minor injuries, any potential confounding by access to health services is removed. Any workplace injury, regardless of whether medical help was sought, was reported by 6275 participants; 14% of men and 11% of women reported a workplace injury. Women reported having had any workplace injury 5.8 as often as they reported a workplace injury for which medical help was sought, among men this was 4.1 times. The pattern of association between exposure variables and outcome was similar to that shown in Table 4, with one noteworthy exception. For women, increasing age was statistically significantly associated with less workplace injury (age 30-39: OR 0.9 [95%CI 0.8-1.0]; age 40-49: 0.7 [0.6-0.8], age ≥50: 0.6 [0.4-0.8]; reference ages <30 years).

Discussion

Among Thai Cohort Study participants, workplace injury resulting in medical care was common, particularly among men. Those working more than 48 hours per week and working for a low income, and particularly self-employed workers working for a low income, were at increased risk. Study participants working ≥10 hours per week were at increased injury risk *per hour worked*, but their injury risk per worker-year was reduced compared to full-time workers.

The strengths of this study are its large sample size and distribution of participants across Thai regions, urban and rural areas, occupations, formal and informal work, and wage levels. Informal work was partially captured by distinguishing self-employed workers from other workers. Potential injury reporting bias related to health service access, i.e. under-reporting of serious injuries because of limitations in health service access, were addressed by repeating the analysis for all reported injuries, regardless of seeking medical attention. A study limitation was the self-report nature of the data, which relies on accurate recall and reporting. This was a cross-sectional analysis. Not only was the data accuracy dependent on recall of exposure and injury, but it was assumed that exposure lead to injury and not vice-versa. Potentially, factors such as working hours, income and alcohol use may have been modified as a result of the injury. Although it seems unlikely that working hours would be increased as a result of an injury, workplace injury may have affected income and alcohol intake. Causality in the association between these factors and workplace injury cannot be established in this study.

Occupational injury incidence studies are limited in their generalisability by the methodology used and the study sample: Thai Cohort Study participants are undergoing long-distance education and they are a little younger and better educated than the Thai population. Really poor and uneducated workers are not in the cohort, and this may be reflected in the occupational injury rates. Because injury rates were increased in the low income group, the workplace injury rate in the Thai population is therefore likely to be greater than that of Thai Cohort Study participants. This should be taken into

account when comparing the overall annual incidence of workplace injuries reported in this study with national statistics reported in other studies.

Comparison of incidence across studies becomes more complex when study methodologies differ. For example, workplace injury rates reported in this study were considerably higher than those reported in a study of non-fatal occupational injuries in employees in Malaysia: 34 and 18 injuries per 1000 worker years for men and women respectively in the Thai Cohort Study participants, compared with 10.7 and 3.6 reported for Malaysia [13]. In the study by Abas et al. Social Security Organisation claims for workplace injury and disease were analysed. Arguably not every occupational injury for which help was sought will result in a benefit claim, and Abas et al are therefore analysing a more severe workplace injury selection. Emergency department visits for occupational afflictions are 60% greater than the rate of accepted lost-time compensation claims, according to a Canadian study comparing incidence determined from emergency department visits to incidence determined from workers' compensation claims[14]. In another example, a study conducted in a commune in Vietnam that is transitioning from agriculture to new industries, occupational injury incidence was reported based on face-to-face household surveys [15-16]. The reported rates were more than 30-fold the findings for the Thai Cohort Study, with an annualised incidence rate of 1001 per 1000 full time employee equivalents. Although this may reflect a discrepancy in injury rates in the Thai and Vietnamese populations, the results also highlight the difficulties in occupational injury comparisons between countries.

In developing and newly industrialised countries, surveys provide an alternative to workers' compensation claims analysis for deriving injury rates, but the results are highly dependent on the study sample (e.g. an agricultural commune compared to a nation-wide sample of working long-distance Open University students). Results also reflect the wording and translation of the survey and other methodological choices such as whether to include injuries arising from unpaid work, self-employment and work in the family business. The present study demonstrates the association

between individual determinants and workplace injury; it is not the purpose of this study to present overall Thai occupational injury rates suitable for comparison to other national statistics.

Working more than 48 hours per week and working for low wages were independent risk factors for workplace injury in the Thai Cohort Study participants. A US survey-based study has reported a similar trend; however, this was observed in women but not in men [17], possibly due to the higher burden of household activities for women and decreased time for rest and recovery. Other US survey-based studies have shown a similar correlation between increased working hours and work-related injury; results were not shown separately for men and women [5 18]. Decreased self-reported sleep was also found to be correlated with increased injury [5]. A US study among workers in manufacturing showed that long hours of work increase the risk for an injury in a dose-response manner, and the case cross-over study design contributed to the evidence for a causal relationship between working hours and injury [4]. In the present study the association between working hours and injury rates was confirmed for the Thai study participants. Interestingly, this trend was not seen when the injury incidence was expressed per 10^6 hours worked. If the injury incidence associated with overwork exceeds that expected based on increased 'expose duration'[18], one would expect the incidence per hours worked to increase with >40 working hours per week; however, this was not the case. Working less than 40 hours, however, and in particular working 10 hours or less was associated with the greatest injury risk per hour worked. This may be due to relative job inexperience.

Thailand has recently introduced a minimum wage of 300 Baht per day for all employees. Although the current study cannot establish causality in the relationship between income and workplace injury (and the minimum wage of 300 baht per day is still in the lowest income category of <7000 Baht as categorised in this study), the introduction of the minimum wage may reduce need to work multiple jobs. This could lead to a decrease in the number of workers working more than 48 hours per week, which is likely to directly reduce the incidence of workplace injury.

Occupational injury incidence varied by gender and age in our study. Injury rates in previous studies are mostly reported to be greatest around the ages 20-25, and to decline with increasing age [19-21]. In a Canadian study, the types of jobs of young workers were found to play an important role in the high injury risk: adjusting for job characteristics substantially reduced the increased injury risk of young workers [22]. In other words, not youth itself but the jobs and work circumstances of youth contribute to the risk of injury. The peak injury incidence at age 30-39 among Thai workers, therefore, might partly be explained by the continued participation in heavy physical work and high risk jobs by Thai workers (particularly by men), beyond the age of 25.

Self-employed workers, representing a substantial proportion of the informal workforce, were at increased risk of injury. Unionisation rates in the informal workforce are generally low, and informal workers are not protected by existing workplace laws and regulations [23]. Improvement of wages, working hours and workplace safety for these workers may require a gradual transition to formalised employment, and more wide-spread formation of labour unions.

In conclusion, among Thai workers represented in the Thai Cohort Study, occupational injury incidence was greater for men than for women and injury rates peaked at ages 30 to 39. Injury rates were increased among the self-employed, suggesting that statistics based on the formal workforce only may underestimate the injury rates in the combined (formal and informal) working population. The highest injury rates were recorded for those working more than 48 hours per week and for low wage earners; this did not appear to exceed the risk expected from increased exposure. Overall reductions in occupational injury rates might therefore be achieved by limiting working hours to 48 per week, particularly among low wage earners. The population of Thailand is growing, as is the Thai working population, including low wage earners and those with longer workdays. Particularly for these groups, there is an increasing need for effective injury preventive programs.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JBG and RM analysed that data and conceptualized and drafted the manuscript. BT provided background information on the Thai labour force. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

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Table 1. Workplace injury types for agricultural and non-agricultural injuries for which medical care was sought*.

	Agricultural workplace injury (n=347)		Non-agricultural workplace injury (n=970)		Chi-square, DF, P-value		
	N	(%)	N	(%)	X^2	DF	p
Nature of the injury							
Fracture	32	(9%)	96	(10%)	0.1	1	0.7
Sprain, strain or dislocation	127	(37%)	313	(32%)	2.2	1	0.1
Cut, bite or open wound	136	(39%)	324	(33%)	3.8	1	0.05
Bruise or superficial injury	109	(31%)	234	(24%)	7.0	1	0.008
Burn/scald	19	(5%)	47	(5%)	0.2	1	0.6
Concussion	61	(18%)	137	(14%)	2.4	1	0.1
Organ system (internal) injury	42	(12%)	104	(11%)	0.5	1	0.5
Other	41	(12%)	130	(13%)	0.6	1	0.5
Injury types reported							
None	5	(1%)	18	(2%)	7	2	0.03
One	218	(63%)	678	(70%)			
Two or more	124	(36%)	274	(28%)			

* Participants can report more than one injury.

Table 2. Incidence of workplace injury from the second Thai Cohort Study survey*.

Variable	Paid workers	Hours worked	Injured at the work-place	Incidence (events per 1000 workers years)		Incidence (events per 10^6 hours worked)	
					95% CI		95% CI
Age (years)							
<30	13,466	484,352	338	25	[22 28]	13	[12 15]
30 to 39	22,609	818,742	639	28	[26 31]	15	[14 16]
40 to 49	12,392	430,020	284	23	[20 26]	13	[11 14]
≥50	3284	105,121	56	17	[13 22]	10	[8 13]
Gender							
Women	28,428	976,250	524	18	[17 20]	10	[9 11]
Men	23,323	861,985	793	34	[32 36]	18	[16 19]
Marital status							
First marriage	24,924	883,648	570	23	[21 25]	12	[11 13]
Never married	17,229	619,014	490	28	[26 31]	15	[14 17]
Other	5182	184,475	141	27	[23 32]	15	[12 17]
Missing data	4416	151,098	116	26	[22 32]	15	[12 18]
Area							
Rural	22,104	773,206	597	27	[25 29]	15	[14 16]
Urban	29,077	1,044,702	706	24	[23 26]	13	[12 14]
Monthly income (Baht)							

≤7000	7005	226,603	285	41	[36 46]	24	[21 27]
7001 to 10,000	12,168	418,784	350	29	[26 32]	16	[14 18]
10,001 to 20,000	19,595	711,783	426	22	[20 24]	11	[10 13]
20,001 to 30,000	7660	278,719	159	21	[18 24]	11	[9 13]
≥30,001	5233	199,328	94	18	[15 22]	9	[7 11]
Weekly hours of paid work							
≤10	14,561	116,813	304	21	[19 23]	50	[44 56]
11 to 39	6360	155,600	148	23	[20 27]	18	[15 21]
40	10,921	436,840	240	22	[19 25]	11	[9 12]
41 to 48	8088	379,064	224	28	[24 32]	11	[10 13]
≥49	11,821	749,918	401	34	[31 37]	10	[9 11]
Self employment							
Yes	8863	311,580	301	34	[30 38]	19	[16 21]
No	42,888	1,526,655	1016	24	[22 25]	13	[12 14]
Alcohol							
None	35,149	1,236,917	755	21	[20 23]	12	[11 13]
1-5 per week	7086	257,715	236	33	[29 38]	18	[15 20]
6 or more per week	7407	275,276	264	36	[31 40]	18	[16 21]

* The most serious non-traffic injury that occurred in the last 12 months was included if it occurred in the workplace, and if medical care was received for the injury. To take differences in exposure duration into account, incidence was also reported per 1,000,000 hours of paid work.

Table 3. Incidence of workplace injury (injuries per 1000 worker-years) by hours worked and monthly income, for men and women. Darker shades correspond with higher workplace injury incidence.

MEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	47 [38-58]	46 [37-57]	62 [53-73]
10,001-20,000 Baht	24 [18-31]	23 [19-29]	35 [30-42]
≥20,001 Baht	15 [10-23]	23 [18-30]	28 [22-35]

WOMEN	Hours of paid work per week		
Monthly Income	<11 hours	11-40 hours	≥41 hours
<10,000 Baht	19 [15-23]	21 [16-26]	27 [23-32]
10,001-20,000 Baht	10 [7-15]	14 [10-19]	20 [16-25]
≥20,001 Baht	16 [10-24]	11 [7-17]	19 [13-25]

Table 4. Multiple logistic regression model of workplace injuries requiring medical care; the model is stratified by gender*.

	Women 492/26,858			Men 746/22,070		
	OR	[95% CI]		OR	[95% CI]	
Age (years)						
<30	1	[REF]	0.07	1	[REF]	0.007
30 to 39	1.3	[1.1 -1.7]		1.1	[0.9 -1.4]	
40 to 49	1.2	[1.0 -1.8]		0.9	[0.7 -1.1]	
≥50	1.3	[0.7 -2.2]		0.6	[0.4 -0.9]	
Marital status						
First marriage	0.6	[0.5 -0.8]	0.0005	1.0	[0.8 -1.2]	0.59
Never married	1	[REF]		1	[REF]	
Other	0.8	[0.6 -1.1]		1.2	[0.9 -1.6]	
Area						
Rural	0.9	[0.8 -1.1]	0.42	1.0	[0.8 -1.1]	0.85
Urban	1	[REF]		1	[REF]	
Weekly hours of paid work						
≤10	0.8	[0.6 -1.1]	0.0002	0.9	[0.7 -1.1]	0.001
11 to 39	0.9	[0.7 -1.3]		0.9	[0.7 -1.2]	
40	1	[REF]		1	[REF]	
41 to 48	1.2	[0.9 -1.6]		1.2	[0.9 -1.5]	
≥49	1.4	[1.1 -1.9]		1.3	[1.0 -1.6]	
Monthly personal income (Baht)						

≤7000	2.0	[1.5 -2.6]	<0.0001	2.5	[2.0 -3.1]	<0.0001
7001 to 10,000	1.4	[1.1 -1.8]		1.6	[1.3 -1.9]	
10,001 to 20,000	1	[REF]		1	[REF]	
20,001 to 30,000	1.0	[0.7 -1.3]		1.0	[0.8 -1.2]	
≥30,001	1.1	[0.8 -1.7]		0.8	[0.6 -1.0]	
Self employment						
Yes	1.1	[0.8 -1.4]	0.52	1.4	[1.2 -1.7]	0.0003
No	1	[REF]		1	[REF]	
Alcohol						
None	1	[REF]	0.35	1	[REF]	0.002
1-5 per week	1.0	[0.7 -1.4]		1.3	[1.1 -1.6]	
6 or more per week	1.4	[0.9 -2.4]		1.3	[1.1 -1.5]	

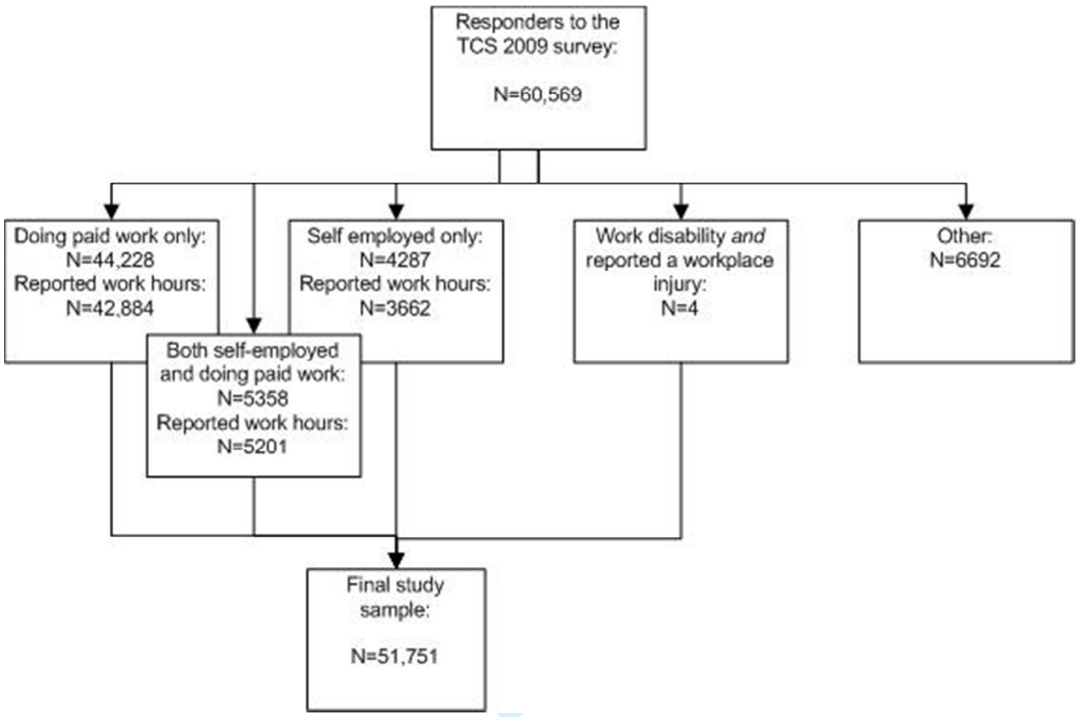

Figure 1. Inclusions and exclusions of study sample.

Only those reporting work hours were included: 42,884 were doing paid work only; 3662 were self-employed, 5201 were both self-employed and doing paid work and 4 reported a work disability as well as a recent workplace injury.

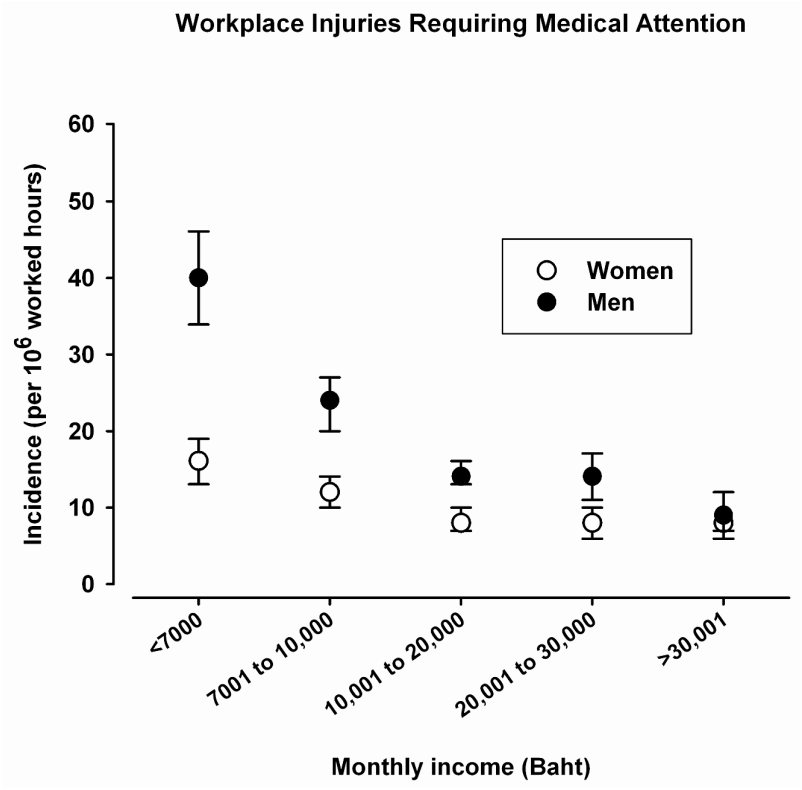

Figure 2. Incidence of workplace injury by monthly income

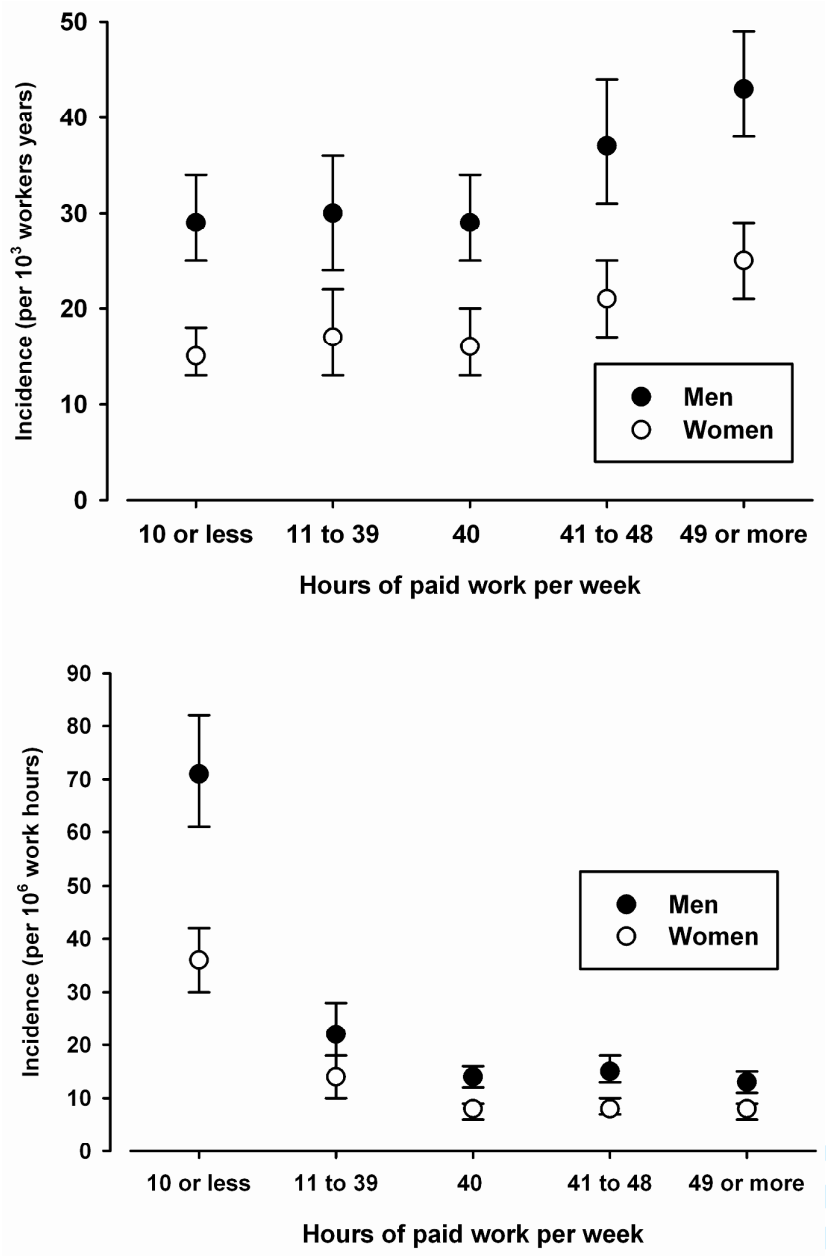

Figure 3. Incidence of workplace injury by weekly working hours

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7,8*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	22
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8,9
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	22
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	22
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6, 10
		(b) Indicate number of participants with missing data for each variable of interest	22
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	10, 16, 17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17-18, 20-21
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.