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Personal protective equipment (PPE) use and its relation to accidents among construction workers

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Summary

Background: *The construction industry is characterized by a high prevalence of accidents and injuries. Inadequate risk management measures, including failure to use or incorrect use of personal protective equipment (PPE) may significantly increase the risk of accidents.* **Objectives:** *The main objectives of the current study were to measure the prevalence of PPE use and accidents and their associated factors among construction workers.* **Methods:** *A cross-sectional field study with an analytic component was carried out on 384 workers from different sites in Port-Said, Egypt, using an interview administered questionnaire. The questionnaire included sociodemographic and occupational data, practice of PPE use and accident analysis.* **Results:** *About 60% of workers use PPE during work. Main reasons for non-use are discomfort, lack of knowledge on how to use it and poor fit. Occupational accidents in the last 12 months were reported by 64.3% of workers. The main accident types were: being hit by falling objects, falls from height, and tool related accidents. Safety training was the significant independent predictor of PPE use (AOR=2.0). However, age, marital status, smoking, safety training, and PPE use were also significant independent predictors of accidents (AOR=2.4, 3.1, 0.5, 0.5, and 0.2; respectively).* **Discussion:** *Among construction workers, PPE utilization is low with significant relation to safety training while occupational accidents are common and significantly related to safety training and PPE use. Therefore, safety training should be provided, and PPE use should be enforced at construction sites.*

Riassunto

«Uso dei dispositivi di protezione individuale (DPI) e relazione con infortuni nei lavoratori dell'edilizia». **Introduzione:** *La cantieristica edile è caratterizzata da un'alta prevalenza di incidenti ed infortuni. Misure inadeguate per la gestione dei rischi, incluso il mancato o scorretto utilizzo dei dispositivi di protezione individuale (DPI) possono aumentare significativamente il rischio di infortuni.* **Obiettivi:** *Misurare la prevalenza dell'uso di DPI e infortuni e dei fattori ad essi correlati tra i lavoratori dell'edilizia.* **Metodi:** *È stato condotto uno studio trasversale su 384 lavoratori di diversi cantieri edili di Port Said, Egitto, usando un questionario somministrato da intervistatore. Il questionario includeva dati sociodemografici e occupazionali, pratica d'uso dei DPI e analisi degli infortuni.* **Risultati:** *Circa il 60% dei lavoratori usano DPI durante il lavoro. I motivi principali per il mancato uso di DPI sono scomodità, mancanza di conoscenza sul corretto utilizzo e scarsa vestibilità. Il 64.3% dei lavoratori ha riferito incidenti sul lavoro negli ultimi 12 mesi. Le principali tipologie di incidenti sono: essere colpiti da oggetti in caduta,*

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caduta dall'alto, incidenti collegati all'uso di attrezzi. La formazione sulla sicurezza è un significativo predittore indipendente dell'uso dei DPI (AOR=2.0). Anche l'età, lo stato civile, l'abitudine al fumo, la formazione alla sicurezza e l'uso di DPI si sono rivelati predittori indipendenti e significativi di incidente (AOR=2.4, 3.1, 0.5, 0.5, e 0.2 rispettivamente). **Discussione:** *Tra i lavoratori edili l'uso di DPI è basso e ha una correlazione significativa con la formazione alla sicurezza, mentre gli incidenti sul lavoro sono frequenti e correlati con la formazione alla sicurezza e all'uso di DPI. È importante che nei cantieri sia garantita la formazione sulla sicurezza e che venga fatto rispettare l'uso dei DPI.*

Introduction

The construction industry accounts for 5 to 15% of the national economy of most countries. In Egypt, it is considered one of the main pillars of development due to its unique characteristics, multiple and variable activities included and dense workforce (8).

Construction workers are exposed to a wide variety of hazards: physical (e.g. noise, extreme temperature and slippery floors), chemical (e.g. solvents, cement, respirable crystalline silica, airborne particles and dust), mechanical (e.g. slips, falls, heavy tools, injuries by machinery including trapping, entanglement, crushing and severing), and ergonomic (e.g. repetitive tasks, awkward postures, overexertion, using wrong tools for the job or using tools improperly or using improperly maintained tools) that make them vulnerable to many occupational diseases (e.g. musculoskeletal disorders, respiratory problems, dermatitis, hand-arm syndrome), occupational injuries and absenteeism at work (30, 31, 39).

Globally, construction is considered the riskiest industry: construction workers have a doubled risk of being injured than workers in other occupations, and there are more than 60,000 annual fatal accidents around the world (13, 19).

Accidents usually have multiple root causes that include either an unsafe environment (e.g. poor work organization, site management, tools and equipment) and/or unsafe behavior (limited experience and skills, psychological and physical illnesses and poor knowledge about occupational safety) (28). Unsafe environment and unsafe behavior are often referred to as immediate or primary causes. On the other hand, secondary causes, which are harder to identify, are also just as important; these include the failure of the management system to provide safe work systems and include failure to anticipate hazards, lack of training, and maintenance (17).

Vitharana et al (39) categorized the potential causes of poor safety practices into safety equipment, safety management, safety attitude of workers, safety training and other factors. The most often identified causes were related to personal protective equipment under "safety equipment."

Occupational safety and health administration (OSHA) defines personal protective equipment, commonly known as "PPE", as equipment worn to minimize exposure to a variety of hazards, and recommends a battery of protective gear to construction workers. It includes eye and face protection (safety glasses, goggles, or face shields), foot protection (safety shoes), hand protection (gloves), head protection (hard hats) and hearing protection (earplugs/earmuffs) (34).

Correct use of appropriate PPE is vital to construction workers' safety and can be a crucial defining factor between accidents and safety. Indeed, several researches had pointed to a significant association between lack of PPE use and work-related injuries. Either dislike to wear PPE, low awareness level toward their use, inadequate use or not use them at all, had significantly contributed to the higher risk of occupational injuries among construction workers (12, 14, 30, 39, 40).

Little data is known about the practice of PPE use and occupational accidents among Egyptian construction workers, and their underlying factors. Thus, this study aims to measure the prevalence of PPE use and accidents and their associated factors among construction workers.

Population and methods

1. **Study design and setting:** this observational descriptive cross-sectional field study with analytic component was conducted in Port-Said,

Egypt, during the period from March 1st, 2019 until the end of May 2019.

2. **Sample size and method:** a sample size of 382 workers was calculated using Epi Info 7 of the CDC (http://www.cdc.gov/epiinfo.), with alpha error of 5%, and 5% precision, based on a previous study which found that 46.2% of construction workers reported occupational injuries in the past 12 months (1). Construction workers were recruited from one main construction company (which was responsible for construction work in The University Hospital), engineering offices (as contractors) and some nearby different private construction sites. Workers with at least one-year work duration and willing to participate were included in the study.
3. **Tools:** data were collected using an interview administered questionnaire constructed after an extensive literature review and created based on related studies (1, 25, 27). The questionnaire included:
   3.1. Sociodemographic data: such as sex, age, residence, marital status, education, smoking habits, medical history, use of both prescribed and illegal non-prescribed drugs, usual sleep hours and self-perception of weight.
   3.2. Occupational data: such as job category, work experience, working hours, shiftwork, employment pattern, engagement in another job, periods of rest during work and previous safety training.
   3.3. PPE use was assessed by finding out whether workers use PPE or not during their work. Reasons for non-use of PPE (among PPE non-users), or, types of PPE used, their source, how to deal with damaged PPE and whether the worker takes off PPE during work and why (among PPE users) were ascertained.
   3.4. Accidents analysis: included history of ever having previous occupational accident/injury, history of occupational accident/injury in the last 12 months. This analysis also included the profile of last accident (type of accident, resultant injury [type, site, required treatment and days lost] and risk factors at the time of the accident). The following definitions were adopted:
   • *Occupational accident:* An occurrence arising out of or in the course of work which results in fatal or non-fatal occupational injury (18).
   • *Occupational injury:* Death, any personal injury or disease resulting from an occupational accident (18).
4. **Statistical analysis:** Data were collected, coded and analyzed using IBM SPSS version 22. No missing data were detected. Data were tested for normality using Kolmogorov-Smirnov test. Quantitative data were summarized as mean and standard deviation. Qualitative data were summarized as number and percent. Chi-square test was used for comparison of categorical variables. Bivariate analysis was performed to find out the factors contributing to PPE use and accidents. Crude odds ratios (CORs) and their 95% confidence interval (CI) were calculated. Significant associations in bivariate analysis were entered into multivariate binary logistic regression model to identify the independent predictors of PPE use and accidents. Adjusted odd's ratios (AORs) and their 95% confidence interval were calculated. *P* value ≤0.05 was considered statistically significant.
5. **Ethical considerations:** the proposal was approved from Institutional Research Board (IRB), Faculty of Medicine - Mansoura University (Reference number R.19.04.485) and Committee of Ethics and Scientific Research, Faculty of Nursing – Port-Said University (Reference number R.101.02.121). Informed consent was obtained from all workers who agreed to participate in the study.

Results

Out of the 400 reached workers who met the inclusions criteria, 384 agreed to participate in the study with a 96% response rate. Non-participating workers were not interested in the study. All respondent workers were males, had a mean age of 37.8±11.6 years with range 17-59 years. Most of

them were from rural residence (61.2%) and married (69.8%). About 43% were illiterate, 32.6% had basic education and 24.7% had secondary or higher education. The main job categories of workers are masons, glaziers, plumbers, and carpenters (17.2%, 12.8%, 12.5%, and 9.1%, respectively).

Exactly 59.4% of workers use PPE during their work. The most common reported reasons by non-users were uncomfortable (78.2%), lack of knowledge on how to use PPE (73%), poor fit/falling off (69.2%), feel too hot (69.2%), unavailability (67.3%) and PPE aren't obligatory (66%). Among those who use PPE, the most frequent used PPE were mask/respirators, ear plugs, gloves, helmets, and goggles used by 48.7%, 35.1%, 33.3%, 29.4%, 29.4% of workers; respectively. Mostly, PPE were provided by the employers (55.7%). Only 39.5% of workers replace the lost/torn PPE with a new one. More than half (50.9%) of workers who are used to wear PPE take them off while working. Most frequent reasons for that were: falling off PPE during work (75.4 %) and that PPE make tasks harder to do (56.1 %) (Table 1).

Bivariate analysis of factors associated with PPE use shows that age, level of education, job category and previous safety training were significantly associated with PPE use among workers. Those who use PPE are older in age, with a higher educational level and previously trained in work safety. Binary logistic regression of those significant factors showed that having received previous safety training double the opportunity of PPE use during work among studied workers (AOR, 2.0; 95% CI, 1.3-3.0) (Table 2).

Among responders, 84.9% reported having at least one occupational accident during their whole working years, while, 64.3% of workers experienced an occupational accident in the last 12 months. The most common types of the last accident in the last 12 months were, hit by falling objects (17.8%), falling from height (15%) and machine/tool related accidents (15%). Cuts, lacerations, and eye injuries comprised the most frequent types of injuries at 51.8%, 51% and 46.2% respectively. Multiple body parts (56.7%), lower limbs (55.1%), trunk (51%) and hands (48.2%) were the most common injured body parts. At the time of the accident, 65.2% of workers weren't wearing PPE, 49.4% were rushed, 47.8% were doing a task with an unusual method and 46.6% were

Table 1 - PPE use and causes of non-use among construction workers

	n (%)
Use of PPE[#]	228 (59.4)
Causes of not using PPE among never users (n=156) *	
Uncomfortable	123 (78.2)
Don't know how to use	114 (73.0)
Poor Fit/fall off	108 (69.2)
Make me feel too hot	108 (69.2)
Not available	105 (67.3)
To save time	103 (66.0)
Not obligatory	103 (66.0)
Expensive	102 (65.4)
Wrong size	102 (65.4)
Poor vision	100 (64.1)
Make task harder to do	100 (64.1)
Dislike shape	95 (60.9)
Type of PPE used among PPE users (n=228)*	
Dust masks/respirators	111 (48.7)
Ear plugs/muffs	80 (35.1)
Heavy duty gloves	76 (33.3)
Helmet	68 (29.4)
Goggles	67 (29.4)
Safety harness/ belts	66 (28.9)
Safety boots/shoes	64 (28.0)
Overalls	61 (26.8)
Face shield	59 (25.9)
Welding helmet	55 (24.1)
Source of PPE among PPE users (n=228)	
Provided by Employer	127 (55.7)
Bought by oneself	73 (32.0)
Borrowed	28 (12.3)
Measures taken if PPE is torn/lost (among PPE users; n=228)	
Replace with new one	90 (39.5)
Use anyway	60 (26.3)
Throw away	49 (21.5)
Don't know	29 (12.7)
Removal of PPE while working on site (among PPE users; n=228)	116 (50.9)
Causes of removing PPE during work (among PPE users; n=228)*	
Fall off	172 (75.4)
Make task harder to do	128 (56.1)
Make me feel too hot	112 (49.1)
Poor vision	98 (42.9)
To save time	83 (36.4)

Abbreviations: n, number

[#]PPE use, Always 7.6%, Most of the time 12%, Sometimes 39.8%; *Responses are not mutually exclusive

Table 2 - Bivariate and multivariate analysis of factors associated with PPE use among construction workers

Factors		Total n (%)	PPE use n (%)	*p*	COR (95% CI)	AOR (95% CI)
Overall		384 (100)	228 (59.4)	-	(35.7-45.6)	
Age, years:	≤35	169 (44.0)	90 (53.3)		1	
	>35	215 (56.0)	138 (64.2)	0.03	1.6 (1.1-2.4)	
Residence:	Rural	235 (61.2)	145 (61.7)		1	
	Urban	149 (38.8)	83 (55.7)	0.24	0.8 (0.5-1.2)	
Marital status:	Single	53 (13.8)	29 (54.7)	-	1	
	Married	268 (69.8)	165 (61.6)	0.86	1.3 (0.7-2.4)	
	Divorced/Widowed	63 (16.4)	34 (54.0)	0.94	1.0 (0.5-2.0)	
Education:	Illiterate	164 (42.7)	86 (52.4)	-	1	
	Primary/preparatory	125 (32.6)	79 (63.2)	0.06	1.6 (0.9-2.5)	
	Secondary/higher	95 (24.7)	63 (66.3)	0.03	1.7 (1.1-3.0)	
Smoking:	Non-smoker	112 (29.2)	69 (61.6)	-	1	
	Ex-smoker	58 (15.1)	37 (63.8)	0.78	1.0 (0.6-2.1)	
	Smoker	214 (55.7)	122 (57.0)	0.42	0.8 (0.5-1.3)	
Non-prescribed drugs*		193 (50.3)	116 (60.1)	0.77	1.1 (0.7-1.6)	
Medical history:	Hypertension *	124 (32.3)	79 (63.7)	0.23	1.3 (0.9-2.0)	
	DM*	110 (28.6)	66 (60.0)	0.87	1.0 (0.7-1.6)	
	Visual problems*	259 (67.4)	156 (60.2)	0.62	1.1 (0.7-1.7)	
	Hearing problems*	217 (56.5)	125 (57.6)	0.42	0.9 (0.6-1.3)	
	Others*	146 (38.0)	83 (56.8)	0.43	0.9 (0.6-1.3)	
Prescribed medications*		146 (38.0)	82 (56.2)	0.32	0.8 (0.5-1.2)	
Self-perception of weight						
	Normal	165 (43.0)	99 (60.0)	-	1	
	Overweight	131 (34.1)	77 (58.8)	0.83	0.9 (0.6-1.5)	
	Obese	88 (22.9)	52 (59.1)	0.88	0.9 (0.6-1.6)	
Job category:	Mason	66 (17.2)	47 (71.2)	-	1	
	Glazier	49 (12.8)	29 (59.2)	0.17	0.6 (0.3-1.3)	
	Plumbers	48 (12.5)	25 (52.1)	0.04	0.4 (0.2-0.9)	
	Carpenter	35 (9.1)	14 (40.0)	0.002	0.3 (0.1-0.6)	
	Laborer	31 (8.1)	17 (54.8)	0.11	0.5 (0.2-1.2)	
	Welder	31 (8.1)	11 (35.5)	0.0008	0.2 (0.1-0.6)	
	Demolition	30 (7.8)	18 (60.0)	0.27	0.6 (0.3-1.5)	
	Electrician	30 (7.8)	18 (60.0)	0.27	0.6 (0.3-1.5)	
	Ceramic	28 (7.3)	23 (82.1)	0.26	1.8 (0.6-5.6)	
	Painter	19 (4.9)	15 (78.9)	0.5	1.5 (0.5-5.2)	
	Plasterer	17 (4.4)	11 (64.7)	0.6	0.8 (0.2-2.3)	
Work experience, years:	≤13	209 (54.4)	120 (57.4)		1	
	>13	175 (45.6)	108 (61.7)	0.39	1.2 (0.8-1.2)	
Work hours/day, hours:	≤8	261 (68.0)	152 (58.2)		1	
	>8	123 (32.0)	76 (61.8)	0.51	1.2 (0.8-1.8)	
Shift work*		194 (50.5)	117 (60.3)	0.71	1.1 (0.7-1.6)	
Employment pattern:	Company	171 (44.5)	100 (58.5)	-	1	
	Contractor	102 (26.6)	56 (54.9)	0.56	0.9 (0.5-1.4)	
	Private	111 (28.9)	72 (64.9)	0.28	1.3 (0.8-2.1)	
Other job *		116 (30.2)	67 (57.8)	0.67	0.9 (0.6-1.4)	

Factors		Total n (%)	PPE use n (%)	*p*	COR (95% CI)	AOR (95% CI)
Usual sleep, hours:	≤6	171 (44.5)	107 (62.6)		1	
	>6	213 (55.5)	121 (56.8)	0.25	0.8 (0.5-1.2)	
Rest/nap during work*		133 (34.5)	73 (54.9)	0.19	0.8 (0.5-1.2)	
Previous safety training*		140 (36.5)	97 (69.3)	0.003	1.9 (1.3-3.0)	2.0 (1.3-3.0)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; n, number; 1, reference
*Reference group is No.

Table 3 - Frequency and pattern of occupational accidents among construction workers

	n (%)		n (%)
Ever had an occupational accident	326 (84.9)	Accident in last 12 months	247 (64.3)
Type of accident		Type of injury [a]	
Hit by falling objects	44 (17.8)	Cuts	128 (51.8)
Falling from heights	37 (15.0)	Laceration	126 (51.0)
Injury from machines/ tool	37 (15.0)	Eye injury	114 (46.2)
Injury from lifting of heavy weights	35 (14.2)	Burn	113 (45.7)
Collapse of earthwork	35 (14.2)	Fracture	110 (44.5)
Electrocution	27 (10.9)	Bruises	106 (42.9)
Slips/trips	19 (7.7)	Muscular strain	89 (36.0)
Fire and explosion	11 (4.8)	None	80 (32.3)
Others [b]	2 (0.8)	Others [c]	36 (14.6)
At the time of accident [a]		Site of injury [a]	
Not wearing PPE	161 (65.2)	Multiple injuries	140 (56.7)
Rushed	122 (49.4)	Lower limbs (except toes and feet)	136 (55.1)
Doing a task using an unusual work method	118 (47.8)	Trunk	126 (51.0)
Using machines/ tool	115 (46.6)	Hands	119 (48.2)
Feeling ill	114 (46.2)	Head and neck	115 (46.6)
Work overtime	112 (45.3)	Eyes	114 (46.2)
Distracted	107 (43.3)	Fingers	115 (46.6)
Tired	104 (42.1)	Feet	110 (44.5)
Equipment/materials malfunction	99 (40.1)	Toes	107 (43.3)
Performing a new/unusual task	97 (39.3)	Upper limbs (except fingers and hands)	105 (42.5)
Required treatment [a]		None	80 (32.3)
None	135 (54.7)	Days lost due to injury (mean±SD)	12.4±25.4
Medical	97 (39.3)		
Surgical	40 (16.2)		

[a] Responses are not mutually exclusive.
[b] Others: held between objects, exposure to welding beam, exposure to chemicals.
[c] Others: hematoma, dislocation, amputation, poisoning.

using machinery/tools. Only 16.2% of injured workers required surgical treatment while 39.3% required medical treatment. The average days lost due to the last accident/injury was 12.4±25.4 (Table 3).

Table 4 shows that age, marital status, smoking history, hearing problems, prescribed medications, job category, work experience, previous safety training and use of PPE were significantly associated with occupational accidents among interviewed workers. Workers who experienced an accident were older in age, married/divorced/widowed, smokers, having hearing problems and with work experience >13 years. They didn't have previous safety training and never used PPE. However, binary logistic

regression showed that independent significant predictors are being older in age (AOR, 2.3; 95% CI,1.3-4.3), married (AOR, 3; 95% CI, 1.4-6.3), divorced/widowed (AOR, 3.1; 95% CI, 1.1-8.4), a smoker (AOR, 0.5; 95% CI, 0.3-0.9), taking prescribed medications (AOR, 0.4; 95% CI, 0.3-0.7), having previous safety training (AOR, 0.5; 95% CI, 0.3-0.8) and using PPE (AOR, 0.2; 95% CI, 0.1-0.4) (Table 4).

Discussion

Construction is a hazardous sector in industry that is characterized by high prevalence of accidents and injuries. Inadequate risk management measures, including failure to use and/or incorrect use of personal protective equipment (PPE) may significantly increase the risk of accidents and injuries among construction workers (40).

Table 4 - Bivariate and multivariate analysis of factors associated with occupational accidents among construction workers.

Factors		Total n (%)	Accidents n (%)	*p*	COR (95% CI)	AOR (95% CI)
Overall:		384 (100)	247 (64.3)	-	(59.5-69.1)	
Age, years:	≤35	169 (44.0)	96 (56.8)		1	1
	>35	215 (56.0)	151 (70.2)	0.006	1.8 (1.2-2.7)	2.4 (1.3-4.3)
Residence:	Rural	235 (61.2)	151 (64.3)		1	-
	Urban	149 (38.8)	96 (64.4)	0.97	1.01 (0.7-1.6)	
Marital status:	Single	53 (13.8)	22 (41.5)	-	1	1
	Married	268 (69.8)	182 (67.9)	<0.001	3.0 (1.6-5.5)	3.0 (1.4-6.3)
	Divorced/Widowed	63 (16.4)	43 (68.3)	0.004	3.0 (1.4-6.5)	3.1 (1.1-8.4)
Education:	Illiterate	164 (42.7)	108 (65.9)	-	1	
	Primary/preparatory	125 (32.6)	81 (64.8)	0.85	0.95 (0.6-1.6)	
	Secondary/higher	95 (24.7)	58 (61.1)	0.43	0.8 (0.5-1.4)	
Smoking:	Nonsmoker	112 (29.2)	80 (71.4)	-	1	1
	Ex-smoker	58 (15.1)	38 (65.5)	0.43	0.8 (0.4-1.5)	0.5 (0.2-1.1)
	Smoker	214 (55.7)	129 (60.3)	0.046	0.6 (0.4-0.99)	0.5 (0.3-0.9)
Non-prescribed drugs*		193 (50.3)	126 (65.3)	0.69	1.1 (0.7-1.7)	
Medical history:	Hypertension *	124 (32.3)	80 (64.5)	0.95	1 (0.7-1.6)	
	DM*	110 (28.6)	70 (63.6)	0.86	1 (0.6-1.5)	
	Visual problems*	259 (67.4)	169 (65.3)	0.58	1.1 (0.7-1.8)	
	Hearing problems*	217 (56.5)	152 (70.0)	0.008	1.8 (1.2-2.7)	
	Others*	146 (38.0)	102 (69.9)	0.07	1.5 (1.0-2.3)	
Prescribed medications*		146 (38.0)	82 (56.2)	0.009	0.6 (0.4-0.9)	0.4 (0.2-0.6)
Self-perception of weight						
	Normal	165 (43.0)	110 (66.7)	-	1	
	Overweight	131 (34.1)	83 (63.4)	0.55	0.9 (0.5-1.4)	
	Obese	88 (22.9)	54 (61.4)	0.40	0.8 (0.5-1.4)	
Job category:	Mason	66 (17.2)	39 (59.1)	-	1	
	Glazier	49 (12.8)	34 (69.4)	0.26	1.6 (0.7-3.4)	
	Plumbers	48 (12.5)	30 (62.5)	0.71	1.2 (0.5-2.5)	
	Carpenter	35 (9.1)	31 (88.6)	0.002	5.4 (1.7-17.0)	
	Laborer	31 (8.1)	18 (58.1)	0.92	1 (0.4-2.3)	
	Welder	31 (8.1)	18 (58.1)	0.92	1 (0.4-2.3)	
	Demolition	30 (7.8)	21 (70.0)	0.31	1.6 (0.7-4.1)	
	Electrician	30 (7.8)	21 (70.0)	0.31	1.6 (0.7-4.1)	
	Ceramic	28 (7.3)	9 (32.1)	0.016	0.3 (0.1-0.8)	
	Painter	19 (4.9)	12 (63.2)	0.75	1.2 (0.4-3.4)	
	Plasterer	17 (4.4)	14 (82.4)	0.07	3.2 (0.9-12.3)	

Factors		Total n (%)	Accidents n (%)	*p*	COR (95% CI)	AOR (95% CI)
Work experience, years:	≤13	209 (54.4)	124 (59.3)		1	
	>13	175 (45.6)	123 (70.3)	0.026	1.6 (1.1-2.5)	
Work hours/day, hours:	≤8	261 (68.0)	171 (65.5)		1	
	>8	123 (32.0)	76 (61.8)	0.47	0.9 (0.6-1.3)	
Shift work*		194 (50.5)	126 (64.9)	0.79	1 (0.6-1.4)	
Employment pattern:	Company	171 (44.5)	111 (64.9)		1	
	Contractor	102 (26.6)	65 (63.7)	0.84	0.95 (0.6-1.6)	
	Private	111 (28.9)	71 (64.0)	0.87	0.95 (0.6-1.6)	
Other job *		116 (30.2)	73 (62.9)	0.71	0.9 (0.6-1.5)	
Usual sleep, hours:	≤6	171 (44.5)	113 (66.1)		1	
	>6	213 (55.5)	134 (62.9)	0.52	0.9 (0.6-1.3)	
Rest/nap during work*		133 (34.5)	87 (65.4)	0.75	1.1 (0.7-1.7)	
Previous safety training*		140 (36.5)	75 (53.6)	0.001	0.5 (0.3-0.8)	0.5 (0.3-0.8)
Use of PPE:	Never	156 (40.6)	125 (80.1)		1	1
	Yes	228 (59.4)	122 (53.5)	<0.0001	0.3 (0.2-0.5)	0.2 (0.1-0.4)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; n, number; 1, reference
*Reference group is No.

Among studied workers, 40.6% don't use PPE during work. Muema (32) reported similarly low utilization of PPE (45.2%) among construction workers in Kenya. Being uncomfortable, not knowing their importance or proper use, poor fit, resultant heat stress, unavailability and to save time were the most frequently reported reasons for the failure to use PPE which was consistent with other studies (14, 32).

For workers who reported practicing PPE use, the most frequently used PPE were: respiratory protection, hearing protection, gloves, helmets, goggles and safety belts, mainly provided by the employer, which were similar to what was reported by other studies (5, 29). However, 50.9% of these workers reported taking PPE off while working for a variety of reasons; poor fit of PPE (thus falling off), increasing difficulty of doing tasks, heat stress and decreasing visibility. This agrees with Kwarteng (25) who stated that 21.4% of workers removed their PPE while working for similar reasons.

PPE users are more likely to be older in age (>35 years), literate and had previous safety training. Similar results were noted by Lombardi et al (29) who stated that younger age and lack of safety training were important factors affecting the use of PPE. In addition, Chepkener (10) found a statistically significant correlation of PPE use with level of education and formal training. However, regression analysis results of current study show that the only significant predictor of practice of PPE use is previous safety training, especially on PPE importance and use, which is consistent with a plethora of studies (14, 20, 32, 35).

Results of the current study show that 64.3% of workers had at least one accident in the last 12 months. Other studies in Egypt found that prevalence of occupational accidents among construction workers was 73.2% and 46.2% (1, 31). However, studies from other countries showed great variation in prevalence of accidents among construction workers, where it was 38.7% in Gondar, Ethiopia (2), 84.7% in Addis Ababa, Ethiopia (30), 22.6% in Malaysia (40), and 31% in Iran (21). This discrepancy between countries, and different cities in the same country, may be due to the differences among countries in level of development, availability of occupational health and safety facilities, work tasks and working conditions involved, different working population and their characteristics and degree of adherence to safety measures (27, 40).

Among studied workers, the most frequent types of accidents were hit by falling objects, fall from height and machinery/tools related accidents. Almost similar results were reported by other studies in different countries (12, 23, 33, 41). Abbas et al (1), in Egypt, stated that falls, injuries by manual tools and being struck by an object were the main causes of injuries among construction workers. In addition, Amiri et al (6) reported that accidents involving falls and falling objects are highly frequent accidents in the construction industry in Iran.

Results of current study noted that accidents commonly involve multiple body parts followed by lower limbs, trunk, and hands. These results are in accordance with Nghitanwa and Lindiwe (33), in Namibia, while results of other studies showed that upper and lower limbs were the most common injured body parts (1, 9, 23, 31).

Cuts, lacerations, eye injuries, burn and fractures were the most common injuries resulting from accidents among studied workers, which agree with the results of several studies. Abbas et al (1) reported cuts, lacerations, and contusions as the most common types of injuries among construction workers. In addition, Mersha et al (30) reported abrasion, cut injury, prick, blunt trauma and laceration as the most frequent reported injuries among construction workers.

Workers who were involved in accidents are more likely to be more than 35 years old. Researches on association between age of worker and risk of having an accident are inconsistent. While some authors reported that accident rates were not related to age (36), others had shown that young construction workers experience more accidents (4, 16), either due to lack of experience and safety training or because they feel immune to hazards and do not take them seriously thus don't follow safety regulations (22). On the other hand, consistent with current study, some researchers concluded that older workers had a higher prevalence of accidents (2, 21, 24). Older workers feel overconfident, familiar with equipment and that they have the expertise to work safely even with the hazards (22).

Married workers are more likely to be involved in occupational accidents. Similarly, Alizadeh et al (4) analyzed reported occupational construction accidents in Iran from 2008 to 2012 and reported that married people comprise the largest number of accidents. Other studies had reached the same result (15, 16, 24), and authors argued that married workers experience more stress from family matters, more financial problems and more fatigue by being employed in multiple jobs, especially hazardous tasks.

Workers who are smokers had less chance of being involved in an accident in contrast to some studies (11, 26). Smoking, and its main component nicotine, was linked to increased vigilance and concentration resulting in improved performance (7). Indeed, Åkerstedt et al (3) found that being a smoker was associated with a reduced risk of unintentionally falling asleep at work in Sweden, and Takahashi et al (38) found a significant association between smoking and good adaptation to shift work in Japan.

Lack of safety training as well as non-use of PPE were significant predictors of accidents among construction workers. Tadesse and Israel (37) reported that lack of safety awareness and PPE are the first and third major causes of injuries among construction workers. In addition, Lette et al (26) revealed that lack of safety training and PPE use increase the odds of injuries among construction workers by 5.1 and 3.6 respectively. Moreover, construction workers attending safety training programs and those who use PPE experienced 3 and 1.5 times decline in the prevalence of injuries than that among other workers (21).

Conclusions

In conclusion, the current study showed a high prevalence of work-related accidents together with a low PPE utilization rate among construction workers. Among studied workers, the most important predictor of PPE use is previous safety training. In addition, factors as older age, married workers, smoking history, previous safety training and PPE use were significantly associated with occupational accidents. Accident in construction sites can be reduced with proper training and PPE use by all workers.

Recommendations

Management at every construction site should provide pre-employment and in-service training to all workers. It should cover hazards and safety procedures at worksites, most importantly training on PPE importance and use. PPE must be provided by every employer with a tailored PPE program to each worksite that should cover present hazards, appropriate PPE selection, maintenance and use. Continuous PPE use, training, and regular monitoring of PPE use among workers should be enforced. Specific training programs should be customized for illiterate workers, particularly if with special needs, when they represent high percentage of workers. These PPE should be constantly available with multiple sizes and fit well. The level of comfort should be improved (e.g. made from lighter material). Regular field monitoring and supervision, along with social support, of workers especially those with higher risk of accidents (e.g. old age and married workers) should be implemented. Alternate methods to enhance alertness in worksites, other than nicotine in cigarettes should be implemented.

The current study is a cross-sectional study which cannot be used to prove a temporal relationship. Possible accident confounders (e.g. noise, poor lightening) were not measured due to logistic difficulties. Recall bias is another limitation of this type of study. Workers with fatal or disabling accidents are not likely to be encountered in this study. The current study is a small-scale study performed in one city. Thus, results cannot be generalized.

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