ORIGINAL ARTICLE

Effectiveness of Finger Safety Intervention Module (FingSIM) in Increasing Finger Safety Knowledge Among Small and Medium Enterprise (SME) Manufacturing Industries in Selangor

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ABSTRACT

Introduction: Occupational finger accidents and injuries (OFAI) are prevalent among Malaysian employees. An analysis of accident statistics from the Department of Occupational Safety and Health (DOSH) Malaysia revealed that 26.25% of accidents between 2017 and 2019 involved finger injuries. This study aims to evaluate the effectiveness of the self-developed Finger Safety Intervention Module (FingSIM) in enhancing finger safety knowledge among manufacturing workers in small and medium enterprises (SMEs). **Materials and methods:** This quasi-experimental study, involving control and intervention groups from 14 manufacturing companies in Selangor, used G*Power v3.1 to determine sample sizes. Employing a pre-test, post-test, and second-post-test, data on finger safety knowledge were collected via the validated FingSTEv questionnaire. Mixed ANOVA compared mean differences within-subject (time and group) and between-subject (group) across three time intervals. **Results:** The results showed a significant increase in mean knowledge scores across all three time intervals ($p<.05$), with a very large effect size (partial eta squared = .549). The interaction between time and group on knowledge scores within subjects also demonstrated a very large effect (partial eta squared = .553, $p<.05$). Similarly, the interaction effect between time and group on knowledge scores between subjects was substantial (partial eta squared = .510, $p<.05$). **Conclusion:** The study found that implementing FingSIM significantly improved manufacturing workers' finger safety knowledge in SMEs, demonstrating its effectiveness and meeting the research objectives.
Malaysian Journal of Medicine and Health Sciences (2025) 21(4): 46-52. doi:10.47836/mjmhs.21.4.7

Keywords: Finger, Manufacturing, Occupational safety and health, Safety knowledge, Training module

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INTRODUCTION

The significance of fingers, particularly, cannot be overstated. Fingers, composed of 14 bones on each hand, play a crucial role in daily life. Due to their soft-tissue coverage, fingers are highly susceptible to injury. Acute traumatic occupational finger accidents and injuries (OFAI) occur when energy is abruptly transferred from the work environment to vulnerable human tissue. Given that fingers are especially prone to injury, it is unsurprising that finger amputation is the most prevalent type of upper extremity amputation occurs most frequently in the workplace, particularly among unskilled manual labourers (1).

OFAI is most common among machinery maintenance employees, machine operators, tenders, craft and similar workers, physical material handlers, and food preparation workers. A lack of knowledge in operating machinery safely is often the primary cause of the operator carelessness. Hazardous working environments, inadequate hazard identification, human error, and insufficient instructions and regulations all contribute to accidents in the manufacturing industry (2). In Lahore, Pakistan, 80.72% of workers reported finger injuries in the small and medium enterprise (SME) metal press industries (3).

In Malaysia, a survey of manufacturing workers with prior accident records showed that 42% of 342 respondents had experienced from finger injuries (4). According to the Department of Occupational Safety and Health (DOSH) Malaysia, 26.25% of OFAI were reported, making fingers the most frequently affected body part in workplace accidents (5). DOSH is responsible for administering and enforcing related occupational safety and health (OSH) legislation, such as the Occupational Safety and Health Act (OSHA) (1994), the Factories and Machineries Act (FMA) (1967), and related regulations. Similarly, the Malaysia Social Security Organization (SOCSO) reported that 13.53% of OFAI occurred between 2012 and 2018, aligning with the trends published by DOSH (6–12).

Effective preventive measures are essential for addressing these global concerns. However, efficacious prevention, remains a significant challenge to workplace safety and health worldwide. Employers and employees with strong OSH knowledge and skills can enhance OSH compliance and assure workplace safety. Knowledge enhancement aims to influence an employee's practices and behaviours to promote a safer and more conducive work environment. This study aims to evaluate the effectiveness of the self-designed Finger Safety Intervention Module (FingSIM) in improving finger safety knowledge among manufacturing employees in SMEs. Although the scope of training is often limited, there is strong evidence supporting the importance of OSH training in improving workplace safety knowledge, attitudes, and beliefs (13). Therefore, this study will investigate the effectiveness of the intervention module in improving occupational finger safety knowledge among workers in the SME manufacturing sector.

MATERIALS AND METHODS

Study design

This quasi-experimental interventional study design, structured in three phases - pre, post, and second-post – was frequently employed to evaluate the efficacy of particular interventions. Quasi-experimental studies encompass a broad spectrum of non-randomized intervention approaches, allowing for the examination of real-world applications. The primary objective of quasi-experiments was to establish causation between the intervention and the observed outcomes, providing valuable insights into the effectiveness of the implemented strategies. By employing this design, researchers aimed to draw meaningful conclusions about the impact of interventions in practical settings.

Study location

This study was conducted in the state of Selangor, renowned for its prominence as a business and commerce hub and for boasting the highest income per capita in the country. Furthermore, Selangor was selected due to its significant concentration of OFAI in Malaysia between 2017 and 2019. The study population comprised manufacturing workers employed in 14 small and medium-sized enterprises (SMEs) across the districts of Petaling, Ulu Langat, and Kuala Selangor.

Sample size

The study sample size was calculated using G*Power software, employing the F test family and ANOVA: repeated measures with within-between interaction parameters for statistical analysis. G*Power served as an open-source tool for conducting power analyses and computing sample sizes. The minimum sample size required for this study was 156 participants, with 78 assigned to each of the control and intervention groups. To account for potential participant withdrawals during the program, an additional 20 percent (32 participants) was added to the initial calculation, resulting in a total required sample size of 188 participants.

Intervention

The study's sample was divided into the control and intervention groups, each composed of workers from the SME manufacturing industry The intervention group received training on finger safety knowledge in the workplace using the FingSIM. The FingSIM was delivered through a half-day programme, accommodating 10 to 25 participants per session. It included a lecture on finger safety knowledge, an interactive session, and discussions. The module was presented solely by the researcher to prevent bias. The data collection tool was a validated and pre-tested self-administered questionnaire known as Finger Safety Training Evaluation (FingSTEv), designed to assess finger safety knowledge among workers in the SME manufacturing industries.

The questionnaire was employed to assess finger safety knowledge at baseline (pre) and after (post) the intervention for both groups. Additionally, the same questionnaire was redistributed to both groups to evaluate their long-term retention of finger safety knowledge three months later (second-post). Participants were allotted approximately 30 minutes to complete the self-administered questionnaire, which they filled out following the signing of an informed consent form. Their finger safety knowledge was quantified through their responses, with a maximum possible score of 50 points. Each correct answer garnered one point, while incorrect responses and those marked "Do Not Know" received zero points. The inclusion of the "Do Not Know" option aimed to promote honest reporting without penalizing participants for uncertainty, thereby fostering a more accurate assessment of their knowledge.

Statistical Analysis

All the data entry and analysis were performed using SPSS. Assuming normally distributed data, a parametric test specific to the research question was utilized to compare group knowledge at three time intervals. In cases where the data did not follow a normal distribution, a non-parametric test was employed. A mixed analysis of variance (mixed ANOVA) was conducted to examine how the two different groups influenced participants' scores on finger safety knowledge across the three different time intervals. All assumptions were satisfied prior to conducting the test. The mean knowledge scores were subsequently analyzed using a paired t-test (for normally distributed data) or a Wilcoxon signed rank test (for non-normally distributed data) to determine if significant differences existed in mean scores between the two groups at two different times (pre/post, pre/second-post, and post/second-post).

Ethical Clearance

Ethical approval for this study was obtained from the Ethics Committee For Research Involving Human Subjects (JKEUPM) Universiti Putra Malaysia (UPM) with approval number JKEUPM-2020-270. All methods were carried out in accordance with relevant guidelines and regulations.

RESULTS

Sociodemographics and employment characteristics of participants

Table I presents the sociodemographic and employment characteristics of the participants.

Table I: Sociodemographics and employment characteristics of participants (N = 192)

	Control n(%)	Intervention n(%)	Total n(%)
Age (years)			
18-25	13 (13.3)	14 (14.9)	27 (14.1)
26-35	33 (33.7)	28 (29.8)	61 (31.8)
36-45	32 (32.7)	16 (17.0)	48 (25.0)
46-58	20 (20.4)	36 (38.3)	56 (29.2)
Gender			
Male	50 (51.0)	60 (63.8)	110 (57.3)
Female	48 (49.0)	34 (36.2)	82 (42.7)
Education level			
Low Certificate	8 (8.2)	13 (13.8)	21 (10.9)
Middle Certificate	56 (57.1)	46 (49.0)	102 (53.1)
High Certificate	11 (11.2)	8 (8.5)	19 (9.9)
Diploma	9 (9.2)	13 (13.8)	22 (11.5)
Degree above	8 (8.2)	13 (13.8)	21 (10.9)
Others	6 (6.1)	1 (1.1)	7 (3.7)
Occupation			
General worker & others	2 (2.0)	5 (5.4)	7 (3.6)
Production operator	51 (52.0)	36 (38.3)	87 (45.3)
Technician	9 (9.1)	7 (7.4)	16 (8.3)
Supervisor	12 (12.3)	18 (19.1)	30 (15.6)
QA/QC inspector	12 (12.3)	2 (2.1)	14 (7.3)
Executive above	12 (12.3)	26 (27.7)	38 (19.9)

CONTINUE

Table I: Sociodemographics and employment characteristics of participants (N = 192). (CONT.)

	Control n(%)	Intervention n(%)	Total n(%)
Working experience (years)			
< 5	59 (60.2)	40 (42.6)	99 (51.6)
6 – 15	27 (27.6)	20 (21.3)	47 (24.5)
16 – 25	8 (8.2)	18 (19.1)	26 (13.5)
Above 25	4 (4.1)	16 (17.0)	20 (10.4)

Comparison of the mean knowledge scores between-within the control and the intervention groups before (pre), after (post), and three months after (second-post) the intervention

There was a change in the knowledge scores across the three time intervals, F(1.884, 357.954)=231.045 and *p*<.05, indicating that the effect of time was significant, with a partial eta squared value of .549, suggesting a very large effect. Furthermore, there was a significant interaction effect between time and group (control and intervention) for all three time points, with Greenhouse-Geisser, F(1.884, 357.954) = 235.486, *p*<.05. The partial eta squared value of .553 indicates a very large effect. Table II presents the results.

Table II: Effect of time on knowledge score across three time interval and interaction between time and groups on knowledge score

	F	Hypothesis df	Error df	Sig	Partial Eta Squared
Effect of time on knowledge score across three time interval					
Time*Group (Greenhouse-Geisser)	231.045	1.884	357.954	**.001**	0.549
Effect of the interaction between time and groups on knowledge score					
Time*Group (Greenhouse-Geisser)	235.486	1.884	357.954	**.001**	0.553

The main effect analysis of the variables among participants from both the control and intervention groups, F(1,190)=197.923, *p*<.05, revealed a significant difference in knowledge scores, with a partial eta squared value of .510, indicating a large effect size. This demonstrates the substantial effectiveness of the intervention program. These findings, detailed in Table III, highlight the positive impact of the intervention on participants' knowledge.

Table III: Tests of between-subject effects

Source	df	Mean Square	F	Sig	Partial Eta Squared
Group	1	21006.184	197.923	0.001	0.510

Comparison of the mean knowledge score (between the control and the intervention groups) according to two different time intervals

A statistically significant reduction in mean knowledge scores was observed in the control group between pre/post time intervals (z=-2.683, *p*<.05) with a large effect size (r=.2). The median knowledge score decreased between pre/post intervals (pre-test, Md=12; post-test, Md=11). Table IV provides the detailed result.

Table IV: Difference in participants median knowledge score of the control group at two different time interval (wilcoxon signed ranks test)

	n	z	Asymp. Sig. (2-tailed)	r
Pre/Post	98	-2.683b	0.007	0.271

There was a significant increase in knowledge scores from the pre-test (M=11.64, SD=6.505) to second-post test (M=15.34, SD=6.566), t(97)=-5.166, *p*<.05, in the control group. The mean increase in knowledge score was 3.7, with a 95% confidence interval ranging from -5.113 to -2.275. The eta squared statistic (.22) indicated a large effect size. Additionally, for the post/second-post-test comparison, there was a statistically significant increase in knowledge scores from post-test (M = 10.95, SD = 7.277) to second-post-test (M=15.34, SD=6.566), t(97)=-5.683, *p*<.05 (two-tailed). The mean increase in knowledge score was 4.39, with a 95% confidence interval ranging from -5.920 to -2.855. The eta squared statistic (.25) indicated a large effect size. Table V details these result.

Table V: Difference in participants mean knowledge score of the control group at two different time interval (paired t-test)

	Mean	SD	95% CI of Difference		t	*p*
			Lower	Upper		
Pre/Second-Post	-3.694	7.079	-5.113	-2.275	-5.166	**.001**
Post/Second-Post	-4.388	7.644	-5.920	-2.855	-5.683	**.001**

A significant increase in knowledge scores was observed from the pre-test (M=14.05, SD=7.746) to the post-test (M=33.94, SD=7.623), t(93)=-25.677, *p*<.05 (two-tailed). The mean increase in knowledge score was 19.89, with a 95% confidence interval ranging from -21.421 to -18.345. The eta squared statistic (.88) indicated a large effect size. In pre/second-post-test comparison, there was a statistically significant increase in mean scores from the pre-test (M=14.05, SD=7.746) to the second-post-test (M=26.18, SD=6.593), t(93)=-15.902, *p*<.05 (two-tailed). The mean increase was 12.13, with a 95% confidence interval ranging from -13.642 to -10.613. The eta squared statistic (.73) indicated a large effect size. For the post/second-post-test, there was a statistically significant reduction in knowledge scores from the post-test (M=33.94, SD=7.623) to second-post-test (M=26.18, SD=6.593), t(93)=13.618, *p*<.05 (two-tailed). The mean decrease in knowledge score was 7.76, with a 95% confidence interval ranging from 6.624 to 8.886. The eta squared statistic (.66) indicated a large effect size. Table VI summarizes these result.

Table VI: Difference in participants mean knowledge score of the intervention group at two different time interval (paired t-test)

	Mean	SD	95% CI of Difference		t	*p*
			Lower	Upper		
Pre/Post	-19.883	7.507	-21.421	-18.345	-25.677	**.001**
Pre/Second-post	-12.128	7.394	-13.642	-10.613	-15.902	**.001**
Post/Second-Post	7.755	5.522	6.624	8.886	13.618	**.001**

DISCUSSION

FingSIM effectively increased the mean knowledge score of intervention group participants by 58.6% from baseline. In contrast, the mean knowledge score of the control group decreased by 6.3%. Although there was a slight decrease in the control group's mean knowledge score, the absolute difference in mean knowledge scores between the two groups was substantial, at 22.99. These results indicate that using FingSIM can significantly improve finger safety knowledge. This finding is consistent with a study in Egypt, which also reported a statistically significant improvement in knowledge of standard isolation precautions (*p*<.05) after implementing a health education programme with booklets (14). Another study determined that the training modules can effectively enhance participants' knowledge level (15).

A similar pattern of increased mean scores (*p*=.001) was observed in a study comparing traditional and online education (16), suggesting that educational interventions generally have a positive impact. Similarly, an educational intervention study using the Health Belief Model (HBM) to educate healthcare workers about standard precautions showed a statistically significant increase in knowledge after the programme was implemented (*p*=0.001) (17). These findings support the notion that interventions based on HBM can enhance healthcare workers' knowledge of standard precautions, aligning with the results of similar intervention studies (18–20). Another study found that the intervention group had a significantly higher mean score on standard precautions knowledge tests after the intervention than the control group (t=13.932, *p* < 0.001)(21). Additionally, a study on nurses' knowledge demonstrated a significant improvement in knowledge of standard precautions after an intervention (*p*=0.05) (22).

Beyond simply measuring the increase in the mean knowledge scores from pre-test to post-test to assess the intervention's effectiveness, it is crucial to analyze whether participants can sustain the knowledge over time (i.e., from post-test to second-post-test) to fully determine the intervention's long-term effectiveness. Although there was a decrease in the second-post-test mean knowledge score for the intervention group compared to the control group, the intervention group's mean score remained higher than that of the control group (16,23). Studies have suggested that knowledge retention may decline without regular practice (24), and perceived relevance of the content to real-world applications may aid in retaining knowledge (25). Even though brief training sessions can increase knowledge, periodic refreshers are necessary for retaining information, particularly for topics not frequently applied (26).

A deficit in knowledge retention was identified six months after initial training, leading to a loss of knowledge across all course-related topics (27). Several factors could contribute to this, including decreased performance interfering with perceptual mechanisms and attention levels, the learners willingness to engage, the logical structure and significance of the content, and the ability of instructors to make learning engaging by refining previously known concepts.

Workers who receive OSH training are better protected from serious injuries in the workplace (28). Proper training and increased awareness of workplace hazards could prevent fatalities resulting from occupational accidents (29). For example, OSH training contributed to a reduction in workplace accidents in Korea's manufacturing industry between 1991 and 1994 (30). Many accidental deaths in South Korea's manufacturing industry were caused by human errors, flawed work processes, and inadequate training (31). Similarly, a lack of safety education and training has been identified as one of the leading causes of coal mine accidents in China over past decade, highlighting the urgent need for expanded safety education and training in the coal mining industry (32).

According to the U.S. Department of Labor and the U.S. Bureau of Labour Statistics, while simple equipment requires minimal training, complex systems necessitate extensive understanding (31). Employees must possess the necessary skills to operate new machinery safely, as this not only enhances productivity but also prevents workplace accidents. Implementing OSH training enables employers to increase employees' safety awareness and knowledge.The effectiveness of OSH training in preventing workplace accidents has been well-documented. Priorities must be established, beginning with the workers' knowledge, comprehension, abilities, and attitudes toward accident prevention (33). Educating industrial workers to be more aware of their surroundings enhanced workplace safety, with the duration of training having a significant influence (34).

The empowerment of safety and health training institutions has led to the introduction of more structured OSH training through specific training modules. As with the educational curricula, safety training should incorporate the concept of structured learning for effective implementation. Training modules are essential for imparting specific knowledge to various groups (35). For example, a training module was employed to educate workers about general safety and hazards (29). These modules are extensible, allowing for the addition of new training content as needed. The knowledge gained through such training modules has been shown to change participants' knowledge and make the learning lasting (36).

In Malaysia, the development of an intervention module on occupational finger safety is crucial for enhancing workers' knowledge and improving overall OSH in SME manufacturing industries (37). In this study, the intervention module was designed to increase SME manufacturing workers' knowledge of finger safety. The content of this module was simplified while remaining comprehensive, taking into account participants' background factors to ensure the information is easy to understand. The findings demonstrate that the FingSIM effectively increases finger safety knowledge among SME manufacturing workers. A significant improvement in knowledge scores was observed when comparing pre and post intervention scores. Moreover, the intervention group's post intervention scores were higher than those of the control group, confirming the effectiveness of the FingSIM intervention.

CONCLUSION

The effectiveness of FingSIM in enhancing employees' finger safety knowledge was thoroughly investigated. The results demonstrate that workers' knowledge increased significantly after (post) the implementation of FingSIM compared to before (pre) the intervention. Additionally, there was a significant statistical difference in finger safety knowledge between the intervention group and the control group following the intervention. To effectively address OFAI, it is crucial to implement practical solutions and proper planning, including ongoing educational programs that emphasize prevention. Educational interventions are likely to significantly improve workers' knowledge of finger safety. Beyond contributing to the academic literature, this study serves as a foundation for further research aimed at enhancing strategies to minimize OFAI in the SME manufacturing sector. In conclusion, FingSIM has proven effective in not only increasing workers' knowledge but also maintaining that knowledge at an adequate level even three months post-intervention (second-post).

ACKNOWLEDGEMENT

The authors would like to express our gratitude to the Department of Occupational Safety and Health Malaysia for providing the data on occupational accidents and injuries.

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