Evaluating the Effectiveness of Participatory Training for Occupational Health and Safety Improvements— A Randomized Controlled Trial with One-year Follow-up in China

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Abstract of thesis entitled:

Evaluating the Effectiveness of Participatory Training for Occupational Health and Safety Improvements-A Randomized Controlled Trial with One-year Follow-up in China

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Abstract (English)

Objectives: To find out whether participatory training is effective in improving occupational health and safety (OHS); to see if participatory training is more effective than didactic training in improving OHS; and to document whether participatory training has a better cost-benefit ratio than didactic training.

Methods: A randomized controlled trial (RCT) was conducted in factories of Shenzhen, China from June 2008 to May 2010. Factories were first paired according to industry and size, and each pair was randomly assigned as one intervention factory and one control factory. Within each intervention factory, around 60 workers were recruited and they were randomly allocated to intervention (participatory training) or control (didactic training) group. Around 60 workers in each control factory received didactic training. The impacts of the training programs were assessed with changes in knowledge attitude and practice (KAP) in OHS, experiences in work-related injuries, sick leave and musculoskeletal disorders (MSD), as well as expert assessment of the factory performance in OHS using a checklist at baseline and one year after training. One-way and repeated measures ANOVA and Linear Regression Analyses were used to compare KAP scores at different time points. Chi square test and two-proportion Z test were applied to compare the injury incidence rates, the proportions of workers taking sick leave and MSD prevalence rates among the groups.

Results: 918 workers in the intervention groups and 2,561 workers in the control groups from 60 factories received participatory training and didactic training, respectively. By the end of May 2010, three-month follow-up has been completed for

30 pairs of factories and one-year follow-up completed for 16 pairs of factories. The follow up rates at three-month and one-year after training were 71.1% (2,473/3,479) and 56.3% (1,321/2,347), respectively.

The average baseline KAP scores of 64.9±15.0, 63.5±14.7 and 78.1±18.0 improved significantly at immediate evaluation (82.7±12.3, 71.9±12.4 and 90.6±12.7), at three months (79.3±11.5, 73.9±10.6 and 91.7±9.6), and at one-year after training (76.7±12.1, 72.0±10.3 and 88.9±10.8). The mean KAP scores of intervention group were higher than those of control group at all three time points after training.

In the year after training, the person-based and event-based incidence rates of injury reduced from 90 per 1,000 workers to 49.8 per 1,000 workers (χ^2=6.377, p=0.012) and from 144.5 per 1,000 person-years to 73.5 per 1,000 person-years (Z=3.199, p<0.001) respectively in the intervention group. The incidence rates of injury in the two control groups also reduced, but the reductions were not statistically significant. The proportion of workers taking sick leave reduced from 32.0% to 24.6% in the intervention group (χ^2=5.609, p=0.018), but no significant reductions were observed in the two control groups (p>0.05). No significant changes in MSD prevalence rates were observed in both the intervention and control groups (p>0.05).

The cost-benefit ratio was 1:1.20 for participatory training and 1:1.06 for didactic training if the cost savings were calculated with median costs and workdays lost. The cost-benefit ratio was 1:2.36 for participatory training and 1:1.97 for didactic training if the cost savings were calculated with mean costs and workdays lost.

Conclusions: Participatory training was more effective in improving KAP scores among the frontline workers than didactic training. Participatory training could reduce injury incidence rate and the proportion of workers taking sick leave, but not the MSD prevalence rate at one year follow up. The cost-benefit ratio of participatory training was better compared to didactic training. The results indicated that participatory training could be recommended for training frontline industrial workers in China.

Keywords: Frontline worker, Participatory training, Occupational health and safety, Randomized controlled trial, Evaluation

論文摘要題目:

中國一線工人職業健康與安全參與式培訓效果評估的隨機對照研究

呈交者: 余文周

學　　位: 哲學博士

於香港中文大學 2010 年 9 月

摘要（中文）

目的: 本文探討參與式培訓方法是否能有效提高工人職業健康和安全，是否比授課式培訓方法更有效提高工人職業健康和安全；探討參與式培訓方法在提高工人職業健康和安全上比授課式培訓方法是否有更好的成本-效益比。

方法: 自 2008 年 6 月至 2010 年 5 月在中國深圳工廠開展一項隨機對照研究。工廠根據行業和規模進行配對，並隨機分配到幹預工廠和對照工廠；每個工廠選擇約 60 名工人作為研究對象，幹預工廠的工人要隨機分配為幹預組和對照組。培訓幹預的效果通過知識態度行為（KAP）問卷、工傷調查和肌肉骨骼勞損（MSD）問卷、專家工廠評價等方法進行評估，在培訓前、培訓後立即以及培訓後 3 個月、1 年收集相關評估數據。使用單因素、重復測量 ANOVA 和線性回歸分析比較不同階段 KAP 評分變化，應用卡方檢驗和 Logistic 回歸分析比較培訓前後工傷發生率、請病假工人比率和 MSD 發生率變化，以及與其他因素的聯系。

結果: 30 對工廠 3,479 名工人參加本研究，918 幹預組工人接受參與式培訓，2,561 對照組工人接受授課式培訓。截止到 2010 年 5 月，30 對工廠開展 3 個月隨訪，16 對工廠開展 1 年隨訪，培訓後 3 個月和 1 年的隨訪率分別為 71.1%（2,473/3,479）和 56.3%（1,321/2,347）。

培訓前 KAP 的平均分分別為 64.9±15.0、63.5±14.7 和 78.1±18.0，培訓後分數顯著增加（$p<0.001$），培訓後評分為 82.7±12.3、71.9±12.4 和 90.6±12.7，3 個月後分數為 79.3±11.5、73.9±10.6 和 91.7±9.6，1 年後分數為 76.7±12.1、

72.0±10.3 和 88.9±10.8。在培訓後 3 個時間點，幹預組工人 KAP 評分均顯著高於對照組工人。

培訓 1 年後工傷發生率以病例計算，幹預組從 90.0/1,000 工人減少到 49.8/1,000 工人（x^2=6.377, p=0.012）；以人次數計算，幹預組從 144.5/1,000 人次減少到 73.5/1,000 人次（Z=3.199, p<0.001）。對照組工傷發生率培訓後減少，但沒有顯著性差異。干預組工人請病假比率從培訓前 32.0%減少到 24.6%（x^2=5.609, p=0.018），對照組工人請病假比率無顯著性減少（p>0.05）。培訓 1 年後 MSD 發生率幹預組和對照組都無顯著性變化（p>0.05）。

如果按照工傷費用和誤工天數 50%中間值計算，參與式培訓成本效益比為 1:1.20，授課式培訓成本效益比為 1:1.06 。如果以工傷費用和誤工天數平均值計算，成本效益比參與式培訓為 1:2.36，授課式培訓為 1:1.97。

結論：參與式培訓和授課式培訓能提高工人關於職業健康安全的 KAP 評分，參與式培訓比授課式培訓能顯著提高 KAP 評分。參與式培訓能降低工傷發生率和工人請病假比率，但兩種培訓方法均不能減少 MSD 的發生。總體上，參與式培訓的成本效益比要高於授課式培訓。建議可以運用參與式培訓方式對一線工人進行培訓。

關鍵詞：一線工人，參與式培訓，職業健康與安全，隨機對照研究，評價

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List of Abbreviations

CBR	Cost-Benefit Ratio
CCT	Clinical Controlled Trial
CI	Confidence Interval
ES	Effect Size
ILO	International Labor Organization
KAP	Knowledge, Attitude, Practice
LBP	Low Back Pain
MSD	Musculoskeletal Disorder
OHS	Occupational Health and Safety
OR	Odds Ratio
POHSI	Participatory Occupational Health and Safety Improvement
PPE	Personal Protective Equipment
POSITIVE	Participatory Oriented Safety Improvements by Trade Union Initiative
RCT	Randomized Controlled Trial
RR	Relative Risk
SD	Standard Deviation
SMD	Standardized Mean Difference
WHO	World Health Organization

Chapter 1 Introduction

1.1 Situation of workers' health and safety

Work-related injuries and occupational diseases have become a major concern to employees, employers and governments because of impacts on workers' health and productivity. According to the data of World Health Organization (WHO) and International Labor Organization (ILO) in 2007, 100 million work-related injuries were estimated to occur annually and some 11 million new cases of occupational diseases might be caused by various exposures at work(1). However, WHO estimates that only 10-15% of workers have access to a basic standard of occupational health service in the world(2). Occupation related injuries and diseases affect 15% to 20% of all Americans(3). A survey found that musculoskeletal disorder (MSD) was an important national health problem with more than one million workers missing time from their jobs at a cost of more than $ 50 billion a year in the United States(4).

China has made great achievements in economic development in the recent decades. Many Chinese workers (about 150 million) left rural areas to seek work in urban and suburban areas(5). These migrant workers face multiple obstacles that work against their abilities to protect themselves from workplace hazards(6). It is estimated that there are more than 16 million enterprises with occupational hazards in China and more than 200 million workers are exposed to hazards in the workplace. About 15,000 new occupational diseases are reported every year according to the data of national surveillance system(7, 8). The ILO estimated that the annual workplace fatality rate in 2001 for China was 11.1 per 100, 000 workers compared with a rate of 4.4 per 100,000 workers in the United States. China's official records indicate that industrial accidents rose 27% from 2000 to 2001, and cases of occupational diseases rose 13% over the same period(9, 10). The official statistics are widely considered to underestimate the actual situation. Occupational injuries and illness seriously threaten worker's health and cause a great deal of direct and indirect loss in economy. The total direct costs due to work-related injuries were estimated to be RMB 100 billion (US $16.64 billion) every year in China(8). However, as some occupational diseases, for example, pneumoconiosis and chronic chemical poisoning, take so long to affect worker's health, experts warn that the problem is likely to get worse even if actions are taken immediately(7).

1.2 Prevention strategies for work-related injury and illness

The most effective prevention strategy for occupational injuries and diseases is through primary prevention, which includes engineering control, workplace management and personal protection(2, 11). Health and safety training program is globally recognized as one means of reducing the costs associated with millions of injuries and illnesses in workplaces.

There are different means for worker's training or education to prevent work-related diseases or injuries. Pamphlets, leaflets or posters are traditional ways to convey information to the workers. Lecturing has been the usual means for education and training, despite the passivity of the learners(12). The general belief is that the information and skills can be acquired using more conventional, didactic training methods(13). However, Kishchuk et al. conducted a survey and found that only one-quarter of respondents recognized the pamphlets or leaflets and only 14% stated that they had learned something through the pamphlets or leaflets(14). Training through lecturing may face another problem - a long and boring lecture will make workers lose interests and go to sleep(15).

Recently, participatory training has been more and more used by employers or institutions for educating frontline workers to improve their health and safety(13). The more involved management and employees are in a participatory approach, the more robust the financial benefits will be(16). As training methods became more active, workers demonstrated greater knowledge acquisition, and reductions were seen in accidents, illnesses, and injuries(13, 17). The curriculum deliberately invites workers experiences and knowledge into the classroom, presents authentic situations for discussion, and develops strategies for critical thinking and social action. Participatory exercises provide opportunities for hands-on interaction and simulation of real hazards(18, 19).

1.3 Participatory training for frontline workers

In some Asian countries, labor organizations and companies are using participatory training method to improve workers' health and safety in recent years(16, 20-23). This training model is of low cost and action-based and it encourages frontline employees' participation. Through the cooperation between employers and employees, it is expected that they could work out practical and concrete solutions. However, no study has been conducted to evaluate the effect of this participatory training method when applied in workplaces in Asia.

In China, frontline workers had little chance to receive relevant training in OHS before the 21st Century. The Law on Occupational Disease Prevention and Treatment, enacted May 1, 2002, specified that the workers should receive training. National Guidelines for Occupational Disease Control and Prevention, issued in 2009, set up a target of 90% for training frontline workers by 2015(24). Participatory training program was first introduced into China to improve frontline workers' health and safety at the turn of the millennium(25). Although some studies have been conducted to evaluate the effectiveness of participatory training in other countries, sufficient convincing evidence is still lacking for the positive effects of participatory training(26-28). Moreover, only a few randomized controlled trials (RCT) have been conducted to evaluate the effectiveness of the participatory training(29-35), but none of these were conducted in China. The current RCT was designed to evaluate the effectiveness of a participatory training program as compared to a conventional didactic program.

1.4 Objectives and hypotheses of this study

The general aim was to evaluate different training models for improving worker's safety and health in the factories of mainland China. The specific objectives were: (1) to find out whether participatory training was effective in improving occupational health and safety (OHS) through a before-after comparison; (2) to see if participatory training was more effective than didactic training in improving occupational health and safety through comparisons between intervention and control groups; (3) to document whether participatory training had a better cost-benefit ratio than didactic training in improving occupational health and safety.

Accordingly there were three hypotheses. Hypothesis 1 - participatory training could improve occupational health and safety, including changing workers' knowledge, attitude and practice (KAP) after the training program, and reducing work injuries and musculoskeletal disorders. Hypothesis 2 - participatory training was more effective than didactic training in improving occupational health and safety. Hypothesis 3 - participatory training had a better cost-benefit ratio in improving workers' OHS than didactic training.

1.5 Outline of this thesis

The current chapter (Chapter 1) introduces the situation of occupational health and safety and prevention strategies for work-related injuries and illnesses in China. The objectives and hypotheses are also described. Chapter 2 reviews the relevant literatures about the effectiveness of participatory training on OHS improvement with best evidence synthesis. Meta-analyses were applied to evaluate specifically the effectiveness for low back pain (LBP) prevention and estimate the effect sizes of KAP improvement after training programs. Chapter 3 introduces the methods used in this study, including sample size calculation, subject allocation, intervention, data collection, follow up and statistical methods. Chapter 4 reports the main results, including changes in KAP, injury incidence rates and MSD prevalence rates in the intervention and control groups and the cost-benefit ratios for the two training programs. Chapter 5 discusses the main findings of this study, and Chapter 6 gives the conclusions and recommendations based on the study results.

Chapter 2 Literature review of the effectiveness of participatory training on occupational health and safety improvement

2.1 The aims of literature review

In this review we tried to evaluate the evidence for the effectiveness of participatory training in the improvement of workers' health and safety by assessing the methodological quality of the studies and level of evidence. More specifically, we reviewed (1) the effectiveness of participatory training programs on work-related injury reduction; (2) the effectiveness of participatory training programs on MSD prevention; (3) the effectiveness of participatory training programs on improvement of KAP; (4) the cost-benefit ratios of different training programs in improving workers' health and safety.

2.2 Search strategies

Relevant articles were identified by computer-aided searches in Medline, EMBASE and China Journal Net (CJN) database. All the searches covered the period January 1980 to December 2009.

The literature search was done using the following keywords and methods. Firstly, we searched the relevant articles with the following key words: *participatory ergonomics* **or** *participatory training* **or** *health education* **or** *intervention* **or** *trial*. Secondly, the articles were searched with the following key words: *occupational health* **or** *occupational safety* **or** *occupational injury*. Thirdly, the articles were searched with the following key words: *evaluation* **or** *effectiveness* **or** *cost-benefit*. Fourthly, we combined the above three steps with "***and***" to search the articles related to training or education and evaluation of workers' health and safety.

Hand searching was also conducted and references quoted in all retrieved articles were screened. Relevant articles were included into the literature review according to the inclusion criteria.

2.3 Criteria used to select the studies for review

The articles selected should meet the following criteria: (1) Type of intervention: participatory training or health education; (2) Type of studies: randomized controlled trial (RCT), Non-randomized Clinical Controlled Trial (CCT) or before-and-after comparison study; (3) Type of subjects: frontline workers; (4) Type of outcomes: injury, sick leave, musculoskeletal disorders or knowledge, attitude and practice on OHS or cost-benefit or cost-effectiveness on improvement of OHS.

Finally, any systematic reviews encountered were read for the purpose of identifying additional primary research studies. The articles were also screened to ensure they met the inclusion criteria.

2.4 Methodological quality assessment

All trials were scored according to the methodological criteria listed in table 1. These criteria are based on generally accepted principles of intervention research. Similar criteria have been used in previous reviews about interventions for low back pain(35-37).

The methodological quality was scored according to a list of 11 criteria based on the guideline for methodological quality assessment, as proposed by the Cochrane Collaboration Back Review Group(35, 36, 38, 39). An item was rated positive (+) when the information in the publication provided sufficient proof for fulfilling the criterion. An item was rated negative (-) in case of sufficient information about not fulfilling the criterion, or in case of lacking any information about the item. An item was rated unclear (?) in case of an unclear interpretation.

Table 1 Criteria for methodological quality assessment

1	**Was the method of randomization adequate?**	+	The randomization process is described and an unpredictable randomized assignment.
		-	Geographically defined strata or allocated on the basis of scheduled time of their visit.
2	**Was the treatment allocation concealed?**	+	The assignment is carried out by an independent person who is not responsible for determining the subjects' eligibility.
3	**Were the groups similar at baseline?**	+	Age, gender and other characteristics are comparable, or methodological criteria 1 and 2 are +.
4	**Was the subjects blinded to the intervention?**	+	The subjects don't know the intervention.
5	**Was the care providers blinded to the intervention?**	+	The care providers don't know the intervention.
6	**Was the outcome assessor blinded to the intervention?**	+	Observers are blinded regarding intervention allocation and the binding is evaluated and adequate.
7	**Co-intervention was avoided or equal**	+	Avoided in the study-design or equally divided among groups and information about other interventions.
8	**Compliance**	+	Description which part of the protocol is followed by the subjects and according to the reviewers satisfactory in all study groups.
9	**Withdrawal rate**	+	If there was < 20% loss of subjects at the main time of outcome measurement for short term follow-up and there was <30% for long-term follow-up.
10	**Was the timing of the outcome assessment in all groups similar?**	+	Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessment.
11	**Did the analysis include an intention-to-treat analysis?**	+	All randomized subjects are analyzed in the group they were allocated to by randomization for the most important moments of effect measurement irrespective of noncompliance and co-interventions.

Note: Based on Van Tulder et al. 1997, 2003 and Eline M Meijer(35, 39-41)

The methodological quality of the randomized controlled trials and clinical controlled trials selected were tested, using these 11 criteria. High quality trials were defined as those with positive scores on at least six criteria. Studies with positive scores on five-or fewer criteria were classified as low quality(35, 42, 43).

2.5 Data extraction and analysis

To be able to combine the outcomes of different studies statistically, data were extracted from each study. The following data were of interest: the number of subjects in each study group, incidence rates of injury and prevalence rates of work-related musculoskeletal disorders (WMSD), the change of knowledge, attitude and practice and cost-saving of intervention before and after the training.

Effect sizes (ES) were calculated for the available outcome measures and follow up periods using the MetaView option of Review Manager Software (RevMan version 5.0). Some studies explored the effects of training or education programs in preventing low back pain (LBP). We extracted and summarized odds ratios from relevant articles describing the association between training or education program and LBP prevention because there were RCTs and CCTs only for LBP prevention. The calculated effect sizes were expressed for dichotomous data as odds ratio with 95% confidence intervals (CI).

For continuous data, for example, knowledge scores, attitude scores and practice scores, we chose the standardized mean difference (SMD) to calculate the effect size, and more particularly the Cohen'd as the method for estimating the combined effect size. The effect size consequently expressed the magnitude of an effect as the number of pooled SDs. Effect sizes were calculated with data from the intervention group and the control group from the latest measurement after follow-up. The fixed effects model was used if homogeneity of the study on effect sizes was not rejected. Otherwise, the random effects model was used.

2.6 Best evidence synthesis

The outcomes of the studies were considered to be contradictory if <75% of the studies reported the same outcome, otherwise outcomes were considered to be consistent. The results were classified into five levels of evidence based on the number of high quality studies and the consistency of the findings(44-46): (1) strong evidence — multiple relevant, high quality randomized controlled trials with consistent outcomes; (2) moderate evidence — one relevant, high quality RCT and one or more relevant low quality RCTs and/or non-randomized controlled trials with consistent outcomes of the studies; (3) limited evidence —one low quality RCT and/or non-randomized CCTs with consistent outcomes of the studies; (4) no evidence — no RCT or CCT, no relevant studies, or contradictory outcomes of the studies; (5) conflicting evidence — inconsistent findings among multiple randomized controlled trials.

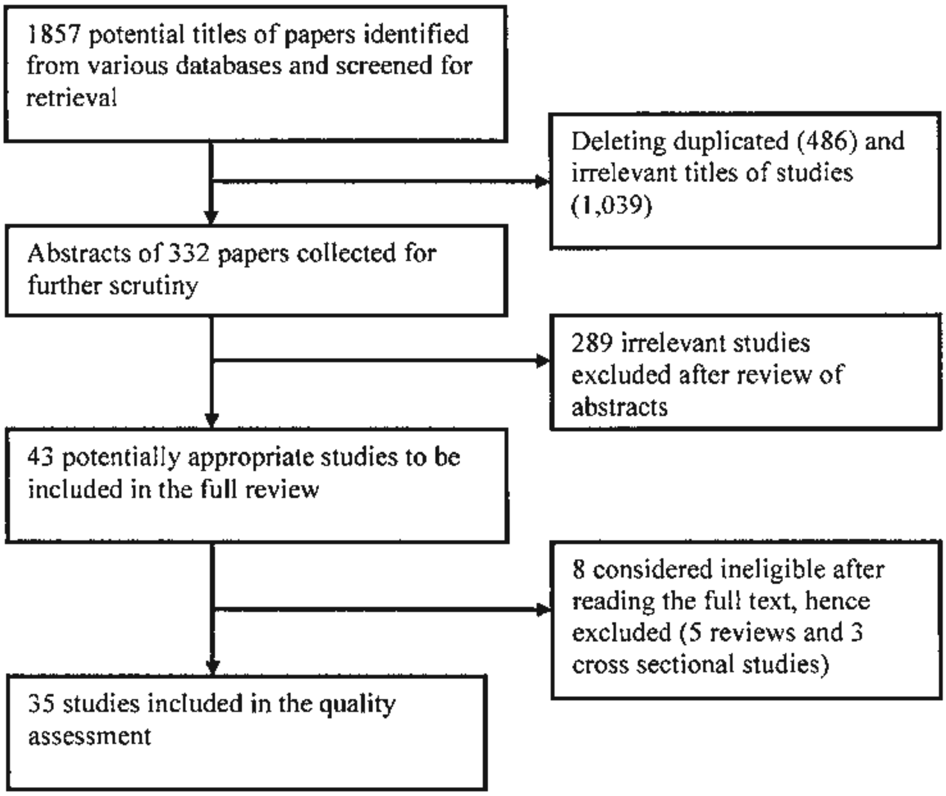
2.7 Searching articles

We identified 1,857 articles through Medline and EMBASE and China Journal Net using the search strategy described earlier. There were five articles in Chinese introducing workers' training or education programs in factories of China.

Finally, 35 publications, including one Chinese paper, were selected and assessed for this review and the process is shown in Figure 1. There were seven RCTs, fourteen CCTs and fourteen before-and-after comparison studies that reported results of training or education programs related to workplace injuries, MSD, KAP.

Five RCTs studied MSD prevalence after training programs and two RCTs reported the subjects' KAP improvement. These seven RCTs investigated office workers (three studies), home care or hospital workers (two studies), cargo workers and postal workers with 12-66 months follow-up (two studies). Five CCTs reported MSD prevention and other CCTs reported KAP changes after training programs. The participants of studies were mainly office workers and nursing and home-care workers. Most of before-and-after comparison studies examined KAP changes after training programs, but of four studies reported injury reduction. The subjects of before-and-after comparison studies included industrial workers, construction workers and farming workers.

Figure 1 Flow chart of the publication screening process



2.8 Quality of relevant publications

Table 2 summarized the methodological quality scores of seven RCTs and fourteen CCTs. In general, the methodological quality of the randomized controlled trials in this review was moderate. Three studies got 6-9 scores and were considered high in quality. Other four RCTs scored five or below and were classified as low quality according to the standard of the rating system. The scores of fourteen CCTs ranged from one to three and so these studies were regarded as low quality.

Table 2 Assessment of methodological quality of RCTs/CCTs evaluating effects of training/education on worker's safety and health

Reference	Adequate randomization	Allocation concealment	Baseline similarity	Blinding subjects	Blinding care providers	Blinding assessor	Co-intervention	Compliance	Drop out rate	Timing of followup	ITT analysis	Total score
RCT												
Horneij, et al 2001(29)	+	+	+	-	-	?	-	?	+	+	?	5
Brisson, et al 1999(28)	+	+	+	-	-	?	-	?	+	+	-	5
van Poppel, et al 1998(30)	+	+	+	-	-	-	-	+	+	+	-	6
Daltroy, et al 1997(31)	+	+	+	+	-	-	+	+	+	+	+	9
Tsutsumi, et al 2009(32)	+	-	+	-	-	+	?	-	+	+	-	5
Daltroy, et al 1993(33)	+	+	+	+	-	-	+	-	-	+	-	6
Donchin, et al, 1990(34)	+	-	+	?	-	?	-	-	-	+	?	3
CCT												
Hulshof, et al 2006(38)	-	-	+	-	-	-	-	-	-	+	-	2
Greene, et al 2005(40)	-	?	+	-	-	-	-	-	-	+	-	2
Acosta, et al 2005(41)	-	-	-	-	-	-	-	-	-	+	-	1
Hartvigsen, et al 2005(42)	-	-	+	-	-	-	?	-	-	+	-	2
Fanello, et al 2002(43)	-	-	+	-	-	-	-	-	+	+	-	3
Bohr 2000(44)	-	-	+	-	-	-	?	-	-	+	-	2
Schenk, et al 1996(45)	-	-	+	-	-	-	-	-	+	+	-	3
Versloot, et al 1992(46)	-	-	+	-	-	-	?	-	-	+	-	2
Heymans, et al 2006(47)	-	-	+	-	-	-	-	-	-	+	-	2
Brown, et al 1991(48)	-	-	+	-	-	-	?	-	-	+	-	2
Amick, et al 2003(49)	-	-	+	-	-	-	?	-	+	+	-	3
Albers, et al 1997(50)	-	-	+	-	-	-	?	-	+	+	-	3
Sinclair, et al 2003(51)	-	-	+	-	-	-	-	-	-	+	-	2
Johnsson, et al 2002(52)	-	-	+	-	-	-	-	-	-	+	-	2

+=sufficient proof of fulfilling criterion; -=sufficient information on not fulfilling criterion; ?=interpretation unclear

2.9 Review on injury reduction

There were four before-and-after comparison studies reporting work-related injury (acute trauma injury) after training or education program. Darragh, et al. collected the data about injury of 97 construction companies before and after the HomeSafe training program in 1997. They found that the average injury incidence rate per 200,000 worker-hours declined from 17.4 (16.5-18.3) pre-training to 14.7 (13.4-15.9) post-training(53).

Dong, et al analyzed 8,568 construction workers' health insurance records of 1993-1994 and concluded that the trained workers were approximately 12% less likely than those without training to have filed a compensation claim. This study also found that the training was associated with a 42% (95% CI = 0.35-0.95) reduction in claims among workers aged 16 to 24(54). Kinn, et al's study in 2000 indicated that the trained plumbers and pipe fitters experienced lower injury incidence rate compared with workers without training (3.4% vs. 11.1%) and safety training was associated with a significant reduction in injuries (OR=0.23, 95% CI =0.15, 0.35)(55).

Bena, et al in 2009 evaluated the training program for 2,795 construction workers and found that the incidence of occupational injuries had fallen by 16% after the basic training module and by 25% following the specific training modules(56).

On the other hand, Robins, et al. in 1990 evaluated a joint labor-management training program and found that no important or statistically significant differences were observed during the two study years for occupationally related illnesses and injuries(57).

Although four studies reported that the training programs could reduce injury incidence rates among five studies, we still concluded that there was no good evidence to support injury reduction because these four studies were before-and-after comparison studies. If there were RCTs and CCTs reporting the injury reduction, the evidence would be strong.

2.10 Review on MSD prevention

2.10.1 Reduction of LBP prevalence

Since the early 1980s, the scientific and occupational health community has devoted a great deal of attention to low back pain(58, 59). More specifically, previous studies have indicated workers often performed monotonous, highly repetitive, and high speed precision tasks requiring non-neutral and awkward joint postures. These exposures placed workers at risk for developing work-related musculoskeletal disorders of the neck, shoulder, back, and upper and lower extremities(59-61). Van Tulder estimated that in the industrialized countries, the total of the direct and indirect costs associated with musculoskeletal disorders might surpass 1% of the gross national product(62). In the province of Quebec, Canada, musculoskeletal disorders constituted 35.9% of the industrial accidents involving compensation in 2001(63).

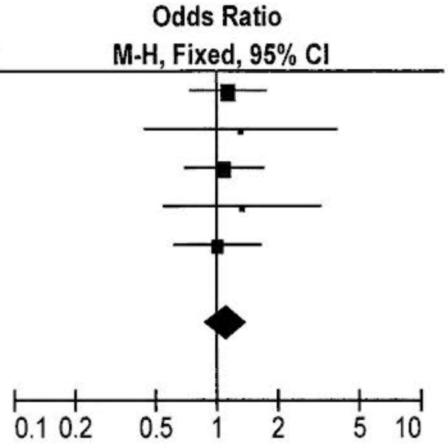
Three RCTs and two CCTs included in this review examined the effectiveness of training or education programs for the prevention of LBP. Two RCTs were regarded as high-quality studies and another RCT was classified as low quality because the study only got 5 scores, as shown in Table 3. The effects of these training or education programs were evaluated at 12-66 months after training.

None of the three RCTs and two CCTs showed a reduction of LBP prevalence rates after training or education. Daltroy, et al. conducted a large-scale, randomized controlled trial with 5.5 years of follow-up and found no long-term benefits associated with training on LBP prevention (OR=1.14, 95% CI=0.74, 1.74)(31). The following forest plot (Figure 2) shows the risk estimates and 95% CIs for training or education programs on LBP prevention in the five studies. The combined odds ratio was 1.11 (95% CI= 0.87, 1.42) and there was no significant effect of training program in preventing LBP.

Figure 2 Odds ratios and 95% CIs for the training or education programs in reducing LBP prevalence in three RCTs and two CCTs

Study or Subgroup	Weight	Odds Ratio M-H, Fixed, 95% CI
Daltroy, 1997	32.2%	1.14 [0.74, 1.74]
Fanello,2002	4.7%	1.31 [0.44, 3.87]
Hartvigsen, 2005	30.4%	1.09 [0.70, 1.69]
Horneij, 2001	6.8%	1.33 [0.55, 3.23]
van Poppel, 1998	25.9%	1.01 [0.62, 1.65]
Total (95% CI)	**100.0%**	**1.11 [0.87, 1.42]**
Total events		

Heterogeneity: Chi² = 0.42, df = 4 (P = 0.98); I² = 0%
Test for overall effect: Z = 0.85 (P = 0.40)



Three relevant RCTs (including two high quality RCTs) and two CCTs reported consistent outcomes - no effect on LBP prevalence reduction after training or education programs. Therefore, we could conclude that this review has found strong evidence for no effect of training or education programs in preventing LBP.

Gebhardt analyzed data from six studies through a meta-analysis and found a modest relationship between training of employees and a decrease in the occurrence of back pain or sick leave associated with this disorder(64). However, these articles had some limitations, such as small sample size, selection bias, etc. In that review the author pointed out that it was difficult to establish whether the positive effect could be attributed to the training intervention(64). Maher, et al. also reported that training programs were ineffective to prevent low back pain with a systematic review. They definitely concluded that training or education could not be recommended in the prevention of musculoskeletal disorders in industry(64, 65). Therefore, we got strong evidence for no effect of training or education programs in preventing LBP.

Reasons for the lack of effect of training in the primary prevention of LBP include difficulty in changing behaviors, many causes outside of work, low compliance and short period of follow-up. This lack of evidence for the effectiveness of training or education at the workplace might be partly due to the fact that these interventions aimed at changing behaviors of workers that had often been adopted long ago, and behavior change is not usually easily achieved(66).

Table 3 Results of training programs on low back pain (LBP) prevention in relevant articles

Authors	Subjects	Intervention	Follow-up (months)	Findings and effect size	Quality Score
RCT					
Horneij, et al. 2001(29)	Home-care workers	1.Physical training group (n=90) 2. Control group (n=99)	18	No significant effects of the intervention program on low back pain. OR = 1.33, 95% CI=0.55, 3.23	5
van Poppel, et al. 1998(30)	Cargo workers	1.Lumbar support and education (n=70) 2.Education (n=82) 3.Lumbar support (n=83) 4.Control (n=77)	12	No statistically significant differences in back pain incidence were found among education groups and control group. OR = 1.01, 95% CI=0.62, 1.65	6
Daltroy, et al. 1997(31)	Postal workers	1.Training program with three-hour lecture and 3-4 reinforcement sessions (n=1703) 2.Control group (n=1894)	66	The education program did not reduce the rate of low back injury. OR=1.14, 95% CI=0.74, 1.74	9
CCT					
Hartvigsen, et al. 2005(42)	home care workers	1.Training with low-tech ergonomic program (n=171) 2.Control group (n=145)	24	No significant differences were found in reducing and preventing LBP. OR = 1.09, 95% CI=0.70, 1.69	2
Fanello, et al. 2002(43)	nurses and nursing assistants	1.LBP prevention training program (n=136) 2.Control group (n=136)	24	The training of patient-handling techniques seems to be ineffective. OR= 1.31, 95% CI=0.44, 3.87	3

However, some studies found that training or education programs had other impacts on LBP prevention, for example, early return-to-work (reducing workdays lost), pain reduction and fewer re-injuries(34, 43, 46, 48, 49). One RCT and four CCTs with low quality reported these effects, as shown in Table 4.

Table 4 Workdays lost and pain remission and other impacts on LBP prevention after training

Authors	Subjects	Intervention	Follow-up (months)	Findings	Quality score
RCT					
Donchin, et al, 1990(34)	Hospital workers	1. Instruction on body mechanics and on exercises (n=46) 2. Control group (n=50)	12	Reduction in incidence of low back pain episodes (number of painful months).	3
CCT					
Fanello, et al. 2002(43)	Nurses and nursing assistants	1.LBP prevention training program (n=136) 2.Control group (n=136)	24	1. The rate of LBP remission was significantly higher (36% vs. 17%, $p<0.05$). 2. The control group suffered a longer duration of LBP (49% vs. 30%, $P=0.01$).	3
Versloot, et al. 1992(46)	Drivers of a Dutch bus company	1.Back school program (n=200) 2. Control group (n=300)	24	The decrease in mean length of absenteeism was calculated about 5-6.5 days per employee per year in intervention group.	2
Brown, et al. 1992(48)	Municipal employees	1.Back school group (n=70) 2.Control group (n=70)	6	Back school participants had significantly fewer LBP re-injuries.	2
Amick, et al. 2003(49)	Office workers	1.Adjustable chair with training (n=87) 2. Training-only group (n=52) 3.Control group (n=53)	12	1. The training lowered symptom growth over the workday ($p=0.012$). 2. Average pain levels were reduced between training group and control group.	3

2.10.2 Prevention of MSD in other body parts

There were two RCTs and two CCTs reporting the effects of training or education programs on preventing MSD in other body parts, as shown in Table 5. Horneij et al conducted a RCT and found that improvements in neck and shoulder pain did not differ between the training group and control group(29). Brisson, et al. conducted a RCT in 1999 to evaluate the effects of a training program on workers with video display units and found that upper extremity MSD decreased from 19% to 3% among the younger workers(28). Bohr also found that the trained workers reported less pain and discomfort of MSD(44). Johnsson in 2002 reported that there was no significant decrease in the subjects' musculoskeletal problems(52).

Table 5 Effects of training or education programs on the prevention of MSD in neck, shoulder and other body parts

Authors	Subjects	Intervention	Follow-up (months)	Findings	Quality score
RCT					
Horneij, et al. 2001(29)	Home-care personnel	1.Physical training (n=90) 2.Stress management (n=93) 3. Control group (n=99)	18	Improvements in neck and shoulder pain did not differ within the three groups.	5
Brisson, et al. 1999(28)	Workers with video display units	1.Ergonomic training program (n=284) 2.Reference group (n=343)	6	MSD prevalence decreased among the workers <40 yrs from 19% to 3% determined by physical examination.	5
CCT					
Johnsson, et al. 2002(52)	Hospital and home care personnel	1. Participatory training during 4-6 months (n=21) 2. Traditional training (n=30)	6	There was no significant decrease in the participants' musculoskeletal problems.	2
Bohr. 2000(44)	Office workers in transport company	1.Participatory education (n=50) 2.Traditional education (n=51) 3.Control group (n=53)	12	Those who received training reported less pain or discomfort and psychosocial work stress.	2

2.11 Review on improvements in knowledge, attitude and practice with training or education programs

Twenty studies reported results related to the change of knowledge, attitude and practice after the training or education program. There were two RCTs, seven CCTs and eleven before-and-after comparison studies.

2.11.1 Knowledge improvement

Thirteen studies, one RCT, five CCTs and seven before-and-after designs, reported that the knowledge has been improved after the training or education program. We found that the knowledge of work-related health and safety has been improved through comparing for the knowledge condition between intervention group and control group, as shown in Table 6(33, 38, 40, 41, 50, 51). These studies in Table 6 were classified into two groups according to duration of follow up: long-term (>=12 months) and short-term (<12 months). The combined effect size for long-term follow up was 0.40 (95% CI=0.23, 0.56) in four studies, as shown in Figure 3. The combined effect size of short-term follow up was 0.59 (95% CI = 0.30, 0.89) in two studies, as shown in Figure 4.

Seven before-and-after comparison studies also reported that the knowledge scores increased with training. The rates of know-how about OHS were 44%-71% at the baseline in different studies. After the training or education program, the know-how rates increased by over 20 percent (68%-99%), as shown in Figure 5(66-72).

The RCT which reported remarkable knowledge improvement had high quality with long-term follow-up. There were also some non-randomized controlled trials and before-and-after comparison studies. All studies reported consistent results of knowledge improvement after the training. Consequently, we concluded that there was moderate evidence for knowledge improvement after the training or education programs.

Table 6 Clinical trials on the long-term and short-term effects of training programs in improving knowledge on OHS

Authors	Subjects	Intervention	Follow up (months)	Quality score	Findings	Effect size (95% CI)
Long-term						
Daltroy, et al. 1993(33)	Postal workers	1.Training program (n=120) 2.Control group (n=89)	24	6 (RCT)	Increased knowledge scores in experimental group	0.65 (0.36, 0.93)
Hulshof, et al. 2006(38)	Drivers	1.Training with specific program (n=180) 2.Usual care (n=80)	12	2	An increase in knowledge of OHS professionals.	0.20(-0.07, 0.46)
Sinclair, et al. 2003(51)	Workers of food service	1.New safety training (N=31) 2.Usual training (N=63)	12	1	Knowledge test scores were apparently higher.	0.29 (-0.14, 0.72)
Greene, et al. 2005(40)	Computer users	1.Active ergonomics training (n=43) 2.Control group (n=44)	12	2	Significant increases in knowledge in the intervention group.	0.44 (0.01, 0.86)
Short-term						
Acosta, et al. 2005(41)	Farmers	1.Trained with pesticide program (n=75) 2.Control group (n=77)	1	2	Effectively increased the farmer's knowledge.	0.60 (0.27,0.92)
Albers, et al. 1997(50)	Carpenters in Cincinnati	1.Ergonomic training (n=18) 2. Control group: (n=19)	3	2	Knowledge increased for the trainee carpenters.	0.37 (-0.08,1.24)

Note: The term *effect size* can refer to a standardized measures of effect (such as *r*, Cohen's *d*, and odds ratio), or to an unstandardized measure (e.g., the raw difference between group means and unstandardized regression coefficients). Cohen's *d* is defined as the difference between two means divided by a standard deviation for the data.

Figure 3 Long-term effect sizes of knowledge improvement for intervention group and control group after training in four studies

Study or Subgroup	Weight	Std. Mean Difference IV, Fixed, 95% CI
Daltroy, 1993	33.4%	0.65 [0.36, 0.93]
Greene, 2005	14.6%	0.44 [0.01, 0.86]
Hulshof, 2006	37.9%	0.20 [-0.07, 0.46]
Sinclair, 2003	14.1%	0.29 [-0.14, 0.72]
Total (95% CI)	**100.0%**	**0.40 [0.23, 0.56]**

Heterogeneity: $Chi^2 = 5.44$, df = 3 (P = 0.14); $I^2 = 45\%$
Test for overall effect: Z = 4.77 (P < 0.00001)

Std. Mean Difference
IV, Fixed, 95% CI

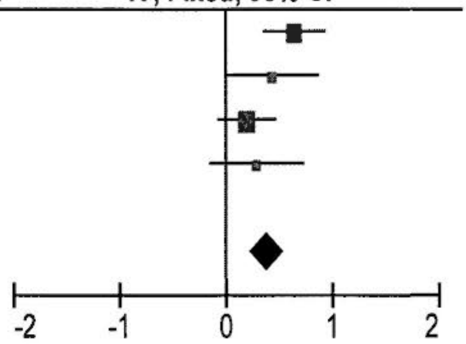


Figure 4 Short-term effect sizes of knowledge improvement for intervention group and control group after training in two studies

Study or Subgroup	Weight	Std. Mean Difference IV, Fixed, 95% CI
Acosta, 2005	80.5%	0.60 [0.27, 0.92]
Albers, 1997	19.5%	0.58 [-0.08, 1.24]
Total (95% CI)	**100.0%**	**0.59 [0.30, 0.89]**

Heterogeneity: $Chi^2 = 0.00$, df = 1 (P = 0.97); $I^2 = 0\%$
Test for overall effect: Z = 4.00 (P < 0.0001)

Std. Mean Difference
IV, Fixed, 95% CI

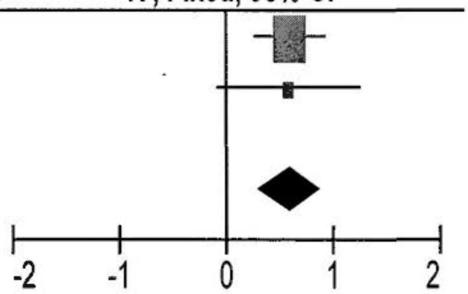
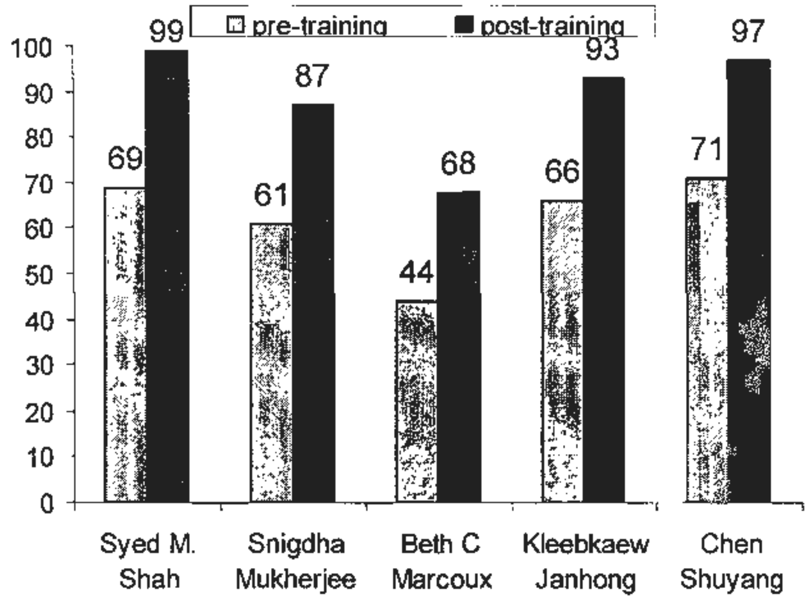


Figure 5 Knowledge improvement (%) after the training or education program in different studies



2.11.2 Attitude change

Two CCTs and five before-and-after comparison studies reported the results which were related to workers' attitude on health and safety. Hulshof, et al. in 2006 and Greene, et al. in 2005 evaluated the effects of training programs on workers' attitude on health and safety as compared to control groups, and reported effect sizes of 0.34(95% CI=0.08, 0.61) and 0.82(95% CI=0.38, 1.26) respectively, as shown in Table 7(38, 40). When the combined effect size was calculated, we found homogeneity of the effect sizes was rejected. So we used the random effects model to estimate the combined effect size. The combined effect size was 0.55(95% CI=0.08, 1.01), as shown in Figure 6.

Table 8 displays the changes of perception or awareness or willingness to improve their health status or work condition in workplace reported in five before-and-after comparison studies(17, 68, 71, 73, 74).

Although there was no RCT that evaluated attitude, there were two low quality CCTs reporting attitude improvement. So we concluded that there was limited evidence for workers' attitude improvement after training or education programs.

Brosseau et al. thought that workers' attitude could definitively lead to behavior change and reduction of work injuries and MSD, and increase product quality(75). Results from the above studies suggest that the workers' attitudes might influence their intentions (and thus behaviors) to improve their health and safety.

Table 7 Clinical trials on attitude change on OHS after training or education program

Authors	Subjects	Intervention	Follow up (months)	Quality score	Main findings	Effect size (95% CI)
Hulshof, et al. 2006(38)	Drivers	1.Training with specific program (n=180) 2. control group: usual care (n=80)	12	2	An increase in attitude of OHS professionals in intervention group.	0.34 (0.08, 0.61)
Greene, et al. 2005(40)	Computer users	1.Active ergonomics training (n=43) 2.Control group (n=44)	12	2	Significant increases in self-efficacy in the intervention group.	0.82 (0.38, 1.26)

Figure 6 Effect sizes of attitude change comparing intervention group to control group after training in two clinical trials

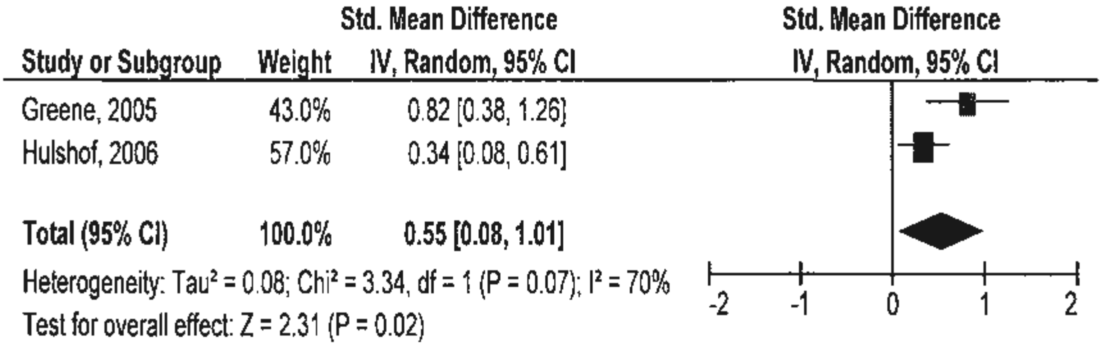


Table 8 Before-and-after comparison studies on the effectiveness of attitude change after the training or education program on OHS

Authors	Subjects	Intervention	Follow up (months)	Main findings
Becker, et al. 2004(73)	Chemical workers	Specific training program of chemical control were conducted in 1999, Detailed survey was conducted for 55 workers.	18	56% of trainees had attempted to make some change prior to training while 89% attempted some change following training.
Wells, et al. 1997(68)	Workers of small businesses	Training program was developed to assist small businesses through train-the-trainer method (8 companies).	12	The training group had better perceptions of access to protective devices.
Michaels, et al. 1992(17)	Local government employees	Right-to-Know training on workplace health and safety (n=1602).	-	Improve workers' attitude on OHS (43.8% to 71.5%).
Lippin, et al. 2000(74)	Chemical and energy workers and managers	A cross-sectional phone survey was conducted with 362 workers and managers in 6-12 months following training.	-	Changed in awareness on workers' health and safety.
Janhong, et al. 2005(71)	Thailand farmers	Health education training program on safe use of pesticides provided to voluntary farmers (n=33).	-	The mean scores for attitude increased from 32.2 to 38.9 (maximum score=40)

2.11.3 Practice improvement

One low-quality RCT, one CCT and six before-and-after comparison studies evaluated workers' practice after training or education. All these papers reported positive effects on practice improvement after the intervention, as shown in Table 9 and Table 10. Tsutsumi, et al. conducted a RCT and found that workers' performance scores increased in the intervention groups and the effect size was 0.35(95% CI: -0.05, 0.76)(32). The effect size of a health education program on practice improvement was 0.06 (95%CI: -0.20, 0.33) in a CCT conducted by Hulshof, et al.(38). The combined effect size was 0.15 (95% CI: -0.07, 0.37), as shown in Figure 7.

Other before-and-after comparison studies reported training or education programs changed workers' behaviors(57, 67, 69, 71, 72, 74). Janhong, et al. in 2005 and Chen et al. in 1996 evaluated practice improvement through comparison of practice scores change at baseline and after training(71, 72). The scores improved from 36% to 85% and from 55% to 89%, respectively.

Although there were consistent results for the effect of training or education programs, only one low-quality RCT and one CCT supported the positive effects. Based on these studies and the standard of evidence criteria, the evidence for the effects of training or education programs on changing worker's practice was considered limited.

Undoubtedly, the primary strategy to improve worker's health and safety is the reduction of environmental risk factors (e.g., machine guarding, adequate lighting and ventilation, etc) and changing incorrect work practices(76). In some studies the authors reported that training or education improved workers' behaviors or practices(58, 67, 69, 71, 72, 74), but the evaluation might overestimate the effect of intervention because the results were based on self-reporting by workers. Knowledge and practice may not go parallel. Workers may acquire enough knowledge through relevant training on health and safety, but they still implement incorrect practice because they are under work pressure or have low control.

Table 9 Clinical trials on practice improvement on OHS by training or education program

Authors	Subjects	Intervention	Follow up (months)	Quality score	Main findings	Effect size (95% CI)
Tsutsumi, et al. 2009(32)	A medium-sized company in Japan	1. Intervention group: n=47 workers receive participatory approaches. 2. Control group: n=50.	10	3	Work performance scores increased.	0.35(-0.05, 0.76)
Hulshof, et al. 2006(38)	Forklift truck drivers	1.Experientmental group: health education with specific program (n=180) 2. control group: usual care (n=80)	12	2	A positive influence on behavior of forklift workers (2.9 vs. 4.0).	0.06(-0.20, 0.33)

Figure 7 Effect sizes of practice improvement after training in two trials

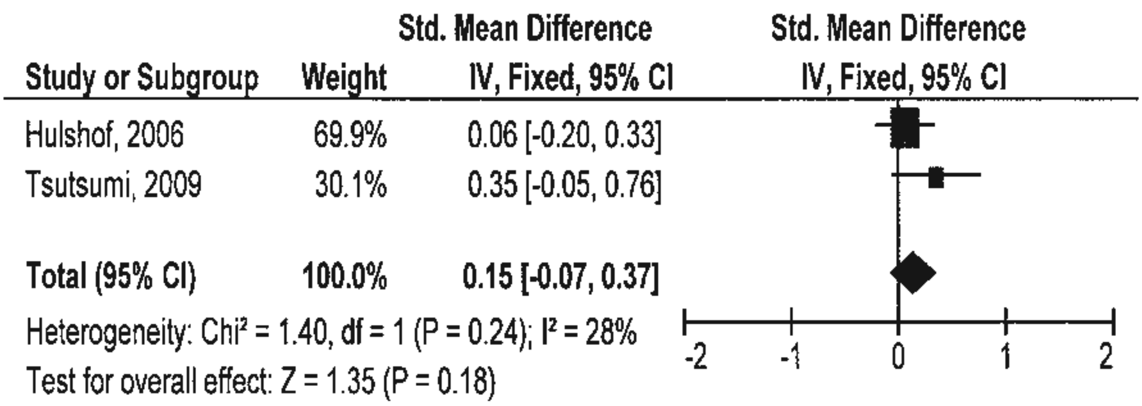


Table 10 Before-and-after studies on practice improvement on OHS by training or education program

Authors	Subjects	Intervention	Follow up (months)	Main findings
Mukherjee, et al. 2000(67)	Chemical workers	The UAB/CLEAR program had trained 1000 participants in 1992-1996. 300 workers were selected to investigate through mail.	-	Participants improved personal safety and health behaviors.
Robins, et al. 1990(57)	Employees of manufacturing facilities	5 plants were selected to evaluate the training effects (n=173).	24	60% of the employees reported having changed their work practices.
Marcoux, et al. 2000(69)	Office workers	Educational activities included posters and e-mail messages, workshops and information booklet (n=124).	12	Significant changes in self-reported posture were found.
Lippin, et al. 2000(74)	Chemical and energy workers and managers	Phone survey conducted with 362 workers and managers 6-12 months following empowerment-based health and safety training.		Changed in practice on workers' health and safety.
Janhong, et al. 2005(71)	Thailand farmers	Health education training program on safe use of pesticides provided to voluntary farmers (n=33).	-	The mean score (maximum score=42) for practice increased from 23.4 (56%) to 35.5 (85%).
Chen, et al. 1996(72)	Farmers in China	Educational program on safe use of pesticides for farmers in China.	-	The mean practice score improved from 36% to 89%.

2.12 Review on cost effectiveness and/or cost-benefit analyses of OHS training or education program

There were three non-randomized controlled trials which compared the cost and effectiveness of training or education program. Versloot, et al reported that the decrease in mean length of absenteeism was about 5-6.5 days per employee per year through the training program, which indicated that the program could save [US]$700-900 per employee per year(46). Heymans, et al. found that back school was most effective in reducing work absence and functional disability during 6 months follow up for the workers with LBP(47). Brown et al. investigated the effect of a back school rehabilitation program in municipal employees and examined the actual dollars saved in lost time and medical costs between groups for the workers with LBP. The study findings offered support for the back school as a cost-effective measure(48).

Lahirl, et al evaluated the effectiveness of different intervention methods for the prevention of occupationally induced back pain through model analysis and data collection from different WHO regions. They found that the effectiveness (reduction of low-back incidence) of training intervention was rather small (20% as compared to 74% for full ergonomics program and 56% for engineering controls). However, training intervention ranked high in terms of cost-benefit ratios (CBRs) because the total costs per worker of training were significantly lower than those of the other interventions (US$ 7.1 vs. US$ 37.8 for full ergonomics program and US$ 25.1 for engineering controls)(77).

Although these studies showed that training or education programs could save money for the companies or the program was cost-effective, we still concluded that there was no evidence for cost-effectiveness of training or education program because no RCT or CCT has been conducted to provide support.

2.13 What have we learnt from this literature review?

In summary, training or educational program has been regarded as one of the primary prevention measures by governments, organizations and companies. However, the effects of intervention measures were still under debate. Based on the review of previous studies, there was strong evidence for no effect of training or educational program on LBP prevention; moderate evidence for knowledge improvement in health and safety, and limited evidence for attitude change and practice improvement. There was no good evidence for injury reduction and cost saving through training or education programs. Different training methods might have different effects on injury and MSD prevention, and KAP change.

The failure to detect any effect of an intervention program may be due to inadequate sample size, a short period of follow up, inadequate implementation of the program, or a fundamental lack of efficacy of the intervention. Daltroy et al. conducted a RCT involving about 4,000 postal workers with 66 months follow up. This study was a large-scale, high-quality trial and could provide convincing evidence that a participatory training program had no long-term benefits associated with preventing LBP(31). However, most clinical trials evaluating the effects of training or education programs had small sample sizes. Moreover, some studies assessed the training effects only within a short follow up period and hence small numbers of outcome events. These factors might result in low statistical power in evaluating the effects of specific interventions.

The different studies included in our review evaluated the effects of OHS training programs. However, the training programs were quite heterogeneous, for example, back school program, active ergonomic program, participatory training, specific training or education on chemical harm and lifting technique, didactic training or education, etc. Training model, training period and training instructors varied with different studies, which should be considered when the main results from these studies were summarized. Although frontline workers were the main subjects in these studies, they could still be quite heterogeneous. Some studies focused on LBP prevention and so most of subjects were workers with much lifting activities, such as, home-care and hospital workers and cargo workers, etc. Few studies evaluated the effectiveness of training or education programs for OHS improvements among industrial workers. Moreover, no study was conducted to evaluate the effectiveness of participatory training and traditional training at same time.

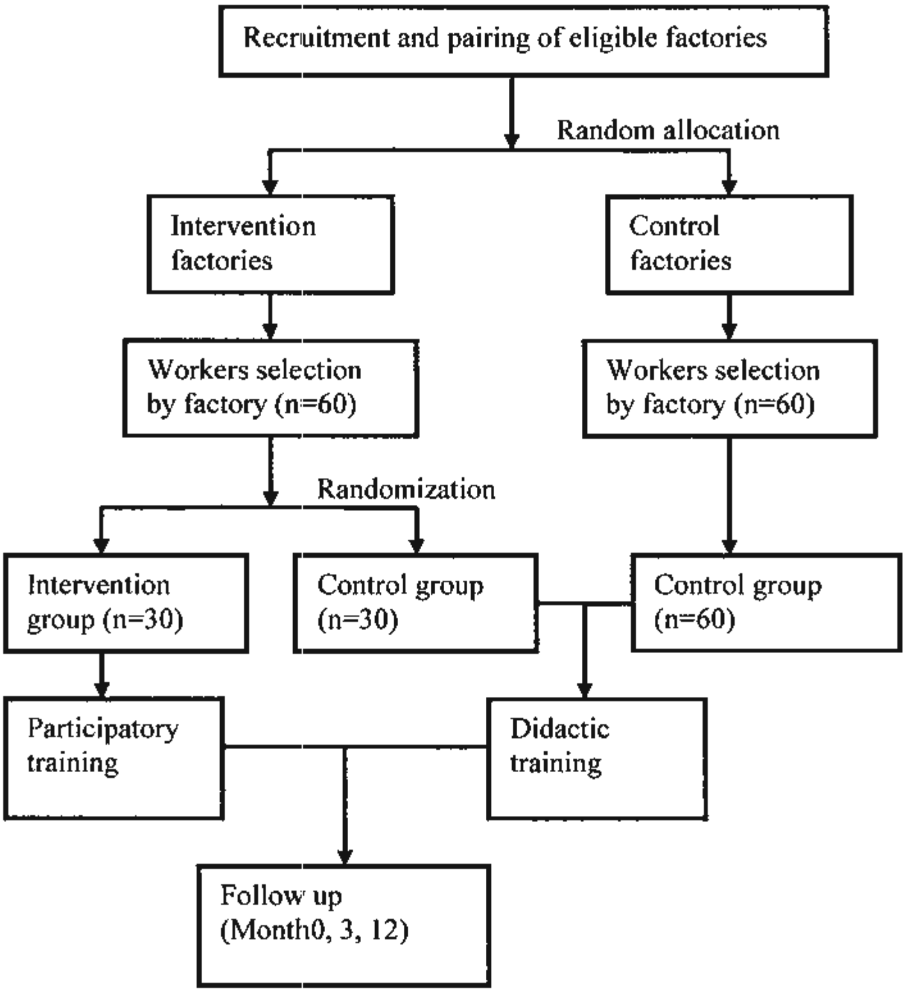
In the recent years, participatory training programs have become more and more popular for improving workers' health and safety. Obviously, the effects of this training method on improvement of workers' health and safety need further investigation and evaluation. Participatory training program would be introduced into factories of China for training the frontline workers. However, we don't know the effect of this training program. So this RCT was designed to evaluate the effectiveness of this training program.

Chapter 3 Methods

3.1 Research design

A Randomized Controlled Trial (RCT) with 0- (immediately after training), 3- and 12-month follow-ups was carried out to evaluate the effectiveness of different training programs in manufacturing factories in Shenzhen, China between January 2008 and May 2010.

Figure 8 Flow chart depicting subject recruitment and intervention allocation



A two-level random allocation process was adopted. Selected factories were first paired according to industry and size, and one of each pair was randomly assigned as intervention factory and the other as control factory. Within each intervention factory, around 60 workers were recruited and half were randomly allocated to the intervention group and half to the control group (Figure 8).

3.2 Factory and worker sampling

3.2.1 Sample size of factories and workers

The numbers of workers needed to detect important differences in injury incidence rates between intervention and control groups after training were calculated using the following formula, with a two-sided alpha of 0.05 and a statistical power (1-ß) of 0.90:

$$N = [(Z_{\alpha/2}\sqrt{4P\ (1-P)} + Z_{\beta}\sqrt{2P1(1-P1)+2P2(1-P2)})/(P1\text{-}P2)]^2$$

$Z_{\alpha/2}$=1.96
Z_{β} =1.282
P1=proportion of one indicator in the intervention group
P2= proportion of one indicator in the control group
P=(P1+P2)/2
Assuming equal numbers in the two groups

3.2.1.1 Sample size of workers

We selected injury incidence rates as the indicator to calculate sample size of workers. According to the results of pilot study, the incidence rate of work-related injury was about 10% in industrial workers in Shenzhen. We expected that the incidence rate would decline to 5% after intervention. So P1 and P2 were determined as 10% and 5%, and then the sample size of workers was calculated to be about 1,162 based on the above formula.

To allow for a 30% drop-out rate due to the high mobility of migrant worker in Shenzhen, the sample size was adjusted to 1,512 workers.

Adjusted sample size of workers = 1,162 × 1.3 = 1,512

Further adjustment was also made for the cluster sampling used and the required number of individuals in each group should be multiplied by a variance inflation factor (VIF) or design effect. The variance inflation factor equals to [1+(m-1) ρ], where m=average of unit size (60 workers per factory) in a cluster, ρ =ICC (intra-cluster correlation coefficient). Based on Kerry and Ukoumunne's papers, we assumed the ρ = 0.0032 for this study(78, 79), and then the variance inflation factor was estimated to be 1.195.

Adjusted final sample size of workers = 1,162 × 1.30 × 1.195 inflation factor ≈ 1,800

Then the final actual sample size of workers was about 1,800 in total for both groups-intervention group and control group. So there would be about 900 workers in the intervention groups and 900 workers in the control groups.

3.2.1.2 Sample size of factories

We planned to train about 30 frontline workers in each training course in one intervention factory with participatory training. So the sample size for intervention factories was 30.

Sample size of intervention factories = 900 frontline workers/(30 workers/factory) = 30

Accordingly there were 30 control factories. The total sample size of factories was 60 in this study.

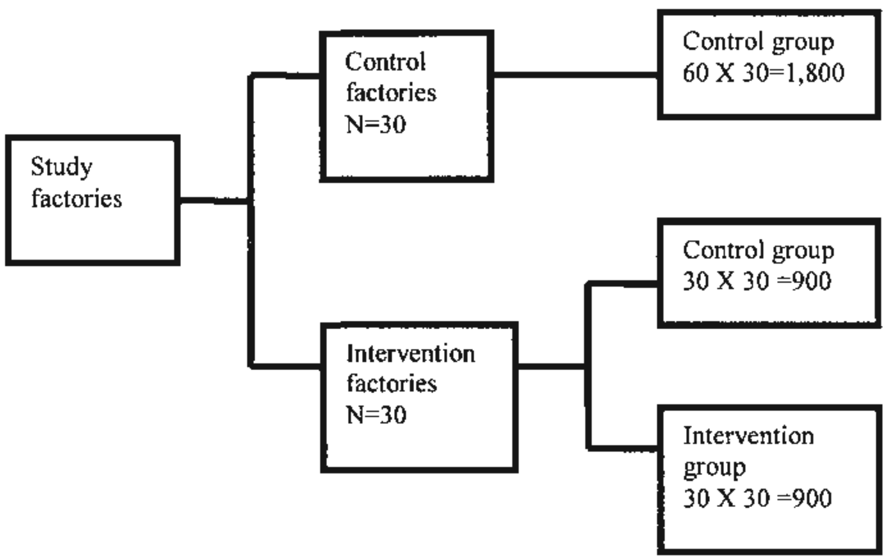
3.2.1.3 Actual sample sizes of factory and worker

In this study we included a control group in each intervention factory in an attempt to minimize the influences of different management systems and cultures in different factories. On the other hand, to clarify if effects observed in the control group in the intervention factories were not due to contamination, we incorporated a control group from the control factories. There would be 30 intervention subgroups and 30 control subgroups from the 30 intervention factories, and 30 control subgroups from the 30 control factories.

For each intervention factory, around 60 workers would need to be recruited and randomized into two groups. We recruited about 60 workers in each control factory as well, so that the total number of workers receiving training (any form) in each factory would be roughly equal.

Finally the number of intervention workers would be about 900 and the number of control workers would be about 2,700, and the total sample size of workers was 3,600 (Figure 9).

Figure 9 Distribution of workers in the various groups



3.2.2 Recruitment and pairing of eligible factories

Centers for Disease Control and Prevention (CDC) at district and township levels in Shenzhen identified appropriate factories from the local factory registries and invited the factories to participate in the study. The inclusion criteria for factory were: (1) medium-size industrial companies (about 300-2,000 workers in each factory)(80); (2) can be matched with another factory by industry and production processes; (3) less than 30% turn-over rate of workers in one year. Eligible factories were then paired according to industry, production processes and employment size.

Finally 110 matched pair factories were eligible and included as study factories for the training project. We selected 30 matched pair factories from these matched pair factories through random sampling method.

3.2.3 Factory allocation

Once the 30 matched pairs of factories were determined, one factory from each pair was randomly assigned as the intervention factory and the other as the control factory by tossing a coin.

The managers of the factories were not informed of the intervention status, but were just told the requirements of the assigned training program and worker selection criteria.

3.2.4 Worker selection

Factory managers were asked to use the following inclusion and exclusion criteria to select employees as participants in the intervention and control factories. The inclusion criteria were: (1) employment in the current factory for over 12 months; (2) frontline production workers. The exclusion criteria were: (1) employees in administration, design and logistics; (2) illiterate; (3) seasonal migrant workers.

About 60 workers in each factory were selected by the management. The name list of workers was sent to Shenzhen Hospital for Occupational Disease Prevention and Control before the training.

3.2.5 Random allocation of workers to intervention or control groups

After receiving the name list from each intervention factory, a project coordinator in Shenzhen Hospital for Occupational Disease Prevention and Control would use the randomization function of EXCEL to allocate workers into the intervention or control group.

The group lists would then be sent back to the factory, and the management arranged workers to attend the training programs according to the randomized name lists. The workers were only told to attend an occupational health and safety training course, without any information about the hypotheses of the intervention study. During this period, the allocation codes were concealed to the factories and workers.

3.3 Intervention

The workers in the intervention groups of the intervention factories received participatory training, and workers in the control groups of both intervention factories and control factories received didactic training.

Occupational health experts from the Hong Kong Workers' Health Center (a non-governmental organization in Hong Kong providing occupational health education for over 20 years) and the Shenzhen Hospital for Occupational Disease Control and Prevention were invited as instructors to conduct the training activities. Eight experts from the two organizations formed a teaching team for the training programs. They had received relevant training on teaching methods in both participatory training and didactic training before this project.

The investigators (from the Chinese University of Hong Kong) were not involved in the training activities. They were only present during the training sessions to administer the questionnaires and collect the relevant data about the factories and workers before and after training.

3.3.1 Participatory training

3.3.1.1 POHSI training program

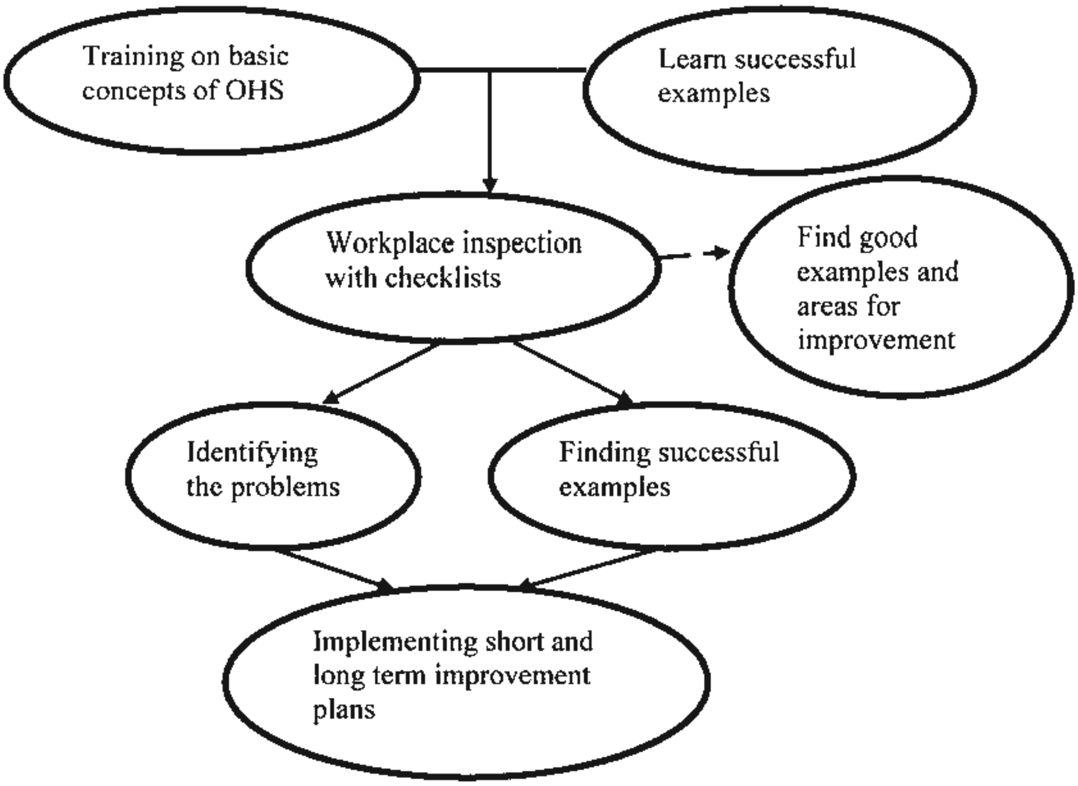
The participatory training approach had been adopted in workplaces in Hong Kong for some years. The Hong Kong Worker's Health Center and other occupational health experts in Hong Kong developed a participatory training model called Participatory Occupational Health and Safety Improvement (POHSI) adopted from the original POSITIVE training program in Japan. POSITIVE (Participatory Oriented Safety Improvements by Trade union InitiatiVE) training was developed by the Japan International Labor Foundation (JILAF) with the cooperation of the Institute for Science of Labor in the beginning of 1990s(81). This training program was subsequently introduced in other countries in Asia, such as Pakistan, Philippines, and Thailand(22, 23). POSITIVE program adopted a new action-oriented approach, which emphasized the active participation of trade union leaders and workers' representatives in planning and implementing practical improvements in safety and health.

Frontline workers receive knowledge of occupational health and safety through participation in activities in the POHSI training. The training program is carried out according to the following guiding principles(82): (1) developing concrete and practical plans for improving occupational health and safety (2) joint evaluation by employee representatives and management to identify good examples of OHS in the workplace, as well as areas that need improvements; (3) based on the principles of low cost and prompt action; 4) start with simple improvement work that can be easily implemented and continue to learn from the good examples of others; 5) improving OHS awareness of workers through group discussions; 6) promote communication between employers and employees, in order to achieve the win-win outcome of improving workplace health and safety.

3.3.1.2 Implementation of POHSI training program

The purposes of POHSI training program are to improve workers' knowledge, change their attitude and enhance their good practice. This training program focuses on learning successful examples from other workplaces or factories and developing concrete and practical plans on OHS improvements. There are four main steps for the whole training program (Figure 10). Workers are first given a brief introduction to strengthen basic concepts of occupational health and safety and learn successful examples on improving OHS in other workplaces. They are then divided into small groups and conduct a workplace inspection exercise using a checklist to identify existing good examples, as well as areas that need improvement. This is followed by group discussions to agree on the list of good/successful examples, and to find solutions for areas that need improvement. All small groups will then report back to the big group, with the management joining in, on their priority lists of action plans for improvements. Finally, participating employee and management representatives will sort out the priority for both immediate and long-term improvement plans.

Figure 10 POHSI training program



3.3.1.3 Program contents of POHSI training

The training materials employed in the current study were developed by the occupational health experts from the Hong Kong Workers' Health Centre and Shenzhen Hospital for Occupational Disease Control and Prevention based on the contents of POSITIVE training course and taking into consideration the situation of factories in China mainland. The training contents covered three core OHS areas and three elective areas. The three core areas were included in the training activities of all factories, and were work station (including ergonomic and materials handling), machine safety, and working environment (including workers' welfare). In addition, one elective area among three - chemical safety, dust control, or noise control was selected for each pair of factories according to the specific industry type.

3.3.1.4 Activities involved in POHSI training

About 30 workers attended the participatory training course in each intervention factory, with the facilitation of three instructors from the training team. The training activities comprised of short presentations on the four OHS areas/topics, games, group discussions, a workplace inspection visit with checklist, demonstration and practice of personal protection equipment (PPE), stretching and strengthening exercise and presentations by group representatives (Table 11). The whole training session lasted about five hours.

A 20-minute short presentation for each of the four topics/areas (working station, machine safety, working environment and dust/chemical/noise prevention) was given by an instructor, and was followed by a small group discussion (6-10 workers per group). The participants learnt good examples through viewing photos and discussions. Group games were also arranged to strengthen the attitude of cooperation and concepts in material handling safety. Stretching and strengthening exercises were taught and practiced after the session on working station.

Workplace inspection visit is a very important component of participatory training. The small groups would do a site inspection exercise using a checklist [Appendix IV] to identify good examples of OHS practices, as well as areas for improvement. In the group discussion following the visit, instructors facilitated participants to summarize the good examples identified and areas that needed improvements in the workplace, and discuss solutions and recommendations for occupational health and safety improvements. Concrete action plans were discussed and prioritized, and reported by group representatives to the whole class afterwards.

3.3.2 Didactic training

Workers in the control group in the intervention factories and the control factories received conventional didactic training. Two instructors from the teaching team provided the training activities. The training contents and materials were the same as for participatory training, covering the same 4 areas/topics. Only short presentations were given, with no group discussions, games or workplace visits. The whole training session lasted about two hours (Tables 11 and 12).

Table 11 Timetable of participatory training and didactic training

Items	Participatory training	Didactic training
Introduction	10 min.	10 min.
Pre-training questionnaire	15 min.	15 min.
Presentation on Machine Safety	20 min.	20 min.
Discussion	20 min.	-
Games	20 min.	-
Presentation on Working Environment	20 min.	20 min.
Discussion	20 min.	-
Presentation on Work Station	20 min.	20 min.
Discussion	20 min.	-
Stretching and strengthening exercise	20 min.	-
Presentation on Dust/Chemical/Noise Control (including PPE demonstration)	20 min.	20 min.
Discussion	20 min.	-
Workplace inspection visit	30 min.	-
Discussion	30 min.	-
Post-training questionnaire	15 min.	15 min.
Total	300 min.	120 min.

Table 12 Comparisons between participatory training and didactic training

Items	Participatory training	Didactic training
Number of participants	about 30	about 30
Training materials#	4 of 6 topics	4 of 6 topics
Instructors#	3	2
Short presentations#	4	4
Group discussions	√	×
Games	√	×
Workplace inspection visit	√	×
PPE demonstration and practice	√	PPE demonstration
Stretching and strengthening exercise	√	×
Group presentation	√	×
Total duration	about 5 hours	about 2 hours

Same contents and instructors involved

3.4 Data collection

The follow up assessments were conducted immediately after training, and at three months and one year after training to evaluate the effectiveness of the training programs. The data included factory information, work-related injury events, MSD prevalence, KAP of workers, and expert assessment of OHS of the factories.

3.4.1 Factory investigation

General information about each factory was obtained at baseline through face-to-face interviews with factory managers and/or staff in charge of occupational health, including industry type, production processes, employment size, known occupational hazards, OHS committees and OHS training activities for workers. In addition, work-related injury events and occupational diseases occurrences were checked in detail through the records. Information about medical costs, compensation costs and workday lost due to injuries was also collected (Appendix I).

Information collection was done at baseline and one year after training. At one-year follow up, co-intervention activities in the factories after the originally assigned training program were also noted.

3.4.2 Evaluation of KAP of workers

3.4.2.1 Contents of KAP evaluation questionnaire

The first part of the Worker's KAP Evaluation Questionnaire (Appendix II) focused on demographic information, including gender, age, educational level and birthplace (province).

The second part of the questionnaire was mainly on the current job, including working hours, job position, experience in current job, work stress, work relationships and satisfaction on current job. Other information collected included pre-employment and on the job training, as well as experiences in previous jobs and injury history.

The third part of questionnaire was evaluation on KAP. Four out of six areas/topics corresponding to the training contents (see above) were included. For each topic, four statements each for knowledge, attitude and practice were given for worker to self evaluate and report, giving a total of 16 statements each for knowledge, attitude and practice.

The final part of questionnaire is worker's evaluation on the training program.

3.4.2.2 Reliability and validity of questionnaire

The KAP Evaluation Questionnaire was developed based on some prior surveys conducted in Shenzhen and Hong Kong, China. The questionnaire was then sent to eight occupational health experts (three Hong Kong experts and five experts of mainland China) to evaluate the content validity. The process was repeated after making modifications suggested by the individual experts. Finally the experts reached an agreement on the relevant items included for knowledge, attitude and practice evaluation under each topic area.

The questionnaire was then pilot-tested in Shenzhen factories to examine the reliability. The Cronbach's Alpha was 0.71 for knowledge, 0.67 for attitude and 0.61 for practice, suggesting reasonably good internal consistency.

3.4.2.3 Investigation methods

All participants filled in the KAP Evaluation Questionnaire before training, immediately after training, and at three months and one year after training. The participants gathered in one training room to fill in the questionnaire with assistant-administered method. The investigator explained the items of the questionnaire and instructed the workers on how to fill in the questionnaire. Participants were given 15 minutes to complete the questionnaire and return it to the investigator.

3.4.3 Investigation on work-related injury

In this study work-related injury events referred to acute traumatic injuries at work that required medical attention or treatment or interfered with work activities.

The work-related injury events during the past 12 months were enquired, and information on the related medical and compensation costs, as well as workdays lost was collected.

All participants filled in the relevant questions to report work-related injury events with assistance of the investigators (Appendix II). The investigations on injury were carried out at baseline and one year after training.

3.4.4 Investigation on sick leave

Sick leave is time off from work during periods of temporary sickness to stay home and address their health and safety needs without losing pay or their jobs.

All participants reported the workdays lost because of sick leave during the past 12 months with assistant-administered method (Appendix II). The investigations on sick leave were carried out at baseline and one year after training.

3.4.5 Investigation on MSD among workers

The Musculoskeletal Disorder Symptom Checklist had been developed based on the Nordic Standard Form for MSD(83) and used for many years in Hong Kong(84) (Appendix III). The workers were asked to report experiences of ache, pain or discomfort in 10 body parts: neck, shoulder, low back, upper back, thigh/knee, low leg, ankle, elbow, hand/wrist and finger, as well as their impacts on work activities and associated medical costs.

The Musculoskeletal Disorder Symptom Checklist was completed twice, first before training and then at one year follow-up after training.

3.4.6 Occupational health expert assessment

An occupational health expert was engaged to assess the occupational health and safety performances of the factories using a checklist. The expert was not involved in the study design, training activities and did not know the intervention allocation for the factories assessed.

3.4.6.1 Contents of assessment checklist

We developed the Expert Assessment Checklist for Worker's Health and Safety (Appendix IV). The checklist was revised two times after taking into consideration the comments and recommendations from eight occupational health experts. The checklist covered exposure assessment, risk characterization and control measures for occupational hazards in factories in the first part. In the second part, the expert was asked to grade the performance of each factory on materials handling, work station, machine safety and working environment.

3.4.6.2 Methods of field assessment

Each factory was visited twice by the occupational health expert: once before the training session and then one year after the initial training. During these visits, the expert conducted a diagnostic walk-through of the facility by using the checklist.

The expert evaluated the potential physical/chemical/biological health hazards through grading of the exposure assessment, risk characterization and control measures.

For exposure assessment, there were three indicators: (1) intensity - from 0-5, ranging from no important exposures to extremely high intensity of exposure; (2) duration - from 0-5, ranging from no important exposures noted for any duration to exposures lasting the entire work-shift; (3) frequency - from 0-5, ranging from seldom exposures noted for any duration to continual or frequent exposures for current work.

For risk characterization, there were two indicators: (1) prevalence ranging from 0 to 5, with 0 indicating health risk not affecting any worker, and 5 indicating majority of workers were likely affected; (2) level ranging from 0 to 5, with 0 indicating health risk not present or negligible, and 5 indicating extremely high risk to health of exposed workers.

For control measures, three aspects were evaluated: (1) engineering, ranging from 0, indicating no engineering control measures were in place, to 5, suggesting that highly effective engineering control measures were used throughout the factory; (2) administrative, ranging from 0 (no administrative control measures being practiced) to 5 (highly effective administrative control measures were in common practice); (3) personal, ranging from 0 (appropriate personal protective measures were not provided and/or utilized) to 5 (appropriate personal protective measures were properly used).

The expert also graded the performances and practices of the factory and workers from 0 to 5 in the four areas of materials handling, work station, machine safety and working environment, with 0 standing for not practiced at all and 5 standing for excellent practices throughout the factory.

3.5 Data analysis

We used EPIData 3.1 to set up the questionnaire and enter the data. Then all data were analyzed with SPSS 16.0 for Windows. The main outcomes of this study included injury incidence, MSD prevalence, workers' KAP and cost-benefit ratios. The above indicators were compared between the intervention groups and the control groups and before and after training. The "intention-to-treat" analysis and per-protocol analysis principles were applied in the statistical analysis.

3.5.1 Descriptive analysis

The basic characteristics of the participating factories and workers by intervention status were described, as well as the participation and response rates at the different time points.

3.5.2 Scoring for KAP

There were four statements each for knowledge, attitude and practice under each of the four topic areas, giving a total of 16 statements each for knowledge, attitude and practice.

3.5.2.1 Knowledge scoring

True or false statements were used to evaluate worker's knowledge on health and safety. One mark was given for each correct answer and zero mark for a wrong or missing answer. The summed raw score from 0-16 was then transformed to a scale of 0-100 by multiplying the raw score by 6.25.

3.5.2.2 Attitude scoring

We used five choices at different levels of agreement to the given statements to evaluate workers' attitude on occupational health and safety. Answers on a five-point Likert scale were rated by assigning a value from 0 to 1, where a higher score was related to a positive attitude and expectancy towards preventive possibilities of the program and a lower score (close to 0) to a negative attitude and a pessimistic outlook.

Example 1, a description of **"Good working posture can prevent musculoskeletal disorders effectively"**, has five choices **"1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree"**. We rate different scores for workers' different selections: 0 for **"strongly disagree"**, 0.25 for **"disagree"**, 0.5 for **"neutral (not disagree or not agree)"**, 0.75 for **"agree"** and 1 for **"strongly agree"**. If one worker selects strongly disagree, then he/she gets zero mark.

Example 2, a statement of "**Machine guards are a nuisance as they cause inconvenience to my work**", has five choices **"1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree"**. We rate different scores for workers' different selections: 1 for **"strongly disagree"**, 0.75 for **"disagree"**, 0.5 for **"neutral (not disagree or not agree)"**, 0.25 for **"agree"** and 0 for **"strongly agree"**. If one worker selects strongly agree, then he/she gets zero mark.

The summed raw score from 0-16 was then transformed to a scale of 0-100 by multiplying the raw score by 6.25.

3.5.2.3 Practice scoring

We listed 16 statements under four areas on behaviors and practices in occupational health and safety, and asked the workers to report yes or no for their usual practices. Yes to a good practice or no for a bad practice would score one mark, otherwise no marks would be given.

The summed raw score from 0-16 was then transformed to a scale of 0-100 by multiplying the raw score by 6.25.

3.5.3 KAP score comparison

The KAP scores were compared with one-way ANOVA at different time points and in different groups and different industry types. Paired T test was used to compare the within differences of knowledge scores in the intervention group and pooled control groups at different time points. The workers' KAP scores before training might affect the effectiveness of training, it was necessary to conduct the analysis of covariance with the baseline scores as a co-variate to compare the KAP differences at different time points between the intervention groups and control groups.

This was a repeated measures design because we evaluated the KAP scores at baseline, immediately post-training, and three months and one year after training. So the approach of repeated measures ANOVA was used to compare the time trend of the KAP score change at different time points.

To explore the factors influencing KAP scores, we used Linear Regression with Backward Stepwise method to evaluate the relationship between KAP score and gender, educational level, job position, previous work experience, duration of employment, pre-employing and on-job training and age. Furthermore, we also explored the correlations among workers' knowledge, attitude and practice.

3.5.4 Injury incidence

We evaluated the person-based incidence rate of injury and the event-based incidence rate of injury in different groups at different time points. The person-based incidence rate of injury refers to the number of workers with injury among all workers in a particular group. The event-based incidence rate refers to the number of work-related injury events among all workers in a particular group. One worker could have several injury events in a year.

The Chi-square test was applied to compare person-based incidence rates of injury for different groups and different industry types. The average medical costs and compensation costs for each injury event were calculated in different groups. Moreover, we compared the difference of incidence rates of injury events in different groups between baseline and one year after training with two-proportion Z test(85, 86).

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - d_0}{\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n2}}}$$

Logistic Analysis with Backward Stepwise method was used to estimate odds ratios and 95% CI of factors associated with injury cases, including gender, educational level, work hours per week, duration of employment, previous work experience, position, work stress, injury history and industry type. Same approach was used to determine associations of knowledge, attitude and practice level with injury events while adjusting for gender, educational level, work hours per week, duration of employment, job position, work stress, injury history and industry type.

3.5.5 The proportion of taking sick leave

The Chi-square test was applied to compare the proportions of workers' taking sick leave for different groups and different industry types at different time points. Logistic Analysis with Backward stepwise method was used to estimate odds ratios and 95% CI of factors associated with sick leave, including gender, educational level, work hours per week, duration of employment, previous work experience, position, work stress, injury history and industry type.

3.5.6 MSD prevalence

The Chi-square test was used to compare MSD prevalence rates during the past 12 months among different groups and different industry types. The characteristics of MSD, such as duration, impacts on work activities and associated medical costs were described. We also compared the MSD prevalence rates of different groups between baseline and one year after training with Chi-square test.

Logistic Regression with Backward stepwise method was used to estimate odds ratios and 95% CI of factors associated with MSD, including gender, educational level, duration of employment, work hours per week, work stress, previous work experience, injury history and industry type and age groups, training experience. Same approach was used to determine associations of knowledge, attitude and practice level with MSD events with the adjustment of gender, educational level, work hours per week, job position, work stress, injury history and industry types and age groups.

3.5.7 Occupational health expert assessment

We used one-way ANOVA to compare the OHS performance scores among the different factories. As workers might over-report on correct practices, we examined the correlation between self-reported practice scores on PPE use and the grading through expert evaluation to see if adjustments for the practice scores were necessary.

Logistic Regression with Enter method was used to estimate odds ratios and 95% CI of factory performance (materials handling, work station, machine safety and working environment) with injury. Paired T test was applied to compare the difference of factory performance at baseline and one year of training.

3.5.8 Worker's self-evaluation on training program

The Chi-square test was used to compare the evaluation of the contents, training methods and KAP improvements, as well as impacts on factory OHS by workers in the different groups.

3.5.9 Costs and benefits of training program

We calculated the costs for participatory training and didactic training. The costs included the expenditures of training organizations and factories. The costs for the training organization included training materials and wages and transportation fees for instructors. Factory costs included wages for workers during the training sessions.

The benefits for different training methods included savings from reduction of medical and compensation costs, as well as reductions in workdays lost from work injuries and sick leaves from MSD and other causes.

3.6 Quality Control

3.6.1 Factory selection

Eligible factories fulfilling clear inclusion criteria were first listed and each factory was paired with another factory in the same industry and with similar production processes and employment size to make the intervention and control factories more comparable.

3.6.2 Random allocation

For each matched factory pair, one was allocated randomly as the intervention factory and the other as control factory. Workers in the intervention factories were also randomly allocated into an intervention group and a control group. Effective randomization should ensure comparability and minimize confounding.

The factories were not informed of the intervention status to ensure concealment of allocation code of factories. The factory arranged the workers attending the training course according to the randomized name list to ensure the concealment of worker allocation.

3.6.3 Training implementation

The same two instructors were involved in delivering the short presentations in both the intervention and control groups in every matched pair of factories. The intervention training sessions had two additional instructors to facilitate the group activities and discussions. Same training materials were prepared for both the intervention and control groups. The number of participants in each training session was similar (about 30 workers).

3.6.4 Data collection

The investigators doing data collection did not know the allocation statuses of the factories and the workers. The occupational health expert conducting factory OHS assessment was blinded to the factory allocation.

3.7 Ethical consideration

The Survey Ethics Committee of the Chinese University of Hong Kong approved this study.

Chapter 4 Results

4.1 General information

4.1.1 Distribution of factories and workers in different groups

From June 2008 to December 2009, OHS training sessions were conducted in 60 factories (30 pairs), including 22 electronics factories (36.7%), 8 printing companies (13.3%), 8 toy factories (13.3%), 6 plastic factories (10.0%), 4 optical factories (6.7%), 4 footwear factories (6.7%), 4 jewelry factories (6.7%) and 2 metal products factories (3.3%) and 2 pharmaceutical factories (3.3%), as shown in Table 13. Follow-up was until one year after training or up to May 31, 2010.

Table 13 Distributions of factories and workers by industry types in the different groups

Industry type	Factory			Trained workers			
	Intervention	Control	Total(%)	Intervention	Control_1	Control_2	Total (%)
Electronics	11	11	22(36.7)	340	306	632	1,278(36.7)
Printing	4	4	8(13.3)	113	127	208	448(12.9)
Toy	4	4	8(13.3)	118	127	184	429(12.3)
Plastic	3	3	6(10.0)	100	100	196	396(11.4)
Optical	2	2	4(6.7)	79	75	113	267(7.7)
Footwear	2	2	4(6.7)	56	73	101	230(6.6)
Jewelry	2	2	4(6.7)	59	66	116	241(6.9)
Metal products	1	1	2(3.3)	24	33	40	97(2.8)
Pharmaceutical	1	1	2(3.3)	29	0*	64	93(2.7)
Total	30	30	60(100)	918	907	1,654	3,479(100)

- Each intervention factory had two groups: intervention group and control group.
- Each control factory only had one control group.
- Control_1 group was the control group in intervention factory
- Control_2 group was the control group in control factory
- *One pharmaceutical factory only selected 29 workers for participatory training course.

Among the 3,479 eligible workers who attended the training programs (350 workers were excluded from this study because they did not work for over 12 months), 918

(26.4%) were in the intervention groups of the intervention factories and received participatory training, 907 (26.1%) were in the control groups of the intervention factories (control_1 group) and 1,654 (47.5%) were in the control factories (control_2 group) and they all received didactic training.

4.1.2 Workers' response rates

Among all workers receiving training, the average response rate for the evaluation immediately after training was 92.0% (85.7% in intervention group, 94.4% in control_1 group and 94.1% in control_2 group).

By the end of May 2010, three-month follow-ups have been completed in all 60 factories. During the global economy crisis and recession in late 2008 and early 2009, two factories closed down and many frontline workers in the surviving factories returned to their hometowns due to reduction or suspension of factory production processes. Hence, the response rates were much lower than expected at the three-month follow-ups during that period. The average response rate for the trained workers at three-month follow-up was 71.1% (71.5% for intervention group, 71.3% for control_1 group workers and 70.7% for control_2 group workers), as shown in Table 14.

At one-year after training, another factory closed down and so the trained workers in the three closed factories were lost to follow up (two electronic factories and one jewelry factory). One year follow-up has been completed for 32 factories (16 intervention factories and 16 control factories) by the end of May 2010. The final follow up rate was 56.3% for the 2,347 trained subjects in the 32 factories. The rates were 56.1% for intervention group, 53.4% for control_1 group and 58.9% for control_2 group.

Table 14 Response rates of trained workers at immediate evaluation, three-month follow up and one-year follow up after training in different groups

Group	Immediate evaluation			3-month follow up		One-year follow up		
	No. of trained workers	No. of respondents	Rate (%)	No. of respondents	Rate (%)	No. of eligible subjects	No. of respondents	Rate (%)
Intervention	918	787	85.7	656	71.5	766	430	56.1
Control_1	907	856	94.4	647	71.3	743	397	53.4
Control_2	1,654	1,557	94.1	1,170	70.7	838	494	58.9
Total	3,479	3,200	92.0	2,473	71.1	2,347	1,321	56.3

4.1.3 Factory information

There were totally 53,866 frontline workers (80.9% of total employees) in the 60 participating factories, and only 3,479 workers (6.5%) of them were included in the training programs.

Only 31.7% (19/60) factories had Committees on Occupational Health and Safety, and no frontline workers were involved in the Committees in these factories, as revealed by the relevant factory records. Furthermore, the Committees seldom conducted specific activities on worker's health and safety in workplace.

About 68.3% (41) and 81.7% (49) factories reported that they conducted pre-job training and on-job training for the frontline workers respectively. However, according to the workers' self-reporting, only 61.4% (1,310/2,134) and 61.2% (1,305/2,134) frontline workers received OHS training before their employment of current work and during current work respectively.

4.1.4 Basic characteristics of trained workers in different groups

Table 15 presents the basic characteristics of trained workers at baseline in the three groups. There were no statistically significant differences in age, gender, education, place of origin, job position, duration of employment, training experience, previous work experience and injury history in the three groups (p values > 0.05).

Table 15 Basic characteristics of trained workers at baseline in intervention group, control_1 group and Control_2 group

Characteristics	Workers distribution (%)			Total	P value
	Intervention	Control_1	Control_2		
No. of workers	918(26.4)	907(26.1)	1,654(47.5)	3,479(100)	-
Age (mean±SD)	29.1±7.3	28.9±7.4	28.3±7.1	28.7±7.2	0.116
Gender:					
Male	541(58.9)	516(56.9)	914(55.3)	1,971(56.7)	0.195
Female	377(41.1)	391(43.1)	740(44.7)	1,508(43.3)	
Education level:					
Primary school	41(4.5)	35(3.9)	72(4.4)	148(4.3)	0.068
Middle school	460(50.2)	472(52.0)	927(56.0)	1,859 (53.5)	
High school	357(38.9)	350(38.6)	556(33.6)	1,263(36.3)	
>=University	59(6.4)	50(5.5)	99(6.0)	208(5.9)	
Place of origin#:					
Eastern China	26(2.8)	27(3.0)	23(1.4)	76(2.2)	0.109
Central China	446(48.6)	419(46.2)	740(44.7)	1,605(46.1)	
Western China	306(33.3)	299(33.0)	622(37.6)	1,227(35.3)	
Local	140(15.3)	161(17.8)	269(16.3)	570(16.4)	
Job position:					
Frontline workers	647(70.5)	654(72.2)	1,166(70.6)	2,467(71.0)	0.908
Team leaders	220(24.0)	203(22.4)	388(23.5)	811(23.3)	
Others▲	51(5.5)	49(5.4)	97(5.9)	197(5.7)	
Duration of employment:					
12-23	472(51.4)	461(50.8)	866(52.4)	1,799(51.7)	
>=24	446(48.6)	446(49.2)	786(47.6)	1,678(48.3)	0.702
Pre-job training:					
Yes	255(62.7)	283(66.4)	772(59.3)	1,310(61.4)	0.101
No	152(37.3)	143(33.6)	529(40.7)	824(38.6)	
On-job training:					
Yes	244(60.7)	285(65.2)	776(59.9)	1,305(61.2)	0.126
No	158(39.3)	152(34.8)	520(40.1)	829(38.8)	
Previous work experience▼:					
Yes	581(63.8)	566(63.2)	1,054(64.5)	2,201(64.0)	0.784
No	329(36.2)	330(36.8)	579(35.5)	1,238(36.0)	
Injury history¥:					
Yes	66(7.2)	63(6.9)	100((6.0)	229(6.6)	0.468
No	852(92.8)	844(93.1)	1,554(94.0)	3,250(93.4)	

#Eastern China includes Shanghai, Jiangsu, Zhejiang, Shandong, Fujian, Liaoning, Beijing, Tianjin; Central China includes Heilongjiang, Jilin, Hebei, Henan, Hunan, Anhui, Jiangxi, Hubei, Hainan, Shanxi; Western China includes Inner Mongolia, Xinjiang, Tibet, Yunnan, Sichuan, Chongqing, Guangxi, Shaanxi, Gansu, Qinghai, Ningxia, Guizhou; Local region includes Guangdong.

▲Others include managers and staff in charge of occupational health.

▼Workers had previous work experience in other factories before current work.

¥Workers had injury events before current work.

4.2 Knowledge improvement

4.2.1 Baseline knowledge scores

The mean knowledge scores at different time points in the intervention group and two control groups are described in Table 16. At baseline the mean knowledge score of 3,479 subjects was 64.9±15.0. There was no statistical significant difference (p=0.394) for knowledge scores between intervention group (64.3±16.3), control_1 group (65.0±13.9) and control_2 group (65.1±14.9).

Table 16 Worker's knowledge scores (mean±SD) at different time points in intervention group, control_1 group and control_2 group

Group	Baseline		Immediate evaluation after training		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Intervention	918	64.3±16.3	787	83.4±10.9	656	80.5±10.9	430	78.3±11.1
Control_1	907	65.0±13.9	856	83.2±12.7	647	80.4±10.9	397	76.8±11.4
Control_2	1,654	65.1±14.9	1,557	82.1±12.8†,‡	1,170	78.2±12.0†,‡	494	75.2±13.2†
Total	3,479	64.9±15.0	3,200	82.7±12.3	2,473	79.3±11.5	1,321	76.7±12.1
P value		0.394		0.012		<0.001		<0.001

† Compared with intervention group, $p<0.05$

‡ Compared with control_1 group, $p<0.05$

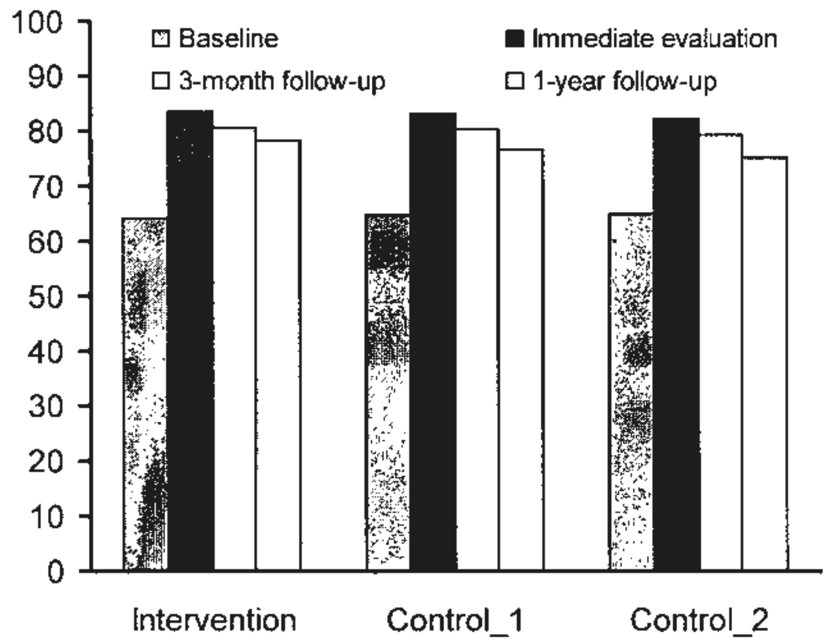
4.2.2 Knowledge score improvement after training

The knowledge scores increased remarkably at different time points after training compared with the baseline score. The average score of 3,200 respondents increased to 82.7±12.3 when we evaluated the scores immediately after training ($p<0.001$). The overall average knowledge scores were 79.3±11.5 at three month of training and 76.7±12.1 at one year of training, much higher than the baseline score (p values <0.001) as shown in Table 16.

4.2.3 Knowledge improvements in different groups

Statistical significances were found for knowledge scores at different time points in different groups ($p=0.012$ at immediate evaluation, $p<0.001$ at three months and at one year after training). Table 16 and Figure 11 showed that the knowledge scores of intervention groups were higher than those of control_2 groups at different time points after the training program (p values <0.001). Although the scores of the intervention group were higher than that of control_1 group at different time points after training, there were no statistically significant differences ($p=0.912$, $p=0.959$ and $p=0.226$).

Figure 11 Mean knowledge scores at baseline, immediately after training, three-month and one-year follow-up in intervention group and control_1 and contrl_2 group



4.2.4 Knowledge scores at different time points

Compared with the scores of immediate evaluation after training, the mean scores declined at three-month follow up and one year follow up. The scores declined from

83.4±10.9 to 80.5±10.9 in intervention group, from 83.2±12.7 to 80.4±10.9 in control_1 group and from 82.1±12.8 to 78.2±12.0 in control_2 group at three month after training.

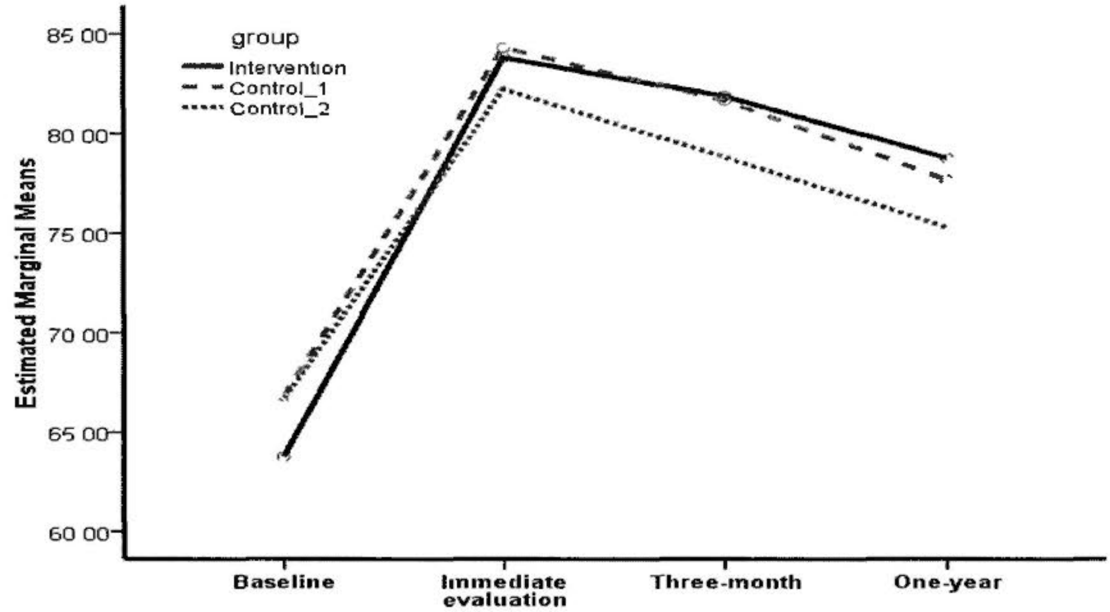
At one year after training the knowledge scores continued to decline compared with the scores of three-month follow up. The mean scores declined to 78.3±11.1 in intervention group, 76.8±11.4 in control_1 group and 75.2±13.2 in control_2 group. However, the scores were still much higher than the baseline scores, as shown in Figure 11 and 12.

Repeated measures ANOVA was used to compare the time trend of the knowledge score change during different periods. This analysis was limited to subjects who completed all follow-ups up to one year (1,321), so the mean knowledge scores were a little different from those of Table 16 and Figure 11.

Figure 12 showed that the knowledge scores in three groups increased remarkably at evaluation immediately after training, but then had a declining trend at three-month and one-year after training. There was statistically significant difference for the knowledge scores at different time points ($F=587.029$, $P<0.001$). The scores of two control groups declined much more than the score of intervention group. There was statistically significant difference for the knowledge scores in different groups ($F=3.408$, $P=0.034$).

At baseline knowledge score in intervention group was lower, but at three time points after training higher than those of two control groups. There were no statistically significant differences for knowledge scores between intervention group and control_1 group at any time point. However, statistical significances between intervention group and control_2 group were found for knowledge scores at three time points after training ($p=0.039$ at immediate evaluation, $p<0.001$ at three month and $p=0.001$ at one year after training).

Figure 12 Trend of knowledge scores of intervention group, control_1 group and control_2 group at different periods



4.2.5 Knowledge score change during different periods

We compared the changes of knowledge scores between different time points of follow up and baseline in different groups, as shown in Table 17.

Table 17 Knowledge score changes and percentage changes between baseline and immediate evaluation, 3-month and one-year after training in three groups

Group	Immediate evaluation and baseline		Three-month follow-up and baseline		One-year follow-up and baseline	
	Change	Percentage▲	Change	Percentage#	Change	Percentage¥
Intervention	19.4±14.9	30.2	16.4±17.2	25.5	13.7±16.4	21.3
Control_1	18.1±13.5	27.8	14.6±15.4	22.5	11.0±15.2†	16.9
Control_2	16.8±13.6†	25.8	12.6±16.3†	19.4	8.6±13.4†,‡	13.2
Total	17.8±14.0	27.3	14.1±16.4	21.7	11.0±15.1	16.9

▲Score difference of immediate evaluation and baseline × 100/baseline knowledge score

\# Score difference of three-month follow-up and baseline × 100/baseline knowledge score

¥ Score difference of one-year follow-up and baseline × 100/ baseline knowledge score

† Compared with intervention group, $p<0.05$, ‡ Compared with control_1 group, $p<0.05$

The changes of knowledge scores in intervention group were 19.4±14.9, 16.4±17.2 and 13.7±16.4 respectively, much greater than those of control_2 group (16.8±13.6, 12.6±16.3 and 8.6±13.4 respectively, p values <0.001). The corresponding percentage changes were 30.2, 25.5 and 21.3 in intervention group respectively, and 25.8, 19.4 and 13.2 in control_2 group respectively.

4.2.6 Knowledge improvements for different training areas

Six training areas were covered, including work station (ergonomic and material handling), machine safety, working environment, chemical prevention, dust control and noise control. At baseline the knowledge scores were similar in three groups. After training the scores increased in all three groups and the scores of these six training areas in intervention groups were mostly higher than those of two control groups, as shown in Table 18.

For work station, there were low scores at baseline (49.9±20.2). After the training program, the scores increased remarkably, but at three months and one year of the training, the scores decreased substantially.

Compared with the scores of work station, the scores of machine safety and working environment only increased a little (about 10 points).

For chemical prevention, there were high scores at baseline and after training the scores increased substantially. At three months and one year after training, the scores remained at a very high level (91.4±15.4).

In the area of dust control, there were low scores at baseline. The scores changed very little after training, from 56.3±35.7 to 63.1±36.4. There were small declines at three months and one year after training.

Scores at baseline for noise control were quite high. The scores increased quite a lot immediately after training, but decreased on subsequent follow-ups.

Table 18 Knowledge scores of work station, machine safety, working condition, chemical prevention, dust control and noise control at different time points in different groups

Training session	Baseline		Immediate evaluation		Three month follow up		One year follow up	
	N	Score	N	Score	N	Score	N	Score
Work station								
Intervention	918	50.2±20.9	787	86.1±16.8	636	78.0±20.2	430	68.4±22.8
Control_1	907	48.6±19.4	856	86.1±18.8	567	77.1±21.1	397	67.9±23.5
Control_2	1,654	50.5±20.1	1,557	85.1±19.7	1,170	74.5±21.9	494	68.2±22.2
Total	3,479	49.9±20.2	3,200	85.6±18.8	2,373	76.0±21.4	1,321	68.2±22.8
Machine safety								
Intervention	918	62.9±25.9	706	75.4±16.7	570	71.1±16.3	376	71.1±15.3
Control_1	907	63.8±18.0	795	74.4±16.6	522	71.3±15.0	369	70.0±16.8
Control_2	1,654	63.9±20.2	1,557	73.5±17.6	1,170	70.4±17.0	494	68.2±15.7
Total	3,479	63.6±19.6	3,058	74.2±17.1	2,262	70.8±16.4	1,239	69.6±15.9
Working environment								
Intervention	918	69.8±25.8	787	80.4±20.9	636	81.2±19.3	430	81.2±18.3
Control_1	907	70.6±24.2	856	81.8±21.2	567	81.8±20.5	397	79.2±19.5
Control_2	1654	69.1±25.6	1,557	80.6±21.3	1,170	77.9±21.2	494	76.6±21.9
Total	3479	69.7±25.3	3,200	80.9±21.2	2,373	79.8±20.6	1,321	78.9±20.2
Chemical prevention								
Intervention	785	73.2±31.0	665	91.7±16.5	558	92.3±14.5	386	92.0±14.9
Control_1	782	77.2±27.6	738	90.9±20.1	496	91.1±15.7	351	91.5±15.2
Control_2	1496	77.9±27.6	1,405	91.2±17.4	1,038	91.5±16.3	436	90.9±16.0
Total	3,063	76.5±28.6	2,808	91.2±17.9	2,092	91.6±15.7	1,173	91.4±15.4
Dust control								
Intervention	156	55.8±38.8	152	62.1±41.9	134	63.9±21.4	61	60.3±32.2
Control_1	132	55.1±35.2	126	64.1±39.3	73	62.3±43.9	46	67.7±19.2
Control_2	154	57.8±29.1	136	62.4±25.8	89	62.8±43.2	66	59.3±28.3
Total	442	56.3±35.7	414	63.1±36.4	296	65.4±37.6	173	61.8±27.6
Noise control								
Intervention	130	73.8±21.1	113	87.6±17.7	92	77.7±24.7	54	81.9±20.8
Control_1	90	72.2±21.9	82	84.1±19.8	65	80.7±20.1	28	73.2±23.5
Control_2	110	72.4±22.2	86	84.2±17.8	67	78.9±23.7	32	79.1±22.2
Total	330	72.9±21.4	281	85.6±18.7	219	78.9±22.9	114	78.9±22.0

4.2.7 Knowledge scores in different industry types

There were different knowledge scores at baseline and after training in different industry types. Table 19 shows that the workers of pharmaceutical industry and electronic industry had high scores at baseline, 73.6±12.7 and 67.5±12.4, respectively. The workers of footwear, toy and jewelry industries got low knowledge scores, 58.8±15.4 and 59.5±17.8 and 60.3±13.9, respectively.

After the training program, the knowledge scores of footwear and toy workers increased to 78.7±14.1 and 81.0±12.7 with the changes of over 20 scores. But jewelry workers' knowledge scores got a small change and only improved to 73.4±15.5. At three-month after training, the scores decreased in all industries. At one year after training the mean scores continued to decrease in footwear, electronics, toy, optical and jewelry industries. The scores of jewelry workers decreased to 66.1±15.6. The scores of printing and plastic workers increased, but the sample sizes were small in these two industries.

Table 19 Worker's average knowledge scores (mean±SD) at different time points in different industry types

Group	Baseline		Immediate evaluation		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Footwear	230	58.8±15.4	189	78.8±14.1	130	74.3±11.3	58	72.3±11.3
Electronics	1,278	67.5±12.4	1,185	84.9±10.0	853	80.4±11.2	539	76.9±12.0
Toy	429	59.5±17.8	406	81.0±12.8	312	78.4±10.5	180	76.3±11.1
Metal products	97	68.2±14.2	88	82.6±12.4	77	79.8±14.4	0	-
Printing	448	65.0±15.6	393	82.6±12.9	330	77.0±12.5	195	77.5±10.4
Optical	267	66.7±14.5	255	84.2±11.1	234	82.8±10.3	124	79.8±11.4
Plastic	396	64.4±14.5	361	82.9±12.3	301	79.7±11.0	116	80.8±8.9
Jewelry	241	60.3±13.9	232	73.4±15.5	153	72.1±10.8	88	66.1±15.6
Pharmaceutical	93	73.6±12.7	91	90.6±7.3	83	89.8±11.4	21	89.8±10.1
Total	3,479	64.9±15.0	3,200	82.7±12.3	2,473	79.3±11.5	1,321	76.7±12.1

4.2.8 Association between knowledge score and relevant factors

Linear Regression Analysis with Backward stepwise method was applied to evaluate the relationship between baseline knowledge score and gender, educational level, job position, previous work experience, duration of employment, pre-job and on-job training and age. We set up dummy variables for education level and workers' position because these categorical variables had more than two levels.

The "goodness-of-fit" (R square) of this model was 0.199, which meant that only 19.9% of the total variance could be explained by the regression model. The variables of gender, education, position, previous work experience, pre-job training and duration of employments showed significant associations with knowledge scores at baseline ($p<0.05$ for the above factors), as shown in Table 20.

For female workers, the knowledge score might decrease 2.56 (95% CI: -3.86, -1.42) compared with male workers. Compared with primary school, the knowledge scores in workers with higher educational level would increase remarkably, 19.56 for middle school (95% CI: 16.40, 22.71), 26.52 for high school (95% CI: 23.21, 29.83) and 29.37 for university or above graduate (95% CI: 25.19, 33.54).

The knowledge score of frontline workers might decrease 3.28 (95% CI: -5.85, -0.72) if compared with managers'.

The knowledge scores would increased 1.58 (95% CI: 0.26, 2.90) and 1.14 (95% CI: 0.16, 2.42) for the workers with previous work experience and pre-job training respectively.

The knowledge scores increased 0.03 (95% CI = 0.01, 0.04) for the workers with one more months of employment.

Table 20 Association between knowledge score and gender, education, position, training and duration of employments at baseline

Factors	B	95%CI for B	t	P value
Constant	53.99	47.73, 60.26	16.90	<0.001
Gender:				
Male	-			
Female	-2.56	-3.86, -1.42	-3.85	<0.001
Education:				
Primary school	-			
Middle school	19.56	16.40, 22.71	12.15	<0.001
High school	26.52	23.21, 29.83	15.71	<0.001
>=University	29.37	25.19, 33.54	13.79	<0.001
Position:				
Manager[#]	-			
Team leader	-0.22	-2.93, 2.49	-0.16	0.873
Frontline worker	-3.28	-5.85, -0.72	-2.51	0.012
Previous work experience:				
No	-			
Yes	1.58	0.26, 2.90	2.35	0.019
Pre-job training:				
No	-			
Yes	1.14	0.16, 2.42	2.21	0.035
Duration of employment	0.03	0.01, 0.04	3.12	0.003
Age	-0.08	-0.18, 0.01	-1.78	0.089

Note: using Linear Regression with Backward stepwise method
R Square = 0.199
[#]including staff in charge of occupational health and safety in factory

4.3 Attitude change

4.3.1 Baseline attitude scores

Table 21 described the attitude scores at different time points in three groups. At baseline the mean attitude score of 3,479 subjects was 63.5±14.7 before training program, similar with knowledge baseline score. There was no statistical difference (p=0.065) between intervention group (62.7±15.9), control_1 group (64.3±13.9) and control_2 group (63.5±14.4).

Table 21 Worker's attitude scores (mean±SD) at different time points in three different groups

Group	Baseline		Immediate evaluation		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Intervention	918	62.7±15.9	787	72.8±11.5	656	75.4±10.0	430	72.6±9.5
Control_1	907	64.3±13.9	856	71.8±12.9	647	73.9±9.8†	397	71.8±10.0
Control_2	1,654	63.5±14.4	1557	71.5±12.5†	1,170	73.1±11.2†	494	71.6±11.0
Total	3,479	63.5±14.7	3200	71.9±12.4	2,473	73.9±10.6	1,321	72.0±10.3
P value		0.065		0.046		0.019		0.310

† Compared with intervention group, $p<0.05$

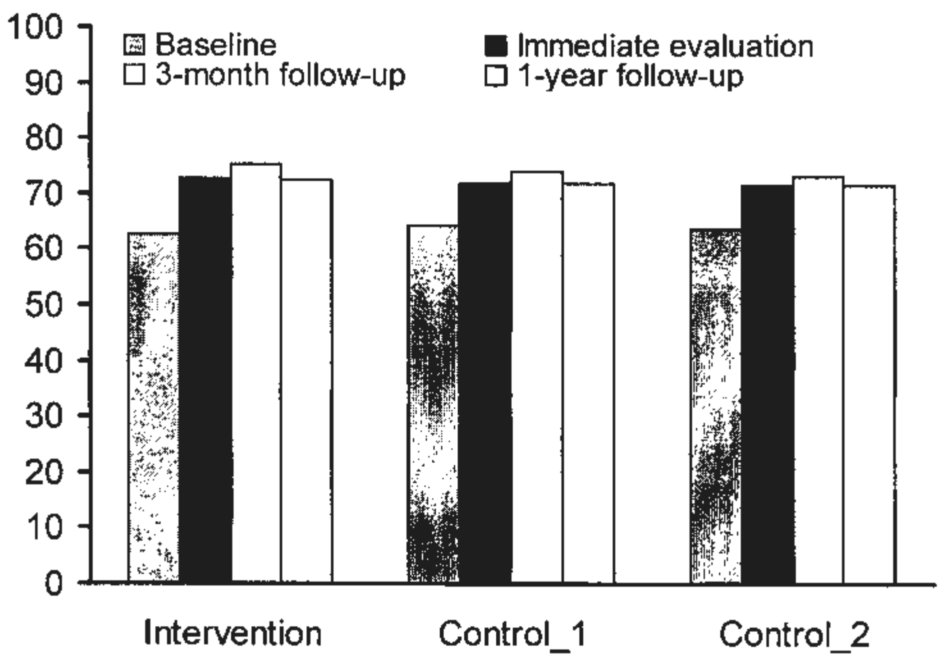
4.3.2 Attitude score after training

The attitude scores increased at different time points after training compared with the baseline score. The average score of 3,200 respondents increased to 71.9±12.4 at immediate evaluation, 73.9±10.6 at three-month after training, 72.0±10.3 at one year after training. Statistical significances were found for these increases (p values < 0.001) when compared with the baseline score, as shown in Table 21.

4.3.3 Attitude improvements in different groups

There were statistically significant differences for attitude at immediate evaluation and three months after training (p=0.046 and p=0.019), but no difference at one year after training (p=0.310). Table 21 and Figure 13 showed that the attitude scores of intervention groups were higher than those of two control groups. There were no statistically significant differences between attitude scores of control_1 groups and control_2 groups.

Figure 13 Attitude scores at baseline, immediate evaluation, 3-month follow-up and 1-year follow-up in different groups



4.3.4 Attitude scores at different time points

Compared with the scores of immediate evaluation after training, the mean scores continued increase at three months of training in three groups. At three months after training the scores increased from 72.8±11.5 to 75.4±10.0 in intervention group, from

71.8±12.9 to 73.9±9.8 in control_1 group and from 71.5±12.5 to 73.1±11.2 in control_2 group.

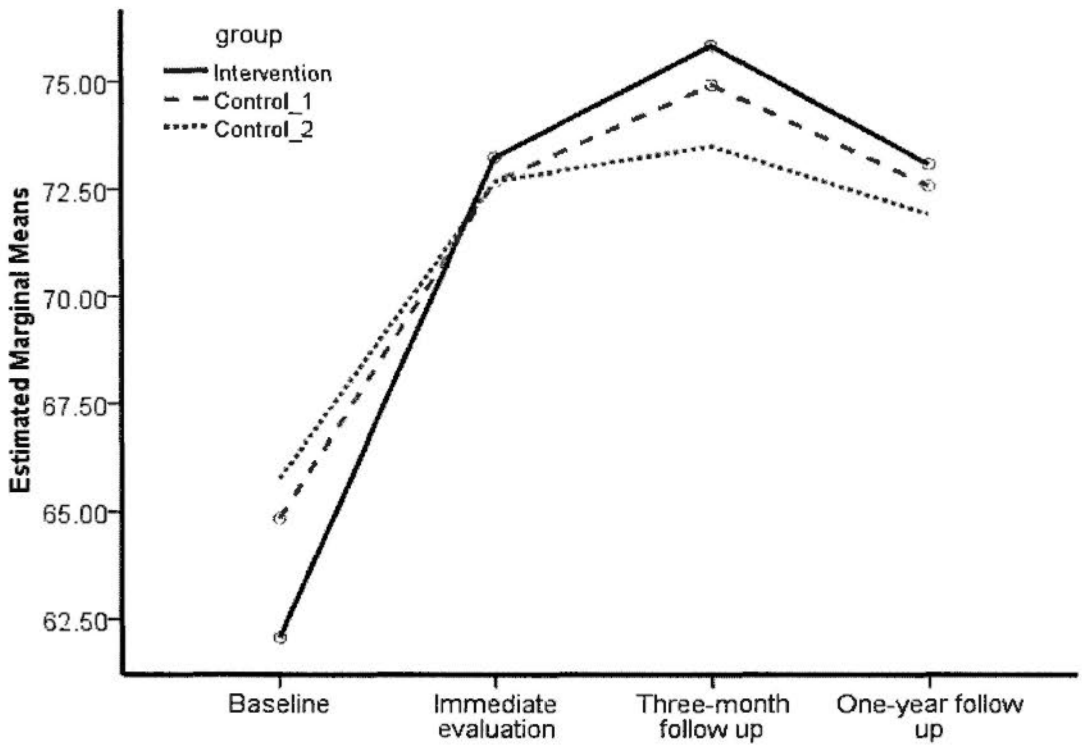
However, at one year after training, the mean scores declined to similar level of immediate evaluation. The score declined to 72.6±9.5 in intervention group, 71.8±10.0 in control_1 group and 71.6±11.0 in control_2 group.

Repeated measures ANOVA was used to compare the time trend of the attitude score change during different periods. This analysis was limited to subjects who completed all follow-ups up to one year (1,321). So the attitude scores were a little different from those of Table 21 and Figure 13.

Figure 14 showed that the attitude scores in three groups increased remarkably at immediate evaluation and three months after training, but then had a declining trend at one-year of training. There was statistically significant difference for the attitude scores at different time points ($F=254.975$, $P<0.001$). The scores of two control groups declined much more than the score of intervention group ($F=7.166$, $p<0.001$).

At baseline the attitude scores of intervention group was lower, but at three time points after training higher than those of two control groups. There were no statistically significant differences for attitude scores of three groups at immediate evaluation ($p=0.675$) and at one year after training ($p=0.281$). At three months after training, statistically significant difference was found for attitude scores between the intervention group and the control_2 group ($p=0.025$).

Figure 14 Trend of attitude scores of intervention group, control_1 group and control_2 group at different periods



4.3.5 Attitude score changes during different periods

The attitude scores increased less than the knowledge scores at different periods after training program. As shown in Table 22, the attitude score changes were only 8.3±11.4 at immediate evaluation, 10.7±11.5 at three-month follow up and 7.8±14.2 at one year after training. The corresponding percentage changes were 13.1, 16.9 and 12.3 for the above three time points respectively.

Through the training program, the changes of attitude scores were 10.6±13.2, 13.4±17.1 and 10.1±14.5 in intervention groups at immediate evaluation and three-month and one-year follow-up respectively. The changes of attitude scores in control_2 group were only 7.8±11.0, 9.7±15.1 and 5.6±11.9 at immediate evaluation and three-month and one-year follow-up respectively.

The attitude score changes in intervention group were bigger than those of two control groups at different time points after training ($p < 0.005$). The attitude score changes were also not statistically significant between two control groups at three time points after training ($p > 0.05$), as shown in Table 22.

Table 22 Attitude score changes and percentage changes between baseline and immediate evaluation, 3-month and one-year after training in three groups

Group	Immediate evaluation and baseline		Three-month follow-up and baseline		One-year follow-up and baseline	
	Change	Percentage▲	Change	Percentage#	Change	Percentage¥
Intervention	10.6±13.2	16.9	13.4±17.1	21.4	10.1±14.5	16.1
Control_1	7.4±10.5†	11.5	9.8±14.1†	15.2	7.9±14.3†	12.3
Control_2	7.8±11.0†	12.1	9.7±15.1†	15.3	5.6±11.9†	8.8
Total	8.3±11.5	13.1	10.7±11.5	16.9	7.8±14.2	12.3

▲Score difference of immediate evaluation and baseline × 100/baseline attitude score

\# Score difference of three-month follow-up and baseline × 100/baseline attitude score

¥ Score difference of one-year follow-up and baseline × 100/ baseline attitude score

† Compared with intervention group, $p < 0.05$

4.3.6 Attitude improvements for different training areas

Six training areas were covered, including work station (ergonomic and material handling), machine safety, working environment, chemical prevention, dust control and noise control. At baseline the attitude scores were similar in three groups. After training the scores increased in all three groups and the scores of these six training areas in intervention groups were mostly higher than those of two control groups, as shown in Table 23.

There were low scores at baseline (60.4±16.8) in the session of work station. The scores increased to 70.0±15.4 at immediate evaluation of training and 73.0±14.9 at three month after training program, but declined to 69.5±15.2.

There were very high scores for the session of machine safety at baseline (76.7±19.5). After the training, the scores increased with a small change, but at three months and one year of training, the scores remained high level.

For working environment, the worker's attitude scores were very low at baseline (only 50.6±20.6). After training the scores increased dramatically (about 16 scores), but compared with other sessions, the scores were still low.

For chemical prevention, there were medium scores at baseline and after training the scores increased substantially. At three months and one year after training, the scores remained at a high level.

In the area of dust control, there were low scores at baseline. The scores changed very little after training, from 56.2±32.8 to 60.3±32.9. At three months and one year after training the scores decreased to the baseline level (55.7±28.8).

There were high scores at baseline for noise control. The scores increased with a small change immediately after training, but decreased on subsequent follow-ups.

Table 23 Attitude scores of work station, machine safety, working condition, chemical prevention, dust control and noise control at different time points in different groups

Training session	Baseline		Immediate evaluation		Three month follow up		One year follow up	
	N	Score	N	Score	N	Score	N	Score
Work station								
Intervention	918	60.1±17.2	787	70.9±14.5	636	76.1±13.2	430	70.6±14.8
Control_1	907	60.9±16.3	856	69.8±15.9	567	72.7±14.1	397	69.3±14.9
Control_2	1,654	60.3±16.9	1,557	69.6±15.4	1,170	71.4±15.9	494	68.6±15.8
Total	3,479	60.4±16.8	3,200	70.0±15.4	2,373	73.0±14.9	1,321	69.5±15.2
Machine safety								
Intervention	918	75.4±20.6	706	80.4±15.0	570	83.9±12.9	376	82.9±12.1
Control_1	907	77.5±18.1	795	80.5±15.8	522	83.2±13.3	369	82.2±13.4
Control_2	1,654	76.9±19.5	1,557	80.6±15.7	1,170	82.8±14.2	494	83.2±13.2
Total	3,479	76.7±19.5	3,058	80.6±15.7	2,262	83.2±13.7	1,239	82.8±12.9
Working environment								
Intervention	918	50.8±21.7	787	67.3±16.1	636	67.0±17.3	430	63.8±16.6
Control_1	907	51.0±20.3	856	65.9±17.5	567	65.2±16.6	397	61.7±17.0
Control_2	1654	50.3±20.1	1,557	65.8±16.9	1,170	64.7±17.8	494	60.3±18.9
Total	3479	50.6±20.6	3,200	66.2±16.9	2,373	65.5±17.4	1,321	61.9±17.7
Chemical prevention								
Intervention	785	62.8±26.8	665	77.4±17.4	558	77.4±13.7	386	76.2±13.4
Control_1	782	65.6±24.1	738	75.2±20.0	496	76.8±12.9	351	75.7±13.4
Control_2	1496	65.4±23.4	1,405	75.4±18.2	1,038	76.1±15.6	436	75.9±13.8
Total	3,063	64.8±24.5	2,808	75.8±18.5	2,092	76.6±14.5	1,173	75.9±13.6
Dust control								
Intervention	156	55.3±36.4	152	59.9±37.9	134	57.4±39.7	61	56.5±36.7
Control_1	132	56.5±33.7	126	60.5±35.8	73	55.1±37.6	46	52.8±20.6
Control_2	154	56.7±23.4	136	60.6±22.9	89	57.3±20.0	66	56.9±23.2
Total	442	56.2±32.8	414	60.3±32.9	296	56.8±33.2	173	55.7±28.8
Noise control								
Intervention	130	72.4±17.8	113	79.0±12.3	92	75.1±18.4	54	71.5±16.9
Control_1	90	69.8±17.1	82	77.2±13.8	65	78.5±11.4	28	69.4±13.2
Control_2	110	71.4±16.6	86	78.2±13.1	67	76.5±14.9	32	70.9±14.2
Total	330	71.3±17.5	281	78.2±12.9	219	76.5±15.9	114	70.8±15.7

4.3.7 Attitude scores in different industries

Table 24 shows that there were different attitude scores for different industry types at baseline (p<0.001). The workers in footwear and toy factories had low attitude scores (59.6±15.3 and 56.6±19.7 respectively). The workers in pharmaceutical and electronics factories got high attitude scores (71.6±8.5 and 66.5±11.1 respectively).

After training the attitude scores increased in all industry types. The attitude score increased a lot (about 13 scores) in toy workers, from 56.6±19.7 to 69.1±12.7. The jewelry workers got small changes in attitude score on occupational health and safety, from 63.3±11.0 to 66.9±12.0.

At three months of training, the scores remained increased for different industry types, but the scores at one-year follow-up decreased in all industries. In jewelry industry the attitude scores decreased almost to the baseline level (65.0±11.8).

Table 24 Worker's attitude scores (mean±SD) at different time points in different industry types

Group	Baseline		Immediate evaluation		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Footwear	230	59.6±15.3	189	67.8±13.2	130	74.1±8.4	58	71.3±9.2
Electronics	1,278	66.5±11.1	1,185	74.2±10.8	853	74.7±10.2	539	72.6±10.6
Toy	429	56.6±19.7	406	69.1±12.7	312	74.6±9.4	180	70.6±9.1
Metal products	97	66.2±15.9	88	72.1±13.9	77	71.4±12.9	0	-
Printing	448	62.1±16.6	393	70.9±14.4	330	71.4±11.9	195	70.2±9.0
Optical	267	64.3±13.0	255	72.7±11.4	234	76.0±10.7	124	75.9±8.9
Plastic	396	62.1±15.9	361	71.1±12.6	301	73.3±11.3	116	73.1±9.4
Jewelry	241	63.3±11.0	232	66.9±12.0	153	69.9±8.6	88	65.0±11.8
Pharmaceutical	93	71.6±8.5	91	80.4±9.7	83	79.4±8.6	21	77.2±7.7
Total	3,479	63.5±14.7	3,200	71.9±12.4	2,473	74.0±10.6	1,321	72.0±10.3

4.3.8 Association between attitude score and relevant factors

Linear Regression Analysis with Backward stepwise method was used to evaluate the association between attitude score and gender, educational level, job position, previous work experience, duration of employments, training and age at baseline. We set up dummy variables for education level and workers' position because they were categorical variables and had more than two levels. The R square of this model was 0.245, which meant that 24.5 % of the total variance could be explained by this regression model.

For female workers, the attitude score might decrease 1.55 (95% CI: -2.83, -0.27) compared with male workers. The attitude scores increased among the workers with high education, 18.75 for middle school (95% CI: 15.64, 21.86), 26.50 for high school (95% CI: 23.25, 29.76) and 32.98 for university or above graduate (95% CI: 28.87, 37.10).

The attitude score of frontline workers might decrease 3.03 (95% CI: -5.54, -0.53) if compared with managers'.

The attitude score of the workers with previous work experience increased 1.21 (95% CI = 0.19, 2.23) as compared to the workers without previous work experience. The attitude score also increased 1.33 (95% CI: 0.06, 2.60) for the workers with pre-job training.

The attitude scores might increase 0.03 (95%CI: 0.01, 0.04) for the workers with one more month of employment. The scores decreased 0.34 (95%CI: -0.43, -0.24) for the workers with one more year old, as shown in Table 25.

Table 25 Association between attitude score and gender, educational level, position, previous work experience, training, duration of employments and age at baseline

Factors	B	95%CI for B	t	P value
Constant	55.54	49.61, 61.47	18.37	<0.001
Gender:				
Male	-			
Female	-1.55	-2.83, -0.27	-2.37	0.018
Education:				
Primary school	-			
Middle school	18.75	15.64, 21.86	11.83	<0.001
High school	26.50	23.25, 29.76	15.95	<0.001
>=University	32.98	28.87, 37.10	15.72	<0.001
Position:				
Manager#	-			
Team leader	0.37	-2.29, 3.02	0.27	0.787
Frontline worker	-3.03	-5.54, -0.53	-2.38	0.018
Previous work experience:				
No	-			
Yes	1.21	0.19, 2.23	2.32	0.021
Pre-job training:				
No	-			
Yes	1.33	0.06, 2.60	2.06	0.040
Duration of employments	0.03	0.01, 0.04	3.25	0.001
Age	-0.34	-0.43, -0.24	-6.96	<0.001

Note: Linear Regression with Backward stepwise Method was used.
R Square = 0.245
#Including staff in charge of occupational health and safety in factory

4.4 Practice enhancement

4.4.1 Baseline practice scores

The mean practice score of 3,479 subjects was 78.1±18.0 at baseline, much higher than knowledge score and attitude score, as shown in Table 26. There was no statistical difference (p=0.085) for practice scores between intervention group (77.2±19.1), control_1 group (79.1±16.4) and control_2 group (78.0±18.3).

Table 26 Worker' average practice scores (mean±SD) at different time points in different groups

Group	Baseline		Immediate evaluation		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Intervention	918	77.2±19.1	787	91.3±10.3	656	92.5±8.8	430	89.7±9.9
Control_1	907	79.1±16.4	856	91.1±13.4	647	92.1±8.3	397	89.5±9.4
Control_2	1,654	78.0±18.3	1,557	90.0±13.4†	1,170	91.2±10.6†	494	87.8±12.5†
Total	3,479	78.1±18.0	3,200	90.6±12.7	2,473	91.7±9.6	1,321	88.9±10.8
P value		0.085		0.038		0.013		0.013

† Compared with intervention group, p<0.05

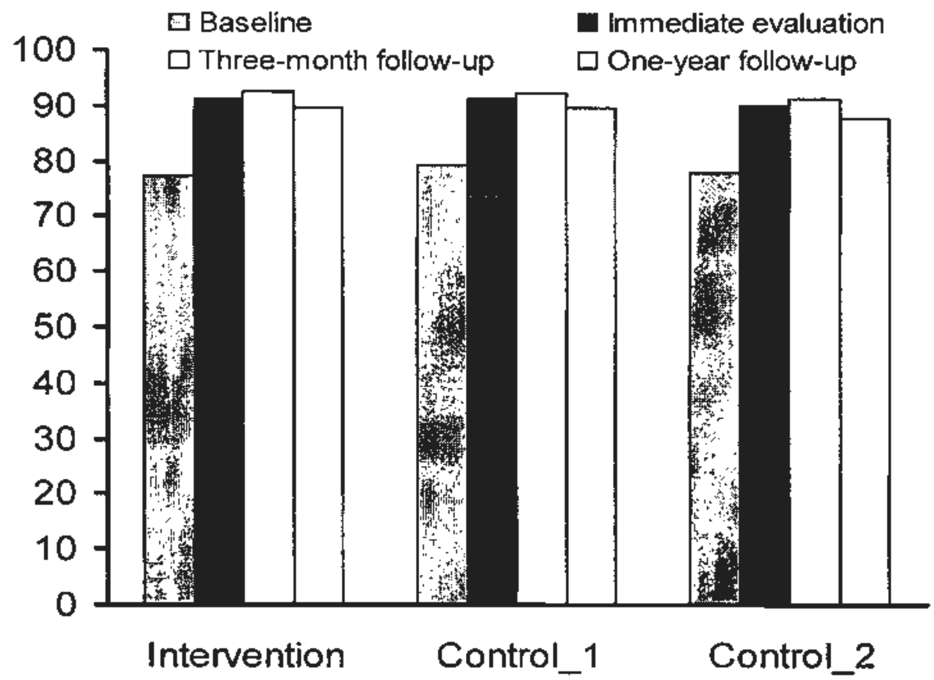
4.4.2 Practice score improvement after training

The practice scores increased remarkably at different time points after training compared with the baseline score (p<0.001), as shown in Figure 19. At immediate evaluation the score increased to 90.6±12.7. Moreover, the scores continued increase to 91.7±9.6 at three months after training. The score at one year after training was 88.9±10.8, still much higher than the baseline score (p<0.001), as shown in Table 26.

4.4.3 Practice scores in different groups

There were statistically significant differences for practice scores in three groups at three time points after training (p=0.038 at immediate evaluation, p=0.013 at three months and at one year after training respectively). As shown in Table 26 and Figure 15, the practice scores of intervention groups were higher than those of control_2 groups at different time points after training (p values < 0.001). The scores were also greater than those of control_1 groups at different time points, but there were no statistically significant differences.

Figure 15 Practice scores at baseline, immediate evaluation, three-month and one-year follow up in intervention group, control_1 and control_2 group



4.4.4 Practice scores at different time points after training

Compared with the scores of immediate evaluation after training, the mean scores continued increase at three months of training in three groups. At three months after training the scores increased from 91.3±10.3 to 92.5±8.8 in intervention group, from 91.1±13.4 to 92.1±8.3 in control_1 group and from 90.0±13.4 to 91.2±10.6 in control_2 group.

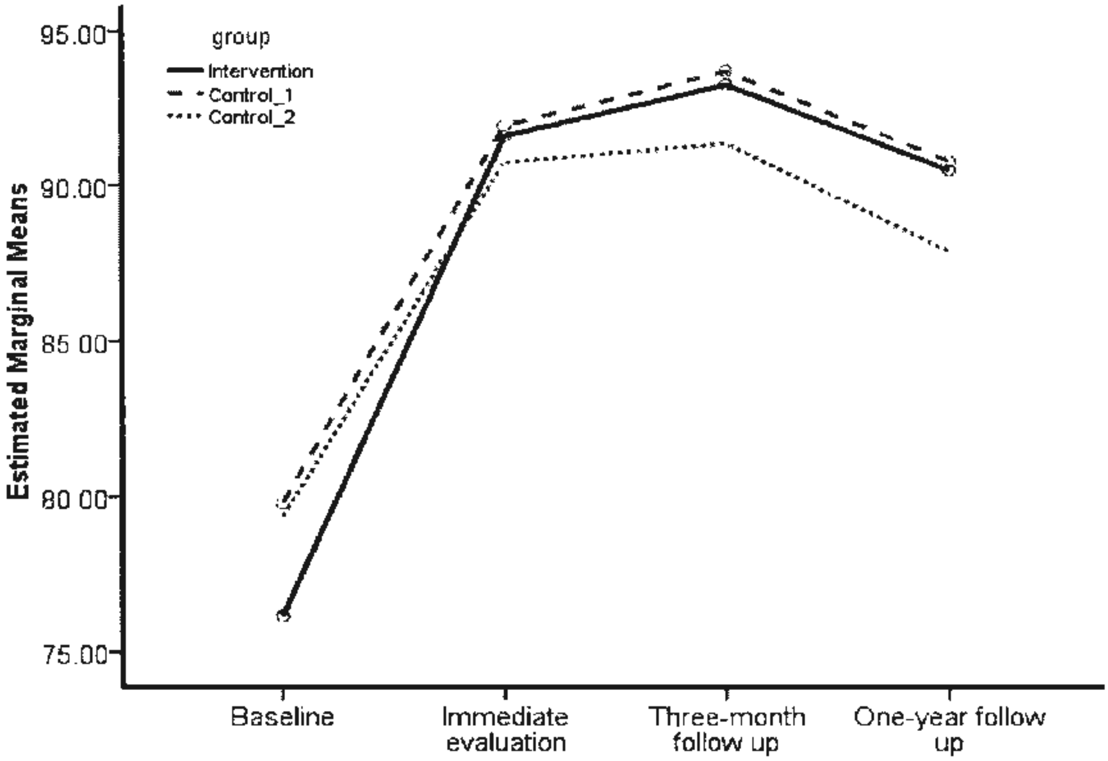
At one year after training, the mean scores declined to less than those of immediate evaluation. The score declined to 89.7±9.9 in intervention group, 89.5±9.4 in control_1 group and 87.8±12.5 in control_2 group, but still much higher than the baseline scores in different groups.

We compared the time trend of the practice score changes of different periods at baseline in three groups with repeated measures ANOVA. This analysis was limited to subjects who completed all follow-ups up to one year (1,321). So the practice scores were a little different from those of Table 26 and Figure 15.

Figure 16 showed that the practice scores in three groups increased remarkably at immediate evaluation and at three months after training, but then had a declining trend at one-year of training. There was statistically significant difference for the practice scores at different time points ($F=360.325$, $P<0.001$). The score of control_2 groups declined much more than the score of intervention group ($F=5.128$, $P<0.001$).

At baseline the practice scores of intervention group was lower than those of two control groups, but at three time points after training higher than that of control_2 group. There was no statistically significant difference ($p=0.681$) for practice scores in three groups at immediate evaluation. There were statistically significant differences for practice scores in intervention group and control_2 group at three months ($p=0.003$) and at one year after training ($p=0.009$). No statistically significant differences were found for practice scores in intervention group and control_1 group at these two time points.

Figure 16 Trend of practice scores of intervention group, control_1 group and control_2 group at different periods



4.4.5 Practice score changes during different periods

The practice score changes were 12.6±15.4 at immediate evaluation, 13.9±19.1 at three-month follow up and 10.2±17.3 at one year after training respectively. The corresponding percentage changes were 16.1, 17.8 and 13.1 at three different time points respectively, as shown in Table 27.

The changes of practice scores in intervention groups were 14.6±16.7 at immediate evaluation, 16.0±20.4 at three months after training, and 12.5±20.2 at one year after training. The score changes were greater than those of control_2 groups at three time points (p values < 0.001). The score changes in intervention groups were also higher than those of control_1 groups, but there was no statistically significant difference at one year after training (p=0.254).

For the changes of two control groups, there were no statistically significant differences at different time points, as shown in Table 27.

Table 27 Practice score changes and percentage changes between baseline and immediate evaluation, 3-month and one-year after training in three groups

Group	Immediate evaluation and baseline		Three-month follow-up and baseline		One-year follow-up and baseline	
	Change	Percentage▲	Change	Percentage#	Change	Percentage¥
Intervention	14.6±16.7	18.9	16.0±20.4	20.7	12.5±20.2	16.2
Control_1	12.0±14.6†	15.2	13.1±17.0†	16.6	10.5±17.4	13.3
Control_2	11.9±15.0†	15.3	13.2±19.4†	16.9	8.0±13.7†	10.3
Total	12.6±15.4	16.1	13.9±19.1	17.8	10.2±17.3	13.1

▲Score difference of immediate evaluation and baseline × 100/baseline practice score

Score difference of three-month follow-up and baseline × 100/baseline practice score

¥ Score difference of one-year follow-up and baseline × 100/ baseline practice score

† Compared with intervention group, $p<0.05$

4.4.6 Practice improvements for different training areas

At baseline the practice scores were similar for every part of six training areas in three groups. After training the scores increased in three groups and the scores in intervention groups were higher than those of control groups in most training areas and at different time points, as shown in Table 28.

There were low scores at baseline (64.1±21.7) in work station. The scores increased remarkably at immediate evaluation of training (86.7±18.3), but decreased substantially at three month and at one year of training.

There were very high scores for the area of machine safety at baseline (86.8±22.1). After the training, the scores increased a little, but the scores remained high level at three months (94.1±14.2) and one year of training (94.5±13.2).

For working environment, the scores increased from 79.9±27.1 at baseline to 90.2±17.4 at three months of training and to 93.1±12.3 at one year after training.

For chemical prevention, the scores were high at baseline. After training the scores increased dramatically. The scores remained high level at three months of training (97.1±12.3) and at one year after training (97.0±10.8).

In dust control, there were very low scores at baseline (60.5±39.3). The scores changed to 69.7±41.1 at immediate evaluation after training, 70.6±25.5 at three months of training and 69.8±36.8 at one year of training.

There were high scores at baseline for noise control. After training the scores increased to 93.3±15.7. However, the score decreased to 86.6±22.9 at one year after training.

Table 28 Practice scores of work station, machine safety, working condition, chemical prevention, dust control and noise control at different time points in different groups

Training session	Baseline		Immediate evaluation		Three month follow up		One year follow up	
	N	Score	N	Score	N	Score	N	Score
Work station								
Intervention	918	64.1±21.9	787	86.5±17.6	636	84.4±17.6	430	78.9±17.3
Control_1	907	64.1±20.2	856	87.3±18.1	567	82.9±17.2	397	78.1±17.9
Control_2	1,654	64.0±22.4	1,557	86.4±18.8	1,170	83.5±18.3	494	77.1±20.5
Total	3,479	64.1±21.7	3,200	86.7±18.3	2,373	83.6±17.8	1,321	78.0±18.7
Machine safety								
Intervention	918	85.9±22.9	706	93.1±14.7	570	94.9±13.3	376	95.5±11.0
Control_1	907	88.5±19.5	795	92.8±17.7	522	94.5±13.3	369	94.9±12.5
Control_2	1,654	86.3±22.8	1,557	91.9±17.8	1,170	93.5±15.0	494	93.3±15.1
Total	3,479	86.8±22.1	3,058	92.4±17.1	2,262	94.1±14.2	1,239	94.5±13.2
Working environment								
Intervention	918	79.3±28.8	787	90.9±15.6	636	93.9±13.2	430	89.7±16.7
Control_1	907	80.3±26.0	856	90.7±17.9	567	93.9±12.9	397	89.0±16.5
Control_2	1654	80.1±26.6	1,557	89.7±17.9	1,170	92.2±15.4	494	87.9±19.0
Total	3479	79.9±27.1	3,200	90.2±17.4	2,373	93.1±12.3	1,321	88.8±17.5
Chemical prevention								
Intervention	785	79.4±34.2	665	94.5±15.8	558	97.7±8.7	386	97.2±9.6
Control_1	782	84.4±29.4	738	93.6±19.4	496	97.6±10.7	351	97.5±8.8
Control_2	1496	82.9±31.4	1,405	94.1±18.3	1,038	96.6±14.5	436	96.3±13.1
Total	3,063	82.4±31.7	2,808	94.1±18.0	2,092	97.1±12.3	1,173	97.0±10.8
Dust control								
Intervention	156	60.4±32.7	152	68.3±45.8	134	71.2±28.3	61	70.9±23.9
Control_1	132	61.2±40.3	126	72.8±41.6	73	68.2±45.6	46	70.8±17.0
Control_2	154	60.1±42.2	136	68.5±35.1	89	71.6±24.1	66	68.0±31.7
Total	442	60.5±39.3	414	69.7±41.1	296	70.6±25.5	173	69.8±36.8
Noise control								
Intervention	130	84.8±24.4	113	94.5±12.8	92	90.5±20.6	54	87.9±24.1
Control_1	90	81.9±24.6	82	91.8±18.9	65	90.4±19.1	28	83.9±20.7
Control_2	110	83.7±24.2	86	93.4±17.1	67	90.5±17.8	32	86.7±19.6
Total	330	83.6±24.5	281	93.3±15.7	219	90.4±19.9	114	86.6±22.9

4.4.7 Practice scores in different industries

There were also different practice scores for different industry types at baseline ($p<0.001$), as shown in Table 29. The workers in toy, jewelry and footwear factories had low practice scores (75.0±21.4, 71.4±23.6 and 72.2±16.0 respectively). The workers got very high practice scores among pharmaceutical workers (87.3±12.1) and metal products workers (82.5±15.6) at baseline.

After the implementation of training program, the practice scores increased at all time points compared with the baseline scores. At three months of training the practice remained increase for all industry types based on the scores of immediate evaluation.

The practice scores at one year follow up decreased slightly in most of industries, but the score for jewelry workers decreased more substantially from 88.6±10.7 to 77.3±19.3.

Table 29 Worker's average practice scores (mean±SD) of different periods in different industries

Group	Baseline		Immediate evaluation		Three-month after training		One-year after training	
	N	Score	N	Score	N	Score	N	Score
Footwear	230	75.0±21.4	189	86.5±15.6	130	88.6±10.2	58	90.9±7.9
Electronics	1,278	81.2±13.3	1,185	93.1±8.8	853	92.3±8.5	539	89.2±10.5
Toy	429	71.4±23.6	406	87.8±15.1	312	92.4±7.9	180	89.4±9.5
Metal products	97	82.5±15.6	88	89.6±13.6	77	90.3±14.5	0	-
Printing	448	77.4±19.9	393	90.4±12.3	330	90.7±10.9	195	90.2±8.0
Optical	267	80.4±16.4	255	91.4±11.2	234	93.8±8.6	124	90.5±7.6
Plastic	396	76.6±20.1	361	90.4±12.3	301	91.1±10.2	116	90.4±8.6
Jewelry	241	72.2±16.0	232	83.6±17.2	153	88.6±10.7	88	77.3±19.3
Pharmaceutical	93	87.3±12.1	91	96.4±5.1	83	94.1±7.6	21	96.1±15.0
Total	3,479	78.2±18.0	3,200	90.6±12.7	2,473	91.7±9.6	1,321	88.9±9.2

4.4.8 Association between practice score and relevant factors

Linear Regression Analysis with Backward stepwise method was applied to analyze the association between practice score and worker's gender, educational level, position, previous work experience, duration of employments, training and age at baseline. We set up dummy variables for education level and workers' position because they were categorical variables and had more than two levels.

The R square of this model was 0.207, which meant that 20.7 % of the total variance could be explained by this regression model.

For female workers, the practice score might decrease 1.03 (95% CI: -2.67, 0.60) compared with male workers, but there was no statistically significant difference (p=0.214).

Compared with primary school, the practice scores in workers with higher educational level increased, 26.21 for middle school (95% CI: 22.25, 30.66), 34.03 for high school (95% CI: 29.89, 38.18) and 36.29 for university or above graduate (95% CI: 31.06, 41.52).

The practice score of frontline workers might decrease 4.18 (95% CI: -7.39, -0.97) if compared with managers'. The score of team leaders increased a little and there was no statistically significance (p=0.454).

The practice scores would increase 2.25 (95% CI: 0.59, 3.90) for the workers with previous work experience compared with the workers without previous work experience. The scores might also increase 1.55 (95% CI: 0.07, 3.17) for the workers with pre-job training compared with the workers without pre-job training.

Like attitude scores, the practice scores increased with long duration of employments (B=0.03, 95%CI: 0.01, 0.05), and decreased with age (B=-0.36, 95% CI: -0.48, -0.24), as shown in Table 30.

Table 30 Association between practice score and gender, education, position, previous work experience, pre-job training, duration of employments and age

Factors	B	95%CI for B	t	P value
Constant	67.39	59.55, 75.24	16.85	<0.001
Gender:				
Male	-			
Female	-1.03	-2.67, 0.60	-1.24	0.214
Education:				
Primary school	-			
Middle school	26.21	22.25, 30.66	13.01	<0.001
High school	34.03	29.89, 38.18	16.11	<0.001
>=University	36.29	31.06, 41.52	13.61	<0.001
Position:				
Manager#	-			
Team leader	0.79	-2.61, 4.18	0.65	0.454
Frontline worker	-4.18	-7.39, -0.97	-2.56	0.011
Previous work experience:				
No	-			
Yes	2.25	0.59, 3.90	2.66	0.008
Pre-job training:				
No	-			
Yes	1.55	0.07, 3.17	2.17	0.031
Duration of employments	0.03	0.01, 0.05	2.43	0.015
Age	-0.36	-0.48, -0.24	-5.92	<0.001

Note: Linear Regression with Backward stepwise Method was used.
R Square = 0.207
#including staff in charge of occupational health and safety in factory

4.4.9 Correlation among practice, attitude and knowledge

There were good positive correlations between workers' practice and attitude, practice and knowledge, as well as attitude and knowledge. Table 31 shows the Pearson correlation coefficients between practice and attitude (0.735, p<0.001), between practice and knowledge (0.674, p<0.001), between attitude and knowledge (0.691, p<0.001).

Table 31 Bivariate correlation among practice, attitude and knowledge scores at baseline (n=3,479)

Items		Knowledge	Attitude	Practice
Knowledge	Pearson Correlation	1.000	0.691**	0.674**
	Sig. (2-tailed)		<0.001	<0.001
Attitude	Pearson Correlation		1.000	0.735**
	Sig. (2-tailed)			<0.001
Practice	Pearson Correlation			1.000
	Sig. (2-tailed)			

** Correlation is significant at the 0.01 level (2-tailed).

4.5 Injury events

4.5.1 Injury incidence rates from factory record

There were totally 57,445 frontline workers in the 60 factories. The annual incidence rates of work-related injury events per 1,000 workers were 9.6 in 2005, 8.9 in 2006, 8.4 in 2007 and 8.2 in 2008. The average incidence rate was 8.8 per 1,000 workers during 2005-2008, as shown in Table 32.

The incidence rates of intervention factories were higher than those of control factories, but there were no statistically significant differences (p=0.455 in 2005, p=0.708 in 2006, p=0.744 in 2007 and p=0.830 in 2008 respectively), as shown in Table 32.

Table 32 Work-related injury incidence rates (injury events/1,000 frontline workers) according to factory record during 2005-2008 in intervention factories and control factories

Factory	No. of	No. of	2005		2006		2007		2008		Average	
	factory	worker	Events	Rate	Events	Rate	Events	Rate	Events	Rate	Events	Rate
Intervention	30	31,607	367	11 6	326	10 3	309	9 8	295	9 3	324	10 3
Control	30	25,838	184	7 1	184	7 1	176	6 8	175	6 8	180	7 0
Total	60	57,445	551	9 6	510	8 9	485	8 4	470	8 2	504	8 8
P value				445		708		744		830		

4.5.2 Injury incidence rates by self-reporting among participating workers

Among 3,477 participating workers, 330 reported injury cases in current work at baseline. The person-based incidence rate of injury was 94.9 per 1,000 workers. No statistically significant difference was found for injury incidence rates among the three groups (p=0.155), 106.8 per 1,000 workers for intervention group, 80.5 per 1,000 workers for control_1 group and 96.2 per 1,000 workers for control_2 group.

There were 290 workers who suffered from injury events in the previous 12 months and the person-based incidence rate was 83.4 per 1,000 workers. There was no statistically significant difference (p=0.454) for the incidence rates of injury among the three groups (89.3 per 1,000 workers in intervention group, 73.9 per 1,000 workers in control_1 group and 85.4 per 1,000 workers in control_2 group), see Table 33.

There were 416 injury events among the 290 workers with injury in past 12 months of current work and the event-based incidence rate was 119.6 events per 1,000 person-years. The event-based incidence rates of injury were 127.5 per 1,000 person-years in intervention group, 92.6 per 1,000 person-years in control_1 group and 130.1 per 1,000 person-years in control_2 group, as shown in Table 33.

Table 33 Self reported injury incidence rates in current work and in past 12 months among the workers who worked over 12 months at baseline

Group	N♥	Injury for current work		Injury in past 12 months			
		Cases	Incidence (per 1,000)	Cases	Incidence (per 1,000)	Events	Incidence (/1,000 person-years)
Intervention	918	98	106.8	82	89.3	117	127.5
Control_1	907	73	80.5	67	73.9	84	92.6
Control_2	1,652	159	96.2	141	85.4	215	130.1
Total	3,477	330	94.9	290	83.4	416	119.6
P value			0.155		0.454		

♥Two trained workers did not respond to injury question.

4.5.3 The change of injury events from factory record

According to factory record, the annual incidence rates of injury events per 1,000 workers in intervention factories were 9.3 at baseline and 8.9 at one year after training, there was no statistically significant difference for the incidence rates of these two periods (p=0.667).

Table 34 Annual injury incidence rates (per 1000 workers) before training and at one year after training in intervention and control factories according to factory record

Factory	Injury events at baseline				Injury events at one year after training				P value
	No. of factory	No. of worker	Events	Incidence (/1,000)	No. of factory	No. of worker	Events	Incidence (/1,000)	
Intervention	30	31,607	295	9.3	16	28,449	256	8.9	0.667
Control	30	25,838	175	6.8	16	9,252	73	7.9	0.271
Total	60	57,445	470	8.2	32	37,701	329	8.7	0.368
P value				0.830				0.736	

In control factories, the annual incidence rates of injury events per 1,000 workers were 6.8 at baseline and 7.9 at one year after training. No statistically significant difference was found for the incidence rates of these two periods (p=0.271).

The average incidence rates of injury events per 1,000 workers were 8.2 at baseline and 8.7 at one year after training for all factories. There were no statistically significant differences for incidence rates of intervention factories and control factories in these two periods (p=0.830 and p=0.736 respectively), as shown in Table 34.

4.5.4 The change of injury from worker's self-reporting

4.5.4.1 The change of person-based injury incidence rate

The Chi-square test was used to compare the person-based incidence rates of injury between baseline and one year after training. The incidence rate of injury in intervention group reduced significantly (χ^2=6.377, p=0.012), from 89.3 per 1,000 workers at baseline to 49.8 per 1,000 workers at one year after training. There were no statistically significant differences for the person-based incidence rates at baseline and one year after training in two control groups (p=0.620 and p=0.600, respectively), as shown in Table 35.

Table 35 Worker self-reported incidence rates of injury cases of past 12 months at baseline and at one year after training in different groups

	injury		Total	Incidence	χ^2	P
	Yes	No		(/1,000)		value
Intervention group						
Baseline	82	836	918	89.3	6.377	0.012
One year after training	21	401	422	49.8		
Control_1 group						
Baseline	67	840	907	73.9	0.246	0.620
One year after training	26	367	393	66.2		
Control_2 group						
Baseline	141	1,511	1,652	85.4	0.275	0.600
One year after training	38	450	488	77.9		

There were similar results if we recalculated the person-based incidence rates of injury based on the subjects completing one year follow up. The incidence rate of injury in intervention group reduced significantly (χ^2=5.266, p=0.022), from 90.0 per 1,000 workers at baseline to 49.8 per 1,000 workers at one year after training. There were no statistically significant differences for the person-based incidence rates at baseline and one year after training in two control groups (p=0.675 and p=0.261, respectively), as shown in Table 36.

Table 36 Worker self-reported incidence rates of injury cases of past 12 months at baseline and at one year after training in different groups based on subjects completing one year follow up

	injury		Total	Incidence	X^2	P
	Yes	No		(/1,000)		value
Intervention group						
Baseline	38	384	422	90.0	5.266	0.022
One year after training	21	401	422	49.8		
Control_1 group						
Baseline	29	364	393	73.8	0.176	0.675
One year after training	26	367	393	66.2		
Control_2 group						
Baseline	49	439	488	100.4	1.527	0.261
One year after training	38	450	488	77.9		

4.5.4.2 The change of event-based injury incidence rate

Table 37 displays the annual incidence rates of injury event at baseline and at one year after training according to worker's self-reporting. The two-proportion Z test was applied to compare the differences between the two event-based incidence rates of injury at baseline and one year after training.

The incidence rate of injury events in intervention group reduced significantly (Z=3.212, p<0.01), from 127.5 per 1,000 person-years at baseline to 73.5 per 1,000 person-years at one year after training. There were no statistically significant differences for the event-based incidence rates at baseline and one year after training in two control groups (Z=0.356 and Z=0.795, respectively, P>0.05), as shown in Table 37.

Table 37 Worker self-reported incidence rates of injury events of past 12 months at baseline and at 1 year after training in different groups

	No. of events	No. of workers completing 1 yr follow up	Incidence rate (per 1,000 person-yrs)	Z value[#]	P value
Intervention group					
Baseline	117	918	127.5	3.212	<0.01
One year after training	31	422	73.5		
Control_1 group					
Baseline	84	907	92.6	0.356	>0.05
One year after training	34	393	86.5		
Control_2 group					
Baseline	215	1652	130.1	0.795	>0.05
One year after training	57	488	116.8		

[#]z test for two proportions:

The injury incidence rates in the above table were calculated for the total subjects at baseline, but limited only to subjects completing follow up at one year after training. The event-based incidence rates were recalculated based on the subjects at one year follow-up.

In the intervention group, the incidence rates of injury events reduced from 144.5 per 1,000 person-years at baseline to 73.5 per 1,000 person-years at one year after training, and there was statistically significant difference (Z = 3.199, p<0.01). The event-based incidence rates of injury in two control groups also reduced, but there were no statistically significant differences (Z=0.126 and Z=1.051, respectively, P>0.05), as shown in Table 38.

Table 38 Comparison on injury events of past 12 months at baseline and one year of training in different groups based on subjects completing one-year follow up

	No. of events	No. of workers completing 1 yr follow up	Incidence rate (per 1,000 person-yrs)	Z value[#]	P value
Intervention group					
Baseline	61	422	144.5	3.199	<0.01
One year after training	31	422	73.5		
Control_1 group					
Baseline	36	393	91.6	0.126	>0.05
One year after training	34	393	86.5		
Control_2 group					
Baseline	69	488	141.4	1.051	>0.05
One year after training	57	488	116.8		

[#]z test for two proportions:

4.5.5 Reinjured cases in three groups

In intervention group about 23.8% (9/38) injured workers reinjured during one year of training. The reinjured rates were 34.5% (10/29) and 36.7% (18/49) in control_1 group and control_2 group, respectively, as shown in Table 39.

Table 39 Comparison on injury events of past 12 months between baseline and one year after training in different groups

		Injury at baseline		Total
		Yes	No	
Intervention group				
Injury at one year after training	Yes	9(23.7)	12(3.1)	21(5.0)
	No	29(76.3)	372(96.9)	401(95.0)
	Total	38(100)	384(100)	422(100)
Control_1 group				
Injury at one year after training	Yes	10(34.5)	16(4.4)	26(6.6)
	No	19(68.0)	348(95.6)	367(93.4)
	Total	29(100)	364(100)	393(100)
Control_2 group				
Injury at one year after training	Yes	18(36.7)	20(4.6)	38(7.8)
	No	31(63.3)	413(95.4)	450(92.2)
	Total	49(100)	433(100)	488(100)

4.5.6 Injury incidence rates for different industries

There were different person-based and event-based incidence rates of injury for different industry types during the previous 12 months at baseline and at one year after training (p values <0.001).

The workers in jewelry factories and printing factories reported very high person-based incidence rates (199.2 per 1,000 workers and 120.5 per 1,000 workers, respectively) and event-based incidence rates (294.6 per 1,000 person-years and 198.7 per 1,000 person-years, respectively) of work-related injury at baseline. The pharmaceutical and electronics workers had low person-based and event-based incidence rates of injury. The event-based incidence rates of injury were much higher than the person-based incidence rates among the workers of jewelry, printing and plastic industries, as shown in Table 40.

Table 40 Person-based and event-based incidence rates of injury for past 12 months by different industry types at baseline and one year after training

Industry	Injury at baseline					Injury at one year after training				
	No of subjects	Case	Incidence (/1,000 workers)	Events	Incidence (/1,000 person-yrs)	No of subjects	Case	Incidence (/1,000 workers)	Events	Incidence (/1,000 person-yrs)
Footwear	229	21	91 7	23	100 4	58	6	103 4	6	103 4
Electronics	1,277	64	50 1	83	65 0	552	29	52 5	35	63 4
Toy	429	36	83 9	42	97 9	180	6	33 3	10	55 6
Metal products	97	10	103 1	14	144 3	0	-	-	-	-
Printing	448	54	120 5	89	198 7	195	17	87 2	34	174 3
Optical	267	19	71 2	35	131 1	124	4	32 3	5	40 3
Plastic	396	37	93 4	58	146 5	86	6	69 8	9	104 7
Jewelry	241	48	199 2	71	294 6	87	17	195 4	22	252 9
Pharmaceutical	93	1	10 8	1	10 8	21	0	0	1	47 6
Total	3,477[#]	290	83 4	416	119 6	1,303[▲]	85	65 2	122	93 6

[#]Two subjects did not respond to the injury question at baseline.

[▲]Eighteen subjects did not respond to the injury question at one year after training.

One year after training the person-based and event-based incidence rates of injury reduced more or less in most of industries except for footwear and pharmaceutical industry. However, the person-based and event-based incidence rate of injury among jewelry workers was still high (195.4 per 1,000 workers and 252.9 per 1,000 person-years) at one year after training, as shown in Table 40.

4.5.7 Association between work-related injury and relevant factors

We applied Binary Logistic Regression to estimate the association between work-related injury and some relevant variables. Worker with work-related injury in current work was used as dependent variable because information of relevant variables was collected for current work at baseline. The results of Hosmer Lemeshow test showed that there was good model fit (Chi-square = 2.603, df = 8, p=0.957).

Table 41 presents the association between work-related injury and various factors. About 5.2% female workers and 12.8% male workers suffered from work-related injuries. Female workers had a significantly lower risk of injury with an odds ratio of 0.51(95% CI: 0.38, 0.68).

The injury incidence rates were 12.2%, 9.2%, 10.5% and 3.8% for the workers with primary school, middle school, high school and university or above education respectively. Compared with workers with primary school education, the differences were not statistically significant for the workers with middle school and high school education, but for workers with university or above education, the risk of injury reduced significantly and the odds ratio was 0.25 (95% CI: 0.09, 0.68).

Working more hours per week increased risk for work-related injuries. The injury incidence rates were 6.7%, 11.0% and 14.2% for the workers who worked less than 40 hours, 41-54 hours and over 55 hours per week respectively. The odds ratios were 1.45 (95% CI: 1.06, 1.98) for the workers with 41-54 work hours per week and 1.57 (95% CI: 1.16, 2.13) for the workers with over 55 hours per week.

Workers who had longer duration of employment in current work had increased risk of injury. The odds ratios for the workers with 24-35 and over 36 months of employment were 1.41 (95% CI: 0.96, 2.08) and 1.41 (95% CI: 1.07, 1.87) respectively compared to workers with 12-23 months of employment.

The injury incidence rates of the workers with self-reported low, medium and high work stress were 5.4%, 8.1% and 20% respectively. The odds ratio was 1.65 (95% CI: 0.84, 3.26) for the workers with medium work stress, but the difference was not statistically significant. For the workers with high work stress, the risk of injury increased a lot and the odds ratio was 3.85 (95% CI: 1.87, 7.92) compared to that of workers with low work stress.

The injury incidence rates were 8.0% among the workers without past history of injury and 30.6% among workers with injury history. The odds ratio of injury was 4.28 (95% CI: 2.97, 6.17) for workers with a past history of injury.

Compared with electronics workers, the workers from toy, footwear, printing, plastic and jewelry factories had high risks of injury. The odds ratios of the workers of toy, footwear, printing, metal products, plastic and jewelry factories were 1.86 (95% CI: 1.19, 2.91), 2.16 (95% CI: 1.26, 3.69), 1.72 (95% CI: 1.15, 2.57), 2.07 (95% CI: 1.04, 4.14), 1.91 (95% CI: 1.26, 2.90) and 3.79 (95% CI: 2.39, 6.01) respectively, as shown in Table 41. The pharmaceutical and optical workers had similar risk of injury as the electronics workers (OR=0.60, 95% CI: 0.21, 1.74 and OR=1.41, 95% CI: 0.85, 2.33, respectively).

Table 41 Odds ratios and 95% CIs of various factors for work-related injuries in current work

Factor	Injury		Odds Ratio	95%CI
	Yes (%)	No (%)		
Gender				
Male	252(12.8)	1,719(87.2)	1.00	
Female	78(5.2)	1,430(94.8)	**0.51**	**0.38, 0.68**
Educational level				
Primary school	18(12.2)	130(87.8)	1.00	
Middle school	171(9.2)	1,688(90.8)	0.72	0.40, 1.28
High school	133(10.5)	1,130(89.5)	0.80	0.44, 1.48
University	8(3.8)	200(96.2)	**0.25**	**0.09, 0.68**
Work hours/week				
<= 40 hours	126(6.7)	1,756(93.3)	1.00	
41-54 hours	87(11.0)	706(89.0)	**1.45**	**1.06, 1.98**
>=55 hours	113(14.2)	684(85.8)	**1.57**	**1.16, 2.13**
Duration of employment				
12-23 months	132(7.4)	1,640(92.6)	1.00	
24-35 months	44(10.6)	373(89.4)	1.41	0.96, 2.08
>=36 months	152(11.9)	1,129(88.1)	**1.41**	**1.07, 1.87**
Work stress				
Low	10(5.4)	174(94.6)	1.00	
Medium	229(8.1)	2,598(91.9)	1.65	0.84, 3.26
High	89(20.0)	356(80.0)	**3.85**	**1.87, 7.92**
Injury history				
No	260(8.0)	2,990(92.0)	1.00	
Yes	70(30.6)	159(69.4)	**4.28**	**2.97, 6.17**
Industry type				
Electronics	68(5.3)	1,210(94.7)	1.00	
Pharmaceutical	4(4.3)	89(95.7)	0.60	0.21, 1.74
Toy	41(9.6)	388(90.4)	**1.86**	**1.19, 2.91**
Footwear	22(9.6)	208(90.4)	**2.16**	**1.26, 3.69**
Optical	27(10.1)	240(89.9)	1.41	0.85, 2.33
Printing	55(12.3)	393(87.7)	**1.72**	**1.15, 2.57**
Metal products	12(12.4)	85(87.6)	**2.07**	**1.04, 4.14**
Plastic	51(12.9)	345(87.1)	**1.91**	**1.26, 2.90**
Jewelry	50(20.7)	191(79.3)	**3.79**	**2.39, 6.01**

Note: Binary Logistic Regression with Backward Methods was used. Other variables included colleague relationship, work satisfaction, job position, age, pre-job and on-job training and previous work experience, but not shown in this model because of no statistical significances.

The KAP scores were classified into low, medium and high levels. The Binary Logistic Regression was also applied to analyze the association between work-related injuries and workers' knowledge, attitude and practice after adjusting for gender, educational level, work hours, duration of employment, job position, work stress, injury history and industry type.

We found that there were no associations between work-related injury and workers' baseline levels of knowledge and attitude (see Table 42). For practice, the workers with medium scores (81-89 scores) or high scores (>=90 scores) had low injury incidence rates (8.4% and 8.3% respectively vs. 13.0% among those with low scores). The odds ratios for these two groups of workers were 0.64 (95% CI: 0.46, 0.88) and 0.58 (95% CI: 0.38, 0.89) respectively and were both statistically significant.

Table 42 Odds ratios and 95% CIs of knowledge, attitude and practice levels for work-related injuries during current work

Factors	Injury		Odds Ratio	95%CI
	Yes (%)	No (%)		
Knowledge score				
<=64	154(9.8)	1,417(90.2)	1.00	
65-79	117(8.8)	1,218(91.2)	0.91	0.67, 1.24
>=80	59(10.3)	514(89.7)	1.01	0.68, 1.51
Attitude score				
<=64	132(9.2)	1,306(90.8)	1.00	
65-79	164(9.7)	1,528(90.3)	1.26	0.93, 1.72
>=80	34(9.7)	315(90.3)	1.42	0.87, 2.33
Practice score				
<=79	108(13.0)	721(87.0)	1.00	
81-89	156(8.4)	1,701(91.6)	**0.64**	**0.46, 0.88**
>=90	66(8.3)	727(91.7)	**0.58**	**0.38, 0.89**

Note: Adjusted by gender, educational level, work hours per week, duration of employments, position, work stress, injury history, and industry type with Enter method.

The mean baseline scores were regarded as the cut-off points to classify low score and medium score. Then medium and high score was classified according to the difference between mean scores and the highest scores.

4.6 Sick leave

4.6.1 Sick leave and workdays lost

Table 43 shows that at baseline 1,022 workers reported workdays lost because of sick leave during the previous 12 months at current work, which accounted for 29.9% (1,022/3,417). At one year after training the proportion of workers' taking sick leave was 25.6% (334/1,304). In intervention group the proportions of taking sick leave reduced from 32.2% (293/909) at baseline to 24.6% (104/422) at one year after training and there was statistically significant difference (X^2 = 7.930, p=0.005). In control_1 group the proportions reduced from 29.5% (263/891) to 24.4% (96/394), but there was no statistically significant difference (X^2 = 3.602, p=0.058). The proportions in control_2 group were similar at baseline and one year after training (X^2 = 0.340, p=0.560).

Table 43 Self reported sick leave and workdays lost (mean±SD) at baseline and at one year after training in different groups

Group	Sick leave at baseline				Sick leave at 1-year after training			
	No. of subjects	No. of workers with sick leave	%	Mean work days lost	No. of subjects	No. of workers with sick leave	%	Mean work days lost
Intervention	909	293	32.2	4.1±6.4	422	104	24.6	3.5±3.9
Control_1	891	263	29.5	4.7±8.2	394	96	24.4	3.3±4.5
Control_2	1,617	466	28.8	3.9±5.6	488	134	27.5	3.6±3.9
Total	3,417[#]	1,022	29.9	4.1±6.6	1,304[▲]	334	25.6	3.5±2.1
P value			0.243	0.304			0.496	0.807

[#]62 participants did not respond to sick leave at baseline.
[▲]17 participants did not respond to sick leave at one year after training.

At baseline the average workdays lost due to sick leave was 4.1±6.6 for all these workers. The mean workdays lost were 4.1±6.4 in intervention group, 4.7±8.2 in control_1 group and 3.9±5.6 in control_2 group respectively and there was no significant difference (p=0.304). At one-year follow up, the workdays lost reduced to

3.5±2.1. The mean workdays lost were 3.5±3.9 in intervention group, 3.3±4.5 in control_1 group and 3.6±3.9 in control_2 group, respectively, as shown in Table 43.

To properly examine the changes in the proportions of workers taking sick leave before and after training, only subjects completing the one year follow-up were included, as shown in Table 44.

In intervention group the proportion of workers taking sick leave reduced from 32.0% (135/422) at baseline to 24.6% (104/422) at one year after training. Statistical significant difference was found for this reduction (X^2 = 5.609, p=0.018).

For control_1 group, the proportion of workers taking sick leave reduced from 26.6% (105/394) at baseline to 24.4% (96/394) at one year after training. There was no statistically significant difference (X^2 = 0.541, p=0.462).

In control_2 group, the proportion of workers taking sick leave reduced from 30.3% (148/488) at baseline to 27.5% (134/488) at one year after training. There was no statistically significant difference (X^2 = 0.977, p=0.323), as shown in Table 44.

Table 44 Comparison on sick leave of past 12 months between baseline and one year after training in different groups

	Sick leave		Total	%	X^2	P value
	Yes	No				
Intervention group						
Baseline	135	287	422	32.0	5.609	0.018
One year after training	104	318	422	24.6		
Control_1 group						
Baseline	105	289	394	26.6	0.541	0.462
One year after training	96	298	394	24.4		
Control_2 group						
Baseline	148	340	488	30.3	0.977	0.323
One year after training	134	354	488	27.5		

4.6.2 Sick leave and workdays lost in different industry types

As shown in Table 45, there were different proportions of workers taking sick leave and workdays lost for different industry types. About 42.3% (102/241) jewelry workers reported they had workdays lost because of sick leave in past 12 months. There were only 81 toy workers who reported workdays lost due to sick leave, which accounted for 19.8% of 409 total toy workers.

The proportion of workers taking sick leave reduced in most of industries after one year of training. For footwear workers the proportion increased from 27.1% at baseline to 41.4% at one year after training. The jewelry workers still reported high proportion of taking sick leave (38.6%) after one year of training program.

Table 45 Self-reported workdays lost because of sick leave at baseline in different industry types

Industry	Sick leave at baseline				Sick leave at one year after training			
	No. of subjects	No. of workers with sick leave	%	Work days lost	No. of subjects	No. of workers with sick leave	%	Work days lost
Footwear	210	57	27.1	5.5±5.6	58	24	41.4	4.8±4.0
Electronics	1,262	411	32.6	4.0±6.1	552	170	30.8	3.4±3.5
Toy	409	81	19.8	3.3±4.1	180	23	12.8	2.2±1.0
Metal products	97	23	23.7	4.0±8.9	0	-	-	-
Printing	448	133	29.7	4.3±8.4	195	32	16.4	2.6±3.1
Optical	267	83	31.1	4.1±5.8	124	25	20.2	3.2±5.8
Plastic	390	96	24.6	5.3±7.2	86	20	23.3	5.4±8.5
Jewelry	241	102	42.3	3.9±4.7	88	34	38.6	3.8±4.0
Pharmaceutical	93	36	38.7	4.0±4.1	21	6	28.6	4.1±3.7
Total	3,417#	1,022	29.9	4.1±6.6	1,304▲	334	25.6	3.5±4.1

#62 participants did not respond at baseline.
▲17 participants did not respond at one year after training.

At baseline the longest workdays lost were 5.5±5.6 in footwear factories and the shortest workdays lost were 3.3±4.1 in toy factories. At one year after training the workdays lost due to sick leave shortened in most of industries.

4.6.3 Association of sick leave and risk factors

Table 46 presents the association between work-related injury and various factors, such as gender, work hours, duration of employment, work stress, injury history and age.

Firstly, about 28.5% male workers and 29.9% female workers reported sick leave. The odds ration of sick leave was 1.20 (95% CI: 1.02, 1.42) for female workers.

The proportions of taking sick leave were 25.3%, 31.9% and 36.1% for the workers who worked less than 40 hours, 41-54 hours and over 55 hours per week respectively. The odds ratios were 1.32 (95% CI: 1.08, 1.61) for the workers with 41-54 work hours per week and 1.50 (95% CI: 1.24, 1.83) for the worker working over 55 hours per week.

The proportions of taking sick leave were 27.0%, 36.2% and 30.4% for the workers who worked 12-23 months, 24-35 months and over 36 months respectively. The odds ratios were 1.59 (95% CI: 1.24, 2.04) for the workers with 24-35 months employment and 1.42 (95% CI: 1.17, 1.72) for the worker with over 36 months employment.

The proportions of taking sick-leave of the workers with low, medium and high work stress were 20.7%, 28.4% and 39.6% respectively. The odds ratio was 2.02 (95% CI: 1.29, 3.17) for the workers with high stress compared with the workers with low stress.

The workers with injury during previous work reported high proportion of sick leave (50.2%). The odds ratio was 2.45(95% CI: 1.81, 3.22).

Compared with toy workers, the workers from printing, optical, electronics and jewelry factories had high risks of sick leave. The odds ratios of the workers of printing, optical, electronics and jewelry factories were 1.49 (95% CI: 1.05, 2.12), 1.59 (95% CI: 1.06, 2.37), 1.82 (95% CI: 1.35, 2.45) and 2.47 (95% CI: 1.67, 3.64) respectively, as shown in Table 43. The plastic, footwear, pharmaceutical, metal products workers had similar risk of sick leave as the toy workers.

Finally, older workers reported lower proportions of sick leave (33.7%, 31.1% and 19.3% and 11.1% for less than 24 years, 25-34 years, 35-44 years and over 45 years age groups respectively). The odds ratios of the workers aged 25-34 years and 35-44 years and over 45 years were 0.78 (95% CI: 0.65, 0.95), 0.38 (95% CI: 0.29, 0.80) and 0.21 (95% CI: 0.10, 0.46) respectively.

Table 46 Association between sick leave and gender, work hours per week, duration of employment, working position, working stress, injury history, industry type and age

Factor	**Sick leave**		**Odds Ratio**	**95%CI**
	Yes (%)	**No (%)**		
Gender				
Male	561(28.5)	1,410(71.5)	1.00	
Female	451(29.9)	1,055(70.1)	**1.20**	**1.02, 1.42**
Work hours/week				
<= 40 hours	475(25.3)	1,405(74.7)	1.00	
41-54 hours	253(31.9)	540(68.1)	**1.32**	**1.08, 1.61**
>=55 hours	288(36.1)	509(63.9)	**1.50**	**1.24, 1.83**
Duration of employment				
12-23 months	479(27.0)	1,293(73.0)	1.00	
24-35 months	151(36.2)	266(63.8)	**1.59**	**1.24, 2.04**
>=36 months	390(30.4)	891(69.6)	**1.42**	**1.17, 1.72**
Work stress				
Low	38(20.7)	146(79.3)	1.00	
Medium	802(28.4)	2,023(71.6)	1.21	0.81, 1.81
High	176(39.6)	269(60.4)	**2.02**	**1.29, 3.17**
Injury history				
No	907(27.9)	2,341(72.1)	1.00	
Yes	115(50.2)	114(49.8)	**2.45**	**1.81, 3.22**
Industry type				
Toy	81(19.8)	328(80.2)	1.00	
Metal products	23(23.7)	74(76.3)	1.13	0.64, 1.98
Plastic	96(24.6)	294(75.4)	1.00	0.69, 1.45
Footwear	57(27.1)	153(72.9)	1.39	0.92, 2.11
Printing	133(29.7)	315(70.3)	**1.49**	**1.05, 2.12**
Optical	83(31.1)	184(68.9)	**1.59**	**1.06, 2.37**
Electronics	411(32.6)	851(67.4)	**1.82**	**1.35, 2.45**
Pharmaceutical	36(38.7)	57(61.3)	1.62	0.94, 2.81
Jewelry	102(42.3)	139(57.7)	**2.47**	**1.67, 3.64**
Age group				
<=24 years	377(33.7)	743(66.3)	1.00	
25-34 years	410(31.1)	909(68.9)	**0.78**	**0.65, 0.95**
35-44 years	115(19.3)	480(80.7)	**0.38**	**0.29, 0.80**
>=45 years	8(11.1)	64(88.9)	**0.21**	**0.10, 0.46**

Note: Binary Logistic Regression with Backward Methods was used. Other variables included colleague relationship, work satisfaction, job position, pre-job and on-job training and previous work experience, but not shown in this model because of no statistical significances.

4.7 Musculoskeletal disorders

4.7.1 MSD prevalence rates in different groups

We developed the checklist based on the Nordic Standard Form to evaluate MSD prevalence for trained workers. The workers self-evaluated musculoskeletal disorders for neck, shoulder, low back, upper back, thigh/knee, low leg, ankle, elbow, hand/wrist and finger. Table 47 shows that about 51.6% workers (1,636/3,171) reported MSD with at least one body part. The MSD prevalence rates were 51.8%, 51.6% and 51.2% for intervention group, control_1 group and control_2 group (p=0.987).

Table 47 Self-reporting prevalence rates of musculoskeletal disorders in different groups

Group	Normal	Number of body parts with MSD (%)					
	(%)	1	2	3	4	≥5	Total
Intervention	399(48.2)	146(17.6)	102(12.3)	72(8.7)	47(5.7)	62(7.5)	429(51.8)
Control_1	406(48.4)	169(20.2)	113(13.5)	62(7.4)	46(5.5)	42(5.0)	432(51.6)
Control_2	730(48.8)	267(17.7)	169 (11.2)	125 (8.3)	100(6.6)	114(7.6)	775(51.2)
Total	1,535(48.4)	582(18.4)	384(12.1)	259(8.2)	193(6.1)	218(6.8)	1,636(51.6)

4.7.2 Basic characteristics of MSD

We can find from Table 48 that workers commonly suffered from MSD at low back, neck, shoulder and upper back and the prevalence rates for these four body parts were about 28.3%, 24.5%, 19.0% and 15.7% at baseline. Back pain became a popular problem among frontline workers and the prevalence rate of low back pain and upper back pain together was about 33.5% (1,079 workers suffering from back pain) in this study.

Among MSD cases, about 50% workers reported pain or discomfort with < one month duration and 12.8%-26.7% workers had pain or discomfort for specific body parts every day in past 12 months. 25.5%-36.5% workers reduced working and leisure activities because of specific MSD symptoms. Only few workers (6.2%-12.1%) went to see doctors or therapists to treat MSD. The medical costs for specific MSD ranged from 339 to 1,098 Yuan (US$ 49.6-160.5). The average medical costs of one MSD case were 601 Yuan (US$ 93.6).

4.7.3 Associations between MSD prevalence and relevant factors

We used Binary Logistic Regression to estimate associations between MSD prevalence and gender, education, work hours, work stress, injury, industry type and age at baseline. The results of Hosmer Lemeshow test showed that there was no problem for the model fit (Chi square = 13.435, df=8, p=0.098).

As shown in Table 49, the MSD prevalence rates of male workers and female workers were 49.8% and 53.8% respectively. The risk for MSD increased as a female workers and the odds ratio was 1.62 (95% CI: 1.38, 1.90).

The MSD prevalence rates were 31.1%, 42.4%, 53.2% and 62.5% for the workers with primary school, middle school, high school and university or above respectively. Compared with the workers with primary school, the difference was not statistically significant for the workers with middle school (OR=1.32, 95% CI: 0.86, 2.02). For the workers with high school or university or above, the risks of MSD unexpectedly increased and the odds ratios were 1.67 (95% CI: 1.06, 2.62) and 2.97 (95% CI: 1.20, 3.57), respectively.

The MSD prevalence rates were 43.7%, 47.7% and 53.1% for the workers who worked less than 40 hours, 41-54 hours and over 55 hours per week respectively. The odds ratio was 1.06 (95% CI: 0.88, 1.28) with no statistically significance for the workers who worked 41-54 work hours per week. For the workers who worked over 55 hours per week, the risk which associated with MSD increased significantly and the odds ratio was 1.46 (95% CI: 1.20, 1.77) compared with the workers with less than 40 hours per week.

The MSD prevalence rates among the workers with higher work stress were higher than that of the workers with low work stress. The MSD prevalence rates of the workers with low, medium and high work stress were 30.4%, 46.3% and 58.9% respectively. The odds ratios of the workers with medium and high work stress were 1.75 (95% CI: 1.20, 2.56) and 2.52 (95% CI: 1.64, 3.88) times that of the workers with low work stress.

The workers with injury events before had much higher MSD prevalence rate (63.8% vs. 45.8%). The risk of MSD increased for these workers and the odds ratio was 2.79 (95% CI: 1.96, 3.98).

Compared with toy workers, the workers from plastic, printing, optical, electronics, jewelry and pharmaceutical factories had high risks to suffer from MSD. The odds ratios of the workers of plastic, printing, optical, electronics, jewelry and pharmaceutical factories were 1.46 (95% CI: 1.04, 2.04), 1.93 (95% CI: 1.39, 2.69), 3.10 (95% CI: 2.10, 4.56), 2.11 (95% CI: 1.46, 3.06), and 5.47 (95% CI: 2.97, 10.09) times of that of toy workers. The odds ratios of footwear workers and metal products workers were 1.08 (95% CI: 0.74, 1.57) and 1.58 (95% CI: 0.95, 2.63) and there were no statistically significances.

Older workers reported lower rates of MSD (50.2%, 48.7%, 41.0% and 23.6% for less than 24 years, 25-34 years, 35-44 years and over 45 years age groups respectively). The odds ratios of the workers aged 25-34 years and 35-44 years were 0.96 (95% CI: 0.81, 1.14) and 0.82 (95% CI: 0.65, 1.02) respectively and there were no statistically significant differences. However, among the workers aged >= 45 years, the risk of MSD reduced and the odds ratio was 0.44 (95% CI: 0.24, 0.80), as shown in Table 49.

Table 48 Duration of pain or discomfort, activity reduction, treatment and medical costs associated with MSD in 10 different body parts

Body part	No. of respondents	No. of MSD (%)	Duration of pain or discomfort of MSD				Reducing work activity (%)	Seeing doctor or therapist (%)	Cost per case (Yuan)
			Every day	>= 1 month	< 1 month	Missing			
Low back	3,260	922(28.3)	141(15.3)	181(19.6)	465(50.4)	135(14.6)	300 (32.5)	112 (12.1)	644
Neck	3,241	794(24.5)	177(22.3)	135(17.0)	389(49.0)	93(11.7)	251 (31.6)	62 (7.8)	575
Shoulder	3,231	615(19.0)	124(20.2)	102(16.6)	281(45.7)	108(17.6)	168 (27.3)	38 (6.2)	339
Upper back	3,243	510(15.7)	99(19.4)	74(14.5)	270(52.9)	67(13.1)	170(33.3)	43(8.4)	546
Finger	3,216	326(10.1)	87(26.7)	46(14.1)	132(40.5)	61(18.7)	119 (36.5)	33 (10.1)	533
Thigh	3,229	320(9.9)	41(12.8)	60(18.8)	158(49.4)	61(19.1)	98 (30.6)	30 (9.4)	885
Hand/Wrist	3,215	279(8.7)	67(24.0)	41(14.7)	116(41.6)	55(19.7)	91 (32.6)	30 (10.8)	571
Low leg	3,216	271(8.4)	49(18.1)	51(18.8)	130(48.0)	41(15.1)	69 (25.5)	18 (6.6)	1,098
Ankle/foot	3,210	267(8.3)	60(22.5)	58(21.7)	113(42.3)	36(13.5)	94 (35.2)	25 (9.4)	641
Elbow	3,213	241(7.5)	51(21.2)	30(12.4)	121(50.2)	39(16.2)	78 (32.4)	15 (6.2)	369

Table 49 Associations (Odds ratios and 95% CI) between MSD and gender, age, work hours, duration of employments, industry type and age

Factors	MSD		OR	95%CI
	Yes (%)	No (%)		
Gender				
Male	883(49.8)	889(50.2)	1.00	
Female	753(53.8)	647(46.2)	**1.62**	**1.38, 1.90**
Educational level				
Primary school	46(31.1)	102(68.9)	1.00	
Middle school	788(42.4)	1,071(57.6)	1.32	0.86, 2.02
High school	672(53.2)	591(46.8)	**1.67**	**1.06, 2.62**
University	130(62.5)	78(37.5)	**2.97**	**1.20, 3.57**
Work hours/week				
<= 40 hours	822(43.7)	1,060(56.3)	1.00	
41-54 hours	378(47.7)	415(52.3)	1.06	0.88, 1.28
>=55 hours	400(53.1)	354(46.9)	**1.46**	**1.20, 1.77**
Work stress				
Low	56(30.4)	128(69.6)	1.00	
Medium	1,308(46.3)	1,519(53.7)	**1.75**	**1.20, 2.56**
High	262(58.9)	183(41.1)	**2.52**	**1.64, 3.88**
Injury history				
No	1,490(45.8)	1,760(54.2)	1.00	
Yes	146(63.8)	83(36.2)	**2.79**	**1.96, 3.98**
Industry type				
Toy	124(33.6)	245(66.4)	1.00	
Footwear	82(37.3)	138(62.7)	1.08	0.74, 1.57
Plastic	167(47.2)	187(52.8)	**1.46**	**1.04, 2.04**
Printing	203(53.3)	178(46.7)	**1.93**	**1.39.2.69**
Metal products	46(50.5)	45(49.5)	1.58	0.95, 2.63
Optical	140(60.9)	90(39.1)	**3.10**	**2.10, 4.56**
Electronics	671(56.3)	521(43.7)	**2.03**	**1.54, 2.68**
Jewelry	133(55.2)	108(44.8)	**2.11**	**1.46, 3.06**
Pharmaceutical	70(76.1)	22(23.9)	**5.47**	**2.97, 10.09**
Age group				
<=24 years	563(50.2)	558(49.8)	1.00	
25-34 years	643(48.7)	677(51.3)	0.96	0.81, 1.14
35-44 years	244(41.0)	351(59.0)	0.82	0.65, 1.02
>=45 years	17(23.6)	55(76.4)	**0.44**	**0.24, 0.80**

Note: Binary Logistic Regression with Backward Methods was used. Other variables included colleague relationship, work satisfaction, job position, pre-job and on-job training and previous work experience, but not shown in this model because of no statistical significances.

Unexpectedly the workers with high knowledge scores had higher MSD prevalence rates (56.0% for >= 80 scores, 51.2% for 65-79 scores and 40.2% for <= 64 scores), as shown in Table 47. The risk increased and odds ratios were 1.32 (95% CI: 1.10, 1.58) and 1.42 (95% CI: 1.11, 1.81) for the workers with medium level scores and high level scores respectively.

For attitude, the workers with medium level (65-79 scores) or high level (>= 80 scores) had high MSD prevalence rates (51.9% and 60.7% respectively). The odds ratios for these two groups of workers were 1.28 (95% CI: 1.07, 1.53) and 1.80 (95% CI: 1.33, 2.43).

There were no associations between MSD and workers' baseline practice scores, as shown in Table 50. The odds ratios for the workers with medium practice level (80-89 scores) and high knowledge level (>= 90 scores) were 1.11 (95% CI: 0.90, 1.36) and 1.02 (95% CI: 0.79, 1.33) and there were no statistically significant.

Table 50 Associations (Odds ratios and 95% CI) between MSD events and Worker' KAP

Factors	MSD		Odds Ratio	95%CI
	Yes (%)	No (%)		
Knowledge score				
<=64	632(40.2)	939(59.8)	1.00	
65-79	683(51.2)	652(48.8)	1.32	1.10, 1.58
>=80	321(56.0)	252(44.0)	1.42	1.11, 1.81
Attitude score				
<=64	546(38.0)	892(62.0)	1.00	
65-79	878(51.9)	814(48.1)	1.28	1.07, 1.53
>=80	212(60.7)	137(39.3)	1.80	1.33, 2.43
Practice score				
<=79	317(38.2)	512(61.8)	1.00	
80-89	917(49.4)	940(50.6)	1.11	0.90, 1.36
>=90	402(50.7)	391(49.3)	1.02	0.79, 1.33

Note: Binary Logistic Regression was used with adjusting by gender, educational level, work hours per week, work stress, injury history, and industry types with Enter method. The mean baseline scores were regarded as the cut-off points to classify low score and medium score. Then medium and high score was classified according to the difference between mean scores and the highest scores.

4.7.4 MSD prevalence rates at baseline and one year after training

Table 51 displays the MSD prevalence rates at baseline and at one year after training according to worker's self-reporting. The prevalence rates of MSD were 51.6% at baseline and 48.9% at one year after training. There were no statistically significant differences for MSD prevalence rates in three groups at these two time points (p=0.912 and p=0.830 respectively). The MSD prevalence rates reduced in three groups at one year after training, but no statistically significant differences were found for these MSD reduction (X^2 = 1.740, p=0.187 for intervention group, X^2 = 0.258, p=0.611 for control_1 group and X^2 = 0.911, p=0.340 for control_2 group, respectively)

Table 51 MSD prevalence rates at baseline and one year after training in different groups

Group	MSD prevalence at baseline			MSD prevalence at one year after training		
	No. of subjects	MSD cases	Prevalence (%)	No. of subjects	MSD cases	Prevalence (%)
Intervention	828	429	51.8	422	202	47.9
Control_1	838	432	51.6	394	197	50.0
Control_2	1,506	775	51.5	488	239	49.0
Total	3,172#	1,636	51.6	1,304▲	601	48.9
P value			0.912			0.830

#308 participants didn't response at baseline.
▲17 participants didn't response at one year after train

The MSD prevalence rates in the above table were calculated for the total subjects at baseline, but only for the limited subjects of follow up in one year of training. To compare the change of MSD prevalence rates before and after training, the rates were recalculated based on the subjects at one year of training, as shown in Table 52.

In intervention group the MSD prevalence rates changed from 48.1% (203/422) at baseline to 47.6% (201/422) at one year after training. There was no statistically significant difference for the change (X^2 = 0.019, p=0.890).

For control_1 group, the MSD prevalence rates changed from 48.0% (189/394) at baseline to 50.0% (197/394) at one year after training. There was no statistically significant difference ($X^2 = 0.325$, p=0.569).

In control_2 group, the MSD prevalence rates reduced from 49.6% (242/488) at baseline to 49.0% (239/488) at one year after training. There was no statistically significant difference ($X^2 = 0.037$, p=0.848), as shown in Table 52.

Table 52 Comparison on MSD of past 12 months between baseline and one year after training in different groups

	MSD		Total	Prevalence (%)	X^2	P value
	Yes	No				
Intervention group						
Baseline	203	219	422	48.1	0.019	0.890
One year after training	201	221	422	47.6		
Control_1 group						
Baseline	189	205	394	48.0	0.325	0.569
One year after training	197	197	394	50.0		
Control_2 group						
Baseline	242	246	488	49.6	0.037	0.848
One year after training	239	249	488	49.0		

4.7.5 Prevalence rates of MSD for different industries

Table 53 displays that the workers from pharmaceutical factories and optical factories reported very high MSD prevalence rates, 76.1% and 60.9% respectively. However, footwear workers and toy workers had relative low prevalence rates (37.1% and 33.6% respectively). At the same time we found that the average durations of employment were 27.9 months for footwear workers and 33.2 months for toy workers, but 39.1 months for other industry workers.

At one year after training the prevalence rates of MSD reduced in electronics, printing, optical, plastic and pharmaceutical industries. In footwear industry, toy industry and jewelry industry the MSD prevalence rates increased compared with baseline rates. Furthermore, the prevalence MSD rate in jewelry workers increased from 55.2% to 60.2%, as shown in Table 53.

Table 53 Prevalence rates of MSD for different industry types according to worker self-reporting

Industry of respondents	MSD cases and prevalence at baseline			MSD cases and prevalence at one year after training		
	No. of participants	Cases	Prevalence rate (%)	No. of participants	Cases	Prevalence rate (%)
Footwear	221	82	37.1	58	34	58.6
Electronics	1,192	671	56.3	552	280	50.7
Toy	369	124	33.6	180	76	42.2
Metal products	91	46	50.5	0	-	-
Printing	381	203	53.3	195	86	44.1
Optical	230	140	60.9	124	62	50.0
Plastic	354	167	47.2	86	35	40.7
Jewelry	241	133	55.2	88	53	60.2
Pharmaceutical	92	70	76.1	21	12	57.1
Total	3,171[#]	1,636	51.6	1,304[▲]	638	48.9

[#]308 participants did not respond at baseline.
[▲]17 participants did not respond at one year after train

4.8 Occupational expert assessment

4.8.1 Exposure assessment and risk characterization and control measures in different factories

We only managed to conduct expert factory OHS assessment in 38 factories (19 intervention factories and 19 control factories) at baseline. All factories had exposure to solvents and the mean scores of intensity, duration and frequency of solvent exposure were 3.0±1.0, 3.7±1.0 and 3.2±1.4 respectively, as shown in Table 54. The mean scores of prevalence and level of solvent exposure characterization were 2.8±1.0 and 2.8±1.2 respectively. The mean scores of engineering, administrative and personal control measures were 3.0±1.4, 2.8±1.4 and 2.0±1.0 respectively.

Twenty-eitht factories had noise exposure and the mean scores were 2.5±1.1, 3.6±1.1 and 3.5±1.1 for intensity, duration and frequency, 2.7±1.4 and 2.1±1.4 for prevalence and level of exposure, and 2.6 ± 1.4, 2.8 ± 1.4 and 2.3 ± 1.0 for engineering, administrative and personal control measure respectively.

Six factories had dust exposure and the mean scores were 2.2±0.8, 3.4±1.1 and 3.6±1.3 for intensity, duration and frequency, 1.6±0.5 and 2.0±1.9 for prevalence and level of exposure, and 2.0±1.9, 1.9±1.5 and 1.6±1.0 for engineering, administrative and personal control measure respectively. There were no statistically significant differences between two groups of factories.

Table 54 Exposure assessment, risk characterization and control measures for hazards in intervention and control factories

Hazards	Factory	No. of	Exposure assessment			Risk characterization		Control measures		
identification	group	factories	Intensity	Duration	Frequency	Prevalence	Level	Engineering	Administrative	Personal
	Intervention	15	2.7±0.9	3.5±1.1	3.5±1.0	2.6±1.4	2.2±0.8	2.7±1.4	2.9±1.4	2.2±0.9
Noise	Control	13	2.4±1.4	3.6±1.2	3.5±1.2	2.7±1.4	2.1±1.1	2.5±1.5	2.7±1.3	2.4±1.1
	Total	28	2.5±1.1	3.6±1.1	3.5±1.1	2.7±1.4	2.1±1.0	2.6±1.4	2.8±1.3	2.3±1.0
	P value		0.508	0.889	0.991	0.828	0.664	0.778	0.624	0.532
	Intervention	19	3.1±0.7	3.5±0.9	2.8±1.3	2.8±0.7	2.8±1.2	2.9±0.9	2.7±1.2	1.8±0.8
Solvent	Control	19	3.0±1.2	3.8±1.1	3.6±1.4	2.8±1.2	2.7±1.2	3.2±1.7	2.9±1.7	2.3±1.1
	Total	38	3.0±1.0	3.7±1.0	3.2±1.4	2.8±1.0	2.8±1.2	3.0±1.4	2.8±1.4	2.0±1.0
	P value		0.836	0.430	0.179	0.840	0.731	0.664	0.681	0.295
	Intervention	3	2.3±0.6	3.0±1.0	3.3±1.5	1.7±0.6	1.7±0.6	2.0±1.7	1.8±1.7	1.6±1.0
Dust	Control	3	2.0±1.4	4.0±1.4	4.0±1.4	1.5±0.7	1.5±0.7	2.0±1.8	2.0±1.4	1.6±1.4
	Total	6	2.2±0.8	3.4±1.1	3.6±1.3	1.6±0.5	1.6±0.5	2.0±1.9	1.9±1.5	1.6±1.0
	P value		0.724	0.413	0.658	0.789	0.789	1.000	0.550	1.000

Note: 1. Grading for Exposure Assessment

(1) Intensity: 0-no important exposures noted in factory; 5-extremely high intensity of exposure (at least for some workers)

(2) Duration: 0-no important exposures noted for any duration: 5-exposure lasting the entire work-shift

(3) Frequency: 0-seldom exposures noted for any duration; 5-continual or frequent exposures for current work

2. Grading for Risk Characterization

(1) Prevalence: 0-health risk not affecting any worker; 5-majority of workers are likely affected

(2) Level: 0-health risk not present or negligible; 5-extremely high risk to health of exposed workers

3. Grading for Control measures

(1) Engineering: 0-no control measures are in place; 5-highly effective engineering control measures are used throughout the factory

(2) Administrative: 0-no administrative control measures are practiced; 5-highly effective control measures are in common practice

(3) Personal: 0-appropriate personal protective measures are not provided and/or utilized; 5-appropriate protective measures are used

4.8.2 Grading on material handling, ergonomics, machine safety and working environment

The external occupational experts conducted the field assessment for grading on materials handling, work station, machine safety and working environment in 38 factories at baseline and 22 factories at one-year follow up. Table 55 showed the mean grades of materials handling, work station, machine safety and working environment at these time points in intervention factories and control factories.

The average grades of material handling were 3.4 ± 0.7 at baseline and 3.6 ± 0.8 at one year after training. The average grades of work station were 2.7 ± 0.8 at baseline and 2.8 ± 0.6 at one year after training. The average grades of machine safety were 4.0 ± 0.7 at baseline and 4.1 ± 0.5 at one year after training. The average grades of working environment were 3.4 ± 0.5 at baseline and 3.6 ± 0.4 at one year after training. At baseline or one year after training there were no statistically significant differences for material handling, work station, machine safety and working environment in intervention factories and control factories (p values >0.05), as shown in Table 55.

After one year of training, the grades of materials handling, work station, machine safety and working environment seemed to be higher than the baseline grades in intervention factories and control factories. However, the grades focused on the 38 factories and there were only 22 factories for the one-year follow up.

The paired T test was used to compare the grades for the same 22 factories at baseline and one year after training. The grades at one year of training seemed to be higher than the baseline grades in intervention factories and control factories, but there were no statistical significant differences for these changes (p values >0.05), as shown in Table 55.

Table 55 Expert grading for material handling, work station, machine safety and working environment in intervention and control factories at baseline and 1-yr follow-up

Items and factory	Factory assessment at baseline		Grade comparison of same paired factories between baseline and one year of training			
	No. of factories	Grade	No. of factories	Grade at baseline	Grade at one year	P value
Material handling						
Intervention factory	19	3.3±0.6	11	3.4±0.8	3.6±0.8	0.194
Control factory	19	3.5±0.7	11	3.5±1.0	3.5±1.0	0.887
Total	38	3.4±0.7	22	3.5±0.9	3.6±0.8	
P value		0.448		0.912	0.933	
Work station						
Intervention factory	19	2.4±0.9	11	2.3±0.6	2.5±0.6	0.102
Control factory	19	2.9±0.6	11	2.9±0.6	3.0±0.5	0.338
Total	38	2.7±0.8	22	2.7±0.6	2.8±0.6	
P value		0.061		0.052	0.071	
Machine safety						
Intervention factory	19	3.9±0.9	11	3.7±1.1	3.9±0.6	0.192
Control factory	19	4.0±0.6	11	4.1±0.9	4.2±0.5	0.625
Total	38	4.0±0.7	22	3.9±1.0	4.1±0.5	
P value		0.613		0.567	0.891	
Work environment						
Intervention factory	19	3.4±0.6	11	3.3±0.5	3.5±0.5	0.053
Control factory	19	3.5±0.4	11	3.4±0.6	3.7±0.4	0.102
Total	38	3.4±0.5	22	3.4±0.5	3.6±0.4	
P value		0.711		0.763	0.279	

Note: 0-not practiced at all, 5-excellent practices throughout factory
Paired T test was used to compare the grades for 22 factories.

4.8.3 Association between injury and factory performance

The effects of factory performances in material handling, work station, machine safety and working environment on work-related injury among the participating worker at baseline and one year after training were explored using Logistic Regression analysis.

Table 56 shows that high grades of machine safety in factory could reduce the risk of injury. The odds ratios were 0.53 (95% CI: 0.33, 0.86) for factories scoring 3.1-4.0 and 0.46 (95% CI: 0.27, 0.78) for the factories scoring 4.1-5.0 grades in machine safety. No statistically significant differences were found for factory performance on materials handling, work station and working environment, as shown in Table 56.

Table 56 Associations (Odds ratios and 95% CI) between injury and factory performance in materials handling, work station, machine safety and working environment

	Injury		Odds ratio	95% CI
	Yes	No		
Materials handling				
0-3.0	77(10.0)	696(90.0)	1.00	
3.1-4.0	125(10.3)	1,087(89.7)	0.98	0.71, 1.36
4.1-5.0	21(7.1)	273(92.9)	1.06	0.56, 1.99
Work station				
0-3.0	40(10.3)	347(89.7)	1.00	
3.1-4.0	107(9.2)	1,061(90.8)	1.51	0.86, 2.66
4.1-5.0	73(10.9)	593(89.1)	1.82	0.99, 3.32
Machine safety				
0-3.0	35(15.2)	196(84.8)	1.00	
3.1-4.0	97(8.9)	991(91.1)	**0.53**	**0.33, 0.86**
4.1-5.0	91(9.5)	869(90.5)	**0.46**	**0.27, 0.78**
Working environment				
0-3.0	58(10.5)	497(89.5)	1.00	
3.1-4.0	160(10.1)	1,430(89.9)	0.82	0.55, 1.22
4.1-5.0	5(3.7)	129(96.3)	0.41	0.16, 1.08

Note: 0-not practiced at all, 5-excellent practices throughout factory

4.9 Cost-benefit ratio for different training methods

4.9.1 Cost and workdays lost for injury events

Totally 57 factories reported 470 work-related injury events in the past 12 months before training and the total medical costs and compensation costs for these cases were RMB 1,984,375 Yuan (US$ 2,909,113) according to factory record. The average medical costs and compensation costs were 33,073 Yuan (US$ 4,835) for one factory. The average medical and compensation costs were 4,251 Yuan (US$ 623.3) for one injury event according to factory record, and the mean costs per one injury event were 4,145 Yuan (US$ 606.0) in intervention factories and 4,352 Yuan (US$ 636.3) in control factories.

The average workdays lost per event were 9.7 and the mean workdays lost were 9.4 and 9.9 in intervention factories and control factories respectively, as shown in Table 57.

Table 57 Cost and workdays lost for each injury event in intervention factory and control factory according to factory record

Factory	Injury events at baseline				Injury events at one year after training			
	No. of factory	Injury events	Cost per event#	Workdays lost per event	No. of factory	Injury events	Cost per event#	Workdays lost per event
Intervention	30	295	4,145	9.4	16	173	3,748	8.8
Control	30	175	4,352	9.9	16	156	2,813	8.9
Total	60	470	4,251	9.7	32	329	3,135	8.9

#including medical costs, compensation costs.

According to worker self-reporting at baseline, 290 workers reported a total of 416 injury events during the previous one year before training. The median cost per injury event was 400 Yuan (US$ 58.5) in intervention group and 350 Yuan (US$ 51.2) in control_2 group, as shown in Table 55. The mean costs per injury event were 1,129.8 Yuan (US$ 165.2) in intervention group, 1,336.8 Yuan (US$ 195.4) in control_1 group and 1,076.3 Yuan (US$ 157.4) in control_2 group.

At one year after training the median cost per injury event was 300 Yuan (US$ 43.9). The mean costs for every injury event were 1,001.2 Yuan (US$ 146.4) in intervention group, 1,134.8 Yuan (US$ 165.9) in control_1 group and 1,043.3 Yuan (US$ 152.5) in control_2 group.

During the previous one year before training the median workdays lost due to injury were 3.0 (Q_{25}:Q_{75}=1.0, 5.0) in three groups. The workdays lost per injury event were 4.1 in intervention group, 4.7 in control_1 group and 4.5 in control_2 group.

At one year after training the median workdays lost were 3.0 (Q_{25}:Q_{75}=1.0, 5.0). The mean workdays lost due to injury event were 3.5 in intervention group, 3.3 in control_1 group and 3.6 in control_2 group, as shown in Table 58.

Table 58 Self-reported cost and workdays lost for each injury case at baseline and one year after training in three groups

Group	Injury events	Mean cost per event (Yuan)	Median cost (Yuan) (25%, 75%)	Mean work days lost per event	Median work days lost (25%, 75%)
Costs and workdays lost at baseline					
Intervention	117	1129.8	400(150, 550)	4.1	3.0(1.0, 5.0)
Control_1	84	1336.8	400(100, 525)	4.7	3.0(2.0, 5.0)
Control_2	215	1012.6	350(100, 550)	4.5	3.0(1.0, 5.0)
Total	416	1076.3	400(150, 550)	4.4	3.0(1.0, 5.0)
Costs and workdays lost at one year after training					
Intervention	31	1001.2	300(150, 500)	3.5	3.0(1.0, 5.0)
Control_1	34	1134.8	350(150, 500)	3.3	3.0(1.0, 5.0)
Control_2	57	1043.3	300(150, 500)	3.6	3.0(1.0, 5.0)
Total	122	1057.6	300(150, 500)	3.5	3.0(1.0, 5.0)

[#]including medical costs, compensation costs.

4.9.2 Cost for different training methods

The whole training program involved training organizers (health sectors and non-government organizations), factories and frontline workers. The costs included the expenses of the training organizers and factories. Table 59 shows the cost estimation process for one training course separately for participatory training and didactic training.

The costs of training organizers included instructors' wages, and expenses on transportation, training materials and others. On average the training organizers spent 512 Yuan (US$ 74.9) for one participatory training course and 244 Yuan (US$ 35.7) for one didactic training course (refer to Table 59).

Although the training activities were free for all factories, there were potential costs of production time loss as a result of frontline workers attending the training course. The current wage per hour was 6.25 Yuan (US$ 0.9) in Shenzhen for frontline workers. The wages paid by the factory were 968.8 Yuan (US$ 141.6) for one participatory training course and 400 Yuan (US$ 58.5) for one didactic training course (refer to Table 59).

The total costs were 1,480.8 Yuan (US$ 216.5) for one participatory training course and 644 Yuan (US$ 94.2) for one didactic training course respectively. The average costs were 47.8 Yuan (US$ 7.0) per worker for participatory training and 20.1 Yuan (US$ 2.9) per worker for didactic training. The cost of didactic training was only 42.1% that of participatory training.

Table 59 Costs for participatory training and didactic training (about 30 participants for one training course)

Items	Participatory training		Didactic training	
	Activity description	Cost (Yuan)	Activity description	Cost (Yuan)
Costs for training organizers				
Instructors	3 instructors × 5 hours of training × 20 Yuan/ hour[1]	300	2 instructors × 2 hours of training × 20 Yuan/ hour[1]	80
Materials	2 Yuan/copy × 31 copies[2]	62	2 Yuan/copy × 32 copies[2]	64
Transportation	50 Yuan/instructor × 3 instructors	150	50 Yuan/instructor × 2 instructors	100
Costs for factory:				
Wage for the trained workers[3]	6.25 Yuan/worker/hour × 31 workers × 5 hours	968.8	6.25 Yuan/worker/hour × 32 workers × 2 hours	400
Total costs		1,480.8		644
Average cost (Yuan/worker)[4]		47.8		20.1

[1]Calculated with 160 Yuan wage per day (8 hours) for one instructor based on the instructors' salary of Shenzhen Hospital for Occupational Disease Control and Prevention

[2]There were 918 workers for 30 participatory training courses and about 31 participants for every training course. There were 2,561 workers for 80 didactic training courses and 32 participants for every didactic training course.

[3]Wage paid by factory due to training course of frontline workers

[4]Average cost = total costs/number of the participants. The average cost for participatory training = total costs/31 participants, the average cost for didactic training = total cost/32 participants.

4.9.3 Cost savings for different training methods

The direct outcomes included injury reduction, sick leave reduction and MSD prevention. The direct cost savings included savings in medical cost and workday cost from reduction of injury events, savings in workday cost from reduction of sick leave as a result of other causes, and savings from MSD prevention.

We took a factory with 1,000 frontline workers as an example to estimate the cost savings for two training programs in one year, as shown in Table 60 and 61.

4.9.3.1 Cost savings with calculation of median cost and workdays lost

(1) Cost savings of injury reduction

After training the incidence rates of injury events reduced from 144.5 per 1,000 person-years to 73.5 per 1,000 person-years in intervention group and from 141.4 per 1,000 person-years to 116.8 per 1,000 person-years in control_2 group. 71 injury events and 24.6 injury events per 1,000 workers would be prevented by participatory training and didactic training respectively in one year.

Reducing injury events for participatory training = 1,000 workers × (144.5-73.5)/1,000 workers = 71

Reducing injury events for didactic training = 1,000 workers × (141.4-116.8)/1,000 workers = 24.6

The costs saving were 28,400 Yuan (US$ 4,152.0) and 8,610 Yuan (US$ 1,258.8) for the two training programs respectively according to the median cost per injury event in intervention group and control_2 group (see Table 60).

Costs saving for participatory training = 71 injury events × 400 Yuan/event = 28,400 Yuan

Costs saving for didactic training = 24.6 injury events × 350 Yuan/event = 8,610 Yuan

The median workdays due to injury event were 3.0 in intervention group and control group. So the workdays saving were 213 and 73.8 for the prevention of the above events.

Workdays saving for participatory training = 71 injury events × 3.0 days/event = 213 days

Workdays saving for didactic training = 24.6 injury events × 3.0 days/event = 73.8 days

The potential cost savings were calculated with the workdays saving multiplied workers' wages per day. The potential cost savings were 10,650 Yuan (US$ 1,557.0) and 3,690 Yuan (US$ 539.5) for participatory training and didactic training respectively.

Cost savings for participatory training = 213 days × 8 hours/day × 6.25 Yuan/hour= 10,650 Yuan

Cost savings for didactic training = 73.8 days × 8 hours/day × 6.25 Yuan/hour= 3,690 Yuan

(2) Cost savings of sick leave reduction

The proportions of workers with sick leave reduced from 32.0% at baseline to 24.6% at one year after training in intervention group and from 30.3% to 27.5% in control_2 group (see Table 44). We used mean workdays lost to calculate the cost savings because there were similar results for mean workdays lost and median workdays lost due to sick leave. The saving workdays were 303.4 in intervention group and 109.2 in control_2 group respectively.

Workdays saving for participatory training = 1,000 × (32.0%-24.6%) × 4.1 days = 303.4 days

Workdays saving for didactic training = 1,000 × (30.3%-27.5%) × 3.9 days = 109.2 days

The potential cost savings were 15,170 Yuan (US$ 2,217.8) and 5,460 Yuan (US$ 798.2) for participatory training and didactic training respectively.

Cost savings for participatory training = 303.4 days × 8 hours/day × 6.25 Yuan/hour= 15,170 Yuan

Cost savings for didactic training = 109.2 days × 8 hours/day × 6.25 Yuan/hour= 5,460 Yuan

(3) Cost savings of MSD prevention

The prevalence rates of MSD reduced from 48.1% at baseline to 47.6% at one year after training in intervention group and from 49.6% to 49.0% in control_2 group (see Table 52). The medical cost savings were 3,005 Yuan (US$ 439.3) and 3,606 Yuan (US$ 527.2) for participatory training and didactic training respectively.

Costs saving for participatory training = 1,000 × (48.1%-47.6%) × 601 Yuan = 3,005 Yuan

Costs saving for didactic training = 1,000 × (49.6%-49.0%) × 601 Yuan = 3,606 Yuan

(4) Total Cost savings of participatory training and didactic training

The total cost savings were estimated to be 57,225 Yuan (US$ 8,366.2) for participatory training and 21,366 Yuan (US$ 3,123.7) for didactic training among 1,000 trained workers, as shown in Table 60. The average cost savings were 57.2 Yuan (US$ 8.4) per worker for participatory training and 21.4 Yuan (US$ 3.1) per worker for didactic training. The cost saving of didactic training was only 37.4% that of participatory training.

(5) Cost-benefit ratio of participatory training and didactic training

Cost-benefit ratio equals to the reciprocal of the ratio between the cost saving and the costs of training program. So in this study the cost-benefit ratios of 1.16 (47.8/57.2=1:1.20) for participatory training and 1.06 (20.1/21.4=1:1.06) for didactic training were obtained from the results of costs and costs saving. Participatory training needed more resources or higher costs, but could achieve a better cost-benefit ratio than didactic training.

4.9.3.2 Costs saving with calculation of mean cost and workdays lost

We used the mean cost (1,129.8 Yuan and 1,012.6 Yuan per injury event) and workdays lost (4.1 days and 4.5 days per injury event) in intervention group and control_2 group to calculate the costs saving for the participatory training and didactic training. The costs saving were showed in Table 61.

Finally the total costs saving were 112,945.8 Yuan (US$ 16,512.5) for the participatory training and 39,510.9 Yuan (US$ 5,776.4) for the didactic training for 1,000 workers in one year. The costs saving per worker were 112.9 Yuan (US$ 16.5) and 39.5 Yuan (US$ 5.8) for the participatory training and didactic training respectively. The cost-benefit ratios were 2.36 (47.8/112.9=1:2.36) for the participatory training and 1.97 (20.1/39.5=1:1.97) for the didactic training.

Table 60 Costs saving for participatory training and didactic training (take 1,000 trained workers as an example) according to median cost workdays lost

Items	Participatory training		Didactic training	
	Benefit	Saving cost	Benefit	Saving cost
Injury reduction				
Reducing events	1,000 workers × (144.5-73.5)/1.000 workers[1] = 71 events	71 events × 400 Yuan/event[2] = 28,400 Yuan	1,000 workers × (141.4-116.8) /1,000 workers[3] = 24.6 events	24.6 events × 350 Yuan/event[4] = 8,610 Yuan
Saving days	71 events × 3.0 days/event[5] = 213 days	213 days × 8 hours/day × 6.25 Yuan/hour[6]= 10,650 Yuan	24.6 events × 3.0 days/event[7] = 73.8days	73.8 days × 8 hours/day × 6.25 Yuan/hour= 3,690 Yuan
Sick leave				
Reducing days	1,000 workers × (32.0%-24.6%)[8] × 4.1 days/worker[9] = 303.4 days	303.4 days × 8 hours/day × 6.25 Yuan/hour= 15,170 Yuan	1,000 workers × (30.3%-27.5%)[10] × 3.9 days/worker[11] = 109.2 days	109.2 days × 8 hours/day × 6.25 Yuan/hour= 5,460 Yuan
MSD reduction				
Reducing cases	1,000 workers × (48.1%-47.6%)[12] = 5 cases	5 cases × 601 Yuan/case[13] = 3,005 Yuan	1,000 workers × (49.6%-49.0%)[14] = 6 cases	6 cases × 601 Yuan/case[15] = 3,606 Yuan
Total costs saving		57,225 Yuan		21,366 Yuan
Average costs saving (per worker)		57.2 Yuan		21.4 Yuan

[1]The incidence rate of injury in intervention group at baseline and one year after training (Table 38). [2]The average cost for every injury event in intervention group at baseline (Table 58). [3]The incidence rate of injury in control_2 group at baseline and one year after training (Table 38). [4]The average cost for every injury event in control_2 group at baseline (Table 58). [5]Workdays lost due to injury events for every case in intervention group (Table 58). [6]The average wage for frontline workers (Shenzhen Bureau of Trade and Industry(80). [7]Workdays lost due to injury events for every case in control_2 group (Table 58). [8]The rate of sick leave in intervention group at baseline and one year after training (Table 44). [9]Workdays lost due to sick leave in intervention group (Table 44). [10]The rate of sick leave in control_2 group at baseline and one year after training (Table 44). [11]Workdays lost due to sick leave in control_2 group (Table 44). [12]The rate of MSD in intervention group at baseline and one year after training (Table 52)
[13]The medical cost for every MSD case in intervention group at baseline (Table 48). [14]The rate of MSD in control_2 group at baseline and one year after training (Table 52). [15]The medical cost for every MSD case in control_2 group at baseline (Table 48)

Table 61 Costs saving for participatory training and didactic training (take 1,000 trained workers as an example) according to mean cost and workdays lost

Items	Participatory training		Didactic training	
	Benefit	Saving cost	Benefit	Saving cost
Injury reduction				
Reducing events	1,000 workers × (144.5-73.5)/1,000 workers[1] = 71 events	71 events × 1,129.8 Yuan/event[2] = 80,215.8 Yuan	1,000 workers × (141.4-116.8) /1,000 workers[3] = 24.6 events	24.6 events × 1,012.6 Yuan/event[4] = 24,909.9 Yuan
Saving days	71 events × 4.1 days/event[5] = 291.1 days	291.1 days × 8 hours/day × 6.25 Yuan/hour[6]= 14,555 Yuan	24.6 events × 4.5 days/event[7] = 110.7days	110.7 days × 8 hours/day × 6.25 Yuan/hour= 5,535 Yuan
Sick leave				
Reducing days	1,000 workers × (32.0%-24.6%)[8] × 4.1 days/worker[9] = 303.4 days	303.4 days × 8 hours/day × 6.25 Yuan/hour= 15,170 Yuan	1,000 workers × (30.3%-27.5%)[10] × 3.9 days/worker[11] = 109.2 days	109.2 days × 8 hours/day × 6.25 Yuan/hour= 5,460 Yuan
MSD reduction				
Reducing cases	1,000 workers × (48.1%-47.6%)[12] = 5 cases	5 cases × 601 Yuan/case[13] = 3,005 Yuan	1,000 workers × (49.6%-49.0%)[14] = 6 cases	6 cases × 601 Yuan/case[15] = 3,606 Yuan
Total costs saving		112,945.8 Yuan		39,510.9 Yuan
Average costs saving (per worker)		112.9 Yuan		39.5 Yuan

Note: [1-15]data resource like Table 60.

4.10 Workers' evaluation of training program

4.10.1 Evaluation for each training session

About 85% participants thought the basic training sessions including work station, machine safety and working environment were useful for their health and safety. 84.3%, 83.8% and 81.0% workers reflected that the contents of chemical control, dust prevention and noise control were useful for usual work in workplace, as shown in Table 62.

Among the workers of intervention groups, 85.4% and 85.8% workers thought PPE demonstration and stretching exercise were useful contents for OHS improvement respectively. Only about 73% trained workers thought that the field visit, group discussions and games were useful respectively.

Table 62 Worker's evaluation on the components of the training sessions immediately after training

Items	N	Whether each component was useful			
		Yes	No	Unknown	Missing
Work station	3,200	2,717(84.9)	47(1.5)	47(1.3)	393(12.3)
Machine safety	3,200	2,735(85.5)	33(1.0)	44(1.4)	388(12.1)
Working environment	3,200	2,749(85.9)	29(0.9)	32(1.0)	390(12.2)
Chemical control	2,733	2,304(84.3)	41(1.5)	25(0.9)	363(13.3)
Dust prevention	272	228(83.8)	11(4.0)	3(1.1)	30(11.0)
Noise control	237	192(81.0)	4(1.7)	15(6.3)	26(11.0)
Field visit	787	580(73.7)	23(2.9)	33(4.2)	151(19.2)
Group discussion	787	581(73.8)	28(3.6)	28(3.6)	150(19.1)
Games	787	580(73.7)	28(3.6)	25(3.2)	154(19.6)
PPE demonstration	787	672(85.4)	5(0.6)	25(3.1)	85(10.8)
Stretching exercise	787	675(85.8)	7(0.9)	20(2.5)	85(10.8)

4.10.2 Evaluation on knowledge and practice improvement

At three months after training program 92.4% workers thought that their knowledge of occupational health and safety increased in intervention group. 91.6% workers could identify the hazards in workplace and 90.1% workers thought they changed their unsafe behaviors. 91.7% workers could use PPE correctly and 88.9% workers could attend OHS promotion activities in factories. In two control groups the proportions of workers' self-evaluation on OHS improvement were lower than those of intervention group (Table 63).

Table 63 Worker self-evaluation of knowledge and practice improvement in three groups at three-month follow up after training

Items	Intervention group		Control_1 group		Control_2 group	
	No. of subjects	No. of positive response (%)	No. of subjects	No. of positive response (%)	No. of subjects	No. of positive response (%)
Knowledge increase	595	550(92.4)	512	461(90.0)	886	797(89.9)
Identify and analyze the hazards	593	543(91.6)	508	451(88.8)	886	789(89.1)
Change unsafe behaviors	595	536(90.1)	512	460(89.8)	888	786(88.5)
Comply with the operating regulations	595	539(90.6)	508	453(89.2)	884	785(88.8)
Use PPE correctly	593	544(91.7)	512	462(90.2)	883	795(90.0)
Attend OHS promotion activities	592	526(88.9)	510	449(88.0)	881	772(87.6)

4.10.3 Evaluation on training methods

Table 64 shows workers' evaluation on six training methods for participatory training and didactic training at one year after training. In intervention group about 38.4% workers thought that PPE demonstration was the most useful training method for OHS improvement, and this was followed by lecture (23.8%). Only 16.9% workers regarded factory field visit as the most useful training method.

In control group, 45.0% and 38.5% workers selected lecture and PPE demonstration respectively as the most useful methods for OHS improvement.

Table 64 Workers' self-evaluation on six training methods for participatory training and didactic training at one year after training

	Participatory training		Didactic training	
	No of subjects	%	No of subjects	%
Lecture	93	23.8	235	45.0
Field visit	66	16.9	-	
PPE	150	38.4	201	38.5
Stretching exercise	17	4.3	-	
Discussion	62	15.9	86	16.5
Game	3	0.8	-	
Total	391	100.0	522	100.0

4.10.4 Evaluation on communication between factory and workers

Table 65 showed that Impact of training program on communication between factory and workers, factory improvement on OHS at three months and one year after training. At three months after training 85.0% (1,891/2,224) workers thought that the training activities strengthened communication between factory and workers. About 81.3% (1,803/2,219) workers thought that the factory took more actions to improve their OHS than before. About 88.7% (1,966/2,216) workers agreed that they needed the continuing training for OHS improvement.

At one year after training the evaluation on communication between factory and workers, factory OHS improvement and continuing training was similar with the results of three months after training, as shown in Table 65.

After training about 90% trained workers thought that the training program strengthened communications between the employers and the employees for the participatory training in intervention group (only about 84% in two control groups). Compared with two control groups, more trained workers thought that they would like to attend more factory OHS promotion activities in intervention group, as shown in Table 65.

Table 65 Impact of training program on communication between factory and workers, factory improvement on OHS at three months and one year after training

Items and groups	Three-month follow up		One year follow up	
	No. of subjects	No. of positive response (%)	No. of subjects	No. of positive response (%)
Intervention group				
More communication between factory and workers	594	521(87.7)	419	374(89.3)
More factory activities to improve OHS	595	506(85.1)	418	365(87.3)
Need more continuing training	589	524(89.0)	417	376(90.2)
Control_1 group				
More communication between factory and workers	529	445(84.1)	383	319(83.3)
More factory activities to improve OHS	531	423(79.7)	381	305(80.1)
Need more continuing training	528	466(88.3)	383	341(89.0)
Control_2 group				
More communication between factory and workers	1,101	925(84.0)	414	350(84.5)
More factory activities to improve OHS	1,093	874(80.0)	413	335(81.1)
Need more continuing training	1,099	976(88.9)	414	372(89.9)
Total				
More communication between factory and workers	2,224	1,891(85.0)	1,216	1,043(85.8)
More factory activities to improve OHS	2,219	1,803(81.3)	1,212	1,005(82.9)
Need more continuing training	2,216	1,966(88.7)	1,214	1,089(89.7)

4.11 Characteristics of the workers successfully followed up and those lost to follow-up

Table 66 compared the basic characteristics between the workers successfully followed up and those lost to follow up at one year after training. We found that there were statistically significant differences for the distributions of age, gender, position, duration of employment and training and work hours per week (p values < 0.05). Distributions of other main characteristics, such as education, work stress, previous work experience, injury history, baseline KAP scores, and injury events, sick leave and MSD for past 12 months, were similar between those followed-up and those lost to follow-up.

Table 67 shows the differences between the workers followed-up and the workers lost to follow-up by intervention group and two control groups. For the workers followed-up at one year after training, there were statistically significant differences for age, gender, work hours per week and work stress in three groups (p values <0.05). Workers successfully followed up in the intervention group were older, more likely male, worked for shorter hours and had lower stress compared to the control groups. No statistically significant differences were found in three groups for position, duration of employment, training experience, education, previous work experience, injury history, KAP scores, injury and sick leave and MSD for past 12 months.

For the workers lost to follow up, there was statistically significant difference for work hours per week in three groups ($p=0.001$). Other characteristics were similar in three groups, including age, gender, position, duration of employment, training, work stress, education, previous work experience, injury history, KAP scores, injury, sick leave and MSD for past 12 months, as shown in Table 67.

Table 66 Characteristic comparison between workers successfully followed up and workers loss to follow up at one year after training

Characteristics	Loss-to-follow up		Total	P value
	No	Yes		
Age	29.9±7.2	26.2±6.2	28.5±7.2	<0.001
Gender:				
Male	780(59.6)	566(52.0)	1,346(56.2)	0.002
Female	528(40.4)	523(48.0)	1,051(43.8)	
Position:				
Frontline workers	885(67.8)	895(82.3)	1,780(74.4)	<0.001
Team leaders	348(26.6)	148(13.6)	496(20.7)	
Managers	73(5.6)	45(4.1)	118(4.9)	
Employment duration:				
12-23	563(43.0)	687(63.1)	1,250(52.1)	<0.001
>=24	745(57.0)	402(36.9)	1,147(47.9)	
Pre-employment training:				
Yes	521(71.4)	238(63.1)	759(68.6)	<0.001
No	209(28.6)	139(36.9)	348(31.4)	
On-job training:				
Yes	507(70.0)	243(63.9)	750(67.9)	<0.001
No	217(30.0)	137(36.1)	354(32.1)	
Work hours				
<= 40 hours	793(60.8)	620(57.1)	1,413(59.1)	0.015
41-54 hours	252(19.3)	195(18.0)	447(18.7)	
>= 55 hours	260(19.9)	270(24.9)	530(22.2)	
Work stress				
Low	66(5.1)	76(7.0)	142(5.9)	0.094
Medium	1,072(82.2)	887(81.7)	1,959(82.0)	
High	166(12.7)	123(11.3)	289(12.1)	
Education level:				
Primary school	58(4.4)	37(3.4)	95(4.0)	0.467
Middle school	692(52.9)	563(51.7)	1,255(52.4)	
High school	476(36.4)	420(38.6)	896(37.4)	
>=University	81(6.3)	69(6.3)	150(6.2)	
Previous work experience:				
Yes	836(64.6)	711(65.8)	1,547(65.2)	0.465
No	458(35.4)	369(34.2)	827(34.8)	
Injury history:				
Yes	84(6.4)	74(6.8)	158(6.6)	0.465
No	1,224(93.6)	1,015(93.2)	2,239(93.4)	
KAP scores:				
Knowledge score	65.7±15.1	64.9±13.4	65.3±14.3	0.182
Attitude score	64.3±14.7	64.8±12.9	64.5±13.9	0.320
Practice score	78.7±17.4	78.5±15.8	78.6±16.7	0.714
Injury for past 12 months				
Yes	119(9.1)	100(9.2)	219(9.1)	0.902
No	1,189(90.9)	989(90.8)	2,178(90.9)	
Sick leave for past 12 months				
Yes	388(29.7)	347(31.9)	735(30.7)	0.187
No	920(70.3)	742(68.1)	1,662(69.3)	
MSD in past 12 months				
Yes	609(46.6)	543(49.9)	1,152(48.1)	0.107
No	699(53.4)	546(50.1)	1,245(51.9)	

Table 67 Characteristics comparisons between workers successfully followed up and workers lost to follow up by different groups

Characteristics	Workers successfully followed up					Workers lost to follow up				
	Intervention	Control_1	Control_2	Total	P value	Intervention	Control_1	Control_2	Total	P value
Age	30.4±7.3	30.3±7.3	29.2±7.2	29.9±7.2	0.028	26.4±6.3	25.8±6.0	26.2±6.4	26.2±6.2	0.386
Gender										
Male	281(66.1)	239(60.7)	260(53.2)	780(59.6)	0.001	169(49.6)	184(52.7)	213(53.4)	566(52.0)	0.551
Female	144(33.9)	155(39.3)	229(46.8)	528(40.4)		172(50.4)	165(47.3)	186(46.6)	523(48.0)	
Job position										
Frontline worker	278(65.4)	261(66.2)	346(71.0)	885(67.8)	0.098	274(80.4)	293(84.2)	328(82.2)	895(82.3)	0.190
Team leader	122(28.7)	116(29.4)	110(22.6)	348(26.6)		56(16.4)	43(12.4)	49(12.3)	148(13.6)	
Manager	25(5.9)	17(4.3)	31(6.4)	73(5.6)		11(3.2)	12(3.4)	22(5.5)	45(4.1)	
Duration of employment										
12-23 months	175(41.2)	163(41.4)	225(46.0)	563(43.0)	0.091	215(63.0)	207(59.3)	265(66.4)	687(63.1)	0.133
>=24 months	250(58.8)	231(58.6)	264(54.0)	745(57.0)		126(37.0)	142(40.7)	134(33.6)	402(36.9)	
Pre-job training										
Yes	144(74.6)	139(73.5)	238(68.4)	521(71.4)	0.140	39(59.1)	52(65.0)	147(63.6)	238(63.1)	0.738
No	49(25.4)	50(26.5)	110(31.6)	209(28.6)		27(40.9)	28(35.0)	84(36.4)	139(36.9)	
On-job training										
Yes	133(71.9)	142(74.0)	232(66.9)	507(70.0)	0.071	39(57.4)	54(67.5)	150(64.7)	243(63.9)	0.413
No	52(28.1)	50(26.0)	115(33.1)	217(30.0)		29(42.6)	26(32.5)	82(35.3)	137(36.1)	
Work hours										
<= 40 hours	272(64.0)	221(56.2)	300(61.6)	793(60.8)	0.001	208(61.2)	191(54.9)	221(55.7)	620(57.1)	0.001
41-54 hours	83(19.5)	96(24.4)	73(15.0)	252(19.3)		72(21.2)	70(20.1)	53(13.4)	195(18.0)	
>= 55 hours	70(16.5)	76(19.3)	114(23.4)	260(19.9)		60(17.6)	87(25.0)	123(31.0)	270(24.9)	
Work stress										

Low	20(4.7)	26(6.6)	20(4.1)	66(5.1)	0.002	21(6.2)	26(7.4)	29(7.3)	76(7.0)	0.694
Medium	366(86.5)	322(81.7)	384(78.9)	1,072(82.2)		275(80.6)	288(82.5)	324(81.8)	887(81.7)	
High	37(8.7)	46(11.7)	83(17.0)	166(12.7)		45(13.2)	35(10.0)	43(10.9)	123(11.3)	
Education level										
Primary school	24(5.7)	18(4.6)	16(3.3)	58(4.4)	0.068	12(3.5)	12(3.4)	13(3.3)	37(3.4)	0.105
Middle school	217(51.2)	221(56.1)	254(51.9)	692(52.9)		170(49.9)	166(47.6)	227(56.9)	563(51.7)	
High school	166(39.2)	129(32.7)	181(37.0)	476(36.4)		132(38.7)	153(43.8)	135(33.8)	420(38.6)	
>=University	17(4.0)	26(6.6)	38(7.8)	81(6.3)		27(7.9)	18(5.2)	24(6.0)	69(6.3)	
Work experience										
Yes	269(63.9)	242(62.4)	325(67.0)	836(64.6)	0.338	217(64.0)	223(64.1)	271(69.0)	711(65.8)	0.338
No	152(36.1)	146(37.6)	160(33.0)	458(35.4)		122(36.0)	125(35.9)	122(31.0)	369(34.2)	
Injury history										
Yes	33(7.8)	25(6.3)	26(5.3)	84(6.4)	0.321	21(6.2)	27(7.7)	26(6.5)	74(6.8)	0.685
No	392(92.2)	369(93.7)	463(94.7)	1,224(93.6)		320(93.8)	322(92.3)	373(93.5)	1,015(93.2)	
KAP score										
Knowledge	64.4±17.4	65.8±13.9	66.7±13.9	65.6±15.1	0.076	64.9±13.5	63.8±13.7	64.6±13.7	64.5±13.6	0.539
Attitude	62.4±16.6	63.9±14.2	64.8±13.1	63.8±14.8	0.091	64.2±12.8	64.9±13.6	64.4±12.7	64.5±13.0	0.740
Practice	76.9±19.9	79.0±16.4	79.7±15.8	79.7±15.8	0.056	78.5±15.2	78.4±16.3	77.7±16.9	78.2±16.2	0.773
Injury for past 1 yr										
Yes	38(8.9)	26(6.6)	55(11.2)	119(9.1)	0.057	29(8.5)	29(8.3)	42(10.5)	100(9.2)	0.504
No	387(91.1)	368(93.4)	434(88.8)	1,189(90.9)		312(91.5)	320(91.7)	357(89.5)	989(90.8)	
Sick leave for past 1 yr										
Yes	135(31.8)	105(26.6)	148(30.3)	388(29.7)	0.259	121(35.5)	109(31.2)	117(29.3)	347(31.9)	0.191
No	290(68.2)	289(73.4)	341(69.7)	920(70.3)		220(64.5)	240(68.8)	282(70.7)	742(68.1)	
MSD for past 1 yr										
Yes	185(43.5)	182(46.2)	242(49.5)	609(46.6)	0.194	178(52.2)	183(52.4)	182(45.6)	543(49.9)	0.103
No	240(56.5)	212(53.8)	247(50.5)	699(53.4)		153(47.8)	166(47.6)	217(54.4)	546(50.1)	

Chapter 5 Discussion

From June 2008 to May 2010, we conducted this randomized controlled trial in 60 medium-sized factories (30 intervention factories and 30 control factories) in Shenzhen, China. Among 3,479 subjects, 918 workers in intervention groups received participatory training, 2,561 workers in control groups received didactic training.

We collected the data at baseline, immediately after training, and at three months and one year after training to evaluate the effects of participatory training and didactic training. Up to the end of May 2010, three-month follow-up was completed in all 60 factories and 32 factories (16 intervention factories and 16 control factories) have completed the one-year follow up. Two factories were closed after the 3-month follow-up and another factory was also closed down one year after training because of the global economy crisis and recession during 2007-2009 (two electronics factories and one jewelry factory). The followed up rates for workers were 71.1% (2,473/3,479) at three months and 56.3% (1,321/2,347) at one-year after training.

The overall average baseline KAP scores among all subjects of 64.9±15.0, 63.5±14.7 and 78.1±18.0 improved significantly at immediate evaluation (82.7±12.3, 71.9±12.4 and 90.6±12.7 respectively), at three months (79.3±11.5, 73.9±10.6 and 91.7±9.6, respectively), and at one-year after training (76.7±12.1, 72.0±10.3 and 88.9±10.8, respectively). The mean KAP scores of the intervention group were higher than those of two control groups at all three time points after training.

In the year after training, the person-based and event-based incidence rates of injury reduced from 90 per 1,000 workers to 49.8 per 1,000 workers (χ^2=6.377, p=0.012) and from 144.5 per 1,000 person-years to 73.5 per 1,000 person-years (Z=3.199, p<0.001) in the intervention group. The person-based and event-based incidence rates of injury in two control groups also reduced, but the reductions were not statistically significant. The proportions of workers taking sick leave changed from 32.0% to 24.6% in intervention group (χ^2=5.609,p=0.018). The proportions of workers taking sick leave did not reduce significantly in the two control groups (p=0.462 and p=0.323, respectively). The MSD prevalence rates changed from 48.1% to 47.6% in the intervention group (p=0.890), from 48.0% to 50.0% in control_1 group (p=0.569) and from 49.6% to 49.0% in control_2 group (p=0.848).

The cost was 47.8 Yuan (US$ 7.0) per worker for participatory training and 20.1 Yuan (US$ 2.9) per worker for didactic training. The estimated cost savings in one year were 57.2 Yuan (US$ 8.4) per worker for participatory training and 21.4 Yuan (US$ 3.1) per workers for didactic training based on the median cost (medical and compensation) and workdays lost of injury. The cost-benefit ratio was 1:1.20 for participatory training and 1:1.06 for didactic training. The cost savings were 112.9 Yuan (US$ 16.5) per worker for participatory training and 39.5 Yuan (US$ 5.8) per worker for didactic training when applying the mean cost and workdays lost of injury. The cost-benefit ratio was 1:2.36 for participatory training and 1:1.97 for didactic training.

5.1 Summary of major findings

5.1.1 Change of workers' KAP

5.1.1.1 Improvement of KAP scores after training

There was a significant improvement (p<0.001) in the overall KAP scores at immediate evaluation, three months and one year after training as compared to the baseline for both participatory training and didactic training. Both participatory training and didactic training could improve the KAP scores on OHS for trained workers effectively. Moreover, the KAP scores of participatory training group were greater than those of didactic training groups at three time points after training. There were significant differences among the groups for the improvements except for attitude scores at one year after training. Participatory training could improve KAP scores more than didactic training, but the actual differences in improvements of KAP scores were small.

Some researchers also reported that the training program increased knowledge scores from about 55% at baseline to about 85% after training(66-72). In this study the knowledge scores increased substantially after training in the intervention group and two control groups (from about 65% to about 83%). Compared with the results of some other studies, the score differences were small (only 16-19%). In addition, the knowledge scores in the intervention group were higher than those of the control groups at three time points after training. Participatory training improved knowledge scores more than didactic training, but the differences of knowledge scores were mainly between the intervention group and the control_2 group. The effect size of knowledge scores in this study was 0.06-0.30, similar to those of some other studies(33, 38, 40, 41, 50, 51).

Some studies pointed out that training course could improve the perception or awareness or willingness to change workers' health status and improve work condition (17, 68, 71, 73, 74). In this study the attitude scores increased significantly after training programs, from about 63% to about 74%. The attitude scores of intervention groups were higher than those of control groups. The changes of attitude scores in intervention groups were larger than those of the control groups for three time points after training. However, the attitude score differences between pre-training and post-training were only 7.4-10.6%, which might indicate that it was not easy to change workers attitude on OHS. The effect size of attitude scores in this study was 0.03-0.22, less than those reported in other studies(38, 40).

Some studies also reported that training programs could change workers' behavior in workplace. Janhong, et al. in 2005 and Chen, et al. in 1996 evaluated the practice change and found that the improvements were from 36% to 85% and from 55% to 89% respectively(71, 72). The current study found that the training programs increased practice scores significantly. The practice improvements changed from about 78% at baseline to about 91% at immediate evaluation, but the difference was small. The practice scores of intervention groups were higher than those of two control groups after training, and the differences were statistically significant. In this study the effect size was 0.03-0.10 for comparisons of practice scores in intervention group and two control groups at three time points after training. Tsutsumi, et al conducted a RCT and found the workers' performance scores increased in intervention groups and the effect size was 0.35 (-0.05, 0.76)(32). Hulshof, et al in 2006 conducted a study and reported a practice improvement for the training program and the effect size was 0.06 (-0.20, 0.33)(38), similar to our study.

5.1.1.2 Decreasing trend of KAP scores at one year after training

A significant decrease was seen in the knowledge, attitude and practice scores from immediate evaluation to one year after training. This may be attributed to a decrease in retention of knowledge over time between the follow ups. The knowledge retention seemed to be quite good in intervention group.

Although the knowledge retention seemed to be better in participatory training group than in didactic training groups, there was a decreasing trend for knowledge scores at three months and one year of training. This reflected that the ability to retain knowledge tended to weaken with time. We found that some factories had over 50% turn-over rate, especially due to economic crisis during late 2008 and early 2009. The workers took their knowledge and experience with them when they left, which lead to knowledge attrition in the factories(87-90). With respect to loss of knowledge and high turnover rate, it is very important to carry out continuous training for industrial workers to improve their knowledge on workplace safety and health.

There was also a trend for attitude and practice scores to decrease one year after training. However, in this study, the attitude and practice scores at three months after training were greater than the scores at immediate evaluation in all three groups. Firstly, it should take more time to change the frontline workers' attitude to occupational health and safety. Secondly, this study asked the participants to report their actual behaviors in workplace. At immediate evaluation we assumed the baseline work condition to ask the participants to evaluate their attitude and practice. So the practice scores at three month follow up reflected actual practice in workplace. Finally, these results indicated that positive/good attitude and practice might be retained longer than knowledge.

5.1.1.3 Correlation between knowledge, attitude and practice

The results of this study showed that there were good positive correlations between knowledge, attitude and practice. The findings indicated that there were higher knowledge, better attitude and better practice about occupational health and safety among the trained workers. According to the findings, there was a significant relationship between knowledge and attitude. It meant that, by increasing workers' knowledge, their attitude to occupational health and safety would become better. A significant relationship was also found between workers' knowledge and practice. It was expected that knowledge affected behavior and behaviors should also become better by increasing knowledge. There was significant relationship between workers' attitude and practice on occupational health and safety and their practice became better with improving their attitude.

A study carried out by Salameh PR, et al in 2004 found that the preventive measures taken were directly proportional to the knowledge, i.e., the lower the knowledge, the lower were the preventive measures applied(91, 92). Knowledge was also associated with a more positive attitude toward workplace health and safety. Improvement in the knowledge by an educational intervention may lead to a direct improvement in practice(92, 93), thus helping to minimize occupational exposure. The training program could help people choose healthier life-styles or better practice in workplace by improving their knowledge of the relationships between health behaviors and health outcomes. However, some studies reported lower correlation between knowledge and practice scores. For example, Kennedy T. et al found that an educational intervention, which have successfully increased clinicians' knowledge, have failed to have a significant impact on clinicians behavior and health care outcomes(94, 95). Altamimi and Peterson in 1998 also reported that women's knowledge and practice on oral and dental care were sometimes different. They knew about the bad impression of sweetness on oral and dental parts, but they still used too much(96). In fact this study also found that some industrial workers had good knowledge about chemical hazard prevention, but they did not wear personal protection equipment in workplace sometimes.

5.1.1.4 KAP improvements in different training areas

The knowledge scores and practice scores of machine safety were higher in intervention group than those in two control groups after training. The knowledge scores and attitude scores of chemical prevention were greater in intervention group than in two control groups after training. So compared with the didactic training, the participatory training had beneficial effects on machine safety and chemical prevention.

The knowledge scores of work station increased dramatically after training, but at one year after training the scores decreased remarkably. Frontline workers had high KAP scores of machine safety and chemical prevention before and after training programs, which meant factories and workers could aware the danger of machine and chemical in workplace.

For dust control, the knowledge, attitude and practice scores kept very low at baseline and any time points of training. At one year after training the scores were almost similar with baseline scores in three groups. This indicated training programs didn't have good effectiveness to improve workers' knowledge, attitude and practice on dust control.

5.1.1.5 KAP improvements in different industries

Compared with other industry workers, the workers of footwear, toy and jewelry factories had low KAP scores at baseline. Footwear, toy and jewelry were labor intensive industries and factories which employed many workers with low education level. The workers who graduated with primary school and middle school took up about 75%, 80% and 85% of total workers in these three industries, but about 50% for other industries. So at baseline the KAP scores were low for the workers in footwear, toy and jewelry factories.

After training the KAP scores of footwear and toy workers improved a lot, but the scores of jewelry workers was still low after training. This study also found that the training programs didn't have good effectiveness to improve workers' KAP on dust control. About 85% jewelry workers graduated with low education level. These findings indicated that the contents of training programs might be complicated or not suitable for the jewelry workers.

5.1.2 Injury reduction

Participatory training and didactic training could reduce the person-based and event-based incidence rates of injury for the frontline workers, and there was statistically significant reduction for participatory training ($p<0.01$) but no statistically significant difference for didactic training ($p>0.05$).

5.1.2.1 Change of incidence rates from factory record

The incidence rates of injury did not change significantly in the intervention factories and the control factories at one year after training ($p>0.05$) according to factory record. The training programs only trained a small proportion of frontline workers for each factory in this study. About 6.5% (3,479/53,866) frontline workers received participatory training or didactic training in 60 trained factories. These 60 factories didn't take action for training more frontline workers or promoting occupational health and safety in all workplaces after training programs. So the training programs should not have big impacts on occupational health and safety at factory level. The participatory training and didactic training did not reduce the incidence rates of injury events for the whole intervention and control factories.

The injury incidence rate from factory record was about one-tenth (8.2/1,000:83.4/1,000) of that from worker self-reporting. There were two main reasons for low incidence rate from factory record: 1) underreported injury cases in factory record; 2) only included severe injury cases. Although injury incidence rate from factory record was objective to evaluate the outcome of training program, this indicator did not include all injuries and the numbers of injury cases or events easily interfered with factory managers. So in this study we only used the incidence rates from worker self-reporting to compare the effectiveness for different training programs.

5.1.2.2 Change of incidence rates self-reported by worker

This study found that the participatory training could reduce the person-based or event-based incidence rates of injury and the didactic training could not reduce the incidence rates significantly. The results were similar when restricted to those subjects completing one year follow up.

The person-based incidence rates were 89.3 per 1,000 workers, 73.9 per 1,000 workers and 85.4 per 1,000 workers in intervention group, control_1 group and control_2 group at baseline and there was no statistically significant difference (p=0.454). However, there were more injured workers who reported >5 injury events in the intervention group and the control_2 group in previous one year. This caused a significant difference for the event-based incidence rates in three groups (127.5, 92.6 and 130.1 per 1,000 person-years for intervention group, control_1 group and control_2 group, respectively). The event-based incidence rates of injury were recalculated based on the subjects completing one year follow up. The incidence rates all changed in the three groups, but there were no statistically significant differences for the incidence rates of all participants and the subjects completing one year follow up in each group.

5.1.2.3 Injury and gender

Compared with female workers, male workers increased risks of traumatic injury. The precious studies focused on construction workers or plumbers to discuss the traumatic injuries(53-55, 97, 98). Few female workers were seen to work on these industries and so few studies explored the risks of traumatic injuries for female workers. However, some studies reported that female workers increased the risks of musculoskeletal injury (93, 99, 100). This study found that female workers reduced the risk of traumatic injury in industrial factories. The reduced risk of injury among female workers no doubt reflected a variety of factors, including differences in job tasks, experience and cautiousness during work.

5.1.2.4 Injury and education level

Subjects with a high educational degree had a significantly higher knowledge and more acceptable practice at baseline than subjects with primary school. This study also proved that training or education program supported higher knowledge and would result in more preventive measures. Actually the injury incidence rate among the workers with only primary school was higher than the workers with high education level, but there were no significantly differences.

The workers who graduated from university reported much lower injury incidence rate than that of workers with primary school (3.8% vs. 12.2%). The risk of injury events decreased for these workers (OR=0.25, 95% CI: 0.09, 0.68). Usually the workers with university deal with office work, and they have little chance for the work of producing line. For the workers with high school and middle school, they work in producing line together with the workers with primary school. So they have almost similar opportunity to get injury events.

5.1.2.5 Injury and work hours and work stress

Working more hours per week increased risk for injury events. The odds ratios were 1.45 (95% CI: 1.06, 1.98) for the workers with 41-54 work hours per week and 1.57 (95% CI: 1.16, 2.13) for the workers working over 55 hours per week. Some other studies also proved that long working hours increased occupational injuries and illness. Ilhan, et al in 2006 reported that the factors increasing the rate of sharp and needle-stick included working for more than eight hours per day in nurses(101). Dembe, et al looked at the data (including 110,236 employees) from 1987 to 2000 and found that workers who do overtime were 61% more likely to become hurt and ill. They also concluded that long working hours indirectly precipitate workplace accidents through a causal process, for instance, by inducing fatigue or stress in affected workers(102).

The workers with higher work stress had higher injury incidence rates. For the workers with high work stress, the odds ratio was 3.85 (95% CI: 1.87, 7.92) times that of the workers with low work stress. In China the frontline workers undergo long work hours and high work stress and low wages in many factories(10). The governments and factories should learn a lesson from 12 injury fatalities Foxconn Technology Group from January 1 to May 27, 2010(103). Preventive measures should be taken to reduce work hours and work stress for the frontline workers.

5.1.2.6 Injury and knowledge, attitude and practice

In this study the findings showed that the knowledge scores and attitude scores were not significantly associated with lower injury rates. However, the workers with medium level and high level of practice scores had low injury incidence rates compared with the workers with low practice scores. In our expectation, occupational injuries can be prevented by changing the workers' knowledge about safety, their attitudes toward safety, and their behaviors in the performance of their jobs. Measuring trainees' individual knowledge following training or education is a common but controversial practice. Weidner in a study concluded that knowledge was a poor predictor of behavior and argued that programs would do better by measuring change in more influential traits, such as risk perception, motivation, etc(104).

5.1.2.7 Re-injury

The findings of this study showed that the reinjured rate of the intervention group (about 24%) was less than those of the control groups (about 35% and 37%). Less uninjured workers suffered injury accidents in the intervention group (about 3%) than the control groups (about 4.5%). These results indicated that the injury accidents preferred to occur among a small group of workers repeatedly, but the reinjured rate in the participatory training group was lower than in the didactic training groups.

This study also found that the workers with injury events during their previous work increased the risk suffering from injury again. The odds ratio of injury was 4.28 (95% CI: 2.97, 6.17). The high risk of injury for the workers with injury history reflects complex factors such as lack of cautiousness, no specific training after injury and continuous work stress. Daltroy, et al reported in 1997 that 75 postal workers were injured again after they return to work among 360 injured workers (20.8%) and the repeated injury rate was much higher than that of other workers(31).

5.1.2.8 Injury incidence rates in different industries

The workers in jewelry factory and printing factory reported very high injury incidence rates at baseline. The occupational health experts found that the jewelry workers usually work in poor conditions and the control measures are limited. However, the jewelry workers faced dust hazards and other high risk tasks like cutting, grinding and polishing jewelry stones. So the frontline workers were easy to suffer from injury and this study found that the odds ratio of injury in jewelry workers was 3.79 (95% CI: 2.39, 6.01) times of that in electronics workers. The workers in printing factory operated many machines and machine safety was also their priority to prevent injury accidents. On the other hand, the frontline workers in electronics and pharmaceutical factories exposed some chemicals and they had relative low incidence rates of injury.

After training programs the injury incidence rates reduced more or less in most of industries. However, the incidence rate of injury in jewelry workers still remained very high. The control measures both from workers and factories should be taken to prevent injury accidents. If we only trained the frontline workers, the effect of injury prevention would be small. The factory should take specific control measures, including engineering and administration, to prevent injury accidents.

5.1.3 Sick leave reduction

So many factors affects sick leave that this indicator could not reflect the effect of training program directly. However, sick leave might be one of intermediate outcomes for musculoskeletal disorders or other occupational diseases.

It is assumed that factory records might be more reliable than self-reporting by workers. Although factories had the record of workers' leaves, we could not identify whether workers' leaves were due to sickness or other personal reasons. So we analyzed the proportions of workers taking sick leave based on their self-reporting.

5.1.3.1 Proportion of workers taking sick leave

Participatory training reduced the proportion of workers taking sick leave for the frontline workers and there was statistically significant difference ($p=0.018$). The didactic training didn't reduce the proportion of taking sick leave in control groups ($p>0.05$). This study reported that the workdays lost reduced in three groups, but there were no statistically significant differences for the reduction. Some other studies also reported the proportion of taking sick leave and workdays lost to evaluate the effects of training program. Wells, at al conducted the train-the-trainer training in 8 factories in 1997 and found that the training group had fewer illnesses(68). Heymans, et al in 2006 found that training was most effective in reducing work absence for workers with 3-6 weeks sick leave of LBP during 6-month follow up (47). Versloot, et al in 1992 conducted a study for drivers and found that the incidence of absenteeism of training group and control group did not change, but the mean length of absenteeism decreased(46). There were some studies, for example, Blangsted, et al in 2008 and Martimo, et al in 2007, that reported no effect of training program on reducing sick leave(105, 106).

5.1.3.2 Factors associated with sick leave

Female workers increased the risk of taking sick leave. The workers who worked with more hours per week also increased the risk of taking sick leave. The odds ratios were 1.32 (95% CI: 1.08, 1.61) for the workers with 41-54 hours per week and 1.50(95% CI: 1.24, 1.83) for the workers with over 55 hours per week. The workers with high work stress had higher proportions of taking sick leave and the odds ratio was 2.02 (95% CI: 1.29, 3.17).

Compared with the toy workers, the printing, optical, electronics and jewelry workers increased the risks of taking sick leave. This might be related with poor working condition, more occupational exposure and workers working with long hours and high stress in these industries.

Normally we would assume that older people are more likely to have sick leave than young people, but this study found that older workers reported lower proportions of taking sick leave. The odds ratios of the workers aged 25-34 years and 35-44 years and over 45 years were o.78 (95% CI: 0.65, 0.95), 0.38 (95% CI: 0.29, 0.80) and 0.21 (95% CI: 0.10,0.46), respectively. Usually elder workers have strong tolerance and are unwilling to ask sick leave if they can tolerate the discomfort. Moreover, the elder workers might promote to be team leaders or senior supervisors and they had lower work stress than young workers.

5.1.4 MSD prevention

5.1.4.1 MSD prevalence in frontline workers

United States Bureau of Labor Statistics pointed out that musculoskeletal disorders are expected to increase in the future because of the changing nature of work, the aging of the workforce, and rising numbers of women entering material handling and computer jobs in one study(107).

In China musculoskeletal disorders were not yet regarded as occupational diseases to report and compensate. Few articles described this health problem for frontline workers. Musculoskeletal disorders are most common complaints in industrial countries. Durand, et al reported that in one province of Canada musculoskeletal disorders constituted 35.9% of the industrial accidents involving compensation(63). The reported back pain lifetime prevalence varies from 60% to 90%(108). In this study about 51% workers reported musculoskeletal disorders for at least one body part and the prevalence rates of MSD in some industries even reached 70%.

Most specifically, previous studies have indicated workers often perform monotonous, highly repetitive, and high speed precision tasks requiring non-neutral and awkward joint postures. These exposures place workers at risk for developing work-related musculoskeletal disorders of the neck, shoulder, back and upper and lower extremities(59-62). In this study low back, neck, shoulder and upper back were commonly affected by MSD, and MSD prevalence rates for these four body parts were 28.3%, 24.5%, 19.0% and 15.7% respectively. Back pain was common for the frontline workers and the prevalence rate of low back pain and/or upper back pain reached 33.5%.

5.1.4.2 MSD prevalence rates after training

There were no statistically significant differences for MSD prevention for participatory training and didactic training, which meant that the training programs could not prevent

MSD substantially. Many previous studies also proved that the training programs could not prevent MSD, especially LBP prevention(29-31, 42, 43). In literature review we concluded that strong evidence was found for no effect of training or education programs on preventing LBP. The combined OR was 1.11 (95% CI: 0.87, 1.42) for training programs on preventing LBP with Meta-analysis.

This lack of evidence for the effectiveness of training programs at the workplace might be partly due to the fact that these interventions aimed at changing behaviors of workers, which they often adopted long ago. Changing behavior is not achieved easily(109). In control_2 group the prevalence rate of MSD increased a little at one year after training. Certainly the training program would not cause MSD directly. This might be related with long duration of employment and incorrect behaviors in workplace. Other reasons might include many causes outside of work affecting LBP occurrence, and low compliance and short period of follow up.

5.1.4.3 MSD and gender

Unlike reducing the risk of traumatic injury, female workers increased the risk of musculoskeletal disorders and the odds ratio was 1.62 (95% CI: 1.38, 1.90). According to M.Estryn-Behar's study, musculoskeletal disorders are particularly frequent among female workers: an annual prevalence rate of 35% to 52% has been observed(110). That might have two reasons for high MSD prevalence in female workers. Firstly, most of female workers are involved in arduous household work except for their daily work in factory. Secondly, most of the tools, machines and work stations have been designed for average male and are unsuitable for women from an ergonomic angle, which easily causes awkward postures for female workers(111-114).

5.1.4.4 MSD and educational level and age

The risks of MSD for the workers with high school and university were 1.67 (95% CI: 1.06, 2.02) and 2.97 (95% CI: 1.20, 3.57) times that of the workers with primary school. Usually the workers with high education level worked with higher stress than the workers with low education level. In this study more workers with high school (16.5%)

and with university (24.5%) reported they had high stress in workplace as compared to the workers with primary school (6.9%). This also explained that the workers with medium and high knowledge and attitude scores had higher MSD prevalence rates. It was because the workers with high educational level had high KAP scores.

The workers with older age reported lower prevalence rates of MSD. Among the workers aged over 45 years old, the risk of MSD reduced and the odds ratio was 0.44 (95% CI: 0.24, 0.80). This might exist a recall bias for MSD occurrence among older age workers. They might tolerate more pain and discomfort caused by MSD than young workers. In addition, the older workers might be promoted as team leaders and senior supervisors and so they had shorter working hours and lower work stress.

5.1.4.5 MSD and working hours and work stress

The workers who worked with more hours per week and high work stress had higher MSD prevalence. Lundberg reported that psychological stress and or strain may induce physiological stress and muscle tension, which may result in adverse changes in immune system response, or even changes in adrenaline or noradrenaline(114). Alternatively, it has been speculated that increased levels of psychological stress/strain might cause individuals to perform tasks differently, producing variation in biomechanical loading.

5.1.4.6 MSD in different industries

The footwear workers and toy workers had relative low prevalence rates of MSD (37.1% and 33.6% respectively) and the workers from pharmaceutical factories and optical factories reported high MSD prevalence rates. The management of footwear and toy factories was not strict and the self-reported work stress was lower for the frontline workers in these factories compared with pharmaceutical factories and optical factories. In addition, the average durations of employment were different for the workers in different factories, 27.9 months for footwear workers and 33.2 months for toy workers, but 39.1 months for other industry workers. These reasons caused different MSD prevalence rates in different industries at baseline. For jewelry workers, they still had high risk of MSD and the odds ratio was 2.11 (95% CI: 1.46, 3.06).

After training program the MSD prevalence rate did not reduce significantly for the subject completing one year follow up. However, in some industries, for example, footwear and toy and jewelry, the MSD prevalence rates increased. This might be caused by no effect of training program or because of small sample size at one year follow up for these industries.

5.1.5 Cost-benefit analysis for different training methods

In this study the participatory training expended more money than the didactic training. However, the participatory training program saved more money for factory than didactic training. The cost-benefit ratio of participatory training was better than that of didactic training.

Although the factories did not pay for the training in this study, but actually intervention activities involved costs to cover instructors' honorarium, transportation, training materials and potential production loss during training. In this study, participatory training cost more money than didactic training (47.8 Yuan per worker vs. 20.1 Yuan per worker).

In this study there was a big difference between mean costs or workdays lost and median costs or workdays lost for each injury event. So we calculated the cost savings with two models. The cost savings were calculated with the median cost and workdays lost for each injury in Model 1. The cost-benefit ratios were 1.20 (1:1.20) and 1.06 (1:1.06) for f participatory training and didactic training respectively. The cost savings were calculated with the mean cost and workdays lost for each injury in Model 2. The mean cost and workdays lost were greater than the median cost and workdays lost because there were several severe injury events who reported high costs and many workdays lost. So the cost-benefit ratios in Model 2 were greater than in Model 1. The cost-benefit ratios were 2.36 (1:2.36) and 1.97 (1:1.97) for participatory training and didactic training respectively.

The indirect cost savings, for example, caring for severe injury cases, potential work and wage lost due to disability of injury or MSD, transportation and accommodation cost for seeing doctors, were not included in our calculations. Moreover, the cost savings were for the first year after training. The effects of training program should last more than one year for factory or workers. So the costs saving might be underestimated in this study.

Versloot, et al reported that the decrease in mean length of absenteeism was calculated about 5-6.5 days per employee per year through the training program, which indicated that the program could save $700-900 per employee per year(46). In our study the costs saving were lower than that of this study. Heymans, et al. in 2006 found that the back school was most effective in reducing work absence and functional disability during 6 months follow up(47). Brown et al. in 1991 conducted a study to investigate the effect of a back school rehabilitation program in municipal employees and found that actual dollars saved in lost time and medical costs between groups(48). These studies only evaluated the effectiveness of training program, but not analyzed the cost-benefit of different training programs.

5.1.6 Worker self-evaluation on training programs

The training program have been found to increase the worker's realization of the serious health consequences associated with the irrational use of PPE, increase the use of PPE, raise awareness of workers on chemical use, read the chemical label before application, and create a awareness among workers on the potential hazards.

About 85% trained workers thought that the following training sessions, such as, work station, machine safety, working environment, dust prevention and chemical control, PPE demonstration and stretching exercise, were useful for usual work.

About 38% workers regarded PPE demonstration as the most useful training method in intervention groups and in control groups. Only about 16.9% participants thought that factory field visit was the most useful training method for participatory training.

After training high proportions of trained workers thought that the training program strengthened communications between the employers and the employees for the participatory training in intervention group. Compared with two control groups, more trained workers thought that they would like to attend more factory OHS promotion activities in intervention group.

5.1.7 Factory OHS assessment by occupational health expert

Chemical exposure was very common among the investigated factories. Frontline workers had to deal with some chemicals which might affect their health. The mean scores of intensity, duration and frequency of workplace chemical exposure were 3.0±1.0, 3.7±1.0 and 3.2±1.4 at baseline respectively. Noise pollution was also common in some factories. The mean scores of intensity, duration and frequency of workplace noise pollution were 2.5±1.1, 3.6±1.1 and 3.5±1.1 at baseline respectively. Dust pollution usually took place in the trained jewelry factories. The mean scores of intensity, duration and frequency of workplace dust pollution were 2.2±0.8, 3.4±1.1 and 3.6±1.3 at baseline respectively.

Evaluation and control of chemical exposure, noise pollution and dust pollution in the workplace are major components of an effective safety and health program. Workplace controls at the source of chemical, noise and dust release are inherently better than controls at the workers. In this study the occupational health expert assessed the control measures from engineering, administrative and personal situation. Engineering control and administrative control were better than personal control measures. Only 32%-46% workers took correct personal control measures for chemical exposure, noise pollution and dust pollution.

After one year of training, the grades of material handling, work station, machine safety and working environment seemed to be higher than the baseline grades in intervention factories and in control factories, but there were no statistically significant differences for these changes ($p > 0.05$). The training organizers only trained about 60 frontline workers in one factory. The trained workers only accounted for 6.5% total frontline workers in these 60 factories. Moreover, the trainers didn't popularize the training programs in the whole factories. So there were no improvements on OHS in the whole factories for participatory training and didactic training.

5.2 Strengths of this study

This study is a randomized controlled trial that comprehensively evaluated the effects of two training programs on injury reduction, sick leave reduction, MSD prevention and KAP improvement. To the best of our knowledge, this was the first RCT to compare injury reduction and the cost-benefit ratios for different training programs in industrial workers. The investigators and field assessment experts came from organizations not linked to those of the training instructors, and were not involved in the training programs. Hence, they were able to conduct independent evaluation of outcomes. This study also included two control groups and had a large sample size to evaluate the effectiveness of different training programs.

5.2.1 Independent evaluation of outcomes

OHS improvement programs are strategies for protecting workers' health, yet there are few studies on methods for assessing them, or on the prevalent characteristics of OHS programs(115). In the current study, Shenzhen Hospital for Occupational Disease Control and Prevention and Hong Kong Workers' Health Centre conducted the training programs, and the School of Public Health and Primary Care of the Chinese University of Hong Kong took charge of the design of the study and data collection independently. The investigators and field assessment experts were not involved in the training programs and also blinded to the factory and worker allocation.

5.2.2 Randomization and allocation concealment

A two-level random allocation process was adopted. Selected factories were first paired according to industry and size, and one of each pair was randomly assigned as intervention factory and the other as control factory. Within each intervention factory, around 60 workers were recruited and half were randomly allocated to the intervention group and half to the control group.

The investigators were only in charge of explaining the questionnaires and collecting them and did not know the allocation statuses of the factories and the workers. In this study the factory was not informed of the intervention or control information. The workers didn't know the intervention or control methods. The randomization allocation was concealed to the factories and workers.

The factory questionnaire included the information about co-intervention activities, such as occupational health inspection by government, other training programs and other occupational health intervention. There were no occupational health inspection activities from government and other training programs and other occupational health intervention activities for all 60 factories during the one year follow-up period.

5.2.3 Sample size

This study had relatively large sample size. Up to May 2010, 60 factories took part in the training program, and included various industries - electronics, printing, toy, plastic and hardware, optical, footwear and jewelry, etc. The industry distribution of this study was similar with that of all medium-sized enterprises in the city(80). Furthermore, a total of 3,479 subjects were successfully trained and interviewed at baseline, which included 918 workers in intervention groups and 2,561 workers in control groups. This relatively large sample size would provide enough power to address the effects of injury reduction and sick leave prevention.

5.2.4 Two control groups

When we selected target factories before training, we matched every factory by industry and employment size to ensure similar characteristics for intervention groups and control groups. Moreover, our study had two control groups: one control group in intervention factory and another control group in control factory. Administrative measures and cultures might be different in different factories, which would affect workers' knowledge, attitude and practice on OHS, injury and MSD prevention. So a control group was set up within one intervention factories to minimize the confounding factors of different factories.

5.2.5 Objective and subjective indicators

We used not only subjective indicators, for example, worker self-reported KAP, injury events and MSD, but also objective indicators, factory records on injury events, occupational health expert's field assessment on factory and workers' prevention measures. When workers reported their own practice or behaviors in workplace, they preferred to report correct practice even though they did not do like that(116). So we got high practice scores about occupational health and safety at baseline because of self-reporting bias. However, the scores of personal protective measures from occupational expert assessment could be used to adjust this bias.

5.2.6 Comprehensive evaluation on occupational health and safety

Our study compared the reduction of acute traumatic injuries resulting from participatory training and didactic training. There were so many obstacles to conduct randomized controlled trials in field settings, such as, number and choice of units for randomization, group contamination, workers' loss to follow up, etc(65). So in the literature review there were only before-and-after comparison studies to report injury reduction. This study should be the first RCT to study injury reduction in industrial workers.

Moreover, we explored the associations between injury, MSD and relevant factors, which allowed us to know more about high risk factors of injury and MSD. So we can take specific measures to control and prevent injury and MSD for industrial workers.

Furthermore, this study evaluated the intermediate indicators of occupational illness and diseases-knowledge, attitude and practice from baseline to one year after training for participatory training and didactic training. We can know the trend of knowledge attrition and determinants for knowledge, attitude and practice in workplace, which help make policies on training program for the frontline workers.

5.2.7 Cost-benefit ratios for different training methods

This study compared cost-benefit ratios for participatory training and didactic training. Some researchers reported the training program could save money for low back pain prevention. Lahirl, et al used one model analysis to evaluate the effectiveness of preventing low back pain through comparing training program with ergonomics program and engineering control and found that the training program ranked high in terms of cost-benefit ratios(77). Our study would like to explore an appropriate training scenario for frontline workers. So in this study the data about costs of different training programs and the possible health outcomes were collected in details. The cost-benefit ratio could provide direct and comprehensive evidence to evaluate participatory training and didactic training.

5.2.8 Training model for frontline workers

Participatory training is becoming popular among employers or institutions for the training of frontline workers to improve their health and safety. In some Asian countries, labor organizations and companies are using participatory training method to improve workers' health and safety in recent years(16, 20-23). The workers who received the train-the-trainer training conducted the continuous training for frontline workers with the support of trade unions. So many frontline workers could receive the training on OHS in their workplace. This should be an appropriate training way for frontline workers in developing countries with strong labor organizations.

In this study trade unions or factory occupational health and safety committee were not involved in the training programs, resulting in the lack of enough manpower to generalize the training throughout each factory. We have enough data to support participatory training in terms of better effectiveness in changing knowledge, attitude and practice and injury reduction and sick leave reduction. However, participatory training needed more resources and was more demanding on participants and instructors.

According to the study conducted in 1997 by All-China Federation of Trade Unions, the input of the trade union and Staff and Workers' Representative Congress (SWRC) did have a significant impact on the protection of the workers' occupational health and safety(117). Strong trade unions cover almost all factories in China and participatory training for frontline workers should utilize the support of trade unions in China.

5.3 Limitations of this study

5.3.1 Loss to follow up

5.3.1.1 Follow up in this study

A big challenge was subjects' loss to follow up in this study. The follow up rates were only 71.1% and 56.3% at three month and at one year after training, respectively. This was a main limitation for this study and might result in self-selection bias affecting the validity of the outcomes including KAP scores, injury, sick leave and MSD.

The training programs were initiated in early 2008. Unfortunately, the global financial crisis that began in the United States in December 2007 led to in a sharp drop in international trade and rising unemployment(118). During late 2008 and early 2009, Shenzhen industries had to face with many problems, such as factory close-down and high unemployment rate, etc(119).

Originally in Shenzhen the average annual worker's turnover rate was about 18%, and some smaller firms saw turnover rate as high as 30% according to the data of 2005 and 2006(120, 121). During financial crisis we had to face this problem: more workers lost to follow up in this study. At the end of 2008 two factories were closed down and one factory moved out of Shenzhen and about 5.6% (193/3,479) trained workers were lost to follow up in these three factories. In addition, many workers (about 10%) could not make enough money in some factories or were laid off and had to go back to their home villages because of economy recession. We were only able to follow up about 45% trained workers in some factories at three months and one year after training during the period of severe economy crisis.

5.3.1.2 Follow up and validity of study

In RCTs, a loss of ≥20% poses serious threats to validity, with in-between rates leading to intermediate levels of problems. Indeed, a cut-off of 80% for short-term and 70% for long-term follow up was used in Evidence-Based Medicine (EBM) Levels of Evidence to separate high and low quality randomized trials(122, 123). Although we acknowledge the importance of aiming for maximum follow-up in any study, in practice it is inevitable that loss to follow up will occur, and likely increase with time. Rates of 50-80% follow-up have been suggested as acceptable by some researchers, although in most cases the validity of these recommendations have not been tested(123-125). Kristman et al found no important bias even with losses of up 60% when data were "missing completely at random"(124).

5.3.1.3 Comparisons of baseline characteristic in different groups

In this study it is very difficult to reach ≥ 80% trained workers at one year follow up. So we should consider possible selection bias when the follow-up rate was low. In our study we should compare the characteristics between the measured and unmeasured before we evaluated the effectiveness of relevant indicators. If baseline characteristics are found to differ between those seen and not seen at follow-up, this may suggest bias.

There were statistically significant differences for the distributions of age, gender, position, duration of employment, training and work hours per week. The workers lost to follow up were younger and more likely to be female, working in producing line, and had shorter duration of employment or less training. During the economical crisis in 2008-09, these workers were the most likely group to be laid off by the factories. Distribution of other main characteristics, such as education, work stress, previous work experience, injury history, baseline KAP scores, and injury events, sick leave and MSD for past 12 months, were similar between those successfully followed up and those lost to follow-up.

For the workers followed-up at one year after training, there were statistically significant differences for age, gender, work hours per week and work stress in three groups. No statistically significant differences were found in three groups for position, duration of employment, training experience, education, previous work experience, injury history, KAP scores, injury and sick leave and MSD for past 12 months. For the workers lost to follow up, there was statistically significant difference for work hours per week in three groups. Other characteristics were similar in three groups, including age, gender, position, duration of employment, training, work stress, education, previous work experience, injury history, KAP scores, injury, sick leave and MSD for past 12 months.

5.3.1.4 Loss to follow up and KAP

This study found that the factors of gender, education, position, previous work experience, pre-job training, duration of employment and age showed significant associations with KAP scores. No statistical significances were found for most factors in three groups of the workers completing follow up except for age and gender.

The workers in three groups of those followed-up were older than those lost to follow up and so KAP scores might decrease in those three groups. This might underestimate the effect of training program. However, there were more male workers in intervention group and control_1 group among those completing follow up. KAP scores would increase in these two groups and this might overestimate the effect of training program. So finally it was hard to judge whether the loss to follow up underestimated or overestimated the effect of training program on KAP scores. The differences of these two factors in three groups might have a little influence on KAP scores.

5.3.1.5 Loss to follow up and injury

This study found that the injury accidents in workplace associated with the following factors: gender, job position, duration of employment, working hours, work stress, training experience, educational level and injury history. No statistical significances were found for job position, duration of employment, training experience, educational level and injury history in three groups of those completing one-year follow up, but there were significant differences for gender, working hours and work stress.

There were more male workers in intervention group, which might increase injury incidence rate and so might underestimate the training effect of injury reduction in this group. However, the workers in intervention group worked shorter hours and lower stress level so that injury incidence rate might be reduced and the training effect might be overestimated. Finally we didn't know whether the differences of gender, working hours and work stress overestimated or underestimated the training effect of injury reduction in intervention group. On the other hand, the workers in control groups worked with longer hours and higher stress level, which might increase injury incidence rate and might underestimate the training effect of injury reduction.

5.3.1.6 Loss to follow up and sick leave

For sick leave, no statistical significances were found for job position, duration of employment, training experience, educational level and injury history in three groups of those completing one-year follow up, but there were significant differences for age, gender, working hours and work stress.

At one year after training the intervention group left older and less female workers and the workers self-reported shorter working hours and lower stress level. This might reduce the proportions of workers taking sick leave and overestimate the training effect. However, there were also older and less female workers in control groups, which might reduce the proportion of workers taking sick leave and overestimate the training effect; the workers self-reported working with longer hours and higher stress level and this might increase the proportion of workers taking sick leave and underestimate the training effect. It was hard to justify whether overestimate or underestimate the training effect in control groups.

5.3.1.7 Loss to follow up and MSD

The balance distribution of job position, duration of employment, training experience, educational level and injury history in three groups of those completing one-year follow up might cause no influence or a little influence on preventing musculoskeletal disorder. However, there were significant differences for age, gender, working hours and work stress and the selection bias might influence the training effect.

At one year after training the intervention group left older and less female workers and the workers self-reported shorter working hours and lower stress level. This might prevent MSD occurrence and overestimate the training effect. However, older and less female workers in control groups might reduce MSD and so overestimate the training effect; working with longer hours and higher stress level might increase MSD and underestimate the training effect. It was hard to justify whether overestimate or underestimate the training effect in control groups.

5.3.2 Information bias and the Hawthorne effect

In this study many outcomes, such as KAP scores, injury events, MSD and health behaviors, were evaluated based on workers' self-reported data. As for outcome measurements, only self-reported indices were employed, which raised the issue of a possible response bias.

The practice scores were much higher than knowledge scores and attitude scores at baseline and at any time points after training. This might not indicate actual good performances, as the practices were self-reported. However, this at least reflected that workers knew the preferred or socially accepted practices in OHS. These improvements might be attributable in part to a Hawthorne effect. Cook and Campbell have pointed out that subjects tend to report what they believe the researcher expects to see, or report what reflects positively on their own abilities, knowledge, beliefs, or opinions(65, 126). It was believed that subjects tended to over-report their practice on occupation health and safety but under-report their injury and MSD. Obviously, this kind of error pattern is bias rather than variance. A possible explanation of over-report their practice was that the workers wanted to present correct operation in workplace. For under-reporting their injury and MSD, the workers might fear supervisors' pressure and want to show healthy body suitable for their jobs.

In this study one occupational health expert was invited to conduct factory assessment on hazard exposure, control measures and factory and worker's performance of workplace activities. The assessment of personal control measures at baseline might reflect the worker's actual practice in workplace.

To avoid the subjects' over-report practice or under-report injury accidents, the anonymity should be used in the questionnaires. However, this study would conduct two times of follow up and the record in this study needed to be matched for repeated measures ANOVA. In this study the questionnaire used required the participants to provide their names. Before the investigators explained that all personal information would be treated as confidential and would only be available to the researchers for follow-up and data analysis and their names would not show in any reports.

5.3.3 Low statistical power for injury and MSD prevention

If sample size is too small, the experiment will lack the precision to provide reliable answers to the questions it is investigating. If sample size is too large, time and resources will be wasted, often for minimal gain. In this study we would have enough sample size and enough statistical power to compare the differences of injury and MSD between baseline and one year after training in fact according to the original study plan.

As a result of the economic crisis, recruitment of factories was slowed down, and the attrition rate of trained workers was more than expected. By the end of May 2010, only 32 of the 60 factories had completed the 1-year follow-up. Hence, the statistical power for some analyses was lower than originally planned. The limited power due to dropout of participants might have limited a more positive effect.

5.3.4 Group contamination

Study group contamination and population turnover are frequent and related possibilities within factories because study subjects may come and go and or transfer from one unit to another during follow up of training. In this study there were one intervention group and one control group in one intervention factory. Control workers work and live together with intervention workers in an intervention factory. They can communicate and exchange the training contents, which may even make control workers expose them to the experimental study condition. Similar scores of KAP between two groups in intervention factories indicated group contamination could have occurred.

There was also a risk of another contamination due to simultaneous presence of untrained workers at the same workplaces, who may have negatively influenced their colleagues who attended the courses. This contamination might hamper the implementation of safe practice interventions. Only about 6.5% of the frontline workers attended and completed the training programs. This would also tend to flatten the difference of main outcomes before and after training.

5.3.5 Other confounding factors

The improvements of knowledge, attitude and practice are intermediate indicators which will affect injury and MSD prevention in workplace. Injury and MSD control and prevention are two main objectives for this study. Personal factors that put workers at risk for occupational back pain and injury may include short career, lack of experience on the job, work stress, heavy alcohol consumption, job dissatisfaction and negative attitude, and lack of strength or physical fitness. Workplace factors may include heavy lifting, repetitive bending and twisting, prolonged sitting, and operation of vibrating machinery. In this study we explored the association between injury and MSD and personal factors in details, but did not discuss workplace factors.

Chapter 6 Conclusions and recommendations

6.1 Conclusions

6.1.1 Effects of participatory training

Participatory training could improve the KAP scores of the frontline workers. At one year after training the person-based and event-based incidence rate of injury, and the proportion of worker taking sick leave were reduced significantly in the intervention group. However participatory training could not reduce MSD prevalence rate significantly. We concluded that participatory training was effective in improving the KAP scores, and reducing the injury incidence rate and the proportion taking sick leave among frontline workers.

6.1.2 Effects of participatory training and didactic training

The KAP scores of the participatory training group were greater than those of the didactic training groups at all time points after training. At one year after training participatory training could reduce the injury incidence rate and the proportion of workers taking sick leave. However, no statistically significant reductions in injury, sick leave and MSD were found for didactic training. In general we concluded that participatory training was more effective than didactic training in improving KAP scores and preventing injuries and sick leave for the frontline workers.

6.1.3 Cost-benefit ratios for participatory training and didactic training

In this study participatory training expended more money than didactic training. However, participatory training saved more money than didactic training after one year follow up. Participatory training had a better cost-benefit ratio than didactic training in improving workers' OHS, despite the higher costs and greater resources involved.

6.2 Recommendations

6.2.1 Using appropriate training methods to train frontline workers

This study proved that participatory training was an effective training approach and had a better cost-benefit ratio for improving workers' health and safety, including improving KAP scores and reducing injury and sick leave. So we recommend that the participatory training should be used in training frontline workers for improving their health and safety.

However, participatory training needed more resources and was more demanding for participants and instructors. In order to maximize the benefits, we propose using the train-the-trainer approach, so that more trainers would become available for reaching the vast numbers of frontline workers. We also recommend soliciting the support of trade unions in China to facilitate the wider adoption of the training method in various workplaces.

6.2.2 Continuous training for frontline workers

This study provided enough evidence that participatory training is an effective way to improve workers' health and safety. The training program could improve worker's knowledge, attitude and practice on occupational health and safety. However, decreasing trends of knowledge, attitude and practice scores were seen after certain time lapses after training. Moreover, factories in Shenzhen face a challenge with high turnover rates and low education level among migrant workers. We recommend that governments, organizations and factories should carry out continuous training programs for industrial workers on occupational health and safety.

6.2.3 Applying multiple measures preventing injury and MSD

Occurrences of injury events and musculoskeletal disorders were multifactorial for frontline workers. This study provided enough evidence that good performance on machine safety and material handling by factories and workers' could reduce injury events and MSDs. So it is logical to recommend strengthening engineering and administrative control measures through the support of the governments, organizations and factories. At the same time it is also necessary to pay great attention on personal control measures which include training and PPE application.

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Appendix I Factory Evaluation on Participatory Training for Occupational Health and Safety Improvement in Shenzhen

A1 Investigation Date:________YYYY____MM DD
A2 Factory: 1 intervention 2 control
A3 Serial number:
A4 It is: *1Baseline 2 0-month 3 3-month 4 6-month 5 12-month*

1. Company name: ______________________________
2. Company address: ______________________________
3. Total employers and employees: __________________persons
   Frontline employees: __________________persons
4. Type of industry:
   1=footwear 2=electronics 3=toy 4=metal products
   5=printing 6=spectacles 7=hardware 8=Jewelry
   9=other(_________)
5. What are the main risk factors in working places?
   Physical hazards (Note:___________________) 1 Yes 2 No
   Chemical hazards (Note:___________________) 1 Yes 2 No
   Biological hazards (Note:___________________) 1 Yes 2 No
   Ergonomics hazards (Note:___________________) 1 Yes 2 No
6. Is Committee of Occupational Health and Safety in the company? 1 Yes 2 No
7. Did the company conduct the training pre-employment? 1 Yes 2 No
8. Did the company conduct the training on-job? 1 Yes 2 No
   If yes, please continue, or skip to the next question.
   8.1 How many times in one year? ___________times
   8.2 How long does every training last? ___________minutes
9. Work hours
   9.1 How many hours do the employees work per day? ___________Hours
   9.2 How many hours do the employees work per week? ___________Hours
10. Salary for the frontline workers: ______________RMB/hour
11. Work-related injury during 2005-2007 (check factory record)
   11.1 How many injury events related with work in 2005? ________events
   11.2 How many injury events related with work in 2006? ________events
   11.3 How many injury events related with work in 2007? ________events

12. Work-related injury events during past one year

12.1 How many injury events related with work? __________events

12.2 Medical cost for injury cases: ________________Yuan RMB

12.3 Compensation cost: _________________Yuan RMB

12.4 Other cost: __________________Yuan RMB

12.5 Total absenteeism days because of injuries: _____________days

13. Occupational disease

13.1 How many occupational diseases are there in last year? ____________Cases

13.2 Medical cost______Yuan RMB for occupational diseases

13.3 Compensation cost_____________Yuan RMB

13.4 Total absenteeism days because of occupational diseases:__________days

After the training program:

14. Did the factory receive health inspection and relevant improvements for worker's health and safety? 1 Yes 2 No

15. Did the workers receive other trainings? 1 Yes 2 No

16. Did the factory conduct other intervention activities? 1 Yes 2 No

Appendix II Questionnaire of Workers' Knowledge, Attitude and Practice for Occupational Health and Safety

A1 Investigation Date:_______YYYY____MM____DD	
A2 Serial number of factories:	□□□
A3 Worker: *1 intervention 2 control*	□
A4 Serial number of workers:	□□
A5 It is: *1Baseline 2 0-month 3 3-month 4 6-month 5 12-month*	□
A6Potential hazards: *1=dust 2=chemical 3=noise 4=dust+chemical 5=dust+noise 6=chemical+noise 7=dust+chemical+noise*	□

This questionnaire is to evaluate your knowledge, attitude and practices regarding Occupational Health and Safety in the workplace and can be completed in about 20 minutes. You are free to respond to the questions in a manner you feel most appropriate and applicable to your situation.
All personal information will be treated as confidential and will only be available to the researchers for follow-up and data analysis, and only group data without personal identity will be used in the reports of the study.

1. Demographic information

1.1 Name of worker: ________________

1.2 Gender: 1=Male 2=Female

1.3 Date of birth:_________YYYY_______MM_______DD

1.4 Educational level:

1= illiteracy 2= primary school 3 = Junior school 4 = high school 5 = university and above

1.5 Which province are you from? _______________Province

1.6 Family telephone number: Mobile phone number:

2. Work description

2.1 How many hours do you work for each day?_________Hours

2.2 How many hours do you work for each week?_________Hours

2.3 Your work position:

1=common worker 2=group leader 3=manager in charge of occupational health 4=others

2.4 How many months have you been worked for this work: ____months

2.5 What is your work stress?

1=very low 2=low 3=acceptable 4=high 5=very high

2.6 What is relationship with supervisors and colleagues:

1=very poor 2=poor 3=acceptable 4=good 5=very good

2.7 Satisfaction with the job:

1=very poor 2=poor 3=acceptable 4=good 5=very good

2.8 Have you suffered from injury in current workplace? 1=yes 2=no

If yes, please continue, or skip to Question 9.

How many times in past 12 months:__________times

Costs for medical care /treatment due to injury:_________Yuan RMB

Compensation cost for injury:__________Yuan RMB

How many workdays lost in past 12 months: _________days

2.9 How many workdays lost for sick leave in past 12 months: _________days

2.10 Have you ever attended the pre-employment training? 1=yes 2=no

2.11 Have you ever attended the on-job training? 1=yes 2=no

2.12 Have you ever worked in another factory before this work? 1=yes 2=no

If yes, please continue, or skip to next part.

Industry type of past work: 1=footwear 2=electronics 3=electromechanical
4=metal products 5=home electrical appliances 6=computer
7=food processing 8=garment 9=other(_________)

Duration for last work: ___________months

How many times of injury during last work? ______Times

3. Questions for Knowledge, attitude, and practice (Please circle the answer that best describes your response to each statement)

3.1 Ergonomic

3.1.1 Knowledge

Statement	Correct?
1. I would like to transport more materials every time to reduce transportation times when transport heavy materials.	□1 Yes □2 No
2. The best working height for most tasks is at elbow height.	□1 Yes □2 No
3. When lifting heavy objects from the floor level, one should bend down the back to do that.	□1 Yes □2 No
4. Tools, controls and materials should be kept within easy reach to avoid the need for frequently raising the hands to reach out.	□1 Yes □2 No

3.1.2 Attitude

1. We need a lifter or machine device to transport heavy materials because of limited body power. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. Good working posture can not prevent musculoskeletal disorders effectively. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3. Using vices and clamps to hold materials and work items can not ensure convenient and safe operation for workers. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. Providing arm/hand support for repeating precision work can help reduce fatigue. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.1.3 Practice

Statement	Yes or no?
1. I usually use carts or mobile racks to transport materials from one location to another.	☐1 Yes ☐2 No
2. When lifting heavy objects from the floor level, I usually bend my knees and keep my back straight.	☐1 Yes ☐2 No
3. I don't use jigs, clamps, vices or other fixtures to hold items while work is done.	☐1 Yes ☐2 No
4. I usually modify my working posture (sitting/standing) once in a while during a work-shift to avoid fatigue.	☐1 Yes ☐2 No

3.2 Machine safety

3.2.1 Knowledge

Statement	Correct?
1. The cotton glove should be put on when you operate the moving parts of machines.	☐1 Yes ☐2 No
2. The machine guard should be dismantled to repair the machine when it is out of order.	☐1 Yes ☐2 No
3. The properly fixed guards or barriers may not be used to prevent contact with moving parts of machines or electricity.	☐1 Yes ☐2 No
4. Personal protective equipment should be used as a last resort for preventing injuries.	☐1 Yes ☐2 No

3.2.2 Attitude

1. Machine guards are a nuisance as they cause inconvenience to my work. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. Emergency controls should be clearly visible and easy to reach. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
3. Machines may not be checked and maintained regularly if there are no irregularities in their operations. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. The workers should receive the training of operating and repairing machines.

1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.2.3 Practice

Statement	Yes or no?
1. I usually read and understand the labels and safety instructions of new machines before using them.	☐1 Yes ☐2 No
2. I usually try to repair machines when they are not functioning properly, even if I have not received proper training to do so.	☐1 Yes ☐2 No
3. I usually take down machine guards or shields if they are obstructing my work and slowing down production.	☐1 Yes ☐2 No
4. I usually avoid putting my hands near moving parts or cutting edges of machines, but used assisted devise or tools instead.	☐1 Yes ☐2 No

3.3 Working environment

3.3.1 Knowledge

Statement	Correct?
1. Poor illumination can cause visual fatigue and reduce productivity.	☐1 Yes ☐2 No
2. Highlight can increase illumination of workstation and profit for worker's operation.	☐1 Yes ☐2 No
3. Local exhaust ventilation should be installed in the places where the hazards cause and ventilation guards should be near to the hazards.	☐1 Yes ☐2 No
4. Good workplace should be free from contaminants, but no requirements for illumination and ventilation.	☐1 Yes ☐2 No

3.3.2 Attitude

1. Combination of daylight and artificial light can increase illumination for the workplace effectively. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. Keeping the air in the workplace cool and dry is less important to me than keeping it clean and free from contaminants. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
3. Introduction of local exhaust ventilation cannot reduce dust, chemicals and other hazards. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. Work hazards are unavoidable and the only way to prevent being injured is to remind myself to be careful.

1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.3.3 Practice

Statement	Yes or no?
1. I usually handle toxic substances in work-stations with opening windows and electrical fans to increase natural ventilation.	□1 Yes □2 No
2. I don't use local lighting to increase illumination even though I carry out precise work.	□1 Yes □2 No
3. I usually put work materials and items in order to keep unobstructed for the workplace and aisle.	□1 Yes □2 No
4. I know the locations of fire extinguishers and know how to use them.	□1 Yes □2 No

3.4 Chemical hazards

3.4.1 Knowledge

Statement	Correct?
1. The chemical can enter the body through esophagus and respiratory tract, but not through the skin.	□1 Yes □2 No
2. Local ventilation system in workplace can prevent worker's intake of the chemical hazards effectively.	□1 Yes □2 No
3. Mask, glove and eyeshade are the last resort of preventing chemical intake.	□1 Yes □2 No
4. All organic solvent, pigments and glue should be put into the airtight containers.	□1 Yes □2 No

3.4.2 Attitude

1. Individual protective equipment causes me very uncomfortable, but it can protect myself and prevent the chemical's harm. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. The chemical category can be identified through the experiences and so the chemical names don't need to be labeled on the containers. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
3. Putting a towel into the mask can prevent the chemical intake more effectively. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. To provide the convenience for the others, the containers need not to be covered when you used the chemicals. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.4.3 Practice

Statement	Yes or no?
1. I usually deal with the chemicals without mask when local ventilation system is running.	☐1 Yes ☐2 No
2. For convenience, I usually take the chemicals without wearing the gloves.	☐1 Yes ☐2 No
3. I usually check the containers periodically to prevent leak of the chemicals.	☐1 Yes ☐2 No
4. I usually read MSDS before using new chemicals.	☐1 Yes ☐2 No

3.5 Dust prevention

3.5.1 Knowledge

Statement	Correct?
1. The smaller the dust, the shorter floating in the air and the less chance you will inhale dust.	☐1 Yes ☐2 No
2. Water can make the floating dust sediment and reduce dust flying in the air.	☐1 Yes ☐2 No
3. Drawing and separating dust are most effective to prevent workers' intake of the dust.	☐1 Yes ☐2 No
4. A common mask can prevent dust intake and silicosis.	☐1 Yes ☐2 No

3.5.2 Attitude

1. Dust intake only irritates the respiratory system and can not cause bad effect for other parts of the body. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. Smoking can increase the risk of silicosis for the workers when they work in the dust environment. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
3. Local exhaust ventilation and mask can prevent dust intake and silicosis more effectively. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. It is wasting time to clean the workplace after work every day. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.5.3 Practice

Statement	Yes or no?
1. I usually do not wear mask when there is a local ventilation system in workplace.	☐1 Yes ☐2 No
2. I usually change my mask periodically.	☐1 Yes ☐2 No
3. I usually water on the working station to reduce dust	☐1 Yes ☐2 No

production and transmission.	
4. Every day I usually clean the working station and wash the workplace after work.	☐1 Yes ☐2 No

3.6 Noise control

3.6.1 Knowledge

Statement	Correct?
1. Noise is all disgusting and agitated voices which are harmful for people's health.	☐1 Yes ☐2 No
2. Long term exposure to noise only brings about harms for the auditory system.	☐1 Yes ☐2 No
3. The workers can be separated from noise through using wallboard, windows and sound deadening shield, which can separate sound and reduce noise.	☐1 Yes ☐2 No
4. Ear shield has better effect on noise reduction than earplug.	☐1 Yes ☐2 No

3.6.2 Attitude

1. It is very important to avoid overexposure to noise because the noise is harm for health. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
2. Working environment with high decibel sound can not affect work efficacy. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
3. Sound deadening shield, sound insulating materials and construction can baffle noise transmission. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree
4. Wearing ear protective device is one way of reducing noise and decreasing harm. 1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

3.6.3 Practice

Statement	Yes or no?
1. I used to working in high decibel sound and usually not wear earplug and other ear protective devices.	☐1 Yes ☐2 No
2. I usually leave the workplace of high noise during break to reduce time exposure to noise	☐1 Yes ☐2 No
3. I don't check hearing periodically even though I work in noisy environment.	☐1 Yes ☐2 No
4. If I work in noisy environment, I will ask the employers to reduce noise or provide ear protective devices.	☐1 Yes ☐2 No

4. Comments on the training

4.1 Is each part of the training help for you?

4.1.1 Body ergonomic:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.2 Machine safety:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.3 Working environment:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.4 Dust prevention:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.5Chemical:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.6 Noise control:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.7 Field check:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.8 Group discussion:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.9 Games:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.10 Demonstration on PPE:	☐ 1 yes	☐ 2 no	☐ 3 unknown
4.1.11 Stretching exercise:	☐ 1 yes	☐ 2 no	☐ 3 unknown

4.2 Do you think which part is very useful?

1=Discussion 2=Lecture 3=Field visit 4=PPE 5=Stretching exercise 6=Game

4.3 The knowledge of occupational health and safety increased after the training.	1=agree	2=disagree	3=unknown
4.4 I can identify and analyze the hazards factors during the operation procedures after the training.	1=agree	2=disagree	3=unknown
4.5 I changed unsafe behaviors after the training.	1=agree	2=disagree	3=unknown
4.6 I can abide by the operation regulations on occupational health and safety after the training.	1=agree	2=disagree	3=unknown
4.7 I can use PPE according to the requirements.	1=agree	2=disagree	3=unknown
4.8 I can take part in the relevant activities of occupational health and safety in the factory after the training.	1=agree	2=disagree	3=unknown

4.9 I will pay more attention on hazards in workplace than before after the training.

1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

4.10 I have the confidence to guide and instruct knowledge of working health and safety for other workers after the training.

1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

4.11 I become more confident to provide recommendations or suggestions on working health and safety for the managers after the training.

1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree

4.12 Do you think whether the training strengthen communication between the managers and the workers?

1=no 2=some 3=yes 4=unknown

4.13 Do you think whether the recommendations or suggestions adopted by the factory?

1=no 2=some 3=yes 4=unknown

4.14 Would you like to introduce other workers to attend this kind of training on work health and safety?

1=no 2=some 3=yes 4=unknown

Appendix III Musculoskeletal symptom checklist

Please complete the following tables in each of the area that bothers you (Please tick √ in the right place).

Place	Have you ever had trouble (ache, pain or discomfort) in the respective body region in the last 12 months?	What is the total length of time that you have had this problem during the last 12 months?	Have the problem caused you to reduce your work activity?	Have you been seen by a doctor, physiotherapist, or other such person for this problem?	How much is the medical cost for the problem?
1. Upper back	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
2. Low back	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
3. Thigh/ Knee	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
4. Low leg	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
5. Ankle/ Foot	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
6. Neck	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
7. Shoulder	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
8. Elbow/ Forearm	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
9. Hand/ Wrist	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB
10. Finger	□1 Yes □2 No If "No", skip the right questions.	□1 every day □2 >1month □3 <1month	□1 Yes □2 No	□1 Yes □2 No	____ RMB

Appendix IV Expert Assessment Checklist for Worker's Health and Safety

Investigation Date: ______YYYY___MM___DD

Serial number of factory □□□

Assessment: 1 pre-training 2 post-training □

1. Basic information about factory

1.1 Name and address of Company

1.2 Number of workers employed and other characteristics

1.3 Production processes and number of workers involved in the process or exposures

2. Potential health hazards

Please grade the following from **0** to **5** according to the descriptions below:

Grading for Exposure Assessment

Intensity

- **0** no important exposures noted in factory
- **5** extremely high intensity of exposure (at least for some workers)

Duration

- **0** no important exposures noted for any duration
- **5** exposure lasting the entire work-shift

Frequency

- 0 seldom exposures noted for any duration
- 5 continual or frequent exposures for current work

Grading for Risk Characterization

Prevalence

- **0** health risk not affecting any worker
- **5** majority of workers are likely affected

Level

- **0** health risk not present or negligible
- **5** extremely high risk to health of exposed workers

Grading for Control measures

Engineering

0 no engineering control measures are in place

5 highly effective engineering control measures are used throughout the factory

NA not applicable (hazard not present or no important health risk)

Administrative

0 no administrative control measures are practised

5 highly effective administrative control measures are in common practice

NA not applicable (hazard not present or no important health risk)

Personal

0 appropriate personal protective measures are not provided and/or utilized

5 appropriate personal protective measures are used throughout the factory

NA not applicable (hazard not present or no important health risk after engineering control)

Hazards Identification	**Exposure Assessment**	**Risk Characterization**	**Control Measures**	**Remark**
Physical				
Noise	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Vibration (upper limb/ whole body)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Extreme temperature (hot/cold)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	

Ionizing radiation (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Non-ionizing radiation (Specify: ______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Laser (Specify:_____)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Others (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
<u>Chemical</u>				
Toxic gases (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Solvents (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Corrosives (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	

Metals (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Dusts (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Others (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Biological				
Infectious agents (Specify:_______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Biologically active substances (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	
Others (Specify:______)	☐ Intensity ☐ Duration ☐ Frequency	☐ Prevalence ☐ Level	☐ Engineering ☐ Administrative ☐ Personal	

Please grade items under **Sections 3 to 6** from **0** to **5** according to the descriptions below:

0 not practiced at all
5 excellent practices throughout factory

3. Materials handling

Items	Grading	Remarks
3.1 Transport routes (50% for clear and 50% for mark).		
3.2 Provide multi-level shelves or storage racks to store tools, materials, items and products in worksite.		
3.3 Provide place for every tool (50% for fixed and 50% for convenient).		
3.4 Use carts, hand-trucks and other wheeled devices or rollers, when moving materials.		
3.5 Use mobile storage racks to store and move materials, tools and products.		
3.6 Use crane and other mechanical devices for lifting, lowering and moving heavy materials.		

4. Work station

Items	Grading	Remarks
4.1 Adjust the working height for each worker at elbow level or slightly below it.		
4.2 Place frequently used materials, tools and controls within easy reach.		
4.3 Use vices and clamps to hold materials and work items.		

4.4 Use hanging tools for operation repeated in the same place.		
4.5 Provide sitting workers with appropriate height chair with a backrest (ensure their feet can be placed ground comfortably).		
4.6 Use markings or colors on display to help workers understand what to do and prevent errors.		

5. Machine safety

Items	Grading	Remarks
5.1 Guards should be installed to all dangerous moving parts of machines (50%) and power transmission equipment (50%).		
5.2 Use safe equipment to prevent machine operation threatening worker's hand.		
5.3 Make sure that the machine has good maintenance, no damaged and unstable parts.		
5.4 Make sure that all machines and electrical equipment can be used safely.		
5.5 Make emergency controls clearly visible and easily accessible.		
5.6 Workers take good and enough prevention measures (e.g. glove, goggle, long hair and jewelry)		

6. Working environment

Items	Grading	Remarks
6.1 Provide efficient lighting for worksites through increasing light source, reflection equipment and relocating lighting according to the requirements of different works.		

6.2 Increase air circulation and open windows and doors to increase natural ventilation.		
6.3 Install (50%) and improve (50%) local ventilation system.		
6.4 Isolate and screen dust, hazardous chemicals, noise and heat source for working environment.		
6.5 Make sure that the containers holding hazardous chemicals are airtight (50%) and labeling (50%).		
6.6 Workers wear PPE correctly (e.g. mask, earplug, glove, and goggle)		
6.7 Provide sufficient and safe drinking water for all workplaces.		
6.8 Provide rest room and eating areas separated with the workplace.		

Appendix V Publications resulting from this study

1. Wenzhou YU, Ignatius T.S. YU, Zhimin LI, et al. A Randomized Controlled Trial to Evaluate the Effectiveness of Participatory Training for Occupational Safety and Health Improvements in China. Proceedings of Asia Conference on Emerging Issues in Public Health, 2009, 163.
2. Wenzhou YU, Ignatius T.S. YU, Zhimin LI, et al. Evaluating the Effectiveness of Participatory Training for Worker's Knowledge, Attitude and Practice Improvements: A Randomized Controlled Trial. EPICOH-Medichem 2010 & RHICOH 2010 Conference, oral presentation.
3. Ignatius TS YU, Wenzhou YU, Zhimin LI, et al. Evaluating the Effectiveness of Participatory Training for Occupational Injury Reduction: A Randomized Controlled Trial. ICAP 2010 Conference (accepted).
4. Wenzhou YU, Ignatius T.S. YU, Zhimin LI, et al. Study on situation of occupational health and safety among industrial workers in China. 2010 Shenzhen-Hong Kong Forum for Occupational Health (accepted).
5. Wenzhou YU, Ignatius T.S. YU, Zhimin LI, et al. The effectiveness of participatory training for work-related injury reduction and musculoskeletal disorder prevention: A Randomized Controlled Trial. The International Symposium on Work Injury Prevention and Rehabilitation 2010 (accepted).