# Effectiveness of a Mobile Application-Based Intervention to Improve Knowledge and Practice Regarding Silicosis Among High-Risk Workers of Dust Exposure in a Northern Province of Vietnam

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## Abstract

*Objectives: to analyze changes in knowledge and practices regarding silicosis in groups of workers at high risk of silicosis before - after an intervention. Methods: The study was conducted from 2018 to 2019 based on structured questions related to knowledge and practices of silicosis of workers directly exposed to silica dust in a Northern province of Vietnam. The mobile app-based intervention was applied to steel workers, then compared with ironworkers in improvements in silicosis knowledge and practices. Results: Significant changes in the intervention group related to workers' knowledge about the signs suggestive of silicosis, disease consequences, measures to reduce the risk of silicosis, and participation in annual occupational disease examinations were reported. Conclusion: Mobile application-based interventions could improve silicosis knowledge and practice among workers at high risk of exposure to silica dust.*

**Keywords:** *knowledge, practice, workers, silicosis, mobile application, effectiveness*

## 1. Introduction

According to the World Health Organization, silicosis is one of the oldest occupational diseases. The prevalence of silicosis among workers exposed to dust in developing countries was about 20–50% [1]. In Vietnam, silicosis has been diagnosed in Vietnam since 1976, accounting for 88% of all cases of an occupational disease diagnosed in Vietnam during the period 1976–1997 [2, 3]. According to a recent report by the Vietnam Health Environment Management Agency, silicosis is still one of the most common occupational diseases in Vietnam and has not tended to decrease [4]. During the period 2018–2019, a study was conducted in five provinces of Vietnam on workers at high risk of exposure to silica dust, and study results showed that the rate of workers participating in the study with silicosis was 12.27% [5]. Workers in the construction materials, mining, and metallurgy industries are often exposed to adverse factors such as silica dust, which has adverse effects on health [6, 7, 8, 9]. Currently, there is no specific treatment for silicosis, and thousands of people has died every year because of this disease. However, silicosis is a preventable disease by improving workers' knowledge about the disease. In the world, at present, there are only a few studies on the knowledge and practice of workers about silicosis, typically a study conducted in South Africa showed that the percentage of workers with correct knowledge about silicosis was 20.7% [10]. In Vietnam, a research by Le Thi Thanh Xuan and Le Thi Huong (2018) showed that 44.3% of workers did not know the signs of silicosis, and 31.5% of tuberculosis did not know the consequences of this disease. The percentage of employees complying with occupational disease prevention measures was still limited. The rate of workers having annual medical examinations was 66.6%, compliance with occupational hygiene was 64.7%, and annual occupational disease examinations were 39.1% [11, 12] Interventional studies on the change in knowledge and practice of workers were largely lacking. In recent decades, the use of mobile technology including mobile applications, text messaging, etc. to improve human health has attracted more attention. Medical applications on smartphones have developed more and more widely. These applications have various content such as drug references, medical training, and document search, supplementing knowledge for users [13, 14, 15, 16]. The development of applications for the health field has made an important contribution to maintaining or improving people's healthy behaviors, quality of life, and well-being [17]. These mobile-based intervention studies have assisted people in the management of many chronic diseases through improved knowledge and associated risk behaviors [18, 19, 20, 21, 22, 23, 24, 25].

Thai Nguyen province which is a province in the North of Vietnam has abundant mineral resources. Therefore, Thai Nguyen province has a great advantage in developing metallurgical and mining industries. These industries have attracted thousands of workers. However, these manufacturing industries also generate a large amount of silica dust in the working environment. The top concern of managers is the health of workers, including silicosis. Currently, there is no intervention study to change the knowledge and practice of workers about silicosis in Thai Nguyen province. Therefore, the study was conducted to evaluate the effectiveness of mobile application-based intervention in improving knowledge

Tab. 1. Demographic characteristics of study subjects

| Characteristics | | Steel factory (n=309) | | Iron factory (n=356) | | Total (n=665) | |
|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % |
| Gender | Male | 286 | 92.6 | 276 | 77.5 | 562 | 84.5 |
| | Female | 23 | 7.4 | 80 | 22.5 | 103 | 15.5 |
| Age group (years) | 20 – 29 years | 64 | 20.7 | 49 | 13.8 | 113 | 17.0 |
| | 30 – 39 years | 157 | 50.8 | 165 | 46.3 | 322 | 48.4 |
| | 40 – 49 years | 64 | 20.7 | 110 | 30.9 | 174 | 26.2 |
| | ≥ 50 years | 24 | 7.8 | 32 | 9.0 | 56 | 8.4 |
| | $\bar{X}$ ± SD (min; max) | 36.0 ± 7.7 (22; 59) | | 38.1 ± 7.8 (22; 55) | | 37.2 ± 7.8 (22; 59) | |
| Education level | Under high school | 3 | 1.0 | 9 | 2.6 | 12 | 1.7 |
| | High school | 58 | 18.8 | 53 | 14.9 | 111 | 16.7 |
| | Technical/vocational school | 120 | 38.8 | 160 | 44.9 | 280 | 42.2 |
| | College/university | 128 | 41.4 | 134 | 37.6 | 262 | 39.4 |
| Silica exposure time | < 10 năm | 155 | 50.2 | 129 | 36.2 | 284 | 42.7 |
| | 10 – 19 năm | 114 | 36.9 | 117 | 32.9 | 231 | 34.7 |
| | ≥ 20 năm | 40 | 12.9 | 110 | 30.9 | 150 | 22.6 |
| | $\bar{X}$ ± SD (min; max) | 11.0 ± 8.2 (1; 39) | | 14.0 ± 8.7 (1; 36) | | 12.6 ± 8.6 (1; 39) | |

and practice on silicosis of workers at high risk of exposure to silica dust in the North of Vietnam. The research results provided evidence for the authorities and businesses to make appropriate policies and programs to prevent silicosis for workers at high risk of exposure to silica dust.

## 2. Materials and Methods

### *2.1. Study Setting and Participants*

A study was conducted from 2018 to 2019 at two factories that generated silica dust in the working environment in Thai Nguyen province. The study was conducted in 3 stages:

(1) Stage 1: an assessment of the knowledge and practice regarding the silicosis of workers in the two factories before the intervention was carried out in December 2018.

(2) Stage 2: the development and application of interventions at the factory were carried out from January 2019 to December 2019.

(3) Stage 3: assessing workers' change in knowledge and practice about silicosis post-intervention in December 2019. The effectiveness of the mobile application-based intervention was evaluated.

Eligible criteria for selecting participants were as follows: (1) workers who were directly exposed to silica dust while working, (2) working time at the factory at least 1 year or above, (3) consenting and participating fully in the study, (4) have a smartphone to access the intervention application on the phone. Exclusion criteria included the participants refusing to participate by signing an informed consent form.

### *2.2. Sample and Sampling*

The following formula was used for calculating the sample size in the study:

$$n = \frac{Z^2_{(1-\alpha/2)}.p.(1-p)}{d^2}$$

Where n is the minimum sample size, Z(1-α/2) = 1,96 (α=0,05) is the statistic corresponding to a level of confidence (95%), p = 0,13 (the proportion of workers in the mining sector exposed to silica dust and suffering from silicosis – according to study result by Le Thi Hang 2007) [26]; and d = 0.03 is precision (corresponding to effect size). A minimum sample size of 600 can be calculated.

In fact, before the intervention, research recruited 667 participants, including 309 employees of the Steel factory (out of a total of 352 employees of the steel factory) and 358 employees of the Iron Factory (out of the total of 403 workers of the iron factory). In post-intervention, 665 workers were participating in the study (309 employees of the Steel Factory and 356 employees of the Iron Factory), because there were 2 workers of the Iron factory who did not participate in the post-intervention survey. Thus, the sample size of the study for analysis in this study was 665 workers.

### *2.3. Intervention package*

*a) Intervention group*

Based on the baseline survey results, the Steel Factory had a higher rate of workers suffering from silicosis than the Iron Factory (11.7% compared with 10.1%). Besides, the percentage of workers in the Steel Factory who had correct knowledge of the signs and symptoms of silicosis and its consequences was lower than this rate in the Iron Factory. In addition, we also received the support and commitment to willingly participate in the research of the Steel Factory's Board of Directors. Therefore, we conducted an intervention at the Steel Factory (Intervention group).

The "VIHEMA Survey" application on smartphones had been developed by researchers, experts, and engineers from the Vietnam Health Environment Management Agency to provide information on silicosis. The application was available on both Android and iOS platforms.

The application consists of two main parts: Part 1: providing knowledge related to silicosis, including 4 main contents: (1) legal documents related to silicosis, (2) information about causes of silicosis, (3) signs and symptoms suggestive diagnosis of silicosis, (4) measures prevented silicosis. Part 2: providing questions to assess the level of knowledge and practice of workers related to silicosis.

Tab. 2. Intervention effectiveness on knowledge regarding silicosis (i-group: intervention group; c-group: control group); * The effectiveness of the intervention decreased (between the intervention group and the control group)

| Variables | Intervention group (n=309) | | Control group (n=356) | | Efficiency indicators | | Effectiveness (%) | p-value (i-group/ c-group) |
|---|---|---|---|---|---|---|---|---|
| | Baseline (%) | 4 months (%) | Baseline (%) | 4 months (%) | i-group (%) | c-group (%) | | |
| **Signs and symptoms of silicosis** | | | | | | | | |
| Cough | 55.7 | 70.9 | 61.2 | 64.2 | 27.3 | 4.9 | 22.4 | < 0.001 |
| p-value | < 0.001 | | 0.15 | | | | | |
| Sputum | 45.0 | 56.6 | 47.8 | 55.6 | 25.8 | 16.3 | 9.5 | < 0.001 |
| p-value | < 0.01 | | < 0.001 | | | | | |
| Chest pain | 57.6 | 61.8 | 64.8 | 68.7 | 7.3 | 6.0 | 1.3 | < 0.05 |
| p-value | 0.26 | | 0.57 | | | | | |
| Shortness of breath | 59.9 | 61.5 | 65.6 | 63.4 | 2.7 | 3.4 | 0.7* | 0.82 |
| p-value | 0.68 | | 0.12 | | | | | |
| Fever | 22.7 | 28.2 | 27.1 | 29.3 | 24.2 | 8.1 | 16.1 | < 0.01 |
| p-value | < 0.01 | | 0.16 | | | | | |
| **Consequences of silicosis** | | | | | | | | |
| Declining in health | 81.2 | 84.8 | 82.1 | 80.2 | 4.4 | 2.3 | 2.1 | 0.76 |
| p-value | 0.23 | | 0.45 | | | | | |
| Increasing risk of getting other serious | 33.7 | 45.6 | 36.6 | 43.9 | 35.3 | 19.9 | 15.4 | < 0.001 |
| p-value | < 0.01 | | < 0.01 | | | | | |
| Declining worker power | 69.9 | 73.5 | 74.0 | 75.1 | 5.2 | 1.5 | 3.7 | 0.28 |
| p-value | 0.27 | | 0.68 | | | | | |
| Reducing labor income | 39.5 | 57.9 | 44.4 | 46.6 | 46.6 | 5.0 | 41.6 | < 0.001 |
| p-value | < 0.001 | | 0.36 | | | | | |
| **Preventing silicosis** | | | | | | | | |
| Wearing mask | 78.0 | 89.0 | 76.3 | 70.7 | 14.1 | 7.3 | 6.8 | 0.22 |
| p-value | < 0.01 | | < 0.01 | | | | | |
| Wearing protective clothes at the worksite | 41.4 | 42.7 | 36.9 | 42.2 | 3.1 | 14.4 | 11.2* | 0.02 |
| p-value | 0.64 | | < 0.001 | | | | | |
| Providing periodic medical examinations | 57.9 | 64.4 | 52.2 | 55.6 | 11.2 | 6.5 | 4.7 | 0.01 |
| p-value | 0.09 | | 0.01 | | | | | |
| Providing periodic occupational medical examinations | 54.0 | 62.1 | 49.4 | 51.4 | 15.0 | 4.0 | 11.0 | < 0.01 |
| p-value | 0.02 | | 0.09 | | | | | |
| Occupational health and safety compliance | 63.4 | 68.6 | 60.1 | 62.8 | 8.2 | 4.5 | 3.7 | 0.02 |
| p-value | 0.13 | | 0.01 | | | | | |

The intervention program was implemented in 4 months, from August 2019 to November 2019. Each participant was provided an account and password to access the application. To manage participants' compliance with a mobile app-based intervention, we monitored the frequency of application visited every 2 weeks for the first month and fed back to the users with an audio notification on the application reminding the users to access the application.

*b) Control group*

The subjects in the control group which was at the Iron factory received only conventional education through periodic factory training sessions (Control group).

### *2.4. Instruments and Measures*

Research subjects were interviewed directly through a pre-designed closed-ended structured questionnaire based on Circular 15/2016/BYT of the Ministry of Health on covered occupational diseases [2]. The questionnaire also referenced the questionnaire of the study on knowledge and attitudes about silicosis in South Africa [10]. The questionnaire focused on the demographic characteristics of the study subjects; the knowledge and practice of workers about silicosis. Most of the questions were used as closed-ended questions with two options namely "Yes" and "No" for each question. By evaluating the improvement of workers' knowledge and practice about silicosis, the research team determined the effectiveness of a mobile app-based intervention for workers exposed to silica dust at work.

### *2.5. Statistical analysis*

Data were analyzed on Stata software version 14.0. Descriptive statistics were applied to present the frequency, percentage of complete knowledge, and appropriate practice of the study subjects related to silicosis. The effectiveness of the intervention was assessed through efficiency indicators (comparison pre and post-intervention to see changes in knowledge and practice regardings silicosis).

### *2.6. Ethical Consideration*

The study was approved by The Hanoi Medical University Review Board (No.42/BB HDDD DHYHN on October 31st, 2018), and the study adhered to the principles of the Declaration of Helsinki. All participants signed a written informed

Tab. 3. Intervention effectiveness on practices related to silicosis (i-group: intervention group; c-group: control group); * The effectiveness of the intervention decreased (between the intervention group and the control group)

| Silicosis prevention practices | Intervention group (n=309) | | Control group (n=356) | | Efficiency indicators | | Effectiveness (%) | p-value (i-group/c-group) |
|---|---|---|---|---|---|---|---|---|
| | Baseline (%) | 4 months (%) | Baseline (%) | 4 months (%) | i-group (%) | c-group (%) | | |
| **Using Personal Protective Equipment (PPE)** | | | | | | | | |
| Hard hat | 98.7 | 98.1 | 96.6 | 94.4 | 0.6 | 2.3 | 1.7* | < 0.05 |
| p-value | 0.53 | | < 0.05 | | | | | |
| Safety shoes | 96.4 | 96.4 | 95.5 | 95.3 | 0.0 | 0.2 | 0.2* | 0.83 |
| p-value | - | | 0.81 | | | | | |
| Mask | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 | - | - |
| p-value | - | | - | | | | | |
| Gloves | 98.4 | 97.7 | 96.1 | 97.2 | 0.7 | 1.1 | 0.4* | 0.62 |
| p-value | 0.48 | | 0.16 | | | | | |
| Protective clothes | 99.4 | 98.7 | 97.8 | 97.2 | 0.7 | 0.6 | 0.1 | 0.21 |
| p-value | 0.32 | | 0.41 | | | | | |
| Safety glasses | 75.4 | 70.2 | 51.7 | 46.9 | 6.9 | 9.3 | 2.4* | < 0.001 |
| p-value | 0.03 | | < 0.01 | | | | | |
| **Personal measures preventing silicosis** | | | | | | | | |
| Periodic medical examinations | 80.3 | 83.5 | 81.3 | 82.7 | 4.0 | 1.7 | 2.3 | 0.18 |
| p-value | 0.23 | | 0.49 | | | | | |
| Periodic occupational medical examinations | 68.9 | 83.8 | 58.7 | 60.9 | 21.6 | 3.7 | 17.9 | < 0.001 |
| p-value | < 0.001 | | 0.37 | | | | | |
| Compliance with occupational safety | 83.2 | 90.9 | 81.2 | 81.7 | 9.3 | 0.6 | 8.7 | 0.01 |
| p-value | <0.01 | | 0.80 | | | | | |
| Compliance with occupational hygiene | 77.3 | 84.1 | 79.2 | 77.2 | 8.8 | 2.5 | 6.3 | 0.21 |
| p-value | <0.01 | | 0.39 | | | | | |
| Compliance Factory Rules | 71.2 | 76.4 | 72.1 | 73.7 | 7.3 | 2.2 | 5.1 | 0.05 |
| p-value | 0.03 | | 0.48 | | | | | |

consent form for their willingness to participate. The research problem did not affect the health or other problems of the subject. The information collected from the subjects is for research purposes only.

## 3. Results

The majority of participants were male (accounting for 84.5%). The proportion of male workers in steel mills was 92.6%, and this rate in iron factories was 77.5%. The respondents were mainly the 30–39 years old group (48.4%) and had a technical/vocational school education level of 42.2%. The average age of participants in the steel factory and iron factory was 11.0 years and 14.0 years, respectively. However, participants in the age group of fewer than 10 years accounted for the majority in both factories (50.2% and 36.2% respectively, table 1).

Table 2 presents intervention effectiveness on knowledge regarding silicosis. In the group of workers receiving the intervention, the percentage of workers whom correctly knowledge the signs and symptoms of silicosis (cough, sputum, fever) and the consequences of silicosis (increased risk of other diseases and reduced labor income) increased compared with pre-intervention ($p<0.05$).

Compared with the control group, the percentage of workers in the intervention group correctly knowledge the signs and symptoms of silicosis (such as cough, sputum, chest pain, and fever) and the consequences of silicosis (such as the increased risk of other diseases, reduced labor income) increased significantly after the intervention ($p < 0.01$). Intervention effectiveness on the knowledge about signs/symptoms and consequences of silicosis increased (ranging from 1.3–41.6%). The percentage of workers in the intervention group who had proper knowledge regarding preventing silicosis (such as wearing protective clothing at the worksite, providing periodic medical examinations, and annual occupational medical examinations, and compliance with occupational health and safety) increased significantly in post-intervention ($p<0.01$). Intervention effectiveness in preventing silicosis knowledge increased (ranging from 3.7–11.0%).

Table 3 illustrates the changes in practices related to silicosis among our study participants. The percentage of respondents wearing masks at the workplace reached 100% in both groups.

Compared with the control group, in the intervention group, the percentage of participants using glasses at the worksite decreased significantly ($p<0.05$) and the intervention effectiveness on wearing glasses decreased (2.4%).

Table 3 showed that the percentage of participants in the intervention group who performed annual occupational medical examinations, compliance with occupational safety, occupational hygiene, and factory rules to prevent silicosis increased significantly ($p<0.05$). Compared with the control group, the percentage of participants in the intervention group who performed annual occupational medical examinations increased significantly after the intervention ($p<0.001$), and the intervention effectiveness increased (17.9%). The per-

centage of respondents in the intervention group who complied with occupational safety increased significantly and the intervention effectiveness increased by 8.7%.

**4. Discussion**

The study was an initial survey in Vietnam to assess the effectiveness of mobile application-based interventions in improving workers' knowledge and practice of silicosis. The study results showed that the mobile application could contribute to improving the knowledge and practice of participants regarding silicosis, which in turn could contribute to preventing this disease. The study was implemented at 02 factories with a total of 665 participants, including 309 workers at the Steel Mills and 356 workers at the Iron Factory. These were two factories with full characteristics of the metallurgical industry in Thai Nguyen. The production process at the two factories generated many harmful occupational factors such as dust, noise, adverse microclimate, restrictive working posture, and especially silica dust in the labor environment.

Most of the study participants were male. This might be due to the specific working conditions of the metallurgical industry, which was hard labor, so it needed mainly male workers. The study results were similar to the other authors' research results [27, 28, 29, 30]

The workers in our study mainly had higher education levels than those in some factories with typical hard labor characteristics. In the study of the authors Souza T.P., Gizaw Z., and Ferrante G. the majority of workers had a high school education or less [31, 32, 33]. With such a level of education, workers living in two factories have a background in absorbing new knowledge faster.

Workers at the two factories had almost no change in the workplace since starting work. Therefore, the working age was generally calculated as the time from the beginning of working at the factory to the time of doing the study. In addition, we aimed to exploit both workers' other work and the time working exposed to silica dust before working at the two present factories. The purpose of this action was to accurately calculate a worker's exposure to silica dust. However, the workers involved in this study had never worked in jobs that were exposed to silica dust. The average age of workers in the two factories was lower than that of workers in the Souza T.P. study (20.4 ± 12.8 years) [31].

The baseline assessment showed that the percentage of workers in the Steel factory correctly knowledge the signs and symptoms of silicosis (cough, sputum, chest pain, shortness of breath, fever) and the consequences of silicosis (declined in health, declined worker power, decreased in labor income) were lower than in the Iron Factory. Therefore, the study conducted intervention on workers of Steel factory.

Currently, the number of smartphone users was becoming larger and large. The age of users has also expanded, including young people as well as the elderly. According to data provided by Statista, by the end of 2020, 78.05% of the world's population used smartphones [34]. Many studies around the world have recorded the positive effect of the intervention methods based on mobile technology in improving the knowledge, attitude, and practice of the research subjects. These mobile-based intervention studies have helped study subjects to improve their risk behaviors, manage, and prevent a variety of chronic diseases [18, 19, 20, 21, 22, 23, 24, 25]. When comparing interventions by mobile technology, the use of intervention as a communication application brought more advantages such as intervention information being stored and continuously updated on the communication application. This helped the intervention subjects to review regularly the content related to the research topic. In addition, we also integrated images and videos related to research topics into the application that text messages cannot deliver. This supported well the subjects participating in the research.

In the pre-intervention, the percentage of study participants who knew about the signs suggestive of silicosis such as cough, sputum, chest pain, shortness of breath, and fever ranged from 22.7% to 65.6%. These results were different from the results in the Indian study of Nandi S [35]. This difference can be explained by the different study populations. This result also suggested that we needed to improve the knowledge of workers regarding the signs and symptoms of silicosis. After the intervention, the percentage of participants who had correct knowledge about the signs and symptoms of silicosis increased. The rate of respondents knowing that cough was a symptom suggestive of silicosis increased from 55.7% to 70.9% after the intervention ($p<0.05$). The percentage of participants who knew that sputum was a symptom suggestive of silicosis increased from 45.0% to 56.6% after the intervention ($p<0.05$). Compared with the control group, the percentage of workers who knew about the signs and symptoms suggesting silicosis increased, and the intervention effectiveness increased significantly from 1.3% to 22.4% ($p<0.05$). In our opinion, this improvement had helped workers to proactively detect the disease early. When workers have had such signs and symptoms, they could go to the hospital earlier to screen for disease and prompt treatment.

Regarding the knowledge of the consequences of silicosis, declining health accounted for the highest rate, followed by declining worker power and income reduction. This result was higher than the research results of the author Phan Thi Mai Huong and the author Le Thi Thanh Xuan [11, 36]. These consequences caused disease burden as well as economic effects for individuals, families, and society. In this study, the percentage of workers in the intervention group whom correctly knowledge the consequences of silicosis increased. Compared with the control group, the effectiveness of the intervention increased, ranging from 2.1% to 41.6%. In which, the percentage of workers who correctly knew silicosis increased the risk of other diseases (from 33.7% to 45.6%) and reduced the workers' income (from 39.5% to 57.9%) increased significantly after the intervention ($p<0.001$). Our findings on positive changes in knowledge among study participants may help high-risk workers would have positive changes in attitudes and practices to prevent diseases.

If the workers did not know about the signs and symptoms of silicosis and the consequences of the disease, the workers would have a subjective attitude when preventing the disease. Therefore, the study should enhance knowledge about signs, symptoms, and consequences for these workers. This result suggested that we come up with specific and appropriate interventions for the study.

Regarding measures to prevent silicosis, the majority of participants knew that wearing a mask, compliance with oc-

cupational safety and health, annual health examination, and annual occupational medical examination could prevent silicosis. Our study gave better results than the results of other authors [10, 35]. The two factories in this study might have included these contents in the periodic occupational safety and health training, so the subjects in the study might have better knowledge than other researchAlthough occupational medical examination was the earliest method to detect silicosis, only about half of the workers participating in the study knew about this method. This rate suggested that we needed to coordinate with the two factories to improve the knowledge of employees about methods to detect silicosis early, especially annual occupational medical examinations. After the intervention, our study had positive results on this issue. The percentage of employees who were correctly knowledge about measures to reduce the risk of silicosis increased post-intervention. In which, the percentage of workers who knew that wearing a mask is an effective measure to prevent silicosis increased significantly after the intervention (from 78.0% to 89.0%) ($p<0.01$). The efficiency indicators in the intervention group increased from 3.1% to 15.0% and the intervention effectiveness increased (ranging from 4.7% to 11.0%) ($p<0.05$).

In the intervention group, the percentage of employees participating in annual health check-ups increased from 80.3% to 83.5%. In particular, the percentage of employees participating in annual occupational medical examinations increased significantly from 68.9% to 83.8%, the intervention efficiency increased by 17.9% ($p<0.001$). The rate of employees complying with occupational safety increased statistically significantly from 83.2% to 90.9% after the intervention and the effectiveness increased by 8.7% ($p<0.05$). The rate of employees complying with occupational hygiene increased significantly from 77.3% to 84.1% after the intervention ($p<0.01$) and the intervention effectiveness increased by 6.3%. The rate of employees complying with factory rules increased from 71.2% to 76.4% ($p<0.05$) and the intervention effectiveness increased by 5.1%.

The study had some limitations that needed to solve in other studies. Firstly, research on the knowledge and practice of workers about silicosis in Vietnam was rare. Therefore, the questionnaire might not fully reflect the purpose and objectives of the study. Secondly, the study used mobile application-based intervention, which would make it difficult for some elderly workers to use the application.

Despite the above limitations, the research results showed that the mobile application-based intervention had changed the knowledge and practice of the study subjects in preventing silicosis. This brought certain effects on employees. The research results also showed that the responsibility to prevent silicosis was not only the employers but also the employees.

**5. Conclusions**

Mobile application-based interventions could contribute to improving participants' knowledge and practices regarding silicosis. Therefore, factories should apply and extend mobile health applications as a measure of workplace health promotion and drive workers to adopt the use of mobile health applications.

Knowledge of workers about signs and symptoms of silicosis (cough, sputum, chest pain, fever), consequences of silicosis (increased risk of getting other serious, reduced labor income), and measures to prevent silicosis (periodic health examination, annual occupational medical examination, compliance with occupational safety and health) had improved markedly after the intervention. The percentage of workers wearing masks at the workplace reached 100% in both groups. The percentage of workers participating in annual occupational medical examinations increased significantly (intervention effectiveness increased by 17.9%).

**Declarations**

Acknowledgments: We would like to thank Professor. Le Thi Huong, Head of the School of Preventive Medicine and Public Health, at Hanoi Medical University, allowed us to participate in this research.

Consent to participate: A consent form was sent to participants before the study was conducted.

Ethics approval: Subjects were adequately informed about the purpose of the study and participated voluntarily. The research problem did not affect the health or other problems of the subject. The information collected from the subjects is for research purposes only.

Availability of data and materials: Data are available from the corresponding author upon reasonable request.

Competing Interest: All authors declare no conflict of interest.

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