



Health Promotion Model Insights on Determinants of Personal Protective Equipment Use in Occupational Settings



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ABSTRACT

Aims Occupational illnesses remain a pressing concern for workers exposed to hazardous materials in industrial settings. While personal protective equipment is a primary safeguard against such risks, its inconsistent utilization highlights critical gaps in understanding the determinants of personal protective equipment compliance. This study investigated personal and situational factors influencing personal protective equipment usage among employees handling organic solvents in three major industrial companies.

Instrument & Methods This cross-sectional study of 340 workers employed the health promotion model as the theoretical framework to identify personal protective equipment utilization predictors. Data were analyzed using the Chi-square test, t-test, and two-level logistic regression.

Findings Only 47.9% of workers regularly used face masks, while 67.4% wore gloves, signifying substantial non-compliance. Interpersonal factors, such as trust, mutual respect, and collegial relationships, among the health promotion model components, were significantly associated with personal protective equipment adherence. Additionally, organizational factors, including workplace policies and support systems, were strongly correlated with using protective gloves. These findings underscore the critical role of fostering interpersonal relationships and implementing robust organizational policies to promote compliance with personal protective equipment.

Conclusion The health promotion model can be utilized to understand compliance with personal protective equipment in industrial settings.

Keywords Personal Protective Equipment; Health Promotion; Occupational Exposure; Patient Compliance

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Introduction

In hazardous work environments, workers prioritize their protection against potential risks. At the same time, they develop a heightened sense of vulnerability due to prolonged exposure to these risks. This refers to increased awareness of potential dangers, which may lead to greater caution or stress over time ^[1]. Their behaviors and decision-making processes reflect this heightened risk awareness, underscoring the need for effective protective measures ^[2]. Additionally, the perception of safety is crucial in influencing workers' well-being, productivity, and adherence to safety protocols ^[3]. Therefore, creating environments where workers feel safe and healthy is essential. By providing appropriate training and support, perceptions of safety risks stemming from exposure to health and safety hazards can be mitigated, leading to safer and more productive workplaces ^[4, 5].

Working in hazardous situations, such as extreme noise, heat stress, and radioactivity, can put workers at risk of developing severe occupational diseases. In recent years, the number of occupational disease cases has increased, with noise-induced deafness, musculoskeletal disorders, and skin diseases being among the most prevalent. These rising cases highlight the critical role of personal protective equipment (PPE) in mitigating occupational health risks ^[6-8]. Such alarming statistics emphasize the importance of PPE as a preventive measure in reducing the prevalence of occupational diseases, particularly in high-risk industrial sectors. Despite the availability of preventive measures, including PPE, occupational diseases continue to pose a significant challenge in high-risk industries ^[9]. This underscores the necessity of identifying key determinants influencing PPE adherence and addressing barriers to its proper use.

Previous research has extensively examined workplace hazards and the importance of PPE; however, significant gaps remain in understanding the specific factors affecting compliance in different occupational settings. Additionally, exposure to multiple workplace hazards, such as heat stress and chemical agents, can amplify health risks, emphasizing the necessity of effective control measures and PPE usage ^[10, 11].

While risk management measures, like elimination and engineering controls, are preferred, their implementation is often limited by budget constraints, poor supervision, and workplace restrictions. In such cases, PPE is the last defense against occupational diseases ^[12-14]. Although PPE may not be as effective as engineering controls, it offers a significant layer of protection when other safety procedures fail ^[15, 16]. These essential tools act as a shield, protecting workers from potential hazards and decreasing the likelihood of injury or illness. Depending on the risks present in a

workplace, PPE can consist of a range of items tailored to those risks ^[17, 18].

Despite existing studies on PPE compliance, there is still a need for deeper investigation into the specific personal, organizational, and situational determinants influencing its utilization. In many workplaces, while production workers may use PPE, it is not uncommon to see some of them using equipment unsuitable for the specific risks they are exposed to ^[19]. This could be due to a lack of appropriate training ^[20], misinterpretation of the hazards involved ^[21], or even the inaccessibility of the right type of PPE ^[22]. Moreover, using inappropriate PPE can significantly diminish its effectiveness, leaving employees vulnerable to the health and safety risks they encounter ^[23].

PPE compliance is influenced by workers' perceptions of safety, personal attitudes, and social factors such as peer support and organizational policies ^[24]. Common barriers include discomfort, poor fit, and the belief that PPE interferes with work ^[25, 26]. However, many previous studies have not provided comprehensive solutions to these challenges, underscoring the necessity for further research that identifies practical strategies to enhance PPE compliance.

Some workers might even think PPE is unnecessary if they do not perceive immediate risks or believe the benefits do not justify the hassle ^[27]. Wong et al. ^[17] suggest that by understanding and addressing these obstacles, we can encourage more regular use of PPE, ultimately leading to a safer work environment for everyone ^[28]. Additionally, when workers perceive that PPE makes their workplace safer and helps prevent incidents, they are more likely to be motivated to use it regularly. However, if they find the PPE uncomfortable or inconvenient, they may be less inclined to use it ^[29].

Furthermore, using PPE is shaped by several other key issues that can significantly influence workplace safety, including how employees perceive risk, their age and experience, and whether the employer provides the proper PPE. When businesses ensure that their workforce has access to appropriate protective gear, it becomes easier for them to adhere to safety regulations. Ultimately, these elements all work together to improve workplace safety. Beyond worker-related factors, a study by Larson & Liverman ^[30] demonstrates that organizational factors are also significant in the level of PPE usage among workers. A study by Sarfraz *et al.* shows that factors such as PPE availability, gear quality, workplace safety policies, and safety training all play a significant role ^[31].

Experienced workers are more aware of the importance of PPE due to their familiarity with workplace hazards. In contrast, younger or new employees often require additional training and supervision to enhance compliance ^[32]. This

underscores the need for tailored safety programs that address the varying levels of awareness and compliance across different experience levels within the workforce [33, 34]. By exploring these multifaceted influences, this study aims to provide a deeper understanding of the determinants of PPE utilization, ultimately guiding the development of tailored interventions for diverse workplace settings. By explicitly addressing the gaps in previous studies, this research aims to provide new insights into the determinants of PPE utilization, ultimately guiding the development of targeted interventions to improve adherence in high-risk workplaces.

Many studies have highlighted a strong association between wearing PPE and the health promotion model (HPM). Items like masks and gloves protect hazardous materials and infectious agents, reducing the risk of illness or injury. The HPM focuses on encouraging preventive health behaviors by emphasizing the importance of PPE usage as a key strategy in mitigating health risks. Whether in healthcare settings, workplaces, or daily routines, PPE is a fundamental component of the HPM's approach to proactive health management, ensuring individual and societal well-being. By promoting consistent and proper PPE use, the HPM helps reduce exposure to hazardous conditions, preventing illness and injury. This approach enhances workplace safety and fosters a culture of prevention and resilience in public health [35-37].

Several research studies have investigated the use of the HPM in improving PPE adherence among workers, especially in industrial settings. Khoshakhlag *et al.*, involving small and medium enterprises found that workers' attitudes toward PPE and workplace safety training are strong predictors of PPE use. Workers with safety training are significantly more likely to use PPE consistently. The primary barriers to PPE utilization include lack of availability, poor comfort, and inadequate training [38]. In another study conducted among construction workers, factors such as government oversight, the provision of safety briefs, and PPE training substantially increase the likelihood of PPE use [39]. Thus, applying the HPM through targeted interventions, such as workplace safety education and regular training, can effectively increase PPE adherence and reduce occupational hazards.

In another study, the application of the HPM is linked to better PPE usage in hazardous industries, such as mining. In the mentioned study, the model was used to develop interventions focusing on perceived barriers and benefits, risk perception, and self-efficacy [40].

Additionally, the COVID-19 pandemic led to increased focus on PPE usage in healthcare settings [41]. La Torre *et al.*'s study indicates that the use of PPE is associated with a 70% reduction in SARS-CoV-2 infections among healthcare workers, reinforcing the need for proper education and behavioral

interventions based on the HPM to improve consistent PPE use in various industries [42].

Studies have shown that the HPM improves workers' understanding, attitudes, and behaviors toward safety and PPE use, highlighting knowledge, perceived benefits, and self-efficacy [43]. A study conducted in small and medium-sized enterprises (SMEs) found that workers' attitudes and risk perceptions significantly affect PPE usage. The study emphasized the significance of training interventions to enhance knowledge and positively shape workers' perspectives toward PPE, merging these factors to achieve higher compliance rates [44]. Additionally, a study on construction employees in Addis Ababa, Ethiopia, underlined that elements, such as the availability of safety training and knowledge of PPE use, are crucial in boosting usage rates. Employees who receive safety training are up to four times more likely to use PPE than those who do not. This study also highlighted the role of external enforcement, such as government supervision, in reinforcing PPE compliance [39]. A study conducted by Alinejad *et al.* applies the health belief model (HBM) to examine how training can improve PPE compliance in healthcare settings. The HBM is introduced here because it highlights psychological factors, such as the perceived severity of health risks and perceived barriers to compliance, which influence individuals' decisions to use PPE. This contrasts with the HPM, which takes a broader approach by promoting preventive health behaviors as a proactive and structured strategy. While the HBM focuses on personal risk perception and motivational barriers, the HPM emphasizes systematic and organizational measures to embed PPE use within daily routines [45]. These studies highlight health models' practical and theoretical applications in improving PPE adherence, which is crucial for understanding its determinants in various industries [46, 47].

The HPM provides a practical framework for addressing the research gap and understanding the integrated influence of personal and situational factors on PPE usage across various workplace settings. While previous studies focus narrowly on individual compliance or organizational safety practices, few investigate how these factors shape PPE utilization. This study uniquely bridges the gap by examining individual, interpersonal, and organizational dynamics, offering a holistic understanding of the factors influencing PPE adherence in complex workplace environments.

Guided by the main elements of the HPM, this study examined the interplay between employees' characteristics (such as experience and risk perception) and organizational factors (like PPE availability and safety training), offering an integrated perspective. The originality of this study also lies in its focus on workers in major companies that have established international standards for safety and health, such as ISO 45000, ISO 45001, ISO

14001, and HSE-MS. This provides a unique perspective on PPE usage in settings with progressive occupational health protocols where workers are exposed to highly hazardous chemical materials such as BTEX (Benzene, Toluene, Ethylbenzene, and Xylene) compounds.

Focusing on organizations with advanced safety standards highlights best practices and uncovers persistent challenges, providing valuable lessons for less-regulated settings. By investigating PPE compliance within companies that are already committed to high safety and health measures, this research presented insights into how even well-regulated environments face challenges related to interpersonal and organizational characteristics. This context enhances our understanding of PPE usage beyond regulatory adherence, underscoring the nuanced factors of employee behavior and interaction that can affect safety and health practices even in optimal circumstances.

The findings are expected to inform policymakers and industry leaders in designing more effective, tailored interventions that enhance PPE adherence, even in high-risk and well-regulated industries. Through this approach, the study aims to identify targeted procedures to improve PPE adherence by considering interpersonal, situational, and organizational dynamics across different industries.

Instrument and Methods

In hazardous work environments, workers prioritize their protection against potential risks. At the same time, they develop a heightened sense of vulnerability due to prolonged exposure to these risks. This refers to increased awareness of potential dangers, which may lead to greater caution or stress over time ^[1]. Their behaviors and decision-making processes reflect this heightened risk awareness, underscoring the need for effective protective measures ^[2]. Additionally, the perception of safety is crucial in influencing workers' well-being, productivity, and adherence to safety protocols ^[3]. Therefore, creating environments where workers feel safe and healthy is essential. By providing appropriate training and support, perceptions of safety risks stemming from exposure to health and safety hazards can be mitigated, leading to safer and more productive workplaces ^[4, 5].

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reducing the prevalence of occupational diseases, particularly in high-risk industrial sectors. Despite the availability of preventive measures, including PPE, occupational diseases continue to pose a significant challenge in high-risk industries ^[9]. This underscores the necessity of identifying key determinants influencing PPE adherence and addressing barriers to its proper use.

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perspective on PPE usage in settings with progressive occupational health protocols where workers are exposed to highly hazardous chemical materials such as BTEX (Benzene, Toluene, Ethylbenzene, and Xylene) compounds.

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The findings are expected to inform policymakers and industry leaders in designing more effective, tailored interventions that enhance PPE adherence, even in high-risk and well-regulated industries. Through this approach, the study aims to identify targeted procedures to improve PPE adherence by considering interpersonal, situational, and organizational dynamics across different industries.

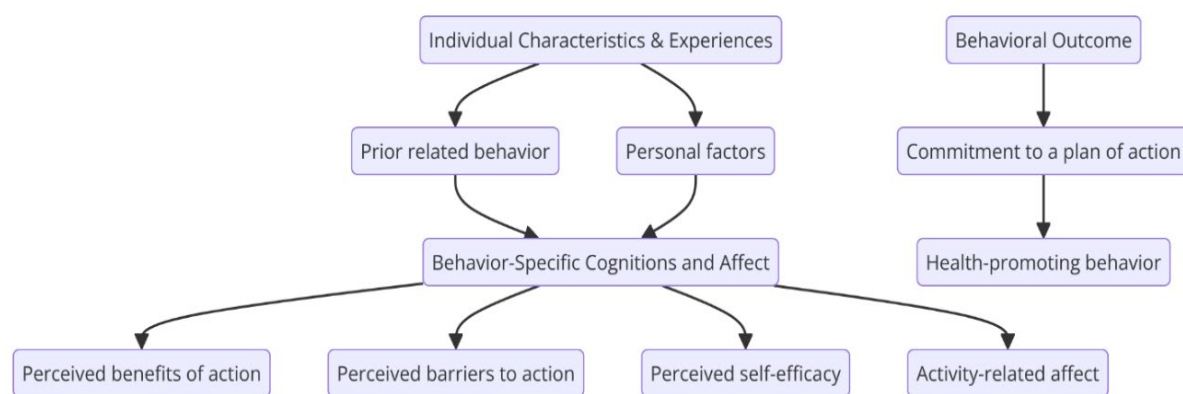


Figure 1. Conceptual framework of the health promotion model (HPM)

Table 1. Questionnaire construct items

Construct	Item	Range	Alpha
Perceived benefits	1- It is possible to decrease exposure to toxic material if I use personal protective equipment (PPE) during work	2-10	0.75
	2- Using PPE when exposed to toxic material can prevent occupational diseases		
Perceived barriers	1- I feel uncomfortable when using PPE	2-10	0.84
	2- I think using PPE will slow my work speed and therefore reduce my income		
Perceived self-efficacy	1- If using PPE were not uncomfortable, I would definitely use it	3-15	0.72
	2- If using PPE did not make me work slowly, I would definitely use it		
	3- If PPE was easy to obtain, I would definitely use it		
Social models for PPE	1- How often does my team leader use PPE when exposed to toxic substances?	2-10	0.60
	2- How often do my fellow workers use PPE when exposed to toxic substances?		
Social norms for PPE	1- What is the attitude of my co-workers towards my PPE use?	3-15	0.74
	2- What is the attitude of my family members towards my PPE use?		
	3- What is the attitude of my supervisor towards my PPE use?		
Interpersonal support for PPE	1- Do your coworkers encourage you to use PPE?	3-9	0.68
	2- Do your family members encourage you to use PPE?		
	3- Do your supervisors encourage you to use PPE?		
Organizational factors	1- I can obtain new PPE when I need to use or replace it	2-10	0.60
	2- My factory emphasizes on the use of PPE		

Statistical analysis

We examined the reliability of the questionnaire by assessing its internal consistency using Cronbach's Alpha. According to Sørensen and Slater's study, an alpha coefficient of 0.60 or higher indicates that the measure is reliable [63]. Our scales for perceived benefits (Table 1), barriers, self-efficacy, social modeling, social norms, interpersonal support, and organizational factors all met this standard, with alpha coefficients ranging from 0.60 to 0.84. We also evaluated the normality of our numeric variables using the Kolmogorov-Smirnov test. We presented our data as means and standard deviations for normally distributed numeric variables and medians with ranges for non-normal ones. In contrast, categorical data were shown as frequencies and percentages. To associate health promotion measures between those who wear PPE (like face masks or gloves) and those who do not, we used chi-square tests for categorical data and t-tests for normally distributed continuous data. A p-value of 0.05 or less was considered statistically significant [64].

Finally, we used a two-level logistic regression model to identify how different factors affected the use of PPE in the workplace while adjusting for individual demographics. In the current research, we employed a two-level logistic regression model because it accounts for the hierarchical structure of the data, such as individuals nested within groups (e.g., patients in clinics). This model captures individual and group-level variations, handling unobserved heterogeneity at the group level while accounting for clusters' correlations. Using logistic regression is suitable for binary outcomes (e.g., health behaviors), providing more accurate estimates and improving the model's fit compared to single-level approaches. This results in more reliable and interpretable outcomes in contexts where individual and group-level elements affect results [65]. We considered results with p-values under 0.05 significant [66].

Cronbach's alpha values were calculated, as presented in Table 1, to assess the reliability of the scales used in this study. Cronbach's alpha is widely used to measure internal consistency, reflecting the degree to which items within a scale correlate with each other, thereby demonstrating that they collectively assess the same underlying construct. Typically, alpha values above 0.5 are considered acceptable, suggesting adequate reliability, whereas values exceeding 0.7 are considered a solid reliability indicator. In this context, Cronbach's alpha values help confirm that the variables included are suitable for further analysis and reliably represent factors influencing PPE usage.

For the analysis of categorical variables, we employed logistic regression, a statistical method designed to model binary outcomes. Logistic regression is particularly useful in this study as it

allows us to estimate the probability of PPE compliance as influenced by various predictor variables, such as interpersonal and organizational factors. This approach provides an understanding of how each independent variable contributes to the likelihood of PPE usage, yielding insights that can support targeted interventions to improve compliance in industrial settings. Data analysis was done using SPSS 26.

Findings

Most workers were men (95.9%), and most were married (89.7%). Approximately half were in their 30s, particularly aged 31 to 40 (46.1%), and had been employed for 10 to 15 years, indicating a fairly experienced group. In terms of education, a significant portion had completed junior secondary school (37.4%), providing insight into their academic situation. Over half were exposed to their work environment for over 8 hours daily (50.6%), indicating extended work shifts. While most workers took precautions by wearing protective gloves (67.4%), more than half did not use face masks (52.1%). This pattern indicates a gap in protective practices, especially concerning safeguarding against airborne hazards. These findings emphasize the need for continued attention to safety measures in the workplace (Table 2).

Table 2. Frequency of samples' characteristics

Parameter	No. (%)
Age group (year)	
≤20	2(0.6)
21-30	61(17.9)
31-40	157(46.1)
41-50	100(29.4)
>50	20(5.8)
Work experience (year)	
5≤	52(15.3)
5-10	79(23.2)
10-15	115(33.8)
15-20	30(8.8)
>20	64(18.8)
Marital status	
Married	305(89.7)
Single	35(10.3)
Using gloves	
Yes	229(67.4)
No	111(32.6)
Education	
Primary school or below	58(17.1)
Junior secondary school	127(37.4)
Senior secondary school	64(18.8)
Junior college and above	91(26.8)
Exposure time (hour)	
≤1	19(5.6)
1-2	25(7.4)
2-8	124(36.5)
>8	172(50.6)
Gender	
Male	326(95.9)
Female	14(4.1)
Using masks	
Yes	163(47.9)
No	177(52.1)

The Chi-square test and t-test revealed that the education level was closely associated with the probability of wearing protective gloves. Moreover, the time workers are exposed to hazards played a significant role in whether they used face masks and gloves ($p < 0.05$). Regarding cognitive and perceptual factors, individuals who perceived clear benefits and encountered barriers in their work environment were more likely to use gloves. Additionally, those who felt confident in their ability to protect themselves were more inclined to use both types of PPE ($p < 0.05$). Social norms, commonly accepted in one's social circle, were particularly influential in encouraging the use of face masks and gloves. Lastly, organizational factors significantly influenced PPE usage ($p < 0.05$; Table 3).

Table 3. Relationship between compliance with the use of personal protective equipment (PPE) and individual demographics, cognitive-perceptual, interpersonal, and situational factors

Parameter	Compliant (Y1=wearing face masks)	Compliant (Y2=wearing gloves)
Demographic factors		
Age	0.581	0.925
Work experience	0.521	0.166
Marital status	0.0650	0.054
Education	0.268	0.022*
Exposure time	0.032*	0.006*
Gender	0.925	0.985
Cognitive-perceptual factors		
Perceived benefits	0.087	0.018*
Perceived barriers	0.121	0.026*
Perceived self-efficacy	0.043*	0.005*
Interpersonal factors		
Social models	0.120	0.263
Social norms	0.015*	0.007*
Interpersonal support	0.154	0.230
Organizational factors	0.043*	0.019*

* $p < 0.05$: based on a Chi-square test for categorical measures and a T-test for continuous measures.

In the next stage, we developed a two-level logistic regression model that involved several explanatory variables. Gender affected whether workers were likely to wear face masks and protective gloves. After considering differences in demographics, the interpersonal factors from the HPM emerged as the most important drivers for PPE use. In contrast, cognitive-perceptual factors did not appear to have much impact. Upon closer examination, interpersonal support and organizational factors were only associated with using gloves. For face mask use, workers with higher scores in social support networks were significantly more likely to use them, with an odds ratio of 3.51 (95% CI: 1.23-1.50). On the other hand, regarding gloves, organizational factors were a powerful predictor, with a higher score in this area leading to an odds ratio of 3.15 (95% CI: 1.12-1.15) for increased use. Individuals' PPE habits were influenced differently depending on the type of PPE. Social factors enhanced face mask usage, while

workplace or organizational support had a greater effect on whether someone wore protective gloves (Table 4).

Table 4. Factors associated with personal protective equipment (PPE) use

Parameter	Y1=wearing face masks Odds ratio (95%CI)	Y2=wearing gloves Odds ratio (95%CI)
Demographic factors		
Age	1.23(0.81-1.88)	0.99(0.63-1.56)
Work experience	0.99(0.77-1.28)	0.997(0.74-1.30)
Marital status	0.89(0.39-2.01)	0.48(0.18-1.28)
Education	0.87(0.71-1.07)	1.04(0.89-1.23)
Exposure time	1.07(0.80-1.44)	1.18(0.84-1.63)
Gender	3.48(1.59-1.18)*	0.36(0.07-1.74)*
Cognitive-perceptual factors		
Perceived benefits	0.93(0.80-1.08)	1.06(0.91-1.24)
Perceived barriers	0.97(0.84-1.10)	0.99(0.86-1.104)
Perceived self-efficacy	0.99(0.90-1.09)	0.99(0.89-1.09)
Interpersonal factors		
Social models	3.51(1.23-1.50)*	3.09(1.33-1.50)*
Social norms	1.22(0.99-1.50)	2.03(1.99-2.20)*
Interpersonal support	1.50(0.99-1.24)	1.12(1.01-1.24)*
Organizational factors	2.00(1.50-1.66)	3.15(1.12-1.15)*

* $p < 0.05$

Discussion

This study assessed how the HPM model can help predict workers' attitudes toward using PPE. By examining specific factors, we demonstrated that the model could predict and provide a deep understanding of how PPE is being used in the workplace. Similar studies have verified these findings [25, 67, 68], in which the HPM model has also been employed to understand PPE use among workers. These studies emphasize the importance of using predictive models to improve workers' safety and health.

When the right PPE is chosen and used properly, it can help reduce workplace accident rates, occupational exposure, and the severity of potential risks. Properly using PPE is imperative to improving worker safety and decreasing the likelihood of serious harm on the job [25, 69]. There is little information about the use of PPE among workers, but our findings show that only a few workers use PPE. Shamsi *et al.*'s study on attitudes and behaviors related to using PPE among subway construction station employees showed that using PPE by the staff is not desirable [70]. This study provides practical insights into the attitudes and behaviors affecting PPE usage among construction workers, underscoring the significance of audience analysis for developing effective behavior change interventions. Their findings emphasize that organizational culture, perceived risk, and the availability of PPE significantly impact compliance, aligning with the elements of the HPM in our study. Additionally, another study by Moshashaei *et al.* showed that clothing components and other PPE, such as masks,

with a score below 20%, among the most undesirable components of safety and health [18]. Another study conducted by Sehshah *et al.* among construction workers demonstrated that safety and health training can improve workers' attitudes and beliefs toward using PPE, which can subsequently affect occupational accidents and injuries. Furthermore, the authors noted that the main reasons for not using PPE are a lack of knowledge and fitting problems related to worker posture [71]. The results of this study are in line with our findings. Mahmood *et al.*'s study emphasizes the importance of proper training for healthcare workers in donning, doffing, and safely handling PPE to minimize the risk of self-contamination [72]. The results of their study align with our findings regarding the use of the HPM to adopt proper training to promote PPE usage among employees.

Many workers have stated that PPE tends to decrease efficiency and slow down work. In some cases, they find PPE annoying or restrictive, which makes it difficult for workers to move easily and reduces their performance. This view demonstrates the ongoing challenge of ensuring safety while also improving productivity. Several studies have confirmed these findings [68, 73, 74]. About 25% of academic workers had inadequate access to PPE due to economic and financial limitations. This issue is prevalent in many companies with limited financial margins; nevertheless, they still try to provide sufficient safety equipment [75]. Not only does this put workers' health at risk, but it also highlights the broader challenge of ensuring worker safety in the face of economic pressures. These findings are consistent with several studies [76-78]. Here, utilization rates for face masks were 47.9%, while gloves were 67.4%. Previous studies have found the compliance rate for PPE use to be between 40% and 70% [79, 80]. Additionally, Lu *et al.*'s research showed that 54% of individuals use face masks and 77% use gloves, similar to our utilization rates. Face masks are used less than gloves due to the inadequate supply of face masks and presumably the discomfort associated with wearing one [60]. While our findings indicate high compliance with glove usage, the relatively lower face mask compliance warrants further exploration.

Several factors may contribute to this gap in face mask usage. First, the perceived risk associated with the tasks performed may affect employees' attitudes toward PPE. For instance, if employees believe that their primary exposure risks are linked to skin contact rather than inhalation of hazardous substances, they may prioritize gloves over masks. This perception could arise from insufficient education or communication regarding hazardous organic solvents' specific health and safety hazards [81, 82].

Second, comfort and convenience play a vital role in PPE compliance. Face masks can often be perceived as uncomfortable, particularly during prolonged use,

leading employees to forgo them in favor of gloves, which are generally easier to wear and adjust. Employers should consider evaluating the types of masks provided to ensure they are comfortable and appropriate for the tasks [83].

Finally, social influences and workplace culture may impact PPE adherence [84]. If managers or supervisors do not visibly reinforce face mask usage, employees may feel less compelled to wear them [85]. Cultivating a workplace culture that prioritizes comprehensive PPE usage, including face masks, is crucial for bridging this compliance gap [86].

We demonstrated the effect of interpersonal factors on forecasting acceptance of PPE usage. The parameter of social norms questioned workers about how much their colleagues, family, and supervisors believed that respondents should use PPE. The parameter of social models involved questions about how much workers believed their team leaders and colleagues used PPE when exposed to hazardous agents. The parameter of interpersonal support questioned workers regarding whether their colleagues, family, and supervisors advised them to use PPE. Workers' interpersonal factors were more strongly associated with their use of PPE than any personal or organizational characteristics [37, 67]. Neves *et al.* underscore that ensuring the safety of nursing staff requires more than just the provision of PPE; it also involves addressing interpersonal, organizational, and educational determinants of PPE use. The study advocates for a holistic approach to improve adherence, ensuring the well-being of healthcare workers while minimizing occupational risks [87]. This finding is in line with the results of our study.

Interpersonal support requires more management effort than other parameters; therefore, it is practical to state that interpersonal support is related to the agreement on PPE use. However, some studies report that self-efficacy is important in PPE use [88-90]. This indicates that the user's ability and comfort with PPE significantly affect its usage.

Cognitive-perceptual factors (perceived benefits, barriers, and self-efficacy) did not significantly predict PPE adherence. This may be due to workers' reliance on external influences, such as workplace policies, peer behaviors, and organizational support, rather than personal beliefs. Additionally, inadequate training and awareness of occupational hazards may limit the impact of cognitive-perceptual factors on PPE use. Lu *et al.* showed that some cognitive parameters, such as perceived benefits and barriers to PPE use and self-efficacy, have no significant association with wearing PPE. They suggest that interventions should focus more on strengthening interpersonal and organizational support rather than solely addressing individual perceptions [60]. Workers may lack the confidence and persistence to use PPE, which may be due to a lack of awareness of workplace hazards and the benefits and barriers of PPE use

resulting from insufficient occupational health and safety education and training.

Our findings align with the results of Budhathoki *et al.*'s study^[91], showing that while many workers are aware of various occupational hazards, their actual use of safety measures is inadequate. Elements affecting safety practices include education status, training on occupational safety and health, and access to appropriate PPE. The study concludes that improving awareness and providing adequate access to safety training and PPE are vital for enhancing the health and safety of workers.

Several solutions can be proposed to improve workers' use of PPE. These include increased mutual supervision, providing training programs to enhance peer-group support and supervision of PPE use, and developing occupational health and safety policies^[92, 93]. This study summarized several key recommendations for implementing organizational modifications to enhance and promote PPE usage. These recommendations address critical areas, such as training, accessibility, policy evaluation, and fostering interpersonal support (Figure 2).

Our study is one of the first in Iran to apply the HPM model to analyze potential determinants of PPE use among workers in major industrial companies

exposed to organic solvent hazards.

PPE usage revealed gaps, with only 47.9% of workers wearing face masks compared to 67.4% for gloves, underscoring a disparity in PPE compliance, especially for airborne hazards. Higher education levels correlated with better glove use due to increased awareness about the nature of hazards, while longer exposure to hazards was linked to increased PPE usage. Also, perceived benefits, barriers, and self-efficacy played a role in glove use. Confidence in self-protection was significant for both gloves and masks. Social norms and organizational characteristics significantly affected PPE adherence, particularly mask use, demonstrating how workplace culture shapes protective behavior. Interpersonal and organizational characteristics were the most effective in promoting PPE use, specifically social models for mask use (odds ratio of 3.51) and organizational factors for gloves (odds ratio of 3.15). Organizations and managers should encourage a safety culture through continuous evaluations, policy reviews, and supervisor-led reinforcement. To improve PPE adherence, peer-group support, training programs, establishing reward systems, and ensuring easy access to appropriate PPE can enhance PPE usage.

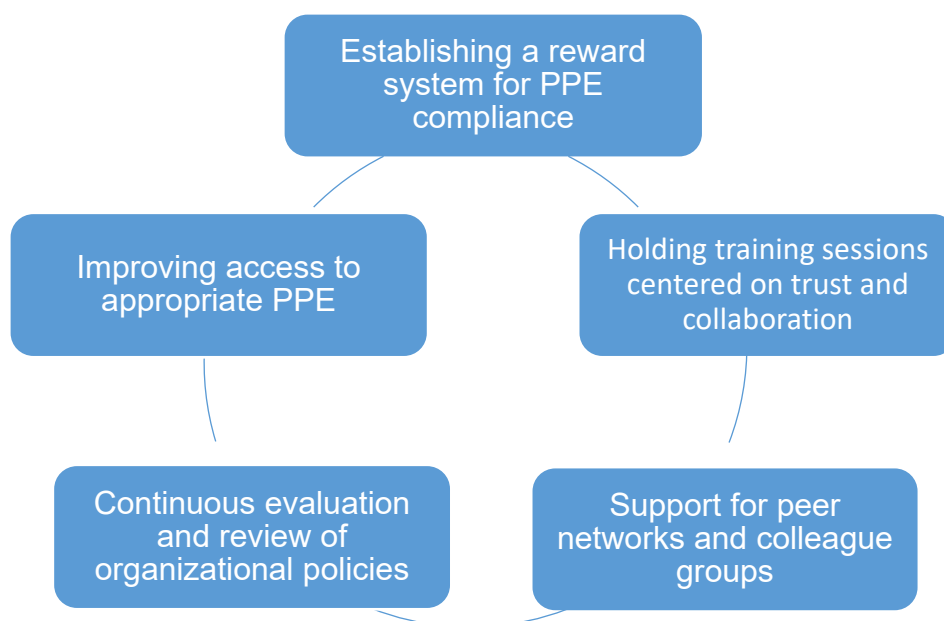


Figure 2. Recommendations for improving and promoting personal protective equipment (PPE) usage

This study indicated the application and potential of the HPM in predicting and understanding workers' perspectives on safety and the use of. The model effectively underscores how personal beliefs, perceived benefits and barriers, self-efficacy, and interpersonal influences shape workers' safety behaviors. This study emphasized the critical role of supportive environments in enhancing PPE compliance by determining key interpersonal and

organizational factors, such as peer support, management commitment to safety, and access to training. Promoting a workplace culture that prioritizes safety through leadership involvement and collaborative efforts can significantly improve the likelihood of workers adhering to safety protocols. Like many other studies, ours has its limitations. One of the significant challenges of this study was the restricted access to certain companies,

as some managers refused to permit research activities and data collection within their facilities. This issue reduced the number of potential study sites and the diversity of organizational settings that could have enriched the findings. The reluctance of some managers may be rooted in concerns about confidentiality, potential disruptions to workflow, or apprehension about revealing workplace procedures. This barrier highlights the significance of building trust and transparent communication with management in future research, ensuring that companies understand the value of such studies in improving occupational safety and health. This limitation naturally restricts the range of associations we could discover within the model. Moving forward, future research should consider including a wider range of variables so that we can better understand the different factors at play. Another significant point is that because our study was cross-sectional, we cannot draw firm conclusions about cause and effect. We were able to classify the relationships among variables, but it is difficult to determine what is driving what or if there are other unmeasured influences at work. One of the limitations of this study is that the questionnaire does not explicitly assess the role of necessary training, the establishment of mandatory rules, and the provision of PPE by companies. While organizational factors related to PPE accessibility were considered, aspects such as formal training programs, regulatory enforcement, and company policies were not directly measured. These factors are crucial in shaping workers' adherence to PPE usage, as proper training enhances awareness, mandatory rules reinforce compliance, and PPE availability ensures accessibility. Future research should incorporate these elements to gain a more comprehensive understanding of PPE adherence. Qualitative methods like interviews or focus groups could provide deeper insights into how company policies and training initiatives influence workers' behavior. Additionally, including specific survey items on training frequency, enforcement of PPE regulations, and company-provided PPE resources would help capture these dimensions more effectively. Future studies could use a longitudinal approach to truly understand these relationships. This would allow researchers to track changes over time, providing a clearer picture of cause and effect. Furthermore, focusing on specific interventions, whether through programs or policies, could help pinpoint what improves workers' use of PPE. However, it does not stop there. Evaluating these interventions and conducting thorough policy analyses could provide valuable insights that help individual organizations and shape broader policy decisions.

By addressing these limitations through more data, following individuals over time, and experimenting with targeted strategies, we can better understand how to improve PPE use in the workplace. Ultimately,

this will help create safer work environments where workers are better protected, and health outcomes significantly improve. By taking these steps, future research can play a critical role in shaping theory and practical workplace safety solutions.

Despite these limitations, our study demonstrates that the HPM framework is relevant in different cultural contexts. Additionally, our study highlights the importance of interpersonal and organizational factors concerning other variables influencing the use of PPE. We hope organizations will focus on these important variables to enhance PPE usage further.

Future studies should adopt more comprehensive variables and designs to strengthen the understanding of cause-and-effect relationships. Increasing PPE through targeted interventions and policy support can lead to safer work environments and better health outcomes for workers.

Conclusion

The health promotion model can be utilized to understand compliance with personal protective equipment in industrial settings.

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