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# Statistical Evaluation of Asbestos Exposure Awareness That May Arise From Removal of Building Debris in the 2023 Kahramanmaras Earthquakes

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## 2023 Kahramanmaraş Depremlerinde Bina Enkazlarının Kaldırılmasından Kaynaklanabilecek Asbest Maruziyeti Farkındalığının İstatiksel Olarak Değerlendirilmesi

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**Abstract**

In addition to the dangers posed by earthquakes, long-term health concerns arise from asbestos exposure during demolition activities. Our study aimed to assess the awareness and perceptual effects of asbestos dust on individuals involved in or near demolition sites. We conducted a survey involving 110 participants across three groups: a. Demolition Officers (DO) (27 participants), b. Environmental Safety Officers (SO) (28 participants), and c. Individuals Present (IP) (55 participants). Participants provided demographic information and answered questions related to asbestos exposure and safety practices. The SO group demonstrated relatively higher awareness levels but often failed to implement adequate safety protocols. This study makes a significant contribution by identifying the most vulnerable groups and emphasizing the systemic deficiencies in current safety practices. Practical implications include the necessity of mandatory training modules for demolition workers and public information campaigns to mitigate the health risks of asbestos exposure. By addressing these gaps, the findings provide a foundation for integrating asbestos risk management into disaster response frameworks, thereby improving occupational safety and public health in post-disaster scenarios.

**Keywords:** Asbestos; Kahramanmaraş earthquakes; exposure; demolition; safety precautions.

**Öz**

Depremlerin oluşturduğu tehlikelere ek olarak, yıkım faaliyetleri sırasında asbeste maruz kalmaktan kaynaklanan uzun vadeli sağlık sorunları da vardır. Çalışmamızın amacı, yıkım sahalarında veya yakınında bulunan kişilerde asbest tozunun farkındalığını ve algısal etkilerini değerlendirmektir. Üç grupta 110 katılımcıyı kapsayan bir anket gerçekleştirdik: a. Yıkım Görevlileri (YK) (27 katılımcı), b. Güvenlik Görevlileri (GG) (28 katılımcı) ve c. Çevredeki Halk (ÇH) (55 katılımcı). Katılımcılar demografik bilgiler sağladı ve asbeste maruz kalma ve güvenlik uygulamalarıyla ilgili soruları yanıtladılar. ÇG grubu nispeten daha yüksek farkındalık seviyeleri sergilemiş olsa da genellikle yeterli güvenlik protokollerini uygulamada başarısız olmuştur. Bu çalışma, en savunmasız grupları belirleyerek ve mevcut güvenlik uygulamalarındaki sistemik eksiklikleri vurgulayarak önemli bir katkı sağlamaktadır. Pratik çıkarımlar arasında yıkım çalışanları için zorunlu eğitim modüllerinin hayata geçirilmesi ve halkı bilgilendirmeye yönelik kampanyaların düzenlenmesi yer almaktadır; böylece asbeste maruz kalmanın sağlık riskleri azaltılabilir . Bu eksikliklerin giderilmesiyle elde edilen bulgular, asbest risk yönetiminin afet müdahale çerçevelerine entegre edilmesi için bir temel oluşturarak, afet sonrası iş sağlığı ve güvenliği ile halk sağlığının iyileştirilmesine katkı sağlamaktadır.

***Anahtar kelimeler:*** *Asbest: Kahramanmaraş depremleri: maruziyet; yıkım; güvenlik önlemleri.*

## 1. Introduction

Asbestos is a naturally occurring mineral, has a storied history of industrial use due to its exceptional physical properties (Furuya et al. 2018). Comprising fine, durable fibers, asbestos is highly resistant to heat, fire, and chemicals, which made it an invaluable material for a wide array of applications (Dirisu et al. 2022). In its natural state, asbestos can be found in rock formations worldwide, but it wasn't until the late 19th century, during the industrial revolution, that its flexibility and strength made it a revolutionary material for many sectors, most notably construction and its building components (Krówczyńska and Wilk 2019). The composition of asbestos, primarily silicate minerals, gives it a fibrous nature, making it extremely versatile. There are six fibrous minerals that have been used in commercial products. The six types of asbestos are chrysotile, crocidolite, amosite, anthophyllite asbestos, tremolite asbestos and actinolite asbestos (figure 1).

During the mid-20th century, asbestos was known as a revolutionary material due to its versatility, durability, and heat resistance. It became a staple in construction and manufacturing, featured in products such as roofing, insulation, and brake linings (Gualtieri et al. 2022; Emmett

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2021). In a study conducted in Detroit between 2014 and 2017, asbestos was found in 95% of demolished abandoned housing units.

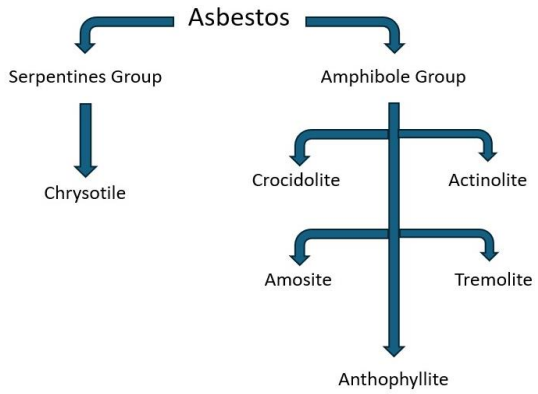


**Figure 1.** Types of asbestos

The most common asbestos-containing materials were flooring, roofing, siding and duct insulation (Franzblau et al. 2020). In another study conducted on 50 buildings in İzmir, asbestos was detected in 22% of the 505 samples taken (Tetik et al. 2024). The findings in these studies reveal that asbestos is widely present in demolished structures, highlighting the critical importance of conducting comprehensive asbestos surveys and abatement studies prior to demolition activities to protect public health and ensure environmental safety. Its popularity surged because of the widespread belief that asbestos posed no significant risk, particularly when it was locked within construction materials. However, over time, as more people became exposed to airborne asbestos dust, health risks began to emerge. While undisturbed asbestos is relatively stable, activities such as cutting, sanding, or damage can release microscopic fibers into the air. Inhalation of these fibers poses significant health risks, as they embed in lung tissues, causing chronic irritation and severe diseases over time (Pawełczyk and Božek 2015; Kim et al. 2020). Despite its classification as a carcinogen and bans implemented in most countries by 1983 (Magnani et al. 2023), asbestos remain prevalent, especially in structures built before its prohibition. In Türkiye, asbestos was widely used in construction until 2010, leaving a legacy of hazardous materials in many buildings, until the regulation comes into force (Republic of Turkey Official Gazette 2010). The 2023 Kahramanmaraş earthquakes, which led to the widespread demolition of older structures, have raised concerns about whether asbestos fibers are present in debris and, if so, at what concentrations—posing serious risks to public health.

Exposure to asbestos can lead to severe, often life threatening health issues, primarily targeting the respiratory system. In those exposed to asbestos, it can lead to diseases with long latent periods during which symptoms may not appear until 20 to 50 years after exposure (Sen 2015; Miao et al. 2024). One of the most aggressive diseases caused by asbestos is mesothelioma, a rare cancer affecting the thin membranes surrounding the lungs, abdomen, or heart (Valenzuela et al. 2016). Mesothelioma is almost exclusively linked to asbestos exposure, and its prognosis remains poor due to late detection (Boffetta et al. 2019). Lung cancer is another significant risk (Nielsen et al. 2014), with the combined effects of asbestos and smoking multiplying the likelihood of the disease (Berry and Liddell 2004; Ngamwong et al. 2015; Klebe et al. 2020). Prolonged exposure can also lead to asbestosis, a chronic lung condition marked by fibrosis and progressive respiratory failure, as well as pleural diseases, such as plaques and thickening of the lung lining (Baur et al., 2017; Harris et al., 2019). While some of these conditions are non-cancerous, they can serve as early warnings for more severe outcomes, underscoring the need for early detection and regular monitoring of at-risk populations.

In addition to long-term health concerns, the destruction of asbestos-containing structures during demolitions significantly heightens the risk of exposure. The release of dust containing asbestos fibers, often mixed with other toxic substances like heavy metals, can severely impact air quality and exacerbate respiratory illnesses (Bloise et al., 2018). These risks are particularly relevant in the aftermath of the 2023 Kahramanmaraş earthquakes, where widespread demolition operations have underscored the need for improved safety protocols. However, a gap remains in understanding how long-term health monitoring can be systematically integrated into disaster response frameworks. Best practices from countries such as the United States and Australia, where asbestos is strictly regulated, emphasize the importance of establishing registries for exposed populations, routine health screenings, and public education campaigns (URL-1), (URL-2). Similarly, Europe has strict regulations on asbestos management. The European Union has developed extensive legislation to regulate the use and management of asbestos. In this context, in addition to the ban of all types of asbestos in 2003, directives were issued to record workers exposed to asbestos, ensure regular health examinations, and protect public health during demolition operations (European Agency for Safety and Health at Work [EU-OSHA], 2020). Policies such as the establishment of national inventories of asbestos-containing buildings implemented in Europe could serve as an example for similar initiatives in Turkey.

The implementation of such measures in Turkey could increase the ability to identify and manage asbestos-related health consequences in affected regions. Implementing similar measures in Türkiye could enhance the ability to identify and manage asbestos-related health outcomes in affected regions.

The destruction caused by the 2023 Kahramanmaraş earthquakes and subsequent building demolitions has emphasized the need to reassess Türkiye's strategies for managing the risks associated with asbestos exposure. Understanding the extent of asbestos exposure following natural disasters is essential for both public health and environmental safety. Our study aims to assess the awareness and protective measures taken by various groups involved in or near demolition activities. By evaluating public knowledge of the health risks associated with asbestos exposure, the data gathered will serve as a guide for future disaster preparedness and response strategies, ensuring better protection for both workers and residents. This research, conducted across heavily affected regions such as Şanlıurfa, Adıyaman, and Kahramanmaraş, represents an important step toward public perception and the necessity of enhanced safety protocols in managing asbestos risks during post-earthquake demolitions.

## 2. Materials and Methods

### *2.1 Study area*

A survey was conducted during the demolition of severely damaged buildings, as mandated by the Ministry of Environment, Urbanization, and Climate Change, following the February 6 earthquakes. The buildings, located in various affected provinces, including Şanlıurfa, Adıyaman and Kahramanmaraş where the survey was specifically carried out, an example from the workspace can be seen in Figure 2. In selecting the demolition area where the survey had conducted, attention was paid to ensuring that the construction dates of the buildings subject to demolition were before 2010. In this way, efforts were made to ensure that there was a high probability of toxic residues in the dust such as asbestos generated during the demolition.

### *2.2 Target group*

The survey focused on three different groups: crane operators and other demolition workers actively involved in the process (DO, 27 individuals), security personnel responsible for maintaining environmental safety around the site (SO, 28 individuals), and individuals who were not on duty but were in the vicinity during the demolition (IP, 55 individuals). You can also see an example of the survey in Figure 3. This study aimed to evaluate potential asbestos exposure among these groups, as the demolition of damaged buildings posed a significant risk of releasing hazardous materials, particularly asbestos, into the environment.

**Figure 2.** One of the demolition areas (Şanlıurfa)

**Figure 3.** Survey of an individual from the SO group during the demolition

### *2.3 Survey application*

Survey questions were designed to evaluate the perceptual effects of potential asbestos exposure during the demolition of severely damaged buildings in the affected region. The survey targeted DO, SO, and IP groups to gather their insights on experiences and perceptions related to these exposures and their potential health impacts. Participation was voluntary, allowing respondents to provide feedback on their observations and concerns regarding asbestos exposure during the demolition process. At the end of the survey,

masks were distributed to the participants, and they were informed about asbestos and its possible negative effects.

### *2.4 Statistical Analysis*

The ages of the participants in the study were expressed as mean ± SD (minimum - maximum) for each group. The participants' working hours in their own sector and working hours in demolition activities were analyzed using ANOVA and Bonferroni was used as a post-hoc test for comparisons between groups. Group comparisons regarding the duration of exposure of the participants to the demolition area were performed using t-test. The non-parametric Wilcoxon-Mann-Whitney U test was used to compare the responses given to the survey questions between groups. The value of "$p<0.05$" was considered statistically significant.

## 3. Results and Discussions

The survey included demographic questions, which are given in Table 1, to capture a comprehensive profile of the participants. Additionally, asbestos awareness and risk perception questions, the details of which are provided in Table 2, were included to assess participants knowledge of the potential health hazards associated with possible asbestos exposure during building demolition.

**Table 1.** Demographic questions.

| |
|---|
| Your age? |
| Your gender? |
| Your education level? |
| Your working hours in this sector? (Years) |
| Your working hours in demolition activities? (Months) |
| Your average Daily presence in the demolition area? (Hours) |

**Table 2.** asbestos awareness and risk perception questions.

| |
|---|
| Do you have information about the content of the dust generated during building demolition? |
| Are you aware that dust form old, demolished buildings (older than 23 years) may contain asbestos? |
| Do you have information about asbestos dust and its health hazards? |
| Do you think that exposure to asbestos during demolition could lead to serious health problems in the future? |
| Have you been given any information about the risks and safety precautions associated with exposure to asbestos during the demolition of dameged buildings? |

The mean age of the participants was found significantly different in the group comparison (ANOVA, $p<0.032$). In the comparison between the groups (Bonferroni used as post-hoc test), the mean age of the DO group (40.04 ± 9.92 years, ranged 24 to 60) was found higher than the SO group (34.54 ± 5.68 years, ranged 25 to 43). The mean age of the IP group was found (42.29 ± 15.75 years, ranged 18 to 73), significantly higher than the SO group ($p<0.009$). This age difference suggests a mix of both experienced professionals and relatively younger workers may reflect differences in experience and familiarity with asbestos-related risks.

In terms of gender distribution, the DO group consisted of 26 males and 1 female, while the SO group included 25 males and 3 females, with the IP group having a more balanced composition of 29 males and 26 females. The low representation of women in the DO and SO groups is not surprising, given that demolition work and safety enforcement in such environments are traditionally male-dominated fields. The physically demanding nature of demolition tasks, combined with historical patterns in the workforce, may explain why female participation in these roles remains limited. Similarly, while the SO group showed slightly higher female participation, the number of women remains low primarily because we did not encounter many women in these roles during the study, even though there may be a certain number of women in such positions.

Educational levels among participants ranged from primary and secondary school graduates to those holding high school and university degrees. This diversity in education likely influenced the participants' awareness and understanding of asbestos hazards, as well as their attitudes toward safety measures. For example, 40.74% of primary school graduates were in the DO group, while 3.57% were in the SO group, and 30.9% in the IP group. Among secondary school graduates, 48.14% were in DO, 0% in SO, and 20% in IP. For high school graduates, 7.4% were in DO, 3.57% in SO, and 20% in IP. Finally, for university graduates, 3.7% were in DO, 92.85% in SO, and 29.1% in IP. This distribution of educational levels offers important context for analyzing their responses to asbestos exposure and related risks.

The duration of work of the participants in their own sectors was compared. It was observed that the DO group had been working significantly longer than the SO group (16.72 and 10.52 years, respectively. $p<0.028$). However, the duration of work in post-earthquake demolition activities was observed to be quite similar in the DO and SO groups (10.41 and 10.52 months, respectively).

According to our survey results, it was observed that the average time spent in the demolition area differed between the groups (ANOVA, $p<0.001$). In the comparison of the groups (Bonferroni used as post-hoc test), while the DO group spent an average of 9.37 hours per day in the demolition area, this time was determined

as 7.85 hours in the SO group ($p<0.001$). The average time spent in the demolition area by the IP group was determined as 8.86 hours, and this time was found to be significantly longer than the SO group ($p<0.044$), while it was found to be shorter than the DO group. These changes in daily exposure between the groups can be considered as a factor in shaping the participants' awareness and perception of asbestos-related risks.

Moreover, we posed targeted questions to participants who may have been exposed to asbestos, and the findings are presented graphically for clarity and impact. Responses are categorized as 'yes' or 'no,' with an emphasis on awareness of potential asbestos hazards.

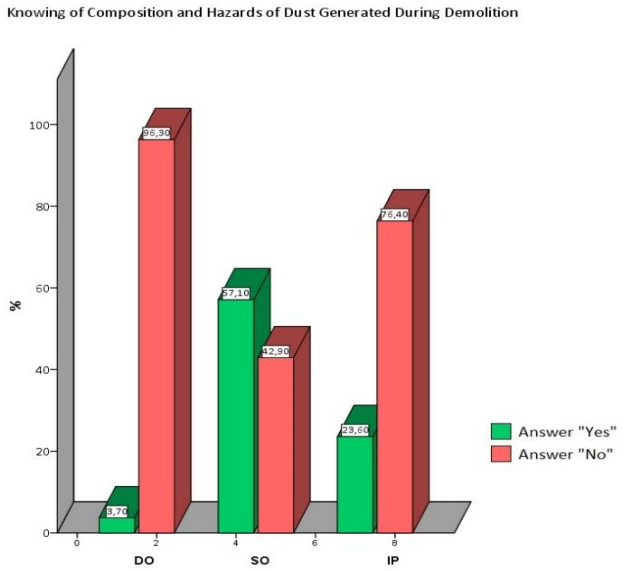


**Figure 4.** Responses from DO, SO, and IP groups to the knowledge of information about the content of the dust generated during building demolition.

Figure 4 shows how much knowledge different groups (DO, So and IP) have about the composition of the dust generated during demolition. It is particularly striking that security guards have a higher level of knowledge compared to other groups. However, the low level of knowledge of demolition workers shows why awareness remains limited in this group despite direct exposure. This may be related to lack of training and inadequate work safety protocols.

Figure 5 clearly shows that awareness raising efforts should focus specifically on demolition workers. It shows the awareness levels of the possibility of asbestos in dust from old buildings. The high awareness level of security guards highlights that this group is more exposed to environmental risks due to their job description and needs information on this issue. In contrast, the low awareness levels of demolition workers and individuals in the surrounding area show that these groups do not sufficiently understand the long-term health risks. The figure highlights the importance of risk communication during the demolition of old buildings and the need for targeted information campaigns on this issue.

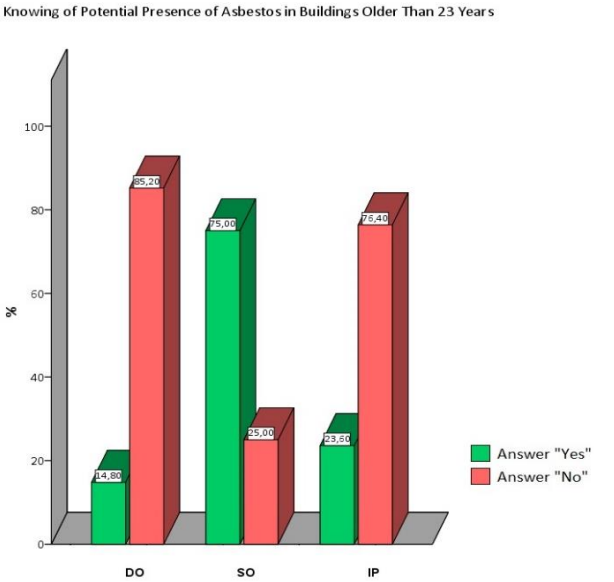


**Figure 5.** Awareness of the potential presence of asbestos in buildings older than 23 years, based on responses from DO, SO, and IP groups. The figure categorizes their understanding of asbestos risks in older structures, highlighting differences in knowledge levels.

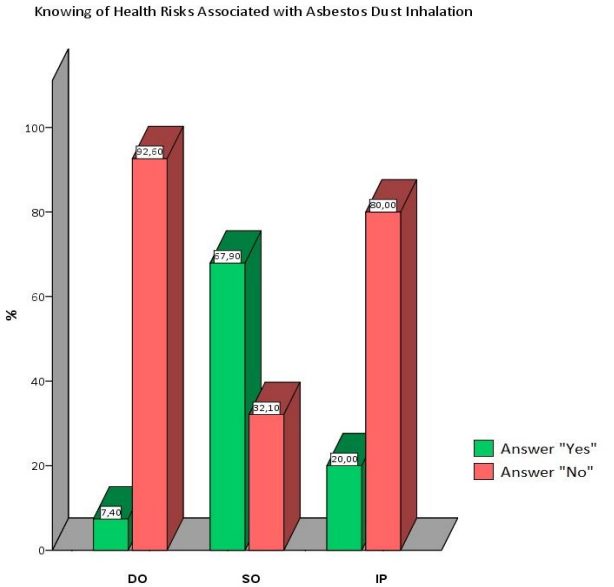


**Figure 6.** Results on the awareness of health risks associated with asbestos dust inhalation among DO, SO, and IP groups. The figure illustrates the variation in knowledge regarding asbestos exposure's potential health impacts across different groups.

Figure 6 shows the level of knowledge of the participants about the health effects of asbestos dust. Although security guards seem to be more aware of this issue than other groups, the lack of knowledge of demolition workers shows that they do not have sufficient access to health education despite the direct risk of exposure. The figure supports the necessity of making training modules and awareness-raising programs on the use of protective equipment mandatory for workers.

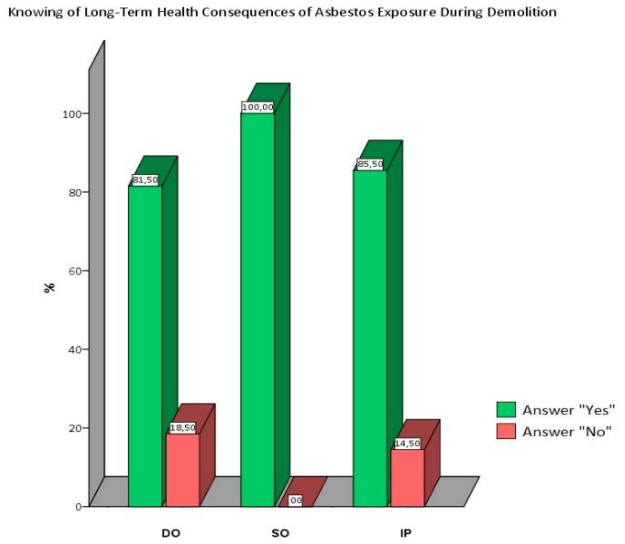


**Figure 7.** Results on the awareness of long-term health consequences of asbestos exposure during demolition among DO, SO, and IP groups. The figure highlights differences in understanding of prolonged asbestos-related health risks, emphasizing variations across the groups.

Figure 7 shows how aware respondents are of the long-term health effects of asbestos exposure during demolition (e.g. mesothelioma and asbestosis). The higher awareness levels among security guards than other groups highlight the role their professional role plays in raising awareness. However, the lack of awareness among demolition workers and the public suggests that the serious health consequences are poorly understood. The figure strongly suggests that more comprehensive education and information efforts are needed on this issue.

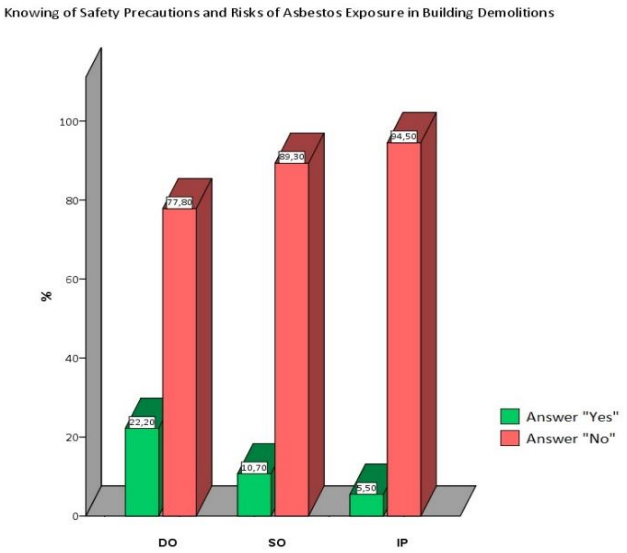


**Figure 8.** Survey results on the awareness of safety precautions and risks associated with asbestos exposure during building demolition among DO, SO, and IP groups. The figure illustrates varying levels of knowledge regarding protective measures and potential hazards across the groups.

Figure 8 shows whether the participants were informed about asbestos risks and protective measures. The results clearly show that all three groups have a serious lack of knowledge on this issue. The fact that demolition workers and individuals living in the area have hardly been informed on this issue reveals the inadequacy of the measures taken on site and the lack of risk communication. The figure supports the necessity of implementing regular and compulsory training programs. The responses from participants in the survey, along with the statistical analysis of the differences between groups, are presented in Table 3. In constructing the table, only the "yes" responses were highlighted, while all responses were included in the statistical analyses to ensure a comprehensive evaluation.

**Table 3.** Proportional evaluation of responses regarding asbestos exposure from the survey participants across the groups.

| Survey questions | Percentage of those who answered "Yes" (%) | | |
|---|---|---|---|
| | DO | SO | IP |
| Do you have information about the content of the dust generated during building demolition? | 3,7 | 57,1[a]** | 23,6[b]* [c]* |
| Are you aware that dust from old, demolished buildings (older than 23 years) may contain asbestos? | 14,8 | 75,0[a]** | 23,6[c]** |
| Do you have information about asbestos dust and its health hazards? | 7,4 | 67,9 [a]** | 20,0 [c]** |
| Do you think that exposure to asbestos during demolition could lead to serious health problems in the future? | 81,5 | 100,0[a]* | 85,5[c]* |
| Have you been given any information about the risks and safety precautions associated with exposure to asbestos during the demolition of damaged buildings? | 22,2 | 10,7 | 5,5[b]* |

Wilcoxon-Mann-Whitney U test was used for comparisons between groups. "a" shows comparisons between DO and SO, "b" between DO and IP, and "c" between SO and IP groups. "" and "*" indicate p<0.05, p<0.001, respectively.

Our data shows that awareness regarding the content of the dust generated during demolition is severely lacking, particularly in the DO group, where only 3,7% had any knowledge of what they might be exposed to. This is concerning, given that these individuals are the ones that directly handle hazardous materials during demolition.

There are several possible reasons for this situation, and further investigation of these reasons may contribute to the effective design of future training and safety protocols. First, it is thought that demolition workers may have limited access to occupational safety training and information activities related to asbestos. Studies show that high-risk groups such as demolition workers are often excluded from standard safety training and have insufficient knowledge about such specific health risks (Patel and Patel 2020). Often, these workers receive only basic information about the hazards of asbestos and lack specific training or educational materials that would create more in-depth awareness. Since demolition workers often work under the influence of daily workloads and time pressures, they may sometimes neglect issues such as safety precautions and the use of protective equipment. This situation may lead to continued lack of awareness and, as a result, continued exposure if training and safety protocols are not given sufficient priority. Another possible reason is the socio-economic factors that affect the awareness levels of the DO group. Workers are mostly selected from low-income groups and individuals in this group generally have less access to health-related education and information (Ceballos et al. 2021). Economic concerns may lead to workers being less motivated to learn about hazards such as asbestos and receive training on safety precautions. The physical conditions that workers encounter in their daily work environments may also affect their awareness levels. Demolition areas are usually noisy, dirty and dangerous work environments. DO group members working in such environments often lack opportunities to learn about safety because daily workload and environmental factors may disrupt training and precautionary processes. In this context, in order to increase the training and awareness levels of demolition workers, it is necessary not only to provide information but also to change the safety culture and make the work environment safe. These findings indicate that the low awareness level of demolition workers may be due not only to lack of training but also to socio-economic and environmental factors. It is recommended that training modules aimed at increasing the health and safety awareness of demolition workers be made mandatory, made more accessible and applicable to workers, training materials be simplified and practical application opportunities be provided. In addition, workers should be able to express their concerns about exposure and have a more open communication channel about safety precautions.

In comparison, the SO group with 57.1% awareness displayed a better understanding of the potential dangers which is likely due to their environmental safety role. However, even this number is far from ideal. A 23.6% of the IP group comprising individuals present but not directly involved in the demolition, had any awareness of these risks. This low level of knowledge raises serious concerns about the adequacy of safety orientations and public communication efforts around demolition sites.

The study also found that the SO group was far more aware of the specific risks posed by asbestos, with 75% acknowledging that older buildings (constructed more than 23 years ago) likely contain asbestos. In contrast, only 14.8% of the DO group recognized this risk. This is alarming because, while the SO group is tasked with environmental oversight, the DO group is most directly exposed to these materials. The IP group, similarly underinformed at 23.6%, suggests that individuals who are indirectly affected (such as nearby residents) are being overlooked in terms of risk communication. These findings suggest a systemic issue: those who are most at risk are often the least informed, pointing to a clear need for more comprehensive training and education efforts targeted at demolition workers and the public. When we look at the awareness of asbestos-related health hazards, 74% of the DO group had some understanding, slightly higher than the 67.9% in the SO group, but again, only 20% in the IP group. While it is encouraging that the majority of DO workers are aware of the potential health risks, it raises the question of how deeply this knowledge extends. Is this awareness translating into action, such as the consistent use of protective equipment? Or is it a passive acknowledgment of the dangers without significant behavioral change? The fact that 20% of the IP group had any awareness of these health risks is particularly troubling, as they could unknowingly be exposed during or after demolition activities. This highlights a pressing need for broader community outreach and information dissemination.

A particularly striking result is the widespread recognition of asbestos exposure as a serious long-term health risk. In the SO group, every participant believed that exposure could lead to significant health problems, compared to 81.5% in the DO group and 85.5% in the IP group. While this near unanimous concern is promising, it also

underscores the gravity of the situation. Even though participants are aware of the risks, they are not being adequately protected or informed. This disconnect between knowledge and action reflects a systemic failure to provide the necessary tools and guidance to mitigate these risks.

One of the most alarming insights from this study is the lack of formal safety information provided to participants. Only 22.2% of the DO group, 10.7% of the SO group, and a staggering 5.5% of the IP group reported receiving any formal safety orientations on the risks of asbestos exposure. It suggests that even though awareness exists in some form it is not being backed up by institutional support or preventive measures. For example, research conducted in Japan after the 2011 Tōhoku Earthquake showed that post-disaster demolition activities can increase the release of asbestos, which can lead to long-term health problems. In particular, improper handling of asbestos-containing materials during demolition posed serious health risks to both workers and the surrounding public (Kato 2015). Similarly, studies conducted in the USA after Hurricane Katrina in 2005 highlighted that inadequate controls to prevent the release of hazardous substances such as asbestos during demolition and debris removal led to an increase in long-term health problems such as respiratory diseases and cancer (Fisher Wilson 2006). While such examples demonstrate the importance of post-disaster asbestos exposure management on a global level, findings obtained after the 2023 Kahramanmaraş earthquake in Turkey provide a new perspective on local conditions and post-disaster management approaches. Lack of awareness about asbestos exposure in post-disaster demolition activities in Turkey poses a major threat not only to demolition workers but also to the surrounding public. This study emphasizes the necessity of making post-disaster awareness programs and training modules mandatory and also reveals the importance of public campaigns for public awareness. This is a strategy similarly suggested in the international literature, a review study conducted after the 2010 Haiti Earthquake demonstrated the success of regular information campaigns to increase public safety in disaster areas (Van Leeuwen and Wiepking 2013).

This disconnect could stem from a lack of enforcement of existing regulations or from insufficient allocation of resources towards training and safety programs. The absence of comprehensive safety information leaves DO and IP alike vulnerable to immediate and long-term health risks. Without clear guidance on the proper use of protective equipment or protocols for handling asbestos exposure, the likelihood of mismanagement in these high-risk environments increases dramatically (Mavroulis et al. 2023). This is particularly concerning given the well documented latency period of asbestos related diseases (Järvholm and Burdorf, 2024), where the damage may not manifest until decades later. In such a scenario, unprotected exposure could have devastating consequences. Furthermore, the data suggests that the responsibility for ensuring safety is being disproportionately placed on the workers themselves, rather than being institutionally driven. This approach not only undermines the role of regulatory bodies but also perpetuates a dangerous cycle of insufficient prevention and delayed response. It becomes clear that without a shift towards a more preventive safety culture, the potential for future public health crises can remain high.

These findings lead us to several important conclusions. First, education is not reaching the right people. Those in the most immediate danger, such as the DO group, are not receiving the necessary training and information to protect themselves adequately. Second, the public remains largely uninformed, which is a significant failure of communication strategies, especially in densely populated areas where the risk of secondary exposure is high. Finally, there is a serious gap in the provision of protective equipment. Even if knowledge is increasing, without the right tools to act on that knowledge, the health risks posed by asbestos exposure remain unacceptably high.

Considering these results, a more coordinated multi-level approach is needed. This approach should include mandatory training for all demolition workers on the risks of asbestos, public awareness campaigns to inform nearby residents and stricter enforcement of protective measures on site. Additionally, institutions must take responsibility for ensuring that protective gear is not only available but enforced. The gap between awareness and action is too large and the consequences too severe to allow these issues to persist unaddressed.

**4. Conclusions**

Reducing the risks associated with asbestos exposure during demolition activities requires a multi-faceted approach tailored to the specific needs and risk levels of different groups. Demolition workers, who face the highest risk of direct exposure, must be equipped with advanced protective gear such as full-face masks, respirators with asbestos-grade filters, disposable protective overalls, and gloves. Proper training is essential to ensure that this equipment is used correctly and consistently. Furthermore, protocols for the safe disposal

of used equipment and asbestos-containing materials must be strictly followed to prevent secondary exposure.

Groups responsible for environmental safety, such as security personnel, should be provided with medium-level protective gear, including half-face masks and light protective clothing designed for mobility and prolonged use. These individuals must also receive regular training to enhance their understanding of site safety and asbestos management practices.

For the public and other groups indirectly affected by demolition activities, lower level but effective protection is crucial. Individuals living near demolition sites should be encouraged to use simple dust masks to minimize exposure. Demolition boundaries must be clearly marked with visible security tape, unauthorized access must be prohibited, and nearby residents should be regularly informed about ongoing risks and safety measures.

By implementing protection measures tailored to each group's risk level and needs, not only can immediate health risks be mitigated, but the long-term burden of asbestos-related diseases on society can also be reduced. These actions, combined with public education and robust safety protocols, represent an opportunity to build a safer, more informed approach to post-disaster demolition activities.

A comprehensive and inclusive strategy, rooted in collaboration among government agencies, local authorities, and public stakeholders, will ultimately lead to more effective management of asbestos risks and create a foundation for healthier communities in the wake of future disasters.

**Declaration of Ethical Standards**
The authors declare that they comply with all ethical standards.

**Credit Authorship Contribution Statement**
Author 1: Research, Analysis, Writing – original draft, Figures, Data.
Author 2: Research, Analysis, Methodology / Study design, Writing – review and editing, Supervision.

**Declaration of Competing Interest**
The authors have no conflicts of interest to declare regarding the content of this article

**Data Availability**
All data generated or analyzed during this study are included in this published article.

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