

# Occupational Safety and Health Awareness of Respirable dust exposure in Apparel Industries in Export Processing Zone in Machakos County, Kenya

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**Abstract:** The apparel and clothing industry is a vital sector in developing countries. The sector engages considerable workers due to the intense manual work in the industry. In Kenya, the Export Processing Zone (EPZ) hosts many large apparel companies that manufacture garments for export. Garment processing releases respirable dust particles into the work area, thus exposing workers to considerable risks to the respiratory system. This study aimed to determine the awareness of the risks posed by respirable dust hazards among workers in apparel processing companies (APC) in EPZ in Machakos County, Kenya. The research utilized a cross-sectional descriptive design during the study. Four (4) APCs with 367 participants were selected using systematic random sampling. Questionnaires were used to gather information from the participants. The study revealed that married workers were 0.413 [95%CI = 0.179– 0.950,  $p = 0.037$ ] times likely to be aware of respirable dust and associated health concerns compared to single workers. Those who had worked in the factory for a period of 4-6 years were 0.193 [95%CI = 0.043– 0.871,  $p = 0.032$ ] times likely to be aware of respirable dust exposure and associated health concerns compared to those who had worked in the factory for 0-2 years. Workers in sewing, stitching and overlock were 0.14 [95%CI = 0.03– 0.59,  $p = 0.007$ ] times likely to be aware of respirable dust exposures and associated health concerns compared to other workers at the factory. In conclusion, the study revealed significant unawareness of respirable dust exposure among workers in APCs EPZ, Machakos County. Thus, the management should consider training and other administrative controls to reduce respirable dust exposure within the companies.

**Key words:** Apparel, Respirable dust, awareness, Occupational Safety and Health

## Background to the Study

The Government of Kenya (GoK), 2007 defines EPZ as a selected part of Kenya where any goods introduced are generally regarded as import duties and taxes, as being outside

the customs territory but are duly restricted by controlled access and wherein the benefits provided under this Act apply. EPZ was inaugurated in 1990 under the Export Processing Zones Act (Chapter 517) Laws of Kenya to stimulate the export of locally produced goods and services. Accordingly, this leads to earning of foreign exchange and industrialization. One industry within EPZ is the Apparel Processing Companies (APCs). The apparel and clothing industry, which represents a significant sector for industrialization in growing countries, is characterized by the use of textiles to produce knit attire for men, women and children, knitted undergarments and outerwear (Gokalp *et al.* 2018). A typically integrated apparel processing factory has four main production departments (cutting, spinning, weaving, finishing, and quality control) merged into a single clothing production line. According to the Istanbul Chamber of Industry (2012), APC produces consumer goods to meet the attire/garments needs of the community and society.

This industry contributes significantly to the economy in Kenya and the global economy. The garment industry yields substantial revenue and income, predominantly to third-world countries. McCormick *et al.* 2006, reveal that the global apparel business contributes approximately US\$400 billion, almost 10% of the income generated through good manufacturing. In particular, developing countries export these goods, including 70% of apparel products. Kenya hosts thousands of apparel companies. Approximately 170 are medium and large, while 74,000 are small and micro companies. Twenty-one companies operate in the EPZ, employing an average of 1,800 people per company. According to EPZA (2020), company directory on garments and garment-related activities has twenty-seven companies, of which thirteen (13) are knitting/apparel manufacturing companies with a total of 21,752 employees.

Apparel processing companies are exposed to airborne particulate from natural and synthetic fibrous materials in their work environment (Vredenburg, 2019). Exposure to cotton dust in the apparel processing industry has been associated with several works specific and non-specific respiratory. Sisal, cotton and mouldy hay dust are often contaminated with gram-negative bacteria, which contain endotoxins (lipopolysaccharide) in their outer cell wall. Endotoxin is released into the air during processing. Exposure to

Sisal, cotton, bagasse and mouldy hay dust and endotoxin has been involved with several diseases, including cancers, byssinosis, chronic bronchitis and chronic obstructive pulmonary disease, along with nasal and ocular irritation. The concentrations of Sisal, cotton and mouldy hay dust and endotoxin in the workplace are considerably influenced by diverse conditions, including the production rate, material quality, the ventilation system and the processing method (Steudel and Desruelle, 2018). Thus, the need to assess the dust awareness levels among the workers in apparel processing companies.

## **Materials and Methods**

### **Study Design**

The study employed a cross-sectional descriptive design aimed to collect data on dust exposure awareness among workers in Apparel processing companies in EPZ, Machakos County Kenya.

### **Study population**

The study was conducted at the EPZ in Machakos County, Kenya. The EPZ is located in Athi River, Machakos County, Kenya, as illustrated in Figures 1-1 and 1-2. According to the EPZA directory, the export Processing Zone Authority (EPZA) has approximately 21,750 employees (EPZA, 2020).



**Figure 1-1: Map of Kenya**

Source: Kenya Bureau of Statistics, 2019



**Figure 1-2: Map of Machakos County**

Source: Kenya Bureau of Statistics, 2019

Seven companies are registered by the Directorate of occupational safety and health (DOSHS), out of which four companies were selected for the study. These companies had 7,800 employees (EPZA, 2020) who were the study population. A sample size of 367 employees was calculated using the Yamane formula, 2000. Study participants were sampled from across all departments using proportionate distribution as presented in Table 1-1. The factories and the participant were coded for confidentiality purposes.

### **Determining Respirable dust awareness level among workers**

The research assessed dust hazard awareness levels through interviews of the workers. The research utilized structured questionnaires, observation guides and a review of existing records. The questionnaires were administered in August, September, October and November 2021.

### **Data Analysis and Presentation**

Data analysis was done using Statistical Package for the Social Science (SPSS) Version 25. Data cleaning and validation was performed to achieve a clean data set and then entered into (SPSS) Version 25 for analysis.

## Results and discussions

### Distribution of Response Rate

The research sampled and focused on Four apparel processing companies. **Table 1.1** presents data on the attributes of each of the four companies.

**Table 1-1: Apparel processing companies in EPZ, Machakos County Kenya**

Code	Total No of Workers	No. of General employees sampled	No of Management sampled	Total Sample Size
APC1	200	8	2	11
APC2	600	22	6	28
APC3	4500	179	32	211
APC4	2500	102	15	117
<b>TOTAL</b>	<b>7800</b>	<b>311</b>	<b>55</b>	<b>367</b>

The companies employed a different number of workers. Thus, the research utilized proportionate distribution to determine the number of respondents from each company.

### Distribution of Age and gender

**Table 1-2** illustrates the proportionate distribution of the 367 participants who participated in the study. Close to 34% (122) of the respondents were aged between 29-39 years, while 31.3% (115) were aged between 18-28 years, whereas 26.7% (98) were between 40-50 years. More than 50% (190) of the respondents were female, while male counterparts were close to 48% (175). A comparable study by Cua (2018) revealed that workers in APCs were between the ages of 25 to 40, which is the prime and productive age. According to the study, those below 25 years focus on their studies, while those above 40 are largely unwell, pushing them away from careers.

**Table 1-2: Distribution of Age and Gender**

Variables	n	%
<b>Age</b>		
18-28	115	31.3
29-39	122	33.2
40-50	98	26.7

<b>Variables</b>	<b>n</b>	<b>%</b>
51-61	23	6.3
62 & above	9	2.5
<b>Gender</b>		
Male	175	47.9
Female	190	52.1
None Response	2	

### **Distribution of work experience and Work schedules**

Most workers, 34.6% (126), had operated in the factory for 0-2 years, while more than a quarter of the participants, 30.8% (112), had operated in the factory for 2-4 years. About a quarter of the participants, 23.4% (85), had operated in the factory for 4-6 years. The majority, 231 (63.1%), work for over 8 hours on average per day, whereas more than a quarter, 135 (36.9%), work 1-8 hours on average per day, whereas a significant proportion, 85.6% (310), worked at night. Most of the employees, 277 (88.8%), worked over 8 hours on average per night, whereas a smaller proportion, 11.2% (35), worked 1-8 hours on average per night. The findings agree with Lunde et al. (2020). The study established that employees work for long hours in developing countries, an average of 8 hours shown by 71%. However, Rana (2005) reveals that in developed countries, working hours are mostly regulated between 2 to 4 hours for blue-collar jobs, demonstrated by 44%.

**Table 1-3: Work Experience and Work schedule**

<b>Variables</b>	<b>n</b>	<b>%</b>
<b>Work experience in the factory</b>		
0-2 years	126	34.6
2-4 years	112	30.8
4-6 years	85	23.4
6-8 years	16	4.4
8-10 years	9	2.5
Over 10 years	16	4.4
None Response	3	
<b>Working hours On Average Per Day</b>		
1-8 hours	135	36.9
Over 8 hours	231	63.1
None Response	1	
<b>Work at night</b>		
Yes	310	85.6
No	52	14.4
None Response	5	

Variables	n	%
<b>Working hours On Average Per night</b>		
1-8 hours	35	11.2
Over 8 hours	277	88.8
None Response	55	

### Use of personal protective equipment in APCs

The PPEs utilized in the APCs included; Nose masks (cloth and surgical masks), gloves, coveralls and safety shoes. Less than half of the participants, 33.8% (124), agreed that using PPEs was a must for all working in the company. More than a quarter of the participants, 136 (37.1%), confirmed that the company provided enough dust masks for all working in the factory. The majority of the participants, 314 (85.6%), confirmed that workers used PPEs while working, whereas a smaller proportion of the respondents, 14.4% (53), revealed that workers did not use PPEs while working. It was evident during the study that multiple workers used PPEs, including nose masks, especially in the sewing, embroidery and cutting units. This is contrary to the findings by Cigolini and Turco (2017), who discovered that 98.3% of the workers in apparel processing companies in Italy did not use PPEs. The findings agree with a study by Brenner et al. (2016), who stated that employees who do not use PPEs were 66%.

Among the respondents who reported PPEs were not utilized, hot work environment contributed 77.9% (286). The workplace environment temperatures were high, impeding the use of PPEs. A study by Agrawal and Blanchard (2017) reveals that 55% of employees chose to use cloth masks because they do not absorb heat and are hence comfortable to use in a relatively hot work environment. A study by Ardyanfitri and Wahyuningtyas (2016) concluded that it was vital to ensure that all employees use personal gear while working. Of those who utilized the PPEs, more than half, 55.7% (165), utilized cloth masks with no filters, less than half, 112 (37.8%) of those used surgical masks, while a smaller proportion of 6.4% (19) used cloth mask with filters.



More than a quarter of the participants, 32% (89), utilized masks before the covid-19 outbreak. The majority of the respondents, 242 (66.1%), provided their PPEs, whereas the employer provided a smaller proportion of the PPEs, 124 (33.9%). The finding is supported by Chepchumba (2020), who established that the workers who were aware of occupational hazards in the quarry provided and used PPEs which ensured they did not get exposed to respiratory-related dust and fumes. **As shown in table 1.4.**

**Table 1-4: PPE use**

<b>Variables</b>	<b>n</b>	<b>%</b>
<b>Use of PPE a must to all those working in the company</b>		
Strongly disagree	24	6.5
Disagree	187	51
Not sure	32	8.7
Agree	83	22.6
Strongly agree	41	11.2
<b>Provision of enough dust masks by the management</b>		
Strongly disagree	33	9
Disagree	176	48
Not sure	22	6
Agree	107	29.2
Strongly agree	29	7.9
<b>Workers use personal protective gears/equipment while working</b>		
Yes	314	85.6
No	53	14.4
<b>Reason(s) for not using PPEs</b>		
Uncomfortable	66	18
Too hot	286	77.9
Not provided	15	4.1
<b>PPE utilized</b>		
Surgical masks	112	37.8
Cloth mask with no filters	165	55.7
Cloth mask with filters	19	6.4
None Response	71	
<b>Use of Mask before covid-19 outbreak</b>		
Yes	89	32
No	189	68
None Response	89	
<b>Who provides the PPEs utilized</b>		
Own self/personal	242	66.1
Employer	124	33.9
None Response	1	

**Association of awareness on respirable dust hazard with Marital status**

Table 1.5 illustrates that employees who were married, 10 (5.2%) were less aware of respirable dust compared to those who were single, 15 (11.8%). The respondent who were married were 0.413 [95%CI = 0.179– 0.950, p = 0.037] times likely to be aware of respirable dust exposure and associated health concerns compared to those who were single. This defines the age difference, considering the unmarried respondents are ordinarily the younger generation. The findings support the study by Rundmo (2019), which demonstrates that singles employees were sensitive to any health hazard as they were self-dependent, unlike those married. Thus, it necessitated the need to confirm their health status on respirable dust hazard exposure. However, a study by Tsang and Chan (2020) elucidates that most married employees were often informed of the health hazards at their workplace. It was motivated by the fact that their partners could witness any differences in their health, unlike the unmarried, who solely relied on how they felt.

**Table 1-5: Association of awareness on respirable dust hazard with Marital status**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Marital status</b>								
Single	15	11.8%	112	88.2%	Ref			
Married	10	5.2%	181	94.8%	0.41	0.18	0.95	<b>0.037</b>
Divorced/ separated	0	0.0%	20	100.0%	UD	UD	UD	UD
Widow/ widower	4	14.8%	23	85.2%	1.3	0.4	4.27	0.667

**Association of awareness on respirable dust hazard with work experience**

The research revealed a smaller proportion of awareness on respirable dust hazards in the workplace among workers who were in the factory for 4-6 years, 2 (2.4%) compared to those employed in the company for 0-2 years, 14 (11.1%). Those employed in the factory for 4-6 years were 0.193 [95%CI = 0.043– 0.871, p = 0.032] times likely to be aware of respirable dust exposure and associated health concerns compared to those who had worked in the factory for 0-2 years as illustrated in **Table 1.6**. The study by Zornoza (2019) sustains the findings by establishing that those who had worked for over ten years (55%, CI = 0.061– 0.811) had less awareness on respirable dust hazards in the workplace compared to those who worked for less than ten years. In contrary, Balanay et al. (2014) established a smaller proportion of awareness on respirable dust hazards in the workplace

was among those who had worked in the industry for less than six years, 2 (1.9%) compared to those who had worked in the factory for over seven years, 16 (9.7%). Besides, Zohar's (2020) study unveils that those who worked for more than three years (39%, CI = 0.055–0.924) in a company were more aware of respirable dust hazards compared to those who worked for less than two years.

**Table 1-6: Association of awareness on respirable dust exposure in workplace with work experience.**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>How long have you worked in the factory</b>								
0-2 years	14	11.1%	112	88.9%	Ref			
2-4 years	11	9.8%	101	90.2%	0.87	0.38	2.01	0.746
4-6 years	2	2.4%	83	97.6%	0.19	0.04	0.87	<b>0.032</b>
6-8 years	1	6.3%	15	93.8%	0.53	0.07	4.35	0.557
8-10 years	1	11.1%	8	88.9%	1.00	0.12	8.60	1.000
Over 10 years	0	0.0%	16	100.0%	UD	UD	UD	UD

**4.1.1.1. Association of awareness on respirable dust hazard with multiple employment**

A significant proportion of awareness on respirable dust hazards in the workplace was evident among employees with multiple employment or other additional work unrelated to the factory, 6 (22.2%) compared to workers employed only at the EPZ factory 23 (6.8%).

Those with different other employment or work unrelated to the EPZ factory were 3.938 [95%CI = 1.447– 10.717, p = 0.007] times more likely to be aware of respirable dust exposures and associated health concerns compared to employees who only had employment at the EPZ factory. The findings are in line with Kakooei et al. (2012), who verified that 56% (CI =3.938) of the employees who had multiple employments other than their typical workplace were more aware of respirable dust exposure compared to those employed only in their customary workplace. Contrary to the current study findings, the study by Cohen (2018) found that employees who had multiple employments were less

likely (41%) to be aware of respirable dust exposures and associated health concerns compared to employees who only worked at their regular workplace.

**Table 1-7: Association of awareness on respirable dust hazard with multiple employment.**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Having other employment or work not related to this factory</b>								
Yes	6	22.2%	21	77.8%	3.94	1.45	10.72	<b>0.007</b>
No	23	6.8%	317	93.2%	Ref			
<b>Other employment or work not related to this factory</b>								
Mechanic	4	80.0%	1	20.0%	6.00	0.35	101.57	0.214
Security guard	0	0.0%	5	100.0%	UD	UD	UD	UD
Others specify	2	40.0%	3	60.0%	Ref			

**Association of awareness on respirable dust with Training**

The study established a minimal proportion of awareness on respirable dust hazards in the workplace among those trained on fusing and pressing before the commencement of the job, 4.8% (4), compared to those trained on plant/machine operation before job commencement, 87.5% (14). Those trained on fusing and pressing before job commencement were 0.01 [95%CI = 0.001– 0.04,  $p < 0.001$  times likely to be aware of respirable dust exposure and associated health concerns compared to employees trained on plant/ machine operation before job commencement. The findings are coherent with the study by Luxh and Thorsteinsson (2017) that established that those trained on the process before job commencement were unlikely to be aware of respirable dust and associated health concerns by 45% compared to those who have undergone other training. The training content included; Controlling exposure to silica hazards, employer requirements, and OSHA silica standards. The findings contradict Tichon and Diver's (2010) study in which reveals that employees trained before job commencement were more likely to be aware of respirable dust and associated health concerns by 53%.

A smaller proportion of awareness of respirable dust hazards was evident among workers trained on sewing/stitching and overlock before job commencement, 6 (3.3%) compared to those trained on plant/ machine operation before job commencement of job 87.5% (14). Employees trained on sewing/stitching and overlock before job commencement were 0.01 [95%CI = 0.001– 0.03,  $p < 0.001$ ] likely to be aware of respirable dust and associated health concerns compared to respondents who had trained on plant/ machine operation before job commencement. Oliver and Thomas's (2018) study reveals that 55% of the employees trained in Sewing were likely to be unaware of respirable dust exposure and associated health concerns compared to those who had other training. This is contrary to Balanay et al. (2014), who found that trained employees were likely to be aware of respirable dust and related health concerns to a great extent, 71%.

A smaller proportion of awareness on respirable dust hazards was among respondents trained on embroidery and screen printing before job commencement, 5.0% (1), compared to respondents trained on plant/ machine operation before job commencement, 14 (87.5%). Employees trained in embroidery and screen printing before job commencement were 0.01 [95%CI = 0.001– 0.09,  $p < 0.001$ ] times likely to be aware of respirable dust and associated health concerns compared to respondents trained in plant/ machine operation before job commencement. The findings align with Aruldass and Karthik's (2019) study that reveals a smaller proportion of workplace awareness of respirable dust hazards among those trained on production before job commencement compared to those with other training. Contrary to a study by Schroeder and Cua (2019), job training facilitates a healthy work environment. Those who were trained (77%) could take high precaution measures, unlike those who were never trained (23%).

Correspondingly, those trained on spot cleaning and laundry before job commencement had a smaller proportion of awareness of respirable dust hazards, 2 (6.1%), compared to those trained on plant/ machine operation before job commencement, 14 (87.5%). Respondents trained on spot cleaning and laundry before job commencement were 0.01 [95%CI = 0.001– 0.07,  $p < 0.001$ ] times likely to be aware of respirable dust and associated

health concerns compared to respondents trained on plant/ machine operation before job commencement. The study by Jones (2018) agrees with the findings. It establishes that those trained in cleaning are less aware at 46% of dust hazard exposure and associated health concerns compared to workers trained in other fields at 54%.

Significantly a smaller proportion of workplace awareness of respirable dust hazards was recorded among respondents trained in packaging before job commencement, 1 (25.0%), compared to participants trained in plant/ machine operation before job commencement, 14 (87.5%). Respondents trained in packaging before job commencement were 0.05 [95%CI = 0.003– 0.71,  $p = 0.027$ ] times likely to be aware of respirable dust and associated health concerns compared to participants trained in plant/ machine operation before job commencement.

A higher proportion of awareness of respirable dust hazards was prominent among employees who had learnt how to do the work through a trainer provided by the organization, 26.8% (19) compared to employees who had learnt how to do the job through school training, 1.4% (1). Employees who learnt how to do the work through a trainer provided by the organization were 26.67 [95%CI = 3.46– 205.56,  $p = 0.002$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who learnt how to do the work through school training. The finding supports the findings by Ardyanfitri and Wahyuningtyas (2016), which affirmed that employee development opportunities through organisation training ensure occupational safety and health, which helps employees to avoid work-related health risks [85%CI = 3.17– 204.35,  $p = 0.002$ ].

Again, a higher proportion of awareness of respirable dust hazards in the workplace was among respondents who learned how to do the work through others within the company, 4 (44.4%) compared to respondents who learned how to do the job through school training 1 (1.4%). Respondents who learned how to do the work through others were 58.40 [95%CI = 5.45– 625.5,  $p < 0.001$ ] times more likely to be aware of respirable dust and associated health concerns compared to employees who learned how to do the work through school training. A similar study by Geller (2017) established that employees who had learned how

to do the job through others were 44.29 [93%CI = 4.15– 478.5,  $p < 0.004$ ] times more likely to be aware of respirable dust and associated health concerns compared to those who learned how to do the work through school training.

**Table 1-7: Association of awareness on respirable dust with training**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Training before commencement of job</b>								
Yes	25	9.8%	22	90.2%	2.27	0.77	6.70	0.140
No	4	4.6%	9	83	95.4%	Ref		
<b>Specific training before job commencement</b>								
Plant/ machine operation	14	87.5%	2	12.5%	Ref			
Fabric relaxing/ spreading and cutting	0	0.0%	23	100.0%	UD	UD	UD	UD
Fusing and pressing	4	4.8%	79	95.2%	0.01	0.001	0.04	<0.001
Sewing/ stitching and overlock	6	3.3%	17	96.7%	0.01	0.001	0.03	<0.001
Embroidery and screen printing	1	5.0%	19	95.0%	0.01	0.001	0.09	<0.001
Spot cleaning and laundry	2	6.1%	31	93.9%	0.01	0.001	0.07	<0.001
Ironing	1	16.7%	5	83.3%	0.03	0.002	0.39	0.008
Packaging	1	25.0%	3	75.0%	0.05	0.003	0.71	0.027
Office and administration	0	0.0%	2	100.0%	UD	UD	UD	UD
<b>Training how to do this work</b>								
School training	1	1.4%	73	98.6%	Ref			
Members of the human resources team	0	0.0%	10	100.0%	UD	UD	UD	UD
A trainer provided by the organization	19	26.8%	52	73.2%	26.6	3.46	205.56	0.002
Work supervisor	0	0.0%	75	100.0%	UD	UD	UD	UD
A co-worker assigned as mentor	2	6.7%	28	93.3%	5.21	0.46	59.80	0.185
Coworkers	1	2.4%	41	97.6%	1.78	0.11	29.22	0.686
Family and friends	2	3.9%	49	96.1%	2.98	0.26	33.76	0.378
Others	4	44.4%	5	55.6%	58.40	5.45	625.5	<0.001

**Association of awareness on respirable dust exposure with nature of work**

A smaller proportion of awareness on respirable dust hazard in workplace was established among those involved in sewing, stitching and overlock 5 (4.2%) compared to those who had other involvement at the factory 4 (23.5%). Employees at sewing, stitching and overlock were 0.14 [95%CI = 0.03– 0.59,  $p = 0.007$ ] times likely to be aware of respirable

dust exposures and associated health concerns compared to those who had other involvement at the factory.

The study was in line with a study by Ostrom (2018), who established that a smaller proportion of awareness on respirable dust hazards in the workplace was among employees involved in factory work as revealed by a mean score of 1.552 as compared to employees who had other involvement at the factory (33%). Further, this is supported by Kennedy and Kirwan (2017) study with a mean score of 1.194 on awareness of factory workers compared to those in other departments at 29%.

This study established minimal awareness levels of respirable dust among employees involved in embroidery and screen printing 1 (2.7%) compared to employees with other involvement at the factory, 4 (23.5%). Respondents who engaged in embroidery and screen printing were 0.09 [95% CI = 0.01– 0.88, p = 0.039] times likely to be aware of respirable dust exposure and associated health concerns compared to respondents who had other involvement in the factory. The findings concur with a study by Hamatui and Beynon (2016), who found that 71% of the respondents who worked in the factory were less aware of respirable dust hazard exposure compared to those who worked in other departments. A study by Brenner et al. (2016) further reveals that those who had other involvement in the workplace were more aware of respirable dust hazards by 52% compared to those who worked directly at the production unit.

**Table 1-8: Association of awareness on respirable dust exposure in workplace with nature of work**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Nature of work at the factory</b>								
Fabric relaxing/ spreading and cutting	0	0.0%	34	100.0%	UD	UD	UD	UD
Fusing and pressing	0	0.0%	30	100.0%	UD	UD	UD	UD
Sewing, stitching and overlock	5	4.2%	11	95.8%	0.14	0.03	0.59	<b>0.007</b>
Embroidery and screen printing	1	2.7%	36	97.3%	0.09	0.01	0.88	<b>0.039</b>
Spot cleaning and laundry	0	0.0%	24	100.0%	UD	UD	UD	UD
Ironing	4	20.0%	16	80.0%	0.81	0.17	3.9	0.795



Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
Packaging	1	4.2%	23	95.8%	0.14	0.01	1.40	0.095
Office and administration	0	0.0%	10	100.0%	UD	UD	UD	UD
All departments	14	27.5%	37	72.5%	1.23	0.34	4.42	0.751
Others	4	23.5%	13	76.5%	Ref			

**Association of awareness on respirable dust exposure with delivery of information and activities in the workplace.**

The research findings established a smaller proportion of awareness of respirable dust among employees who received regular health and safety information verbally 12 (6.4%) compared to employees who received regular health and safety information through posters/memos 16 (41.0%). Employees who received regular health and safety information verbally were 0.1 [95% CI = 0.04– 0.23, p < 0.001] times likely to be aware of respirable dust exposure and associated health concerns compared to employees who received regular health and safety information through posters/memos. This is illustrated in table 1.9. The finding is supported by a study by Chepchumba (2020), who established that most workers (81%) were aware of respirable dust in the quarry through posters and could protect themselves from health risks in their occupation. A study by Zornoza (2020), on the other hand, establishes that most supervisors (55%) preferred verbal information over posters.

**Table 1-9: Association of awareness on respirable dust exposure with how information delivery.**

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Delivery of regular health and safety information</b>								
Yes	7	6.2%	106	93.8%	Ref			
No	22	8.7%	232	91.3%	1.44	0.6	3.47	0.421
<b>Mode of delivery</b>								
Posters/ memos	16	41.0%	23	59.0%	Ref			
Text message/ social media	0	0.0%	11	100.0%	UD	UD	UD	UD
Emails	0	0.0%	14	100.0%	UD	UD	UD	UD
OSH committee meetings	0	0.0%	18	100.0%	UD	UD	UD	UD
Verbal	12	6.4%	175	93.6%	0.1	0.04	0.23	<0.001
Others	0	0.0%	10	100.0%	UD	UD	UD	UD

Variables	Aware		Not aware		OR	95%CI		P-value
	n	%	n	%		Lower	Upper	
<b>Activities that expose one to dust hazard</b>								
Yes	26	8.5%	280	91.5%	1.39	0.41	4.79	0.599
No	3	6.3%	45	93.8%	Ref			

**Association of awareness on respirable dust hazard with engineering controls and use of Signage at the workplace.**

There was a minimal awareness of respirable dust hazard exposure in the workplace among employees who were not sure if the management provided adequate mechanical ventilation systems (e.g., Fans, lev), 7 (6.7%) compared to employees who strongly disagreed that the management provided adequate mechanical ventilation systems, 22 (23.2%). Employees who were not sure if the management provided adequate mechanical ventilation systems (e.g., Fans, lev) were 0.24 [95%CI = 0.1– 0.59, p = 0.002] times likely to be aware of respirable dust exposure and associated health concerns compared to employees who strongly disagreed that the management provided adequate mechanical ventilation systems (e.g., Fans, lev). The findings corroborate with the results by Van Deurssen et al. (2014) in Bulgaria, where a smaller proportion of awareness of respirable dust hazard exposure in the workplace was among employees who were not sure if the management provided adequate mechanical ventilation systems, 6 (5.9%) compared to employees who strongly disagreed that there was a provision of adequate mechanical ventilation systems, 20 (22.7%). However, the study by Tichon and Diver (2010) conducted in Russia reveals the contrary. Those who were not sure if adequate mechanical ventilation was provided (20.5%) were more aware of respirable dust exposure and associated health concerns compared to employees who strongly disagreed (6.1%) that adequate mechanical ventilation systems were provided in the workplace.

Similarly, a smaller proportion of awareness of respirable dust hazards in the workplace was among employees who were not sure if the management inspected mechanical ventilation systems regularly, 7 (5.1%) compared to employees who strongly disagreed

that the management inspected mechanical ventilation systems regularly, 22 (14.6%). Employees who were not sure if the management inspected mechanical ventilation systems regularly were 0.32 [95%CI = 0.13– 0.77,  $p = 0.011$ ] times likely to be aware of respirable dust hazards and associated health concerns compared to employees who strongly disagreed that the management inspected mechanical ventilation systems regularly. Takala et al. (2014) study supports the results further. Employees who were unsure if the management inspected mechanical ventilation systems regularly 6 (4.81%) were less aware of dust hazards and associated health concerns compared to employees who strongly disagreed that the management inspected mechanical ventilation systems regularly 21 (12.5%).

The study revealed less awareness of respirable dust hazards in the workplace among employees who were not sure if engineering controls were in place to reduce the dust emission levels 7 (3.9%) compared to employees who strongly agreed that engineering controls were in place to reduce the dust emission levels 22 (27.2%). Employees who were not sure if engineering controls were in place to reduce the dust emission levels were 0.11 [95%CI = 0.05– 0.27,  $p < 0.001$ ] times likely to be aware of respirable dust hazards and associated health concerns compared to employees who strongly agreed that engineering controls were in place to reduce the dust emission levels. The study correlates with the findings of Roussel and King's (2012) research findings. It established that a smaller proportion of awareness of respirable dust hazards in the workplace was among employees who were not sure if engineering controls were in place to reduce the dust emission levels 6 (2.8%) compared to employees who strongly agreed that engineering controls were in place to reduce the dust emission levels 21 (26.9%). The study by Zornoza (2020) and Geller (2017) reveals a direct positive association between awareness of respirable dust hazards and engineering controls that revolve around housekeeping at the workplace.

Moreover, this study established a substantial proportion of awareness of respirable dust hazards exposure among employees who were not sure if the management provided safety

and health information signage, 22 (41.5%) compared to employees who strongly disagreed that the management provided safety and health signage, 7 (3.7%). Employees who were not sure if the management provided safety and health information signage were 18.35 [95%CI = 7.23– 46.60,  $p < 0.001$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who strongly disagreed that safety and health signage were provided as illustrated in **table 1.20**. The findings support the results of Vredenburg (2019), who established that 78% of the employees were unaware of hazards exposure at the workplace. Thus, the need to increase safety and health awareness by using signage.

**Table 1-20: Association of awareness on respirable dust hazard with engineering controls and use signages at the workplace.**

Variables	Aware		Not aware		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Provision of adequate mechanical ventilation systems (e.g., Fans, lev) are provided</b>								
Strongly disagree	22	23.2%	73	76.8%	Ref			
Disagree	0	0%	109	100%	UD	UD	UD	UD
Not sure	7	6.7%	98	93.3%	0.24	0.1	0.59	<b>0.002</b>
Agree	0	0%	30	100%	UD	UD	UD	UD
Strongly agree	0	0%	28	100%	UD	UD	UD	UD
<b>Inspection of Mechanical ventilation systems</b>								
Strongly disagree	22	14.6%	129	85.40%	Ref			
Disagree	0	0%	52	100%	UD	UD	UD	UD
Not sure	7	5.1%	129	94.90%	0.32	0.13	0.77	<b>0.011</b>
Strongly agree	0	0%	28	100%	UD	UD	UD	UD
<b>Provision of Engineering controls at work place</b>								
Strongly disagree	0	0%	26	100.0%	UD	UD	UD	UD
Disagree	0	0%	82	100.0%	UD	UD	UD	UD
Not sure	7	3.9%	171	96.1%	0.11	0.05	0.27	<b>&lt;0.001</b>
Strongly agree	22	27.2%	59	72.8%	Ref			
<b>Availability of Relevant dust hazard signages e.g. “high dust levels, use PPE” are provided</b>								
Strongly disagree	7	3.7%	181	96.3%	Ref			
Disagree	0	0%	56	100%	UD	UD	UD	UD
Not sure	22	41.5%	31	58.5%	18.35	7.23	46.6	<b>&lt;0.001</b>
Agree	0	0%	42	100%	UD	UD	UD	UD

Variables	Aware		Not aware		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
Strongly agree	0	0%	28	100%	UD	UD	UD	UD

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## Conclusions

Most of the workers (64.5%) in APCs are aged 18-39 years. They work over 8 hours daily with work experience of 0-4 years. Whereas 85.6% of the employees use PPEs within the APCs, those who do not use PPEs (14.4%) complained of high temperatures within the work environment (77.9%) as the impeding factor to the use of PPEs. Those who were married were 0.413 [95%CI = 0.179– 0.950,  $p = 0.037$ ] times likely to be aware of respirable dust and associated health concerns compared to those who were single. Similarly, those who had operated in the factory for 4-6 years were 0.193 [95%CI = 0.043– 0.871,  $p = 0.032$ ] times likely to be aware of respirable dust exposure and associated health concerns compared to those who operated in the factory for 0-2 years. Additionally, employees trained before commencement on fusing/pressing; sewing/stitching/overlock; embroidery/screen printing; spot cleaning/laundry; ironing and packaging were less likely to be aware of respirable dust and associated health concerns compared to those trained on plant/machine operation as represented by 0.01 [95%CI = 0.001– 0.04,  $p < 0.001$ ]; 0.01 [95%CI = 0.001– 0.03,  $p < 0.001$ ]; 0.01 [95%CI = 0.001– 0.09,  $p < 0.001$ ]; 0.01 [95%CI = 0.001– 0.07,  $p < 0.001$ ]; 0.03 [95%CI = 0.002– 0.39,  $p = 0.008$ ]; 0.05 [95%CI = 0.003– 0.71,  $p = 0.027$ ] respectively.

The employees at sewing/overlock and embroidery/screen printing were less aware of respirable dust exposure and associated health concerns compared to those who had other involvement at the factory, as represented by 0.14 [95% CI = 0.03– 0.59,  $p = 0.007$ ] and 0.09 [95% CI = 0.01– 0.88,  $p = 0.039$ ] respectively. Additionally, Workers who learned the work through a trainer provided by the organization were 26.67 [95% CI = 3.46– 205.56,  $p = 0.002$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who learned the work through school training. Correspondingly, those who had learned how to do the work through others were 58.40 [95% CI = 5.45– 625.5,  $p < 0.001$ ] times more likely to be aware of respirable dust and associated health concerns compared to those who had learned the work through school training. In addition to this, Employees who received regular health and safety information verbally were 0.1 [95% CI = 0.04– 0.23,  $p < 0.001$ ] times likely to be aware of respirable dust exposure and associated health concerns compared to employees who received regular health and safety information through posters/memos.

There was minimal awareness on respirable dust hazard exposure in the workplace among employees who were not sure if adequate mechanical engineering control measures were in place. Employees who were not sure if adequate mechanical ventilation systems (e.g., Fans, lev) were provided were 0.24 [95%CI = 0.1– 0.59,  $p = 0.002$ ] times likely to be aware of respirable dust exposure and associated health concerns compared to employees who strongly disagreed that adequate mechanical ventilation systems (e.g., Fans, lev) was provided. Besides, Employees who were not sure if mechanical ventilation systems were inspected regularly were 0.32 [95%CI = 0.13– 0.77,  $p = 0.011$ ] times likely to be aware of respirable dust hazards and associated health concerns compared to employees who strongly disagreed that mechanical ventilation systems were inspected regularly. Employees who were not sure if engineering controls were in place to reduce the dust emission levels were 0.11 [95%CI = 0.05– 0.27,  $p < 0.001$ ] times likely to be aware of respirable dust hazards and associated health concerns compared to employees who strongly agreed that engineering controls were in place to reduce the dust emission levels.

### **Recommendation**

This research recommends further implementation of administrative controls to promote respirable dust awareness levels among the employees. The management should deliberate on providing more training within the organization. Frequent toolbox talks and safety talks are among the options the management can explore. Training provided within the organizations is more preferable compared to trainings undertaken externally or in schools.

### **Ethical Approval and Consideration**

The researcher sought approvals from the Jomo Kenyatta University of Agriculture and Technology, National Commission for Science, Technology, and Innovation (NACOSTI), and the management of the EPZA.

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### **Competing interests**

The authors declare no competing interest.

### **Authors' contributions**

Owino conceptualized the study design, undertook a literature review, acquired ethical permissions, and carried out data collection/analysis, discussion, and manuscript preparation.

Paul Njogu and Dennis Magu analyzed and verified the study proposal and reviewed the research progress. Both the supervisors have reevaluated and approved this manuscript.

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