

# Association between Respirable Dust Exposure and Respiratory Health Concerns among Workers in Apparel Processing Companies in Export Processing Zone (EPZ) in Machakos County, Kenya

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## Abstract

Apparel processing is an essential industry in providing clothing needs for the population. The Export Processing Zone (EPZ) in Kenya employs many employees. Garment processing releases respirable dust particles, thus exposing workers to risks to the respiratory system. The study determined the respirable dust health concerns among workers in Apparel Processing Companies (APCs) in EPZ in Machakos County, Kenya. A cross-sectional descriptive design was employed where four companies were studied. Three hundred and sixty-seven participants were selected through systematic random sampling. Data was collected using questionnaires and Interview guides. The study established that workers were exposed to respirable dust  $PM_{2.5}$  ranging from  $40.89 \pm 24.0 \mu\text{g}\cdot\text{m}^{-3}$  to  $87.49 \pm 45.2 \mu\text{g}\cdot\text{m}^{-3}$  with a mean of  $65.61 \pm 31.5 \mu\text{g}\cdot\text{m}^{-3}$ . While  $PM_{2.5}$  ranged from  $63.59 \pm 21.2 \mu\text{g}\cdot\text{m}^{-3}$  to  $313.41 \pm 468.0 \mu\text{g}\cdot\text{m}^{-3}$ . With a mean of  $104.02 \pm 26.0 \mu\text{g}\cdot\text{m}^{-3}$ . Workers complained of different respirable dust-related diseases. The most prevalent conditions were sneezing and coughing (86.4%), chest pains (41.1%), blocked chests (36.8%), and allergic reactions to dust (18.3%). The APC should develop an OSH management system that includes; a dust management policy, dust monitoring, Risk Assessments, Engineering controls installations, medical examination, Training on dust management, PPE provision, and use enforcement.

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## Keywords

Apparel, Respirable Dust, Health Concerns, Occupational Safety and Health

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### 1. Introduction

EPZ was inaugurated in 1990 under the Export Processing Zones Act (Chapter 517) Laws of Kenya to promote the export of locally produced goods and services. KNBS (2019) [1] estimated Kenya's Export earnings from the United States of America as Kshs. 47.3 billion in 2018, primarily from clothing and apparel products. APPAREL Processing Companies (APCs) are key among the industries within the EPZ. Thousands of workers are engaged in apparel processing companies in EPZ. Workers in apparel processing EPZ, Machakos County, Kenya, are exposed to respiratory dust hazards [2]. In sync, the law clearly states that every employee has the right to a safe and healthy working environment in accordance with the Occupational Safety and Health Act of 2007 [3].

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. 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 1800 people per company. According to EPZA (2020) [4], the company directory on garments and garment-related activities has twenty-seven companies, of which thirteen are knitting/apparel manufacturing companies with a total of 21,752 employees.

One thousand employees die daily from occupational accidents worldwide [5]. There are practically 386,000 demises and close to 6,600,000 Disability Adjusted Life Years (DALYs) associated with respirable dust exposure at the workplace [6]. In addition, respiratory diseases at the workplace comprise 30% of reported occupational diseases, while it is assessed that 10% - 20% of fatalities result from respiratory-related health concerns [7] [8].

Coughing, wheezing and shortness of breath were common in workplaces [9] [10]. Jumat *et al.* (2021) [11] allude that workers in garment processing plants exposed to dust had worse respiratory outcomes because their employers could not provide personal protective equipment. According to a 2018 study by Ali *et al.* [12], 98.3% of workers in the apparel manufacturing industry either did not wear personal protective equipment or followed basic safety procedures. Sweepers (cleaners) typically experience respiratory symptoms such as phlegm, coughing, and wheezing because they were exposed to dust and were less equipped with reliable respiratory protection [13]. Similarly, wheezing and coughing were five to six times more common in exposed people than in non-exposed people [14].

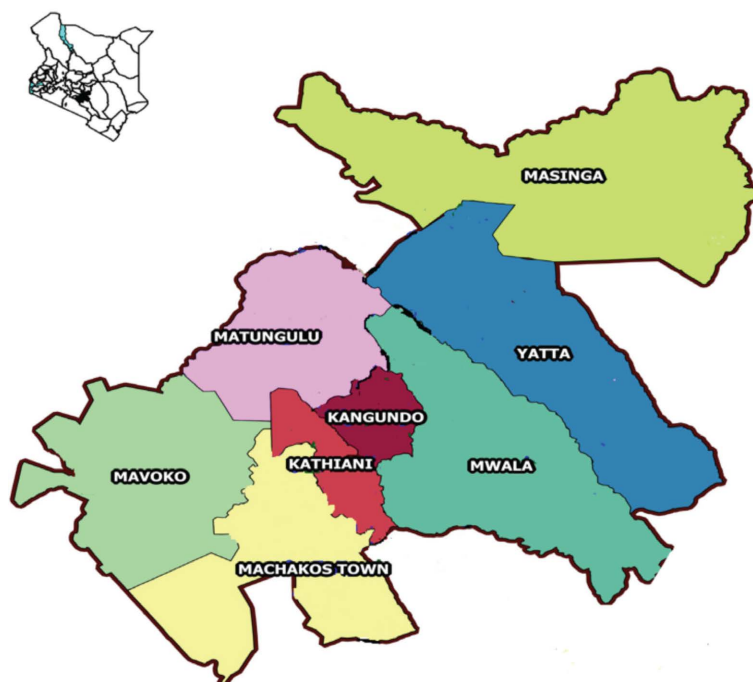
Numerous cross-sectional and a few longitudinal investigations have been

undertaken to identify chronic issues. In South Africa, 582 non-white grain workers and 153 controls were studied to establish any disparities in respiratory symptoms. No differences in lung function levels were found [15]. According to a Chinese study of in Chenyang, China, there are “highly significant differences in respiratory symptoms” [16]. In a Nigeria-based study, lung function levels did not differ between 75 workers and 48 controls [17]. There were significant differences in FEV and respiratory symptoms in 71 subjects in construction workers [18]. To a large extent, exposure levels exceeded  $10 \text{ mg/m}^3$ . A study in Tanzania finds declining trends in occupational health and safety status in the factories on the verge of the expanding economy [19]. This was further accentuated by Hinson *et al.* (2007) [20] and Otieno *et al.* (2022) [9] in their study of apparel textile factories. The study revealed that 44% of employees had byssinosis. Furthermore, the study found that the frequency varied by working unit and age. Accordingly, this study aimed to assess respirable dust health concerns among workers in apparel processing companies in EPZ, Machakos County, Kenya.

## 2. Materials and Methods

### 2.1. Study Design

The study utilized a cross-sectional descriptive design to collect data on respirable dust health concerns among workers in Apparel processing companies in EPZ, Machakos County Kenya as shown in **Figure 1**. EPZ has a total of seven Apparel Processing Companies (APCs) which are registered by the Directorate of Occupational Safety and Health Services (DOSHS). The research purposively selected



**Figure 1.** Map of Machakos county (Source: KNBS, 2019) [1].

4 companies for the study. The selected APCs had 7800 workers [4] study population. A sample size of 367 study participants was calculated using the Krejcie and Morgan (1970) formula [21]. The factories had different sections which include pressing and cutting, Material relaxing; offices, midpoint, embroidery, sewing and dispatch. The research utilized proportionate distribution to sample employees from across all the departments, as presented in **Table 1**. The research coded participants and Factories for confidentiality purposes.

## 2.2. Determining Respirable Dust Health Concern among Workers

The respirable dust health concerns were evaluated through in-depth interviews of the employees and medical facilities/officers. The study utilized structured questionnaires and a review of existing records. Data collection was undertaken in August, September, October and November 2021.

## 2.3. Respirable Dust Measurement

Portable PM Equipment from Turnkey Osiris Airborne Particulate Monitor was used to measure respirable dust  $PM_{2.5}$ . The monitor was positioned in a Lamp Post Box (LPB) to monitor respirable dust levels and then mounted on a stable platform about 2 meters above the ground. The measurements were undertaken in six units within APCs, including Cutting, Fusing and pressing, Midpoint, Sewing and Embroidery, Fabric relaxing and spreading and Office. Data was collected for periods of eight hours' per factory in four months.

## 2.4. Study Area and Population

The assessment was in EPZ in Machakos County, Kenya. The EPZ is located in Athi River, Machakos County, Kenya, as displayed in **Figure 1**. The Export Processing Zone Authority (EPZA) has about 21,750 employees according to EPZA directory [4].

## 2.5. Data Analysis and Presentation

The study analyzed data using Statistical Package for the Social Science (SPSS) Version 25. Cleaning of data cleaning and validation helped achieve a clean data set for analysis.

**Table 1.** Apparel Processing Companies in EPZ.

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
TOTAL	<b>7800</b>	<b>311</b>	<b>55</b>	<b>367</b>

Source: Author (2022).

### 3. Results and Discussion

The study reveals numerous findings as discussed in this chapter.

#### 3.1. Distribution of the Study Population

Four apparel processing companies were studied, **Table 1** presents data on the four companies.

The companies engaged a different number of employees. Therefore, the study utilized proportionate distribution to determine the number of research participants from the four companies.

#### 3.2. Age and Gender

**Table 2** shows the proportionate distribution of respondents 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) [7] revealed that workers 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.

#### 3.3. Work Experience and Work Schedule in Apparel Processing Companies in EPZ

Most of the participants, 126 (34.6%), worked in the company for 0 - 2 years; more than a quarter of the workers, 112 (30.8%), worked in the factory for 2 - 4 years, whereas almost a quarter (85; 23.4%) operated in the factory for 4 - 6 years. A majority of 231 (63.1%) of the employees worked for over 8 hours on average per day, whereas more than a quarter, 36.9% (135), worked 1 - 8 hours on average per day. A significant proportion of the workers, 310 (85.6%), worked at night.

**Table 2.** Age and gender of employees in Apparel Processing Companies in EPZ.

Variables	n	%
<b>Age</b>		
18 - 28	115	31.3
29 - 39	122	33.2
40 - 50	98	26.7
51 - 61	23	6.3
62 & above	9	2.5
<b>Gender</b>		
Male	175	47.9
Female	190	52.1
None Response	2	

Most 277 (88.8%) of the employees worked for over 8 hours on average per night, whereas a smaller proportion, 11.2% (35) worked 1 - 8 hours on average per night as displayed in **Table 3**. This can be associated with workers' exposure to respirable dust for an average of 8 hours daily in apparel processing companies, EPZ Machakos County, Kenya. Lunde *et al.* (2020) [22] agree with the study findings that employees work for long hours, with an average of 8 hours, as represented by 71% of the employees. However, Rana's (2005) [23] study reveals that in developed countries, working hours are primarily regulated between 2 to 4 hours for blue-collar jobs, as unveiled by 44% of the respondents. In addition, it was established that workers suffered from occupational diseases, including carotid intima-media thickness, resting heart rate etc. As a result of work schedules, including job rotation or shiftwork.

### 3.4. Health Concerns among Workers and Medical Examination

As illustrated in **Table 4**, Less than half of the employees, 151 (41.1%), had pain in their chest. Less than half of the employees, 135 (36.8%), had a blocked chest. A small proportion, 13.1% (48), had pain in their lungs, whereas the majority, 317 (86.4%), was sneezing and coughing. A small proportion of the employees,

**Table 3.** Work experience and work schedule in Apparel Processing Companies in EPZ.

Variables	n	%
<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	
<b>Working Hours on Average Per Night</b>		
1 - 8 Hours	35	11.2
Over 8 Hours	277	88.8
None Response	55	

**Table 4.** Health concerns of the employees and medical examinations.

Variables	n	%
<b>Pain in the Chest</b>		
Yes	151	41.1
No	216	58.9
<b>Blocked Chest</b>		
Yes	135	36.8
No	232	63.2
<b>Pain in the Lungs</b>		
Yes	48	13.1
No	319	86.9
<b>Sneezing and Coughing</b>		
Yes	317	86.4
No	50	13.6
<b>Asthma</b>		
Yes	34	9.3
No	333	90.7
<b>Pneumonia</b>		
Yes	23	6.3
No	344	93.7
<b>Allergic Reaction to Dust</b>		
Yes	67	18.3
No	300	81.7
<b>Medical Examinations before Joining EPZA Factory</b>		
Yes	96	26.2
No	271	73.8
<b>Specific Medical Examination</b>		
Clinical Examination	84	100.0
None Response	283	
<b>Medical Examination While Working in the Factory</b>		
Yes	114	33.9
No	222	66.1
None Response	31	
<b>Specific Medical Examination While Working in the Country</b>		
Clinical Examination	35	30.7
Lung Function Test	60	52.6
Audiometric Test	19	16.7
None Response	253	
<b>Frequency of Lung Function Test</b>		
Bi-annually	34	43.0
Annually	45	57.0
None Response	288	

9.3% (34), were asthmatic, while less than a quarter, 23 (6.3%), had pneumonia. Almost a quarter of the employees, 67 (18.3%), had allergic dust reactions. The results support research that established that many workers (71%) are unaware of potential hazards and had complained of chest pains and blockage in the chest, which was a result of inhaling dust in the workplace in California [24]. A study by Kirkeskov (2016) [25] determined that there were health management concerns in ensuring that the dust levels exposure of the workers is measured every day with a score of 77%. The carpentry firm had experienced more than 60% of workers inhaling dust. However, Abaya *et al.* (2020) [26] study reveals that 12 factories out of 15 targeted factories did little on health concerns.

Slightly more than a quarter of the employees, 26.2% (96), went for medical examinations before joining the factory, of which 84 (100%) went for clinical tests. More than a quarter of the employees, 114 (33.9%), had undergone medical examinations while working in the factory. The results concur with the research by Phoon and Chan (2019) [27], who established that 52% of mining workers were exposed to workplace hazards. This compels the management to initiate employee medical tests and examinations by designated medical practitioners approved by the government. Most of the respondents, 52.6% (60), had undergone lung function tests, while slightly more than a quarter, 30.7% (35) had undergone clinical examination, whereas a small proportion, 16.7% (19), had undergone the audiometric test. Among the employees who had undergone lung function test, (45; 57%) was done annually, whereas (34; 43%) was bi-annually. A similar study conducted by Jones (2018) [28] unveils that the majority of the respondent (48.9%) had undergone lung function tests, while (22.8%) had undergone clinical examinations, and all the employees had undergone the audiometric test. The tests were done quarterly and were mandatory.

### **3.5. Association of Awareness of Respirable Dust Exposure with Worker's Health Concern**

A higher proportion of workplace awareness on respirable dust hazards was among employees who did not have pain in their chest, 23 (10.6%) compared to employees who had pain in their chest, 6 (6; 4.0%). Employees with no chest pains were 2.880 [95% CI = 1.143 - 7.255,  $p = 0.025$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who had pain in their chest as presented in **Table 5**. Additionally, employees who had pain in the chest were more willing to wear PPEs as compared to those with no chest pains. Those who had chest pains, 41.5% took no action, 27.1% sought medical care while 18.4% reported to the company management for further check-up. The study finding revealed a high proportion of awareness of respirable dust hazards in the workplace among employees who did not have pain in their chest (68%) compared to employees who had pain in their chest (32%). A comparable study by Han *et al.* (2021) [29], reveals that there was a high proportion of awareness of respirable dust hazards in workplace among employees who did not have



**Table 5.** Association of awareness on respirable dust exposure with worker's health concerns.

Variables	Aware		Not Aware		OR	95% CI		P-value
	n	%	N	%		Lower	Upper	
<b>Pain in Your Chest</b>								
Yes	6	4.0%	145	96.0%	Ref			
No	23	10.6%	193	89.4%	2.88	1.14	7.26	0.025
<b>Blocked Chest</b>								
Yes	4	3.0%	131	97.0%	Ref			
No	25	10.8%	207	89.2%	3.96	1.35	11.62	0.012
<b>Pneumonia</b>								
Yes	5	21.7%	18	78.3%	3.70	1.27	10.84	0.017
No	24	7.0%	320	93.0%	Ref			
<b>Allergic Reaction to Dust</b>								
Yes	11	16.4%	56	83.6%	3.08	1.38	6.87	0.006
No	18	6.0%	282	94.0%	Ref			
<b>Undergone Medical Examinations before Joining the EPZA Factory</b>								
Yes	22	22.9%	74	77.1%	11.21	4.61	27.27	<0.001
No	7	2.6%	264	97.4%	Ref			

pain in their chest (57%) as compared to employees who had pain in their chest (43%).

A higher proportion of awareness of respirable dust hazard in the workplace was among employees who did not have blocked chests, 25 (10.8%), compared to employees who had blocked chests, 4 (3.0%). Employees who did not have blocked chests were 3.955 [95% CI = 1.346 - 11.623,  $p = 0.012$ ] times more likely to be aware of respirable dust and associated health concerns compared to employees who had blocked chests. Tageldin *et al.* (2017) [30] agree with the findings. They established that textile employees were exposed to dust and indeed had chest problems and were unlikely to be aware of dust exposure compared to those who did not have blocked chests. The results conclude that a higher proportion of workplace awareness of respirable dust hazards was among employees who did not have blocked chests (74%) compared to employees who had blocked chests (26%).

Additionally, the research finding established that a higher proportion of awareness of respirable dust hazards was among employees who indicated that they had pneumonia, 5 (21.7%), compared to employees who did not have pneumonia, 24 (7%). Employees who had pneumonia were 3.70 [95% CI = 1.27 - 10.84,  $p = 0.017$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who did not have pneumonia. A more significant proportion of awareness of respirable dust hazards was among employees who had an allergic reaction to dust, 11 (16.4%), compared to

employees who had no allergic reaction to dust, 18 (6%). Employees who had an allergic reaction to dust were 3.08 [95% CI = 1.38 - 6.87,  $p = 0.006$ ] times more likely to be aware of respirable dust exposure and associated health concerns compared to employees who had no allergic reaction to dust. The study is in line with Hanskov *et al.* (2015) [31] study that reveals that a bigger proportion of awareness of respirable dust hazards in the workplace was among employees who had an allergic reaction to dust (98%) compared to employees who had no allergic reaction to dust (2%). However, Purani and Shah (2019) [32] establish that a bigger proportion of employees who had no allergic reaction to dust were two times more likely to be respirable dust exposure, as represented by 75% of the respondents.

A significantly higher awareness of respirable dust hazards in the workplace was among employees who went for medical examinations before joining the factory, 22 (22.9%), compared to employees 7 (2.6%) who did not go for medical examinations before joining that EPZA factory. Employees who went for medical examinations before joining the factory were 11.21 [95% CI = 4.61 - 27.27,  $p < 0.001$ ] times more likely to be aware of respirable dust and associated health concerns compared to employees who did not go for medical examinations before joining the EPZA factory. A study by Shadab *et al.* (2017) [13] supports the finding. The survey reveals that (57%) of employees who went for medical examinations before joining dust-exposed factories were two times more likely to be aware of respirable dust and associated health concerns compared to workers who did not go for medical examinations before joining dust-exposed factories.

### **3.6. Association of Multiple Respiratory Health Concerns with Gender**

There was a more significant proportion of multiple respiratory health concerns among female employees, 132 (69.5%), compared to male employees, 103 (58.9%). Female employees were 1.59 [95% CI = 1.03 - 2.45,  $p = 0.034$ ] times more likely to have multiple respiratory health concerns compared to their male counterparts. The findings are presented in **Table 6**. This can be associated with women being the majority at the workplace, particularly in the sewing/embroidery section, which is related to high respirable dust levels. Correspondingly, Berends's (2020) [14] study revealed multiple respiratory health concerns among women due to their long hours in their workstations compared to men, established at 57% and 43%, respectively. On the contrary, a study by Shadab *et al.* (2017) [13] established that men (81%) had high chances of multiple reported respiratory health as they were more ignorant of the recommended health precautions at work sites.

### **3.7. Association of Multiple Respiratory Health Concerns with Multiple Employments**

A smaller proportion of multiple respiratory health concerns was established

**Table 6.** Association of multiple respiratory health concerns with gender.

Variables	Multiple Health Concern		No Multiple Health Concern		OR	95% CI		P-value	
	n	%	n	%		Lower	Upper		
<b>Age</b>									
18 - 28	78	67.8%	37	32.2%	2.64	0.67	10.39	0.153	
29 - 39	79	64.8%	43	35.2%	2.29	0.59	9	0.222	
40 - 50	62	63.3%	36	36.7%	2.15	0.54	8.54	0.266	
51 - 61	13	56.5%	10	43.5%	1.63	0.34	7.67	0.538	
62 & above	4	44.4%	5	55.6%	Ref				
<b>Gender</b>									
Male	103	58.9%	72	41.1%	Ref				
Female	132	69.5%	58	30.5%	1.59	1.03	2.45	<b>0.034</b>	
<b>Marital Status</b>									
Single	91	71.7%	36	28.3%	1.49	0.62	3.55	0.37	
Married	117	61.3%	74	38.7%	0.93	0.4	2.14	0.865	
Divorced/Separated	9	45.0%	11	55.0%	0.48	0.15	1.56	0.221	
Widow/Widower	17	63.0%	10	37.0%	Ref				
<b>Highest Education Level</b>									
Primary	54	60.0%	36	40.0%	1	0.264	3.79	1	
Secondary	119	65.7%	62	34.3%	1.28	0.35	4.7	0.709	
Diploma	51	71.8%	20	28.2%	1.7	0.43	6.67	0.443	
Degree	5	35.7%	9	64.3%	0.37	0.07	1.97	0.239	
Master's Degree	1	100.0%	0	0.0%	UD	UD	UD	UD	
Others	6	60.0%	4	40.0%	Ref				

among employees who only worked at the factory, 211 (62.1%), compared to employees who had other work other than working at the factory (25; 92.6%). Employees who only worked at the factory were 0.13 [95%CI = 0.03 - 0.56, p = 0.001] times likely to have multiple respiratory health concerns compared to employees who had multiple other employment/not related to the factory, as illustrated in **Table 7**. The study by Tsang and Chan (2020) [33] confirms the findings as the study reveals that those who have several workplaces (38%) and are exposed to dust-related particles have high likelihood (25%) of having multiple respiratory health concerns, unlike those who worked in one station (21%) or worked in one factory have low chances (19%) of getting exposed and getting multiple respiratory health concerns.

### 3.8. Association of Multiple Health Concerns with Dust Levels

The study established a smaller proportion of multiple respiratory health concerns

**Table 7.** Association of multiple respiratory health concern with multiple employments.

Variables	Multiple Health Concern		No Multiple Health Concern		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Designation/Position</b>								
Management	12	57.1%	9	42.9%	Ref			
Supervisor	31	59.6%	21	40.4%	1.11	0.39	3.09	0.845
General Worker	193	65.6%	101	34.4%	1.43	0.58	3.52	0.429
<b>Disability</b>								
Yes	7	70.0%	3	30.0%	1.3	0.33	5.13	0.703
No	229	64.1%	128	35.9%	Ref			
<b>Which Disability</b>								
Hearing	3	50.0%	3	50.0%	Ref			
Physical/Mobility	2	66.7%	1	33.3%	2	0.11	35.81	0.635
Speech	2	66.7%	1	33.3%	2	0.11	35.81	0.635
<b>Work Experience in the Factory</b>								
0 - 2 Years	82	65.1%	44	34.9%	1.45	0.51	4.16	0.488
2 - 4 Years	83	74.1%	29	25.9%	2.23	0.76	6.52	0.137
4 - 6 Years	49	57.6%	36	42.4%	1.06	0.36	3.11	0.917
6 - 8 Years	5	31.3%	11	68.8%	0.35	0.08	1.5	0.154
8 - 10 Years	7	77.8%	2	22.2%	2.72	0.43	17.42	0.282
Over 10 Years	9	56.3%	7	43.8%	Ref			
<b>Other Employment or Work Not Related to This Factory</b>								
Yes	25	92.6%	2	7.4%	Ref			
No	211	62.1%	129	37.9%	0.13	0.03	0.56	<b>0.001</b>

among employees who confirmed that their work department produced dust, 218 (62.8%), compared to employees whose department did not produce dust, 17 (89.5%), as shown in **Table 8**. Employees who were aware their department produced dust were 0.19 [95% CI = 0.05 - 0.87,  $p = 0.018$ ] times likely to have multiple respiratory health concerns compared to employees who knew their department did not produce dust. The study results support the findings by Glendon and Stanton (2018) [17], which establish that 78% of employees confirmed that employees who are aware their department produces dust are less likely to have multiple respiratory diseases by 33%. Contrary to the study by Purani and Shah (2019) [32] and a study by WHO (2020) [34]. The findings reveal that those who participated in the survey ( $N = 147$ ) confirmed that their workplace produced dust and were likely to have multiple respiratory health concerns, revealed by 45% of multiple respiratory diseases compared 22% of employees who had respiratory diseases in departments that were dust free.

**Table 8.** Association of multiple respiratory health concern with dust levels.

Variables	Multiple Health Concern		No Multiple Health Concern		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Workplace Produce dust</b>								
Yes	218	62.8%	129	37.2%	0.19	0.05	0.87	<b>0.018</b>
No	17	89.5%	2	10.5%	Ref			
<b>Dust Levels</b>								
Low	16	84.2%	3	15.8%	Ref			
Moderate	53	55.2%	43	44.8%	0.23	0.06	0.85	0.018
High	147	64.2%	82	35.8%	0.34	0.09	1.19	0.077
Very High	20	87.0%	3	13.0%	1.25	0.22	7.05	0.8
<b>Main Department Which Generates Dust at Workplace</b>								
Fabric Relaxing/Spreading and Cutting	134	69.1%	60	30.9%	Ref			
Fusing and Pressing	29	60.4%	19	39.6%	0.68	0.36	1.31	0.252
Sewing/Stitching and Overlock	21	33.9%	41	66.1%	0.23	0.12	0.42	<b>&lt;0.001</b>
Packaging	26	70.3%	11	29.7%	1.06	0.49	2.28	0.885

A significantly smaller proportion of multiple respiratory health concerns was among employees who confirmed that dust levels were moderate, 54 (55.2%), compared to employees who confirmed that dust levels were low, 16 (84.2%). Employees who confirmed that dust levels were moderate were 0.23 [95% CI = 0.06 - 0.85,  $p = 0.018$ ] times likely to have multiple respiratory health concerns compared to employees who confirmed that dust levels were low. The finding can be associated with awareness of exposure. Hence, the employees take an active role in protecting themselves, unlike those unaware. Da-Silva-Filho *et al.* (2019) [35] establish that those who know dust is high-moderate (67%) take care of themselves compared to those who say the levels are low (33%). Further, the study reveals that the higher the dust levels, the more significant the proportion of multiple respiratory health concerns (79%).

A smaller proportion of multiple respiratory health concerns was among employees who confirmed dust is generated mainly at the sewing/stitching and overlock department, 21 (33.9%), compared to employees who verified dust is generated largely in fabric relaxing/spreading and cutting department, 134 (69.1%). Employees who confirmed sewing/stitching and overlock generated much dust were 0.23 [95% CI = 0.12 - 0.42,  $p < 0.001$ ] times likely to have multiple respiratory health concerns compared to employees who indicated fabric relaxing/spreading and cutting department generated dust. The study findings were in line with Mehwish and Mustafa (2016) [6], which reveal high dust concentration and exposure in fabric spreading and cutting-related factories (37%). The study concludes that employees who confirmed that the primary depart-

ment generating dust was stitching were less likely to have multiple respiratory health concerns [94% CI = 0.11 - 0.39,  $p < 0.001$ ] compared to employees who indicated other departments. Fabric relaxing generated much dust.

### 3.9. Association of Multiple Health Concerns with PPEs Use

A smaller proportion of confirmed multiple respiratory health concerns was among employees who used PPEs, 26 (49.1%), compared to employees who did not use PPEs, 210 (66.9%). Employees who utilized PPEs were 0.48 [95% CI = 0.27 - 0.86,  $p = 0.012$ ] times likely to have multiple respiratory health concerns compared to employees who did not utilize PPE while working. This is displayed in **Table 9**. The study was in line with the WHO report (2020) [34] and research by Kirkeskov *et al.* (2016) [25] that recommended the use of PPEs. The findings unveil that workers who did not use PPEs (56%) had multiple respiratory health concerns compared to workers who used PPEs (11%).

A more significant proportion of multiple respiratory health concerns was among employees who did not use PPEs because it was too hot, 194 (67.8%) compared to employees who did not use PPEs because they were uncomfortable, 30 (45.5%). Employees who did not use PPEs because it was too hot were 2.53 [95% CI = 1.47 - 4.36,  $p = 0.001$ ] times more likely to have multiple respiratory health concerns compared to employees who did not use PPEs because they were uncomfortable. A high proportion of multiple respiratory health concerns was among employees who did not use PPEs because the employer did not provide them, 12 (80%), compared to employees who did not use PPEs because they were uncomfortable, 30 (45.5%). Employees who did not use PPEs because the employer did not provide them were 4.8 [95% CI = 1.24 - 18.6,  $p = 0.016$ ] times more likely to have multiple respiratory health concerns compared to employees

**Table 9.** Association of multiple respiratory health concern with PPE use.

Variables	Multiple Health Concern		No Multiple Health Concern		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Workers Use Personal Protective Gears/Equipment While Working</b>								
Yes	210	66.9%	104	33.1%	Ref			
No	26	49.1%	27	50.9%	0.48	0.27	0.86	<b>0.012</b>
<b>The Reason(s) for Not Using PPEs</b>								
Uncomfortable	30	45.5%	36	54.5%	Ref			
Too Hot	194	67.8%	92	32.2%	2.53	1.47	4.36	<b>0.001</b>
Not Provided	12	80.0%	3	20.0%	4.8	1.24	18.6	<b>0.016</b>
<b>Provision of PPEs</b>								
Own self/Personal	144	59.5%	98	40.5%	Ref			
Employer	91	73.4%	33	26.6%	1.88	1.17	3.01	<b>0.009</b>

who did not use PPEs because they were uncomfortable. Bandyopadhyay and De (2015) [36] study reveals that those who don't use PPE because it is hot were represented by 71% and were aware they were likely to have multiple health concerns. Minority of 29% represented those who do not use PPE because it is uncomfortable.

In another study, the findings further reveal that employees who did not use PPEs because the employer did not provide them (63%) were more likely to have multiple respiratory health concerns than employees who did not use PPEs because they were uncomfortable [12]. It is recommended that employees should always wear protective gear for safety and to promote productivity [37].

This research established a more significant proportion of multiple respiratory health concerns among employees provided with PPEs, 91 (73.4%), compared to employees who provided their PPEs, 144 (59.5%). Employees provided with PPEs by the employer were 1.88 [95% CI = 1.17 - 3.01,  $p = 0.009$ ] times more likely to have multiple respiratory health issues compared to employees who provided their PPEs. In a comparable study, the findings reveal a more significant proportion of multiple respiratory health concerns among employees whose employers provided PPEs (68.9%) compared to workers who provided their PPEs (31.4%) [7].

### 3.10. Association of Dust Exposure Levels with Health Concerns

A higher proportion of exposure levels to respirable dust was established among workers with pain in their chest, 103 (68.2%), compared to workers who did not have pain in their chest (105; 48.6%). This is outlined in **Table 10**. Workers with chest pains were 2.27 [95% CI = 1.47 - 3.50,  $p < 0.001$ ] times more likely to have high exposure to respirable dust compared to workers who did not have pain in their chest. Wheezing and coughing is 5 to 6 times more likely to be among employee's exposed to high dust levels compared to non-exposed workers [38].

A higher exposure level to respirable dust was among workers with blocked chests, 93 (68.9%), compared to workers without blocked chests, 115 (49.6%). Workers with blocked chests were 2.25 [95% CI = 1.44 - 3.52,  $p < 0.001$ ] times more likely to have high respirable dust exposure compared to workers without block chest. The findings approve a study undertaken in Nigeria [17]. High significance difference of [74% CI = 0.09 - 0.31,  $p < 0.01$ ].in respiratory symptoms was revealed among 665 workers. On the contrary, differences in respiratory signs were established between 582 workers and 153 controls and no variances in lung function levels was established [16].

### 3.11. Association of Dust Exposure Levels with Medical Examinations

A higher proportion of dust exposure levels and associated health concerns was among workers who had undergone medical examination while working in the factory, 83 (72.8%), compared to workers who had not undergone medical examination while working in the factory, 104, (46.8%) as demonstrated in **Table 11**.

**Table 10.** Association of dust exposure levels with health concerns.

Variables	Dust above Threshold		Dust below/at Threshold		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Pain in Your Chest</b>								
Yes	103	68.2%	48	31.8%	2.27	1.47	3.50	< 0.001
No	105	48.6%	111	51.4%	Ref			
<b>Blocked Chest</b>								
Yes	93	68.9%	42	31.1%	2.25	1.44	3.52	< 0.001
No	115	49.6%	117	50.4%	Ref			
<b>Pain in Your Lungs</b>								
Yes	32	66.7%	16	33.3%	1.63	0.86	3.08	0.137
No	176	55.2%	143	44.8%	Ref			
<b>Sneezing and Coughing</b>								
Yes	175	55.2%	142	44.8%	Ref			
No	33	66.0%	17	34.0%	1.58	0.84	2.94	0.155
<b>Asthma</b>								
Yes	18	52.9%	16	47.1%	Ref			
No	190	57.1%	143	42.9%	1.18	0.58	2.4	0.645
<b>Pneumonia</b>								
Yes	13	56.5%	10	43.5%	Ref			
No	195	56.7%	149	43.3%	1.01	0.43	2.36	0.988
<b>Allergic Reaction to Dust</b>								
Yes	35	52.2%	32	47.8%	Ref			
No	173	57.7%	127	42.3%	1.25	0.73	2.12	0.418

**Table 11.** Association of dust exposure levels with medical examination.

Variables	Dust above Threshold		Dust below/at Threshold		OR	95% CI		P-value
	n	%	n	%		Lower	Upper	
<b>Medical Examinations before Joining This EPZA Factory</b>								
Yes	60	62.5%	36	37.5%	1.39	0.86	2.23	0.181
No	148	54.6%	123	45.4%	Ref			
<b>Medical Examination While Working in This Factory</b>								
Yes	83	72.8%	31	27.2%	3.04	1.86	4.96	<0.001
No	104	46.8%	118	53.2%	Ref			
<b>Type of Medical Examination While Working in the Factory</b>								
Clinical Examination	27	77.1%	8	22.9%	Ref			
Lung Function Test	41	68.3%	19	31.7%	0.64	0.25	1.67	0.360
Audiometric Test	15	78.9%	4	21.1%	1.11	0.29	4.31	0.879
<b>If you Undergo Lung Function Test, How Often Is it Done</b>								
Bi-annually	19	55.9%	15	44.1%	Ref			
Annually	37	82.2%	8	17.8%	3.65	1.32	10.14	0.013



Workers who had undergone medical examination while working in the factory were 3.04 [95% CI = 1.86 - 4.96,  $p < 0.001$ ] times more likely to have high exposure levels to respirable dust and associated health concerns compared to workers who had not undergone medical examination while working in the factory. A study by Luxh and Thorsteinsson (2017) [39] confirms the findings. Employees who had undergone medical examination while working in the factory were more likely to have high exposure levels [95% CI = 1.05 - 3.42,  $p < 0.001$ ] to respirable dust and associated health concerns (87%) as compared to workers who had not undergone medical examination while working in the factory (13%). Hopkins's (2017) [40] findings give a divergent view. It establishes that employees who had not undergone medical examination while working in the factory were more likely to have high exposure levels to respirable dust and associated health concerns (72%) compared to workers who had undergone medical examination while working in the factory (23%).

A more considerable proportion of respirable dust exposure and associated health concerns was established among workers who underwent lung function tests annually, 37 (82.2%), compared to workers who underwent lung function tests bi-annually, 19 (55.9%). Workers who went for lung function annually were 3.65 [95% CI = 1.32 - 10.14,  $p = 0.013$ ] times more likely to have high exposure levels to respirable dust and associated health concerns compared to workers who undergo lung function tests bi-annually. Regular lung function test done bi-annually is recommended. This is associated with [95% CI = 0.12 - 0.42,  $p < 0.001$ ] low levels of respirable dust exposure and associated health concerns for workers in industrial areas [41].

#### 4. Conclusion

Respirable dust health concerns were established among workers in apparel processing factories in EPZ, Machakos Kenya. The distribution of employees' health concerns comprised blocked chest; pain in the lungs, whereas the majority of the employees, 317 (86.4%), were sneezing and coughing. Employees with respirable health concerns were significantly less aware of respirable dust health concerns compared with employees with no respirable dust health concerns. On the other hand, the employees who went for pre-employment medical examination while joining the company were more aware of respirable dust concerns. The study further revealed that female employees were more likely to have multiple respiratory health concerns in the workplace than their male counterparts. Similarly, employees who worked at the factory were more likely to have multiple health concerns than employees who had other different employment in companies unrelated to the factory. Finally, employees with health concerns were more likely to be working in a department with high dust levels, and thus, the high exposure levels in the workplace.

#### Recommendation

The research recommends management oversight and commitment to address-

ing respirable dust concerns at the APCs. There is a need to develop and review the respirable dust management policy. Complimentarily, the management should initiate dust monitoring/evaluation and implement the formulated recommendations. Engineering controls should be considered top of the hierarchy in dust controls. This should be compounded with management controls, including training workers, medical examinations, and risk assessments. Ultimately, the APCs should provide PPEs and enforce their use.

### **Ethical Approval and Consideration**

The study pursued approvals from the Jomo Kenyatta University of Agriculture and Technology, EPZA Management, APCs Senior, National Commission for Science, Technology, and Innovation (NACOSTI).

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### **Authors' Contributions**

Allan Owino Otieno conceptualized the study design, launched a literature review, acquired ethical permissions, and conducted data collection/analysis, discussion, and manuscript preparation.

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

### **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

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