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A cross sectional study on the occupational airborne exposure and the prevalence of self-reported asthma, and respiratory symptoms amongst workers in selected factories in Nairobi, Kenya

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Background Inhalation of airborne particulate matter of less than ten microns diameter (PM_{10}) in workplaces causes a variety of respiratory ailments and symptoms. This cross-sectional study was conducted on factory production workers (N=388) to investigate the association between occupational airborne exposure to PM_{10} and the prevalence of asthma and respiratory symptoms amongst factory workers in selected Nairobi factories.

Methods The Touhilampi respiratory health questionnaire was modified to include home environment and used in this study. PM_{10} concentrations of the working environment breathing zones was also measured using air Samplers and a 24-hour average recorded for each of the five factories. Lung function tests of all the respondents using Spirometers were also recorded.

Results The results show that the highest percentage of the factories (33.0%) had a mean concentration of 17.16 mg/m^3 of PM_{10}. A considerable percentage (41.5%) of respondents had cough with wheezing or whistling sound. The mean concentration in mg/m^3 of PM_{10} for factory environment among respondents who reported cough without flu/cold was significantly higher (14.19mg/m^3) than to those who indicated otherwise (12.56 mg/m^3) (P=0.005). Respondents with FEV1/FVC % (ratio of the forced expiratory volume in the first one second to the forced vital capacity of the lungs) of less than 80 normal predicted value had significantly more proportion of cough without flu/cold (44.3% [odd ratio OR=1.62; 95% confidence interval CI=1.03-2.56; P=0.038] as compared to those who had FEV1/FVC% of 80 and above normal predicted value (33.0%).

Conclusions Most of the factories had high levels of PM_{10} concentration possibly leading to respiratory health problems. The relevant Government agencies should be enabled to make efforts towards reducing the same.

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Asthma is one of the most common chronic diseases in the world. The World Health Organization (WHO) estimated that around 300 million people in the world in 2002 were suffering from asthma and the trend was rapidly increasing. Looked at critically, a higher estimate could have been obtained with a lesser conservative criterion for the diagnosis of clinical asthma. We believe the prevailing international patterns of asthma symptoms prevalence cannot be explained by the current knowledge of the causation of asthma (*1*). That is why we concur that, research into the possible causation and prevalence of the same amount to key priority areas in the field of asthma research as was found out by Burney in 2002 (*1*). Review of literature shows that asthmatic respiratory symptoms and asthma have become more common in both children and adults around the world in recent years. This increase in prevalence has been associated with an increase in atopic sensitization, and as well as similar increases in other allergic disorders such as eczema and rhinitis (*2*).

A WHO report in 2002 confirmed that the rate of asthma and its symptoms increases as communities adopt western lifestyles and become urbanized. With the WHO's projected increase in the proportion of the world's urban population to about 59% by 2025, we expect a marked increase in the number of people with asthma and related respiratory symptoms worldwide. WHO estimates that, there may be an additional 100 million persons with asthma by the year 2025.

It is then our opinion that, asthma should be recognized as a crucial cause of morbidity and therefore its economic cost and mortality worldwide should be calculated and put in perspective. We should therefore make sure that there is continuous measurement and monitoring of the prevalence of asthma, and its morbidity throughout the world. Thereby, identifying and addressing the factors that limit the availability of service delivery to reduce this burden (*2*).

In Africa, there is a general increase of asthma cases in the general population as indicated by different studies that have been undertaken across the continent. These studies have shown wide differences between the rural populations compared to the urban population (*3*). Most of the studies documented were done in the general population and school children.

In East Africa, the prevalence of asthma is variable, with low rates in Ethiopia but relatively high rates in Kenya (*4*). Literature shows that, the prevalence of asthma is higher in urban compared with rural areas. The magnitude of the urban-rural differences has lessened over recent years due to the relatively greater increase in asthma prevalence in rural communities as they increasingly adopt Western lifestyles (*4*, *5*). Two epidemiological studies done five years a part (2002 and 2007) in children in Nairobi show that the disease is on the increase (*6*). With the continued trend for those in rural communities to move to urban centers and the general improvement in living standards, the prevalence of asthma within the region is likely to further increase over the next few years. Work is an important cause for the development of asthma in both men and women and hence this study to quantify the concentration of PM_{10} in selected factories and relate it to the prevalence of self-reported asthma and related symptoms.

METHODS

This study was carried out in industrial area Nairobi, Kenya. This was a cross sectional study where the study population was all factory workers in five different types of factories' production lines. Only workers who had worked for at least one year in the selected factories were included in the study. We randomly selected five factories from each list of the five different categories of factories that from literature review were suspected to have high PM_{10} concentration. A list of all workers in the selected factories was generated to act as our sampling frame. Simple random sampling was used to get the number of participants for the study. Each factory was given a number of respondents proportional to its population picked randomly from the sampling frame. A sample of three hundred and eighty eight respondents (N=388) participated in the study.

Data collection

The Touhilampi questionnaire, a validated respiratory health questionnaire (*7*), was modified to include home environment and used in this study. PM_{10} concentrations of the working environment breathing zones was also measured using SKC sidekick air Samplers placed at strategic breathing zones in the factories and a 24-hour average recorded for each of the five factories. Lung function tests of each of the respondents using an AME calibrated Spirometer was also undertaken by a trained Technician from the Department of Occupational Health and Safety, Ministry of Labour and the findings registered for each of the workers. The best FEV_1 (L/sec) and the best FVC (L) was taken from three technically satisfactory forced expiratory maneuvers. Tests were conducted with the subjects seated, without nose clips. The FEV_1 / FVC % of each respondent was compared to the normal predicted value for age and gender using the Spirometry tables provided in the *Pocket Guide to Spirometry* (*8*) as our reference. The percentage difference in mean pulmonary function between the given Caucasian values and the black African respondents was assumed at 0.6% and 0.8% for females and males respectively. We therefore consequently reduced all our values by the same margin as suggested by the Report of the Global Lung Function Initiative (GLI), ERS Task Force to establish improved Lung Function Reference Values (*9*).The tests were done in ambient temperatures of between 18 to 28 degrees centigrade. Observational data on the use of nose masks was also noted as well as the provided air ventilation space of the working environments measured and recorded. Proper ventilation was calculated as per the requirements as provided by the Kenyan Building Code (subsidiary legislation from the Public Health ACT CAP 242 Laws of Kenya). The questionnaire included questions about the participant's lung health in the last one year preceding the interview. It also inquired on the presence of self-reported asthma, cough with wheeze or whistling and shortness of breath. Also recorded from the questionnaire were the results of a Knowledge index test on asthma. The knowledge index included information on the causes, ability to mention at least one or more symptoms and use of protection measures against inhalation of asthmagens. The participants were also asked about their environmental health conditions of their home environment and route to work as well as whether they engaged in the habit of smoking.

Data management

Quantitative data from the field questionnaires was double entered into a computer database designed using MS-Access application (Microsoft Inc, Seattle WA, USA). File back-up was regularly done to avoid any loss or tampering. Data cleaning and validation was performed in order to achieve a clean dataset that was exported into a Statistical Package format (IBM SPSS) (IBM Inc, Armonk, NY, USA) ready for analysis. All the questionnaires were secured in box files and stored under lock and key under the custody of the principal investigator.

Data analysis

Data analysis was conducted using IBM SPSS version 24.0 statistical software. Exploratory data techniques were employed at the initial stage of analysis to uncover the structure of data and identify outliers or unusual entered values. Descriptive statistics such as proportions were used to summarize categorical variables while measures of central tendency such as mean, standard deviations, median, and range were used to summarize continuous variables.

In our bivariate analysis, Pearson's χ^2 test and Fisher exact test were used to determine factors associated with specific dependent variables (*wheezing with cough without a flu/cold* and s*hortness of breath with abnormal breathing between episodes).* All independent variables were singularly associated with specific dependent variables to determine which ones have significant association. Odds ratio (OR) and 95% confidence interval (CI) were used to estimate the strength of association between independent variables and each of the dependent variables.

In our multivariate analysis, all independent variables identified to significantly associate with *wheezing with cough without a flu/cold* and s*hortness of breath with abnormal* *breathing between episodes* at bivariate analysis were considered together in a Multivariate analysis. The analysis was performed using Binary logistic regression where different methods were specified in order to identify confounders and/or effect modifiers. Adjusted odds ratios (AOR) and 95% confidence interval (CI) were used to estimate the strength of association between the retained independent variables (factors) and specific dependent variables (*wheezing with cough without a flu/cold* and s*hortness of breath, with abnormal breathing between episodes)*. The threshold for statistical significance was set at $P<0.05$.

Ethical considerations

Approval was sought and was given by both the Jomo Kenyatta University of agriculture and technology's Board of post graduate studies and the KEMRI scientific and ethical review committees before the start of the research.

RESULTS

A total of 388 respondents consented and participated in the present study working in five different factories in an industrial area of Nairobi, Kenya.

Pulmonary function test and work environment dust level measurement results

Pulmonary function test and work environment dust level measurement results are shown in Table 1. The Mean FEV1/FVC% was 80.9 with a 2.4 standard deviation and majority of the respondents (73.5%) had 80 or more FEV_1/FVC%. Most of the respondents (81.7%) had less than the expected value of EFV1/FVC%. The highest percentage of the factories (33.0%) had 17.16 mean of mg/m^3 (PM_{10}) for factory environment.

Table 1. Spirometry and air sampling test results

VARIABLES	N=388	%
Mean spirometry (FEV1/FVC%) = 80.9(2.4 SD)		
FEV1/FVC% value < 80	103	26.5
FEV1/FCV %value ≥ 80	285	73.5
Mean spirometry (FEV1/FVC %)		
<Expected MPF	317	81.7
≥Expected MPF	71	18.3
Factory environment PM_{10} in mg/m^3		
Bakery (3.08)	69	17.8
Flour packaging (9.70)	24	6.2
Stone cutting (11.22)	80	20.6
Cereal store (17.16)	128	33.0
Furniture manufacture (17.96)	87	22.4

FEV1/FCV – Forced expiratory volume1/Forced vital capacity, SD – standard deviation, MPF – Mean pulmonary function

Working conditions

All the respondents indicated that they used nose masks only sometimes. Similarly, inspections revealed that the type of ventilation provided was back to back in all the factories and about two-thirds of the factories (67.0%) had no local air exhaust mechanisms. The dominant proportions of the respondents worked in the furniture manufacturing factory (33.0%).

Awareness on asthma

More than half (56.7%) of the respondents agreed that asthma can also affect children. The highest proportion (39.2%) did not think that asthma and pregnancy are related. Likewise, less than half (38.9%) indicated there is no cure for asthma while a considerable percentage (32.2%) did not know whether there is cure for asthma or not. Slightly less than half of the respondents (47.7%) reported that tobacco use can increase severity of asthma. The highest percentage (41.5%) indicated that stress can lead to asthma. Regarding dangers of asthmatic attack, 36.9% did not recognize its danger and 33.8% did not know whether it was dangerous or not. The highest percentage (39.2%) indicated that asthma can be self-monitored; however, 34.8% did not know the possibility of self-monitoring. The highest proportion (38.9%) and (41.2%) of the respondents indicated that there are existing triggers for asthma and different medications for asthma respectively.

Household level factors

Almost all the respondents (96.1%) indicated that their kitchen was located within their living rooms. Majority (64.2%) were using Kerosene as domestic fuel for cooking. Half of the respondents' houses (50%) were constructed with stone. The majority of the respondents (67%) had only one window and 78.6% of the rooms had a mean of one window per room.

Carpet availability was examined and 60.1% of the respondents had no carpets. About three quarters of the respondents (76.6%) were frequently exposed to possible outdoor pollution.

Self-reported respiratory symptoms of asthma

A considerable percentage (41.5%) of respondents had cough with wheezing or whistling sound. Out of 161 who experienced cough with wheezing or whistling sound, 87.0% had wheezing with cough without a flu/cold. A relatively low percentage of respondent (12.6%) experienced shortness of breath. Out of 49 participants who experienced shortness of breath, majority (87.4%) had abnormal breathing between episodes of shortness of breath. Nobody reported having asthma.

Association between socio-demographic characteristics and wheezing with cough without a flu/cold

The proportion of cough without flu/cold was significantly higher among male respondents (38.4%; OR=1.80, 95% CI=1.01-3.22; P=0.046) as compared to their female counterpart (25.7%). The proportion of cough without flu/cold was high among older respondents. However, this was not statistically significant. However, there was no significant association observed between cough without flu/cold and the other socio-demographic characteristics.

Relationship between pulmonary function test and wheezing with cough without a flu/cold

Table 2 shows relationship between pulmonary function test and wheezing with cough without a flu/cold. The respondents with chest function test of less than 80 the normal expected value had significantly more proportion of cough without flu/cold (44.3%, OR=1.62; 95%CI=1.03-2.56; P=0.038) compared to those who had 80 and above the normal expected value (33.0%).

Table 2. Association between pulmonary function test and wheezing with cough without a flu/cold

VARIABLES	YES (N=140)		NO (N=248)		OR	95% CI		*P*-VALUE*
	N	%	N	%		LOWER	UPPER	
Mean spirometry (FEV1/FCV):								
FEV_1/FVC% value < 80	42	40.8%	61	59.2%	1.31	0.83	2.09	0.247
FEV_1/FVC% value ≥ 80	98	34.4%	187	65.6%	1.00			
Mean spirometry (FEV1/FCV):								
<Expected MPF	114	36.0%	203	64.0%	0.97	0.57	1.66	0.917
≥Expected MPF	26	36.6%	45	63.4%	1.00			
Factory environment PM_{10} in mg/m^3:								
Bakery (3.08)	21	30.4%	48	69.6%	1.66	0.55	5.05	0.370
Flour Packaging (9.7)	5	20.8%	19	79.2%	1.00			
Stone Cutting (11.22)	19	23.8%	61	76.3%	1.18	0.39	3.60	0.766
Cereal Store (17.16)	57	44.5%	71	55.5%	3.05	1.07	8.67	**0.036**
Furniture Manufacture (17.96)	38	43.7%	49	56.3%	2.95	1.01	8.61	**0.048**

OR – odds ratio, CI – confidence interval, FEV1/FCV – Forced expiratory volume1/Forced vital capacity, MPF – mean pulmonary function
*Significant at P<0.05 bolded MPF.

Comparison of means of pulmonary functioning tests and wheezing with cough without a flu/cold

Independent t test was used to compare the mean of pulmonary functioning test results among respondents who had cough without flu/cold or not (Table 4). The mean PM_{10} concentration in mg/m^3 for factory environment among respondents who had a cough without flu/cold was significantly higher (14.19) than to those who indicated otherwise (12.56) (P=0.005).

Relationship between pulmonary function test and wheezing with cough without a flu/cold

Table 3 shows relationship between pulmonary function test and wheezing with cough without a flu/cold. The proportion of cough without flu/cold was significantly more among respondents who work with local exhaust provided (44.5%; OR=1.71, 95% CI=1.11-2.65; *P*=0.015) than to those who indicated otherwise (31.9%). Respondents working at the Cereal store had significantly increased proportion of cough without flu/cold (43.7%; OR=2.95, 95% CI=1.01-8.61; *P*=0.048) and those working in furniture manufacturing (44.5%; OR=3.05, 95% CI =1.07-8.67; *P*=0.036) compared to those respondents who were working at the stone cutting factory (20.8%).

Table 3. Association between working conditions and wheezing with cough without a flu/cold

VARIABLES	YES (N=140)		NO (N=248)		OR	95% CI		*P*-VALUE*
	N	%	N	%		LOWER	UPPER	
Local exhaust provided and working:								
Yes	57	44.5%	71	55.5%	1.71	1.11	2.65	**0.015**
No	83	31.9%	177	68.1%	1.00			
Type of factory:								
Cereal store	38	43.7%	49	56.3%	2.95	1.01	8.61	**0.048**
Flour packing	19	23.5%	62	76.5%	1.17	0.38	3.54	0.788
Bakery	21	30.9%	47	69.1%	1.70	0.56	5.16	0.351
Furniture Manufacture	57	44.5%	71	55.5%	3.05	1.07	8.67	**0.036**
Stone cutting	5	20.8%	19	79.2%	1.00			

OR – odds ratio, CI – confidence interval
*Significant at *P*<0.05 bolded.

Relationship between awareness about asthma and wheezing with cough without a flu/cold

There was significantly increased proportion of cough without flu/cold among respondents who were not aware about asthma presentation or attack (44.2%; OR=1.76, 95% CI=1.06-2.94; *P*=0.030) compared to those who were aware (31.1%). However, there was no significant association observed among the other variables.

Association between household level factors and wheezing with cough without a flu/cold

The proportion of cough without flu/cold was significantly more among respondents who had carpet in their house (42.6%; OR=1.58 95% CI=1.05-2.43; P=0.030), than those who did not have (31.8%).

Association between pet animal ownership and wheezing with cough without a flu/cold

Bivariate analysis indicated that there was no significant association observed between pet ownership and wheezing with cough without a flu/cold.

Relationship of smoking and sleeping area characteristics with wheezing with cough without a flu/cold

Table 4 shows the relationship of smoking and sleeping area characteristics with wheezing with cough without a flu/cold. There was increased proportion of cough without flu/cold among respondents who were sleeping in a single room (41.0%; OR=2.13, 95% CI=1.12-4.05; *P*=0.021), compared to those who were sleeping in a bedroom (24.6%).

Table 4. Relationship of smoking and sleeping area characteristics with wheezing with cough without a flu/cold

VARIABLES	YES (N=140)		NO (N=248)		OR	95% CI		*P*-VALUE*
	N	%	N	%		LOWER	UPPER	
Sleeping area characteristics:								
Bedroom	16	24.6%	49	75.4%	1.00			
Living room	53	35.8%	95	64.2%	1.71	0.89	3.30	0.110
Single room	71	41.0%	102	59.0%	2.13	1.12	4.05	**0.021**
Smoker:								
Yes	23	43.4%	30	56.6%	1.43	0.79	2.57	0.233
No	117	34.9%	218	65.1%	1.00			

OR – odds ratio, CI – confidence interval
*Significant at *P*<0.05 bolded.

Multivariable analysis of factors associated with wheezing with cough without a flu/cold

Table 5 shows the factors associated with wheezing with cough without a flu/cold.

Multiple regression analysis was performed in order to identify factors independently associated with cough without flu/cold as shown in Table 5. Seven factors that associated with cough without flu/cold at *P*<0.1 during bivariate analysis were subjected all together in a multiple regression analysis (Table 4; Full model). Upon fitting these factors using binary logistic regression and by specifying *'backward LR'* method with removal at *P*<0.05, three (*3*) factors remained in the final analysis or reduced model. Respondents working in factories with air sample analysis level of 17.16 were approximately 3 times (AOR=3.97, 95% CI=1.03-8.56; *P*=0.044) more likely to have cough without flu/cold compared to those respondents who were working in factories with air sample analysis level of 9.07. Similarly, respondents working in factories with air sample analysis level of 17.96 mg/m^3 were approximately 4 times (AOR=3.65, 95% CI=1.22-10.93; *P*=0.021) more likely to have cough without flu/cold compared to those respondents who were working in factories with air sample analysis level of 9.07. Cough without flu/cold was approximately 2 times (AOR=1.92, 95% CI=1.13-3.28; *P*=0.017) more among respondents who were not aware about asthma presentation or attack compared to those who were aware. Respondents sleeping in a single room were 2.5 times (AOR=2.45, 95% CI=1.25-4.89; *P*=0.011) more likely to have cough without flu/cold compared to those who were sleeping in a bedroom as shown in Table 5.

Table 5. Factors associated with wheezing with cough without a flu/cold

VARIABLES	AOR	95% CI		*P*-VALUE*
		LOWER	UPPER	
Factory environment breathing zones PM_{10} in mg/m^3:				
Bakery (3.08)	1.94	0.62	6.03	0.252
Flour packaging factory (9.7)	1.00			
Stone cutting factory (11.22)	1.23	0.40	3.77	0.723
Cereal store (17.16)	2.97	1.03	8.56	0.044
Furniture manufacture factory (17.96)	3.65	1.22	10.93	**0.021**
Asthma attack presentation:				
Suddenly	1.00			
Not suddenly	1.92	1.13	3.28	**0.017**
Don't know	1.32	0.79	2.21	0.296
Sleeping area characteristics:				
Sleeps in bedroom	1.00			
Sleeps in living room	1.90	0.96	3.75	0.065
Sleeps in single room	2.45	1.23	4.89	**0.011**

AOR – adjusted odds ratio, CI – confidence interval
*Significant at P<0.05 bolded.

Abnormal breathing between shortness of breath episodes in relation to socio-demographic characteristics

Bivariate analysis of association between socio-demographic characteristics and abnormal breathing between shortness of breath episodes indicated that, there was no significant association observed between the two variables.

Comparison of means of pulmonary functioning tests and breathing problem

Independent *t* test was used to compare the mean of pulmonary functioning test results among respondents who had abnormal breathing between shortness of breath episodes verses those who did not have. However, there was no significant difference observed between those with abnormal breathing between shortness of breath episodes and those without on means of pulmonary function tests results.

Multivariable analysis of factors associated with abnormal breathing between shortness of breath episodes

Table 6. Multivariable analysis of factors associated with abnormal breathing between shortness of breath episodes

VARIABLES	AOR	95% CI		*P*-VALUE*
		LOWER	UPPER	
Asthma attack oresentation:				
Suddenly	1.00			
Not suddenly	2.46	1.02	5.96	**0.046**
Don't know	0.73	0.25	2.15	0.571
Carpet availability:				
Yes	2.37	1.08	5.19	**0.031**
No	1.00			

AOR – adjusted odds ratio, CI – confidence interval
*Significant at P<0.05 bolded.

Table 6 shows factors associated with abnormal breathing between shortness of breath episodes. Multiple regression analysis was performed in order to identify factors independently associated with abnormal breathing between shortness of breath episodes. Three factors that associated with Abnormal breathing between shortness of breath episodes at $P<0.1$ during bivariate analysis were subjected together in a multiple regression analysis. Upon fitting these factors using binary logistic regression and specifying *"backward conditional"* method with removal at $P<0.05$, 2 factors remained in the final analysis or reduced model.

Abnormal breathing between shortness of breath episodes was 2.5 times (AOR=2.46, 95% CI=1.02-5.96; *P*=0.046) more likely among respondents who were not aware about asthma presentation or attack compared to those who were aware.

Respondent who had a carpet in their house were 2.4 times (OR=2.37, 95% CI=1.08-5.19; *P*=0.031) more likely to have abnormal breathing between shortness of breath episodes compared to those who did not have.

DISCUSSION

All the factories had poor ventilation with high levels of PM_{10} beyond recommended levels by WHO (*10*) and hence the likelihood of impairment of lung functions amongst the factory workers as was found in other related studies (*11*-*16*, *18*, *20*). The mean concentration of PM_{10} in the factory environment breathing zones amongst those who reported cough without flu/cold was significantly higher than those who indicated otherwise this is consistent with other studies done before (*13*, *15*, *19*). Respondents with chest function (FEV1/FVC %) of less than 80 normal (a sign reduced lung function) expected value had significantly more proportion of cough without flu/cold compared to those who had FEV1/FVC% of 80 (a sign of adequate pulmonary ventilation) and above normal, the same trend was seen in other related studies done in the past (*17*, *18*). A majority of the workers had worked for more than eight years and consequently had been exposed to higher levels of pollution for long periods of time which could have resulted in the development of the respiratory conditions just as Mohammedien et al (*20*) had found out in 2013 in a similar study in Egypt. They found out that, the more years one had worked in such environment the more one was likely to have respiratory symptoms and reduced lung function. This study found out that, there was inadequate knowledge on asthma attack presentations amongst the respondents and hence the reason probably none of them reported to having asthma despite the findings showing that many of them had impaired lung function and hence the likelihood of them having asthma. Without the knowledge on asthma the respondents could not seek a clinicians intervention and hence none having been diagnosed with the disease. Unlike most studies, the present study considered both the factory environment and the home environment to adjust for confounders and good enough the results indicate that, both environments (factory and home environment) play a role in one likely reporting to have aforementioned outcomes. The general findings are not different from other studies done before in the same environment confirming that the finding on lung function tests in this study could be attributable to the indicated variables. What is interesting though is the finding that, working in a factory with reported working local exhaust system, was a predisposing factor to reduced lung function. This could be attributed to the fact that, though local exhaust was provided and looked like they were working in some factories, it was not working. Likewise, it could mean that, the more the factories were polluted the more the owners tried to provide local exhaust which seemed to have been working appropriately to the naked eye but in essence they were not. In fact, when asked, the management for all the factories reported that they had never tested their local exhausts to conform their working condition. The limitation of this study is that, we could not have picked the respondents who had asthma just because diagnosis of asthma takes a long time and yet this was a cross sectional study and hence inadequate time frame. Likewise, the respondents due to lack of knowledge on asthma attack presentation and therefore could not have known if they had asthma and hence a self-reported rate of 0% which is most probably not true. Consequently due to time limitations, the present study could not attribute a cause effect association. A longitudinal cohort surdy would have been better to effectively associate the various variables.

CONCLUSIONS

The present study shows that many of the workers in the selected factories had reduced lung function that could be attributed to the high levels of PM_{10} concentration in their working environment. Directorate of Occupational Health and Safety and the County Government of Nairobi, should be capacitated to increase inspections and health education in factories and accelerate slum improvement programs to improve on ventilation in the slum areas where most of our respondents live respectively, in order to reduce on the reported symptoms.

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