Original Article

Respiratory Symptoms and Lung function among Female Flower Farm workers in Ethiopia

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Abstract

Background: The workforces in the growing flower farms of Ethiopia are mainly females. Greenhouse workers are exposed to pesticides, fertilizers and dust, and might be at risk for developing respiratory diseases.
Objectives: This study aimed to assess respiratory symptoms and lung function of greenhouse workers and compare them to packinghouse flower farm workers.
Methods: A comparative cross-sectional study was conducted comparing female flower farmworkers from greenhouses, with female workers in packinghouses. Participants were interviewed for chronic respiratory symptoms using a standardized questionnaire from the British Medical Research Council. A Minispir light spirometer, with Winspiro software was used for lung function tests to measure Forced vital capacity (FVC) and Forced expiratory volume at one second (FEV_1). Study groups background characteristics were compared using an independent t-test and chi-square test. Poisson regression analysis and a general linear model were also performed.
Results: Three hundred fourteen workers participated,160 from greenhouses and 159 from pack houses. The response rate showed that 99.7% was for the interview and 98% was for spirometry. The mean (SD) age of greenhouse workers was 26(8) years and of packinghouse workers 24(7) years. There was no significant difference in respiratory symptoms and spirometry indices while comparing workers in greenhouse with workers from packinghouse. But service month was a significant predictor for the reduction of $FEV_{1,}$ by a reduction of 2ml/month with a p-value of 0.01.
Conclusion: There was no difference in respiratory symptoms and lung function parameters comparing greenhouse and packinghouse workers from flower farms. Service duration was a significant predictor for the reduction of FEV_1. This may indicate the development of lung obstruction among flower farm workers over a course of time. Workers respiratory health including lung function change needs to be monitored regularly. [*Ethiop. J. Health Dev.* 2023; 37(1) 000-000]

Introduction

Flower farming is one of the growing agricultural sectors in East Africa. These large -scale flower farms use greenhouse technology for the cultivation of flowers. In greenhouse shields flowers are planted on beds, cultivated, weeded, and supplied with necessary fertilizers for their growth. Spraying pesticides also takes place within these greenhouse shields to prevent and control pest infestation. Flowers ready for harvest will be harvested and sent to the packinghouse where they will be packed for export. Women make up the highest proportion of the workforce which is more than 70% (1-4). The tasks women are mostly involved in include planting, cultivating, and harvesting flowers in greenhouses. They are also involved in bundling and packing flowers within the packinghouse (2, 3, 5, 6).
Commercial horticulture and flower farms, use a variety of pesticides from WHO toxicity class I pesticides to class IV to control pests on the flowers (7-10). Several studies have shown that workers inside greenhouses are exposed to pesticides used for spraying (7, 9, 11). For instance, a study conducted in Italy showed that workers are exposed to more than 50 complex mixtures of pesticides in flower farms, and about 67% of the pesticides used were organophosphates and carbamate pesticides (12). In addition to exposure to pesticides, workers in greenhouses may also be exposed to organic dust and aerosols which can influence respiratory health (13). Due to the confined nature of greenhouses, the exposure to dust and chemicals among greenhouse workers is very likely to be higher than experienced in open fields or areas nearby the greenhouses (14). In Ethiopian flower farms, it is mostly women involved in cultivating and harvesting flowers in the greenhouses. These workers are called greenhouse workers and use minimum or no protective equipment (1, 4).

Packinghouse workers are mainly engaged in packing harvested flowers that are brought to them from the greenhouses. The packing is performed in separate buildings outside the greenhouses, and no soil, fertilizers, or pesticide is used there (1). There is limited evidence on the risk of exposure of packinghouse workers. But the descriptions and observations of this work environment strongly suggest that the packinghouse workers are not exposed to pesticides or aerosols from soil or fertilizers (4). For

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the present study, we assumed that greenhouse workers will be more exposed than packinghouse workers to pesticides, fertilizers, and dust, both by inhalation and skin contact with the substances.

Exposure to pesticides has been reported to be associated with respiratory problems including asthma, chronic obstructive disease, and increased prevalence of respiratory symptoms (15, 16). Respiratory symptoms such as wheezing and chest tightness have been reported among agricultural workers exposed to pesticides (17). In a study by Negatu et al (18), the prevalence of cough, phlegm, and shortness of breath were significantly higher among pesticide exposed workers compared to unexposed study participants.
Some studies have also shown decreased pulmonary function among farmworkers who are exposed to pesticides (18-20), indicating a relationship between pesticides and adverse respiratory health effects. Pesticide exposed participants also had a significantly lower FEV_1 and FEF_{25-75} compared to unexposed workers. This study included participants from different types of farming including large scale greenhouse, large scale open fields, and small scale irrigated farms (18).

Previous studies on flower farm workers in Ethiopia have shown a high prevalence of self-reported respiratory problems among pesticide exposed workers compared to unexposed controls (4, 18, 21). A study conducted among three commercial flower farms in Ethiopia found an increased prevalence of respiratory symptoms such as coughing and shortness of breath comparing workers from flower farms with workers in shops (4). Another Ethiopian study reported that the prevalence of respiratory symptoms and exposure to endotoxins were higher among female workers inside greenhouses than among those working outside greenhouses, but lung function was not examined (22). These studies on flower farmworkers are not conclusive because they are based on reported symptoms only and did not have an objective measurement of lung function. It is unclear if these workers develop respiratory symptoms due to their exposure or not.

Thus, this study is aimed to assess respiratory symptoms and pulmonary function among women employees who are working in flower farms, comparing two groups of workers: greenhouse and packinghouse workers. In addition, the study aimed to assess the association between respiratory health variables and the number of months worked on flower farms.

Methods

The Study Area and Design A comparative cross sectional study was conducted in 2017 on female flower farms located within a 50 km radius of Addis Ababa, the capital city of Ethiopia. The area was selected because most of the flower farms in Ethiopia are concentrated here, where the high altitude is favourable to the production of high-quality roses. It is also close to Bole international airport, which is important for the extensive rose export.

Sample size determination

The sample size for respiratory symptoms was calculated using a double proportion formula. We used a recent paper about flower farm workers, where 38.5% of exposed workers reported coughing during the day/night, whereas unexposed workers only had a coughing prevalence of 20.3% (4). The calculated sample size was 132 for each of our study groups, to obtain 90% statistical power with a 95% confidence interval. When a possible 10% non-response rate was included, the sample size rose to 146 respondents. The sample size calculated for lung function estimation was based on Forced Expiratory Volume at one second (FEV_1) finding from a study conducted among spraying and non-spraying farmers in Ethiopia (23). The estimation was from figures regarding male workers because we could not find studies that assessed lung function parameters among a comparable group of female agricultural workers. The mean FEV_1 among exposed (sprayers) was 3.06 L with a standard deviation of 0.59 and among non-spraying farm workers (unexposed comparison groups) it was 3.26 L with a standard deviation of 0.45 (4). We were thereby able to calculate a sample size of 145 for each group, using the mean difference formula, statistical power of 90%, and 95% confidence interval. When we add a 10% possible non-response rate, the final sample size was 160 in each group. Since the minimum sample size calculated for the lung function test was larger compared to the respiratory symptom sample size, we opted for using the larger number, testing 160 greenhouse and 160 packinghouse workers.

Sampling Procedure

In the selected area there were 31 rose producing farms from which the researchers randomly selected eight farms for this study. Two of the farms refused to take part in the study. Thus, the study was conducted on six farms. The number of greenhouse workers in each flower farm ranged from 112 to 256; while the number of packinghouse workers ranged from 50 to 63 Workers who participated in the study were selected by systematic random sampling technique. The description of the sampling procedure including the total number of workers in the greenhouse and packing house from each farm is provided in Table 1.

Table 1: Total number of workers, selected and participating flower farm workers in each farm

Workers	Total	Farm					
		1	2	3	4	5	6
Total number of female greenhouse workers	1282	225	112	256	242	237	210
Total number of invited greenhouse workers	160	28	14	32	30	30	26
Number of participating greenhouse workers	156	27	13	32	30	30	24
Total number of packinghouse workers	324	54	50	60	63	57	40
Total number of invited packinghouse workers	160	28	25	29	30	28	20
Number of participating packinghouse workers	155	28	23	28	30	26	20

Data Collection

Respiratory Symptoms

The respiratory symptoms data was collected using a standardized questionnaire adopted from British Medical Research Council and American Thoracic Society respiratory symptom questionnaire (24, 25). Similarly, previous studies conducted among flower farm workers used the same questionnaire (4, 22, 23). The questionnaire was prepared in English and translated into two local languages (Amharic and Afan Oromo) and back translated into English. A trained data collector, who had experience from previous studies, and the principal investigator, collected the data. Together they underwent a two-day training to reach a common understanding of the questionnaire and interviewing technique. The questionnaire included information on socio-demographics, including age in years, educational status as well as ever alcohol drinking and smoking, the number of months working on the farm, as well as whether the participant had transferred from another working section to the present. Also, the questionnaire included questions on respiratory symptoms cough, cough with sputum chest tightness, wheezing, and breathlessness. In addition, the participants were asked if they had any previous respiratory disease (bronchitis, pneumonia, tuberculosis, bronchial asthma), heart problems, or any other chest disease. The questionnaire also included questions on the cooking place in the home and the fuel used for cooking. After completing the interview, the interviewer measured the height and weight of each participant using standardized weight and height scales. Body mass index was calculated for each participant (weight in kilograms divided by height in meters squared). The participant interviews were undertaken inside an office designated for data collection on each farm.

Spirometry Test

A spirometry test for each participant was undertaken inside an office designated for the data collection process. It was taken by two technicians who had previous experience conducting spirometry tests both at clinics as well as for research purposes. Besides their previous experience, the technicians underwent two days of training. The spirometry test was performed using a Minispir light spirometer, with Winspiro software (Producer: Medical International Research), using a disposable turbine flow meter for each person. The test was performed according to the recommendations of the American Thoracic Society (26). All tests were performed from 08:00 AM to 4:00 PM with the participant in a sitting position. Participants took a deep breath to their maximum lung capacity and then blow it out forcefully; the procedures were repeated until three acceptable measurements were obtained. The maximum number of efforts made by a participant was eight, and if the participants could not perform three acceptable measurements the result was excluded. The maximum of the three acceptable measurements for the spirometry test was recorded for FVC, $FEV_{1,}$ FEV_1/FVC, and FEF 25-75%. We used absolute values of pulmonary function test results because we did not have a reference value for predicted pulmonary functions of the Ethiopian population. Results from 59 workers (28 from the packinghouse and 31 from the greenhouse workers) were excluded because of unacceptable measurements.

Operational Definitions

Cough: a person was considered to have a "cough" if she said yes to any of the questions: usually cough first thing in the morning? usually cough during the day or at night? Usually, cough as much as 4-6 times a day for 4 or more days in a week. usually cough on most of the days for as much as 3 consecutive months or more in a year? (24, 25).

Cough with sputum: a person was considered to have a "cough with sputum" if she said yes to any of the questions: cough with sputum first thing in the morning? Cough with sputum during the day or at night? usually cough with sputum as much as 4-6 times a day or 4 or more days in a week? usually cough with sputum on most of the days for as much as 3 consecutive months or more in a year? (24, 25).

Breathlessness: a person was considered to have "Breathlessness" if she said yes to any of the questions: Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? Do you get shortness of breath walking with other people of your age on level ground? Do you have to stop for breath walking at your own pace on level ground? (24, 25).

Wheezing: a person was considered to have "Wheezing" if she said yes to the question: Have you had attacks of wheezing in your chest at any time?

Chest tightness: a person was considered to have "chest tightness" if she said yes to the question: Do you usually experience chest tightness while at work or just after work? (24, 25).

Data Management and Statistical analysis

Greenhouse and packinghouse workers data were compared using an independent t-test for continuous variables and chi-square tests for categorical variables. Respiratory symptoms were also compared between the two study groups using Poisson regression adjusting for age, height, and education. A general linear model was used to compare spirometry indices (FVC, FEV_1, FEV_1/FVC, FEF25-75%) between the greenhouse and packinghouse workers after checking assumptions of linear regression while controlling for height, service months, and education. Age was found to be correlated with service months (with r=0.48 and p-value=0.01). In our model age was categorized into three and fed based on equivalent percentile for statistical ease. The greenhouse and packing house were similar when cooking variables were compared, so we did not adjust for cooking variables. The data was analysed in STATA version 14 (Stata Corp, College Park, TX, USA). For all analyses, a value of P<0.05 was taken to indicate statistical significance.

Ethical Considerations

The ethical approval was obtained from the Addis Ababa University College of Health Science institutional review board with a protocol number of 058/16/SPH. A letter of support was written from the Addis Ababa University School of Public Health to the respective farms. We also requested each participating farm for permission to conduct the study. Workers were requested to give written consent after reading the information sheet, providing information on the purpose of the study, confidentiality, and voluntary participation. For those workers unable to read; the data collectors read the information sheet in the presence of a witness who could both read and write. Both the interview and a spirometry test were performed after the participants signed their consent to participate in the study.

Results

Characteristics of female workers

Only one participant refused to answer the respiratory symptom questionnaires giving in a response rate of 99.7%. Whereas six workers did not participate in the lung function test giving a response rate of 98%. The mean (SD) age of overall participants was 25(7) years, 26(8) years for greenhouse and 24(6) years for packinghouse workers with an overall range of 18-57. The median number of service months for greenhouse workers was 13 months and packinghouse workers were 24 months. Twenty-two workers from the packinghouse had previously been working in another working section of which 20 had worked in the greenhouse. Greenhouse workers had a lower educational level than packinghouse workers. There were no other differences between the groups (Table 2). Two participants (0.6%) reported ever smoking cigarettes but none of the participants was current smokers.

Table 2: Characteristics of the study participants

Variables		All workers n=314	Greenhouse workers n=160	Packinghouse workers n=159	P-value
Age in years; mean (SD)		24.7 (7.3)	25.5 (7.8)	24.0 (6.6)	0.06[1]
Weight in kg; mean (SD)		51.7 (7.3)	51.2(7.3)	52.1 (7.3)	0.2[1]
Height in cm; mean (SD)		158.3 (6.4)	157.9 (6.3)	158.4 (6.4)	0.4[1]
Body mass index; mean (SD)		20.6 (2.6)	20.5 (2.6)	20.7 (2.6)	0.51[1]
Service months; mean (SD)		30.6 (29.4)	30.0 (31.8)	31.2 (26.8)	0.71[1]
Education	No formal education n (%)	60 (18.8)	41 (25.6)	19 (12.0)	<0.01*[2]
	1^0 education n (%)	167(52.4)	77 (48.1)	90 (56.6)	
	2^0 and above n (%)	92 (28.8)	42 (26.3)	50 (31.5)	
Previous respiratory disease	Yes n (%)	20 (6.3)	9 (5.6)	11 (6.9)	0.63[2]
	No n (%)	299 (93.7)	151 (94.4)	148 (93.1)	
Previously worked in other working section	Yes	24(7.5)	2(1.3)	22(13.8)	<0.01*
	No	295(92.5)	158(98.7)	137(86.2)	
Cooking place	Inside main house n (%)	199 (62.4)	98 (61.3)	101 (63.5)	0.57[2]
	Kitchen detached from main house n (%)	120 (37.6)	62 (38.8)	58 (36.5)	
Cooking Fuel	Use Biomass for cooking n (%)	316 (99.1)	159 (99.4)	157 (98.7)	0.56[2]
	Use kerosene n (%)	3 (0.9)	1 (0.6)	2 (1.3)	

SD=standard deviation,[1]=Students t-test, [2]=Chi-square test, n= frequency , *=significant at p<0.05

Respiratory Symptoms

Breathlessness (32.5% % and 25.6 %) and chest tightness (23.7% and 18.1%) among greenhouse and packinghouse workers respectively, were the two most reported symptoms. Wheezing was the least prevalent symptom in the studied flower farm workers, 4.4% among greenhouse workers and 1.9% among packinghouse workers. There were no significant differences in the prevalence of respiratory symptoms between the greenhouse and packinghouse workers. (Table 3).

Table 3: Respiratory symptoms among greenhouse and packinghouse female flower farmworkers

Respiratory symptoms	All workers No (%)	Greenhouse workers No (%)	Packinghouse workers No (%)	Chi-square test P-value	Prevalence ratio (95% CI)[a]
Cough	37 (11.6)	20 (12.5)	17 (10.6)	0.61	1.02(0.55-1.89)
Cough with sputum	20 (6.3)	11 (6.9)	9 (5.6)	0.66	1.09(0.46-2.57)
Breathlessness	93 (29.1)	52 (32.5)	41 (25.6)	0.15	1.15(0.81-1.63)
Chest Tightness	67 (21.0)	38 (23.7)	29 (18.1)	0.23	1.19(0.77-1.84)
Wheezing	10 (3.2%)	7 (4.4)	3 (1.9)	0.34[b]	-

CI= confidence interval

[a] Poisson regression comparing greenhouse and packinghouse (packinghouse workers were the reference group) workers while Adjusted for Age, service month and education.

[b] Fisher's exact test due to the small numbers

Pulmonary function tests

The mean FVC, FEV1, FEV1/FVC, and FEF25-75% for the participant were 3.23 l, 2.69 l, 83.43 %, and 2.90 respectively (Table 4). There was no statistically significant difference between the greenhouse and packinghouse workers in any of the measured spirometry indices.

Table 4: Pulmonary function test result among all workers, greenhouse and packinghouse flower farmworkers

Lung function indices	All workers AM (SD) n=255	Greenhouse workers AM (SD) n=126	Packinghouse workers AM (SD) n=129	P value[1]
FVC (l)	3.23 (0.51)	3.23 (0.50)	3.22 (0.51)	0.31
FEV_1 (l)	2.69 (0.42)	2.69 (0.43)	2.69 (0.42)	0.36
FEV_1/FVC	83.43 (4.81)	83.3 (5.1)	83.5 (4.3)	0.86
$FEF_{25-75\%}$	2.90 (0.73)	2.91 (0.80)	2.90 (0.65)	0.45

[1]Multiple linear regression comparing greenhouse and packinghouse workers adjusted for education, service month and height,

AM= arithmetic mean, SD= standard deviation

FVC=Forced Vital Capacity, FEV_1= Forced expiratory Volume at one second, $FEF_{25-75\%}$=Mid expiratory flow rate

But, after controlling the possible effects of height and education, the number of service months was significantly associated with FEV_1 in a multiple regression model. FEV_1 decreased by 2ml for every monthly increase in service duration of working in flower farms (Table 5). We also ran analogous multiple linear regressions for FVC and FEV_1/FVC by controlling the effect of height and education. However, there was no statistically significant association for these indices with the work section or with the number of service months.

Table 5: The relationship between service months and forced expiratory volume at one second among flower farmworkers

Variable	B	SE_B	p-VALUE	95% CI B
FEV_1 ,R^2Adj=0.198 n=255				
Constant	-1.47	0.62	0.04*	
Service duration in months	-0.002	0.001	0.01*	-0.004 - -0.0004
Height (cm)	0.03	0.004	<0.001*	0.02 - 0.03
Education (No formal education (ref) VS				
Primary education	0.03	0.07	0.69	-0.11 - 0.17
secondary and above	0.08	0.08	0.30	-0.08 - 0.24
Age in years (<=20 reference category)				
[21-24]	0.06	0.06	0.31	-0.06-0.18
>=25	0.007	0.07	0.92	-0.13-0.15

B = Unstandardized Beta; SE=Standard Error of Beta; R2 adj = Adjusted R square; FEV1= Forced expiratory Volume a t 1 second; * Significant p-value; CI = Confidence interval

Discussion

This study shows an association between months of service in flower farms and a reduction in FEV_1. This finding was seen even after adjustments for height and education, and the population was non-smoking. In addition, this was found in a rather young population, making it quite serious. It showed that these workers may be at risk of developing obstructive lung disease due to their work.

Obstructive lung diseases have been documented among different agriculture workers (27). In Ethiopia, studies have shown an increased prevalence of chronic respiratory symptoms among agricultural workers (4, 18, 23, 28). One study showed a decreased FEV_1 among agricultural workers as the duration of workplace exposure increased (28). This might be caused by exposure to workplace hazards such as organic dust, fungi, and pesticides. Although previous studies in flower farms in Ethiopia have documented, a high prevalence of respiratory symptoms, a similar association between service month in flower farms and reduced FEV_1 has not previously been seen (4, 22).

In this study, greenhouse workers had no statistically significant difference with packinghouse workers in both respiratory symptoms and spirometry indices. a similar finding was shown in a study conducted by Negatu A. et al where the researchers compared respiratory symptoms of cough, wheezing, and chest tightness among women greenhouse and packinghouse workers and did not find any statistically significant difference (22). The reason for the absence of difference in reported respiratory symptoms might be explained by there being insufficient differences in exposure to the hazards affecting respiratory health between women working in greenhouses and packinghouses. In addition, the relatively short time of work experience with associated exposure, and the fact that the participants were young might contribute to the lack of a significant difference in respiratory symptoms between the two groups.

Breathlessness and chest tightness were the most reported respiratory symptoms among the studied flower farm workers, in both greenhouse and packinghouse workers. The prevalence of breathlessness found among the greenhouse workers in our study was comparable to that experienced by women farmworkers exposed to pesticides and engaged in plantation activities in Costa Rica (36%) (29). The prevalence of chronic respiratory symptoms; cough, phlegm, and breathlessness was comparable with another finding among Ethiopian farm workers (18). The reason for the high prevalence of respiratory symptoms in flower farm workers might be attributable to pesticide exposure. Studies have shown an increased prevalence of respiratory symptoms among agricultural workers who are exposed to pesticides (30, 31). The high prevalence of respiratory symptoms among agricultural workers may also be related to the development of allergies to agricultural products, but roses seldom cause allergies. On the other hand, there might be other allergens in the greenhouses, and more studies on the environment seem to be needed (32).

The finding of this study shows that respiratory symptoms ((cough 37 (11.6%), cough with sputum 20 (6.3%), and Breathlessness 93 (29.1%)) were lower compared to previous studies conducted among flower farm workers in Ethiopia (4, 22, 33). However, the participants in these studies were older than our study. In addition, their working situation might have been different from what we found during our study. Also, workers might be more familiar with flower farms today than earlier, and any potential fears relating to health problems may have decreased, thus decreasing the complaints of workers.

A strength of this study is we conducted a lung function test in addition to registering the symptoms, to have a more objective measure of respiratory health.
The finding of respiratory symptoms was slightly higher among greenhouse workers, but we did not find statistically significant differences among the groups; this might be attributable to the small sample size in our study. The study compared two groups of flower farm workers. The researchers anticipated that the exposure to pesticides, dust, and fungi would be higher in the greenhouses, compared to the packinghouses. A study weakness is that we did not take exposure measurements, only workplace descriptions. On the other hand, several authors have described a more likely exposure to pesticides within the greenhouses compared to outside these workplaces (7, 34, 35). The other weakness of the study might be the choice of packinghouse workers as a reference group since we do not have any objective exposure data to support that

they are lower exposed to pesticides and aerosols than the greenhouse workers. However, packinghouse workers preferred over population-based controls because the packinghouse workers are similar to the greenhouse workers when it comes to lifestyle and social status. The flower farmworkers are likely to have a different social status than the general population in the area (36), and this would have influenced the results if we had chosen a population based control group. We might also have a bias towards a "healthy worker effect" in the flower farms, as workers with a respiratory problem might either avoid working in a greenhouse or, if employed, might have left work if any respiratory or other health problems were developed (37).

Two farm administrators declined to permit the study to be conducted on their farms. They described their reason for not participating as; they simply did not want to take part in such a study. We do not know the health status of the workers working there. This might have introduced a selection bias to our study, but we do not know about this.

Conclusion

The study found a significant association between months worked in the flower farms and a reduction in FEV1. This may indicate the development of lung obstruction among flower farm workers over time. There was no difference between greenhouse and packinghouse workers on reported respiratory symptoms and spirometry function indices.

Recommendations

Further studies need to be conducted to examine the exposure in flower farms in more detail as well as determine the long-term respiratory health effects among the workers. Flower farm workers respiratory health including lung function change needs to be monitored regularly.

Conflict of interest: All authors declare no conflict of interest.

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References

1. Shentema MG, Kumie A, Bråtveit M, Deressa W, Ngowi AV, Moen BE. Pesticide Use and Serum Acetylcholinesterase Levels among Flower Farm Workers in Ethiopia-A Cross-Sectional Study. Int J Environ Res Public Health 2020;17(964):1-14.
2. Gobie W. A Seminar Review on Impact of Floriculture Industries in Ethiopia International Journal of Agricultural Economics. 2019;4(5):216-24.
3. Staelens L, Desiere S, Louche C, D'Haese M. Predicting job satisfaction and workers' intentions to leave at the bottom of the high value agricultural chain: evidence from the Ethiopian cut flower industry. The International Journal of Human Resource
4. Management. 2018;29(9):1609-35. Hanssen VM, Nigatu AW, Zeleke ZK, Moen BE, Bratveit M. High Prevalence of Respiratory and Dermal Symptoms Among Ethiopian Flower Farm Workers. Archives of environmental & occupational health. 2015;70(4):204-13.
5. Kuiper G. Agro-industrial Labour in Kenya Cut Flower Farms and Migrant Workers' Settlements. Switzerland: Springer Nature 2019. 284 p.
6. Lowthers M. On Institutionalized Sexual Economies: Employment Sex, Transactional Sex, and Sex Work in Kenya's Cut Flower Industry. Journal of Women in Culture and Society. 2018;43(2):449-72.
7. Amoatey P, Al-Mayahi A, Omidvarborna H, Baawain MS, Sulaiman H. Occupational exposure to pesticides and associated health effects among greenhouse farm workers. Environmental Science and Pollution Research. 2020;27:22251–70.
8. Breilh J, Pagliccia N, Yassi. A. Chronic pesticide poisoning from persistent low-dose exposures in Ecuadorean floriculture workers: toward validating a low-cost test battery. International Journal of Occupational and Environmental Health. 2012;8(1):7-21.
9. Bolognesi C, Creus1 A, Ostrosky-Wegman P, Marcos. R. Micronuclei and pesticide exposure. Mutagenesis. 2011;26(1):19-26.
10. Von Essen SG, Banks DE. Life-long exposures on the farm, respiratory symptoms, and lung function decline. Chest. 2009;136(3):662-3.
11. García-García CR, Parrón T, Requena M, Alarcón R, M.Tsatsakis A, F.Hernándeze A. Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level. Life Science. 2016;145:274-83.
12. Bolognesi C, Perrone E, Landini. E. Microneucleous monitoring from of a floriculturist from Western Liguria, Italy. Mutagenesis. 2002;17(5).
13. Madsen AM, Thilsing T, Baelum J, Garde AH, Vogel U. Occupational exposure levels

of bioaerosol components are associated with serum levels of the acute phase protein Serum Amyloid A in greenhouse workers. Environ Health. 2016;15:9.

14. Rahimi T, Rafati F, Sharifi H, Seyedi F. General and reproductive health outcomes among female greenhouse workers: a comparative study. BMC Women's Health. 2020;20(103).
15. Kima K-H, Kabir E, Jahan SA. Exposure to pesticides and the associated human health effects. Science of the Total Environment. 2017;575:525-35.
16. Salameh P, Waked M, Baldi I, Brochard P, Saleh BA. Respiratory diseases and pesticide exposure: a case-control study in Lebanon. J Epidemiol Community Health. 2006;60(256-261).
17. Dhananjayan V, Ravichandran B. Occupational health risk of farmers exposed to pesticides in agricultural activities. Environmental Science and Health. 2018;4:31-7.
18. Negatu B, Kromhout H, Mekonnen Y, Vermeulen R. Occupational pesticide exposure and respiratory health: a large-scale cross-sectional study in three commercial farming systems in Ethiopia. Thorax. 2017;72(522-529).
19. Chalak SS, Junghare V. Evaluation of dynamic lung volumes and capacities in farm laborers exposed to occupational pesticide spraying. National Journal of Physiology, Pharmacy and Pharmacology. 2019;9(10):1001-5.
20. Fareed M, Pathak MK, Bihari V, Kamal R, Srivastava AK, Kesavachandran CN. Adverse Respiratory Health and Hematological Alterations among Agricultural Workers Occupationally Exposed to Organophosphate Pesticides: A Cross Sectional Study in North India. PLOS ONE 2013;8(7):1-11.
21. Kipsengeret KK, Mbaria JM, Muchemi GM, Kitala PM, Kanja LW. Occupational exposure to pesticide and associated health problems in Kenya’s floriculture industry. Prudent Research Journal of Medicine and Medical Sciences. 2016;1(1):1-10.
22. Nigatu AW, Bratveit M, Deressa W, Moen BE. Respiratory symptoms, fractional exhaled nitric oxide & endotoxin exposure among female flower farm workers in Ethiopia. Journal of occupational medicine and toxicology. 2015;10:8.
23. Mekonnen Y, Agonafir T. Lung function and respiratory symptoms of pesticide sprayers in state farms of Ethiopia. Ethiopian medical journal. 2004;42(4):261-6.
24. Medical Research Council's Committee on Environmental and Occupational Health. Questionnaire on respiratory symptoms. Medical research council. 1986.
25. America Thoracic Society-Division of Lung Diseases. Recommended Respiratory Disease Questionnaires for Use with Adults and Children in Epidemiological Research. ATS; 1978.
26. Carrie A. Redlich, Susan M. Tarlo, John L. Hankinson, Mary C. Townsend, William L. Eschenbacher, Susanna G. Von Essen, et al. Official American Thoracic Society Technical Standards: Spirometry in the Occupational Setting. American Journal of Respiratory and Critical Care Medicine. 2014;189(8):983-93.
27. Guillien A, Soumagne T, Dalphin JC, Degano B. COPD, airflow limitation and chronic bronchitis in farmers: a systematic review and meta-analysis. Occup Environ Med. 2019;76(1):58-68.
28. Woldeamanuel GG, Mingude AB, Yitbarek GY, Taderegew MM. Chronic respiratory symptoms and pulmonary function status in Ethiopian agricultural workers: a comparative study. BMC Pulm Med. 2020;20(1):86.
29. Fieten KB, Kromhout H, Heederik D, Joode BvWd. Pesticide Exposure and Respiratory Health of Indigenous Women in Costa Rica. American Journal of Epidemiology. 2009;169(12):1500-6.
30. Ye M, Beach J, Martin JW, Senthilselvan A. Occupational Pesticide Exposures and Respiratory Health International Journal of Environmental Research and Public Health. 2013;10:6442-71.
31. Fariaa NMX, Facchinib LA, Fassab AG, Tomasic E. Pesticides and respiratory symptoms among farmers. Rev Saude Publica. 2005;39(6).
32. Arcangeli G, Traversini V, Tomasini E, Baldassarre A, Lecca LI, Galea RP, et al. Allergic anaphylactic risk in farming activities: a systematic review. International Journal of Environmental Research and Public Health. 2020;17(14):4921.
33. Defar A, Ali A. Occupational induced health problems in floriculture workers in Sebeta and surrounding areas, West Shewa, Oromia, Ethiopia. Ethiop J Health Dev. 2013;27(1):64-71.
34. Negatu B, Vermeulen R, Mekonnen Y, Kromhout H. A Method for Semi-quantitative Assessment of Exposure to Pesticides of Applicators and Re-entry Workers: An Application in Three Farming Systems in Ethiopia. Ann Occup Hyg. 2016;60(6):669-83.
35. Nuraydin A, Bilek O, Kenziman AK, Korkusuz MA, Atagun AI, Cakar NO, et al. The Mersin Greenhouse Workers Study. Surveillance of Work-related Skin, Respiratory, and Musculoskeletal Diseases. Ann Glob Health. 2018;84(3):504-11.
36. Mekonnen YY. Assessment of the Economic and Working Conditions of the Cut Flower Farm Workers in Ethiopia, a Case of Bahir Dar City: Ritsumeikan Asia Pacific University; 2017.
37. Pearce N, Checkoway H, Kriebel D. Bias in occupational epidemiology studies. Occup Environ Med. 2007;64(8):562-8.