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Respiratory Health Among Hand Pickers in Primary Coffee-Processing Factories of Ethiopia

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Objective: The aim of this study was to assess chronic respiratory symptoms and lung function among female hand pickers. **Methods:** A total of 374 hand pickers exposed to coffee dust and 175 female controls from water bottling factories were included. The symptoms were assessed using a standardized questionnaire. Personal total dust exposure and lung function tests were performed. **Results:** Hand pickers experienced a higher dust exposure, displayed a higher prevalence ratio for cough [prevalence ratio (PR) = 3.0, 95% confidence interval (95% CI): 1.4 to 6.2] and work-related shortness of breath (PR = 2.5, 95% CI: 1.1 to 5.6), and had a lower FEF_{25-75} than controls. Hand pickers without tables had a significantly higher prevalence ratio of cough with sputum (PR = 3.9, 95% CI: 1.6 to 9.5) and lower forced vital capacity, forced expiratory volume in 1 second, and mean forced expiratory flow between 25% and 75% of the FVC than hand pickers with tables. **Conclusion:** Hand pickers show a range of adverse symptoms and lung function impairments that warrant efforts to improve working conditions.

Keywords: coffee workers, dust, Ethiopia, hand pickers, lung function

BACKGROUND

In Ethiopia, the coffee beans are grown and processed at the farms before being transported to primary coffee-processing factories. There are two types of post-harvest coffee-bean processing at the farms in Ethiopia.[1] One type is dry processing, where the whole coffee cherries are allowed to dry in the sun under natural conditions.[2] Wet processing is the second type of on-farm processing, and involves pulping the coffee cherries on the same day as they are harvested, followed by fermentation, washing to remove the mucilage, and drying in the sun.[2] After processing coffee beans at the farms, coffee passes through different stages of cleaning in primary coffee-processing factories in order to be sold and shipped to secondary processing factories, where the coffee is roasted. The primary coffee-processing factories perform mechanical cleaning of debris from green coffee beans, as well as sorting, grading, and packing.[3] In Ethiopia, almost all primary coffee-processing factories are to be found in three regions: Oromia, Addis Ababa, and the Southern Nations, Nationalities and Peoples' Region (SNNPR). Only Arabica coffee is grown in Ethiopia.

The final stage of coffee cleaning in the primary coffee factories is carried out by hand pickers, and involves separating defective and discolored coffee beans (ie, black, yellow, and red coffees) from the sound coffee beans.[4] A large number of women work as hand pickers in the primary coffee-processing factories in Ethiopia. This work is the main source of income for many poor women. The hand-picking women might be exposed to coffee dust at their workplace.[4] Only a few studies of primary coffee-processing factories have been performed, but they all indicate that exposure to coffee dust is likely to cause respiratory health problems.[3,5–8] Some of the studies are very old,[5–8] and none of these studies have specifically looked at respiratory health among hand pickers. A study conducted in Tanzania assessed the total dust-exposure level among 10 hand pickers, and showed endotoxin levels higher than recommended standards. This study also indicated an association between exposure to endotoxin and inflammation in the airways measured in terms of exhaled nitrogen oxide. However, this study was based on a small sample size and did not assess respiratory symptoms and lung function among the workers.[4]

Although the tasks of all hand pickers in Ethiopia are the same, the working conditions vary from factory to factory. In general, hand pickers in the country can be classified into two groups: those with sorting tables and those without. The hand pickers in primary coffee-processing factories in Addis Ababa work with tables. The hand pickers sit inside the processing machine room on chairs 40 to 50 cm high, and sort both wet and dry processed coffee beans on a long table or a conveyor belt (Fig. 1).

Hand pickers without tables are to be found in Oromia and SNNPR primary coffee-processing factories. These hand pickers perform their work while sitting on the ground, either outdoors on a veranda or in a separate room. They only sort dry processed coffee from piles of green coffees (Fig. 2). In occupational health settings, there is discussion as to which method is best for the workers: work with or without tables. This is an important topic to be considered for the hand-picking workers, and more knowledge of these issues will have consequences for the working conditions for hand pickers all over the country.

To our knowledge, no previous studies have assessed respiratory health and dust exposure among hand pickers, and consequently, no one has studied such working conditions in the two types of hand pickers.

The aim of this study was to assess respiratory health among hand pickers by using two measures: chronic respiratory symptoms and lung–function parameters. Previous studies of workers exposed to coffee dust have examined lung function parameters such as forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1). However, organic dust, such as coffee dust,

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SWA planned the study, collected and analyzed data, and drafted the manuscript in consultation with other authors. MB, WD, AK, and BEM participated in the design, collection, and analysis of data, provided scientific support throughout the project, and commented on the manuscript. All authors have read and approved the final manuscript.

This research was funded by the Norwegian Program for Capacity Building in Higher Education and Research for Development (NORHED).

The authors declare that they have no competing interest.

Clinical Significance: Understanding the respiratory health problem among coffee workers in Ethiopia, can help public health professionals and other relevant stakeholders for planning preventive and control strategies.

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DOI: 10.1097/JOM.0000000000001613

FIGURE 1. Hand pickers working at coffee-sorting tables (Photo: S. W. Abaya).

may cause asthma-like conditions. We therefore decided to study mean forced expiratory flow between 25% and 75% of the FVC (FEF_{25-75}) as well, as this parameter is known to reflect changes in small airways.[9] Hand pickers and a control group with low dust exposure were compared. In addition, we compared hand pickers working with and without tables.

METHODS

Study Design and Study Setting

All of the participants included in this study were female. A comparative cross-sectional study was conducted during May to October 2016 among hand pickers with sorting tables working in Addis Ababa, and hand pickers without tables in Oromia and SNNPR primary coffee-processing factories. Hand pickers from 12 primary coffee-processing factories were included, four factories from each of the three regions. The number of hand pickers varied from factory to factory, ranging from 40 to 70. In addition, women from three water-bottling factories—one from each of the three study areas—were selected as a control group. The workers in the water-bottling factories were chosen, as there are no specific dust-emitting processes in this industry, and we thus assumed that they were exposed to less dust at work. The workers in the water bottling factories and the coffee production factories were assumed to have a similar socioeconomic status.

Dust Sampling

The number of personal dust samples was calculated based on Rappaport and Kupper,[10] who suggested repeated samples from 5 to 10 randomly selected individuals per similar exposure group (SEG). We assumed that hand pickers working without tables in each of the eight factories perform similar tasks, and that they were considered to constitute one SEG. Hand pickers working with tables in each of the four factories perform similar tasks, and were assumed

FIGURE 2. Hand pickers working on the ground, without tables (Photo: S. W. Abaya).

to constituent another SEG. However, as we did not know whether there were any differences between the factories, we sampled individuals from each factory. Five hand pickers were thus randomly selected for dust sampling in each factory, for two consecutive days. In total, 40 dust samples were taken from hand pickers with tables and 80 samples from pickers without tables.

Full-shift personal sampling of total dust was performed in the hand picker's breathing zone, using 25 mm three-piece, closed-faced conductive cassettes (Millipore MAWP 025 AC, Millipore Corp., Bedford, MA) with a cellulose acetate filter (Millipore AAWP02500). The filters were attached to Side Kick Casella pumps with a flow rate of 2 L/min.[11] In addition, five women were randomly selected from each of the three water-bottling factories chosen as controls for dust sampling. In the water-bottling factories, workers from the light-inspection department were chosen as an SEG. Light inspectors check whether the bottled water is properly filled, cleaned, capped, and labeled. The activities in the light-inspection room do not generate dust. Sampling was also performed on two consecutive days for each worker in the water-bottling factories, giving a total of 30 total dust samples. Owing to sampling errors, five dust samples from hand pickers without tables were not included in the analysis. After sampling, the cassettes were capped, put in a box and flown to Norway as hand luggage. The samples were gravimetrically analyzed in the accredited laboratory SINTEF MOLAB in Norway, where the filters had been pre-weighed before sampling. No damage to the box or the samples was registered.

Study Population and Sample Size

The sample size for the respiratory-symptom assessment was calculated using the double population formula, considering a prevalence of morning cough with sputum among workers exposed to coffee dust of 23% and a prevalence among nonexposed workers of 10%.[3] To obtain 90% statistical power for detection of this difference in morning cough with sputum between the two groups, at a significance level of 0.05, we needed 190 hand pickers and 190 controls. As the plan was to compare the prevalence of chronic respiratory symptoms in three groups (ie, hand pickers with tables, hand pickers without tables, and controls), 190 participants from each of the three groups were included, making the total number of participants 570. In the respective groups, the number of participants selected was in proportion to the size of the factories. Lists of workers were available for the researchers who selected the workers, with no knowledge about their health status or dust exposure levels.

The number of hand pickers without tables selected from each factory was in proportion to the size of the eight primary coffee-processing factories in Oromia and SNNPR, to produce the requisite total of 190. Similarly, the selected number of hand pickers with tables was in proportion to the size of the four primary coffee-processing factories in Addis Ababa, to be added up to produce the figure of 190. In addition, 190 controls were selected in proportion to the size of the three water-bottling factories. When the number of workers required from each factory had been settled, the workers were selected from the registration lists of workers in each factory using the systematic random sampling method. Only women were invited to take part in the study, as only women work as hand pickers in Ethiopia. In the control group, too, only women were asked to participate.

DATA COLLECTION

Chronic Respiratory Symptoms Interview

Face-to-face interviews were held. The questionnaire included background data (age, smoking habits (ever smoked: yes/no), occupational history (years of work experience in the present dusty factory and other dusty factories), and past respiratory diseases (pneumonia, tuberculosis, bronchitis, asthma, and chest injury), as well as questions about the use of respiratory protective devices (RPDs) while working (yes/no) and the reason for not using RPDs. The questionnaire also included questions about the type of fuel used for cooking and the cooking place (kitchen inside or outside living room). Furthermore, the questionnaire included questions about chronic respiratory symptoms using a standardized questionnaire adopted from the American Thoracic Society (ATS),[12] with the following symptoms: cough, cough with sputum, breathlessness, work-related shortness of breath, wheezing, and chronic bronchitis.

The questionnaire was translated from English into Amharic and Afan Oromo languages, then back into English. A preliminary test was conducted before the actual data collection for validation of the data collection tool. The question about wheezing was not easy for the participants to understand, so we rephrased it, using the appropriate local term for the symptom. The data were collected by the principal investigator together with an experienced research assistant who was trained for this task.

Operational Definitions

Cough participants were considered to have cough if they answered ''yes'' to at least one of the following four questions: cough first thing in the morning, cough during the day or night, cough as much as four to six times a day for a week, or cough on most days for as much as three consecutive months of the year.

Cough with sputum participants were considered to have a cough with sputum if they answered ''yes'' to at least one of the following four questions: cough with sputum first thing in the morning, cough with sputum during the day or night, cough with sputum as much as four to six times a day for a week, or cough with sputum for most days for as much as three consecutive months of the year.

Breathlessness participants were considered to be experiencing breathlessness if they were troubled by shortness of breath when hurrying on level ground or walking up a slight hill, or got short of breath when walking at their own pace on level ground or when walking with other people of their own age on level ground.

Work-related shortness of breath participants were considered to be experiencing work-related shortness of breath if they usually experienced chest tightness while at work or just after work.

Wheezing participants were considered to be experiencing wheezing if their chest ever sounded wheezy (whistling sound).

Lung-Function Test

The sample size for lung function was calculated using the mean difference formula for FEV_1/FVC. We expected 0.027 mean difference and 0.05 standard deviation among female coffee workers and controls in water-bottling factories.[13] A significance level of 0.05 and 80% power were used to calculate the sample size. After considering 10% nonresponse, we needed 60 hand pickers and 60 controls. As the plan was to compare lung-function parameters in three groups (ie, hand pickers with tables, hand pickers without tables, and controls), 60 participants from each of the three groups were included, making the total number of participants 180. Ten hand pickers from each of the 12 primary coffee-processing factories and 20 participants from each of the three water-bottling factories were selected by means of the systematic random sampling method, using the workers' registration list as a sampling framework for each factory. Lung-function tests were conducted in accordance with the ATS recommendation regarding spirometry[14] using a portable spirometer (SPIRARE 3 sensor model SPS 320, Diagnostica AS, Oslo, Norway). The standing height and weight of the participants were measured using the Seca 786 weight and height scale (Seca Hamburg, Germany). The test was performed with the worker in a sitting position. The tests were conducted during the day shift from 2 AM to 4 PM.

TABLE 1. Characteristics of Participants

Variables	All Hand Pickers $n = 374$	Controls $N = 175$	Significance Level: All Hand Pickers Versus Controls	Hand Pickers with Tables $n = 185$	Hand Pickers Without Tables $n = 189$	Significance Level: Hand Pickers Without Tables Versus With Tables
Age, years: AM (range)	29.6 (18–60)	25.7 (18–46)	<0.001†	31.9 (18.0–55.0)	27.5 (18.0–60.0)	<0.001†
Height, m: AM (range)	1.6 (1.3–1.8)	1.6 (1.4–1.7)	0.03†	1.6 (1.4–1.8)	1.6 (1.3–1.8)	0.25†
Weight, kg: AM (range)	51.9 (35.1–94.3)	53.0 (39.2–95.1)	0.14†	53.6 (35.2–94.3)	50.2 (35.1–78.8)	<0.001†
BMI, kg/m^2: AM (range)	21.2 (14.2–36.7)	21.4 (14.8–32.9)	0.59†	21.8 (15.2–36.7)	20.7 (14.2–27.6)	<0.001†
Duration of employment at present work years: AM (range)	5.3 (1.0–38.0)	3.97 (1.0–15.0)	<0.001†	5.9 (1.0–38.0)	4.7 (1.0–23.0)	0.06†
Education						
Unable to read and write	122 (32.6)	1 (0.5)	<0.001$	71 (34.6)	51 (22.8)	0.04$
Primary and junior secondary education	205 (54.8)	33 (17.4)		90 (43.9)	115 (51.3)	
Secondary education and above	47 (12.6)	141 (74.2)		24 (11.7)	23 (10.3)	
Cooking						
Cooking food at home: *n* (%)	369 (98.7)	172 (98.3)	0.71 ±	184 (99.5)	185 (97.9)	0.37 ±
Kitchen located inside the living room: *n* (%)	118 (32.0)	57 (33.1)	0.79$	48 (26.1)	70 (37.8)	0.02$
Use biomass for cooking: *n* (%)	357 (96.7)	164 (95.3)	0.42$	178 (96.7)	179 (96.8)	0.99$
Pesticide use						
Sprayed pesticide in the past	2 (0.5)	0	*N*	0	2 (1.1)	*N*
Previous respiratory disease						
Bronchitis: *n* (%)	10 (2.7)	0	*N*	4 (2.2)	6 (3.2)	0.75 ±
Pneumonia: *n* (%)	18 (4.8)	5 (2.9)	0.29$	10 (5.4)	8 (4.2)	0.59$
Pleurisy: *n* (%)	1 (0.3)	1 (0.6)	*N*	1 (0.5)	0	*N*
Tuberculosis: *n* (%)	7 (1.9)	0	*N*	4 (2.2)	3 (1.6)	*N*
Asthma: *n* (%)	11 (2.9)	5 (2.9)	0.95$	7 (3.8)	4 (2.1)	0.34$
Chest injury; *n* (%)	5 (1.3)	1 (0.6)	*N*	2 (1.1)	3 (1.6)	*N*
Participants who have had at least one of the respiratory diseases: *n* (%)	44 (11.8)	11 (6.3)	0.04$	24 (13)	20 (10.6)	0.47$

n: number of study participants. † Independent t test; $ Pearson chi-square test; ± Fisher's exact test to compare hand pickers with table and without table and to compare each hand-picker group with controls, N: not calculated, owing to low numbers.

FVC, FEV_1, the ratio FEV_1/FVC, and the $FEF_{25-75\%}$ were measured in this study. Three acceptable maneuvers with consistent (''repeatable'') results were retained, and the best one was recorded. Repeatability means that the difference between the largest and second-largest values should be within 150 mL.[15] Participants with a ratio of FEV_1/FVC less than 0.70 were considered to be experiencing airflow limitation.[16]

A total of 15 spirometer results (five from hand pickers with tables, four from hand pickers without tables, and six from controls) were excluded from analysis owing to unacceptable readings.

Data Management and Analysis

EpiData 3.1 (EpiData Association, Denmark) was used to enter the data, which was then exported to SPSS Version 22 (IBM Corp., Armonk, NY) for analysis. Data were encoded, and no names were included in the database. The code list and the data were kept confidential. Body mass index (BMI) was calculated for each of the three groups.

Independent *t* tests were used to compare continuous variables in one group with those in the other group. The Pearson Chi-square test was used to test differences in the prevalence of respiratory symptoms and other categorical variables between the groups. Fisher exact test was used for comparisons of categorical variables when the variables had values of less than 5. A linear mixed-effects regression model with a variance component structure was used to analyze for any difference in dust-exposure level between hand pickers with tables and those without. In this model, employee ID was entered as a random factor and exposure group as a fixed factor. Poisson regression analyses with robust variance were used to determine the prevalence ratio of different respiratory symptoms in hand pickers and controls, adjusting for age, education level, previous respiratory disease, and kitchen located inside the house. The variables were included in the analyses, as they showed significant differences between the groups. Multiple linear regression analyses were used to compare the mean lung-function parameters in hand pickers with those in controls, adjusting for age, height, education level, previous respiratory disease, and kitchen located inside the house. In all tests, *P* values of less than 0.05 were considered to be statistically significant.

Ethical Approval

The Institutional Review Board of the College of Health Sciences at Addis Ababa University and the National Research Ethical Review Committee of the Ethiopian Ministry of Science and Technology approved the study. Permission to conduct the study was obtained from the factory managers. Written informed consent was obtained from each participant, and participation in the study was voluntary.

RESULTS

Characteristics of the Study Participants

All participants were females, with a mean age of 28.4 years, ranging from 18 to 60. A total of 549 individuals participated in this study, making the response rate 98.4% for hand pickers and 92.1% for controls. None of the participants were current or former smokers. Control workers had a significantly higher education level and were younger than the hand pickers, but no statistical difference was found in terms of the duration of previous work in dusty factories or in use of biomass for cooking, comparing controls and hand pickers. The mean duration of work as hand picker was 5.3 years (Table 1). There was no significant difference in mean years work experience between hand pickers with tables and without tables.

The group of hand pickers without tables included significantly more people unable to read and write, and they more frequently had a kitchen inside the living room than was the case for hand pickers with tables (Table 1). The weight and BMI of hand pickers with tables was significantly higher than in hand pickers without tables (Table 1).

Use of Respiratory Protective Device

Only three hand pickers used any type of RPD. The majority of those not using RPD ($n = 368$; 99%) indicated that the reason for not using one was that none was available or provided at the workplace. During dust sampling, we observed that some hand pickers used a piece of cloth to cover their mouth and nose, otherwise no RPDs were to be seen.

Dust Exposure Level

Personal total dust exposure was significantly higher among hand pickers (GM = 1.1 mg/m^3) than among controls (0.2 mg/m^3) ($P < 0.001$) (Table 2). There was no significant difference in exposure level between hand pickers with tables (1.4 mg/m^3) and those without (1.0 mg/m^3) ($P = 0.19$).

Chronic Respiratory Symptoms

Hand pickers displayed a significantly higher prevalence of most of the chronic respiratory symptoms than controls (Table 3). The highest prevalence ratio for hand pickers relative to controls was for cough [PR = 3.0, 95% confidence interval (95% CI): 1.4 to 6.2], followed by work-related shortness of breath (PR = 2.5, 95% CI: 1.1 to 5.6). For most of the chronic respiratory symptoms, hand pickers without tables displayed a significantly higher prevalence ratio than in hand pickers with tables (Table 3).

TABLE 2. Personal Total Dust Exposure Among Two Groups of Hand Pickers of Coffee and a Control Group From Water-Bottling Factories in Ethiopia

				Total dust exposure (mg/m^3)		
Activity	NW	NS	Sampling Time (min) AM (range)	AM (range)	GM (GSD)	No (%) > 5mg/m^3 (OEL)
All hand pickers	60	115	406 (320–479)	1.6 (0.12–9.74)	1.1 (2.4)	3 (2.6)
Hand pickers with tables	20	40	395 (330–463)	1.6 (0.65–4.6)	1.4 (1.7)	0
Hand pickers without tables	40	75	413 (320–479)	1.5 (0.12–9.74)	1.0 (2.7)	3 (4)
Controls	15	30	421 (337–476)	0.2 (0.11–0.45)	0.2 (1.3)	0

All hand picker, includes both types of hand pickers (hand pickers with table and hand pickers without tables); AM, Arithmetic mean; controls, workers in water bottling factories; GM, Geometric mean; GSD, Geometric Standard Deviations; Hand pickers with table, sort coffee beans on a long table or a conveyor belt while sitting inside the processing machine room on chairs 40 to 50 cm high; Hand pickers without tables, perform their work while sitting on the ground, either outdoors on a veranda or in a separate room; mg/m3, Milligram per meter cube; No, Number of participants; NS, number of dust samples; NW, number of workers; OEL, Occupational exposure limit – 5 mg/m^3.

TABLE 3. Frequency of Chronic Respiratory Symptoms Among Two Groups of Hand Pickers of Coffee and a Control Group Exposed to a Low Dust Level

	All Hand Pickers n = 374	Controls n = 175	All Hand Pickers versus Controls	Hand Pickers With Tables n = 185	Hand Pickers Without Tables n = 189	Comparing Hand Pickers Without Tables With Hand Pickers With Tables
Variables	n (%)		Prevalence Ratio (95% confidence interval)	n (%)		Prevalence Ratio (95% confidence interval)
Cough	78 (20.9)	12 (6.9)	3.0 (1.4–6.2)	28 (15.1)	50 (26. 5)	2.0 (1.3–3.1)
Cough with sputum	26 (7.0)	4 (2.3)	–	7 (3.8)	19 (10.1)	3.9 (1.6–9.5)
Breathlessness	130 (34.8)	37 (21.1)	1.7 (1.1–2.5)	63 (34.1)	67 (35.4)	1.2 (0.9–1.6)
Wheezing	47 (12.6)	8 (4.6)	2.1 (0.9–4.8)	13 (7.0)	34 (18)	2.3 (1.3–4.3)
Work-related shortness of breath	69 (18.4)	13 (7.4)	2.5 (1.1–5.6)	25 (13.5)	44 (23.3)	1.8 (1.1–2.8)
Chronic bronchitis	3 (0.8)	0	–	0	3 (1.6)	–

n: number of participants; prevalence ratio adjusted for age, educational level, cooking inside the living room and previous respiratory diseases; the prevalence ratio was calculated when the number of symptoms in the control group was over 5.

Lung Function

There were no statistical differences in FVC, FEV_1, FEV_1/FVC, or in the prevalence of airflow limitation between controls and hand pickers (Table 4). However, there was significant difference in FEF_{25-75} between hand pickers and controls, with lower values among the hand pickers. Furthermore, FVC, FEV_1, and FEF_{25-75} were significantly lower among hand pickers without tables than among hand pickers with tables, after adjusting for age, height, educational level, cooking inside the living room, and previous respiratory disease (Table 4). The prevalence of airflow limitation among hand pickers without tables was also higher (12.5%) than among hand pickers with tables (7.3%), but not significant (Table 4).

DISCUSSION

The hand pickers had experienced a higher level of dust exposure, had more respiratory symptoms, and a lower FEF_{25-75} than the controls. Hand pickers without tables displayed a higher prevalence of respiratory symptoms and a lower level of lung function than hand pickers with tables, but there was no difference in dust exposure between these groups.

The personal total dust exposure (GM) of 1.1 mg/m^3 among the hand pickers in the present study is comparable to that in a previous study conducted among hand pickers in primary coffee-processing factories in Tanzania (0.9 mg/m^3).[4]

The prevalence of almost all respiratory symptoms in the hand pickers was higher than among the controls. Our findings were consistent with previous studies conducted in Ethiopia, Tanzania, Uganda, and Papua New Guinea, which reported a higher prevalence of respiratory symptoms among coffee-processing workers than in controls.[3,6,7,17] However, it is difficult to compare these findings with those for the present study, as these previous projects studied male workers in the processing areas with considerably higher dust exposure, and did not include female hand pickers. In the present study, the prevalence of respiratory symptoms such as cough and cough with sputum for both groups of hand pickers was lower than among male Ethiopian coffee-production workers, where the prevalence was 46.4% and 23.2%, respectively.[17] This difference in symptom prevalence might be related to the difference in dust exposure level.

The present study found a higher prevalence of almost all respiratory symptoms, as well as a lower FVC, FEV_1, and FEF_{25-75}

TABLE 4. Lung-Function Parameters Among Two Groups of Hand Pickers in Primary Coffee-Processing Factories and Controls Exposed to a Low Dust Level

			All Hand Pickers vs Controls				Hand Pickers With Table vs Hand Pickers Without Table	
Lung Function Parameters	All Hand Pickers n = 111	Controls n = 54	B (SE)	*P*-value	Hand Pickers With Table n = 55	Hand Pickers Without Table n = 56	B (SE)	*P*-value
FVC – mean (SD)	3.08 (0.59)	3.33 (0.50)	−0.07 (0.11)	0.52*	3.20 (0.63)	2.96 (0.51)	−0.32 (0.10)	0.002*
FEV_1 – mean (SD)	2.43 (0.55)	2.69 (0.41)	−0.07 (0.09)	0.46*	2.53 (0.57)	2.33 (0.51)	−0.29 (0.08)	0.001*
FEV_1/FVC – mean (SD)	0.78 (0.07)	0.81 (0.07)	−0.01 (0.02)	0.57*	0.79 (0.07)	0.78 (0.07)	−0.02 (0.01)	0.18*
FEF_{25-75} – Mean (SD)	2.08 (0.63)	2.72 (0.73)	−0.40 (0.12)	0.001	2.16 (0.50)	2.01 (0.73)	−0.26 (0.09)	0.01*
FEV_1/FVC<0.70 n; (%)	11 (9.9)	2 (3.7)	–	0.23†	4 (7.3)	7 (12.5)	–	0.36‡

B, beta coefficient in multiple linear regression; n, number of workers participated in the study; SE, standard error; FEF_{25-75}, mean forced expiratory flow between 25% and 75% of the FVC; FEV_1, forced expiratory volume in 1s; FEV_1/FVC, the ratio of forced expiratory volume in 1s to forced vital capacity; FVC, forced vital capacity; *P*-value, 95% significance level; SD, standard deviation.

*Linear regression between hand pickers and controls as well as between hand pickers with table and without tables while adjusting for age, height, educational level; cooking inside the living room and previous respiratory disease.

†Fisher exact test.

‡Chi-square test.

among hand pickers without tables than in pickers with tables. One possible reason could be that there are differences in the type of coffee used in these two hand-picking groups. Hand pickers without tables handle coffee beans processed using the dry method on the farms, while hand pickers with tables handle coffee beans processed using either the wet or the dry method. The methods may influence the content of the dust inhaled during the hand-picking work.[13] Future studies should assess the content of the dust—bacteria, fungi, and endotoxins—in addition to the total dust levels.

FVC, FEV_1, and FEV_1/FVC measured among hand pickers were not significantly different to those in controls. However, there was significant difference in FEF_{25-75} between hand pickers and controls. This indicates obstruction of small airways among the hand pickers, which is likely to be caused by the organic coffee dust they are exposed to.[18] This parameter has not been studied among coffee workers before. However, a Tanzanian study found a significant difference in FEV_1/FVC between coffee workers and controls,[13] suggesting that work in coffee factories is associated with a low but significant level of lung-function impairment. The study did not, however, involve hand pickers, and the production workers were engaged in other parts of the coffee processing. Also, the workers examined were males. In addition, the findings from this Tanzanian study might be related to differences in type of coffee, post-harvest processing method at the farm, working conditions, and dust exposure level compared with what we have in Ethiopia. In Tanzania, both Robusta and Arabica coffee were processed, while only Arabica coffee was processed in Ethiopia. Similarly, in Tanzania, Arabica coffee was mostly processed on the farm using the wet method, while Robusta coffee was processed using the dry method. In Ethiopia, Arabica coffee is processed using both the wet and the dry method, depending on the individual farmer. In a previous study among male coffee workers (ie, machine room and transport workers), we found that coffee workers in the age groups 28 to 39 and at least 40 had a significantly lower FVC and FEV_1 than the controls in the similar age groups. This might be related to a higher dust-exposure level.[17]

Respiratory symptoms were self-reported, and the method has weaknesses, as the workers might not remember their symptoms or might be biased owing to the focus on dust at their workplace. On the contrary, this was also the situation for the control group, and use of a control group that experienced lower exposure was a strength of this study. The questionnaire method might be a weakness, but it is a good method for obtaining indications of health problems at an early stage, before a serious disease has developed. This is important in studies of workers, as they often represent the ''healthy workers,'' that is, the ones who have not become ill.

We used validated questions concerning chronic respiratory symptoms, but the answers might also represent acute symptoms. It is often difficult to differentiate between these two categories of symptoms, as they frequently occur at the same time.[19] The results clearly indicate that these workers experience symptoms that should not occur at a workplace, and their work environment should be further examined. However, the design of this study was cross-sectional, and no clear causal relationship between coffee-dust exposure and respiratory symptoms can be concluded. This also means that factors other than dust may be present, and may cause the symptoms registered.

CONCLUSION

Hand pickers had experienced higher dust exposure, displayed a higher prevalence of almost all respiratory symptoms, and lower FEF_{25-75} than the controls. Hand pickers without tables displayed a higher prevalence of almost all respiratory symptoms and a lower level of lung function than hand pickers with tables.

ACKNOWLEDGMENTS

We would like to thank the coffee-factory management teams and workers for their permission to conduct the study and for participating in the study. We thank the Norwegian Program for Capacity Building in Higher Education and Research for Development (NORHED) for their support.

REFERENCES

1. Musebe R, Agwanda C, Mekonen M. Primary coffee processing in Ethiopia: patterns, constraints and determinants. *Afr Crop Sci Conf Proc*. 2007; 8:1417–1421.
2. Schwan R, Silva C, Batista L. Coffee fermentation. In: Hui Y, editor (s). Plant-Based Fermented Food and Beverage Technology. 2nd ed. London: CRC Press; 2012. p. 367–396.
3. Sakwari G, Bråtveit M, Mamuya SHD, Moen BE. Dust exposure and chronic respiratory symptoms among coffee curing workers in Kilimanjaro: a cross sectional study. *BMC Pulm Med*. 2011;11:54–61.
4. Moen B, Kayumba A, Sakwari G, Mamuya S, Bråtveit M. Endotoxin dust and exhaled nitrogen oxide among hand pickers of coffee; a cross-sectional study. *J Occup Med Toxicol*. 2016;11:17.
5. Zuskin E, Vali F, Skuri Z. Respiratory function in coffee workers. *Br J Ind Med*. 1979;36:117–122.
6. Smith D, Brott K, Kokisource G. Respiratory impairment in coffee factory workers in the Asaro valley of Papua New Guinea. *Br J Ind Med*. 1985;42:495–498.
7. Sekimpi K, Agaba E, Okot-Nwang M, Ogaram D. Occupational coffee dust allergies in Uganda. *Afri News Occup Health Safety*. 1996;6:6–9.
8. Uragoda C. Acute symptoms in coffee workers. *J Trop Med Hyg*. 1988; 91:169–172.
9. Raji H, Shoushtari MH, Idani E, et al. Forced expiratory flow at 25–75% as a marker for airway hyper responsiveness in adult patients with asthma-like symptoms. *Tanaffos*. 2018;17:90–95.
10. Rappaport S, Kupper L. Quantitative Exposure Assessment. El Cerrito, Calif.: S. Rappaport, c2008; 2008, ISBN 978-0-9802428-0-5.
11. Occupational Safety and Health Administration. OSHA Technical Manual: Section ii, Chapter 1: Personal Sampling for Air Contaminants. Occupational Safety and Health Administration; 2014 Available at: https://www.osha.gov/dts/osta/otm/otm_ii/otm_ii_1.html#total_dust. Accessed November 25, 2018.
12. American Thoracic Society – Division of Lung Diseases. Recommended Respiratory Disease Questionnaires for Use with Adults and Children in Epidemiological Research. ATS. 1978. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.607.2516&rep=rep1&type=pdf. Accessed November 15, 2018.
13. Sakwari G, Mamuya S, Bråtveit M, Moen B. Respiratory symptoms, exhaled nitric oxide, and lung function among workers in tanzanian coffee factories. *J Occup Environ Med*. 2013;55:544–551.
14. American Thoracic Society. Standardization of spirometry, 1994 update. American Thoracic Society. *Am J Respir Crit Care Med*. 2005; 152:1107–1136.
15. National Institute for Occupational Safety and Health (NIOSH). Spirometry Quality Assurance: Common Errors and Their Impact on Test Results. Health and human service. 2012. Available at: https://www.cdc.gov/niosh/docs/2012-116/pdfs/2012-116.pdf. Accessed November 15, 2018.
16. Pauwels A, Buist S, Calverley A, Jenkins R, Hurd S. Globally strategy for the diagnosis management and prevention of chronic obstructive pulmonary disease: NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. *Am J Respir Crit Care Med*. 2001;163:1256–1276.
17. Abaya S, Bråtveit M, Deressa W, Kumie A, Moen B. Reduced lung function among workers in primary coffee processing factories in Ethiopia: a cross sectional study. *Int J Environ Res Public Health*. 2018;15:pii: E2415.
18. Burgel P, Bergeron A, Blic J, et al. Small airways diseases, excluding asthma and COPD: an overview. *Eur Respir Rev*. 2013;22:131–147.
19. Lätti MA, Pekkanen J, Koskela H. Defining the risk factors for acute, subacute and chronic cough: a cross-sectional study in a Finnish adult employee population. *BMJ Open*. 2018;8:e022950.

