Respiratory Symptoms and Dust Exposure Among Male Workers in Small-Scale Wood Industries in Tanzania

Larama M. B. Rongo, MSc
Anoek Besselink, MSc
Jeroen Douwes, PhD
Françoise Barten, PhD
Gernard I. Msamanga, ScD
Wil M.V. Dolmans, PhD
Paul A. Demers, PhD
Dick Heederik, PhD

Few studies have assessed respiratory symptoms and dust exposure levels in small-scale wood industry workers in Africa. We interviewed 546 workers exposed to wood dust and 565 control subjects using a respiratory health questionnaire. Inhalable dust measurements were collected for 106 workers. The dust exposure was high, and job title–based geometric mean exposure levels ranged from 2.9 to 22.8 mg/m^3. Prevalence of respiratory symptoms in the previous 12 months was significantly higher in the exposed group compared with the nonexposed office workers. Allergy and sensitivity symptoms were reported regularly in the exposed group with Odds ratios and 95% confidence intervals (CIs) varying from 2.4 (95% CI = 1.8–3.1) for low-and 2.7 (1.8–4.0) for high-exposure groups compared with controls. We conclude that working in the small-scale wood industry in Tanzania is associated with an increased prevalence of respiratory symptoms. (J Occup Environ Med. *2002;44:1153–1160*)

Hardwood is the common name given to broad-leaved trees, classified botanically as *Angiosperms*, whereas softwood is the common name given to conifers, classified botanically as *Gymnosperms*.[1] In the 1990s, nearly 5% of hardwood and 89% of softwood produced in Tanzania (by volume) was processed in either large- or small-scale industries.[1] Large-scale wood industries in Tanzania process mostly softwood, whereas small-scale wood industries (SSWI) process a mixture of hard and softwoods. The SSWI are mostly found in the informal sector. The term informal sector is defined broadly to refer to very small-scale private units employing less than 10 people and involved in the production of goods and services for sale in both rural and urban areas.[2]

Workers in SSWI are exposed to many hazards, including exposure to wood dust and specific agents herein. Workers exposed to wood dust have an increased risk of developing occupational asthma[3–5] lung function deficits,[6] and respiratory symptoms.[1,5–10] Respiratory symptoms and lung function changes have been associated with a variety of different species of hard and softwoods. Asthma, for instance, has been associated with exposure to both softwood dusts from eg, Eastern white cedar[11,12] Western red cedar,[13] and pine[5] and hardwood dust from eg, iroko/teak, blood wood (*Pterocarpus angolensis*], mahogany (Khaya spp.) and *Tanganyike aningre*. Many of these studies have been conducted in

From the Community Health Department, Muhimbili University College of Health Sciences, Tanzania (Mr Rongo, Dr Msamanga); Institute for Risk Assessment Sciences, Division of Environmental and Occupational Health, Utrecht University, The Netherlands (Mr Rongo, Ms Besselink, Dr Douwes, Dr Heederik); Nijmegen Institute for International Health (NIIH), University of Nijmegen, The Netherlands (Mr Rongo, Dr Barten, Dr Dolmans); and School of Occupational and Environmental Hygiene, University of British Columbia, Vancouver, Canada (Dr Demers).

Funding of this study was provided by the Netherlands Foundation for the Advancement of Tropical Research (WOTRO).

Address correspondence to: Mr Larama M.B. Rongo, Nijmegen Institute for International Health, P.O. Box 9101–103, 6500 HB Nijmegen, The Netherlands; e-mail: rongolmb@yahoo.com.

DOI: 10.1097/01.jom.0000044118.59147.c9

large-scale industries in developed countries. However, to our knowledge, only three studies have been conducted in the continent of Africa.[7,9,10] Shamssain[7] assessed lung function and respiratory symptoms among 145 nonsmoking workers exposed to wood dust in a furniture factory in Umtata, Republic of Transkei, and 152 nonsmoking controls subjects from bottling factory. The exposed workers had more respiratory symptoms than the control subjects. In this study, no dust exposure was evaluated.[7] Fatusi and Erhabor[9] evaluated the health impact of exposure to saw dust on 59 sawmill workers from Southwest Nigeria using a respiratory symptoms questionnaire. A high prevalence of respiratory symptoms was common in the exposed subjects compared with nonexposed subjects.[9] Ige and Onadeko[10] assessed occupational-induced lung impairment in 500 saw mill workers as result of exposure to sawdust using a questionnaire compared with 500 workers from University College Hospital. Lung function was lower in forced vital capacity (FVC) saw millers than the control subjects.[10] Because industrial hygiene has been developed only poorly in developing countries and particularly in the SSWI, it is expected that exposures may be high and therefore health risks may also be increased. The three African studies are of little relevance for the situation in the SSWI in Tanzania because other tree species were involved and the study population came not from SSWI but from larger industrial operations.

The objective of the study was to assess respiratory symptoms and dust exposure among workers in SSWIs. We have conducted a questionnaire survey assessing the prevalence of respiratory symptoms among workers exposed to both softwood and hardwood dust and nonexposed workers. Dust exposure was characterized by taking personal measurements.

Methods

Subjects

We did a walk-through survey in all Dar es Salaam City Municipalities and prepared a list of all SSWIs (400), ie, 103 in Ilala Municipality, 126 in Kinondoni, and 171 in Temeke, with a population of 2000 workers. All industries of interest were identified. We got clearance from the owners or heads of workshops (121) selected randomly to continue with the respiratory symptoms study. More than 90% of these SSWIs were located near the main roads to attract customers with the exception of those in Gerezani in Ilala Municipality (n = 103). We randomly sampled 121 industries in all the three municipalities in proportion to the number of industries; 31, 38, and 52 industries for Ilala, Kinondoni, and Temeke municipalities, respectively. The workers of industries selected were informed in details the purpose of the study and requested to declare for participation. From the selected industries, 601 woodworkers (all workers from the random sample of 121 industries) and 600 nonexposed workers from nearby offices agreed to participate in a respiratory health questionnaire. After the interviews, some were excluded from the analysis because several answers were not recorded, women were excluded from the study because only very few participated, and we finally were left with 546 (91%) and 565 (94%) exposed and nonexposed workers, respectively.

SSWIs

The characteristics of these SSWIs are different from those found in large-scale industries in developed countries. Most of the industries consist of a temporary shelter with four poles supporting a roof thatched with old corrugated iron sheets or palm leaves. Most of the tasks there were done manually. The only small-scale industries with permanent shelters were the ones fitted with wood machinery. No exposure control equipment, such as exhaust ventilations, were fitted in any of the workshops. The wood machine operators received tasks from other SSWIs using hardwood that is difficult to process manually. The tasks commonly performed are planing, sawing, carving, and drilling hardwood, like East African teak trees (*Chlorophora excelsa*), mahogany (*Khaya nyasiga*), blood wood (*Pterocarpus angolensis*), East African camphor (*Ocotea usambarensis*),[14] East African Afzelia Burl (*Afzelia quanzensis*), "mtanga" (*Albizia ssp*), African pencil cedar (*Juniperus procera*), African blackwood (*Dulbergia melanoxylon*), and "kawilia" (*Grevillea robusta*). Podo (*Podocarpus gracilion*), cypress (*Taxodium distichium*), and pine (*Pinus patulla*) are the commonly used softwood species. Some species of soft wood (cypress, podo, pine) and hard wood like (teak, *Grevillea robusta*) have been imported in the past and are nowadays farmed.

Questionnaire

A physician competent in English and Kiswahili translated the questionnaire into Kiswahili, the National language of Tanzania. Another physician translated it into English and it was compared with the original. No differences of importance for the meaning of the questions were seen. We employed research assistants (intern doctors) to pretest the questionnaire and then assisted in data collection. We interviewed all the workers using a questionnaire and consisted of three parts, including 1) personal and work characteristics; 2) respiratory health symptoms; and 3) smoking habits (current and exsmokers). The respiratory health questions were adopted from a recent study conducted by Douwes and colleagues,[15] which was based on an international study of asthma and allergies in Childhood (ISAAC),[16] the British Research Council questionnaire (BMRC),[17] and the European Community Respiratory Health Survey (ECRHS)[18] and supple-

mented with additional questions to assess whether symptoms were work related (eg, do symptoms lessen or disappear over the weekend or during holidays). Moreover, several questions on nose, eye, and skin irritation and questions on the frequency of symptom occurrence were included. We considered to use the ECRHS definition,[18] which is based on the proportion of subjects answering "yes" to: 1) whether they were awakened by shortness of breath in the last 12 months; 2) had an asthmatic attack in the last 12 months; or 3) were currently on asthma medication. However, medication use is low in Tanzania because it is costly and most workers have no health care insurance to cover expenses, and this approach would therefore lead to biased estimates in this study and was therefore not considered useful.

Dust Sampling

A random sample of 106 exposed workers in SSWI participated in inhalable dust measurements. One hundred and six full-shift (7 to 9 hours) inhalable dust samples were collected from employees with a broad range of job titles: in the woodwork machine operators (planing, sawing, drilling, carving, joinery, and servicing); in carpentry work (planing, sawing, drilling, joinery, polishing/varnishing, and sanding manually); and in workshop cleaning manually. Measurements were taken from 8.00 to 17.00 hours from Monday to Saturday. Dust particles were sampled on glass fiber filters at a flow rate of 2.0 L per minute using portable pumps (Casella) and the Institute of Occupational Medicine (IOM) heads attached to the workers' collar close to the breathing zone.[5] The filters were pre- and postweighed on an analytical balance (0.01 mg sensitivity). Response rate was nearly 100%. Twenty-two workers were not included in further analysis because they got tasks not completely related to woodwork such as sewing and key making, or they were excluded because they were not assigned any work to do during the sampling period.

Exposure Categories

Dust exposure categories that were based on workers area and job title were formed on the basis of observations during a walk-through survey before taking actual measurements. Five exposure categories were distinguished: 1) nonexposed (office workers near SSWIs); 2) low exposure (workers planing and sawing manually); 3) medium exposure (machine drilling, planing, and sawing); 4) high exposure (workers carving using wood machines, cleaning the workshops, and repairing the wood machines), and 5) others (key making, machine sewing, manual sewing, tax collecting, and those waiting for job opportunities). Dust measurements were used to obtain levels for these exposure categories except for the category "others."

Analysis

Data were analyzed using statistical analysis software (SAS 6.12; SAS Institute, Cary, NC). The prevalence of respiratory symptoms in the various exposure categories (low, and high [intermediate and high combined]) was compared with nonexposed workers. Odds ratio (OR) and 95% confidence intervals (CIs) were calculated by means of logistic regression analysis to describe the association between exposure and the occurrence of symptoms.[5,19] Associations were adjusted for potential confounders, such as age and smoking status. Statistical significance for different symptoms between smoking and between exposure categories was tested by chi-square analyses.

Results

Table 1 shows dust exposure levels for four categories of wood dust exposure. Because the number of subjects in the high category was small, we categorized the exposed workers into low and high exposure (intermediate and high combined) as shown in Table 2. Workers in the low-exposure category are relatively exposed according to studies in Western Europe and United States (Western World). Workers in the category of "others" were not included in the study for further analysis because they were not involved in jobs related to woodwork. All workers exceeded the limits of 1 mg/m^3 for hardwood, and a quarter exceeded 5 mg/m^3 for softwood as recommended recently by the American Conference of Government Industrial Hygienists (ACGIH) threshold limit value (2001).[20] It was assumed that adverse respiratory health effects are unlikely to occur at exposure levels below this limit. The lowest and highest geometric mean (GM) and geometric standard deviation (GSD) dust exposure levels were GM = 2.9 mg/m^3, GSD = 1.8, and GM = 22.8 mg/m^3, GSD = 2.77, respectively. The overall geometric mean was 3.86 mg/m^3 and geometric standard deviation was 2.33.

Table 2 shows the characteristics of the study population stratified by exposure category. We used chi-square analysis to test whether there was any significant difference between exposed and nonexposed; low exposure and nonexposed; and high exposure and nonexposed. Significant differences existed in age, height, weight, duration of employment in the current job, hours per week of work, smoking status, and daily use of protective equipment. The observed difference of 5% between high-exposure smokers and nonexposed smokers was not statistically significant. A substantial higher percentage of high-exposure workers used respiratory equipment compared with low-exposure workers. Office workers (1.4%) were daily wearing respiratory protective equipment because they were selling some of the volatile materials used in wood workshops, such as solvents, varnish, and polish, as well as machine lubricants in small quantities.

TABLE 1
Dust Concentration (GM in mg/m^3 and GSD) for Various Exposure Groups and by Job Title in SSWI in Dar es Salaam, Tanzania

Exposure Category	Tasks	*n*	GM	GSD	Min–Max
Total		106	3.86	2.33	0.90–52.44
Low		58	2.92	1.78	1.22–15.78
	Carpentry manual	8	2.86	1.52	1.33–6.15
	Planing manual	32	3.13	1.97	1.30–15.78
	Planing/drilling manual	2	2.69	1.06	2.57–2.81
	Planing/sawing manual	10	2.32	1.62	1.22–6.59
	Sanding manual	2	3.28	1.20	2.89–3.72
	Sawing manual	4	2.99	1.48	1.84–4.59
Medium		19	6.86	2.03	2.78–27.43
	Drilling machine	2	5.58	1.17	5.00–6.22
	Planing machine	4	8.36	2.78	2.78–27.43
	Planing/sawing machine	7	7.78	2.03	4.04–26.63
	Sawing machine	6	5.57	1.97	2.85–15.20
High		7	22.76	2.77	3.99–52.44
	Carving machine	7	22.76	2.77	2.99–52.44
Others‡		22	2.83	1.74	0.90–9.19
	Key making	2	2.05	1.20	2.03–2.07
	Sewing machine	5	2.75	2.00	0.90–5.95
	Sewing manual	1	1.43	–	1.43
	Tax collecting	1	2.67	–	2.67
	Waiting for job task	13	3.18	1.73	1.63–9.19

* GM, geometric mean; GSD, geometric standard deviation; SSWI, small-scale wood industry; Min–Max, minimum to maximum.
‡ Workers in SSWI who were not involved or did not get tasks involving woodwork.

TABLE 2
General Characteristics of Nonexposed Workers and Workers in Various Exposure Categories; Dar es Salaam, Tanzania*

Characteristics	Nonexposed *n* = 565	Total exposed *n* = 546	Low exposure *n* = 415	High exposure *n* = 131
Age (y, SD)	28.0 (8.2)	29.6 (10.0)†	28.8 (9.6)	32.1 (11.1)†
Height (m, SD)	165.6 (8.3)	164.7 (6.7)	164.4 (6.7)†	165.5 (6.5)
Weight (m, SD)	63.6 (9.6)	61.1 (10.2)†	60.5 (10.3)†	62.8 (9.9)
Duration of employment in current job (y, SD)	5.3 (6.1)	6.9 (8.3)†	6.2 (7.4)	9.0 (10.4)†
Hours/week of work (h, SD)	67.6 (15.1)	61.7 (13.7)†	62.8 (13.5)†	58.3 (14.0)
Smokers (%)	23.2	23.6	22.2	28.2
Ex-smokers (%)	9.0	9.0	8.7	9.9
Daily use of respiratory protective equipment (%)	1.4	9.4†	1.7	33.8†

* All workers were male.
† $P < 0.01$, compared with nonexposed group.

Asthma symptoms during the last year were significantly more prevalent in the exposed compared with nonexposed workers ie, shortness of breath with wheezing (OR = 1.9, 95% CI = 1.1–3.4) and were twice as likely to be woken-up by shortness of breath (OR = 2.1, 95% CI = 1.4–3.1) (Table 3). Symptoms of cough (last year) were more common in the low- and high-exposure workers than in the nonexposed group. After adjusting for various confounding factors (age, height, weight, duration of employment in the current job, hours per week of work, daily use of protective equipment), including smoking, the prevalence ratios of cough between exposed and nonexposed were similar (OR = 1.6, 95% CI = 1.2–2.0). A similar pattern was observed for "cough with phlegm" but "were woken-up due to breathlessness" was only significant for the low-exposure group. The prevalence of cough symptoms did not differ in low- exposure compared with high-exposure groups.

Nose, eye, and skin symptoms were more dominant in the high-exposure group (Table 3). Running nose and sneezing in particular were strongly associated with exposure to dust (OR = 3.2, 95% CI = 1.7–6.1 and OR = 2.0, 95% CI = 1.2–3.3) in the high- and low-exposure groups, respectively. Symptoms of allergy/sensitivity to house dust, foods, animals, or grasses/plants were significantly associated with exposure (OR = 2.4, 95% CI = 1.8–3.1 and OR = 2.7, 95% CI = 1.8–4.0) for low- and high-exposure groups, re-

TABLE 3
Symptom Prevalence (%) for Nonexposed Workers and Workers in Various Exposure Categories. ORs were adjusted for age, Current, and Ex-smokers in Dar es Salaam, Tanzania*

Symptom	Nonexposed $n = 565$	Total exposed $n = 546$	OR (CI)‡	Low exposure $n = 415$	OR (CI)‡	High exposure $n = 131$	OR (CI)‡
Cough symptoms in last 12 months							
Cough†	39.5	50.7¶	1.6 (1.2–2.0)¶	50.6¶	1.6 (1.2–2.0)¶	51.1‖	1.6 (1.1–2.4)‖
Coughing up phlegm†	30.3	47.0¶	2.1 (1.6–2.7)¶	47.6¶	2.1 (1.6–2.7)¶	48.1¶	2.1 (1.4–3.1)¶
Woken regularly because of cough	7.8	13.3¶	1.7 (1.2–2.6)¶	14.9¶	2.0 (1.3–3.0)¶	9.2	1.1 (0.6–2.2)
Asthma symptoms in last 12 months							
Wheezing	7.3	9.4	1.3 (0.8–2.0)	10.2	1.5 (0.9–2.3)	6.9	0.8 (0.4–1.8)
Wheezing without a cold	3.5	5.9	1.6 (0.9–2.9)	6.5‖	1.9 (1.0–3.5)‖	3.9	0.9 (0.3–2.4)
SOB with wheezing‡	3.4	6.1‖	1.9 (1.1–3.4)‖	7.0¶	2.3 (1.2–4.1)¶	3.1	0.7 (0.2–2.3)
Woken by SOB‡	8.1	15.9¶	2.1 (1.4–3.1)¶	15.9¶	2.1 (1.4–3.2)¶	16.0¶	2.1 (1.2–3.7)‖
Asthma attack	3.2	2.7	0.8 (0.4–1.7)	2.7	0.8 (0.4–1.8)§	3.1	0.9 (0.3–2.7)
Nose, eye, and skin symptoms							
Runny nose, sneezing >1/week	5.1	11.0¶	2.3 (1.4–3.6)¶	10.1¶	2.0 (1.2–3.3)¶	13.7¶	3.2 (1.7–6.1)¶
Itching, watering eyes >1/week	2.1	4.8‖	2.3 (1.4–4.6)‖	4.3‖	2.2 (1.1–4.7)‖	6.1‖	3.0 (1.2–7.8)‖
Itchy skin, skin rash >1/month	0.2	1.1	6.3 (0.8–52.2)§	1.2‖	6.9 (1.8–59.1)§,¶	0.8	4.3 (0.3–69.8)§
Allergy/sensitivity symptoms							
Sensitive to house dust, food, animal, or grasses/plants	38.1	59.9¶	2.4 (1.9–3.1)¶	59.2¶	2.4 (1.8–3.1)¶	61.8¶	2.7 (1.8–4.0)¶

* All workers were male.
† Daily for at least part of the year.
‡ SOB, shortness of breath; OR (CI), Odds ratio (95% confidence interval).
§ Only a crude odds ratio could be found because the number of subjects for this particular case was to small.
¶ $P \leq 0.01$, ‖ $P \leq 0.05$; compared with the nonexposed group.

spectively. The relations between dust exposure and symptoms were independent of self-reported sensitization, but the prevalence of symptoms was highest among subjects with self-reported sensitization.

Table 4 shows the prevalence and adjusted ORs (for age, current and ex-smokers) for regularly occurring symptoms that lessen during weekends or holidays. Respiratory symptoms (cough, asthma, nose, eye, and skin) occurred once a month in the previous year that disappeared during weekends and holidays were significantly more likely to be reported by exposed compared with nonexposed workers.

When we compared the low- and high-exposure groups with the nonexposed group (Table 4), we found that work related dry cough and cough with phlegm occurred more frequently in the high-exposure group (OR = 4.8, 95% CI = 3.0–7.8; 8.6 [5.2–14.0]) compared with the nonexposed group respectively.

Recurrent asthma symptoms (shortness of breath) (Table 4) were observed more frequently in the exposed than the nonexposed group (OR = 2.9, CI = 1.5–5.6). However, the low-exposure group had a higher prevalence of symptoms than the nonexposed group, whereas in the high-exposure group, the prevalence of symptoms was the same to nonexposed group.

Asthma symptoms (wheezing, shortness of breath, or chest tightness) in relation to work in the last 12 months did not seem to lessen during weekends or holidays when the low and high exposed groups were compared to the nonexposed.

Discussion

In this study, we found an increased prevalence of respiratory symptoms in the exposed SSWI workers compared with nonexposed office workers. A significant increase in symptoms, such as cough; coughing up phlegm; awakened regularly because of cough; shortness of breath with wheezing; awakened by shortness of breath, runny nose, and sneezing more than once a week; itching and watering eyes; and allergy/sensitivity to house dust, food, animals, or grasses/plants was demonstrated. High-exposure workers seemed to have a slightly higher prevalence of symptoms compared to the low(er)-exposure workers, although this difference was not statistically significant. No clear cutoff were observed within low- and high-exposure groups.

Probably the response rate in the study was more than 90% and higher than in many other studies.[5] Despite this high response rate we cannot rule out selection bias because of the healthy worker's effect. There might be a possibility of exposure misclassifications. However, the job categories were strongly associated with dust-sampling results and this may suggest that misclassification will be limited. Despite the clear difference

TABLE 4
Prevalence (%) for Work-Related/Temporal Symptoms in Weekends in the Various Exposure Categories. ORs Were Adjusted for Age, Current, and Ex-smokers; Dar es Salaam, Tanzania*

Symptom	Nonexposed $n = 565$	Total exposed $n = 546$	OR (CI)‖	Low exposure $n = 415$	OR (CI)‖	High exposure $n = 131$	OR (CI)‖
Cough symptoms > once a month (in last 12 months)							
Dry cough	9.0	27.7¶	3.8 (2.7–5.4)¶	26.0¶	3.6 (2.5–5.1)¶	32.8¶	4.8 (3.0–7.8)¶
Coughing up phlegm	7.1	31.5¶	6.0 (4.1–8.7)¶	29.2¶	5.4 (3.6–8.0)¶	38.9¶	8.6 (5.2–14.0)¶
Asthma symptoms > once a month (in last 12 months)							
Wheezing	1.2	4.6¶	3.9 (1.7–9.3)¶	5.3¶	4.6 (1.9–11.0)¶	2.3	1.9 (0.5–7.3)§
SOB with wheezing†	0.7	4.0¶	5.7 (1.9–16.8)¶	4.8¶	7.1 (2.4–21.2)¶	1.5	2.2 (0.4–12.0)§
SOB†	2.3	6.6¶	2.9 (1.5–5.6)¶	7.2¶	3.2 (1.6–6.3)¶	4.6	2.0 (0.7–5.4)
Chest tightness	3.0	7.1¶	2.4 (1.3–4.3)¶	8.0¶	2.8 (1.5–5.1)¶	4.6	1.3 (0.5–3.5)
Asthma symptoms in relation to work (in last 12 months)							
Wheezing, SOB,† or chest tightness in relation to work‡	4.4	19.4¶	5.4 (3.4–8.5)¶	19.3¶	5.3 (3.3–8.6)¶	19.8¶	5.3 (2.9–9.8)¶
Nose, eye and skin symptoms > once a week (in last 12 months)							
Stuffy, runny nose, sneezing	2.7	9.2¶	3.7 (2.0–6.6)¶	9.4¶	3.7 (2.0–6.8)¶	8.4¶	3.4 (1.5–7.5)¶§
Itching, burning, watering eyes	0.9	3.1¶	3.6 (1.3–9.8)‖	2.9‖	3.3 (1.2–9.5)§‖	3.8‖	3.9 (1.1–14.4)*
Itchy skin, skin rash	0.2	0.5	3.1 (0.3–30.1)§	0.5	2.7 (0.3–30.2)§	0.8	4.3 (0.3–69.8)§

* All workers were male.
† SOB = Shortness of breath.
‡ Symptoms that did not particularly lessen or disappear during weekends and holidays.
‖ OR (CI), Odds ratio (95% confidence interval).
§ Only a crude odds ratio could be found because the number of subjects for this particular case was to small.
¶ $P \leq 0.01$, ‖ $P \leq 0.05$; compared with the nonexposed group.

in mean dust values between the four categories, a substantial overlap was present according to min-max values. Therefore, nondifferential misclassification cannot be excluded. The respiratory symptom prevalence was high compared with other studies elsewhere.[5–7,10] Because 95% of SSWI were close to the main road, exposure to dust from roads generated by vehicles, in addition to exhaust pipe fumes, may have contributed to the high prevalence. However, controls were also exposed to these hazards, and their prevalence of respiratory symptoms was not as high as observed in exposed workers. Other confounders, such as duration of employment, age, and smoking, were controlled for, and it is unlikely that confounding affected the results. Other nonoccupational health problems, such as tuberculosis as a result of low immunity and malnutrition, could play a role, but with heavy-duty work like manual carpentry, this seems unlikely because the workers would have most likely left the job (healthy workers effect). Therefore, it is most probable that the respiratory symptoms were associated with exposure to wood dust, possibly in combination with a variety of other exposures of either natural origin (molds and bacteria) or industrial made additives, formaldehyde (glues and resins) and pesticides. Chemicals used in the SSWI were lubricant oils for wood machines, wood glues with thinners, polish, and varnish. It was unlikely that use of turpentine as a thinner could have major changes on respiratory symptoms because it is used infrequently and the respiratory symptoms among low- and high-exposure woodworkers exposed did not differ.

Despite the fact that elevated respiratory symptom levels were observed in exposed workers, we were not able to show exposure-response relationships. A substantially higher percentage of high-exposure workers used protective equipment compared with low-exposure workers and this is perhaps the reason for no dose-response relation. Also in a stratified analysis by allergy/sensitivity exposure-response relationship was not observed. Interestingly, the association between allergy/sensitivity and chronic respiratory symptoms and work-related respiratory symptoms was relatively strong. Independent studies have recently shown that in other African countries but also in Tanzania, the association between self-reported allergy and respiratory symptoms and asthma is usually low or even completely absent,[21,22] In our study, allergy/sensitivity was evaluated by a questionnaire. The wording of the questionnaire most likely also includes individuals with bronchial hyper-responsiveness and

not only allergic individuals. It is assumed that subjects who were allergic/sensitive because of work-related exposure had symptoms occurring more frequently. These results are therefore not necessarily conflicting with earlier studies, but these findings need to be verified by skin-prick testing or serological evaluations. Only in a few cases a positive exposure-response relationship was seen with dust exposure. Because job mobility is low, very few high-exposure subjects tend to move to less-dusty areas (healthy worker effect). This area needs further evaluation. It seems more plausible that because of the high dust exposure, we reached a plateau value of the exposure response relationship and therefore differences in symptom prevalence between low- and high-exposure workers are small.

Studies performed elsewhere have concentrated on well-established industries (saw mills, plywood, furniture making, etc.) processing a particular wood type, or comparing more than one industry processing similar or different types of wood. Most studies have concentrated on softwood mills.[5,7,9,10] However, our dust exposure levels were high and were not specific for a particular type of a tree.

Although the workers in SSWI were exposed to a mixture of dust from softwood (pine) and hardwood dust (teak, mahogany, and blood wood), it is not known whether the mixture is more hazardous with regard to causing asthma or not. This area needs an evaluation. The study has documented an increased prevalence of respiratory symptoms among woodworkers using mixed wood species compared with nonexposed workers. Effects of specific trees from elsewhere causing asthma are known. It is well documented that Western Red Cedar can cause asthma.[4] Exposure to pine has been associated with asthma and other respiratory symptoms.[5] Asthma has also been associated with dust from hardwood like iroko/teak,[23] blood wood/mninga,[24] and mahogany.[25]

In conclusion, exposure to softwood and hardwood in SSWI is associated with a wide range of symptoms, including cough, asthma, eye and nose symptoms, and allergy/sensitivity. These symptoms appear to be more common in exposed than nonexposed workers. However, a more rigorous exposure assessment in combination with a health evaluation is needed to establish the underlying mechanism.

Acknowledgment

The authors are indebted to the management and workers of the small-scale wood industries for their participation. The authors also thank the Research Assistants for their assistance in data collection. Larama MB Rongo was supported by a research fellowship from the Netherlands Foundation for the Advancement of Tropical Research (WOTRO) and Netherlands Organization of Scientific Research (NWO).

References

1. Demers PA, Teschke K, Kennedy SM. What to do about softwood? A review of respiratory effects and recommendations regarding exposure limits. *Am J Ind Med.* 1997;314:385–398.
2. Bagachwa MSD. The informal sector under adjustment in Tanzania. In: Msambichaka LA, Kilindo AAL, Mjema GD, eds. *Beyond Structural Adjustment in Tanzania. Successes, Failures, and New Perspectives.* Dar es Salaam: University Publishing Press; 1996.
3. Godnic-Cvar J, Gomzi M. Case report of occupational asthma due to palisander wood dust and bronchoprovocation challenge by inhalation of pure wood dust from a capsule. *Am J Ind Med.* 1990;185: 541–545.
4. Bardana EJ. Western Red Cedar asthma and asthma secondary to other wood dust and wood or plant related products. In: Bardana EJ, Montanaro A, Hollaren MT, eds. *Occupational Asthma,* Chapter 8. Philadelphia: Hanley and Belfus; 1992: 87–106.
5. Douwes J, McLean D, Slater T, Pearce N. Asthma and other respiratory symptoms in New Zealand pine processing sawmill workers. *Am J Ind Med.* Jun 2001;396: 608–615.
6. Norrish AE, Beasley R, Hodgkinson EJ, Pearce N. A study of New Zealand wood workers: exposure to wood dust, respiratory symptoms, and suspected cases of occupational asthma. *N Z Med J.* 1992; 105934:185–187.
7. Shamssain MH. Pulmonary function and symptoms in workers exposed to wood dust. *Thorax.* 1992;472:84–87.
8. Hessel PA, Herbert FA, Melenka LS, Yoshida K, Michaelchuk D, Nakaza M. Lung health in sawmill workers exposed to pine and spruce. *Chest.* 1995;1083: 642–646.
9. Fatusi A, Erhabor G. Occupational health status of sawmill workers in Nigeria. *J R Soc Health.* 1996;1164:232–236.
10. Ige OM, Onadeko OB. Respiratory symptoms and ventilatory function of the sawmillers in Ibadan, Nigeria. *Afr J Med Med Sci.* 2000;292:101–104.
11. Cartier A, Chan H, Malo JL, Pineau L, Tse KS, Chan-Yeung M. Occupational asthma caused by eastern white cedar (*Thuja occidentalis*) with demonstration that plicatic acid is present in this wood dust and is the causal agent. *J Allergy Clin Immunol.* 1986;77(4):639–645.
12. Malo JL, Cartier A, Desjardins A, Van de Weyer R, Vandenplas O. Occupational asthma caused by oak wood dust. *Chest.* 1995;1083:856–858.
13. Chan-Yeung M. Western red cedar and other wood dusts. In: Bernstein IL, Chan-Yeung M, Malo JL, Bernstein DI, eds. *Asthma in the Workplace.* New York: Marcel Dekker; 1993:503–532.
14. Mbuya LP, Msanga HP, Ruff CK, Birnie A, Tengnas B. Useful Trees and Shrubs for Tanzania. Identification, Propagation and Management for Agricultural and Pastoral Communities. Nairobi: Regional Soil Conservation Unit (RSCU) Swedish International Development Authority; 1994.
15. Douwes J, McLean D, van der Maarl E, Heederik D, Pearce N. Worker exposures to airborne dust, endotoxin and beta (1,3)-glucan in two New Zealand sawmills. *Am J Ind Med.* 2000;384:426–430.
16. Asher MI, Keil U, Anderson HR, et al. International study of asthma and allergies in childhood (ISAAC): rationale and methods. *Eur Respir J.* 1995;8:483–491.
17. BMRC. *Questionnaire on Respiratory Symptoms*. London: British Medical Research Council; 1976.
18. Burney PGI, Luczynska C, Chin S, Jarvin D. The European Community Respiratory Health Survey. *Eur Respir J.* 1994; 7:954–960.
19. Harrell F. *The LOGISTIC procedure. SAS Supplemental Library Users Guide.* Cary, NC: SAS Institute; 1983.
20. ACGIH-TLV. *Documentation of the threshold limit values and biological exposure indices*. American Conference of

Governmental Industrial Hygienists. Ohio: Cincinnati; 2002.
21. Sunyer J, Torregrosa J, Anto JM, et al. The association between atopy and asthma in a semirural area of Tanzania, East Africa. *Allergy*. 2000;558:762–766.
22. Faniran OA, Peat JK, Woolcook AJ. Prevalence of atopy, asthma symptoms and diagnosis, and management of asthma: comparison of an affluent and a non-affluent country. *Thorax*. 1999;547: 606–610.
23. Azofra J, Olaguibel JM. Occupational asthma caused by iroko wood. *Allergy*. 1989;442:156–158.
24. Ordman D. Wood dust as an inhalant allergen. Bronchial asthma caused by kejaat wood (*Pterocarpus-angolensis*). *S Afr Med J*. 1949;23:973–975.
25. Sosman AJ, Schlueter DP, Fink JN, Barboriak JJ. Hypersensitivity to wood dust. *N Engl J Med*. Oct 30 1969;281(18):977–980.