

## ORIGINAL ARTICLE

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## Respiratory function and immunological reactions in sisal workers

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**Abstract** A cross-sectional study of respiratory function was performed in 50 sisal textile workers in 1972. Twenty of the 50 sisal workers still employed in the sisal mill were reexamined 19 years later. At the time of the initial study there were higher prevalences of all chronic respiratory symptoms in sisal compared with control workers. By the time of the follow-up study a significant increase had occurred in almost all chronic respiratory symptoms among the 20 sisal workers. At the time of the initial study there were similar and statistically significant across-shift reductions of forced vital capacity (FVC) and the 1-s forced expiratory volume (FEV<sub>1</sub>) on Monday and the following Thursday of the work week. Across-shift reductions in FVC and FEV<sub>1</sub> in the 20 sisal workers at the follow-up study were larger than at the first measurement. Two sisal workers out of 20 (10.0%) had a positive skin test reaction to an extract sisal; both related symptoms of occupational asthma. In two sisal workers (10.0%) increased IgE was measured; one of these had symptoms of occupational asthma. Our data suggest that exposure to sisal dust in the textile industry may, in some workers, cause the development of respiratory difficulties. Immunological testing may be of value in identifying such workers at risk for occupational asthma.

**Key words** Sisal workers · Respiratory function  
Immunological status

### Introduction

Early studies by Stott (1958) in sisal workers showed that respiratory illness was twice as common in card room workers as in workers in other parts of the industry. In this study no worker exposed to sisal dust gave a characteristic history of byssinosis. Subsequent work by Gilson et al. (1962) found no significant effect on ventilatory capacity of dust exposure in sisal factory workers. Rope workers handling manila, sisal, and hemp had a significantly higher prevalence of chest tightness associated with this work than did control workers (Munt et al. 1965). By contrast, Kondakis et al. (1967) reported that 13% of 54 textile workers exposed to hemp and sisal had symptoms of byssinosis with objective 1-s forced expiratory volume (FEV<sub>1</sub>) changes being documented. In addition, Mustafa et al. (1978) described a high prevalence of respiratory symptoms, including byssinosis, and functional changes in sisal workers. Lung function in sisal rope makers was also studied by Baker et al. (1979), who found lung function changes attributable to sisal dust and lubricants used in making rope. These differences in severity are perhaps explained by comparative studies in textile workers of the effect of different vegetable dusts which have shown that sisal and jute are less potent than cotton, hemp, and flax in provoking respiratory disease (Valic and Zuskin 1972; Zuskin et al. 1972).

The presence of histamine in sisal, bagasse, cotton, and hemp has been shown by Subiza et al. (1967). The same authors described that these plants, when processed, caused bronchoconstrictor and congestive changes considered to be of an allergic nature. A histamine-releasing potential in guinea pig and human tissue and a bronchoconstricting effect of sisal were subsequently described by Nicholls et al. (1973). These results suggested that histamine release by dry or oiled sisal may be the cause of acute respiratory changes in sisal workers. The authors found no long-term effects of sisal exposure on lung function.

The present investigation was undertaken to study the possible long-term effects of sisal dust on respiratory

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function and their relation to immunological status in sisal textile workers in a single textile mill in Zadar, Croatia.

## Materials and methods

**Subjects.** The initial study conducted in 1972 included 50 women textile workers. They represented 90% of all the workers in the mill. The mean age of the women was 29 years (range: 18–35 years), mean height 160 cm (range: 156–171 cm), and mean duration of exposure 8 years (range: 1–12 years) (Table 1). Only 10% of the women were regular smokers, averaging 10–15 cigarettes daily. A group of 32 unexposed female control workers of the same age and smoking habits employed as office workers was used as a control for respiratory symptoms. Textile workers were employed in opening bales, and the operating of carding, spinning, and weaving machines. All procedures were located in one large hall and workers frequently changed jobs so that average exposures were similar in all workers. A group of 20 sisal workers were available for the follow-up study 19 years after the initial study (1991). They represented all those workers of the original 50 still working in the textile mill. Their mean age and mean duration of exposure are presented in Table 2. In addition a group of 30 female office workers similar in age, duration of employment, and smoking habit was studied as a control for the prevalence of chronic respiratory symptoms in the 20 sisal workers seen at the follow-up.

**Respiratory symptoms.** Chronic respiratory symptoms were recorded using the British Medical Research Council questionnaire on respiratory symptoms (1960) with additional questions on occupational asthma (WHO 1986) and byssinosis (Schilling et al. 1963). In all workers a detailed occupational history as well as questions about their smoking habit were recorded. The following definitions were used:

1. Chronic cough or phlegm: cough and/or phlegm production for at least 3 months per year
2. Chronic bronchitis: cough and phlegm for a minimum of 3 months a year for not less than 2 successive years
3. Dyspnea grade: grade 3 – shortness of breath when walking with other people at an ordinary pace on level ground; grade 4 – shortness of breath when walking at their own pace on level ground
4. Occupational asthma: recurring attacks of dyspnea, chest tightness, and pulmonary function impairment of the obstructive type diagnosed by physical examination and spirometric measurements during exposure to dust at or following work
5. Byssinosis grades: grade 1/2 – occasional chest tightness on Monday; grade 1 – chest tightness and/or difficulty in breathing on Monday only; grade 2 – chest tightness and/or difficulty in breathing on Mondays and other working days.

The presence of acute symptoms during work shift such as cough, dyspnea, chest tightness, irritation or dryness of the throat, secretion, dryness or bleeding of the nose, eye irritation, and headache were recorded in the 20 sisal workers seen at the follow-up study.

**Ventilatory capacity.** Ventilatory capacity measurements were performed on two occasions: at the initial and the follow-up studies. Forced expiratory flows were recorded on a Pulmonet spirometer (Godart, Holland). On these curves the forced vital capacity (FVC) and the FEV<sub>1</sub> were calculated. At the initial study measurements were performed on the first working day of the week (Monday) and the following Thursday before and after the work shift. At the follow-up study, ventilatory capacity measurements were performed only on Monday before and after the work shift. At least three spiograms were recorded for each subject at the time of measurement and the best value was used as the result of the test. The measured Monday preshift values of ventilatory capacity were compared with the predicted normal values of the Commission des Communautés Europeennes (1971) for FVC and FEV<sub>1</sub>.

**Immunological study.** Skin prick tests were performed in the 20 sisal workers at the follow-up study and 35 control workers. Sisal dust extract was prepared, using a standard immunological technique, from the dust collected in the workroom where workers were examined (Sheldon et al. 1967). In addition, workers were skin prick tested with jute extract, cotton extract, house dust, histamine base (1.0 mg/ml), mold, and a buffer as a control solution. Skin prick testing with sisal and cotton dust extract was performed using a dilution of 1:10 w/v. Skin reactions were read after 20 min. Skin prick test was considered positive if the diameter of the observed wheal was > 3 mm.

The serum level of total immunoglobulin E (IgE) was determined by a reference laboratory PRIST (Pharmacia Diagnostics, AB, Upsala, Sweden) using the direct radioimmunological “sandwich” technique. Levels of IgE below 125 IU/ml were considered normal.

**Environmental dust measurements.** Airborne dust in the sisal mill was sampled with a Hexhlet horizontal two-stage samplers during the 8-h work shift at the work site of the examined workers. Airborne dust samples were collected in the areas where workers were examined. Sampling was performed during the initial as well as during the follow-up study. Dust concentrations were expressed separately for the total and respirable dust fractions.

**Statistical analysis.** The results of ventilatory capacity measurements were analyzed by using the paired t-test (across-shift and baseline to predicted values). The chi-square test or Fisher’s exact test was used for testing differences in the prevalence of respiratory symptoms. A value for  $P < 0.05$  was considered statistically significant.

## Results

### Respiratory symptoms

Table 1 shows the prevalence of chronic respiratory symptoms in the original 50 sisal and in the 32 control workers elicited at the initial study. There were no significant dif-

**Table 1** Prevalence of chronic respiratory symptoms in sisal and in control workers

Group	Mean age (yrs)	Mean exposure (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Occupational asthma	Dyspnea	Chest tightness	Nasal catarrh	Sinusitis
Sisal (n = 50)	29	8	7 14.0% NS	7 14.0% NS	6 12.0% NS	2 4.0% NS	5 10.0% NS	12 24.0% < 0.01	5 10.0% NS	2 4.0% NS
Control (n = 32)	28	7	2 6.3%	2 6.3%	1 3.1%	0 0%	0 0%	0 0%	0 0%	0 0%

NS, Difference not statistically significant ( $P > 0.05$ )

**Table 2** Prevalence of chronic respiratory symptoms in 20 sisal workers during the initial (I) and follow-up (II) studies

Measure- ment	Mean age (yrs)	Mean exposure (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Occu- pational asthma	Dyspnea	Chest tightness	Nasal catarrh	Sinusi- tis
I	28	7	3 15.0% < 0.05	5 25.0% NS	3 15.0% NS	0 0% NS	1 5.0% < 0.01	5 25.0% < 0.011	1 5.0% < 0.01	0 0% < 0.01
II	47	26	13 65%	6 30.0%	6 30.0%	2 10.0%	16 80.0%	18 90.0%	15 75.0%	5 25.0%

NS, Difference not statistically significant ( $P > 0.05$ )

ferences between these two groups except for chest tightness (sisal: 24.0%; control: 0%;  $P < 0.01$ ). Two sisal subjects (4.0%) had typical symptoms of occupational asthma. They had worked in the mill for 5 and 6 years respectively. No case of byssinosis was found in the original cross-sectional study.

The prevalence of chronic respiratory symptoms in the 20 sisal workers studied at the initial and the follow-up study is presented in Table 2. Significantly higher prevalences were recorded at the follow-up for chronic cough ( $P < 0.05$ ), dyspnea, chest tightness, and nasal catarrh ( $P < 0.01$ ). Two additional sisal workers developed symptoms of occupational asthma during the 19 years of the follow-up period. No typical case of byssinosis was recorded at the follow-up study.

**Table 3** Ventilatory capacity in 50 sisal workers during the initial study on Monday and the following Thursday

Measure- ment	FVC		FEV <sub>1</sub>	
	Before shift (I)	Difference before-after shift	Before shift (I)	Difference before-after shift
Monday	3.60 ± 0.50	-4.4 < 0.01	2.95 ± 0.45	-4.7 < 0.01
	NS		NS	
	3.84a ± 0.41		2.98a ± 0.60	
Thursday	3.60 ± 0.57	-2.2 < 0.01	2.90 ± 0.60	-3.7 < 0.01

Preshift data are presented as mean ± SD

NS, Difference not statistically significant ( $P > 0.05$ )

<sup>a</sup> Predicted normal values

The prevalences (elicited at the cross-sectional study) of chronic respiratory symptoms in those 30 sisal workers who had left the industry were not significantly different (NS) from those of the workers subsequently seen at the follow-up study (chronic cough: 4, 13.3%; chronic phlegm: 2, 6.7%; chronic bronchitis: 3, 10.0%; asthma: 2, 6.7%; dyspnea: 4, 13.3%; chest tightness: 7, 23.3%; nasal catarrh: 4, 13.3%; sinusitis: 2, 6.7%).

A relatively high number of acute symptoms were recorded in the 20 sisal workers at the follow-up study. The highest prevalences were for chest tightness, cough, and eye irritation (60.0%), followed by dry throat and irritation of the throat (45.0%), dyspnea (35.0%), secretion, dryness or bleeding of the nose, and headache (20.0%).

Comparison of the prevalence of chronic respiratory symptoms among the 20 sisal and 30 control workers at the follow-up study revealed higher prevalences of all symptoms in the sisal than in the control workers, the difference being statistically significant for chronic cough (sisal: 65.0%; control: 6.7%;  $P < 0.01$ ), chronic phlegm (sisal: 30.0%; control: 3.3%;  $P < 0.05$ ), chronic bronchitis (sisal: 30.0%; control: 3.3%;  $P < 0.05$ ), dyspnea (sisal: 80.0%; control: 0%;  $P < 0.01$ ), chest tightness (sisal: 90.0%; control: 0%;  $P < 0.01$ ), and nasal catarrh (sisal: 75.0%; control: 3.3%;  $P < 0.01$ ).

#### Ventilatory capacity

Table 3 presents ventilatory capacity data in sisal workers on Monday and on the following Thursday measured at the initial study. There were statistically significant across-shift reductions for FVC and FEV<sub>1</sub> on both days, the reduc-

**Table 4** Ventilatory capacity in 20 sisal workers during the initial (I) and follow-up (II) studies

Mea- sure- ment	FVC				FEV <sub>1</sub>					
	Before shift (I)	Difference before- after shift		% pre- dicted	Difference measured- predicted P	Before shift	Difference before- after shift (I)		% pre- dicted P	
		%	P				%	P		
I	3.53 ± 0.41 < 0.01	-1.1	NS	94.9	NS	2.91 ± 0.36 < 0.01	-0.7	NS	98.6	NS
II	3.02 ± 0.53	-4.6	< 0.05	88.0	< 0.05	2.22 ± 0.37	-5.9	< 0.05	85.7	< 0.01

Preshift data are presented as mean ± SD

NS, Difference not statistically significant ( $P > 0.05$ )

tions being slightly larger on Monday than on the following Thursday. The preshift ventilatory capacity data on Monday and Thursday were not significantly different. No significant differences were recorded on Monday between measured and predicted normal values for FVC and FEV<sub>1</sub>.

Table 4 presents the ventilatory capacity data measured at the initial and the follow-up studies in the 20 sisal workers studied prospectively. Across-shift reductions in FVC and FEV<sub>1</sub> at the initial study were small and statistically not significant (FVC: -1.1%; FEV<sub>1</sub>: -0.7%). However, workers who left the industry and were not followed up had significantly greater across-shift reductions (Table 3). At the follow-up study significant decreases across the work shift were recorded for FVC (-4.6%;  $P < 0.05$ ) and for FEV<sub>1</sub> (-5.9%;  $P < 0.05$ ). In comparison to predicted values no significant differences were found between the Monday preshift and expected normal values at the initial study; these differences became significant at the follow-up study (FVC: 88.0% of predicted,  $P < 0.05$ ; FEV<sub>1</sub>: 85.7% of predicted,  $P < 0.05$ ). Comparison of ventilatory capacity preshift values at the initial and follow-up study revealed a mean annual decrease for FVC of 0.027 l/year and for FEV<sub>1</sub> of 0.036 l/year.

Across-shift reductions in FVC and FEV<sub>1</sub> in those 30 workers who had left the industry after the cross-sectional study were higher than those in workers who participated in the follow-up study (FVC: -8.4%; FEV<sub>1</sub>: -8.7%). Their mean measured preshift values as a percentage of predicted values were 94.4% for FVC and 98.8% for FEV<sub>1</sub>.

### Immunological reactions

The immunological data in the 20 sisal workers collected in 1991 demonstrated that two textile workers (10.0%), both with symptoms of occupational asthma, reacted with a positive skin test to the sisal extract. Eight sisal workers (40.0%) reacted to house dust. None of the sisal workers reacted to mold, jute, or cotton. Two of the sisal workers (10.0%) had an increased serum IgE level (130 IU/l and 195 IU/l). One of these two had symptoms of occupational asthma and the other had a positive skin reaction only to house dust alone.

Of the 35 control workers, two (5.7%) demonstrated positive skin reactions to sisal extract, another two to jute extract, ten (28.6%) to house dust, and none to cotton, mold, or buffer solution. Workers with positive skin reactions to sisal and jute extracts also reacted to house dust. Among the control workers, one (2.9%) had an increased serum IgE level (152 IU/l) and also demonstrated a positive skin reaction to house dust.

### Environmental dust measurements

The mean total dust concentration in our sisal textile mill at the initial study was 1.918 mg/m<sup>3</sup> (range: 0.426–5.201 mg/m<sup>3</sup>) with a mean respirable fraction of 0.714

mg/m<sup>3</sup> (range: 0.323–0.939 mg/m<sup>3</sup>). At the follow-up study the mean total dust concentration was 1.890 mg/m<sup>3</sup> (range: 0.437–5.200 mg/m<sup>3</sup>) with a mean respirable fraction of 0.698 mg/m<sup>3</sup> (range: 0.320–0.920 mg/m<sup>3</sup>). These dust concentrations were considerably below those measured in cotton, hemp, or flax textile mills in Croatia. The dust concentrations in the sisal textile mill were within the limits of the current Croatian standard for textile dust (total dust: 5 mg/m<sup>3</sup>; respirable fraction: 1 mg/m<sup>3</sup>).

### Discussion

Our data indicate that protracted exposure to sisal dust may contribute to the development of chronic respiratory symptoms. At the initial study (with mean exposures in the industry of 8 years) the differences in prevalence of chronic respiratory symptoms between exposed and control workers were not statistically significant, except for chest tightness. These prevalences were considerably smaller than those reported in cotton, flax, or hemp workers (Beck and Schachter 1983; Valic and Zuskin 1972).

Workers who left the industry between the cross-sectional and follow-up study had considerably greater across-shift changes than those who stayed in it. The two sisal workers with occupational asthma symptoms at the time of the initial study left the mill by the time of the follow-up study. At the follow-up study, after a 19-year interval, the findings suggest that prolonged exposure to sisal dust may be associated with a significant increase in the prevalence of chronic respiratory symptoms. These prevalences were particularly high at the follow-up study for chest tightness (90.0%), dyspnea (80.0%), nasal catarrh (75.0%), and chronic cough (65.0%). Two sisal workers included in the follow-up study developed typical asthma symptoms during the 19-year follow-up period. No typical case of byssinosis, however, was recorded at either the initial or the follow-up study. This is contrast to the findings of Mustafa et al. (1978), who reported a high prevalence of byssinosis in sisal workers, varying from 33% to 77%, but is consistent with prior findings of Stott (1958) and Gilson (1962), who failed to show byssinosis among sisal workers. In our sisal workers at the follow-up study a high prevalence of acute symptoms was recorded during the work shift. These prevalences are similar to those found in workers exposed to other organic dusts such as soy (Zuskin et al. 1988a), spices (Zuskin et al. 1988b), animal food (Zuskin et al. 1989), and fur (Zuskin et al. 1988c).

Across-shift changes in sisal workers were considerably smaller than in textile workers exposed to cotton, hemp, or flax (Zuskin and Valic 1975; Zuskin et al. 1975; Valic and Zuskin 1972). However, the across-shift reductions of ventilatory capacity tests in our sisal workers in the present study were similar on Monday and Thursday. The preshift ventilatory capacity data in our sisal workers were also the same on Monday and the following Thursday, which is different from the data of Velvart (1973), who reported higher preshift FVC and FEV<sub>1</sub>

on Monday than on Thursday. The sisal workers who were lost to the follow-up study had similar baseline ventilatory capacity values as those included in the follow-up but, as noted, greater across-shift differences. This latter finding may indicate greater sensitivity to the dust and may in part explain the loss of these workers from the industry.

Long-term exposure to sisal dust was associated with an accelerated decrease in FVC and FEV<sub>1</sub> compared to predicted normal values. Five of the 20 workers followed prospectively (21.5%) had measured FVC and FEV<sub>1</sub> less than 80% of the predicted values (FVC: 75%–73%; FEV<sub>1</sub>: 72%–67%). The mean annual decline in lung function among the 20 sisal workers who were seen after 19 years was 0.027 l/year for FVC and 0.035 l/year for FEV<sub>1</sub>. The mean annual FEV<sub>1</sub> decrease among sisal workers was considerably smaller than the mean FEV<sub>1</sub> annual decline in cotton workers reported in our previous studies, which varied from 42 ml/year to 111 ml/year (Zuskin and Valic 1975; Beck et al. 1982; Beck and Schachter 1983; Zuskin et al. 1991). This mean annual FEV<sub>1</sub> decrease in these sisal workers was similar to that seen in a study of man-made fiber workers, i.e., 32 ml/year (Berry et al. 1973). The mean annual decline in our sisal workers was slightly larger than the expected annual decline of 21–31 ml/year in healthy adult subjects reported by Cotes (1974), Berglund et al. (1963), Ferris et al. (1965), Morris et al. (1971), and Miller et al. (1986). This rate of decline may underestimate the true change in these textile workers since workers leaving the industry may be doing so for health reasons, as suggested by the across-shift data and the departure of workers with occupational asthma.

Lung function data in our sisal workers indicate a predominantly obstructive abnormality associated with long-term exposure to sisal dust. Baker et al. (1979) reported in sisal rope makers the effect of sisal dust on lung function may be due not only to exposure to the dust but also to an effect of airborne lubricants used to soften the fiber. Several reports suggest that such aerosols may have a harmful effect on respiratory health. Cullen et al. (1981) reported pneumonia caused by oil mist exposure in steel rolling tandem mill operators while Hendy et al. (1985) described occupational asthma in a toolsetter due to an emulsified oil mist. Finally, Jarvholm et al. (1982) described an excess of respiratory symptoms in workers exposed to oil mist while turning, grinding, and hardening metals in different industries, compared to control workers.

An excess of respiratory symptoms and lung function abnormalities has been documented in this sisal mill. The frequency and severity of these findings increased with length of exposure. Byssinosis was not a symptom of these workers. Findings were in general less marked than in other textile industries but this may relate to the relatively lower dust exposure. Across-shift changes may be a risk factor identifying workers more likely to leave this industry. Immunological findings in sisal workers, including specific skin tests and elevated IgE, although relatively uncommon, may be helpful in identifying workers at risk of occupational asthma.

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## References

- Baker MD, Irwing LM, Johnston JR, Turner DM, Bezuidenhout BN (1979) Lung function in sisal ropemakers. *Br J Ind Med* 36: 216–219
- Beck GJ, Schachter EN (1983) The evidence for chronic lung disease in cotton textile workers. *Am Statist* 37: 404–412
- Beck GJ, Schachter EN, Maunder LR, Schilling RSF (1982) A prospective study of chronic lung disease in cotton textile workers. *Ann Intern Med* 97: 645–651
- Berglund E, Birath G, Bjure J, Grimby G, Kjellmer I, Sandquist L, Soderholm B (1963) Spirometric studies in normal subjects: forced expirogram in subjects between 7 and 70 years of age. *Acta Med Scand* 173: 185–192
- Berry G, McKerrow CB, Molyneux MKB, Rossiter CE, Tomblinson JBL (1973) A study of the acute and chronic changes in ventilatory capacity of workers in Lancashire cotton mills. *Br J Ind Med* 30: 25–36
- Commission des Communautés Europeennes, CECA (1971) Aide memoire pour la pratique de l'examen de la fonction ventilatoire par la spirométrie. Luxembourg
- Cotes JE (1974) Lung function. Davis, Philadelphia
- Cullen MR, Balmes JR, Robins JM, Walker Smith GJ (1981) Lipoid pneumonia caused by oil mist exposure from a steel rolling tandem mill. *Am J Ind Med* 2: 51–58
- Ferris G, Anderson DO, Zickmantel R (1965) Prediction values for screening test of pulmonary function. *Am Rev Resp Dis* 91: 252–261
- Gilson JC, Stott H, Hopwood BEC, Roach SA, McKerrow CB, Schilling RSF (1962) Byssinosis: the acute effect of ventilatory capacity of dusts in cotton ginneries, cotton sisal, and jute mills. *Br J Ind Med* 18: 9–18
- Hendy MS, Beattie BE, Burge PS (1985) Occupational asthma due to an emulsified oil mist. *Br J Ind Med* 42: 51–54
- Jarvholm B, Bake B, Lavenius B, Thiringer G, Vokmann R (1982) Respiratory symptoms and lung function in oil mist-exposed workers. *J Occup Med* 24: 473–479
- Kondakis XG, Pournaras N, Moraitis J (1967) Byssinose chez les ouvriers du chanvre et du sisal en Grece. *Arch Mal Profess Med Travail Secur Soc* 28: 357–361
- Medical Research Council Committee on the Aetiology of Chronic Bronchitis (1960) Standardized questionnaire on respiratory symptoms. *Br Med J* II: 1665
- Miller A, Warshaw JC, Bernstein J, Selikoff IJ, Tierstein AS (1986) Mean and instantaneous flows, FVC and FEV<sub>1</sub> prediction equations from a probability sample of Michigan, a large industrial state. *Bull Eur Physiopathol Resp* 22: 589–597
- Morris JF, Koski A, Johnson LC (1971) Spirometric standards for healthy nonsmoking adults. *Am Rev Resp Dis* 103: 57–67
- Munt DF, Gauvain S, Walford J, Schilling RSF (1965) Study of respiratory symptoms and ventilatory capacities among rope workers. *Br J Ind Med* 22: 196–203
- Mustafa KY, Lakha AS, Milla MH, Dahoma U (1978) Byssinosis, respiratory symptoms and spirometric lung function tests in Tanzanian sisal workers. *Br J Ind Med* 35: 123–128
- Nicholls PJ, Evans E, Valic F, Zuskin E (1973) Histamine releasing activity and bronchoconstricting effects of sisal. *Br J Ind Med* 30: 142–145
- Schilling RSF, Vigliani EC, Lammers B, Valic F, Gilson JC (1963) A report on a conference on byssinosis. Proceedings of the 14th International Congress on Occupational Health, Madrid, pp 137–145
- Sheldon JM, Lowell RG, Mathews KP (1967) Manual of clinical allergy. W.B. Saunders, Philadelphia, pp 507–531

- Stott H (1958) Pulmonary disease among sisal workers. *Br J Ind Med* 15:23–37
- Subiza E, Alizo H, Diaz P (1967) Estudios experimentales del contenido en histamina y efecto histaminoliberador del sisal, bagazo, canamo, algodón y madera de ukola (*Dumoria africana*). *Rev Clin Esp* 107:202–212
- Valic F, Zuskin E (1972) Effects of different vegetable dust exposures. *Br J Ind Med* 29:293–297
- Velvart J (1973) Changes in lung function due to the effects of sisal dust. *Int Arch Arbeitsmed* 31:25–36
- World Health Organization (1986) Early detection of occupational disease. Geneva, pp 45–67
- Zuskin E, Valic F (1975) Changes in the respiratory response to coarse cotton dust over a ten-year period. *Am Rev Respir Dis* 112:417–421
- Zuskin E, Valic F, Nicholls PJ, Evans E (1972) Respiratory symptoms and ventilatory function in sisal dust exposure. *Int Arch Arbeitsmed* 30:105–111
- Zuskin E, Valic F, Butkovic D, Bouhuys A (1975) Lung function in textile workers. *Br J Ind Med* 32:283–288
- Zuskin E, Skuric Z, Kanceljak B, Pokrajac D, Schachter EN, Witek TJ (1988a) Respiratory symptoms and ventilatory capacity in soy bean workers. *Am J Ind Med* 14:157–165
- Zuskin E, Skuric Z, Kanceljak B, Pokrajac D, Schachter EN, Witek TJ (1988b) Respiratory findings in spice factory workers. *Arch Environ Health* 43:335–339
- Zuskin E, Skuric Z, Kanceljak B, Pokrajac D, Schachter EN, Witek TJ (1988c) Respiratory symptoms and lung function in furriers. *Am J Ind Med* 14:189–196
- Zuskin E, Mataija M, Pokrajac D, Schachter EN, Witek TJ (1989) Respiratory function in animal food processing workers. *Am J Ind Med* 16:179–187
- Zuskin E, Ivankovic D, Schachter EN, Witek TJ (1991) A ten-year follow-up study of cotton workers. *Am Rev Respir Dis* 143:301–305