

AIRBORNE BACTERIA AND BYSSINOSIS IN COTTON MILLS

F. F. CINKOTAI

*Department of Occupational Health, University of Manchester, Manchester,
United Kingdom*

ABSTRACT

Airborne bacteria, the protease content of the airborne dust and the concentration of 2–4 μm particles in the cardroom air were all found to correlate highly significantly with the prevalence of byssinotic symptoms. Byssinotic workers with 20 years or longer cotton spinning experience had a statistically significant excess of symptoms of chronic bronchitis and asthma compared with non-byssinotic workers matched for age, cardroom experience and smoking habits.

Airborne microbes and their constituents which occur abundantly in the cotton industry were, in the past, frequently investigated in connection with byssinosis. In the present investigation we have studied the relationship between airborne microbes and the prevalence of byssinotic symptoms in the cardrooms of 21 cotton spinning mills and in dusty workrooms of factories processing wool, wood, tea and tobacco.

METHOD

The prevalence of byssinotic symptoms among the workers was determined by administering the MRC Questionnaire for Respiratory Symptoms (1963). The concentration of Gram-negative and Gram-positive bacteria, fungi, dust and proteolytic enzymes was determined in the workroom air at about 1.4 m height, in four different places spaced evenly over the work floor, on several different occasions.

Samples of airborne microbes were collected in the "Anderson viable sampler" (Model 10–800) on 5% malt-extract agar plates for culturing selectively fungi, on endoagar plates (including 0.5 unit/ml penicillin) for Gram-negative bacteria and on nutrient agar plates (with 5 $\mu\text{g}/\text{ml}$ nalidixic acid) for Gram-positive bacteria. The plates were then incubated and the resulting colonies were counted.

The airborne dust was sampled by the Rotheroe-Mitchell Sampler (Model L60) fitted with a wire-cage (of 2 mm mesh, measuring 22 \times 22 \times 27 cm) to exclude "fly". The size-distribution of the particles was determined by the Battelle impactor (Model CS-1-6A). Samples of whole dust less "fly" were

assayed for trypsin like proteases by a spectrophotometric technique utilizing the "Azocoll" substrate³.

RESULTS

In all, 1 142 people were employed in the cardrooms of the cotton spinning mills investigated and of the 1 057 people who answered the questionnaire, 184

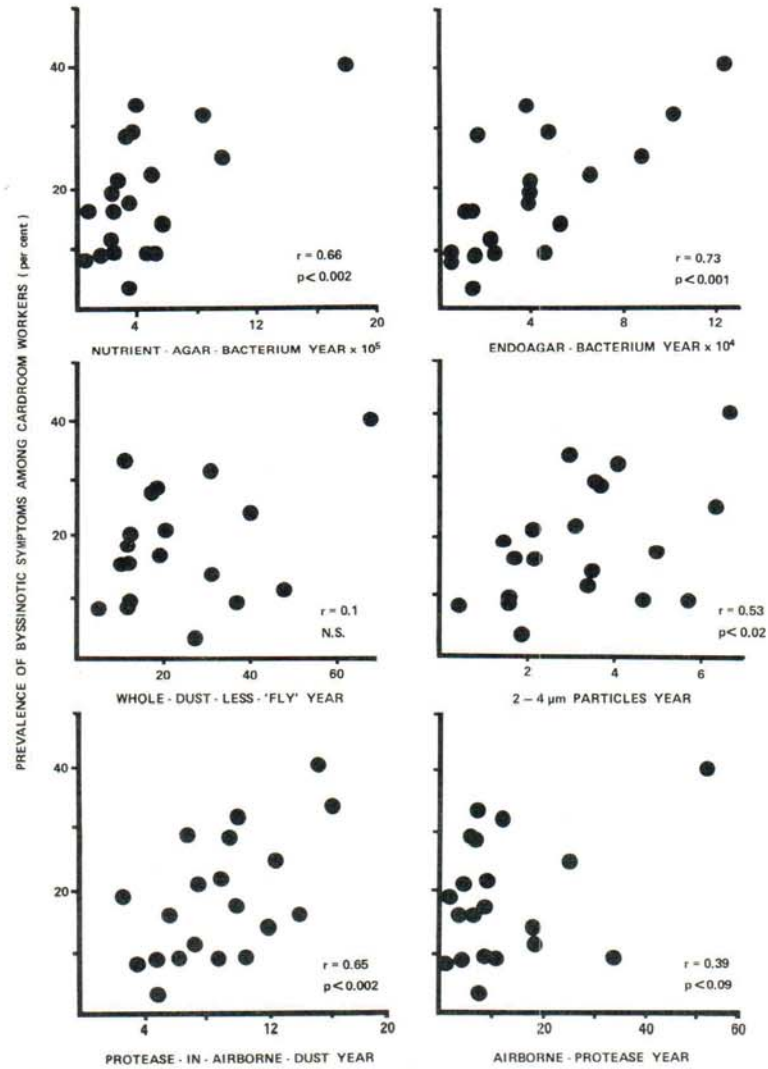


FIG. 1—The cumulative exposure to "endoagar" and "nutrient agar" bacteria, trypsin like proteases, whole dust less "fly" and 2-4 μ m particles in the cardrooms of 21 cotton spinning mills collated with the prevalence of byssinotic symptoms among these workers.

(17.4%) claimed to suffer from some grade of byssinotic symptoms. None of the 157 people interviewed in the non-cotton processing factories indicated any such symptoms. The prevalence of byssinotic symptoms varied from one cardroom to another between zero and 40%.

Eight 1–2 min samples of airborne Gram-positive bacteria were collected in each work place on four different occasions (32 samples in all) and eight 2 min samples of Gram-negative bacteria, on three occasions (24 samples in all). The concentration of Gram-positive bacteria was found to vary between work places from less than 1 000 organisms/m³ to over 90 000 organisms/m³ and that of the Gram-negative bacteria from less than 200 organisms/m³ to over 6 000 organisms/m³. The non-cotton processing factories were practically free of airborne bacteria, except the wool spinning mill which was relatively heavily infested with Gram-positive organisms (c. 15 000 organisms/m³). Cumulative exposure to airborne bacteria (i.e. the mean level of airborne bacteria in a cardroom multiplied by the mean number of years the interviewees worked in cotton spinning) correlated with the prevalence of byssinotic symptoms highly significantly (Fig. 1). The correlation coefficient for Gram-negative bacteria was 0.73 with $p < 0.001$ and for Gram-positive bacteria 0.66 with $p < 0.002$.

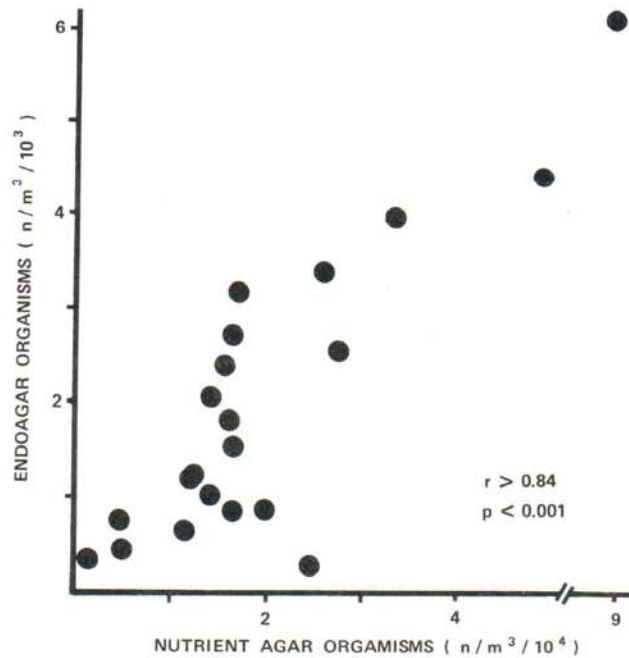


FIG. 2—The concentration of airborne "nutrient agar" bacteria (N/m³) versus that of "endoagar" bacteria (N/m³) in the cardrooms.

The airborne dust was sampled in each cardroom on two different occasions for a total period of between 33 to 182 hours. The concentration of whole dust less "fly" between the different cardrooms varied on average from 0.28 mg/m^3 to 3.85 mg/m^3 and that of trypsin equivalent proteases in the dust samples from $0.03 \text{ } \mu\text{g/mg}$ to $2.66 \text{ } \mu\text{g/mg}$. The mass median diameter of the dust particles as determined by the cascade impactor, ranged from $2.6 \text{ } \mu\text{m}$ to $17 \text{ } \mu\text{m}$. Cumulative exposure to the protease content of the airborne dust and its $2\text{--}4 \text{ } \mu\text{m}$ particle fraction was found to associate significantly with the prevalence of byssinotic symptoms (with $r = 0.65$, $p < 0.002$ and $r = 0.53$, $p < 0.02$ respectively) whereas exposure to whole dust less "fly" or to fungal spores was not.

Gram-negative bacteria correlated significantly with Gram-positive bacteria ($r = 0.84$, $p < 0.001$, Fig. 2) and both types of organisms correlated with airborne proteases ($r = 0.67$, $p < 0.001$ and $r = 0.86$, $p < 0.001$ respectively, Fig.

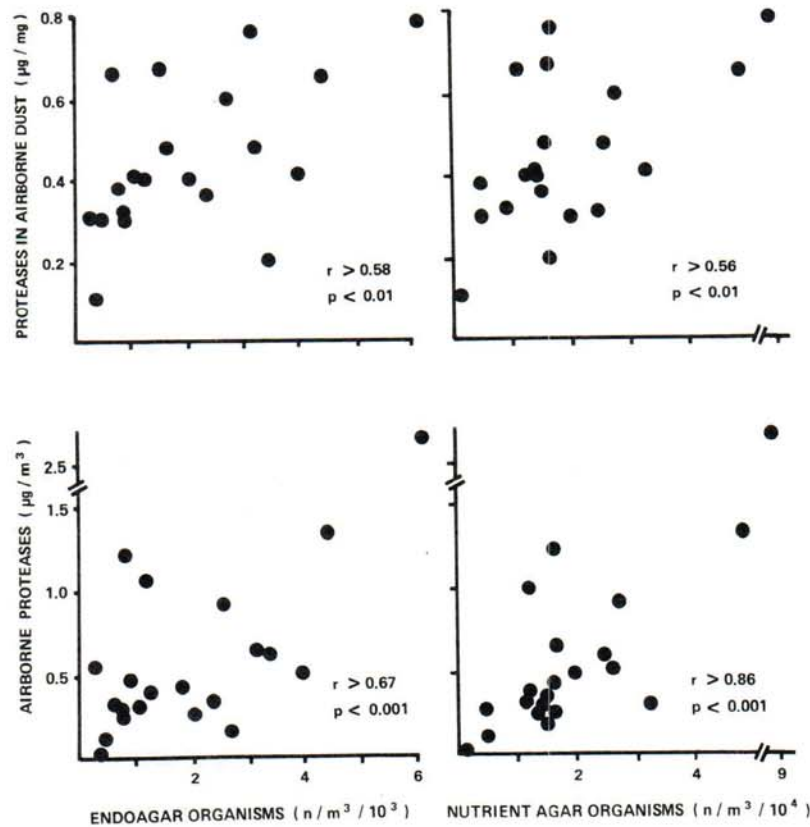


FIG. 3—The concentration of "endoagar" and "nutrient agar" bacteria in the cardroom air (N/m^3) versus the protease content of airborne dust ($\mu\text{g/mg}$) and the concentration of airborne proteases ($\mu\text{g/m}^3$).

3) as well as with the protease content of the airborne dust ($r = 0.58$, $p < 0.01$ and $r = 0.56$, $p < 0.01$ respectively, Fig. 3). Oddly enough Gram-negative bacteria did not correlate with the concentration of whole dust less "fly" whereas Gram-positive bacteria did ($r = 0.60$, $p < 0.005$). However, both types of organisms correlated highly significantly with the concentration of 2-4 μm particles ($r = 0.63$, $p < 0.003$ and $r = 0.81$, $p < 0.001$).

Groups of workers of matching age, cotton spinning experience and smoking habits were compared. Both smoking and non-smoking byssinotics who worked in a cotton spinning mill for 20 years or longer appeared to suffer from the symptoms of chronic bronchitis, that is bringing up phlegm for as long as three months each year, about three times as frequently as matched non-byssinotics. The association, tested by two by two contingency tables and chi-square tests, was statistically highly significant for both smokers ($\chi^2 = 39.3$, d.f. = 1, $p < 0.001$) and non-smokers ($\chi^2 = 17.2$, d.f. = 1, $p < 0.001$).

Byssinotic workers of 20 years or longer cotton spinning experience claimed to suffer from attacks of shortness of breath with wheezing significantly more frequently than their non-byssinotic counterparts. The prevalence of byssinotic symptoms among smokers was not different from that among matching non-smokers. Males did not suffer from the symptoms any more frequently than females.

DISCUSSION

Thus airborne bacteria in this study correlate with byssinotic symptoms better than airborne dust and this appears to confirm some old suspicions^{4,5,6,8,9,12,13,14} about the role of inhaled microbes in the health of cotton spinners. Extrinsic allergic alveolitis brought about by the inhalation of very large doses of thermophilic actinomycetes^{2,10}, for example, involves fever, severe chest symptoms and a considerable drop in FEV. Similar symptoms were observed in people exposed to large doses of non-specific microbes generated in some humidification processes^{7,11}. On the other hand, people exposed to relatively small doses of airborne microbes like wool-spinners¹⁵ or tea-packers¹ do not suffer from either fever or chest symptoms, but they still exhibit a small but significant drop in FEV during the work-shift. Cotton spinners who are exposed to much smaller doses of airborne microbes than farmers forking mouldy hay, but considerably higher doses than wool-spinners or tea-packers, would appear to come in between. They do not suffer from fever (although they may have done in the past) but they do exhibit mild to severe chest symptoms and a sizable drop in FEV. Byssinosis may be considered as a mild form of occupational asthma. The role of airborne micro-organisms in the aetiology of byssinosis remains to be clarified, however.

REFERENCES

1. *Al Zubair, Y. S. and Cinkotai, F. F.* Ventilatory function in workers exposed to tea and wood-dust. *IRCS Med. Sci.*, **5** (1977) 190.
2. *Banaszak, E. F., Thiede, W. H. and Fink, J. N.* Hypersensitivity pneumonitis due to contaminated air conditioner. *N. Engl. J. Med.*, **283** (1970) 271-276.
3. *Bayes, C. D.* Proteolytic enzymes in cotton dust. M. Sc. Thesis, University of Manchester, 1974.
4. *Cinkotai, F. F. and Franklin, D. W.* An evaluation of the effect of airborne dust from a cotton mill on the guinea-pig ileum, with reference to byssinosis. *Br. J. Ind. Med.*, **32** (1975) 239-243.
5. *Cinkotai, F. F., Lockwood, M. G. and Rylander, R.* Airborne microorganisms and prevalence of byssinotic symptoms in cotton mills. *Am. Ind. Hyg. Assoc. J.*, **38** (1977) 554-559.
6. *Drummond, D. G. and Hamlin, M.* Airborne bacteria in cotton mills. Part I. Survey of counts of viable bacteria. *Br. J. Ind. Med.*, **2** (1952) 309-311.
7. *Friend, J. A. R., Gaddie, J., Palmer, K. N. V., Pickering, C. A. C. and Pepys, J.* Extrinsic allergic alveolitis and contaminated cooling-water in a factory machine. *Lancet*, **1** (1977) 297-300.
8. *Furness, G. and Maitland, H. B.* Studies of cotton dust in relation to byssinosis. Part I: Bacteria and fungi in the air of textile mills. *Br. J. Ind. Med.*, **9** (1952) 138-145.
9. *Hamlin, M.* Airborne bacteria in cotton mills. Part II. Determination of types of viable bacteria. *Br. J. Ind. Med.*, **9** (1952) 311-313.
10. *Pepys, J., Jenkins, P. A., Festenstein, G. N., Gregory, P. H., Lacey, P. H. and Skinner, F. A.* Farmers Lung: Thermophilic actinomycetes as a source of "Farmers Lung Hay". *Lancet*, **2** (1963) 607-611.
11. *Pickering, C. A. C., Moore, W. K. S., Lacey, J., Holford-Strevens, V. C. and Pepys, J.* Investigation of a respiratory disease associated with an air-conditioning system. *Clin. Allergy*, **6** (1976) 109-118.
12. *Prausnitz, C.* Investigations on Respiratory Dust Disease in Operatives in the Cotton Industry. MRC Report, HMSO London, 1936.
13. *Rylander, R. and Snella, M. C.* Acute inhalation toxicity of cotton plant dust. *Br. J. Ind. Med.*, **33** (1976) 175-180.
14. *Tuffnell, P.* The relationship of byssinosis to the bacteria and fungi in the air of the textile mills. *Br. J. Ind. Med.*, **7** (1960) 304-309.
15. *Žuškin, E. and Valić, F.* Measurement of respiratory function in wool workers. XVIII International Congress on Occupational Health, Brighton, England, Abstracts, p. 106.