Occupational Lung Disease in China

XIAO-RONG WANG, MD, PHD, DAVID C. CHRISTIANI, MD, MPH, MS

Occupational lung disease has been a major public health problem in China. The recently transformed industrial structure and expansion of the industrial labor force, accompanying the rapid industrialization and economic growth, pose both tremendous challenges and opportunities for occupational health policy and research. New occupational health problems are emerging, while the traditional occupational lung disease continued to occur. Simultaneously, relevant scientific research and professional activities have accelerated notably. The progress and achievement in occupational health research are creating more powerful forces in eliminating industrial hazards and protecting workers' health in China. *Key words*: China; occupational lung disease; pneumoconiosis; silicosis.

INT J OCCUP ENVIRON HEALTH 2003;9:320–325

China, the most populated and the largest developing country in the world, has been undergoing rapid economic development since the 1980s. This traditionally agricultural nation, with more than 75% rural population, has been evolving into an urbanized and industrialized society. The economic structure has changed dramatically over the last two decades. Prior to the 1980s, state-owned industry dominated the national industrial sector. The remainder consisted of collectively owned industries and a very small number of private enterprises. Today, the most striking change of the Chinese economy is speedy development and expansion of rural township- and village-owned enterprises (generally called small-scale industries), with their total working population exceeding that of the employees in state-owned and urban collective enterprises.[1]

The unprecedented rapid industrialization and economic growth has led to changes in the patterns and intensities of industrial exposures, and has created a large challenge for occupational health and safety. Not only have the traditional occupational diseases continued to occur, but also new occupational health problems are emerging.[2] China is learning some lessons from the process of industrialization, as some Western countries did in the early part of the last century. These lessons, in turn, have drawn increasing attention from the government and health researchers, leading to more enacted regulations and standards in occupational health and safety. Simultaneously, relevant scientific research has accelerated. This review covers the current status of occupational lung diseases in China, with reference to the major challenge the country has been facing—pneumoconioses. In addition, we describe some interesting epidemiologic studies of occupational lung disease in China, which were published in international journals over the past ten years.

PNEUMOCONIOSES IN CHINA

Disease Burdens

Pneumoconioses are the earliest recognized occupational lung diseases, contributing the major part of statutory occupational lung diseases in China. In the 1960s, only silicosis was recognized officially as occupational lung disease. By the 1980s, 12 kinds of pneumoconioses and several other types of lung diseases resulting from occupational exposures were recognized by law as occupational diseases (Appendix A).

Pneumoconioses are the most serious occupational lung disease in China, not only because of the high morbidity and mortality of the diseases, but also because of the large number of populations at high risk. For the more than 50 years since 1949, pneumoconioses have increased yearly. Nationwide prevalence surveys have showed that the accumulated cases of pneumoconioses approximated 525,000 from 1949 to 1996, and reached 600,000 by the year 2000. There are 10,000–15,000 of new cases reported annually.[1] In addition, at least 520,000 workers (living) are suspected of having pneumoconioses. It was estimated that pneumoconioses contributed to an average of 19.9 potential years of life lost and 19.7 potential years of work lost between 1949 and 1986.[3] Silico-tuberculosis remains prevalent (10%–30% among patients with silicosis and coal worker's pneumoconiosis) and continues to be one of major causes for mortality of pneumoconiosis patients.[4]

In China, silicosis and coal workers' pneumoconiosis have been the major types of pneumoconioses,

Received from the Department of Environmental Health (Occupational Health Program), Harvard School of Public Health; Pulmonary and Critical Care Unit, Massachusetts General Hospital, Department of Medicine, Harvard Medical School, Boston, Massachusetts. Support by NIOSH Grant R01OH02421.

Address correspondence and reprint requests to: Dr. David Christiani, Occupational Health Program, Harvard School of Public Health, 665 Huntington Avenue, Boston, MA 02115, U.S.A.; telephone: (617) 432-3323; fax: (617) 432-3441; e-mail: <dchris@hohp.harvard.edu>.

accounting for 48% and 39% of cases, respectively, according to the 1986 national survey. The greatest distribution of pneumoconiosis cases was found in coal mining industries (45.1%), as coal remains the major energy source in the country. Occupational health professionals have referred generally to pneumoconiosis in coal miners as anthrasilicosis, not distinguishing between coal workers' pneumoconiosis and silicosis. The prevalence of pneumoconiosis was estimated to be about 6% among all coal miners. In addition, 12.9% of existing pneumoconiosis cases were reported from the metallurgical industry; 8.9% from construction material manufacturing; 5.0% from machinery manufacturing; 3.7% from non-ferrous metallurgical; 3.7% from small-scale industries, and 2.7% from the railway construction industry.[5] Moreover, it is estimated that about 20% of pneumoconiosis cases are not reported.[4] The largest portion of unreported cases may come from small-scale enterprises in which there are poorly regulated working conditions and an incomplete reporting system. The risk of pneumoconiosis has increased in small-scale enterprises, while it may have decreased in state-owned enterprises since the 1990s, quite possibly because of lagging production and the furloughs in the latter sector.

Diagnosis of Pneumoconiosis

The diagnosis of pneumoconiosis in China depends fundamentally on evidence of occupational exposure history and radiographic and/or pathologic findings. Also, pulmonary function testing results are considered. The Chinese radiographic diagnostic criteria for pneumoconioses have been used, instead of the ILO international classification of radiographs of pneumoconiosis. However, the currently applied radiographic diagnostic criteria, which were revised in 1986 and affixed 37 standard films, are comparable to the ILO international classification (Appendix B). In the technique of chest film taking, high-kilovolt radiography has been used since the early of the 1990s, leading to the pictures with higher quality and better clarity. Computed tomography has been used only rarely in the diagnosis of pneumoconiosis because of its high cost and unavailability.

Only government-authorized diagnostic panels at the different levels (province, municipality, county) have the authority to diagnose pneumoconiosis, as well as other occupational diseases. The panels usually consist of radiologists, pathologists, pulmonologists, and occupational physicians. Once a worker is diagnosed as having pneumoconiosis, he or she is provided with limited financial compensation. However, this compensation scheme is restricted largely to state-owned industries.

China regards early detection and early diagnosis of occupational lung disease for the purpose of prompt treatment or removal from further exposure as the second line of prevention. National regulations require periodic medical examinations, including chest radiography for workers who are exposed to hazardous dusts. Previously, the funding necessary for the examinations usually was supported by the central or local government. Nevertheless, with the recent nationwide economic reforms, enterprises have been responsible for their own profits or losses, including the burden of all medical expenditures. As a consequence, some state-owned factories or mines that originally were in compliance with the regulations discontinued periodic medical examinations because of financial shortages, not to mention private-owned or rural township- and village-owned enterprises that never had initiated such programs. Thus, early detection or early diagnosis of pneumoconioses is not realistic in this setting.

Occupational Exposure and Dust Control

Dust control in workplace is always a challenge, particularly in industrializing countries. It is estimated that there are as many as 12 million workers who are occupationally exposed to fibrogenic dust in China.[5] Dust concentrations in workplaces were highest in the 1950s. In the 1960s, a control strategy emphasizing industrial hygiene engineering was instituted. The dust-control strategy included closing operations, wet suppression methods, improving exhaust ventilation, and other engineering hygiene measures. Additionally, personal protective measures, periodic medical surveillance, and workers' education have played important roles. Owing to this strategy, dust concentrations in workplaces decreased gradually, especially in the large-scale state-owned enterprises.[6]

In spite of general improvement of the workplace environment, dust concentrations in a number of workplaces continue to exceed national permissible exposure standards (Appendix C). Inadequate personnel protections are evident, and smoking in workplace has not been prohibited by many enterprises. Furthermore, new problems have arisen, accompanying newly booming rural and urban small-scale industries. These industries generally are characterized by limited capital and human resources, low educational level, poor regulations, and a great lack of awareness of occupational health and safety on the part of both owners and workers. Workers in these industries are more likely to be exposed to higher levels of dust without necessary protective measures. In most cases, these workers have little access to both occupational medical care and primary health care.

There were reports of acute silicosis outbreaks from time to time in small-scale industries and in self-employed settings. A recent report[7] revealed a serious case occurring in a small privately owned agate mill in Guangzhou, a relatively developed city in south China. The work process was operated in primitive conditions, requiring workers to saw raw agate stone into smaller pieces without proper protective measures. The collected dust samplers showed that the dust contained 90.5% silica and the concentrations were far beyond the current maximum allowable concentrations (MACs). As a result of the intense exposure, 15 of 32 workers (47%) were found to have silicosis at stage I or higher. An additional six workers were suspected of having silicosis. The average age of these workers was 29.8 years (ranging from 20 to 40 years), and average exposure duration was only 3.5 years (ranging from 2 to 7 years). The case fatality ratio within nine months since diagnosis was 20%. In China, acute and accelerated silicosis outbreaks such as this one had been uncommon due to the improved working conditions, but now they have re-emerged. Although a forced closure of the mill ensued after investigation by a health administrative department, the case illustrates the current serious situation of occupational health problems in China's newly developed industries. It is likely that other similar enterprises that put workers at extreme risk have not been discovered or reported yet. In brief, China has a long way to go in controlling hazardous dusts in the workplace, and in reaching the WHO's goal of eliminating pneumoconiosis.

RESEARCH IN OCCUPATIONAL LUNG DISEASE

Each country has its own unique occupational health problems that make research necessary for effective interventions. Many industrialized countries have demonstrated the important role of occupational health research and the benefits of improved working conditions on workers' health. Although Chinese researchers are facing numerous challenges and obstacles in undertaking sorely-needed research activities,[8] progress in occupational lung disease research has been remarkable. One indication of this progress is the increasing number, and higher quality, of scientific papers appearing in international journals and international conferences over the last ten years. Previously, epidemiologic studies had mostly been descriptive or cross-sectional in design, or simple exposure assessments. Nowadays, more and more cohort or case–control studies are being conducted. The progress and achievements in occupational health research have created, and will continue to create, powerful forces to establish specific governmental policies and legislative regulations for eliminating hazards and for protecting workers' health in China.

Cotton-dust–related Airway Disease

China is the largest producer and consumer of cotton in the world, with a cotton industry that employs 15 million people.[9] Byssinosis, first reported in 1964, has been officially recognized as an occupational lung disease in this country. Several studies showed byssinosis prevalences in Chinese cotton textile workers ranging from 2% to 15%.[10-13] Cotton dust levels in workplaces varied considerably with mill and with time. Most studies reported that total dust concentrations measured in Chinese settings ranged from 3.0 to 20 mg/m.[3,9] A 15-year cohort study begun in 1981 investigated two cotton textile mills in Shanghai and showed that the highest inhalable dust levels in yarn preparation areas were reduced from 1.6 mg/m^3 in 1981 to 0.5 mg/m^3 in 1996.[13] The decrease in the dust concentrations partly was attributed to increasing usage of blending synthetic materials with cotton.

For many decades, research on the adverse effects of exposure to cotton dust was limited, largely to acute airway responses and the prevalence of respiratory symptoms. Recent efforts have been made to address the natural history of early airway responses to cotton dust. Two prospective cohort studies were conducted in China to determine the changes in respiratory symptoms, lung function and airway responsiveness by observing newly hired cotton textile workers. One study observed a group of workers for one year[14] and reported increasing subjective symptoms and small changes in lung function with increasing time of exposure. Another study followed for 18 months a group of newly hired workers who were nonsmoking and previously healthy.[15,16] The study showed that the earliest pulmonary response was reversible respiratory symptoms, accompanied by substantial cross-shift drops in FEV_1. While declines were not observed at three months, significant longitudinal declines in FEV_1 and FVC were detected after exposure for a year. In addition, both studies observed increasing airway responsiveness with increasing time of exposure and modifying effects of atopy on the changes in lung function and airway responsiveness.

Another notably effort under way is the study of chronic respiratory effects of long-term exposure to cotton dust, an issue to be identified in the area. The recently reported 15-year cohort study[13] observing a group of stable cotton textile workers and a group of silk workers (as controls) suggested significant chronic respiratory effects of long-term exposure to cotton dust. In this study, the cumulative incidence of typical byssinosis was 22% and that of chest tightness was 25%, while the prevalence of byssinosis was 7.6% at baseline. The cotton workers showed more persistent work-specific and nonspecific respiratory symptoms than did the silk workers. Greater excess annual declines in FEV_1 and FVC shown in cotton workers were significantly related to exposure years, exposure to higher levels of endotoxin, and cross-shift drops in FEV_1. Another interesting finding in this study is that workers who reported persistently (i.e., reported at all or most surveys) either specific or nonspecific respiratory symptoms had greater longitudinal losses of lung function. This was first study to document an association between repeated attacks of byssinosis and excessive declines in lung function among cotton textile workers. The ongoing study also sets an example of attainable long-term cooperation between Western scholars and Chinese professionals in occupational lung disease research.

Occupational Lung Cancer and Mineral Dust Exposure

The relationships between exposures to mineral dusts, such as asbestos and silica, and malignant tumors have been a hot topic for occupational epidemiologic studies in China, partly due to the enormous number of working populations exposed to fibrogenic dusts. In addition, numerous mines and factories involving in producing mineral materials or using mineral dust could have provided abundant settings for epidemiologic studies. Also, the unique characteristics of the highly organized working populations and accessible field sites with wide ranges of exposure levels are of great interest to scientists in both China and Western countries, leading to a number of international cooperative research projects.

To date, the burden of occupational lung cancer in China is unknown. Studies of the association between asbestos exposure and lung cancer were initiated only relatively late (in the 1980s). Since the 1990s, lung cancer and mesothelioma induced by occupational exposure to asbestos have been recognized as statutory occupational lung diseases in China. Some of the Chinese epidemiologic studies included large numbers of nonsmoking women, allowing providing estimates of the lung cancer risks posed by asbestos exposure. Furthermore, several studies addressed an interesting issue: the association between exposure to chrysotile alone and lung cancer.

A nation-wide cohort study[17] reported the mortality experience of 5,893 asbestos workers in eight asbestos factories, in which chrysotile asbestos was used to produce textile products and construction materials. One hundred eighty-three cancers (including 67 lung cancers) out of 496 deaths were observed, with the relative risk (RR) of 5.3 ($p < 0.01$) and a standardized relative risk of 4.2 ($p < 0.01$) for lung cancer. There was a synergistic effect between cigarette smoking and lung cancer, but the risk of lung cancer produced by asbestos exposure was found to be twice as high as that produced by smoking. Another study[18] also reported higher mortality from lung cancer among nonsmoking female chrysotile workers (Obs:Exp = 6:0.88). A recently reported prospective cohort study using more sophisticated analysis methods observed RRs of 6.6 for lung cancer and 4.3 for all cancers in a group of workers who were exposed to chrysotile alone.[19] These studies have provided useful information and evidence for chrysotile-associated lung cancer risk.

Few epidemiologic studies investigating whether silica is a carcinogenic agent were available before the 1990s in China. As is evident in the results of studies conducted in other countries, observed associations between exposure to silica and lung cancer risk were conflicting among Chinese studies. Several studies investigated exposed workers in tin mines, tungsten mines, copper mines, iron mines, pottery factories, and an iron–steel plant[20-25] and obtained different results relative to the association. However, there was a consistent result, i.e., a higher risk of lung cancer in silicotic patients, seen in both case–control[23,26] and cohort studies.[22,27] In most cases, the workers were simultaneously exposed to arsenic, radon, cadmium, or PAH. To understand the complex pattern of interactions leading to lung cancer among silica-exposed workers, additional efforts are being made to collect more detailed and accurate information about environmental and individual exposures, and to use novel epidemiologic approaches. To date, lung cancer associated with occupational exposure to crystalline quartz has not been recognized as a statutory occupational disease in China.

CONCLUSIONS

Occupational lung disease has been a major public health problem in China, despite significant achievements in disease recognition and exposure controls. Recent rapid industrialization and economic development have resulted in a changing profile of occupational exposures and disease epidemics, with a decreasing incidence of occupational lung diseases in major urban centers and an increasing incidence in newly-industrialized rural areas. In the latter settings, industrial hazardous agents are poorly controlled, and occupational health services and medical care are lacking or insufficient. The fact that new problems have emerged while old problems have remained poses both tremendous challenges and opportunities for occupational health research. These challenges have spurred much new professional activity, including epidemiologic and toxicologic research, which plays an indispensable part in developing relevant hygiene standards and government policies.

References

1. He F. Occupational medicine in China. Int Arch Occup Environ Health. 1998; 71:79-84.
2. Christiani DC, Tan X, Wang XR. Occupational health in China. Occup Med. 2002; 17: 355-70.
3. Zhong Y, Li D. Potential years of life lost and work tenure lost when silicosis is compared with other pneumoconioses. Scand J Work Environ Health. 1995; 21 suppl 2: 91-4.
4. Zhou C, Shen GA. Coal workers' pneumoconiosis in developing nations. In: Occupational Lung Disease. An International Perspective. Banks DE, Parker JE (eds). London, U.K.: Chapman & Hall Medical, 1998: 183-189.
5. Liang YX, Fu H, Gu XQ. Provision of occupational health services in China. Asian-Pacific Newsletter on Occupational Health and Safety. 1998; 2:1-5.

6. Lou JZ, Zhou C. The prevention of silicosis and prediction of its future prevalence in China. Am J Public Health. 1989;79:1613-6.
7. Jiang CQ, Xiao LW, Lam TH, Xie NW, Zhu CQ. Accelerated silicosis in workers exposed to agate dust in Guangzhou, China. Am J Ind Med. 2001; 40: 87-91.
8. Xu X, Christiani DC. Occupational health research in developing countries: focus on U.S.–China collaboration. Int J Occup Environ Health. 1995; 1:136-41.
9. Chowgule RV. Byssinosis in India and the developing world. In: Occupational Lung Disease. An International Perspective. Banks DE, Parker JE (eds). London, U.K.: Chapman & Hall Medical, 1998: 421-33.
10. Lu PL, Christiani DC, Ye TT. The study of byssinosis in China: a comprehensive report. Am J Ind Med. 1987; 12:743-4.
11. Christiani DC, Ye TT, Wegman DH, Eisen EA, Dai HL, Lu PL. Pulmonary function among cotton textile workers. A study of variability in symptom reporting, across-shift drop in FEV_1, and longitudinal change. Chest. 1994; 105:1713-21.
12. Jiang CQ, Lam TH, Kong C. Byssinosis in Guangzhou, China. Occup Environ Med. 1995; 52:268-72.
13. Christiani DC, Wang XR, Pan LD, et al. Longitudinal changes in pulmonary function and respiratory symptoms in cotton textile workers. A fifteen-year follow-up study. Am J Respir Crit Care. 2001; 163: 847-53.
14. Li D, Zhong YN, Rylander R, Ma QY, Zhou XY. Longitudinal study of the health of cotton workers. Occup Environ Med. 1995; 52:329-31.
15. Wang XR, Pan LD, Zhang HX, Sun BX, Dai HL, Christiani DC. A follow-up study of respiratory health of non-smoking newly-hired female cotton textile workers. Am J Ind Med. 2002; 41: 111-8.
16. Wang XR, Pan LD, Zhang HX, Sun BX, Dai HL, Christiani DC. A longitudinal observation of early pulmonary responses to cotton dust. Occup Environ Med. 2003; 60:115-21.
17. Zhu H, Wang Z. Study of occupational lung cancer in asbestos factories in China. Br J Ind Med. 1993; 50:139-42.
18. Pang ZC, Zhang Z, Wang Y, Zhang H. Mortality from a Chinese asbestos plant: overall cancer mortality. Am J Ind Med. 1997; 32: 442-4.
19. Yano E, Wang ZM, Wang XR, Wang MZ, Lan YJ. Cancer mortality among workers exposed to amphibole-free chrysotile asbestos. Am J Epidemiol. 2001; 154:538-43.
20. Chen R, Wei L, Huang H. Mortality from lung cancer among copper miners. Br J Ind Med. 1993; 50:505-9.
21. Xu Z, Brown LM, Pan GW, et al. Cancer risks among iron and steel workers in Anshan, China, Part II: Case–control studies of lung and stomach cancer. Am J Ind Med. 1996; 30:7-15
22. Qiao YL, Taylor PR, Yao SX, et al. Risk factors and early detection of lung cancer in a cohort of Chinese tin miners. Ann Epidemiol. 1997; 7:530-2.
23. Cocco P, Rice CH, Chen JQ, McCawley MA, McLaughlin JK, Dosemeci M. Lung cancer risk, silica exposure, and silicosis in Chinese mines and pottery factories: the modifying role of other workplace lung carcinogens. Am J Ind Med. 2001; 40:674-82.
24. Hazelton WD, Luebeck EG, Heidenreich WF, Moolgavkar SH. Analysis of a historical cohort of Chinese tin miners with arsenic, radon, cigarette smoke, and pipe smoke exposures using the biologically based two-stage clonal expansion model. Radiat Res. 2001;156:78-94.
25. Chen W, Chen J. Nested case–control study of lung cancer in four Chinese tin mines. Occup Environ Med. 2002; 59:113-8.
26. Cocco P, Rice CH. Non-malignant respiratory diseases and lung cancer among Chinese workers exposed to silica. J Occup Environ Med. 2000; 42:639-44.
27. Wang Z, Dong D. Cancer mortality among silicotics in China's metallurgical industry. Int J Epidemiol. 1996; 25:913-7.
28. Li YR. Prevention and treatment of pneumoconiosis in China. Biomed Environ Sci. 1995; 8:211-7.

Appendix A
Statutory Occupational Lung Diseases in China

Pneumoconiosis

- Silicosis
- Coal workers' pneumoconiosis
- Graphite pneumoconiosis
- Carbon pneumoconiosis
- Asbestosis
- Talc pneumoconiosis
- Cement pneumoconiosis
- Mica pneumoconiosis
- Ceramic pneumoconiosis
- Aluminum pneumoconiosis
- Welders' pneumoconiosis
- Foundryman's pneumoconiosis

Occupational lung tumors

- Lung cancer, mesothelioma induced by asbestos
- Lung cancer induced by bischloromethyl ether
- Carcinoma of lung and skin induced by arsenic
- Polycyclic aromatic hydrocarbon–induced lung cancer (e.g., in coke oven workers)
- Chrome-induced lung cancer

Other occupational lung disease

- Occupational asthma
- Occupational hypersensitivity pneumonitis extrinsic allergic alveolitis
- Byssinosis

Appendix B
Chinese Classification of Radiographs for Pneumoconiosis, 1986

1. No pneumoconiosis (Stage 0)
   (a) 0: X-ray shows no pneumoconiosis
   (b) 0+: X-ray presentation is not sufficient for classifying as I

2. Stage I pneumoconiosis
   (a) I: Profusion grade 1 small rounded opacities, distribution of at least an area of diameter not less than 2 cm, with one area in each of the two lungs; or profusion grade 1 small irregular opacities in not less than two lung zones
   (b) I+: Small opacities are obviously more, but either the profusion or distribution is not sufficient for classifying as II

3. Stage II pneumoconiosis
   (a) II: Profusion grade 2 small rounded or irregular opacities and distribution in more than four lung zones; or profusion grade 3 small opacities and distribution reaching four lung zones
   (b) II+: Profusion grade 3 small opacities and distribution in more than four lung zones; or large opacities not sufficient for classifying as III

4. Stage III pneumoconiosis
   (a) III: Large opacities of length not less than 2 cm and width not less than 1 cm
   (b) III+: Single large opacities with an area, or multiple large opacities with total area, greater than the right upper lung zone

Appendix C

Maximum Allowable Concentrations for Dusts in Workplace Air

Substance	MAC (mg/m^3) (Total Dust)
Promulgated in 1979	
Dusts containing more than 10% free silica (quartz, quartzite etc.)	2
Dusts containing more than 80% free silica (quartz, quartzite etc.)	1
Asbestos and dusts containing more that 10% asbestos	2
Talc dust containing less that 10% free silica	4
Cement dust containing less than 10% free silica	6
Coal dust containing less than 10% free silica	10
Aluminum, aluminum oxide, and aluminum alloy dusts	4
Tobacco dust and tea dust	3
Glass wool and slag wool dusts	5
Other dusts†	10
Promulgated from 1983 to 1989	
Active carbon	10
Metal	4
Oxides	6
Alloys	4
Carbon black	8
Fur (SiO_2 < 10%)	10
Graphite (SiO_2 < 10%)	6
Grinding wheel dust (SiO_2 < 10%)	10
Mica (SiO_2 < 10%)	4
Mixed dust from fluorspar (SiO_2 < 20%)	2
Perlite (SiO_2 < 10%)	10
Silicon carbide (SiO_2 < 10%)	10
Silicon dioxide (SiO_2 50–80%)	1.5
Silicon dioxide (SiO_2 > 80%)	1
Titanium dioxide	10
Vermiculite (SiO_2 < 10%)	5

*Adapted from Li (1995).[28]

†Other dusts refer to mineral or vegetable dusts containing less that 10% free silica and no toxicants.