

# Inorganic Dust Exposure in Western Agriculture

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## Inorganic Dust Exposure and Lung Disease in Agriculture

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- Silica and silicates in agriculture
  - Inorganic dust exposure
- Respiratory morbidity and mortality associated with silica and silicates
- Toxicity of agricultural dusts
- Interstitial lung disease

# Respiratory Hazards in Agriculture

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## EXPOSURE

## EXAMPLES

- Organic dusts
  - Vegetable Grain, hay, cotton
  - Animal Hair, feathers, skin
  - Microbial Bacterial and fungal antigens, endotoxin
- Gases  $H_2S$ ,  $NH_3$ ,  $CH_4$ ,  $CO_2$ ,  $NO_2$
- Chemicals Paraquat, solvents, fuels, exhausts
- Inorganic dust Silica, silicates, asbestos

## Western Agriculture is Dry and Dusty



***“Winds blowing over the barren lands  
churn up storms of dust... I sense what  
dust bowl veterans of the 30’s must have  
witnessed.”***

***“Even my unexposed skin wears a fine  
undergarment of dust; it penetrates most  
every crevice of my body”***

*Epitaph for a peach, 1996*  
David M. Masumoto  
Central Valley farmer

# **Inorganic Dust Exposure in Agriculture**

## Silica and Silicates in Agricultural Soils

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- **Crystalline silica** ( $\text{SiO}_2$ ).
  - Quartz, cristobalite, tridymite
  - 12% of land mass,  $\leq 20\%$  of topsoil
- **Silicates** ( $\text{SiO}_2 + \text{Mg, Ni, Fe, Al}$ )
  - Talc, asbestos
  - 90% of land mass
- **Amorphous silicates** ( $\text{SiO}_2 + \text{H}_2\text{O}$ )
  - In biologic systems, may be fibrous

### Citrus harvest



Respirable  
dust  
sampler  
with cyclone

## Personal Dust Exposure During Field Crop Farming-California

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<u>Operation</u>	<u>Cab</u>	<u>GM (mg/m<sup>3</sup>)</u>
Land plane	No	57.3
Disking	No	98.6
“	Yes	1.6
Fertilize	No	10.4
Plant	No	23.3
Harvest	No	39.1
“	Yes	1.6
Irrigate	No	2.2

## Personal Dust Exposure (mg/m<sup>3</sup>) Fruit, Nut, Dairy Farming - Calif.

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<u>Operation</u>	<u>GM (mg/m<sup>3</sup>)</u>
<b>Fruit &amp; Nut</b>	
- Hand harvest	5.1
- Mechanical harvest	10.6
<b>Dairy Farming</b>	
- Feeding	25.9
- Manure removal	2.6
- Milking	0.7

Niewenhuysen, 1998

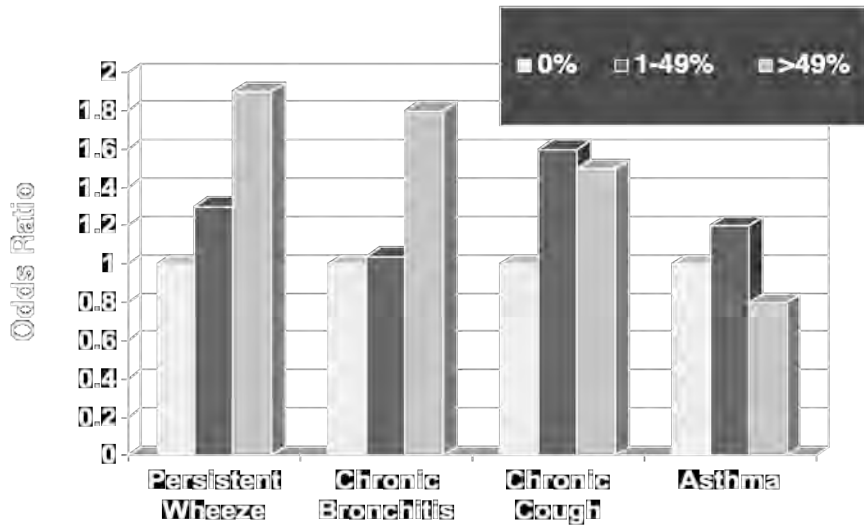
## Airborne contaminants in rice and citrus farming (mg/m<sup>3</sup>)

	Rice Field Prep		Citrus Harvest	
	<u>Avg</u>	<u>Range</u>	<u>Avg</u>	<u>Range</u>
Total dust	35.2	11.1 - 72.1	39.6	19.5 - 100.8
Resp. dust	3.17	1.77 - 5.24	1.14	0.01 - 5.1
Resp. quartz	0.03	0.02 - 0.04	0.08	0.01 - 0.2

Lawson '93

## Inorganic Dust and Respiratory Disease in Agriculture

## Odds Ratios\* for Respiratory Symptoms by Percent Time at Dusty Job



\*Logistic regression model, adjusted for age, smoking status, gender and other variables

## Pneumoconiosis from Agricultural Dust Exposure

## ***“Silicate Pneumoconiosis of Farm Workers”***

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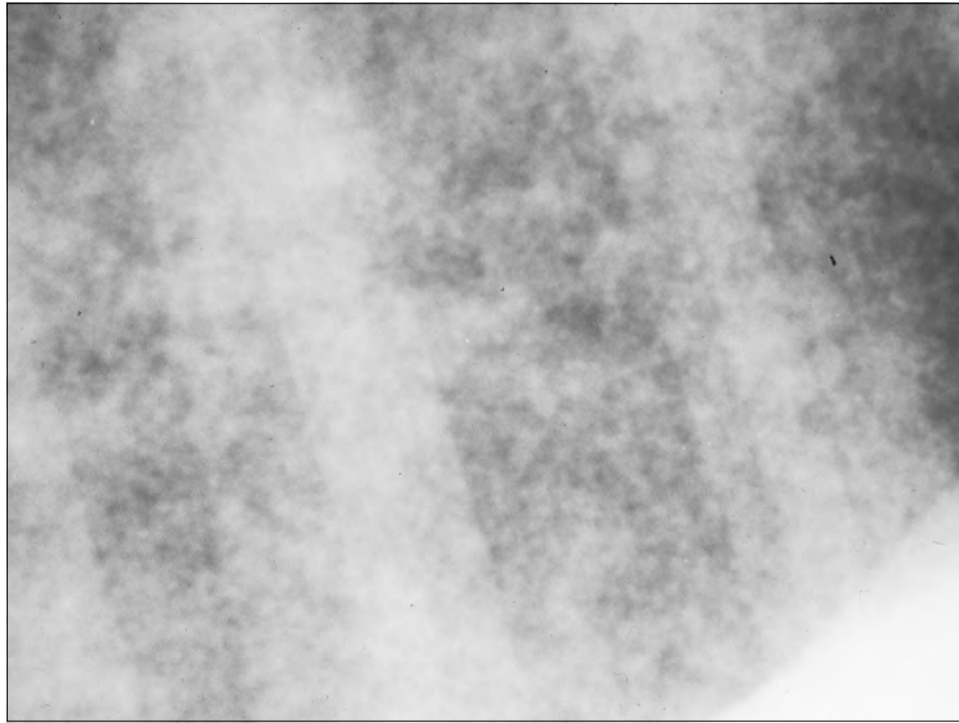
- Seven California Central Valley residents
  - 5 vineyard workers, 1 farmer, 1 rural resident
  - 6/7 non-smokers
- Early to late interstitial inflammation and fibrosis
- No silicotic nodular granulomas
- SEM and EDXA of particles < 5  $\mu\text{m}$  mostly silicates
  - (Si=68%, Al=27%, K=6%),
  - 5 - 10%  $\text{SiO}_2$
  - Soil particle analysis similar composition

Sherwyn, Lab Invest 1979; 40:576

## **SILICATE PNEUMOCONIOSIS**

- 100 autopsies in San Diego Zoo from 11 mammalian and 8 avian species.
- Crystal laden macrophages in alveoli and lymphatics. No nodules.
- Interstitial fibrosis in 20% of cases.
- SEM and TEM: 90% silicates.
- EDXA: mica and degradation products.
- Dust retention related to age, length of zoo stay.

Brambilla, AJP 1979; 96:149



## **Equine Silicosis: A Report of 19 Cases**

- **19 cases of confirmed equine silicoses at UC Davis**
  - 10 geldings, 9 mares
  - Mean age  $10.7 \pm 5.5$  years
  - 14/19 horses from Monterey-Carmel Peninsula
  - **Interstitial fibrosis on x-ray in all cases**
    - » 13/19 miliary
    - » 4/19 reticulonodular
    - » 2/19 linear interstitial
  - **Other radiologic features**
    - » 4/19 hilar adenopathy
    - » 4/19 pleural effusion/thickening
  - **Pathology consistent with accelerated human silicosis**

Berry, J Vet Int Med 1991; 5:248

# Pneumoconiosis from Agricultural Dust Among California Farmworkers

MB Schenker<sup>1</sup>, KE Pinkerton<sup>1</sup>, B Elvine-Kreis,  
V Vallyathan<sup>2</sup>, M Kim<sup>1</sup>, F Green<sup>3</sup>

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<sup>1</sup>University of California at Davis

<sup>2</sup>NIOSH, Morgantown, WV

<sup>3</sup>University of Calgary

## Objectives

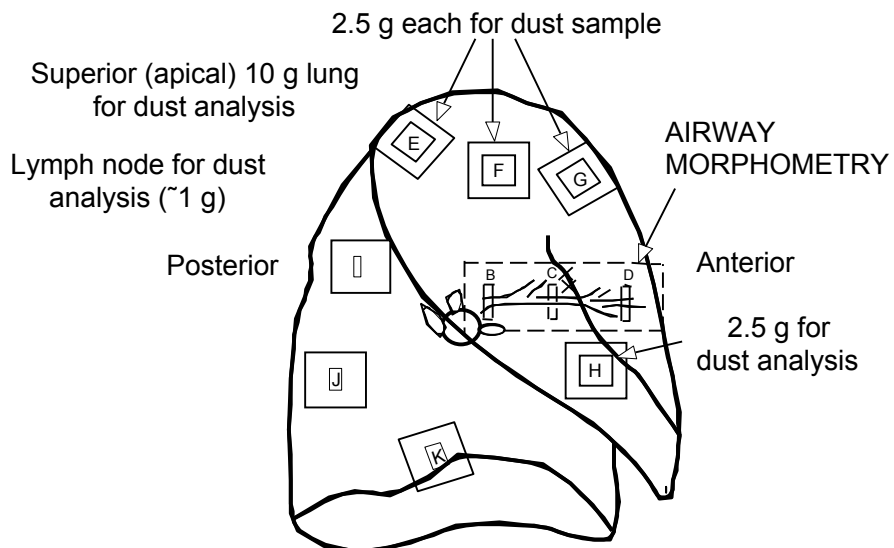
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- To document and quantify pathologic lesions in lung tissues from Hispanic males autopsied by the Coroner's Office in Fresno, California.
- To compare histologic changes in lung tissue samples between deceased agricultural workers and non-agricultural workers.

Autopsy specimen of left lung showing left mainstem bronchus and dissection of distinct airways



## Sampling Strategy - Dust Analysis



## Particle Size and Mineral Characteristics in Farmworker Lungs

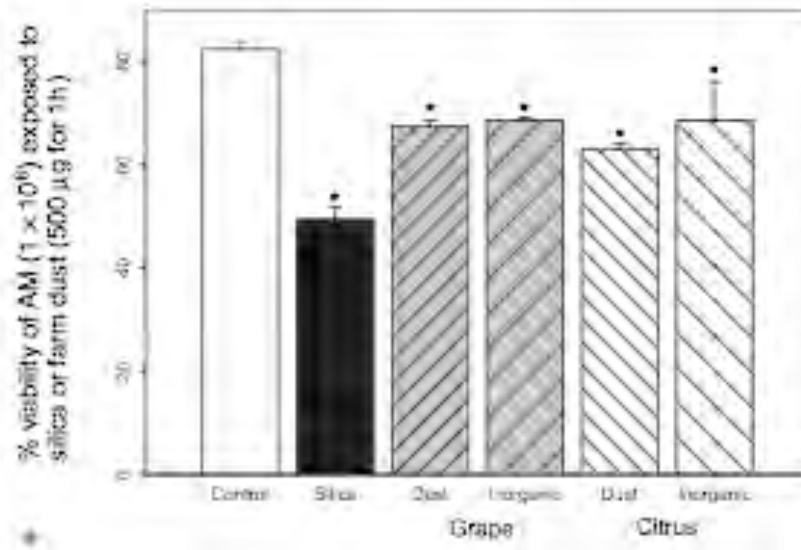
	Case 1	Case 2	Case 3	Case 4	Mean
Diameter ( $\mu$ )*	0.60	0.66	0.68	0.60	0.635
Crystalline Silica**	13.87	15.85	17.14	20.42	16.82
Aluminum Silicates**	72.36	68.50	70.93	70.72	70.63
Other Silicates**	10.89	13.78	7.10	8.36	10.03
Endogenous**	2.88	1.87	4.83	0.50	2.52

\*Median.  
 \*\*Percent concentration of minerals by number determined by x-ray spectrometric analysis of 1000+ particles.

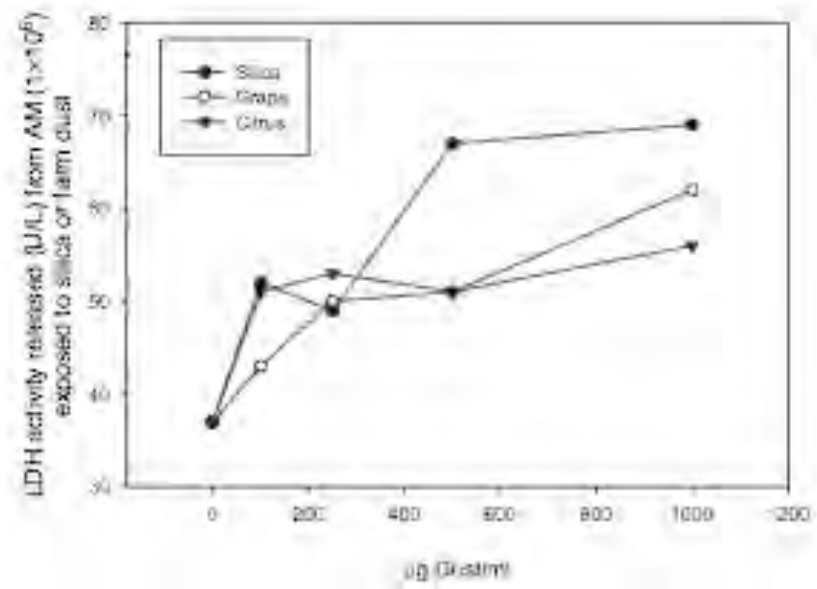
## Particle Analysis of Orange and Grape Foliar Dust

	Orange (%)	Grape (%)
Quartz	10.05	7.9
Alumunum silicates	76.1	79.7
Talc like	0.55	0.4
Iron oxide	0.45	0.2
Rutile like	0.25	0.2
Silicon rich	3.85	3.35
Iron rich	3.35	2.85
Titanium rich	0.85	1
Other Al Si	1	0.4
Aluminum rich	0.1	0
Other	3.45	4

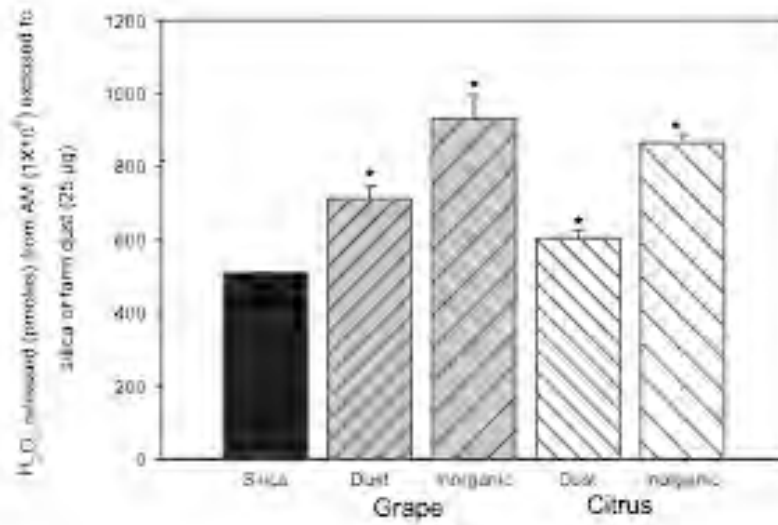
### % Viability of Alveolar Macrophages Exposed to Farm Dusts



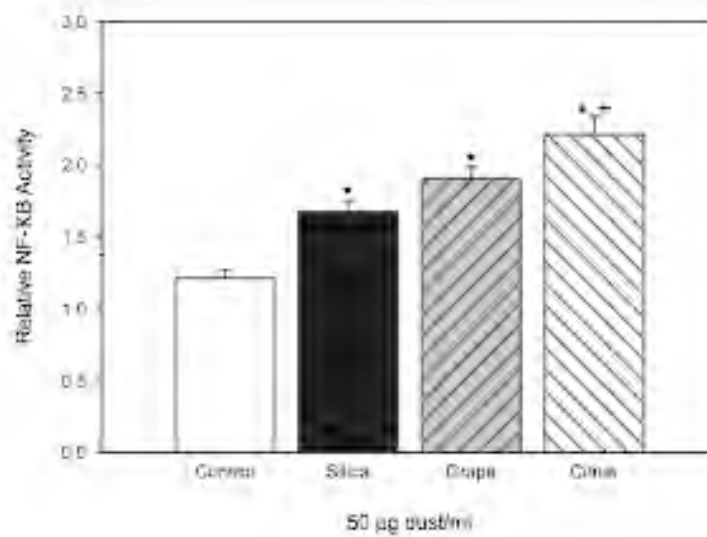
### LDH Activity Released from AM Exposed to Farm Dusts

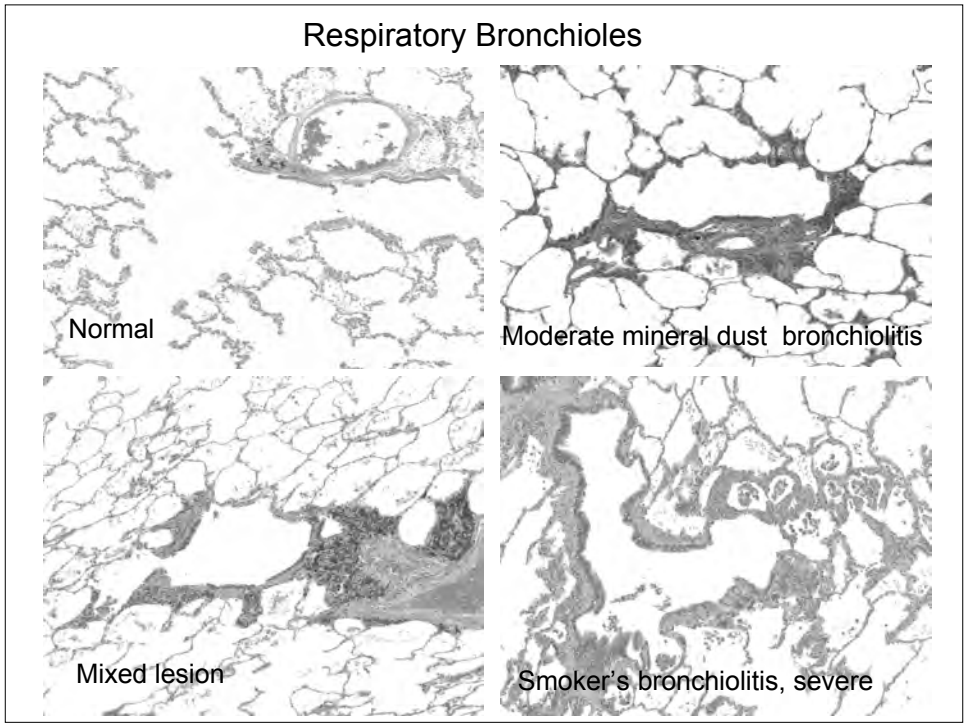


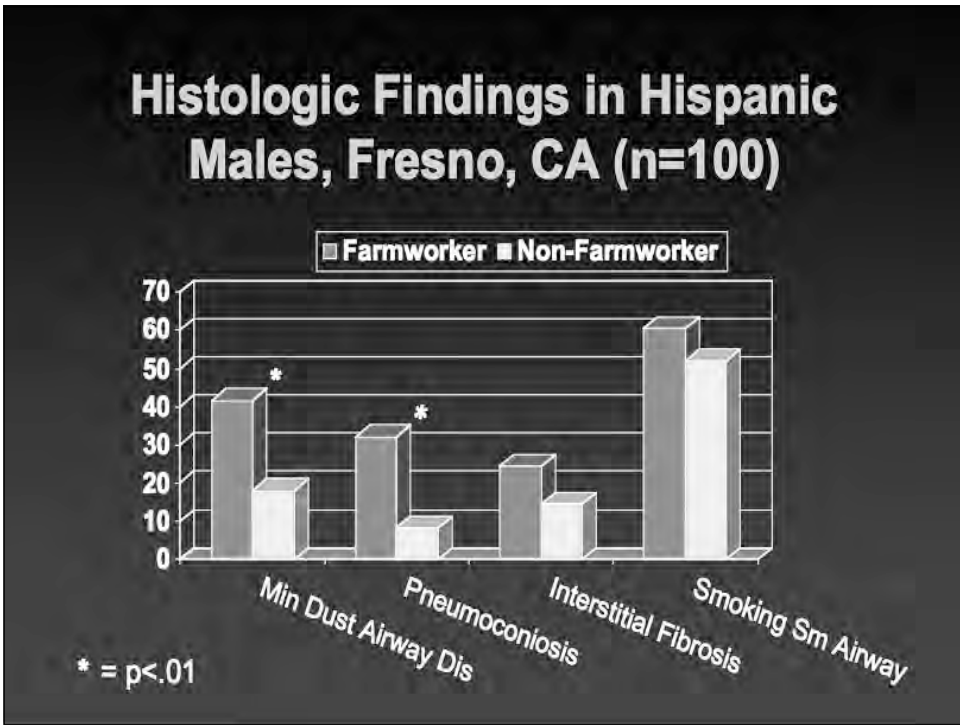
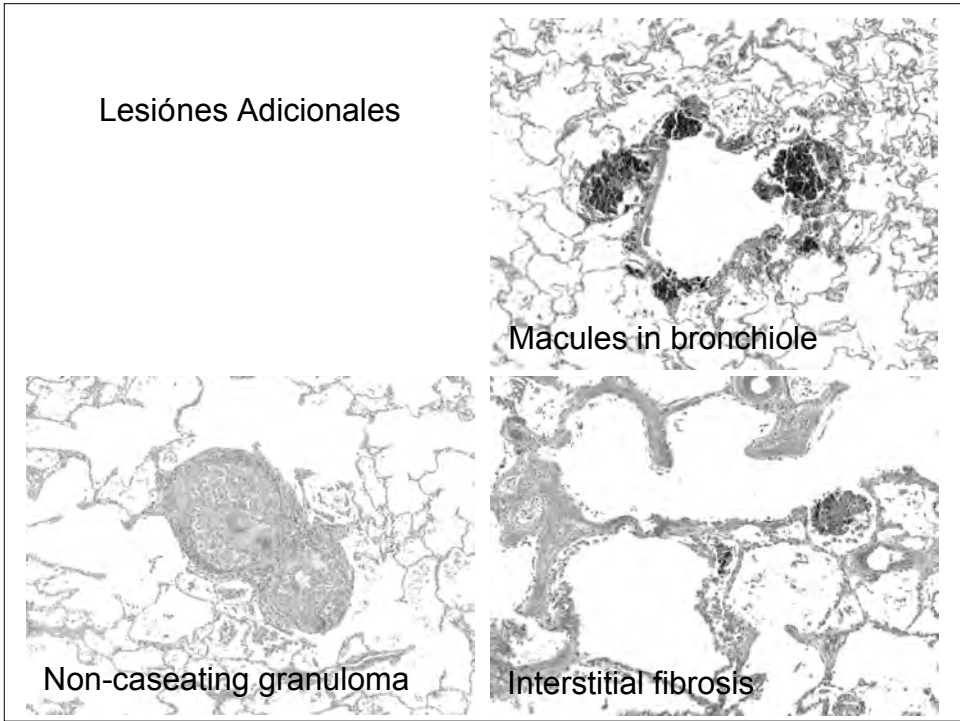
## H<sub>2</sub>O<sub>2</sub> Released from AM Exposed to Silica or Farm Dusts



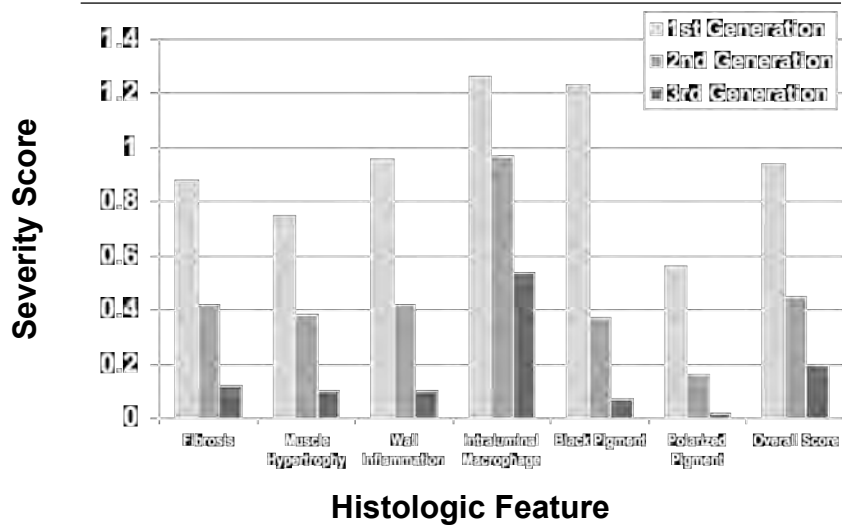
## Relative NF- $\kappa$ B Activity



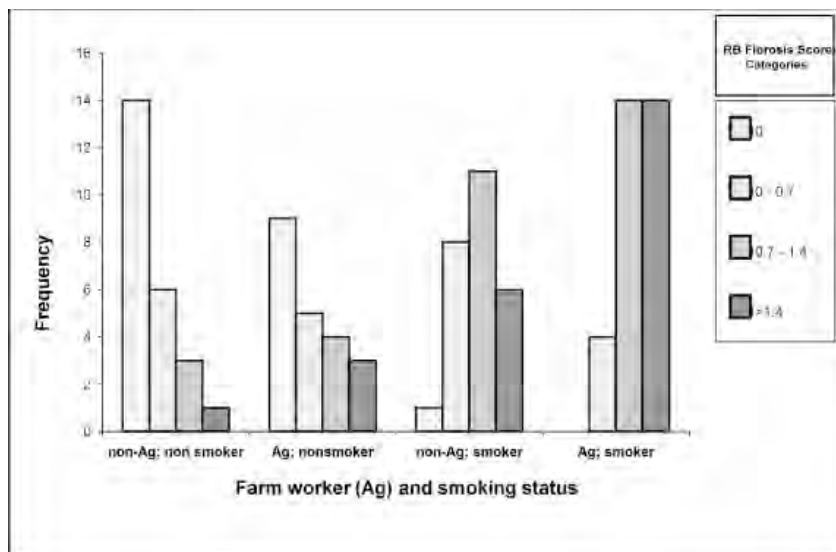


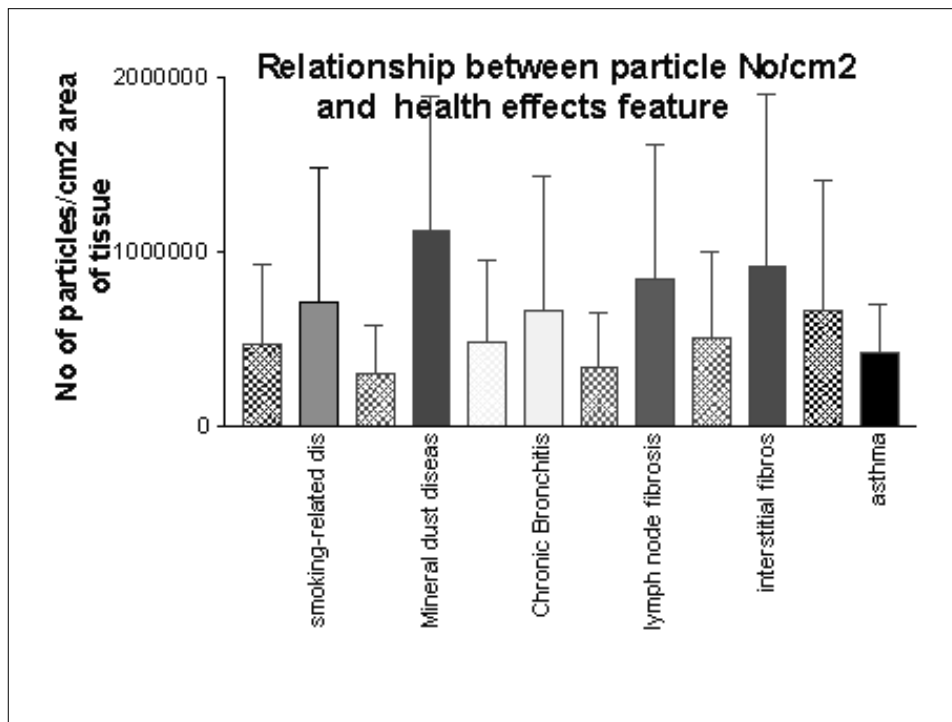


## Severity Scores by Respiratory Bronchiole Generation (n=43)



## Fibrosis Scores by quartiles of Agricultural Work and Smoking Status, 1<sup>st</sup> Generation Respiratory Bronchioles





## Risk Factors for Idiopathic Pulmonary Fibrosis: A Multicenter Case-Control Study

- 16 referral centers in 15 states
- Ages 20-75
- 248 cases, 491 controls

<u>Exposure</u>	<u>O.R.</u>	<u>95% C.I.</u>
Farming*	1.6	1.0 - 2.5
Livestock*	2.7	1.3 - 5.5
Vegetable/animal dust	4.7	2.1 - 10.4

\*Interaction w/ smoking

Baumgartner, AJE 152; 2000

## Case-Control Studies of Idiopathic Pulmonary Fibrosis

Occ/Exp	U.S. (n=248)	UK (n=218)	Japan (n=86)	England (n=40)
Farm/Ag	1.6*		3.0*	
Cattle	2.7*			10.9*
Stone/sand	3.9*	1.8*		0.9
Wood dust	1.6	1.7*		2.9

## Mineralogical Microanalysis of Idiopathic Pulmonary Fibrosis

- 25 samples of Idiopathic Pulmonary Fibrosis, 25 normal lung, 6 pneumoconiosis (Asbestos, Silicosis)
  - SEM - Scanning electron microscopy
  - EDXA - Energy dispersive x-ray analysis
  - Surface silicon/sulfur (Si/S) ratios calculated
- Si/S ratios significantly increased in IPF cases
  - 6/12 IPF cases had hx. ? silica/sulfur exposure
  - Correct diagnosis probably pneumoconiosis

## Interstitial Respiratory Disease in Agriculture: Summary

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- High levels of inorganic dust exposure occur, especially in dry climate farming areas
  - Dust is a mixture of silicates and crystalline silica
- Case reports and animal studies show pneumoconiosis
- Mineral dust disease and pneumoconiosis associated with agricultural dust exposure
- Epidemiologic association of IPF and agriculture dust
  - Prevalence and severity of inorganic dust disease unknown

