Risk Assessment and Health Effects among Asbestos Exposure Workers: A Brazilian Experience

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ASBESTOS EXPOSURE IN BRAZIL

- BACKGROUND
- RISK ASSESSMENT
- HEALTH EFFECTS
- MAIN PUBLICATIONS
1907 - First Asbestos Cement Plant (Imported Asbestos)

1940 - First Open Mine - São Felix - Bahia

1942 - Two Major Asbestos Cement Plant Installed in São Paulo

1967 - Canabrava Mine - Goiás

1995 - Forbidden Amphiboles – Federal Law Recommendation of Chrysotile Control Use

1997 - Asbestos Mining Project
2005 - First Epidemiologic Study

“Non-Malignant Consequences of decreasing asbestos exposure in the Brazil Chrysotile Mines and Mills”

- Data Provided of Asbestos Mining Project

Before 1980
No Hygiene Control

Asbestos Cement
RISK ASSESSMENT

Before 1980
No Hygiene Control → Asbestos Cement
RISK ASSESSMENT

Before 1980
No Hygiene Control

Textile
RISK ASSESSMENT

After 1980

Hygiene Control ➔ Asbestos Cement
Filters Section – Canabrava Mine 1985
RISK ASSESSMENT
Industrial Hygiene Controls

Mean f/cc


Grindling Mixing
## RISK ASSESSMENT

n = 7128 Evaluated Workers

<table>
<thead>
<tr>
<th></th>
<th>Admission</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Asbestos Cement</td>
<td>164</td>
<td>03</td>
</tr>
<tr>
<td>Miner and Miller</td>
<td>53</td>
<td>-</td>
</tr>
<tr>
<td>N = 220</td>
<td>217</td>
<td>03</td>
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</tbody>
</table>

Non-Published Data
### HEALTH EFFECTS

**ASBESTOS MINING PROJECT - I**

"Morbidity and Mortality among Workers exposed to Asbestos In Mining Activities 1940-1996"

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Asbestosis &amp; Plaques</th>
<th>Asbestosis</th>
<th>Pleural Plaques</th>
<th>Lung Cancer</th>
<th>TOTAL n</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>195</td>
<td>11</td>
<td>5</td>
<td>36</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>II</td>
<td>1593</td>
<td>5</td>
<td>10</td>
<td>26</td>
<td>2</td>
<td>43</td>
</tr>
<tr>
<td>III</td>
<td>2432</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4220</td>
<td>18</td>
<td>17</td>
<td>71</td>
<td>3</td>
<td>109</td>
</tr>
</tbody>
</table>
Asbestos Mining in the World

- Colômbia Britânica (Canadá)
- Newfoundland (Canadá)
- Quebec (Canadá)
- Vermont (EUA)
- Califórnia (EUA)
- Brasil
- Colômbia
- Calçada
- Zimbábue
- Africa do Sul
- Itália
- Grécia
- Turquia
- Índia
- China
- Coréia
- Japão
- Chipre
- Rússia
- Iugoslávia
- Formosa
Asbestos Mines in Brazil

South Atlantic Ocean

South Pacific Ocean

Goiás

Bahia
São Félix Mine - Bahia - Mining Operation - 1940-1950
Canabrava Mine - Mining Operation - 2000
Non-malignant consequences of decreasing asbestos exposure in the Brazil chrysotile mines and mills

E Bagatin, J A Neder, L E Nery, M Terra-Filho, J Kavakama, A Castelo, V Capelozzi, A Sette, S Kitamura, M Favero, D C Moreira-Filho, R Tavares, C Peres and M R Becklake


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Research Grants from:
- FAPESP - Public Research Foundation - São Paulo
Institutional Grants:
- State University of Campinas and SAMA
ASBESTOS MINING PROJECT - I

“Morbidity and Mortality among Workers exposed to Asbestos In Mining Activities 1940-1996”

Inter-Institutional Project:

♦ Federal University of São Paulo - UNIFESP
♦ State University of São Paulo - USP
♦ State University of Campinas - UNICAMP
ASBESTOS MINING PROJECT - I

“Morbidity and Mortality among Workers exposed to Asbestos In Mining Activities 1940-1996”

International Scientific Support:

♦ McGill University - Montreal - Canada
♦ Health Canada
♦ University of British Columbia - Vancouver - Canada
♦ West Virginia University - Morgantown - USA
♦ National Heart and the Lung Institute - London - UK

Imperial College of Science
AIMS OF THE STUDY

Investigate the consequences of improvement in the workplace environment over six decades (1940-1996) in asbestos mine and millers from a developing country (Brazil).
Study Population:

Group I - Only workers from SÃO FELIX - 1940-1967
NO MEASUREMENTS/CONTROL OF EXPOSURE
TREMOLITE + CHRYSOTILE

Group II - Workers from CANABRAVA – 1967-1976
NO MEASUREMENTS OF EXPOSURE
PROGRESSIVE IMPROVEMENT IN EXPOSURE
CHRYSOTILE

Group III - Workers from CANABRAVA – 1976-1996
ROUTINE MEASUREMENTS/CONTROL OF EXPOSURE
CHRYSOTILE
METHODS

♦ Clinical Evaluation
- Clinical Findings - Cough, Phlegm, Wheezing, Dyspnea (modified MRC scale)
- Occupational history
- Smoking history (pack/year)

♦ Exposure Evaluation
- Before 1977 – Estimated by logarithmic scale
- After 1977 – Counting fibers using phase contrast microscopy – NIOSH standardization
METHODS

♦ Imaging Evaluation
  - Chest X-Ray (OIT-1980 Classification)
  - High-Resolution Computed Tomography (HRCT) according to Webb, Gamsu and Müller recommendations (Selected Subjects)

♦ Pulmonary Function Evaluation
  - Spirometry
  - Carbon Monoxide Diffusing Capacity
  - Static Volumes
  - Gas Exchange Evaluation at Rest and Exercise (ATS criteria)
Study Population

FROM ALL WORKERS WHO HAD WORKED FOR AT LEAST ONE YEAR AND WERE ALIVE

<table>
<thead>
<tr>
<th>Group</th>
<th>Recruited/Targeted</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP I</td>
<td>180/390</td>
<td>46.1</td>
</tr>
<tr>
<td>GROUP II</td>
<td>1317/1950</td>
<td>67.5</td>
</tr>
<tr>
<td>GROUP III</td>
<td>2137/3325</td>
<td>64.2</td>
</tr>
<tr>
<td>Total</td>
<td>3634/5.565</td>
<td>64.1</td>
</tr>
</tbody>
</table>
RESULTS

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency (yrs)</td>
<td>Exposure (yrs)</td>
<td>Cumulative Exposure (fiber/yrs/cc)</td>
</tr>
<tr>
<td>43.7</td>
<td>25.9 *</td>
<td>109.1</td>
</tr>
<tr>
<td>15.9 **</td>
<td>12.9</td>
<td>39.4 *</td>
</tr>
<tr>
<td>12.9</td>
<td>10.1 *</td>
<td>4.3 **</td>
</tr>
<tr>
<td>10.1 *</td>
<td>7.5 **</td>
<td></td>
</tr>
</tbody>
</table>

* - Group II vs. I and III
** - Group III vs. I and II
<table>
<thead>
<tr>
<th>Variables</th>
<th>Group I (n = 180)</th>
<th>Group II (n = 1317)</th>
<th>Group III (n = 2137)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical findings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current or past smoking (%)</td>
<td>75.6</td>
<td>63.7</td>
<td>49.6</td>
</tr>
<tr>
<td>Smoking (pack-years)</td>
<td>33.1 ± 56.5</td>
<td>14.5 ± 22.4*</td>
<td>8.4 ± 17.0**</td>
</tr>
<tr>
<td><strong>Symptom prevalence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyspnoea (%)</td>
<td>17.8</td>
<td>30.3</td>
<td>15.3†</td>
</tr>
<tr>
<td>Wheezing (%)</td>
<td>7.8</td>
<td>15.9</td>
<td>6.9†</td>
</tr>
<tr>
<td>Cough (%)</td>
<td>16.1</td>
<td>22.4</td>
<td>10.8†</td>
</tr>
<tr>
<td>Phlegm (%)</td>
<td>10.6</td>
<td>14.1</td>
<td>7.5†</td>
</tr>
<tr>
<td><strong>Lung function abnormalities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVC (% pred)</td>
<td>94.4 ± 17.3</td>
<td>102.5 ± 17.41*</td>
<td>106.0 ± 14.9**</td>
</tr>
<tr>
<td>FEV₁ (% pred)</td>
<td>91.0 ± 20.0</td>
<td>97.2 ± 18.2*</td>
<td>100.7 ± 15.7**</td>
</tr>
<tr>
<td>FEV₁/FVC (%)</td>
<td>70.1 ± 7.1</td>
<td>72.2 ± 7.3*</td>
<td>74.2 ± 7.1**</td>
</tr>
<tr>
<td>FEF₂₅–₇₅% (% pred)</td>
<td>77.2 ± 39.3</td>
<td>85.8 ± 39.1*</td>
<td>83.0 ± 38.8</td>
</tr>
<tr>
<td>Abnormal spirometry (%)</td>
<td>29.8</td>
<td>24.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Obstructive (%)</td>
<td>82.3</td>
<td>80.1</td>
<td>88.8</td>
</tr>
<tr>
<td>Restrictive (%)</td>
<td>11.7</td>
<td>18.6</td>
<td>9.9</td>
</tr>
<tr>
<td>Combined (%)</td>
<td>7.0</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>
$P < 0.05$
RESULTS

Frequency (%) of Radiographic Abnormalities by Group

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parenchymal (1/0 or greater)</td>
<td>9.5</td>
<td>2.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Pleural</td>
<td>16.1</td>
<td>4.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Pleural and/or Parenchymal</td>
<td>22.2</td>
<td>6.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

* - p <0.05
RESULTS

Frequency of Pleural and Parenchymal Abnormalities Comparing Groups with SAME LATENCY

- Group I (30 to 45 yrs Latency)
  - Frequency: 18.7%
  - n=107

- Group II (30 to 45 yrs Latency)
  - Frequency: 9.2%
  - n=217

- Group II (20 to 25 yrs Latency)
  - Frequency: 5.6%
  - n=713

- Group III (20 to 25 yrs Latency)
  - Frequency: 3.1%
  - n=713

* - p<0.05
RESULTS

Odds Ratio of Pleural / Parenchymal Abnormalities AS COMPARED TO GROUP I

INDEPENDENT OF AGE, CUMULATIVE EXPOSURE AND SMOKING
CONCLUSIONS

♦ We conclude that improvements over time in workplace conditions are associated with a significant decrease in the risk of non-malignant abnormalities in Brazilian chrysotile asbestos miners and millers.

♦ Our data are relevant for developing countries were asbestos extraction is performed on a large scale and healthcare resources are scarce.
SUMMARY

Policy implications

- Progressive improvement in occupational hygiene in mines and mills is likely to markedly reduce the risk of non-malignant consequences of dust inhalation in miners and millers exposed mainly to chrysotile.
- Asbestos workers with combined pleural and parenchymal abnormalities should be evaluated for early detection of lung function impairment.
- Large scale anti-smoking strategies are warranted in asbestos mines and mills.

- The present results should be further confirmed in prospective and controlled studies, including in the present population.
Counting Asbestos body (gr/dried lung) in 10 cases

- Correlation with time exposure and cumulative exposure
  \[ r = 0.72 \quad p < 0.05 \]

- Tremolite was detected in 2 cases from São Felix Mine - Poções - BA

CaseB, Bagatin E, Capelozzi V. Ann Ocupp Hyg 2002;46:144-49
“Identification of Rounded Atelectasis in Workers Exposed to Asbestos by Contrast Helical Computed Tomography”

- 1658 HRCT
- 9 cases (0.5%) of rounded atelectasis (RA)
- Swensen protocol
  (Average increase UH 62.5 ± 19.7)
- All of cases had contrast increment
- HRCT do not distinguish RA x Lung Cancer

Terra Filho, M et al. Brazilian Journal of Medical and Biological Research 2003;36:1341-47
"Thin-section CT abnormalities and pulmonary gas exchange impairment in workers exposed to asbestos"
“Chronic Dyspnea and Altered Respiratory Function in Former Workers with Asbestosis Evaluated to Determine Benefits”

Dyspnea Scales

Asbestosis

AMA/93
BDI (Mahler)

Presence of Dyspnea
\( \cong 30\% \)

AMA/84
MRC/76

Presence of Dyspnea
\( \cong 70\% \)

No correlation with Pulmonary Function data

“Proposal of high-resolution computed tomography model for quantification of pleural plaques in asbestos-exposed workers”

Classification of quadrants to parietal pleural plaques

<table>
<thead>
<tr>
<th>Grade</th>
<th>External surface of quadrant</th>
<th>Pleural Thickening on the quadrant (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>&lt; 50 %</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>A2</td>
<td>&lt; 50 %</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td>B1</td>
<td>&gt; 50 %</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>B2</td>
<td>&gt; 50 %</td>
<td>&gt; 0.5</td>
</tr>
</tbody>
</table>

CHRYSOTILE EXPOSURE

NEXT STEPS

Health Effects of Chronic Low-Level (< 0.5 f/cc) Chrysotile Exposure in Worldwide Longitudinal Studies

To Determine the Safety Control Use of Chrysotile