EXPOSURE TO AIRBORNE ASBESTOS IN JAMAICAN HOSPITALS

by

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A DISSERTATION

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EXPOSURE TO AIRBORNE ASBESTOS IN JAMAICAN HOSPITALS

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DOCTOR OF PUBLIC HEALTH

ABSTRACT

Asbestos is a crystalline mineral that is found naturally in almost two-thirds of the earth’s crust and it is an established human carcinogen. Occupational exposure to asbestos may be responsible for 5-20% of lung cancers and 80-90% of pleural mesothelioma in developed countries. Asbestos-related diseases account for some 100,000 deaths annually worldwide. Few cases of asbestos-related diseases are reported in Jamaica but two asbestos-cement product manufacturing plants operated in Jamaica during the period 1965-1985. Asbestos was identified in some Jamaican hospitals in 1999.

This study was conducted in 2005-2007 to identify asbestos containing material (ACM), its characteristics and its determinants in Jamaican hospitals; to determine if current asbestos exposure in Jamaican hospitals differs by job category; and to assess the knowledge, attitudes and practices of hospital employees/workers with respect to asbestos. It was hypothesized that current exposure to asbestos was related to job type and exposure among maintenance workers was greater than exposure among other workers. 152 bulk samples of suspected ACM was collected and analyzed by polarized light microscopy (PLM). Based on the results the two largest hospitals with ACM were selected for air sampling and interview of selected employees. 131 personal air samples and 32 area samples were collected and analyzed by phase contrast microscopy (PCM). Half of the personal air samples that tested positive for fibers were subjected to
transmission electron microscopy (TEM) to confirm if the fibers were asbestos. In addition, 277 hospital employees stratified into three groups according to work performed responded to an interviewer administered questionnaire. The response rate was 90%. Two focus group discussions (FGD) were held with heads of departments (HOD) at both hospitals. Sixteen (61.5%) of the 26 hospitals had ACM and 67 (44.07%) of the 152 bulk samples contained ACM. The predominant ACM was thermal system insulation which was generally in a poor condition indicative of fiber release. Amosite was the most common fiber detected in the samples. Of the 163 air samples analyzed, 24 (14.7%) had fiber concentrations above the LOD ranging from 0.002 to 0.013 f/cc. Fiber concentrations were significantly associated with hospital (p=0.0263). There was no difference in the median fiber concentration (0.0015 f/cc) to which the three groups of employees were exposed. Further analysis of samples that tested positive for fibers by transmission electron microscopy (TEM) confirmed that the fibers detected by PCM were not asbestos fibers. Sixty two (22.4%) of respondents had never heard of asbestos and having heard about asbestos was significantly associated with group of employee (p=0.0001). Gender, age, education, marital status, and duration of employment were all significantly associated with group of employee. Correct responses to knowledge questions on asbestos ranged from 41% to 98.5%. Generally, respondents’ attitudes towards asbestos were positive. Based on our study, there were no airborne asbestos fibers with any immediate threat to workers’ exposures. The JMOH/hospital management should institute asbestos abatement/management programs in hospitals as a proactive measure against future exposure. This will require manpower, resources and assistance from national and international agencies.
DEDICATION

To my wife, Sonia; son, Kareem; daughter, Samantha and all Public Health Inspectors in Jamaica
ACKNOWLEDGEMENTS

I would like to express my profound and sincere gratitude and appreciation to all individuals, agencies, and institutions for their contributions to the conceptualization and completion of this research project. The Sparkman Center for Global Health at UAB deserves special mention for offering me a very generous fellowship so that I could complete my course of studies. Thanks to former Director of the Sparkman Center, Professor Sten Vermund for his advice and support in securing the Sparkman fellowship. Thanks also to former Acting Directors, Dr. Sheila Andrus and Dr. Nalini Sathiaakumar; the present Director, Dr. Craig Wilson; Program Director, Dr. Madhav Bhatta and all past and present staff at the Center for their kindness, hospitality and support.

To my research committee comprising Drs. Edward Postlethwait (Chair), Al Bartolucci, Elizabeth Delzell, Reider K. Oestenstad, and Nalini Sathiakumar I must say thanks for your wisdom, brilliance, tolerance, timely feedback, and encouragement.

Thanks to the entire faculty and staff in the Department of Environmental Health Sciences at UAB, especially Ms Cherie Hunt, Program Manager. I want to express heart felt gratitude to Dr. R.K. Oestenstad and Dr. Elizabeth Maples of the Deep South Center for Occupational Safety and Health for their contribution to the development and implementation of the asbestos training program for
Ministry of Health employees and with the loaning of air sampling and other equipment for sample analysis.

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Finally, I wish to thank my family for enduring my long absence from home and for their prayers and confidence in my ability to succeed.
TABLE OF CONTENTS

ABSTRACT .................................................................................................................. ii

DEDICATION ............................................................................................................... iv

ACKNOWLEDGEMENTS ............................................................................................... v

LIST OF TABLES ........................................................................................................ xi

LIST OF FIGURES ...................................................................................................... xiv

LIST OF ABBREVIATIONS ......................................................................................... xvi

CHAPTER

1 INTRODUCTION ........................................................................................................ 1
  Brief History of Asbestos .......................................................................................... 4
  Types of Asbestos ..................................................................................................... 6
  World Asbestos Production and Use ..................................................................... 12
  Asbestos Containing Material .............................................................................. 13
  Categories of Asbestos-containing Building Material ......................................... 14
  Physical Properties Relevant to Exposure ............................................................ 16
  Routes of Exposure to Asbestos ........................................................................... 17
  Asbestos in the Respiratory Tract ......................................................................... 18
  Storage of Asbestos Fibers in the Human Body .................................................... 18
  Clearance Mechanisms for Asbestos Fibers ......................................................... 19
  Assessment of Exposure ....................................................................................... 20
  Epidemiology and Asbestos-related Health Effects ............................................. 20
    Asbestosis ........................................................................................................... 22
    Pleural Plaques ................................................................................................. 27
    Pleural effusion .................................................................................................. 28
    Diffuse pleural thickening ................................................................................. 28
    Bronchogenic carcinoma (Lung cancer) ............................................................. 29
    Mesothelioma ................................................................................................... 30
  Mechanisms of Asbestos Carcinogeneticity ......................................................... 32
  Biomarkers and Monitoring ................................................................................. 33
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 History of Asbestos-related Diseases</td>
<td>5</td>
</tr>
<tr>
<td>2 Chemical Identity of Asbestos Fibers</td>
<td>9</td>
</tr>
<tr>
<td>3 Physical and Chemical Properties of Asbestos</td>
<td>11</td>
</tr>
<tr>
<td>4 Asbestos Production by Country in 2000</td>
<td>12</td>
</tr>
<tr>
<td>5 Ranking and Frequency of Disease among Individuals with 20 or more years of Exposure to Asbestos</td>
<td>22</td>
</tr>
<tr>
<td>6 US EPA Standards for Indoor and Ambient Air at Different Risk Levels</td>
<td>33</td>
</tr>
<tr>
<td>7 Risk Estimates for Mesothelioma</td>
<td>35</td>
</tr>
<tr>
<td>8 T 1/2 for Chrysotile and Tremolite Fibers of Varying Lengths</td>
<td>36</td>
</tr>
<tr>
<td>9 Summary of Typical General Population and Occupational Exposures</td>
<td>37</td>
</tr>
<tr>
<td>10 Exposure to Airborne Asbestos during Asbestos Abatement</td>
<td>38</td>
</tr>
<tr>
<td>11 Exposure to Airborne Asbestos during Building Maintenance or Repair</td>
<td>39</td>
</tr>
<tr>
<td>12 Regulatory Standards History for Asbestos</td>
<td>41</td>
</tr>
<tr>
<td>13 OSHA Regulatory History of Asbestos</td>
<td>42</td>
</tr>
<tr>
<td>14 Hospitals by Region, Type, and Bed Complement</td>
<td>45</td>
</tr>
<tr>
<td>15 Sample Size for Top 20% (τ =0.2) and Confidence 0.95 (α=0.05)</td>
<td>67</td>
</tr>
<tr>
<td>16 Job Fiber Exposure Table used for Hospital Workers</td>
<td>76</td>
</tr>
<tr>
<td>17 Participants for Asbestos Hazard Assessment /Train the Trainer Course</td>
<td>84</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Scanning Electron Micrograph of Serpentine Asbestos, Chrysotile</td>
</tr>
<tr>
<td>2</td>
<td>Scanning Electron Micrograph of Amphibole Asbestos, Crocidolite</td>
</tr>
<tr>
<td>3</td>
<td>Basic Polysilicate Structures of Asbestos</td>
</tr>
<tr>
<td>4</td>
<td>US and World Consumption of Asbestos, 1940-1999</td>
</tr>
<tr>
<td>5</td>
<td>Diagram of the Human Respiratory Tract</td>
</tr>
<tr>
<td>6</td>
<td>Schematic Representation of the Formation of Reactive Oxygen Species and their Interrelationships with the Sequence of Major Events involved in Pulmonary Injury</td>
</tr>
<tr>
<td>7</td>
<td>Pathogenesis of Asbestosis</td>
</tr>
<tr>
<td>8</td>
<td>SEER Age-adjusted Incidence Rates by Race for Mesothelioma, all Ages, and both Sexes. SEER 9 Registries for 1975-2004 Age-adjusted to the 2000 US Standard Population</td>
</tr>
<tr>
<td>9</td>
<td>Multi-compartment Model</td>
</tr>
<tr>
<td>10</td>
<td>Map of Jamaica showing Location of Hospitals</td>
</tr>
<tr>
<td>11</td>
<td>Conceptual Framework</td>
</tr>
<tr>
<td>12</td>
<td>Procedures for PLM Analysis</td>
</tr>
<tr>
<td>13</td>
<td>PI Collecting Bulk Samples at one Hospital</td>
</tr>
<tr>
<td>14</td>
<td>Bulk Samples Collected and Labeled for Shipment to Laboratory</td>
</tr>
<tr>
<td>15</td>
<td>Sampling Train for Calibration of Sampler</td>
</tr>
<tr>
<td>16</td>
<td>Sampling Train for Personal Air Sampling</td>
</tr>
<tr>
<td>17</td>
<td>Bags of ACM which fell from the Roof of Boiler Room at one Hospital where Area Air Samples were collected</td>
</tr>
</tbody>
</table>
18 ACM Lagging Disintegrating on Steam Pipes in the Maintenance Department of one Hospital where Area Air Samples were Collected ..................................................73

19 Distribution of Bulk Samples by Number of Samples Containing ACM, by 16 Hospitals ..................................................................................................................93

20 Distribution of 12 Hospitals by Percent of Samples with ACM by Age .................95

21 Frequency Distribution of 8-hour TWA for 131 Personal Air Samples .......................99

22 Distribution of Respondents by Group .....................................................................103
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACBM</td>
<td>asbestos containing building material</td>
</tr>
<tr>
<td>ACGIH</td>
<td>American Conference of Government Industrial Hygienists</td>
</tr>
<tr>
<td>ACM</td>
<td>asbestos containing material</td>
</tr>
<tr>
<td>AHERA</td>
<td>Asbestos Hazard Emergency Response Act</td>
</tr>
<tr>
<td>AIHA</td>
<td>American Industrial Hygiene Association</td>
</tr>
<tr>
<td>BOHS</td>
<td>British Occupational Hygiene Society</td>
</tr>
<tr>
<td>DSCOSH</td>
<td>Deep South Center for Occupational Health and Safety</td>
</tr>
<tr>
<td>EHU</td>
<td>Environmental Health Unit</td>
</tr>
<tr>
<td>EL</td>
<td>excursion limit</td>
</tr>
<tr>
<td>FGD</td>
<td>focus group discussion</td>
</tr>
<tr>
<td>FVC</td>
<td>forced vital capacity</td>
</tr>
<tr>
<td>HHE</td>
<td>health hazard evaluation</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating ventilation and air conditioning system</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
</tr>
<tr>
<td>JMOH</td>
<td>Jamaican Ministry of Health</td>
</tr>
<tr>
<td>LOD</td>
<td>limit of detection</td>
</tr>
<tr>
<td>MMVF</td>
<td>man-made vitreous fiber</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environment Protection Agency</td>
</tr>
<tr>
<td>NIOSH</td>
<td>National Institute for Occupational Safety and Health</td>
</tr>
</tbody>
</table>
NPHL       National Public Health Laboratory
NSD        no structure detected
OEL        occupational exposure limit
OSHA       Occupational Safety and Health Administration
PCM        phase contrast microscopy
PEL        permissible exposure level
PLM        polarized light microscopy
PPE        personal protective equipment
RCA        refractory ceramic fiber
RBC        red blood cell
REL        recommended exposure limit
RHA        Regional Health Authority
ROS        reactive oxygen species
SCGH       Sparkman Center for Global Health
SOB        shortness of breath
TEM        transmission electron microscopy
TLV        threshold limit value
TLV-TWA    Threshold Limit Value-Time –Weighted Average
(The TWA concentration for a conventional 8-hour
workday and a 40-hour workweek, to which it is
believed that nearly all workers may be repeatedly
exposed, day after day, for a working lifetime without
adverse effect)
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSI</td>
<td>thermal system insulation</td>
</tr>
<tr>
<td>TWA</td>
<td>time weighted average</td>
</tr>
<tr>
<td>UHWI</td>
<td>University Hospital of the West Indies</td>
</tr>
<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>UWI</td>
<td>University of the West Indies, Mona</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

Asbestos is a generic term for a group of six naturally-occurring, fibrous silicate minerals that have been widely used in commercial products. Asbestos minerals occur in large natural deposits or as contaminants in other minerals (ATSDR, 2001). Asbestos is found naturally in almost two-thirds of the earth’s crust (Natural Resources Canada, undated) and it is the smallest naturally occurring fiber (O’Reilly et al, 2007). Due to the worldwide prevalence of asbestos, small amounts are inhaled by humans in every breath (O’Reilly et al, 2007).

The International Agency for Research on Cancer (IARC), the American Conference of Government Industrial Hygienists (ACGIH) and other national and international agencies of unqualified repute have classified asbestos as a definite human carcinogen based on sufficient evidence of carcinogenicity in humans (IARC, 2005; ACGIH, 2004). Although the production and use of asbestos has declined steadily in the past 30 years, significant amounts of asbestos still remain in buildings such as schools, hospitals and other workplaces. The banning of asbestos use in some countries has not led to the reduction of asbestos exposure or asbestos-related diseases. This can be attributed to the fact that in many cases the asbestos causing pollution problems today was used in buildings several decades ago when asbestos was one of the most preferred construction materials. Many of the asbestos-related diseases and deaths occurring today are due to exposures which preceded some of the bans that have been instituted.
Abatement programs for asbestos have either been inadequate or non-existent in many cases.

Given the specific technical properties of asbestos it has been found in about 3,000 different products (WHO, 2000). According to the International Labor Organization (ILO) (2006) some 100,000 deaths annually worldwide are due to asbestos. To help to protect workers, permissible exposure limits (PELs) or occupational exposure levels (OELs) and Threshold Limit Values (TLVs) have been established, and appropriate respiratory and other protective equipment are available for use. The United Kingdom introduced legislation in 1931 to control exposure to asbestos but the US did not introduce similar legislation until 1971 (O’Reilly et al, 2007). Several substitutes to asbestos including man-made vitreous fibers (MMVF) have been developed. These substitutes, however, tend to have similar physical properties as asbestos and being fibrous they could pose some of the same health threats as asbestos (Natural Resources Canada, n.d.).

Jamaica does not have asbestos regulations despite the reported presence of asbestos in several buildings in the country; however the exact number of affected buildings is unknown. The physical condition of asbestos in a building is important in determining a worker’s potential exposure. Maintenance workers and others in some hospitals are potentially exposed to asbestos fibers (Turner, 2005). Hospitals were chosen for the study described in this report based on a request to the Sparkman Center for Global Health (SCFGH) by the Jamaican Ministry of Health (JMOH) for assistance in training employees to help address asbestos pollution identified in some hospitals in 1999 (Kahwa, Reid, Coley, Kahwa, Barton, Chung, Lewis, and Lowe, 1999). There is no
asbestos control/abatement program in any of the hospitals in Jamaica and the level of exposure if any of employees and patients is not known. It is therefore prudent to quantify the level of workers’ exposure to asbestos fibers so that a clearer picture of the risks faced by workers may emerge. Quantified personal and area samples are at the top of the hierarchy of established occupational exposure measurements and both types of samples were expected to be collected during this study.

Historically, most asbestos-related diseases are associated with working with asbestos-containing material (ACM). However, there have been many documented cases where asbestos exposure and subsequent development of health effects were not due to working actively with asbestos but due to the presence of ACM in the building where the work was performed (Anderson, Hanrahas, Higgins, and Sarow, 1991; Oliver, Sprince, and Greene, 1991; Markowitz, Garibaldi, and Landrigan, 1991; Selikoff & Serdmar, 1991). The presence of asbestos in any workplace warrants constant monitoring to establish if workers are at risk. This would enable administrative and regulatory agencies to target the groups of employees with exposures in excess of PELs or other set standards for interventions to reduce or eliminate these exposures.

The success of any asbestos control program will be dependent in part on the knowledge, attitudes and practices of the workforce. Hospital management should feel obliged to provide administrative and engineering controls as well as PPE at the workplace, but the employees also have an obligation to adhere to policies and programs geared at protecting their own health. Where there are gaps in knowledge, and undesirable attitudes and work practices in relation to asbestos, the requisite educational intervention can be designed and implemented to correct the problem
Brief History of Asbestos

The term “asbestos” means “inextinguishable” in Greek (Turner, 2005) and this mineral has been in use for more than 3,000 years (Golden, 1979). In ancient times, asbestos was called the “funeral dress of kings” because it was used to wrap the bodies of kings before they were placed on funeral pyres (Golden, 1979). It was also used as wicks of the oil lamps used by the vestal virgins. The commercial use of asbestos began with the discovery of serpentine asbestos in Canada, and its subsequent use in heat conservation (Rom & Palmer, 1974). The modern asbestos industry began in the early 1800s when the Italians opened a textile manufacturing industry. The use of asbestos became widespread and up to the 1950s, asbestos was lauded for its “service to humanity”; was called a “boon to humanity”; “faithful servant of mankind”, and “the most important of the non-metallic mineral product of the world – and certainly one of the most wonderful” (Virta, 2003). For most of the 20th century the US was a leading user of asbestos (Buckingham and Virta, 2002). The first documented case of an asbestos-related death occurred in 1906, and the term “asbestosis” was coined in 1927, when scientists realized there was a direct relationship between asbestos exposure and pulmonary fibrosis (Turner, 2005). The “bubble burst on asbestos’ popularity” during the late 1960s and early 1970s. Research conducted during the period 1920-1940 demonstrated an association between asbestos and asbestosis. However, it was not until the early 1960s that the association was firmly established (Virta, 2003). A causal relationship between asbestos exposure and lung cancer was established since 1955 and since 1960 for pleural mesothelioma (Ameille, Ruffie, and Bergeret, (2004). Consequently, there was heightened awareness of the adverse health effects of asbestos resulting in public
opposition to its use. In the US several large class action law suits were filed on behalf of workers suffering from asbestos-related diseases. These developments led to a drastic decline in world production and consumption of asbestos during the 1980s.

Despite the abundance of information on the hazards of asbestos, asbestos continues to be used and according to the World Health Organization (WHO) many doctors are not fully aware of its potential for causing disease (WHO, 2000). The asbestos industry has been accused of working in concert with some insurers to develop and then conceal information on the carcinogenicity of asbestos (Lilienfeld, 1991). This led to delays in developing and implementing appropriate interventions for those exposed. Consequently, millions of workers were exposed and hundreds of thousands of them died. Table 1 provides historical information on asbestos-related diseases.

Table 1

*History of Asbestos-related Diseases*

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Description of text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1899</td>
<td>Murray</td>
<td>First case of asbestosis described; “Curious Bodies”</td>
</tr>
<tr>
<td>1906</td>
<td>Auribault</td>
<td>First reported case of asbestos lung disease</td>
</tr>
<tr>
<td>1930-31</td>
<td>Soper, Panacost &amp; Pendergrass</td>
<td>Progression of the disease even after cessation of exposure; long clinical latency- 15, 20 or 25 years</td>
</tr>
<tr>
<td>1933</td>
<td>Ellman</td>
<td>First US case report of asbestosis in an insulation worker</td>
</tr>
<tr>
<td>1935</td>
<td>Lynch &amp; Smith</td>
<td>First asbestosis &amp; lung cancer case reported in the US</td>
</tr>
<tr>
<td>1943</td>
<td>Welder</td>
<td>First pleural tumor reported</td>
</tr>
<tr>
<td>1953</td>
<td>Weiss</td>
<td>First mesothelioma case reported in an insulation worker</td>
</tr>
<tr>
<td>1958</td>
<td>Van Der Shoot</td>
<td>Reports pleural mesothelioma in a Dutch insulation worker</td>
</tr>
<tr>
<td>1963</td>
<td>Mancuso</td>
<td>Mortality study in the US shows asbestos plant workers have increased morbidity rates</td>
</tr>
</tbody>
</table>

Types of Asbestos

The term asbestos is a generic one referring to six types of naturally occurring mineral fibers. These fibers belong to two mineral groups: serpentines and amphiboles. Serpentine asbestos derives its name from the pliable, curled, “serpent-like” property of the fiber (Craighead, Mossman, and Bradley, 1980) (Figure 1). The basic chemical structure of asbestos is (SiO₄). The serpentine group contains a single asbestiform variety, chrysotile. Chrysotile comprises over 90% of the asbestos mined worldwide today (Craighead et al, 1980). The structure, chemical composition and persistence of chrysotile in biological systems differ from those of the amphiboles (Roggli, 1990). Five varieties of amphiboles are known: anthophyllite, amosite, tremolite, crocidolite and actinolite (Virta, 2002). Amosite and crocidolite are the commercially valuable forms of amphibole asbestos. Actinolite, anthophyllite, and tremolite have no significant commercial value and they may be found as contaminants of other mineral substances (Roggli, 1990). Amphibole asbestos is comprised of chains of tetrahedral linked into Si₄O₁₁ units. The chains are four tetrahedra wide and are parallel to the fiber axis (Craighead et al, 1980). Chrysotile is mined in Canada and tremolite and anthophyllite are mined in Finland and North America. Crocidolite and amosite are mined in South Africa and Australia (Khan & Jones, 2004).

Asbestos fibers exhibit high tensile strength, show high aspect ratios (20 to > 1,000); they are sufficiently flexible to be spun; and macroscopically, they resemble organic fibers such as cellulose. The fibers also exhibit other properties such as incombustibility, thermal stability, resistance to biodegradation, chemical inertia toward most chemicals, and low thermal conductivity (Virta, 2002).
Figure 1. Scanning Electron Micrograph of Serpentine Asbestos, Chrysotile. (Note the variability in length and diameter of individual fibers as well as their twisted and curled “serpentine” properties)


The serpentine fiber has a curved or wavy appearance and is more likely to break into long and thin particles while the amphibole fibers are straight and long (Craighead *et al.*, 1980) (Figure 2).
Figure 2. Scanning Electron Micrograph of Amphibole Asbestos, Crocidolite. (As with chrysotile the fibers vary in length and diameter. However, the amphibole fibers are relatively straight and rigid.)


Table 2 provides information on the chemical identity of asbestos fibers.
Table 2

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Amosite</th>
<th>Chrysotile</th>
<th>Tremolite</th>
<th>Actinolite</th>
<th>Anthophyllite</th>
<th>Crocidolite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonyms</td>
<td>Mysocite, brown asbestos; fibrous cummingtonite/Grunerite</td>
<td>Serpentine asbestos; white asbestos</td>
<td>Silicic acid; Calcium magnesium salt</td>
<td>No data</td>
<td>Ferroantio-Phyllite; azbolen Asbestos</td>
<td>Blue asbestos</td>
</tr>
<tr>
<td>Trade name</td>
<td>No data</td>
<td>Avibest; Cassiar AK; Calidria RG 144; Calidria RG 600</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Chemical formula</td>
<td>[(Mg,Fe)₈Si₂O₅(OH)₂]₃</td>
<td>Mg₃Si₃O₇(OH)₄</td>
<td>[Ca₂Mg₅Si₈O₂₅(OH)₂]₃</td>
<td>[Ca₃Mg₂Fe₅Si₈O₂₅(OH)₂]₃</td>
<td>[[Mg,Fe]₂Si₄O₁₁(OH)₂]₂</td>
<td>Na₂Fe₂⁺Fe₃⁺Si₄O₁₁(OH)₂</td>
</tr>
<tr>
<td>CAS registry</td>
<td>12172-73-5</td>
<td>12001-29-5</td>
<td>14567-73-8</td>
<td>13768-00-8</td>
<td>17068-78-9</td>
<td>12001-28-4</td>
</tr>
</tbody>
</table>

Note: Data in Table 2 are from “Toxicological Profile for Asbestos (Update)” by the Department of Health and Human Services, Public Health Service, Agency for Toxic Substances Disease Registry (ATSDR), September 2001, p. 135. Reprinted with permission.
Figure 3. Basic Polysilicate Structures of Asbestos


Table 3 provides information on the physical and chemical properties of asbestos.
Table 3
Physical and Chemical Properties of Asbestos

<table>
<thead>
<tr>
<th>Property</th>
<th>Chrysotile</th>
<th>Amosite</th>
<th>Tremolite</th>
<th>Actinolite</th>
<th>Anthophyllite</th>
<th>Crocidolite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>White, gray, Green, yellowish</td>
<td>Brown, greenish</td>
<td>gray,</td>
<td>White to pale green</td>
<td>Green</td>
<td>Gray, white, brownish-gray, green Solid</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Good</td>
<td>Fair</td>
<td>Brittle</td>
<td>Fair to brittle</td>
<td>Fair to brittle</td>
<td>Good</td>
</tr>
<tr>
<td>Melting point/Decomposition Temperature</td>
<td>800-850°C</td>
<td>600-900°C</td>
<td>1,040°C</td>
<td>No data</td>
<td>950°C</td>
<td>800°C</td>
</tr>
<tr>
<td>Specific gravity</td>
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<td>3.43</td>
<td>2.9-3.2</td>
<td>3.0-3.2</td>
<td>2.85-3.1</td>
<td>3.37</td>
</tr>
<tr>
<td>Solubility:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Organic solvents</td>
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<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Acids</td>
<td>56.00</td>
<td>12.00</td>
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<td>No data</td>
<td>2.13</td>
<td>3.14</td>
</tr>
<tr>
<td>Bases</td>
<td>1.03</td>
<td>6.82</td>
<td>No data</td>
<td>No data</td>
<td>1.77</td>
<td>1.20</td>
</tr>
<tr>
<td>Isoelectric point</td>
<td>11.8</td>
<td>5.2-6.0</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Electric charge at neutral pH</td>
<td>Positive</td>
<td>Negative</td>
<td>No data</td>
<td>No data</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Flammability Limits</td>
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<td>Nonflammable</td>
<td>Nonflammable</td>
<td>Nonflammable</td>
<td>Nonflammable</td>
<td>Nonflammable</td>
</tr>
</tbody>
</table>

Note: Data in Table 3 are from “Toxicological Profile for Asbestos (Update)” by the Department of Health and Human Services, Public Health Service, Agency for Toxic Substances Disease Registry (ATSDR), September 2001, p. 138. Reprinted with permission.
World Asbestos Production and Use

According to the United States Geological Society (USGS), the total amount of asbestos produced in 2000 was 2,110,100 metric tons (USGS, 2006). The leading producer of asbestos was Russia and Kazakhstan with 983,200 tons (46.6%). The amount of asbestos produced by the other countries is given in Table 4.

Table 4

<table>
<thead>
<tr>
<th>Country</th>
<th>Asbestos production (Tons)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia and Kazakhstan</td>
<td>983,200</td>
<td>46.6</td>
</tr>
<tr>
<td>China</td>
<td>315,000</td>
<td>14.9</td>
</tr>
<tr>
<td>Canada</td>
<td>309,719</td>
<td>14.6</td>
</tr>
<tr>
<td>Brazil</td>
<td>209,332</td>
<td>10.0</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>152,000</td>
<td>7.2</td>
</tr>
<tr>
<td>South Africa</td>
<td>18,782</td>
<td>0.9</td>
</tr>
<tr>
<td>Swaziland</td>
<td>12,690</td>
<td>0.6</td>
</tr>
<tr>
<td>United States</td>
<td>5,260</td>
<td>0.3</td>
</tr>
<tr>
<td>Other</td>
<td>104,017</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>2,110,100</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>


In 2000, world consumption of asbestos was estimated to be 1.48 million metric tons, which was 31% of that in 1980 (Virta, 2003). Figure 4 gives a comparison of US and world consumption of asbestos for the period 1940-1999. The consumption of asbestos in the US has declined steadily since 1970.
Asbestos Containing Materials (ACM)

ACMs are of two types: friable and bonded. Friable asbestos is in the form of a powder, or can be crumbled, pulverized or reduced to powder by hand pressure when dry. Friable ACM include sprayed asbestos insulation, pipe and boiler insulation, and non-bonded asbestos fabric. Bonded asbestos is difficult to damage and includes materials such as asbestos cement sheets, vinyl floor tiles, roof tiles and electrical switchboards (Workers Health Center, 2004).
Categories of Asbestos-containing Building Materials (ACBM)

The United States Environmental Protection Agency (USEPA) identifies three categories of ACM used in buildings (The Environmental Institute, 2004). They are:

- **Surfacing Materials**: ACM sprayed or troweled on surfaces such as walls, ceilings, and structural members for acoustical, decorative, or fireproofing purposes.

- **Thermal System Insulation (TSI)**: Insulation used to inhibit heat transfer or prevent condensation on pipes, boilers, tanks, ducts, and various other components of hot and cold water systems and heating, ventilation, and air conditioning (HVAC) systems. End-use includes pipe lagging, pipe wrap; block, batt, and blanket insulation.

- **Miscellaneous Materials**: Other, largely non-friable products and materials such as floor tiles, ceiling tiles, roofing felt, concrete pipe, outdoor siding, and fabrics.

Potential Sources of Occupational and Environmental Asbestos Exposure

O’Reilly et al (2007) identified numerous potential sources of occupational and environmental asbestos exposure. These include:

- Asbestos-containing products: asbestos-containing flight materials, asbestos-lined electrical products, asbestos shipping material, brake linings and clutch pads, building materials

- Asbestos removal: removal of insulation, asbestos removal, waste handling, building demolition and ship breaking
- Environmental exposure: asbestos in public buildings (hospitals, libraries, schools; occurs when the asbestos is disturbed during building or maintenance work), family members of persons occupationally exposed

- Asbestos production: asbestos mining; textile mill workers who weave asbestos into cloth

- Asbestos transport: packing and handling of asbestos.

The exposure to asbestos can be direct or indirect (Golden, 1979). Direct exposure includes:

- The production of the fiber itself involving its mining and milling

- The manufacture of products used in insulation such as textiles, cements, roofing and flooring materials

- The application of these materials or the demolition of structures containing asbestos products

Indirect exposures result from neighborhood and household contacts. The general public may be exposed to asbestos fibers in several ways. “True” environmental exposure to asbestos is predominantly through the ambient air, water, food, and beverages. “Paraoccupational” exposures occur in the home of workers; “neighborhood” exposures take place near to industries and mines; while “leisure-time” exposures result from working with asbestos products (Zeilhuis, 1977). According to McDonald (1985) the level of exposure to asbestos in North America is dependent on location. Occupational exposure is the greatest with levels being 10,000 - > 50,000 ng/m³; neighborhood/
domestic comes next with levels of asbestos being 100 -10,000 ng/m$^3$; exposure in urban areas is 1-100 ng/m$^3$; while rural/background exposure is < 1- 2 ng/m$^3$.

Physical Properties Relevant to Exposure

Asbestos fibers vary with respect to size (length and diameter) and chemical composition. These variations are believed to affect deposition, movement, clearance from the body and carcinogenic potency. Fiber diameter is the most important factor determining penetration and deposition in the lungs. Thin fibers have the greatest inhalation potential and may be deposited very deep in the lungs. According to Stanton’s Hypothesis (Stanton, Layard, Tegeris, Miller, Margaret, and Kent, 1981) long ($\geq 8\mu$m in length) and thin ($\leq 0.25\mu$m in width) asbestos fibers strongly induced malignant mesothelioma while the shorter and thicker fibers posed less risk. Their experiments were conducted on rats. This hypothesis is supported by the US ATSDR which stated that fibers which are longer than 8 microns with a diameter less than 1.5 microns have shown the greatest carcinogenic potency (ATSDR, 2001). However, Suzuki, Yuen, and Ashley, (2005) conducted direct pathological analysis of human mesothelioma tissue and concluded that short, thin, asbestos fibers appear to contribute to the causation of human malignant mesothelioma. They indicated that such fibers were the predominant fiber type detected in lung and mesothelial tissues from human mesothelioma patients. They warned against taking the position that short asbestos fibers convey little risk of asbestos-related disease.
Routes of Exposure to Asbestos

Epidemiological studies of asbestos-exposed workers and supporting animal studies indicate that the primary route of exposure is inhalation. Other routes of potential human exposure are ingestion and dermal absorption. However, dermal absorption is considered minimal, but dermal contact may result in secondary ingestion or inhalation of asbestos dust (ATSDR, 2001). It is estimated that some 2-6 million people in the US have had significant levels of exposure to asbestos. Due to the advent of government legislation enacted in the late 1970s, high exposures to asbestos have declined. The case of Libby, Montana, where the mining of vermiculite has been taking place since 1921 stands out as an example where there has been high occupational and environmental exposure to asbestos. Vermiculite consists of clay minerals that expand when heated to form wormlike particles. It is used in concrete aggregate, fertilizer carriers, insulation, potting soil, and soil conditioners. The Libby deposit is unique among commercial U.S. vermiculite deposits in having an average amphibole asbestos content of 4 to 6 percent. Miners, millers, and some residents of Libby were, at times, exposed to high levels of asbestos-containing dusts and many have been diagnosed with asbestos-related diseases (United States Geological Survey, 2001).

The Libby mines were closed in 1990 but efforts continue to map soil locations with the asbestiform amphiboles to put an end to environmental exposures and asbestos-related diseases in the area. However given the fact that the latency period for most asbestos-related disease is 20 years or longer, asbestos-related diseases remains an important public health problem in the US and other parts of the world (Khan & Jones, 2004).
Asbestos in the Respiratory Tract

The distance an asbestos fiber penetrates the lung depends on its falling speed. The nose effectively filters out compact fibers longer than 5µm (Golden, 1979; Craighead et al, 1980) or these fibers are eliminated by the mucociliary escalator system of the tracheobronchial tree (Craighead et al, 1980) and for particles shorter than 5µm there is peripheral deposition in the lung (Golden, 1979). Inhaled asbestos fibers that reach the respiratory bronchioles come in contact with macrophages which engulf them and coat them with ferritin granules to form asbestos bodies. The presence of asbestos bodies in sputum is indicative of asbestos exposure but not necessarily indicating a pathological process (Golden, 1979). Figure 5 is a diagrammatic representation of the respiratory system of humans.

Storage of Asbestos Fibers in the Human Body

The lung parenchyma is the main storage compartment for asbestos fibers but fibers are also found in lymph nodes, the pleura and kidneys (Huang, Hisanaga, Sakai, Iwata, Ono, Shibata E, and Takeuchi, 1988). There is some uncertainty regarding the route asbestos fibers take to reach extra-pulmonary organs. One theory is that the fibers reach areas such as the parietal pleura and lymph nodes via direct, systemic or lymphatic mechanisms (Lippman, Yates, and Albert, 1980). It is postulated that short asbestos fibers reach the pleura by penetrating the pulmonary parenchyma and visceral pleural (Light, 2007). The pathway to the kidneys could be due to passive transport in the bloodstream (Lippman et al, 1980).
Clearance Mechanisms for Asbestos Fibers

Inhaled asbestos fibers are removed from the lungs by mucociliary transport, translocation to lymph nodes, migration, diffusion, and dissolution in body fluids. It is impossible to directly measure long-term deposition and clearance rates of asbestos fibers in humans and so such data are usually obtained by analysis of retained particles in
tissues obtained during surgery or autopsy of exposed workers (Tossavainen, Karjalainen, and Karhunen, 1994).

Assessment of Exposure

The mineralogical origin of fiber exposure is important in the interpretation of epidemiological data. The investigator should be able to determine whether the exposure was to asbestiform fibers or other fiber-like structures. The human health effect of asbestiform fibers are well known and documented but there are reasons for concern for other fibers such as other silicates (Attapulgite, Erionite, Sepeolite, Talc, Vermiculite and Wollastonite) and man-made mineral fibers (glass fibers, glass wool, rock wool, ceramic and glass microfibers). While visual inspection can often lead to one suspecting that a material or product contains asbestos, the actual determination can only be made by analysis using special instruments. The USEPA stipulates that the asbestos content of suspect materials be determined by collecting bulk samples and analyzing them by polarized light microscopy (PLM). The PLM technique will determine the type of asbestos and percent in the bulk material. Methods used to assess exposure to asbestos fibers include analysis of bulk samples to determine composition of fibers, use of previous exposure data if available, pathological assessment of lung tissue, use of mortality data, and assessment of relevant fiber dimensions (Merchant, 1990).

Epidemiology and Asbestos-related Health Effects

Significant exposure to any type of asbestos will increase the risk of lung cancer, mesothelioma, asbestosis and other non-malignant lung and pleural disorders (IARC,
Diseases from asbestos exposure take a long time to develop. Most cases of lung cancer or asbestosis in asbestos workers occur 15 or more years after initial exposure. Tobacco smokers who have been exposed to asbestos have a “far greater-than additive” (synergistic) risk for lung cancer than do non-smokers who have been exposed. The empirical induction period for mesothelioma is 30 years or more (ATSDR, 2005). The following facts about asbestos should be noted (ATSDR, 2005):

- When asbestos fibers are inhaled, most fibers are expelled, but some can become lodged in the lungs and remain there throughout life. Fibers can accumulate and cause scarring and inflammation can affect breathing, leading to disease.
- People are more likely to experience asbestos-related disorders when they are exposed to high concentrations of asbestos, are exposed for longer periods of time, and/or are exposed more often.
- Mesothelioma has been diagnosed in asbestos workers, family members, and residents who live close to asbestos mines.
- Health effects from asbestos exposure may continue to progress even after exposure has ceased.

The major diseases attributed to asbestos exposure can be placed into two categories; those which are fibrotic and/or restrictive and those which are cancers. Fibrotic and restrictive asbestos-related diseases include asbestosis, pleural plaque, diffuse pleural thickening and rounded atelectasis. The cancers caused by asbestos exposure are bronchogenic carcinoma and mesothelioma. Cases of asbestos-related disease are increasing slowly in the US. The reason for this is not quite clear as it could be secondary to a true increase in incidence or increased recognition (Khan and Jones,
The findings in humans are supported by toxicological studies in experimental animals (Merchant, 1990; Drillbits & Tailings, 1999). Merchant (1990) postulates that when health effects due to asbestos are ranked in terms of primary cause of death case-fatality rates the probable ranking is mesothelioma > lung cancer > asbestosis > diffuse pleural thickening > pleural plaques. The ranking is however different when one considers an estimate of the frequency of disease among persons with 20 or more years of exposure to asbestos (Table 5).

Table 5

<table>
<thead>
<tr>
<th>Disease</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural plaques</td>
<td>40,000/100,000&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Asbestosis</td>
<td>20,000/100,000&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Diffuse pleural thickening</td>
<td>5,000/100,000&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>2,500/100,000&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mesothelioma</td>
<td>1,200/100,000&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Estimates based on prevalence data

<sup>b</sup>Estimates based on mortality data


Asbestosis

Asbestosis occurs in 49-52% of adults with industrial asbestos exposure (Khan & Jones, 2004). Asbestosis deaths among US residents age 15 and over have increased from fewer than 100 in 1968 to more than 1,250 annually in 1999. The first case of pulmonary asbestosis reported was from the Charing Cross Hospital in London in 1900 (Collins, 1967). The name was first given to it by Dr. W.E. Cooke in 1924, with reference to a
woman who had died after 20 years of working as an asbestos textile operator (Cooke, 1927). Asbestosis is a chronic restrictive lung disease due to inhalation of asbestos fibers and is characterized by diffuse interstitial fibrosis. The disease usually results when fiber levels reach 10 million asbestos fibers per gram of pulmonary tissue. The disease develops after a latent period of 15-20 years and progresses even after exposure has ceased (Khan and Jones, 2004). The presenting symptoms of persons suffering from asbestosis are dyspnea and dry cough (US Department of Health and Human Services (DHHS), 2003; CDC, 2004; Price and Ware, 2004; Lilienfeld, Mandel, Coin, and Schuman, 1988). Asbestosis results in decreased lung compliance, inhibited gas exchange in the alveoli, disability, and in some cases, death (Quinlan, 1994). Approximately 200,000 cases of asbestosis are diagnosed with about 2,000 deaths annually. The characteristic X-ray changes of asbestosis are small irregular opacities in the lower and middle lung fields, often accompanied by pleural thickening and pleural calcifications. The pulmonary fibrotic changes develop slowly over the years – often progressively even without further exposure. In some cases, minor fibrosis with considerable respiratory impairment and disability can be present without equivalent X-ray changes. Conversely, extensive radiographic findings may be present with little functional impairment (Lemen, Dement, and Wagoner, 1980). The criteria for diagnosis of asbestosis include pulmonary rales, dyspnea, fingernail clubbing, peribronchiolar fibrosis, cyanosis and a forced vital capacity (FVC) of less than 80% (US DHHS, 2003; CDC, 2004; Price and Ware, 2004; Lilienfeld et al, 1988). While the occupational exposure to asbestos is regulated in many countries, past exposures should not be ignored. The importance of a comprehensive occupational and environmental history to identify persons cannot be overemphasized.
due to past exposure (O’Reilly et al., 2007). There is no specific therapy for asbestosis. Smoking cessation should be recommended and surveillance for lung cancer should be undertaken in all patients (Craighead, Abraham, Chung, Green, Kleinerman, Pratt, Seemayer, Vallyathan, and Weill, 1982; Murphy, Ferris, and Burgess, 1971). The presence of asbestosis is an independent risk factor for the development of lung cancer (O’Reilly et al., 2007). Patients with asbestosis will benefit from influenza and pneumococcal vaccines (US Preventive Services Task Force, n.d.). Epidemiologic studies have demonstrated that there is a dose-response relationship between exposure to asbestos and the development of asbestosis. There is evidence of a clear host-susceptibility factor in severe cases of asbestosis (Golden, 1979). Severe asbestosis may lead to respiratory failure and death over 12-24 years after the onset of symptoms (Khan and Jones, 2004)

*Mechanisms of asbestosis.* The onset of fibrosis is first seen in and around the respiratory bronchioles, particularly in the sub-pleural sections of the lung in the lower lobes. This is followed by involvement of the alveolar walls which ultimately causes honeycombing in a few patients (Khan and Jones, 2004). Several studies point to the role of reactive oxygen species (ROS) in the pathogenesis of asbestosis. The generation of ROS is done through several mechanisms. In ROS-induced cellular injury, damage to membranes of cells and organelles results from direct interaction of ROS or by the formation of peroxides and their metabolites (Vallyathan & Shi, 1997). Figure 6 summarizes the formation of ROS and their interrelationships with the sequence of major events involved in pulmonary injury.
Figure 6: Schematic Representation of the Formation of Reactive Oxygen Species and their Interrelationships with the Sequence of Major Events involved in Pulmonary Injury.

Another depiction of the pathogenesis of asbestos as mediated by (ROS) is illustrated in Figure 7.

Figure 7: Pathogenesis of Asbestosis
(Source: R.M. Liu-2005 - UAB)

One of the pathways that explain the generation of ROS involves the physical interaction of fibers with leucocytes or effector cells of disease (Mossman & Marsh, 1989). Another possible mechanism through which asbestos might damage cells is lipid peroxidation, a process which involves the oxidation of unsaturated fatty acids (Mossman & Marsh, 1989). Gabor and Anca (1975) reported on lipid peroxidation caused by
asbestos fibers. This was evidenced by an increase of thiobarbituric acid substances in red blood cells (RBCs). Chrysotile caused the greatest production of lipid peroxides, followed by anthophyllite, amosite, and crocidolite, in decreasing order.

**Pleural Plaques**

The prevalence of benign pleural plaques in non-asbestos exposed general population is very low. However, the prevalence in environmentally exposed general populations in industrial societies is 0.5-8% while for exposed individuals the prevalence is 3-58%. The prevalence of pleural plaques is 10% in exposed persons after being exposed for 20 years and the figure jumps to 50% after 40 years of exposure (Khan & Jones, 2004). The pleura exhibit higher sensitivity than pulmonary parenchyma to asbestos fibers. Consequently, pleural plaques develop after low, intermittent exposure, while asbestosis develops after cumulative, high-level, long term, continuous exposure (Khan & Jones, 2004). Pleural plaques are the most common pathological pulmonary response to asbestos inhalation (O’Reilly et al, 2007; Khan & Jones, 2004) after a latent period of about 20-40 years (Khan & Jones, 2004).

A typical pleural plaque is whitish and originates from the parietal pleura. The plaques are often found along rib margins (Golden, 1979). Pleural plaques consist of acellular collagen bundles that form a basket-weave pattern (Khan & Jones, 2004). While the origins of these plaques have not been clearly elucidated, two theories have been offered (Golden, 1979). One theory is that there is penetration of the visceral pleural by asbestos fibers that are present on the periphery of the lung. The other theory is that the fibers spread in a retrograde manner from the hilar lymph nodes into the pleural lymphatics. There has been however no data to substantiate either theory. The presence
of pleural plaques is thought to indicate exposure to asbestos and is not a precursor for more serious diseases such as asbestosis, lung cancer and mesothelioma (Golden, 1979; Khan & Jones, 2004). The presenting patient is usually asymptomatic, with incidental finding on chest radiography. Among exposed persons, 3-58% develops the condition, while for the general population; the prevalence is 0.5-8% (US DHHS, 2003; CDC, 2004; Price and Ware, 2004; Lilienfeld et al, 1988)

Pleural effusion

For benign asbestos related pleural effusions, the frequency is 3-7% in exposed individuals (Khan & Jones, 2004). The most common and earliest manifestation of asbestos-related pleural disease is benign asbestos pleural effusions. These are usually unilateral and develop within 10-20 years after exposure (Khan & Jones, 2004; Wagner, 1997) According to the American Thoracic Society (2004) asbestos pleural effusions are exudative and may be indicative of tuberculosis and malignancy and this makes benign pleural effusion a diagnosis of exclusion (O’Reilly et al, 2007) meaning a medical condition whose presence cannot be established with complete confidence from examination or testing

Diffuse pleural thickening

Diffuse pleural thickening is defined as “a smooth, uninterrupted pleural opacity extending over at least one quarter of the chest wall, with or without obliteration of the costophrenic angles”. The occurrence of pleural thickening is reported to be less specific for exposure to asbestos than pleural plaques as thickening is also associated with other conditions such as tuberculosis (TB) pleuritis, hemothorax and emphysema. The latent
period for pleural thickening is about 15 years. Although it is not clear how the condition develops, it is theorized that it is due to inflammation of the visceral pleural lymphatics (Khan & Jones, 2004).

_Bronchogenic carcinoma (Lung cancer)_

Bronchogenic carcinoma develops in 20-25% of heavily exposed asbestos workers (Khan & Jones, 2004). The association between asbestos exposure and an increased risk of developing lung cancer has been well established by epidemiological studies (Craighead & Mossman, 1980). The risk of lung cancer occurring in smokers is magnified several times by exposure to asbestos (O’Reilly et al, 2007; Roggli, Pratt, and Brody, 1986). Smoking increases the risk of lung cancer by a factor of 90 compared to a factor of 5 in exposed non-smokers. The usual latency period for the disease is 25-35 years (Khan & Jones, 2004). The pathological features of lung cancer among asbestos workers are indistinguishable from lung cancer in non-exposed cigarette smokers (O’Reilly et al, 2007; Roggli et al, 1986). Persons with asbestos-related lung cancer present with chest pain, cough, dyspnea, hemoptysis, weight loss, fatigue; the symptoms are due to metastases and direct invasion of cells. Prevalence is put at an estimated 2,000-3,200 lung cancer deaths annually related to asbestos exposure in the US. Treatment of the disease requires a multidisciplinary approach with different modality of treatment inclusive of surgery, radiotherapy, and chemotherapy (US DHHS, 2003; CDC, 2004; Price and Ware, 2004; Lilienfeld et al, 1988).
Mesothelioma

Mesothelioma is a malignant tumor derived from mesothelial cells. The pleura are the most common site, followed by the peritoneum and pericardium (O’Reilly et al, 2007; Roggli, 1990). This is a rare form of malignancy with latency extending to decades after exposure to asbestos (Roggli, 1990). The disease is uniformly fatal and has a median survival time of 6-18 months after diagnosis (O’Reilly et al, 2007). Persons with mesothelioma present with chest pain, cough, dyspnea, weight loss, fatigue, pleural effusion; the symptoms are due to metastases, pericardial invasion and superior vena cava invasion. Approximately 2,000 deaths are reported annually, with incidence and mortality rate being identical (US DHHS, 2003; CDC, 2004; Price and Ware, 2004; Lilienfeld et al, 1988).

There were nearly 2,500 malignant mesothelioma deaths among US residents age 15 and over in 1999 (NIOSH, n.d.). There is an estimated 7-13 case of malignant mesothelioma per million general population in the US. The pleura exhibit higher sensitivity than pulmonary parenchyma to asbestos fibers (Khan & Jones, 2004). Figure 8 provides data from Surveillance Epidemiology and End Results (SEER) on the incidence rate for mesothelioma in the US population for the period 1975 to 2004 (SEER, 2007). Overall, the incidence rate for whites was greater than that of the general population and blacks, respectively for the period. The peak incidence rates for all groups occurred during the period 1991-1995. After 1999 the incidence rates for all groups fell steadily until 2003, when the rates began to increase.
Figure 8 SEER Age-adjusted Incidence Rates by Race for Mesothelioma, all Ages, and both Sexes. SEER 9 Registries for 1975-2004 Age-adjusted to the 2000 US Standard Population

Mechanisms of Asbestos Carcinogenicity

Asbestos and all its commercial forms are known to be human carcinogens based on sufficient evidence of carcinogenicity in humans (Drillbits and Tailings, 1999) but they have very different potentials. Carcinogenesis is described as a multi-step process (Barrett, 1993; Barrett, Lamb, and Wiseman, 1998). Important factors in the carcinogeneticity of asbestos have been described (Barrett et al, 1998). These include fiber size dependence for mesotheliomas and synergism with cigarette smoking for bronchogenic carcinoma. Fiber properties affecting carcinogenesis are fiber dimensions, fiber durability and surface properties of fibers. There is also evidence supporting the initiating and tumor-promoting activity of asbestos fibers (Barrett et al, 1998). It has also been theorized that reactive oxygen species generated by asbestos fibers could mediate the development of malignant mesothelioma (Moyer, Cistulli, Vaslet, C, and Kane 1994).

According to Walker, Everitt, and Barrett, (1992), asbestos fibers may exhibit carcinogenic effects by direct and indirect mechanisms. Direct effects result from the physical interaction of fibers with target cells or by the generation of free radicals by the source of the fibers. Indirect effects arise from the interaction of fibers with cells that cause inflammation which produce mediators such as cytokines and ROS. As a result, genetic alterations sustained by target cell develop into tumors.

The USEPA is concerned about protecting the population against cancers that may be due to asbestos fibers in both indoor and ambient air. The USEPA policy is to protect at the 1 in 1,000,000 cancer risk level. The safe level or goal is $4 \times 10^{-6}$ f/cc and the action level to trigger cleanup is $4 \times 10^{-4}$ f/cc (Jenkins, 2002; USEPA, 1993). The
USEPA Standards for indoor and ambient air at different cancer risk levels are given in Table 6.

**Table 6**

*USEPA Standards for Indoor and Ambient Air at Different Risk Levels*

<table>
<thead>
<tr>
<th>Cancer risk level</th>
<th>Risk level</th>
<th>Air concentration of asbestos fibers (f/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cancers</td>
<td>“PCM” fraction of fibers &gt; 5 microns</td>
<td></td>
</tr>
<tr>
<td>1 in 1,000,000</td>
<td>$10^{-6}$ (= E-6)</td>
<td>0.000004 f/cc (= 4E-6 f/cc)</td>
</tr>
<tr>
<td>1 in 100,000</td>
<td>$10^{-5}$ (= E-5)</td>
<td>0.00004 f/cc (= 4E-5 f/cc)</td>
</tr>
<tr>
<td>1 in 10,000</td>
<td>$10^{-4}$ (= E-4)</td>
<td>0.0004 f/cc (= 4E-4 f/cc)</td>
</tr>
</tbody>
</table>


**Biomarkers and Monitoring**

The major biomarker of exposure to asbestos fibers is the detection of fibers or asbestos bodies in bronchoalveolar lavage fluid. Concentrations of retained fibers found in autopsied lung tissue samples have also been used. Asbestos fibers have also been measured in urine. Chest x-rays are the most common method used to determine the effects of inhalation exposure to asbestos in living persons (ATSDR, 2001) Asbestos can be monitored in air or in bulk materials. Both the Occupational Safety and Health Administration (OSHA) and USEPA have regulations for monitoring asbestos in these media.
Risk Assessment and Toxico-dynamics

Although asbestos-related health risks are well documented, a direct correlation between a given exposures to the health hazard outcome is difficult to quantify. Risk assessment of developing asbestos-related disease is dependent on dose, durability of the asbestos fiber (biopersistence), physical dimension and surface reactivity of inhaled fibers. Experimental studies have demonstrated that the pathological effects of asbestos are based on dose measurement, as well as fiber length and durability (University of Minnesota, n.d.). Not all asbestos fibers produce the same degree of harm. Chrysotile (curly shape) and Amphiboles (tremolite, amosite and crocidolite) have the greatest physiochemical differences. Consequently, when conducting health risk assessment one needs to take into account the physical and chemical properties of asbestos (University of Minnesota, n.d.). The potential of asbestos exposure exists in many kinds of work environments inclusive of textile, mining, manufacturing, thermal insulation and cement, construction and transportation of asbestos product (University of Minnesota, n.d.). Table 7 provides risk estimates of mesothelioma by several authors for different occupational groups.

Numerous animal and human studies have been conducted to investigate the toxicodynamics of asbestos. Both acute and chronic exposure studies have been used to elucidate the clearance of asbestos fibers from the lungs. The resident time of asbestos fibers in the lungs is highly variable and the estimated T ½ (Half-life) varies from minutes to years. T ½ refers to the time required for half of the substance present at the beginning to dissipate or disintegrate The multi-compartment model (Figure 9) has been
used by several investigators to describe the dynamic behavior of asbestos (University of
Minnesota, n.d.). A typical model may have 4 clearance compartments, namely:

1. Fast clearance compartment: $T_{1/2} =$ minutes to hours
2. Medium clearance compartment: $T_{1/2} =$ days
3. Slow clearance compartment: $T_{1/2} =$ months
4. Very slow clearance compartment: $T_{1/2} =$ years

Table 7

Risk Estimates for Mesothelioma

<table>
<thead>
<tr>
<th>Human data/Occupational group</th>
<th>Fiber type</th>
<th>Reported average exposure (fiber-yr/cc)</th>
<th>% increase in cancer (per fiber-yr/cc)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation workers</td>
<td>Mixed (Chrysotile, Crocidolite, &amp; Amosite)</td>
<td>375</td>
<td>1.5E-6</td>
<td>Selikoff et al, 1979; Peto et al, 1982</td>
</tr>
<tr>
<td>Insulation products</td>
<td>Amosite</td>
<td>400</td>
<td>1.0 E-6</td>
<td>Seidman et al, 1979</td>
</tr>
<tr>
<td>Textile products</td>
<td>Chrysotile</td>
<td>67</td>
<td>3.2E-6</td>
<td>Peto, 1980; Peto et al, 1982</td>
</tr>
<tr>
<td>Cement products</td>
<td>Mixed</td>
<td>108</td>
<td>1.2E-5</td>
<td>Finkelstein, 1963</td>
</tr>
</tbody>
</table>


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Figure 9: Multi-compartment Model
Table 8

T1/2 for Chrysotile and Tremolite Fibers of Varying Lengths

<table>
<thead>
<tr>
<th>Fiber Length (µm)</th>
<th>Chrysotile</th>
<th>Tremolite</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>T1/2 = 4 years</td>
<td>T1/2 = 14 years</td>
</tr>
<tr>
<td>5-10</td>
<td>T1/2 = 2-6 years</td>
<td>T1/2 = 2-16 years</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>T1/2 = 2-8 years</td>
<td>T1/2 = 2-150 years</td>
</tr>
</tbody>
</table>

Occupational Exposure

It is estimated that occupational exposure to asbestos could be responsible for 5-20% of lung cancers and 80-90% of pleural mesothelioma, in men in industrialized countries. The risk of cancer is positively correlated to cumulative exposure. There is no threshold below which there is no increased risk of respiratory cancer (ATSDR, 2001). The global banning or restricted use of asbestos and/or ACM has significantly reduced worker exposure to the various forms of asbestos in recent years. Asbestos has reportedly been banned or its use restricted in over 30 countries (International Trends in the Regulations and Control of Asbestos, n.d.). The International Labor Organization (ILO), which by constitution has a mandate for the protection of the workers of the world, has promulgated a Convention on Asbestos since 1986 (ILO, 1986) which forms the minimum requirements for most of the occupational exposure legislation in those jurisdiction that are signatories. Except for those countries that produce asbestos (e.g.
Russia, Canada, Kazakhstan, China, and Brazil) and those that permit the importation of asbestos or ACM, worker exposure is usually limited to maintenance, repair, demolition, and disposal of asbestos or ACM. Consequently, the primary source of occupational exposure is asbestos that is “in place” and in particular asbestos that is in a friable state or which has become so by activities such as drilling, hammering, etc. It follows therefore that contractors and workers need to be aware of the presence of asbestos or ACM in the equipment and buildings on or in which they work.

Table 9 shows the typical general population and occupational exposure to asbestos. It is evident that the exposure in the occupational setting is generally much higher than that for the general population whether outdoor or indoor.

Table 9

<table>
<thead>
<tr>
<th>Exposed population</th>
<th>Exposure medium</th>
<th>Typical concentration</th>
<th>Assumed exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>General population</td>
<td>Ambient air</td>
<td>$2 \times 10^{-6}$ PCM f/cc</td>
<td>20 m$^3$/day, 70 years</td>
</tr>
<tr>
<td></td>
<td>Indoor air</td>
<td>$3 \times 10^{-6}$ PCM f/cc</td>
<td>(10% of time outdoors)</td>
</tr>
<tr>
<td>Asbestos worker</td>
<td>Drinking water</td>
<td>0.017 MFL</td>
<td>2 L/day</td>
</tr>
<tr>
<td></td>
<td>Workplace air</td>
<td>0.1 PCM f/cc</td>
<td>40 years, 8 m$^3$/day, 5 days/week, 49 weeks/year</td>
</tr>
</tbody>
</table>

Table 10 shows some of the typical concentrations of asbestos detected during the abatement programs for different types of ACM. Generally the mean concentrations were below the PEL or Threshold Limit Value (TLV) of 0.1f/cc. A comparison of the data in Table 10 cannot be attempted since the data were obtained from different studies using different types of samples.

Table 10

<table>
<thead>
<tr>
<th>Material abated</th>
<th>No. of samples</th>
<th>Concentration range (f/cc)</th>
<th>Arithmetic mean (f/cc)</th>
<th>Type of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofing material (wet method)</td>
<td>12</td>
<td>0.0047-0.0752</td>
<td>0.015 (0.014)</td>
<td>Personal (Non-TWA)</td>
</tr>
<tr>
<td>Floor tile and mastic</td>
<td>10</td>
<td>&lt;0.008-0.094</td>
<td>0.022 (0.017)</td>
<td>Personal (Non-TWA)</td>
</tr>
<tr>
<td>Dry wall</td>
<td>25</td>
<td>0.12-3.16</td>
<td>0.010 (0.008)</td>
<td>Personal (TWA)</td>
</tr>
<tr>
<td>Floor tile and mastic</td>
<td>23</td>
<td>0.01-0.08</td>
<td>0.04 (0.04)</td>
<td>Personal (TWA)</td>
</tr>
<tr>
<td>Pipe/boiler in a crawl space</td>
<td>102</td>
<td>0.005-1.542</td>
<td>0.202</td>
<td>Area</td>
</tr>
<tr>
<td>Ceiling tile removal in mini-containment</td>
<td>11</td>
<td>0.005-0.331</td>
<td>0.043</td>
<td>Area</td>
</tr>
<tr>
<td>Transite removal</td>
<td>41</td>
<td>0.005-0.278</td>
<td>0.077</td>
<td>Personal</td>
</tr>
</tbody>
</table>


Table 11 shows some of the typical concentrations of asbestos fibers encountered during building maintenance and repair. Based on the data in Table 11 ceiling tile replacement appears to be one of the most hazardous building maintenance or repair activities to undertake in a building containing ACM.
Table 11

*Exposure to Airborne Asbestos during Building Maintenance or Repair*

<table>
<thead>
<tr>
<th>Material abated</th>
<th>Number of samples</th>
<th>Concentration range (f/cc)</th>
<th>Arithmetic mean (SD) (f/cc)</th>
<th>Type of sample</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling removal/installation</td>
<td>6</td>
<td>0.000-0.035</td>
<td>0.0149</td>
<td>Personal</td>
<td>Corn 1994; Corn et al 1994</td>
</tr>
<tr>
<td>Electrical/plumbing</td>
<td>10</td>
<td>0.004-0.054</td>
<td>0.0308</td>
<td>Area</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>8</td>
<td>0.000-0.077</td>
<td>0.0202</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td>Run cable</td>
<td>33</td>
<td>0.001-0.228</td>
<td>0.0167</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous work</td>
<td>9</td>
<td>0.000-0.083</td>
<td>0.0108</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td>Removal/encapsulation</td>
<td>10</td>
<td>0.003-0.019</td>
<td>0.0109</td>
<td>Area</td>
<td></td>
</tr>
<tr>
<td>ACM debris cleanup</td>
<td>9</td>
<td>0.012-0.36</td>
<td>0.074</td>
<td>Personal</td>
<td>Mynarek et al, 1996</td>
</tr>
<tr>
<td>Bulk sample collection</td>
<td>31</td>
<td>0.003-0.17</td>
<td>0.034</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td>Cable pull</td>
<td>37</td>
<td>0.011-0.20</td>
<td>0.048</td>
<td>Personal</td>
<td></td>
</tr>
<tr>
<td>Ceiling tile replacement</td>
<td>67</td>
<td>0.03-3.5</td>
<td>0.35</td>
<td>Personal</td>
<td></td>
</tr>
</tbody>
</table>


Studies on Asbestos Exposures of Workers in Different Occupational Settings

Anderson et al (1991) found that building maintenance workers were at increased risk of developing mesothelioma from exposure to in-place ACBM. A study conducted by Oliver et al (1991) revealed that pleural plaque diagnosed by chest radiographs occurred in 33% of those studied and that 30% (n= 12) of those with pleural plaque had no known exposure to asbestos outside of their usual work as a school custodian. Firefighters were found to be at risk for asbestos-induced pulmonary fibrosis and pleural fibrosis independent of any exposures to asbestos outside of employment as a firefighter.
(Markowitz et al, 1991). In another study, it was discovered that the translocation of inhaled asbestos fibers from the lung to the pleura and peritoneum occurred frequently among asbestos insulation workers (Selikoff and Serdmar, 1991). However, the route of translocation has not been fully elucidated. The effects of asbestos exposure take some time to be manifested. Balmes, Daponte, and Core (1991) confirmed in their study that long-term occupational exposure to ACM in public schools was capable of causing asbestos-related lung disease.

Studies of Asbestos Exposure in Hospitals

In 1988 a team from the National Institute for Occupational Safety and Health (NIOSH) carried out a Health Hazard Evaluation (HHE) at the Queen Elizabeth Hospital located on the Caribbean Island of Barbados (Crandall & Fleeger, 1989). The team found high levels of asbestos in bulk samples collected and analyzed. For example, one sample from the steam line contained nearly 100% of chrysotile asbestos while another sample from the laundry boiler contained 70-80% of asbestos. Analysis of air samples showed airborne concentrations of asbestos in the hospital ranged from <0.002-0.006 f/cc. The investigators concluded that “asbestos constituted a hazard since it was widely used and highly accessible to workers and the general public in Barbados”. In another evaluation conducted by NIOSH at the St. Elizabeth’s Hospital in Washington D.C. in 1977, asbestos concentrations with fibers greater than 5 microns in length ranged from 0.11-3.02f/cc. The author concluded that the construction workers and certain hospital employees were exposed to excessive concentrations of asbestos containing dust during construction (Straub, 1977). In yet another study conducted at the same hospital in 1979
to determine if dust emitted during the installation of fire alarms and smoke detectors could present an asbestos exposure potential, area and breathing zone samples collected and analyzed by PCM resulted in fiber counts below detectable limits and consequently below OSHA standards (Johnson, 1979). In a preliminary survey of control technology for the removal of asbestos conducted at the Veterans Administration Hospital in Denver, Colorado in 1984, asbestos concentrations of less than 2 f/cc inside work areas and 0.005 f/cc outside the work area were detected. OSHA’s PEL at the time was 2 f/cc. On the basis of those measurements it was concluded that “asbestos removal activities of the contractor seem to be well planned and executed” (Caplan, 1985).

Regulatory Standards for Asbestos

According to the University of Minnesota (n.d.) regulatory standards for asbestos were in place as far back as 1948. The regulatory standards history for asbestos is given in Table 12.

Table 12

<table>
<thead>
<tr>
<th>Year</th>
<th>Standard -TLV-TWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948-1973</td>
<td>5mppcf</td>
</tr>
<tr>
<td>1968-1969</td>
<td>12 f/cc</td>
</tr>
<tr>
<td>1970-1978</td>
<td>5 f/cc</td>
</tr>
<tr>
<td>1978</td>
<td>2 f/cc (Chrysotile and other)</td>
</tr>
<tr>
<td></td>
<td>0.5 f/cc (Amosite and tremolite)</td>
</tr>
<tr>
<td></td>
<td>0.2 f/cc (Crocidolite)</td>
</tr>
<tr>
<td>1991</td>
<td>0.2 f/cc (All forms)</td>
</tr>
<tr>
<td>1997 - current</td>
<td>0.1 fiber/cc</td>
</tr>
</tbody>
</table>

Note: From “A Class Project: PubH 5103/5104- Environmental Hazards, Asbestos-Regulatory Standards History” by the University of Minnesota. Available at: http://enhs.umn.edu/hazards/hazardssite/asbestos/asbestosregulatorystandard.html
The first modern approach to establishing an asbestos standard in terms of fiber concentration was proposed by the British Occupational Hygiene Society (BOHS) in 1968 (NIOSH, 2005). Asbestos is one the most regulated substances in the US. Presently the occupational exposure limits are as follows:

- The ACGIH Threshold Limit Value- Time-Weighted Average (TLV-TWA) for asbestos is 0.1 f/cc (ACGIH, 2004)

- The OSHA PEL for asbestos is 0.1 f/cc (OSHA, 2005)

- The NIOSH recommended exposure limit (REL) for asbestos is 0.1 f/cc (NIOSH, 2005).

OSHA Regulatory History of Asbestos

OSHA first regulated asbestos in 1971 when, under authority of section (a) of the Occupational, Safety and Health Act, it adopted the existing Federal standard for asbestos under the Walsh-Healy Public Contracts Act (69). The complete history up to the present time is set out below (OSHA, 2007).

Table 13

OSHA regulatory history of asbestos

<table>
<thead>
<tr>
<th>PEL (f/cc)</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>May, 1971</td>
<td>Emergency temporary standard</td>
</tr>
<tr>
<td>5</td>
<td>December, 1971</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>June, 1972</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>October, 1975</td>
<td>Proposed but never implemented</td>
</tr>
<tr>
<td>2</td>
<td>July, 1976</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>November, 1983</td>
<td>Emergency temporary standard</td>
</tr>
<tr>
<td>0.2</td>
<td>October, 1986</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>August, 1994</td>
<td></td>
</tr>
</tbody>
</table>

In September 1988 OSHA set an excursion limit (EL) of 1 fiber/cc for 30 minute and in 1992, removed non-asbestiform tremolite, anthophyllite and actinolite from their scope.

International Standards for Asbestos

There is no fixed international standard for asbestos. In some countries different standards are set for different asbestos fibers. In Japan the occupational exposure level (OEL) for crocidolite is 0.2 f/cc while for other fibers, it is 2 f/cc (Morinaga, 2003). In Canada the standard varies from province to province. In Quebec the OEL for chrysotile is 0.2 f/cc while in Ontario the OEL for the same fiber is 0.1 f/cc (Brophy, Keith, and Schiema, 2007).

Background Information on Jamaica

Jamaica is an island in the Caribbean Sea, positioned at around 18° north and 77° west. The island is 145 kilometers south of Cuba and 161 km west of Haiti. The nearest part of the American continent is the Mosquito Coast of Honduras, 499 km to the south-west of the island. Jamaica has a maximum length of 235 km and widths varying from 32 to 82 km. The island has an area of 4,244 square miles or 10,991 square km. Jamaica is mountainous but has its fair share of plateaux and plains. Jamaica has a maritime tropical climate. Daily temperatures averages 26.2° Celsius (79.2°F), with an average maximum of 30.3°C (86.5°F), and an average minimum of 22.0°C (71.6°F) (Statistical Institute of Jamaica, 1999). The capital city is Kingston.

Jamaica’s population at the end of 2003 was 2,630,371, representing an increase of 0.5% over the previous year (Registrar General Department, 2003). Approximately,
92% of the population is of Black African descent, of which around 76% are pure-blooded and 15% are Mulattoes who are of mixed White and Black African descent. Other ethnic minorities include East Indians and Afro-East Indians who account for 3.4%, Caucasian who represent 3.2% and Chinese and Afro-Chinese who constitute 1.2% (Jamaica-Atlaspedia, n.d.). The most recent available health indices for Jamaica in 2001 report a life expectancy of 74 years; crude birth rate of 21.2 per 1,000 population; crude death rate of 6.6 per 1,000 population; and an infant mortality rate (IMR) of 24.5 per 1,000 live births. Approximately, 13.9% of the population had health insurance coverage in 2001 (Jamaica Ministry of Health (JMOH), 2001). The three leading causes of mortality in 2003 were cerebrovascular disease, diabetes mellitus, and ischaemic heart disease (Registrar General Department, 2006).

Hospital services in Jamaica are provided through specialist and general facilities. Hospitals in the public sector fall under the jurisdiction of the JMOH and are administered by the Boards of four Regional Health Authorities (RHA). Hospitals are classified as type A, B, or C according to the level of service and the size of the population served. Type C hospitals are basic district facilities providing in-patient and outpatient services in general medicine, surgery, child and maternity care. Basic X-ray and laboratory services are usually provided. Type B hospitals are situated in larger urban centers and provide in-patient and outpatient services in the four basic specialties: general surgery, internal medicine, obstetrics and gynecology, and pediatrics. Type A hospitals are multidisciplinary and serve as referral points for secondary and tertiary services. There are also hospitals that provide specialist care as well as private hospitals (JMOH, 2001). Table 14 provides information about the hospitals in Jamaica.
Table 14

*Hospitals by Region, Type and Bed Complement*

<table>
<thead>
<tr>
<th>Region</th>
<th>Public hospitals</th>
<th>Private hospitals No. of beds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>South East</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>North East</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Western</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Southern</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Source of data: JMOH.

![Map of Jamaica Showing Location of Hospitals](image)

N
↑

**KEY**  🏥 Hospital

___ Boundary of Regional Health Authority

Figure 10. Map of Jamaica Showing Location of Hospitals

**History of Asbestos in Jamaica**

Two asbestos-cement product manufacturing plants operated in Jamaica during the period 1965 -1985 (Anderson, Warren, and Partners Ltd, Folkes, Harrison, and
Partners Ltd. (1974); Caribbean Asbestos Products Ltd.; Lawrence, n.d.). One of the plants was in Montego Bay and it began operations in 1965, while the Marlie Plant located in Old Harbour was constructed in 1969. Both plants were owned by Caribbean Asbestos Products limited. The Marlie Plant closed in 1985 and the Montego Bay Plant had closed earlier. Both plants manufactured asbestos-reinforced cement pipes of varying sizes which were used for conveying drinking water and sewage.

The facilities at the old Marlie Plant are now being used by an animal feed manufacturing company, for storage of animal feed, rice and flour (Kahwa & Reid, 1994). Cement pipes are present on the compound and are used as flower pots, seats, garbage dumps and to pave the yards of residents. Residents reportedly paid waste disposal operators to deposit wet asbestos cement mix in their yards to serve as pavement. Subsequently the dry material in yards and on roadways began to disintegrate releasing dust in the environment (Kahwa & Reid, 1994. This practice could have caused or is still causing serious community exposure to asbestos and has the potential to be Jamaica’s “Libby, Montana”.

Asbestos-related Diseases in Jamaica

Kahwa & Reid (1994) in their study reported on two cases of asbestosis which were diagnosed at the National Chest Hospital. The first case was “a male millwright at an alumina company who lagged boilers with asbestos insulation for twenty years. This patient had asbestosis; a conclusion based on X-ray analysis of the chest and asbestos bodies found in his sputa”. The second case was “a male process operator at the same alumina company as the first case, who lagged boilers and pipes with asbestos insulation
for 16 years. A lung biopsy showed numerous asbestos bodies and chest x-ray revealed a calcified diaphragm”. The study also mentioned three cases of mesothelioma extracted from postmortem pathological reports for the period 1971 to 1994 at the University Hospital of the West Indies (UHWI). Two of the cases were females (one was 17 years of age), and a male. The diagnosis of mesothelioma in a 17 year-old would be a rare occurrence given the long latency period of the disease. Harrison, Bowker, Beath, and Young, (1996) reported on a case of malignant peritoneal mesothelioma in a 2½ year old child. Brenner, Sordillo, and Magill, (2006) reported on seven cases in children seen at Memorial Hospital since 1953. There are some 43 cases of mesothelioma in children reported in the literature (Brenner et al, 2006). Information on occupational or environmental asbestos exposure prior to the death of the Jamaican cases was not known.

The Department of Pathology at the UHWI provided information on two additional cases of mesothelioma:

Case 1: An 85 male whose specimen of pleural tissue was submitted in September 1995. Clinical data revealed a history of chest pain, cough, fever, and anorexia. Chest X-ray showed thickening of the pleura (Right) lung. The patient had haemorrhagic pleural effusion on the same side which was drained. CT scan of area showed pleural thickening with calcifications. The patient had worked for many years in the coal industry in England. Pleural biopsy led to the conclusion that the patient had mesothelioma, sarcomatous type (UHWI Department of Pathology, 2007)

Case 2: A 71 year old male. His clinical data revealed symptoms of progressive cough and shortness of breath (SOB). He had a history of asbestos exposure and was a smoker. Chest x-ray revealed pleural effusion. CT scan of the chest showed thickened
right pleura in areas of consolidation. The clinical diagnosis was mesothelioma of the right lung. A pleural biopsy was performed and the histological report stated that “The biopsy is composed of portions of fibrovascular stroma infiltrated by epithelial cells arranged predominantly in papillae but also in solid nests, acini and occasionally tubules. The cells are cuboidal with dome-like apical portions in places and contain vesicular nuclei with prominent nucleoli. No sarcomatous component is present in this biopsy. Tumour is also seen infiltrating skeletal muscle. The overall picture is consistent with the epithelial type of malignant mesothelioma. Immunohistochemical analysis supports this diagnosis” (UHWI Department of Pathology, 2007).

It could not be ascertained how many cases of lung cancer was due to possible asbestos exposure at the UWHI Department of Pathology as all cases of lung cancer were lumped into one category.

**Hospital Asbestos Policy**

There is no hospital asbestos policy in Jamaica. However, the JMOH was aware of the asbestos pollution problems in some hospitals. The Environmental Health Unit (EHU) within the JMOH has for some time been trying to address the problem in terms of organizing training for workers and procuring much needed equipment for asbestos air monitoring. This laudable effort has not been met with the success anticipated. It is important to note that the JMOH continued to search for ways to deal with the asbestos pollution problem in hospitals. In recent years a number of hospitals have been renovated and it was reported that one of the hospitals that had asbestos pollution no longer had that problem.
In the US a hospital asbestos policy must outline specific OSHA requirements (29 CFR* 1910.1001) for the following (NIOSH, 1993):

- Reports of each asbestos use or exposure (a log of all jobs in which personnel are exposed)
- Work practices for handling asbestos, such as wet handling, development of cleanup protocols, use of plastic sheeting to seal off work areas, and bagging of removed insulation during routine operations, maintenance, and repair
- Asbestos waste collection, labeling, and disposal
- Respiratory protective equipment (types of respirators, maintenance, training programs, use, and recordkeeping)
- Dressing rooms and special clothing
- Air monitoring
- Recordkeeping and maintenance of records (30 years)
- Medical surveillance (requirements are set by OSHA according to the level of asbestos exposure)
- Training

According to OSHA (NIOSH, 1993), “Hospitals use asbestos for many purposes, including the noncombustible, non-conducting, or chemically resistant materials required for fireproof clothing, curtains, and roofing. Before the early 1970’s, asbestos was used as insulation throughout most buildings (including hospitals). Significant asbestos exposures can occur when insulation in old buildings is removed during renovation. Maintenance personnel in most hospitals do not know and often are not trained in the proper methods of performing repairs on systems that contain asbestos. They frequently perform spot repairs without protecting themselves, patients, or staff from exposure. Asbestos is also used to make heat-resistant protective gloves for central supply and laboratories. With time, these gloves may become worn and disintegrate, releasing fibers into the air”.
Most of Jamaica’s hospitals were built before 1970. At that time the health risks associated with exposure to asbestos were not demonstrated conclusively. Asbestos was used to insulate steam pipes and for other purposes in many hospitals. Over time the asbestos has been undergoing degradation, and apparently releasing fibers in the work environment. With no asbestos risk management programs in place at the hospitals it was likely that some workers could be at risk of exposure to asbestos. The occurrence of asbestos-related diseases is possible in any work place where exposure is present. The onset of these diseases is insidious and therefore workers exposed to asbestos should be monitored as well as their work environment.

National Asbestos Policy

The government of Jamaica through its lead agency on environmental matters, the National Environment Planning Agency (NEPA) has proposed an asbestos management plan (AMP) for Jamaica since 2002 (NEPA, 2002). The plan is comprised of four (4) parts namely,

- A draft asbestos policy statement
- Systems and procedures for carrying out the policy
- Code of practice for asbestos abatement
- Asbestos awareness modules

Despite the passage of several years the asbestos policy remains a draft (Appendix A).

Asbestos Abatement Activities in Jamaica

NEPA issues permits to individuals and companies who make applications to undertake asbestos abatement works. Persons involved in asbestos abatement are
expected to abide by “The procedures for handling asbestos” (Appendix B) set out in the AMP. The JMOH has a role to play in the granting of permits and the monitoring of the abatement exercise. Personnel from the JMOH have the responsibility to ensure that abatement workers, building occupants and the general public are not exposed to dangerous levels of asbestos during and after asbestos removal from buildings. It could not be ascertained (despite repeated efforts to get information from NEPA) the number of permits NEPA has issued for asbestos abatement; the types of establishments from which the asbestos was removed; whether or not pre- and post- abatement air sampling took place; the extent to which PPE was provided for workers and how the ACM was packaged and transported for disposal. There is one designated site in the country for the disposal of asbestos. It could not be ascertained if the asbestos removed from buildings was always taken to the designated Riverton City Municipal Waste Disposal Site.

Study Rationale

The extent to which workers may be exposed to airborne asbestos in Jamaican hospitals depends on a number of factors. Firstly, asbestos must be present in the hospital in a condition to cause fiber release and the study by Kahwa et al (1999) confirmed this to be the case in some hospitals. Secondly, the job category of workers is important as workers who may have to disturb ACM during their work may lead to greater exposure among those workers. Maintenance workers are more likely to disturb ACM if present in hospitals during repairs and routine work than any other category of hospital employees. In addition to maintenance workers, the possibility exists for nurses, doctors, patients, and visitors to be exposed to asbestos fibers if they are present in the environment. Thus
if asbestos is present in any hospital the health and welfare of all workers should be protected. In order for hospital staff to provide quality health care they too must be healthy and it would be unfortunate if any of these workers were to become ill as a result of asbestos exposure at the workplace. The condition of patients especially those with existing respiratory illnesses could be severely affected if they too are exposed to asbestos.

This study was undertaken in part to respond to a request made to Sparkman Center for Global Health (SCGH) at the University of Alabama at Birmingham (UAB) by the JMOH to assist with training of employees to manage the asbestos problem in hospitals. The JMOH was apparently responding to the identification of asbestos in some hospitals by Kahwa et al (1999). The SCGH agreed to assist the JMOH but we felt that given the situation a study was warranted to identify the magnitude of the problem and to determine if employees were exposed to airborne asbestos across all hospitals in the country (N=30).

This study was therefore timely and could provide the data that could further alert administrators about lurking dangers related to asbestos and so motivate them to enact policies and implement programs to protect the workforce, patients and visitors. This study could provide data that will inform education and training programs as well pertinent control and abatement programs for asbestos.

Hypotheses

1. The presence of asbestos in hospital buildings is associated with the age of hospitals
2. In Jamaican hospitals, current exposure to asbestos is related to job type; in particular, exposure among maintenance workers is greater than exposure among other workers.

3. Professional health workers are more knowledgeable about asbestos than maintenance and other workers

**Purpose and Objectives**

The ultimate goal of the proposed research project was to identify ACM in Jamaican hospitals and to determine if workers were exposed to airborne asbestos. It was also envisaged that the project could develop information that could be utilized as a basis for designing training and other appropriate interventions for asbestos control and/or abatement in the hospitals concerned. A comprehensive training and education program will result in improved knowledge, attitudes and practices by workers, and will lead to reduced exposure to asbestos fibers in Jamaican hospitals.

**Aims**

The specific aims of the proposed research were:

- **Aim 1 –** To identify ACM, its characteristics and its determinants in Jamaican hospitals;
- **Aim 2 –** To determine if current asbestos exposure in Jamaican hospitals differs by job category; of particular interest is the relation between current asbestos exposure and maintenance jobs and;
• Aim 3 - To assess the knowledge, attitudes and practices of hospital employees/workers with respect to asbestos, its potential health hazards, and management.
CHAPTER 2

METHODS AND MATERIALS

The study was cross-sectional in design. Approval to conduct the study was obtained from the Institutional Review Board (IRB) at the University of Alabama at Birmingham (UAB) and the Ethics Committees of the JMOH and the University Hospital of the West Indies/University of the West Indies (UHWI/UWI), Jamaica (Appendices C, D, and E respectively). The JMOH gave permission for hospitals under its jurisdiction to participate in the study (Appendix F) and the principal investigator (PI) worked closely with the EHU of the Ministry to implement the preparatory phase of the research project. Permission was also obtained from the management of the UHWI and private hospitals to include their employees in the study.

Preparatory Phase of Research Project

Two activities were undertaken in preparation for the research project. These were:

- the attendance of the PI at an asbestos training course in Atlanta, USA
- a training course on asbestos for MOH employees in Jamaica

Asbestos Training Course in Atlanta

The PI attended a 5-day training course entitled “Asbestos in buildings: Air sampling and analysis (NIOSH 582 Equivalent)”, May 16-20, 2005 at The Environmental Institute in Atlanta, USA. This course focused on air sampling for fibers
by phase contrast microscopy (PCM) using the NIOSH Method 7400. The course is designed as an equivalent in structure and objectives to the NIOSH course number 582 (Sampling and Evaluating Airborne Asbestos Dust). It is intended to fulfill the mandatory analyst training requirements (OSHA asbestos regulations for Construction and General Industries) (The Environmental Institute, 2005). The PI was sponsored by the SCGH at UAB. The PI received a certificate and an identification card containing the certificate’s number (Appendix G) confirming successful completion the training course.

Training of JMOH Employees

A request was made in 2005 by the JMOH to the SCGH and the Deep South Center for Occupational Safety and Health (DSCOSH) to provide training on asbestos for selected employees. The SCGH and the DSCOSH agreed to provide the training requested. The training project was a collaborative effort between the SCGH, the DSCOSH, the JMOH and the Department of Community Health and Psychiatry at the UWI, Mona. The major sponsor of the training was the SCGH. The objectives of the training project were to:

a) Build local capacity within the JMOH and allied agencies to adequately respond to asbestos-related problems in JMOH and other facilities in terms of being able to:

- Conduct building inspections/evaluations for ACM
- Evaluate the condition of suspected ACM found in buildings.
- Collect asbestos bulk samples, personal air samples and area samples for laboratory analyses.
- Provide training on asbestos for JMOH employees such as maintenance workers.
- Analyze asbestos bulk samples using PLM
- Analyze asbestos air samples using PCM

b) Provide trained personnel to support data collection activities for the proposed study on “Exposure to airborne asbestos in Jamaican hospitals” to be conducted by UAB doctoral student, Henroy Scarlett (PI).

Fourteen (14) persons were selected to be trained in Jamaica and they were drawn from the JMOH, the UHWI, and NEPA. The training took place in two phases:


2. “Laboratory Methods for Asbestos Air Samples (PCM- NIOSH 582 Equivalent) and Bulk Samples (PLM)” – July 25-29, 2005. A test was administered to participants at the end of the sessions. This was followed by participants completing a written evaluation of the training.

The JMOH pledged to procure much needed equipment for sampling and analysis of asbestos bulk and air samples. The equipment would allow the trained workers to participate in the preliminary sampling and analyses being proposed for this study.

**Conceptual Framework for Research Project**

The PI in consultation with his Research Committee at UAB developed a conceptual framework for the project (Figure 11)
Survey of all Hospitals (N = 30) Bulk Samples by PLM

Hospitals with Asbestos (N = ?)

Air Samples-PCM (some hospitals)

Sample Selection: Questionnaires
   Group 1: Maintenance (N ~75)
   Group 2: Comparison Group (N~75)
   Group 3: Others (N~150)

Focus Groups

Hospital workers

Selected Areas

Sample Selection

Area Samples

Questionnaire Development

Pilot Testing

Administration of Questionnaires

Data analysis

Data file development

Program Plan

Figure 11: Conceptual framework (H.P. Scarlett- 5/9/05)
Methods

The major components of the methods employed were:

1. Walk-through hospital survey and bulk sampling
2. Selection of hospitals, employees and areas for air sampling
3. Conducting, analyzing and describing personal air sampling
4. Construction of a job fiber exposure table
5. Assessment of the knowledge, attitudes and practices of hospital employees/workers with respect to asbestos, its potential health hazards, and management
6. Focus group discussions

1. Walk-through Hospital Survey and Bulk Sampling

This section deals with a) the walk-through hospital survey, b) assessment of fiber release and c) collection of bulk samples and the activities were conducted during the period December 2005 to February 2006.

a) Walk-through hospital survey. A walk-through survey of all hospitals was undertaken to determine which hospitals had ACM. Three of the JMOH employees trained in the aforementioned asbestos training program assisted with this phase. They were thoroughly briefed by the PI about the procedures to be employed in doing inspections and collection of bulk samples. Building records which could provide evidence of asbestos-containing surfacing material, pipe and boiler insulation or miscellaneous ACM were not available for any of the hospitals. Hospital buildings were inspected for insulation on pipes and boilers. Inspection means looking at pipes and
boilers. The detailed protocols for initial steps for the ACM survey, survey procedures for sprayed or troweled on surfacing materials, and survey procedures for pipe and boiler insulation are set out in Appendix H (The Environmental Institute, 2005). The current condition of each instance of suspected ACM found was recorded as “Good”, “Minor damage or deterioration”, or “Poor”. “Good” condition for surfacing materials means there was no water damage, physical damage, or deterioration. “Poor” condition for surfacing material means that there was evidence of water damage, physical damage, or deterioration.

“Good” condition for pipe and boiler insulation means that the wrapping was intact and there was no water damage, physical damage, or deterioration. “Poor” condition for pipe and boiler insulation meant that the wrapping was not intact and there was evidence of water damage, physical damage, or deterioration. The potential for future damage, disturbance, or erosion for both asbestos surfacing material and pipe and boiler insulation was assessed as “Low” or “High”. “High” potential for surfacing material means that the ACM was exposed or accessible, in the air plenum or air-stream, or subject to vibration. “High” potential for pipe and boiler insulation means the ACM was exposed or accessible, or was an air plenum.

b) Assessment of fiber release. The investigator assessed the possibility for fiber release in hospitals identified with suspected asbestos. To do this an evaluation of the suspected ACM’s condition and physical characteristics was performed and the location noted. The evaluation focused on two parameters, current condition of ACM and potential for future disturbance, damage, or erosion of ACM. If water or physical damage, deterioration, or delamination was evident, then fiber release was presumed to
have occurred, was occurring, or was likely to occur. The appearance of the material and the presence of broken or crumbled material on a horizontal surface indicated fiber release.

c) Collection of bulk samples. Bulk samples of insulation and other building materials were collected from 26 (87%) of the 30 hospitals using EPA procedures (Leidal, Busch, and Lynch, 1977). Approximately 1-10 cc of the suspected insulation/building material was collected and packaged for shipment to the laboratory. Appendix I contains the protocol that was utilized in collecting the bulk samples. The protocol included provisions for selecting the survey team, equipment and personal protective equipment (PPE), sampling procedure, restricting access to area where samples are collected, labeling of samples, and repair of sampler damage. From each sampling site it was proposed that one sample would be collected initially and analyzed. If this sample was positive for asbestos, no further sampling from that area would be done. If the initial sample was negative for asbestos then multiple samples would be collected using the EPA’s guidelines. The preliminary analysis of samples was to be conducted by JMOH employees who were trained but this plan had to be abandoned as the JMOH failed to procure the necessary equipment for analysis of the bulk samples. A total of 152 bulk samples were collected. Each sample was labeled to indicate date of collection, hospital, type of sample and location. The relevant “chain of custody forms” provided by the laboratory were completed for all the samples (Appendix J). The samples were shipped to Safety Environmental Laboratories, Inc. in Birmingham, Alabama, in the US. All samples were analyzed by PLM. The analysis procedure was that of the EPA 600/R-93/116 Method (EPA, 1993). The laboratory is accredited under the American Industrial
Hygiene Association (AIHA) and the accreditation number is 100766. For this method stereomicroscopic examination and PLM are mandatory. Stereomicroscopic analysis determines homogeneity, texture, friability, color, and the extent of fibrous components of the sample. This followed by analysis by PLM. The results from both analyses are compared to detect any discrepancies. When problems are encountered with PLM, other analyses are conducted (Figure 12). This method identifies the type and percentage of asbestos fibers present in the samples as well as the type and percentage of all other materials present in each sample. The equipment used includes a microscope, polarized light, 100-400X dispersion staining objective and a stereo microscope: 10-45X. The range for the method is 1% to 100% asbestos and the estimated Limit of Detection (LOD) is <1% asbestos. In addition to the collection of bulk samples at each hospital, the following information was recorded: age of hospital, location of boiler room (attached to hospital or detached), the type of HVAC, engineering and administrative controls as well as personal protective equipment worn by employees that could afford protection against asbestos fibers, number of beds, location of hospital (rural/urban), and type of hospital. Work practices of maintenance workers were observed and recorded.
Figure 12: Procedures for PLM analysis

Figure 13. PI Collecting Bulk Samples at one Hospital

Figure 14. Bulk Samples Collected and Labeled in Preparation for Shipment to the Laboratory
2. Selection of Hospitals, Employees and Areas for Air Sampling

As indicated in Figure 11 air sampling would be done in a sample of the hospitals with ACM as it was envisaged that time and other resources would not allow for air sampling in many hospitals especially if they were scattered all over the island. Based on the lab results for the bulk samples collected a convenience sample of the two hospitals with the greatest asbestos pollution problem was selected to undertake the remainder of the study. These were two of the largest hospitals (Type A) located in the two cities on the island. At these hospitals the largest quantities of ACM was found in a state indicative of fiber release and the number of persons potentially exposed would be tremendous. Also, because maintenance workers were of prime interest in the study, then only the larger hospitals where asbestos was identified, and which had 10 or more maintenance workers qualified for inclusion. This was done to reduce excessive traveling across the island and to reduce costs associated with traveling, sampling and analysis and the administration of questionnaires. The most recently updated computerized list of employees, grouped by category of work performed at the hospitals in the study was requested from each hospital. This list served as the sampling frame. Upon receipt, the lists were checked for homogeneity in the nomenclature for job categories as well as for categories of staff that may be unique to some hospitals. The general approach to subject selection was stratified random sampling at each hospital. The stratification was based on three broad groups of hospital employees/ workers. Group one comprised maintenance workers. They were considered as the group with the most potential for exposure to asbestos fibers in the hospitals based on the work they performed, the materials they worked with and the areas of the hospitals where they often performed tasks. This group
comprised boiler operators, pipe fitters, electricians, plumbers and carpenters. Group two was comprised of workers who were comparable to maintenance workers in terms of gender, education, salary, age, and duration of employment. The maintenance workers were males and therefore the comparison group consisted of only male employees. This group comprised individuals who were deemed to have low potential for exposure to asbestos as they move about on the hospital premises to perform job functions. Group two included male porters, sanitation workers, and security guards. Group three comprised other employees who had the potential for moving around the hospital to do their jobs or who remained almost confined to their office or laboratory but who did not qualify for inclusion in the comparison group either because of gender or socio-economic status (SES). This group of employees was included as it was important to ascertain their exposure to airborne asbestos because this group comprised the majority of hospital employees. This group included professional caregivers (doctors and nurses); laboratory workers (medical technologists, laboratory technicians, radiographers); pharmacists and administrative/clerical staff. Doctors, nurses and medical technologists were further stratified by the department/ward where they worked and then participants were randomly chosen. Each participant selected was asked to sign a letter giving informed consent (Appendix K).

Ideally, each potentially exposed worker should be individually sampled and decisions taken on the extent of the exposure. In this study, the aim was to estimate the exposure of particular groups of workers who were deemed to have a homogenous potential for exposure rather than to measure the exposure of all individual workers.
Table 15 gives the required sample size \( n \) of a random sample drawn from a group of size \( N \) which ensures with 95% confidence that at least one individual from the highest 20% exposure group is contained in the sample. This protocol was developed by NIOSH (Leidal et al, 1977) and adopted for use in this study. The protocol was not strictly adhered in this study but was modified given the resistance experienced in getting some categories of staff to cooperate with the personal air sampling. It was not possible to compare those who participated with those who did not as the information required was not available. After determining the appropriate number of workers to sample, workers were randomly selected from their respective group and their exposure measured by personal air sampling.

<table>
<thead>
<tr>
<th>Size of group (N)</th>
<th>7-8</th>
<th>9-11</th>
<th>12-14</th>
<th>15-18</th>
<th>19-26</th>
<th>27-43</th>
<th>44-50</th>
<th>51-∞</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required No. of measured employees (n)</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

Note: From NIOSH Occupational Exposure Sampling Strategy Manual. Reprinted with permission

3. Conducting, Analyzing and Describing Personal and Area Air Sampling

   a) Personal air sampling. NIOSH Method #7400 (NIOSH, 1994) was the sampling and analytical method used in this study. The equipment used was as follows:
- Five battery-operated, high flow pumps; three with 1- to 3-L/min flow rate and two with 1- to 5-L/min flow rate. Two of the pumps were Gil Air-5/Basic Trimode Air Samplers with serial numbers 14398 and 14432 respectively. The other three were Gillian BDX II Abatement Air samplers made by SENSIDYNE (USA) with serial numbers 2004064004, 20050902075, and 20050902078.

- Three-piece 25-mm filter cassettes with 2-inch extension cowl and 0.8µm pore size, mixed cellulose ester (MCE) membrane filter

- A Bios Dry Cal DC-Lite Primary Flow Meter

- Sampling hose

- Alcohol swabs

Each sampling pump was calibrated before and after monitoring with a cassette in line at approximately 2.0 L/min as shown in Figure 16. Each sample was collected at a flow rate of approximately 2 liters per minute. The sampling procedure was explained to each participating worker. The protocol described in Appendix L was utilized in collecting the personal air samples. The employee exposure measurement record form was completed for each sample collected. Air sampling involved drawing a known volume of air through a filter and analyzing that filter for the presence of asbestos fibers. The filter is housed in a plastic cassette which is attached to a sampling pump with flexible tubing. The sampling pumps were battery operated.
Figure 15. Diagram showing the Set-up of Equipment for Calibration

Figure 16. Sampling Train for Personal Air Sampling
Five personal samplers were used and were calibrated to draw a known volume of air through the filter material over a given period of time (usually expressed as liters per minute). The samplers and flexible tubing was cleaned with alcohol swabs before being attached to each participant. The sampling device was directly attached to the employee and worn continuously during all work and rest operations. The sampling strategy employed was a full period (shift) single sample measurement. This was for 8 hours for the 8-hour standard of 0.1 fiber/cc. Personal air samples was to be collected from each group over a period of five days. The number of samples to be collected from each group was divided by five to get the number of samples to collect daily. For example, if 10 samples were to be collected from maintenance workers at a hospital then two different maintenance workers were sampled each day for five days. This protocol was not strictly adhered to as on occasions the workers who were selected were not available on their scheduled day and so they had to be used whenever they were available. For larger groups of workers such as doctors and nurses the maximum number of samples (14) stipulated by NIOSH that should be collected was exceeded as it was thought necessary to sample these workers on as many hospitals wards as was possible. In some cases the sampling period was less than the anticipated 8-hours. This was due to some workers arriving late for work and also some workers wished to leave work before the end of their shift. Each participating hospital and employee was assigned a special code which was used on lab forms to protect their identity. The samplers worn by employees were checked every two hours when possible or at longer intervals. However each sampling pump was checked at least once during the day to ensure that it was working properly. Workers who wished to leave the hospital compound during lunchtime had their pump
turned off, removed and re-fitted on their return. At the end of sampling the pump was stopped and the top section of the cassette replaced immediately, ensuring that the surface of the filter was not touched. The cassettes were removed and labeled to indicate the date, the pump serial number, flow rate, start and ending time. Information relating to the temperature and atmospheric pressure on the sampling days was obtained from the National Meteorological Center in Kingston. Some maintenance and other workers refused to participate in the personal sampling exercise and so fewer samples than expected were collected from this group. One hundred and thirty one (131) personal air samples were collected from both hospitals during the period July 10, 2006 to January 18, 2007. A blank filter cassette (field blank) was submitted for approximately every ten samples in the batch collected. The blank was taken from the same batch of filters as the samples. The field blanks were handled in the same way as the sample filters but no air was drawn through them. The samples along with the relevant completed chain of custody forms were shipped to Safety Environmental Laboratories Inc. in Birmingham, Alabama, USA for analyses. The results from each set of samples were used to represent the average exposure for the group.

b) Area samples. In addition to personal samples, area samples were collected. Area air samples were taken with a pump, tubing and filter cassette (called the sampling train) placed at breathing zone height at some stationary location within selected work areas in the hospitals. Area air sampling was done in this study to estimate the existing airborne asbestos fiber concentration inside work areas. Two to three samples of 60-120 liters of air are usually adequate to index the airborne asbestos fiber concentration inside work areas. A high-volume sampler was used at selected locations at each hospital. The
sampling time for the area samples was two hours at flow rates of approximately 12 liters/minute. Area samples were taken mainly in the boiler rooms and from other sections of the hospitals where there was indication of disintegrating ACM. Sampling pumps were calibrated pre- and post sampling in a similar manner to the personal air sampling. Appendix M details the protocol for collecting area samples. A total of 32 area samples were collected. These samples along with the relevant completed chain of custody forms were shipped to Safety Environmental Laboratories Inc. in Birmingham, Alabama, USA for analyses.

Figure 17. Bags with ACM which fell from the Roof in the Boiler Room of one Hospital where Area Air Samples were collected
c) Laboratory analysis of air samples by PCM. The sampling and analytical method used by the lab was NIOSH Method: 7400, Issue 2 – Asbestos and Other Fibers by PCM using the “A” rules (Appendix N). The technique employed by the method is light microscopy, phase contrast. Equipment includes positive phase-contrast microscope, Walton-Beckett graticule (100-μm field of view) Type G-22, and phase-shift test slide (HSE/NPL). “The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on the sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. The method gives an index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fiber’s (NIOSH, 1994).
**d) Calculation and reporting of results.** The fiber density on the filter, \( E \) (fibers/mm\(^2\)), is calculated by dividing the average fiber count per graticule field, \( F/n_f \), minus the mean field blank count per graticule field, \( B/n_b \), by the graticule field area, \( A_f \) (approximately 0.00785 mm\(^2\)):

\[
E = \frac{(F/n_f - B/n_b)}{A_f}, \text{ fibers/mm}^2.
\]

Then calculate and report the concentration, \( C \) (fibers/cc), of fibers in the air volume sampled, \( V \) (L) using the effective collection area of the filter, \( A_c \) (approx. 385 mm\(^2\) for a 25-mm filter):

\[
C = \frac{(E)(A_c)}{V \cdot 10^3}.
\]

**e) Consistency and validity checks.** Laboratory reports were checked for face validity. Data were recoded for ease of analysis and transferred to an excel file. The data in the excel file was matched against the lab data to ensure accuracy and consistency.

**f) Analysis.** The unit of analysis was the hospital. The number and percentage of hospitals with ACM and the percentage of hospitals that have asbestos by region were calculated. Fiber concentration range for each sampling method (personal and area) was determined from laboratory results. The arithmetic mean for air samples per hospital and standard deviation was calculated. Where feasible, ANOVA was used to compute within hospital effects and between hospital effects in an attempt to classify hospitals by fiber concentration. To determine whether the average concentration of fibers varied meaningfully by hospital, a comparison of the mean levels of fibers across hospitals was done using Students’ T-tests.
g) Analysis of samples using transmission electron microscopy (TEM). Approximately 50% of the personal air samples (11 of 23) and the single area sample that tested positive for fibers using PCM were further analyzed by Transmission Electron Microscopy (TEM)-Asbestos Hazard Emergency Response Act (AHERA) Analysis and Clearance Protocols - (40 CFR Part 763, Appendix A to Subpart E). This method provides definitive identification of asbestos fiber by type if they are present in the sample. The AHERA method uses a 5:1 fiber aspect ratio and sets 0.5 µm as the minimum fiber length. Data are reported in ranges for all structures < 0.5 microns in length and separately for those structures >5.0 microns in length. Restrictions on sample media, flow rates, sample loading, and uniformity (as observed in the TEM) are set in order to assure reliable data (NIOSH, 1994). The analytical sensitivity of the method should not be greater than 0.005 structure/cc.

4. Construction of a Job Fiber Exposure Table

A job fiber exposure table was constructed to determine if current fiber exposure in the hospitals differed by job category. Of particular interest was the relation between current fiber exposure and maintenance jobs. The job exposure table was developed utilizing the job categories and the exposure data from the personal air sampling. Descriptive statistics such as minimum and maximum exposure for each group, median exposure and arithmetic mean was used to characterize the exposure for each group of workers as depicted in Table 16. Since the majority of fiber concentrations were below the LOD for the sampling and analytical method used; this made it difficult to quantify the exposure of the employees concerned. Having values which are not detectable does
not mean that they are zero. It means that the method cannot differentiate between the
levels present in the sample from background levels (Perkins, 1996). To deal with this
situation we assigned one half of the value of the fiber concentrations below the LOD to
represent the exposure concentration of each worker whose reading was below the LOD
(Gilbert, 1987).

Table 16

*Job Fiber Exposure Table used for Hospital Workers*

<table>
<thead>
<tr>
<th>Job Category</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Median value</th>
<th>Arithmetic mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-maintenance workers (Comparison group):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Porters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Male security guards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sanitation workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional health workers:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Doctors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Nurses</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Medical Technologists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pharmacists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Physiotherapists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Radiographers</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Analysis. Job group was the unit of analysis. The mean, standard deviation, median and interquartile range of fiber measurements for each of the three major job groups and for subgroups for which an adequate number of samples were obtained was computed. These were compared using the same general statistical approaches mentioned earlier. For descriptive purposes, the exposure of the various groups was categorized as high, medium, low, very low/none as follows:

1. Fiber concentration at the PEL (0.1f/cc) or greater – high exposure
2. Fiber concentration at the Action Level (0.01f/cc) or greater but less than the PEL – medium exposure
3. Fiber concentration above the Limit of Detection (LOD) for the method but less than the Action Level – low exposure
4. Fiber concentration below the LOD - very low exposure/none

5. Assessment of the Knowledge, Attitudes and Practices of Hospital Employees/Workers with Respect to Asbestos, Its Potential Health Hazards, and Management

The methods included:
a) Selection of hospital employees for interviews;
b) Questionnaire design and pilot testing;
c) Administration of questionnaire;
d) Focus group discussions
e) Analysis.
a) Selection of hospital employees for interviews. The subjects to be interviewed were selected from the same hospitals at which the air samples were collected. The general approach to subject selection was stratified random sampling at each hospital using the same staff lists mentioned earlier. The stratification was based on job group with an expected 100% selection of maintenance workers and with sampling fractions for other groups determined and specified to achieve a total study size of approximately 300 in the ratio 1 (Group 1):1 (Group 2) :2 (Group 3). The same three broad groups (group 1-maintenance, group 2-non-maintenance – comparison group, and group 3-non-maintenance- medical staff and others) were used.

b) Questionnaire design and pilot testing. A structured questionnaire (Appendix O) was utilized to collect data on knowledge, attitudes and practices relative to asbestos. The questionnaire was designed by the writer after review of the aims of the study and literature on asbestos. The questionnaire is divided into four sections namely, Section 1: socio-demographic data; Section 2: knowledge of asbestos; Section 3: attitudes towards asbestos; and Section 4: practices of maintenance workers. The questionnaire was pilot-tested at other hospitals. Every effort was made to ensure that persons used in the pilot-test were comparable to those selected in the sample. Pilot-testing was done for several reasons: to detect flaws in the questionnaire and correct them prior to the main survey and to explore the feasibility of converting open-ended questions into close-ended questions by determining the range of possible answers for open-ended questions. The time it took to administer a questionnaire was also noted.
c) Administration of questionnaire. Each hospital was asked to provide a room in which the questionnaires would be administered in private. At none of the hospitals was a single room provided for this purpose. Instead in most cases a room was provided in each department to facilitate the administration of questionnaires. In some cases heads of department/supervisors gave up their offices to be used and in other cases employees were interviewed in private on hospital wards and other work areas. Each respondent was approached and asked to participate in the study. Some interviews were conducted at the first contact but in most cases arrangements were made to have the interviews done on subsequent occasions. Hospital management and heads of department (HODs) were notified about the schedule for the interviews and permission requested for employees to be interviewed during their work shift. All interviews were conducted by the PI at the hospitals. The study was introduced as a hospital employee exposure assessment without making specific reference to asbestos. Each respondent signed a consent form (Appendix P). They were informed that they were free not to participate without any form of retribution. The interview format was used to administer the questionnaire. The questionnaires used a code to identify the hospitals and employees participating. A total of 277 questionnaires were administered giving an overall response rate of 90%. The response rate was lowest among the maintenance workers (78%). The questionnaires were administered over the period June 12, 2006 to February 12, 2007.

6) Focus Group Discussions (FGD)

Two focus group discussions were held, one at each hospital that was selected for the air sampling and questionnaire administration. The aim was to have in-depth discussions on
asbestos and to elicit suggestions/recommendations on how best to deal with this problem in the hospitals. HODs and supervisors were targeted to participate in the focus group discussions. In most cases those recruited were hospital employees and at one hospital persons employed to the Regional Health Authority were recruited as their offices were on the hospital building and they were public health professionals. A letter (Appendix Q) was sent to each prospective participant inviting him/her to participate in a discussion on a topic to be announced at the time of the discussion. Persons were advised that they would be required to sign a consent form which would be made available at the time of the discussion. The consent form (Appendix R) had the topic of the discussion on it and so in order not to sensitize participants about the topic the consent forms were not issued in advance. At one hospital eleven employees who were the heads for various professional and non-professional departments were invited to participate. Six individuals (54.5%) participated; two sent apologies for absence while nothing was heard from the remaining three prospective participants. At the other hospital five (50%) of the ten invitees who were heads or representative of departments participated. Personal contact and telephone calls were used to remind persons of the date and time of each discussion. Overall the participants were two males and nine females. All participants read and signed the consent prior to the start of the discussions.

Each discussion was held in an air-conditioned conference with comfortable seating at the hospital. The seating was arranged so that all participants faced each other. The PI was the moderator for the discussions. The topic of the discussion was announced as well as the general procedures for conducting the discussion. The participants gave permission for the discussions to be audio-taped. A recording secretary was present at
each discussion and took copious notes to complement the audio tapes. An interview schedule listing the major topics to be covered during the discussions was utilized by the moderator. Each participant was afforded the opportunity to contribute to the discussion and no individual was allowed to dominate the discussions.

One discussion lasted for approximately 90 minutes and the other for 70 minutes. The detailed protocol for the formation and deliberations of the focus groups is attached as Appendix S. Refreshments were provided after each discussion; in one case by the Western Regional Health Authority and in the other by the PI.

Data Coding/Validity Checks. Data from the questionnaires and the focus group discussion were transferred onto excel files in preparation for analysis. Each questionnaire was checked for completeness. The data were checked to ensure face validity. For example all maintenance workers were males therefore the gender of all maintenance workers should be male both on the questionnaire and excel files. Date of birth was checked to see if it matched the age of respondents. Based on the responses given for some questions the data was recoded into categories to facilitate more meaningful analysis. For the focus group data the notes taken by the recording secretary were compared with the audiotapes to ensure consistency and validity.

Analysis. Analysis was performed using SAS Version 9.1. Logistic regression and Chi Square analyses were done to determine whether maintenance workers and non-maintenance workers had different knowledge and attitudes about asbestos. Odds ratios were computed as the measure of association. For the focus groups, the recorded
discussions were transcribed on a word processor. Key words and concepts were placed into several categories. Scripts were developed from each session using a data recorder and an audio recording tape. Multiple reading of the scripts were conducted and reviewed for accuracy. Data were organized using the thematic approach. Themes were identified based on the frequency and the predominance of replies to the questions that were asked. Key words/concepts were coded for central themes and general sentiment- positive, negative, neutral and suggestion. Central themes and issues were identified. Both quantitative and qualitative results are reported. Quantitative results include the number and percentage of participants who mentioned “X”. Qualitative results captured participants’ feelings and mood.
CHAPTER 3

RESULTS

Asbestos Training Program in Jamaica

Asbestos Hazard Assessment/Train the Trainer Course – July 19-22, 2005

The venue for this training was the University of Technology, Jamaica Off-site Campus, located at 21 Slipe Pen Road, Kingston 5. A short opening ceremony chaired by Henroy Scarlett (PI and Training Coordinator) was held. Mr. Scarlett outlined the background to the training program as well as the objectives. Greetings were brought by Mr. Peter Knight, Director of the Environmental Health Unit (EHU) within the JMOH and Mr. Trevor Ramekie, Director for Applications and Processing at NEPA. Fourteen participants registered for this course (Table 17). The instructor was Mr. William (Bill) Davis, a graduate of Birmingham Southern College. He has worked in the field of industrial hygiene since 1975. He has worked as Director of Industrial Hygiene at UAB for the last 17 years. He is certified by the USEPA as an Asbestos Facilities Assessment Instructor. Mr. Davis was assisted by Henroy Scarlett (PI).

The course covered the following areas:

- Types of asbestos and uses
- Inspecting for friable and non-friable ACM
- Condition assessment and response actions
- Air monitoring and calibration
- Personal protective equipment
• Bulk sampling procedures
• Field trip

Table 17
*Participants for Asbestos Hazard Assessment/Train the Trainer Course*

<table>
<thead>
<tr>
<th>Name</th>
<th>Occupation</th>
<th>Workplace/Employer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sharon Campbell</td>
<td>Public Health Inspector</td>
<td>UHWI</td>
</tr>
<tr>
<td>2 Nicole Knight-Batista</td>
<td>Scientific Officer</td>
<td>National Public health Laboratory (NPHL), JMOH</td>
</tr>
<tr>
<td>3 Vaughn Bernard</td>
<td>Public Health Inspector</td>
<td>Kingston and St. Andrew Health Department</td>
</tr>
<tr>
<td>4 Kamieka Briscoe</td>
<td>Public Health Inspector</td>
<td>St. Catherine Health Department</td>
</tr>
<tr>
<td>5 Leonard Smith</td>
<td>Environmental Engineer</td>
<td>NPHL, JMOH</td>
</tr>
<tr>
<td>6 Nilsia Johnson</td>
<td>Chief Environmental Engineer</td>
<td>NPHL, JMOH</td>
</tr>
<tr>
<td>7 Gilmore Dixon</td>
<td>Engineer Assistant</td>
<td>NPHL, JMOH</td>
</tr>
<tr>
<td>8 Kenneth Blake</td>
<td>Public Health Inspector</td>
<td>Kingston and St, Andrew Health Department</td>
</tr>
<tr>
<td>9 Hydda McPherson</td>
<td>Public Health Inspector</td>
<td>JMOH</td>
</tr>
<tr>
<td>10 Amerith Butler</td>
<td>Public Health Inspector</td>
<td>Southern Regional Health Authority (SRHA)</td>
</tr>
<tr>
<td>11 Steve Morris</td>
<td>Public Health Inspector</td>
<td>Western Regional Health Authority (WRHA)</td>
</tr>
<tr>
<td>12 Kerrine Senior</td>
<td>Environmental Officer</td>
<td>NEPA</td>
</tr>
<tr>
<td>13 Errol Harris</td>
<td>Environmental Technician</td>
<td>NEPA</td>
</tr>
<tr>
<td>14 Norbert Campbell</td>
<td>Lecturer</td>
<td>UWI, Mona</td>
</tr>
</tbody>
</table>

The detailed course schedule is given in Appendix T. The field trip was to the UHWI Maintenance Department, where the group embarked on a brief walk-through inspection and got limited practice in collecting bulk and air samples. A guest lecture was presented by Professor Ishenkumba Kahwa, Head of the Chemistry Department at the UWI. His presentation was on “Jamaican Asbestos Regulations/Guidelines/Policy”. He outlined current efforts by the Jamaican authorities to develop guidelines and regulations
to deal with asbestos. He stressed that much of the work done to date was preliminary and it would take some time for the realization of these regulations.

*Evaluation of participant’s performance.* A pre-test and post-test (Appendix U) was used to evaluate the performance of the participants.

Table 18

*Performance of Course Participants on Pre-test and Post-test*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-Test (%)</th>
<th>Post-Test (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of scores</td>
<td>45-70</td>
<td>65-92.5</td>
</tr>
<tr>
<td>Mean score</td>
<td>56</td>
<td>78.5</td>
</tr>
<tr>
<td>Median score</td>
<td>60</td>
<td>82.5</td>
</tr>
<tr>
<td>Modal scores</td>
<td>50, 60, 62.5, 67.5</td>
<td>82.5</td>
</tr>
</tbody>
</table>

Table 18 shows that the performance of the participants improved by 40% (56% to 78.5%) using the mean post-test score compared to the mean pre-test score as reference. The difference in the mean scores for the pre-test and post-test was statistically significant when analyzed using Student’s T-test (p<0.0001).

*Participant’s evaluation of the training course.* The instrument used in the evaluation is given in Appendix V. The evaluation covered three main areas namely, Course Objectives and Content, Course Participation, and General. A number of statements/questions were included under each area and the participants were required to rate each using the following scale:

1 = Poor
2 = Fair
3 = Average
4 = Good
5 = Excellent

The training was rated highly (86%-92%) by course participants as is illustrated in Table 19.
Table 19

Participants’ Evaluation of Course on Asbestos Hazard Assessment/Train the Trainer

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Overall Mean Score (n=5)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course objectives and content</td>
<td>4.4</td>
<td>88.0</td>
</tr>
<tr>
<td>Course presentation</td>
<td>4.6</td>
<td>92.0</td>
</tr>
<tr>
<td>General</td>
<td>4.3</td>
<td>86.0</td>
</tr>
</tbody>
</table>

The things participants liked most about the course were:

- Very simple, straight forward and informative content 38%
- Hands-on exposure/effective teaching strategies 15%
- Video presentation 15%
- Practical orientation of course 15%
- Field trip 15%

The things participants liked least about the course were:

- Time period too long 15%
- Not enough field trips/practical demonstrations 7.5%
- Not enough practice in taking samples 7.5%
- Difficulty coping with the foreign accent of the instructor 7.5%

Some suggestions given by participants for improvement of the course were:

- Include instructors in the training with local experience such as could be found in the local bauxite industry
- Include more opportunities for practice on the field for sample collection
- Have a more compact training program
- Reduce repetition of some of the course content
Laboratory Methods for Asbestos Air Samples – PCM (NIOSH 582 Equivalent) and Bulk Samples – PLM, held July 25-29, 2005.

This segment of the training took place on July 25-29, 2005 at the Department of Community Health and Psychiatry, UWI, Mona. The participants are listed in Table 20. The Instructor was Mr. Harold (Hal) Jones, Environmental Health Specialist, Air Pollution Control Division, Jefferson County Department of Health, Birmingham, Alabama, USA. Mr. Jones has a BS degree (Geology) from the University of Alabama and has received microscopy training from McCrone Institute in Chicago, Illinois. He worked as a Laboratory Manager and Microscopist at Law Engineering in Birmingham before joining the Jefferson County Department of Health.

Table 20

*Participants for Analysis of Asbestos Air and Bulk Samples Course*

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Occupation</th>
<th>Workplace/Employer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nicole Knight-Batista</td>
<td>Scientific Officer</td>
<td>NPHL - JMOH</td>
</tr>
<tr>
<td>2</td>
<td>Leonard Smith</td>
<td>Environmental Engineer</td>
<td>NPHL - JMOH</td>
</tr>
<tr>
<td>3</td>
<td>Nilsia Johnson</td>
<td>Chief Environmental Engineer</td>
<td>NPHL- JMOH</td>
</tr>
<tr>
<td>4</td>
<td>Gilmore Dixon</td>
<td>Engineer Assistant</td>
<td>NPHL - JMOH</td>
</tr>
<tr>
<td>5</td>
<td>Paula Henry</td>
<td>Scientific Officer</td>
<td>NPHL- JMOH</td>
</tr>
<tr>
<td>6</td>
<td>Errol Harris</td>
<td>Environmental Technician</td>
<td>NEPA</td>
</tr>
</tbody>
</table>

The main areas covered during the training were:

- Phase contrast microscopy
- Reagents and mounting equipment
- Fiber concentration calculations
• Fiber counting rules
• Air sample preparation and slide mounting technique
• Calibration and quality control
• Reading air samples and recording calculations
• Stereomicroscopic analysis of asbestos
• Polarized light microscope set-up
• Identification of asbestos by PLM
• Dispersion Staining and application
• Bulk sample examination methods
• Quantification techniques
• Condenser and objective lens alignment
• Bulk sample examination laboratory

The detailed course schedule is given in Appendix W. There was one major setback with the training on bulk samples analysis by PLM. The PLMs that were rented from the Department of Geography and Geology at the UWI did not have Central Stop Dispersion Staining Objectives and so the identification of specific asbestos fibers could not be done. An end of course test (Appendix X) was administered and a summary of the results is as follows:

• The minimum and maximum scores were 75% and 89% respectively
• Mean score 81.5%
• Median score 82%
• Mode 75% and 86%
Participant’s evaluation of course. The identical evaluation instrument used in the first segment of the training was again used (Appendix V). A summary of the evaluation is presented in Table 21. This segment of the training received very favorable rating (82%-92.5%) by the participants. The things participants liked most about this segment of the training included the hands-on nature of the training; the content was relevant and has practical application, and the vast knowledge and expertise of the instructor. Recommendations for improving the course included having the dispersion objective for the PLM to enable identification of asbestos fibers; having reference samples available; and having training materials distributed to participants in advance of the commencement of the training.

Table 21
Participants’ Evaluation of Course on Analysis of Asbestos Air and Bulk Samples

<table>
<thead>
<tr>
<th>Course parameter</th>
<th>Overall mean scores (n=5)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course objectives and content</td>
<td>4.2</td>
<td>82.0</td>
</tr>
<tr>
<td>Course presentation</td>
<td>4.6</td>
<td>92.0</td>
</tr>
<tr>
<td>General</td>
<td>4.3</td>
<td>86.0</td>
</tr>
</tbody>
</table>
Survey of Hospitals

A survey of the 30 major hospitals in Jamaica was conducted to determine if ACM was present in the buildings. The building plans for the hospitals were not available. The hospitals were distributed in all four health regions. Bulk samples were collected at 26 (86.7%) of the hospitals. The hospitals at which bulk samples were collected were categorized as follows: public hospital – 22 (84.6%); private hospitals – 4 (15.4%); and private/public hospital – 1 (3.8%). The South East Regional Authority (Region 3) had the largest number of hospitals (13 or 50%) from which samples were collected.

The number of beds per hospital ranged from 30 to 1200 with a mean of 202.6 (SD = 258.9) per hospital; the median number of beds per hospital was 101 and the mode was 60 beds. The date of construction could not be ascertained for four hospitals. For the 23 hospitals with information on year built the range was 1776 to 1997 (Table 22). The mean age of the hospitals for which information was available was 81.8 years (SD=50.48); the median age was 63.5 years and the modal age was 52 years.
Table 22: Distribution of hospitals at which bulk samples were collected by type, region, number of beds, date of construction, and age.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Type</th>
<th>Region</th>
<th>No. of beds</th>
<th>Year built</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Private/Public</td>
<td>3</td>
<td>444</td>
<td>1953</td>
<td>53</td>
</tr>
<tr>
<td>B</td>
<td>Private</td>
<td>3</td>
<td>44</td>
<td>1916</td>
<td>90</td>
</tr>
<tr>
<td>C</td>
<td>Private</td>
<td>3</td>
<td>62</td>
<td>1923</td>
<td>83</td>
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<tr>
<td>D</td>
<td>Private</td>
<td>3</td>
<td>36</td>
<td>1959</td>
<td>47</td>
</tr>
<tr>
<td>E</td>
<td>Public</td>
<td>3</td>
<td>320</td>
<td>1938</td>
<td>68</td>
</tr>
<tr>
<td>F</td>
<td>Private</td>
<td>3</td>
<td>30</td>
<td>1945</td>
<td>61</td>
</tr>
<tr>
<td>G</td>
<td>Public</td>
<td>2</td>
<td>180</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>H</td>
<td>Public</td>
<td>2</td>
<td>95</td>
<td>1954</td>
<td>52</td>
</tr>
<tr>
<td>I</td>
<td>Public</td>
<td>2</td>
<td>60</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>J</td>
<td>Public</td>
<td>3</td>
<td>1200</td>
<td>1864</td>
<td>142</td>
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<tr>
<td>K</td>
<td>Public</td>
<td>3</td>
<td>98</td>
<td>1954</td>
<td>52</td>
</tr>
<tr>
<td>L</td>
<td>Public</td>
<td>3</td>
<td>100</td>
<td>1940</td>
<td>66</td>
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<td>M</td>
<td>Public</td>
<td>1</td>
<td>150</td>
<td>1963</td>
<td>43</td>
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<tr>
<td>N</td>
<td>Public</td>
<td>3</td>
<td>422</td>
<td>1776</td>
<td>220</td>
</tr>
<tr>
<td>O</td>
<td>Public</td>
<td>3</td>
<td>192</td>
<td>1892</td>
<td>114</td>
</tr>
<tr>
<td>P</td>
<td>Public</td>
<td>3</td>
<td>51</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>Q</td>
<td>Public</td>
<td>4</td>
<td>101</td>
<td>1837</td>
<td>169</td>
</tr>
<tr>
<td>R</td>
<td>Public</td>
<td>1</td>
<td>520</td>
<td>1974</td>
<td>32</td>
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<tr>
<td>S</td>
<td>Public</td>
<td>1</td>
<td>55</td>
<td>1890s*</td>
<td>116</td>
</tr>
<tr>
<td>T</td>
<td>Public</td>
<td>1</td>
<td>102</td>
<td>1954</td>
<td>52</td>
</tr>
<tr>
<td>U</td>
<td>Public</td>
<td>3</td>
<td>244</td>
<td>1963</td>
<td>43</td>
</tr>
<tr>
<td>V</td>
<td>Public</td>
<td>4</td>
<td>164</td>
<td>1925</td>
<td>81</td>
</tr>
<tr>
<td>W</td>
<td>Public</td>
<td>4</td>
<td>112</td>
<td>1997</td>
<td>9</td>
</tr>
<tr>
<td>X</td>
<td>Public</td>
<td>4</td>
<td>123</td>
<td>1945</td>
<td>61</td>
</tr>
<tr>
<td>Y</td>
<td>Public</td>
<td>4</td>
<td>60</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>Z</td>
<td>Public</td>
<td>2</td>
<td>100</td>
<td>1860</td>
<td>146</td>
</tr>
</tbody>
</table>

* 1890 used in calculation of age of hospital

† Information not available

One hundred and fifty two (152) bulk samples were collected. Laboratory results showed that 16 (61.5%) of the hospitals had ACM in the samples submitted for analysis. Overall 67 or 44.1% of the samples tested positive for ACM. The largest number of samples was taken from Hospital A and 88.8% of the samples contained ACM. Hospital
R was next in line in terms of number of samples (16) and 43.7% of the samples tested positive for ACM. All samples taken from Hospital U contained ACM (Table 23).

Table 23

*Distribution of 26 Hospitals by Number of Bulk Samples Collected, Number of Samples Containing ACM, and the % of Samples with ACM*

<table>
<thead>
<tr>
<th>Hospital</th>
<th>No. of bulk samples collected</th>
<th>No. of samples with ACM</th>
<th>% of samples with ACM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18</td>
<td>16</td>
<td>88.8</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>E</td>
<td>7</td>
<td>1</td>
<td>14.3</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>G</td>
<td>7</td>
<td>3</td>
<td>42.8</td>
</tr>
<tr>
<td>H</td>
<td>10</td>
<td>2</td>
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<td>I</td>
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<td>6</td>
<td>85.7</td>
</tr>
<tr>
<td>J</td>
<td>10</td>
<td>3</td>
<td>30.0</td>
</tr>
<tr>
<td>K</td>
<td>6</td>
<td>3</td>
<td>50.0</td>
</tr>
<tr>
<td>L</td>
<td>7</td>
<td>5</td>
<td>61.2</td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>N</td>
<td>8*</td>
<td>2</td>
<td>25.0</td>
</tr>
<tr>
<td>O</td>
<td>8*</td>
<td>2</td>
<td>25.0</td>
</tr>
<tr>
<td>P</td>
<td>5</td>
<td>4</td>
<td>80.0</td>
</tr>
<tr>
<td>Q</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>R</td>
<td>16</td>
<td>7</td>
<td>43.7</td>
</tr>
<tr>
<td>S</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>T</td>
<td>5</td>
<td>2</td>
<td>40.0</td>
</tr>
<tr>
<td>U</td>
<td>5</td>
<td>5</td>
<td>100.0</td>
</tr>
<tr>
<td>V</td>
<td>7</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>W</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>X</td>
<td>5</td>
<td>2</td>
<td>40.0</td>
</tr>
<tr>
<td>Y</td>
<td>6</td>
<td>5</td>
<td>91.6</td>
</tr>
<tr>
<td>Z</td>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>67</td>
<td>44.0</td>
</tr>
</tbody>
</table>

*Both hospitals shared a boiler room from which samples were taken.*
Figure 19. Distribution of Bulk Samples and Number of Samples Containing ACM, by 16 Hospitals

Figure 19 provides information on the 16 hospitals with ACM. In all but one hospital the number of samples with ACM was less than the total number of samples collected from each hospital. At hospital U all five samples contained ACM.

As seen in Table 24 three types of asbestos namely, chrysotile, amosite, and crocidolite were found in the hospitals. Details are given on the number of samples taken at each hospital and the type and percentage of each fiber that was found in each sample.
Table 24

*Distribution of Hospitals by Type and Percent of Fiber in Samples with ACM, 16 Hospitals*

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Samples with chrysotile</th>
<th>Type of fiber in ACM</th>
<th>Samples with amosite</th>
<th>Samples with crocidolite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>% of fiber in sample</td>
<td>No.</td>
<td>% of fiber in sample</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>25</td>
<td>14</td>
<td>15-30</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>G</td>
<td>3</td>
<td>40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H</td>
<td>2</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>30</td>
<td>6</td>
<td>25-40</td>
</tr>
<tr>
<td>J</td>
<td>3</td>
<td>25-50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>K</td>
<td>-</td>
<td>3</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td>L</td>
<td>3</td>
<td>15-50</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>N*</td>
<td>2</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>O*</td>
<td>2</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P</td>
<td>-</td>
<td>4</td>
<td>20-30</td>
<td>-</td>
</tr>
<tr>
<td>R</td>
<td>3</td>
<td>20-40</td>
<td>7</td>
<td>20-75</td>
</tr>
<tr>
<td>T</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>U</td>
<td>-</td>
<td>5</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>X</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>20-40</td>
</tr>
<tr>
<td>Y</td>
<td>1</td>
<td>35</td>
<td>4</td>
<td>75</td>
</tr>
</tbody>
</table>

* Both hospitals shared the same boiler room in which ACM was found

Table 25

*Summary Data on each Type of Asbestos Fiber in Samples from 16 Hospitals*

<table>
<thead>
<tr>
<th>Type of fiber</th>
<th>Hospitals No.</th>
<th>%</th>
<th>Samples No.</th>
<th>%</th>
<th>Range of % of fiber in samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>16</td>
<td>100</td>
<td>67</td>
<td>100</td>
<td>5-60</td>
</tr>
<tr>
<td>Chrysotile</td>
<td>12</td>
<td>75</td>
<td>24</td>
<td>36</td>
<td>5-60</td>
</tr>
<tr>
<td>Amosite</td>
<td>10</td>
<td>63</td>
<td>49</td>
<td>73</td>
<td>15-75</td>
</tr>
<tr>
<td>Crocidolite</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>5-10</td>
</tr>
</tbody>
</table>

Chrysotile was the fiber type found at most hospitals. It was found in 12 or 75% of hospitals with ACM but only 24 or 36% of the samples collected. Amosite was found...
in fewer hospitals than chrysotile but was present in most samples, 49 or 73%. Crocidolite was found in a few samples in a few hospitals. The percentage of chrysotile in the samples ranged from 5 to 60%; for amosite it was 15-75% and for crocidolite it was 5-10%. Some samples contained more than one fiber type. One sample taken at hospital X contained all three types of asbestos (Table 24).

Figure 20: Distribution of 12 hospitals by percent of samples with ACM by age

As seen in Figure 20 the percentage of samples with ACM per hospital ranged from 14.3 for Hospital E to 100 for Hospital U. It should be borne in mind that different numbers of samples were collected at each hospital. There was no association between the age of the hospital and the percent of ACM found.
Several other materials apart from ACM were found in the bulk samples collected at the hospitals. As seen in Table 26, 13 (50%) of the hospitals had fiberglass in the samples collected with the range being 5-100% and at seven of the hospitals samples contained 100% fiberglass. Mineral wool was found in samples from 8 hospitals and cellulose in 14.

Table 26

Distribution of Hospitals by % of Fiberglass, Mineral wool, and Cellulose found in Bulk Samples

<table>
<thead>
<tr>
<th>Hospital</th>
<th>% Fiberglass</th>
<th>% Mineral Wool</th>
<th>% Cellulose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>15-100</td>
<td>-</td>
<td>2-60</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>D</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>15</td>
<td>5-12</td>
</tr>
<tr>
<td>F</td>
<td>-</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>G</td>
<td>20</td>
<td>40-100</td>
<td>15-90</td>
</tr>
<tr>
<td>H</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>I</td>
<td>-</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>J</td>
<td>100</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>K</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>L</td>
<td>15-100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M</td>
<td>100</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>N</td>
<td>25-100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>O</td>
<td>25-100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P</td>
<td>10</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Q</td>
<td>100</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>80</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>T</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>U</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V</td>
<td>40-100</td>
<td>15-40</td>
<td>15-40</td>
</tr>
<tr>
<td>W</td>
<td>-</td>
<td>30-40</td>
<td>-</td>
</tr>
<tr>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Range 5-100 (n=13 or 50%) or 15-100 (n=8 or 30.7%) or 2-90 (n=14 or 53.8%)
Table 27

*Distribution of Hospitals by Other Materials found in Bulk Samples*

<table>
<thead>
<tr>
<th>Materials</th>
<th>No. of hospitals</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium minerals</td>
<td>16</td>
<td>61.5</td>
</tr>
<tr>
<td>Carbonate minerals</td>
<td>15</td>
<td>57.6</td>
</tr>
<tr>
<td>Binder</td>
<td>11</td>
<td>42.3</td>
</tr>
<tr>
<td>Synthetic fibers</td>
<td>6</td>
<td>23.0</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>8.8</td>
</tr>
</tbody>
</table>

More than 50% of hospitals had calcium and carbonate minerals in samples analyzed. Binder, synthetic fibers and other materials were also present in samples from some hospitals (Table 27).

Air Sampling Data

Table 28

*Frequency Distribution of Fiber Concentration in Air Samples*

<table>
<thead>
<tr>
<th>Fiber concentration (f/cc)</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.002</td>
<td>19</td>
<td>11.6</td>
</tr>
<tr>
<td>&lt;0.003</td>
<td>93</td>
<td>56.7</td>
</tr>
<tr>
<td>&lt;0.004</td>
<td>22</td>
<td>13.4</td>
</tr>
<tr>
<td>&lt;0.005</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>&lt;0.006</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>0.002</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>0.003</td>
<td>6</td>
<td>3.7</td>
</tr>
<tr>
<td>0.004</td>
<td>7</td>
<td>4.3</td>
</tr>
<tr>
<td>0.005</td>
<td>5</td>
<td>3.1</td>
</tr>
<tr>
<td>0.006</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>0.009</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>0.013</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Damaged samples</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 28 shows that of the 164 air samples collected at both hospitals, 24 (14.6%) had fiber concentrations above the LOD for the analytical method used ranging
from 0.002 f/cc to 0.013 f/cc while the majority of samples (138 or 84.1%) had fiber concentrations below the LOD. One sample was damaged and was not analyzed. Of the 24 samples that were positive for fiber concentration 23 or 95.8% were personal air samples while the remaining one was an area sample. In order to compute descriptive statistics, half of each fiber concentration that was below the LOD was used as the exposure concentration for each employee/area concerned. For example, if the fiber concentration was <0.002 f/cc, 0.001 f/cc was used as the fiber concentration level. The assumed concentrations and those above the LOD are given in Table 29. The total number of samples used in Table 29 is 163; the damaged sample was omitted from the calculations. The mean fiber concentration was $1.9 \times 10^{-3}$ f/cc of air with a SD of 0.0014. The median and modal concentrations were identical ($1.5 \times 10^{-3}$ f/cc) while the range and interquartile range were 0.012 and 0.0005 respectively. When the fiber concentrations for the two hospitals were compared a significant association was found ($p=0.026$). Fiber concentrations at hospital A were more likely to be higher than at hospital R.

Table 29

*Frequency Distribution of Fiber Concentrations using one half of the Value for Concentrations below the LOD*

<table>
<thead>
<tr>
<th>Fiber concentration (f/cc)</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>19</td>
<td>11.7</td>
</tr>
<tr>
<td>0.0015</td>
<td>93</td>
<td>57.1</td>
</tr>
<tr>
<td>0.002</td>
<td>24</td>
<td>14.7</td>
</tr>
<tr>
<td>0.0025</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>0.003</td>
<td>7</td>
<td>4.3</td>
</tr>
<tr>
<td>0.004</td>
<td>7</td>
<td>4.3</td>
</tr>
<tr>
<td>0.005</td>
<td>5</td>
<td>3.1</td>
</tr>
<tr>
<td>0.006</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>0.009</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>0.013</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The estimated 8-hr TWA for personal air samples was provided by the laboratory. As seen in Table 30 the majority of estimated 8-hr TWA were below the LOD for the method used. All but one of the fiber concentrations were below the action level and PEL of 0.01f/cc and 0.1f/cc respectively for asbestos. Applying the same method of using half of the value for measurements below the LOD to represent worker exposure for the estimated 8-hour TWA provided by the laboratory, the data in Figure 22 were derived.

Table 30

*Frequency Distribution of Estimated 8-hr Time-Weighted Average (TWA) for 131 Personal Air Samples*

<table>
<thead>
<tr>
<th>Estimated 8-hour TWA (f/cc)</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.002</td>
<td>24</td>
<td>18.32</td>
</tr>
<tr>
<td>&lt;0.003</td>
<td>84</td>
<td>64.12</td>
</tr>
<tr>
<td>0.003</td>
<td>12</td>
<td>9.16</td>
</tr>
<tr>
<td>0.004</td>
<td>8</td>
<td>6.11</td>
</tr>
<tr>
<td>0.006</td>
<td>1</td>
<td>0.76</td>
</tr>
<tr>
<td>0.007</td>
<td>1</td>
<td>0.76</td>
</tr>
<tr>
<td>0.013</td>
<td>1</td>
<td>0.76</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>100.00</td>
</tr>
</tbody>
</table>

![8-hour TWA for personal samples](image)

Figure 21. Frequency distribution of 8-hour TWA for the 131 personal air samples
Approximately 98% of the hospital employees had estimated 8-hour TWA of $\leq 0.004$ fiber/cc of air (Figure 21). The overall mean estimated 8-hour TWA was $1.85 \times 10^{-3}$ fiber/cc with a SD of 0.0013; the median and mode was identical ($1.5 \times 10^{-3}$ fiber/cc). The estimated 8-hour TWA at hospital A was $1.7 \times 10^{-3}$ fiber/cc while at hospital R it was $1.4 \times 10^{-3}$ fiber/cc. When the two hospitals were compared with respect to the estimated 8-hour TWA, a significant association was found ($p=0.03$). On the basis of the foregoing for approximately 98% of the sample the exposure to fibers was considered to very low/none because the fiber concentrations were below the LOD for the SAM and for the other 2% the exposure was considered low as the fiber concentrations were above the LOD for the method but less than the action level of 0.01 fiber/cc of air in most cases.

Table 31

*Distribution of Airborne Fiber Exposure (fiber/cc) by Group of Hospital Workers*

<table>
<thead>
<tr>
<th>Job Category</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Median value</th>
<th>Arithmetic mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance workers (Males)</td>
<td>0.001</td>
<td>0.003</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.8 \times 10^{-3}$</td>
</tr>
<tr>
<td>Non-maintenance (Comparison group)</td>
<td>0.001</td>
<td>0.007</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Male porters</td>
<td>0.001</td>
<td>0.007</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$2.3 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Male security guards</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.5 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Male sanitation workers</td>
<td>0.001</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.4 \times 10^{-3}$</td>
</tr>
<tr>
<td>Health professionals</td>
<td>0.001</td>
<td>0.013</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.8 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Doctors</td>
<td>0.001</td>
<td>0.006</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Nurses</td>
<td>0.001</td>
<td>0.004</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.3 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Medical Technologists</td>
<td>$1.5 \times 10^{-3}$</td>
<td>0.013</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$2.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Pharmacists</td>
<td>0.001</td>
<td>0.003</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.5 \times 10^{-3}$</td>
</tr>
<tr>
<td>- Physiotherapists</td>
<td>0.001</td>
<td>0.003</td>
<td>$1.5 \times 10^{-3}$</td>
<td>$1.6 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

Table 31 shows that there was no difference in the median fiber concentration to which the groups of employees were exposed to and a marginal difference in the mean level of exposure to fibers by the three groups being compared in the study. This
difference however, was not statistically significant. Medical technologists had the highest mean level of exposure to fibers ($2.7 \times 10^{-3} \text{ f/cc}$). This can be attributed to the fact that one member of this group had the highest measured fiber concentration ($0.013 \text{ f/cc}$) and this served to elevate the mean concentration for the group. In such a situation the median fiber concentration is better suited to use in the comparison of the groups.

Table 32

*Summary of Transmission Electron Microscopy (TEM) Results for Asbestos (Air) Samples Collected at two Jamaican Hospitals*

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Air filtered (liters)</th>
<th>Area analyzed (sq.mm)</th>
<th>Analytical sensitivity (structures/cc of air)</th>
<th>Asbestos Structures detected</th>
<th>Structure Density (structure/Sq. mm)</th>
<th>Structure Concentration (structure/Cc of air)</th>
<th>Type Of asbestos</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRHM2</td>
<td>748.25</td>
<td>.100</td>
<td>0.0051</td>
<td>0.0</td>
<td>&lt;10</td>
<td>0.0051</td>
<td>NSD*</td>
</tr>
<tr>
<td>CRHM6</td>
<td>588.00</td>
<td>.130</td>
<td>0.0050</td>
<td>0.0</td>
<td>&lt;7.7</td>
<td>0.0050</td>
<td>NSD</td>
</tr>
<tr>
<td>CRHP5</td>
<td>914.55</td>
<td>.080</td>
<td>0.0052</td>
<td>0.0</td>
<td>&lt;12.5</td>
<td>0.0052</td>
<td>NSD</td>
</tr>
<tr>
<td>CRHN3</td>
<td>819.00</td>
<td>.090</td>
<td>0.0052</td>
<td>0.0</td>
<td>&lt;11.1</td>
<td>0.0052</td>
<td>NSD</td>
</tr>
<tr>
<td>UHP4</td>
<td>765.90</td>
<td>.100</td>
<td>0.0050</td>
<td>0.0</td>
<td>&lt;10</td>
<td>0.0050</td>
<td>NSD</td>
</tr>
<tr>
<td>UHMT3</td>
<td>927</td>
<td>.080</td>
<td>0.0052</td>
<td>0.0</td>
<td>&lt;12.5</td>
<td>0.0052</td>
<td>NSD</td>
</tr>
<tr>
<td>UHMT8</td>
<td>869.4</td>
<td>.090</td>
<td>0.0049</td>
<td>0.0</td>
<td>&lt;11.1</td>
<td>0.0049</td>
<td>NSD</td>
</tr>
<tr>
<td>UHN8</td>
<td>1016.5</td>
<td>.080</td>
<td>0.0047</td>
<td>0.0</td>
<td>&lt;12.5</td>
<td>0.0047</td>
<td>NSD</td>
</tr>
<tr>
<td>UHDR4</td>
<td>898.9</td>
<td>.080</td>
<td>0.0053</td>
<td>0.0</td>
<td>&lt;12.5</td>
<td>0.0053</td>
<td>NSD</td>
</tr>
<tr>
<td>UHDR5</td>
<td>856.9</td>
<td>.090</td>
<td>0.0050</td>
<td>0.0</td>
<td>&lt;11.1</td>
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<td>NSD</td>
</tr>
<tr>
<td>UHA7</td>
<td>1478.4</td>
<td>.050</td>
<td>0.0052</td>
<td>0.0</td>
<td>&lt;19.9</td>
<td>0.0052</td>
<td>NSD</td>
</tr>
<tr>
<td>UHM10</td>
<td>985.9</td>
<td>.080</td>
<td>0.0049</td>
<td>0.0</td>
<td>&lt;12.5</td>
<td>0.0049</td>
<td>NSD</td>
</tr>
</tbody>
</table>

NSD* = No structure detected

Given the fact that PCM does not detect asbestos fibers definitively and the very low fiber concentrations measured, we could not conclude with any degree of certainty that the fibers found in the samples were asbestos despite the presence of disintegrating ACM at the hospitals. We therefore asked the laboratory to further analyze 11 of the 23
personal air samples with the highest fibers counts above the LOD and the only area sample whose concentration was above the LOD by TEM.

Table 33

Summary of Asbestos Sampling (Bulk, Area and Personal) by Hospital

<table>
<thead>
<tr>
<th>Hospital (Region)</th>
<th>No. of beds</th>
<th>Age of hospital</th>
<th>No. of bulk samples</th>
<th>Samples Chrysotile (%)</th>
<th>With Amosite (%)</th>
<th>ACM Crocido-lite (%)</th>
<th>Area samples median fiber conc.</th>
<th>Personal air samples median 8-hr TWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (3)</td>
<td>444</td>
<td>53</td>
<td>18</td>
<td>11.11</td>
<td>77.78</td>
<td>-</td>
<td>0.001 f/cc</td>
<td>1.7x10^-3 f/cc</td>
</tr>
<tr>
<td>B (3)</td>
<td>44</td>
<td>90</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C (3)</td>
<td>62</td>
<td>83</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D (3)</td>
<td>36</td>
<td>47</td>
<td>2</td>
<td>-</td>
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</tr>
<tr>
<td>E (3)</td>
<td>320</td>
<td>68</td>
<td>7</td>
<td>14.28</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F (3)</td>
<td>30</td>
<td>61</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>G (2)</td>
<td>180</td>
<td>*</td>
<td>7</td>
<td>42.86</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H (2)</td>
<td>95</td>
<td>52</td>
<td>10</td>
<td>20.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>I (2)</td>
<td>60</td>
<td>*</td>
<td>7</td>
<td>14.28</td>
<td>85.72</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>J (3)</td>
<td>1200</td>
<td>142</td>
<td>10</td>
<td>30.00</td>
<td>-</td>
<td>20.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>K (3)</td>
<td>98</td>
<td>52</td>
<td>6</td>
<td>-</td>
<td>50.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>L (3)</td>
<td>100</td>
<td>66</td>
<td>7</td>
<td>42.86</td>
<td>28.57</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M (1)</td>
<td>150</td>
<td>43</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>N (3)</td>
<td>422</td>
<td>220</td>
<td>8†</td>
<td>25.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>O (3)</td>
<td>192</td>
<td>114</td>
<td>8†</td>
<td>25.00</td>
<td>-</td>
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<tr>
<td>P (3)</td>
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<td>*</td>
<td>5</td>
<td>-</td>
<td>80.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Q (4)</td>
<td>101</td>
<td>169</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R (1)</td>
<td>520</td>
<td>32</td>
<td>16</td>
<td>18.75</td>
<td>43.75</td>
<td>-</td>
<td>1.5x10^-3 f/cc</td>
<td>1.4x10^-3 f/cc</td>
</tr>
<tr>
<td>S (1)</td>
<td>55</td>
<td>116</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T (1)</td>
<td>102</td>
<td>52</td>
<td>5</td>
<td>-</td>
<td>40.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>U (3)</td>
<td>244</td>
<td>43</td>
<td>5</td>
<td>-</td>
<td>100.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V (4)</td>
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<td>81</td>
<td>7</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>W (4)</td>
<td>112</td>
<td>42</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>X (4)</td>
<td>123</td>
<td>61</td>
<td>5</td>
<td>20.00</td>
<td>40.00</td>
<td>20.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Y (4)</td>
<td>60</td>
<td>*</td>
<td>6</td>
<td>16.67</td>
<td>66.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Z (2)</td>
<td>100</td>
<td>146</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Information not available

† Both hospitals shared a common boiler room in which the ACM was found
The results are summarized in Table 32 where it can be seen that no asbestos structure was detected in any of the samples. On the basis of the TEM results we concluded that the fibers detected by PCM were not asbestos but some other mineral fibers. TEM analysis was used as a validation component in the study.

Questionnaire Data

The administration of the questionnaires took place at the same two hospitals at which the air samples were collected and the sample was divided into three groups. Group 1 comprised maintenance workers; group 2 comprised non-maintenance workers – male porters, male sanitation workers, and male security guards (comparison group); group 3 comprised professional hospital employees- doctors, nurses, medical technologists, pharmacists, radiographers, and physiotherapists. Two hundred and seventy seven of the 300 hospital employees selected participated in this phase of the study giving a participation rate of 90%. The 23 who refused to participate were from the three groups but the majority was from groups 1 and 2. It is not possible to compare those who participated with those who did not as data on the latter group were not available.

Figure 22. Distribution of Respondents by Group
As depicted in Figure 22 Group 3 comprised the largest proportion of the 277 employees interviewed (62%). This was followed by Group 2 and Group 1 with 21% and 17% of respondents respectively.

The sample comprised almost equal numbers of males and females (males, 51%; females, 49%) (Table 34). The majority of respondents (68.96%) were less than 40 years of age. Six respondents (2.17%) refused to give their DOB and so their ages could not be calculated. Group 3 dominated all but one of the age categories. Age was significantly associated with group (Chi-Square = 32.65; DF = 10; p = 0.003). The mean age of hospital employees was 34.75 years (SD = 11.58); median age was 32 years and the modal age was 27 years.

Age was significantly associated with group category. Employees in Group 3 were more likely to be younger than employees in Groups 1 and 2 (p=0.003). The level of education attained by hospital employees was significantly associated with the group of employees (Chi-Square = 205.61; DF = 6; p <0.0001). Employees in Groups 1 and 2 were likely to have finished their formal education at the primary/secondary level while employees in Group 3 were more likely to have expanded their education to have finished their formal education at the college/university level. The group category of employees was associated with their marital status (Chi-Square = 26.38; DF = 6; p = 0.002). Maintenance workers were likely to be married while employees in groups 2 and 3 were likely to be single.
Table 34

Distribution of three groups of respondents (Group 1 = Maintenance workers; Group 2 = Porters, Security guards, Sanitation workers; Group 3 = Professional health workers) by Selected Socio-demographic and Employment Characteristics

<table>
<thead>
<tr>
<th>Socio-demographic/employment characteristics</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>p-value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>47</td>
<td>59</td>
<td>36</td>
<td>100.0</td>
<td>142</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>0</td>
<td>135</td>
<td>79.0</td>
<td>135</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>59</td>
<td>171</td>
<td>100.0</td>
<td>277</td>
</tr>
<tr>
<td>Age (yrs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>10</td>
<td>22</td>
<td>22</td>
<td>37.3</td>
<td>106</td>
</tr>
<tr>
<td>30-39</td>
<td>15</td>
<td>17</td>
<td>53</td>
<td>28.8</td>
<td>85</td>
</tr>
<tr>
<td>40-49</td>
<td>4</td>
<td>11</td>
<td>27</td>
<td>18.6</td>
<td>42</td>
</tr>
<tr>
<td>50-59</td>
<td>13</td>
<td>7</td>
<td>11</td>
<td>11.9</td>
<td>31</td>
</tr>
<tr>
<td>≥ 60</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1.0</td>
<td>7</td>
</tr>
<tr>
<td>Not given</td>
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<td>0</td>
<td>5</td>
<td>2.9</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>59</td>
<td>171</td>
<td>100.0</td>
<td>277</td>
</tr>
<tr>
<td>Education:</td>
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<td></td>
</tr>
<tr>
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<td>5</td>
<td>1</td>
<td>0.5</td>
<td>12</td>
</tr>
<tr>
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<td>11</td>
<td>0</td>
<td>0.0</td>
<td>23</td>
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<tr>
<td>Secondary</td>
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<td>17</td>
<td>0</td>
<td>0.0</td>
<td>30</td>
</tr>
<tr>
<td>High</td>
<td>6</td>
<td>19</td>
<td>1</td>
<td>0.5</td>
<td>26</td>
</tr>
<tr>
<td>College</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1.8</td>
<td>7</td>
</tr>
<tr>
<td>University</td>
<td>6</td>
<td>0</td>
<td>163</td>
<td>95.4</td>
<td>169</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>1.8</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>59</td>
<td>171</td>
<td>100.0</td>
<td>277</td>
</tr>
<tr>
<td>Marital Status:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>16</td>
<td>35</td>
<td>107</td>
<td>62.6</td>
<td>158</td>
</tr>
<tr>
<td>Married</td>
<td>21</td>
<td>19</td>
<td>52</td>
<td>30.4</td>
<td>92</td>
</tr>
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<td>Common Law</td>
<td>9</td>
<td>3</td>
<td>4</td>
<td>2.3</td>
<td>16</td>
</tr>
<tr>
<td>Separated/Divorced</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4.7</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>59</td>
<td>171</td>
<td>100.0</td>
<td>277</td>
</tr>
<tr>
<td>Duration of Employment (yrs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>5</td>
<td>21</td>
<td>39</td>
<td>22.8</td>
<td>65</td>
</tr>
<tr>
<td>1-4</td>
<td>16</td>
<td>19</td>
<td>59</td>
<td>34.5</td>
<td>94</td>
</tr>
<tr>
<td>5-9</td>
<td>4</td>
<td>14</td>
<td>34</td>
<td>19.9</td>
<td>52</td>
</tr>
<tr>
<td>10-14</td>
<td>7</td>
<td>2</td>
<td>19</td>
<td>11.1</td>
<td>28</td>
</tr>
<tr>
<td>15-19</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>4.1</td>
<td>13</td>
</tr>
<tr>
<td>≥ 20</td>
<td>10</td>
<td>2</td>
<td>13</td>
<td>7.6</td>
<td>25</td>
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<tr>
<td>Total</td>
<td>47</td>
<td>59</td>
<td>171</td>
<td>100.0</td>
<td>277</td>
</tr>
</tbody>
</table>
As seen in Table 34, over 70% of the respondents had worked at the two hospitals for less than 10 years. There was a significant association between employment group and duration of employment (Chi-Square =29.82; DF =10; p =0.0009). The mean number of months for which respondents were employed was 79.07 with a SD of 94.97 months; the median duration of employment was 40 months and the mode was 72 months.

Of the 277 participants, 215 (77.6%) reported having heard about asbestos while 62 respondents (22.4%) had never heard of asbestos. When the groups of employees were compared with having heard of asbestos or not a significant association was noted (Chi-Square =96.10; DF = 2; p = 0.0001). Logistic regression was also used to compare the three groups of workers with respect to whether or not they had heard about asbestos. Group 3 was the reference group. Group 1 (maintenance workers) was less likely to have heard about asbestos than Group 3 (health professionals) but the association was not significant (OR=0.67; 95% CI=0.24-1.80). Group 2 (male porters, sanitation workers and security guards) was also less likely than Group3 to have heard about asbestos and this association was significant (OR=0.04; 95% CI=0.02-0.09). A significant association was also found between gender and having heard about asbestos (Chi-Square = 21.87; DF = 1; p = 0.0001). Females were more likely to have heard about asbestos than males. There was no association between duration of employment or age of employees and whether employees had heard about asbestos or not.

Further analysis focused on the 215 subjects (77.62% of the overall group of 277) who had heard about asbestos. Seventy seven (77) hospital employees interviewed (35.81%) reported that they were aware of the presence of asbestos at the hospital at
which they worked. This contrasted with 138 or 64.19% who indicated not being aware of asbestos at their hospital. When awareness of asbestos was cross-tabulated with group of employees, a significant association was found (Chi-Square = 45.91; DF = 2; p < 0.0001). Analysis by logistic regression comparing the groups with respect to being aware of the presence of asbestos at the hospital at which they worked showed that maintenance workers were thirteen times more likely than health professionals to be aware of ACM at the hospitals and this association was significant (OR=13.3; 95% CI=5.64-31.23). Porters, security guards, and sanitation workers were also two times more likely than health professionals to be aware of ACM in the hospitals but this association was not significant (OR=2.05; 95% CI=0.74-5.66). Gender was also associated with awareness of asbestos at the hospitals (Chi-Square = 24.71; DF = 1; p =0.0001). Male employees were more likely to be aware of asbestos being present in the hospitals than females. A significant association was also detected between age of employees and awareness of asbestos at hospitals (Chi-Square = 20.56; DF = 5; p <0.001). There was no association between the hospitals and employees’ awareness of asbestos.

Just fewer than 50% of respondents identified insulation as a major use of asbestos in buildings, while almost a third was unaware of the use of asbestos (Table 35). Approximately 21% identified other uses of asbestos inclusive of fire protection and decoration. The reported use of asbestos in buildings was associated with the group category of respondents (Chi-Square = 13.87; DF = 4; p = 0.0077).

Almost 91% of respondents reported that asbestos was harmful to human while 9.35% indicated that asbestos was not harmful. There was no association between the
group of employees and the perceived harm caused by asbestos. Those respondents who felt that asbestos was harmful were asked to indicate the harm that asbestos could cause. Some respondents gave multiple responses and these are summarized in Table 35a. As seen in Table 35b the hospital employees identified several established effects of asbestos in the human body. Individuals from all groups identified specific asbestos-related diseases such as cancer, asbestosis, and mesothelioma. Members of Group 3 identified most of the diseases/conditions reported.

To help validate responses given in Table 35a, respondents were asked if they could name specific diseases caused by asbestos. Of the 212 respondents, 131 (61.79%) answered in the affirmative while 81 (38.21%) answered in the negative. There was a significant association between group category and the responses given (Chi-square = 9.76; DF = 2; p = 0.0076). Further analysis by logistic regression showed that both maintenance workers and porters, security guards, and sanitation workers were less likely than health professionals to name a disease(s) caused by asbestos and in the case of the latter group the association was significant (OR=0.21; 95% CI=0.07-0.62). However, not everyone who said they could name a disease was able to do so. Of the 131 respondents who indicated that they could name a disease, 99 were able to do so. The three most important asbestos-related diseases were named (asbestosis, lung cancer, and mesothelioma). There was a significant association between groups and their ability to name asbestos-related diseases (p=0.0008). Participants in the professional group were more likely to name specific asbestos-related diseases than the other two groups being compared to.
Table 35a

Distribution of Responses to Selected Parameters Relating to Awareness, Use, and Health Effects of Asbestos by Group of Hospital Employees

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th></th>
<th>Group 2</th>
<th></th>
<th>Group 3</th>
<th></th>
<th>p-value</th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
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<td>Awareness of asbestos in hospitals:</td>
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<tr>
<td>Yes</td>
<td>33</td>
<td>80.5</td>
<td>7</td>
<td>38.9</td>
<td>37</td>
<td>23.7</td>
<td>&lt;0.0001</td>
<td>77</td>
<td>35.8</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>19.5</td>
<td>11</td>
<td>61.1</td>
<td>119</td>
<td>63.3</td>
<td></td>
<td>138</td>
<td>64.2</td>
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<tr>
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<td>100.0</td>
<td>18</td>
<td>100.0</td>
<td>156</td>
<td>100.0</td>
<td></td>
<td>215</td>
<td>100.0</td>
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<tr>
<td>Use of asbestos in buildings:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td>26</td>
<td>63.4</td>
<td>5</td>
<td>27.8</td>
<td>73</td>
<td>47.4</td>
<td>0.0077</td>
<td>104</td>
<td>48.8</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>14.6</td>
<td>9</td>
<td>50.0</td>
<td>29</td>
<td>18.8</td>
<td></td>
<td>44</td>
<td>20.7</td>
</tr>
<tr>
<td>Don’t know</td>
<td>9</td>
<td>22.0</td>
<td>4</td>
<td>22.2</td>
<td>52</td>
<td>33.8</td>
<td></td>
<td>65</td>
<td>30.5</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>100.0</td>
<td>18</td>
<td>100.0</td>
<td>154</td>
<td>100.0</td>
<td></td>
<td>213</td>
<td>100.0</td>
</tr>
<tr>
<td>Asbestos is harmful to human health:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>34</td>
<td>82.9</td>
<td>15</td>
<td>83.3</td>
<td>145</td>
<td>93.5</td>
<td>0.0620</td>
<td>194</td>
<td>90.6</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>17.1</td>
<td>3</td>
<td>16.7</td>
<td>10</td>
<td>6.5</td>
<td></td>
<td>20</td>
<td>9.4</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>100.0</td>
<td>18</td>
<td>100.0</td>
<td>155</td>
<td>100.0</td>
<td></td>
<td>214</td>
<td>100.0</td>
</tr>
<tr>
<td>Can you name a disease caused by asbestos?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>25</td>
<td>62.5</td>
<td>5</td>
<td>27.8</td>
<td>101</td>
<td>65.6</td>
<td>0.0076</td>
<td>131</td>
<td>61.8</td>
</tr>
<tr>
<td>No</td>
<td>15</td>
<td>37.5</td>
<td>13</td>
<td>62.2</td>
<td>53</td>
<td>34.4</td>
<td></td>
<td>81</td>
<td>38.2</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>100.0</td>
<td>18</td>
<td>100.0</td>
<td>154</td>
<td>100.0</td>
<td></td>
<td>212</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 35b

*Distribution of Responses to Selected Parameters Relating to, Health Effects, and Route of Exposure to Asbestos by Group of Hospital Employees*

<table>
<thead>
<tr>
<th>Health Effects of Asbestos:</th>
<th>Group 1 No.</th>
<th>%</th>
<th>Group 2 No.</th>
<th>%</th>
<th>Group 3 No.</th>
<th>%</th>
<th>p-value</th>
<th>Total No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affect Respiratory System/ Lungs</td>
<td>6</td>
<td>14.6</td>
<td>2</td>
<td>11.1</td>
<td>44</td>
<td>28.2</td>
<td>0.0008</td>
<td>52</td>
<td>24.1</td>
</tr>
<tr>
<td>Lung Cancer</td>
<td>10</td>
<td>24.4</td>
<td>2</td>
<td>11.1</td>
<td>54</td>
<td>34.6</td>
<td>66</td>
<td>30.6</td>
<td></td>
</tr>
<tr>
<td>Mesothe-lioma/ Asbestosis</td>
<td>6</td>
<td>14.6</td>
<td>2</td>
<td>11.1</td>
<td>15</td>
<td>9.6</td>
<td>23</td>
<td>10.7</td>
<td></td>
</tr>
<tr>
<td>Harm but No specific Disease</td>
<td>1</td>
<td>2.4</td>
<td>0</td>
<td>0.0</td>
<td>10</td>
<td>6.4</td>
<td>11</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>7.3</td>
<td>5</td>
<td>27.8</td>
<td>6</td>
<td>3.8</td>
<td>14</td>
<td>6.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Route of exposure:</th>
<th>Group 1 No.</th>
<th>%</th>
<th>Group 2 No.</th>
<th>%</th>
<th>Group 3 No.</th>
<th>%</th>
<th>p-value</th>
<th>Total No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalation</td>
<td>30</td>
<td>73.2</td>
<td>11</td>
<td>61.1</td>
<td>138</td>
<td>90.1</td>
<td>0.0002</td>
<td>179</td>
<td>84.4</td>
</tr>
<tr>
<td>Skin absorption</td>
<td>1</td>
<td>2.4</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>0.6</td>
<td>2</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>2.4</td>
<td>4</td>
<td>22.2</td>
<td>5</td>
<td>3.3</td>
<td>10</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>9</td>
<td>22.0</td>
<td>3</td>
<td>16.7</td>
<td>9</td>
<td>5.9</td>
<td>21</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td><strong>41</strong></td>
<td><strong>100.0</strong></td>
<td><strong>18</strong></td>
<td><strong>100.0</strong></td>
<td><strong>153</strong></td>
<td><strong>100.0</strong></td>
<td><strong>212</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>
Of the 212 employees that responded to the question which sought to establish if they knew the major route of human asbestos exposure, 179 (84.43%) correctly identified the major route of human exposure as inhalation. Approximately 10% reported that they did not know the major route of exposure while 2 (0.94%) said the major route was ingestion or absorption through the skin (Table 35b). The ability of participants to enumerate the major route of human exposure to asbestos was significantly associated with group of employees. Group 3 (professionals) were more likely than other groups to name the major route of exposure (p=0.0002).

With respect to the type of protection that should be worn by workers who are exposed to asbestos on the job, several responses were proffered by the workers (N=213). These included respirators (62 or 29.11%); protective clothing (68 or 31.92%); and don’t know (22 or 10.32%).

Respondents were asked to indicate whether each statement in Table 36 was true or false. Six of the statements are true and five are false as indicated in Table 36. Overall, correct responses to the statements were given by 41.42% to 98.54% of respondents with the mean being 77.80 and the median, 82.73%. In all but one case, approximately 60% or more of the participants answered correctly to each statement. The lone exception was in relation to statement “I” which sought to establish whether or not participants knew the rationale for asbestos warning signs in work areas. Less than half (41.42%) of the participants gave the correct answer. For most of the statements there was no association between knowledge of asbestos and group of hospital employees.
Table 36

Distribution of Percent Correct Responses by three Groups of Respondents (Group 1= Maintenance workers; Group 2= Porters, Security guards, and Sanitation workers; Group 3= Professional health workers) to Knowledge Questions on Asbestos

<table>
<thead>
<tr>
<th>Statements (True/False)</th>
<th>Group 1* Correct response (%)</th>
<th>Group 2* Correct response (%)</th>
<th>Group 3* Correct response (%)</th>
<th>Total Correct Response (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Asbestos is a mineral made up of tiny fibers (N=191) (True)</td>
<td>94.7</td>
<td>72.2</td>
<td>80.7</td>
<td>82.7</td>
<td>0.0609</td>
</tr>
<tr>
<td>B. White asbestos is the most commonly used form of the mineral (N=147) (True)</td>
<td>84.9</td>
<td>50.0</td>
<td>74.5</td>
<td>74.2</td>
<td>0.0326 †</td>
</tr>
<tr>
<td>C. A smoker who is exposed to asbestos is at increased risk of developing lung cancer (N=205) (True)</td>
<td>94.6</td>
<td>94.4</td>
<td>96.0</td>
<td>95.6</td>
<td>0.9033</td>
</tr>
<tr>
<td>D. The use of asbestos is banned in Jamaica (N=205) (False)</td>
<td>45.9</td>
<td>75.0</td>
<td>61.7</td>
<td>59.5</td>
<td>0.0977</td>
</tr>
<tr>
<td>E. Trying to remove asbestos from a building can sometimes create a bigger problem than existed before (N=199) (True)</td>
<td>89.5</td>
<td>76.5</td>
<td>84.0</td>
<td>84.4</td>
<td>0.4557</td>
</tr>
<tr>
<td>F. Human risk of asbestos-related disease depends on exposure (N=206) (True)</td>
<td>97.4</td>
<td>100.0</td>
<td>98.7</td>
<td>98.5</td>
<td>0.7234</td>
</tr>
<tr>
<td>G. Asbestos-related diseases show several warning signs before they become dangerous (N=187) (False)</td>
<td>41.2</td>
<td>50.0</td>
<td>67.9</td>
<td>61.5</td>
<td>0.0101 †</td>
</tr>
<tr>
<td>H. You have to work directly with asbestos to be at risk from exposure to airborne fibers (N=204) (False)</td>
<td>61.5</td>
<td>76.5</td>
<td>87.2</td>
<td>81.4</td>
<td>0.0011 †</td>
</tr>
<tr>
<td>I. Warning signs are placed at all entrances to asbestos work areas to prevent accidental or unauthorized entry (N=198) (True)</td>
<td>52.5</td>
<td>31.3</td>
<td>39.4</td>
<td>41.4</td>
<td>0.2304</td>
</tr>
<tr>
<td>J. If you find any material that you suspect may contain asbestos, it is not necessary to inform your supervisor (N=204) (False)</td>
<td>76.3</td>
<td>83.3</td>
<td>94.7</td>
<td>86.7</td>
<td>0.0806</td>
</tr>
<tr>
<td>K. Asbestos waste can be thrown away with regular garbage (N=207) (False)</td>
<td>74.4</td>
<td>83.3</td>
<td>94.7</td>
<td>89.9</td>
<td>0.0006 †</td>
</tr>
</tbody>
</table>
For three of the statements (“White asbestos is the most commonly used form of the mineral”; “You have to work directly with asbestos to be at risk from exposure to airborne fibers”; “Asbestos-related diseases show several warning signs before they become dangerous”; “Asbestos can be thrown away with regular garbage”), knowledge was associated with the group of hospital employees with the p-values being 0.0326, 0.0011, 0.0101 and 0.0006, respectfully.

When the responses to the statements on knowledge about asbestos were cross-tabulated with hospital, only one significant association was found. Respondents at hospital A were more likely not to report suspected ACM to their supervisors than their counterparts at hospital R (p=0.0375)

The responses proffered to the statements on asbestos by hospital employees in Table 37 reflect a generally positive attitude towards the mineral and its management. Over 90% of respondents felt that appropriate warning signs should be posted in hospitals with asbestos; that hospitals with asbestos should have a policy on asbestos and control program in place; that workers exposed to asbestos should undergo periodic medical examination; that hospital employees should be educated about asbestos; and almost everyone wanted to learn more about asbestos. For most respondents (55.34%) the presence of asbestos in hospital buildings would not deter them from working at the hospital. Almost 70% of respondents felt that asbestos in any form or condition found in a hospital should be immediately removed.

The responses to statements reflecting possible attitude to asbestos were combined as follows: Strongly agree/Agree = Yes or 1; Strongly disagree/Disagree = No
or 2; Undecided = 3. When this data was analyzed by group category three significant associations were found (Table 37). Maintenance workers were more likely to agree that “Since asbestos-related diseases take many years to develop, workers should not be concerned about these diseases” than groups 2 and 3 (p < 0.0001). Professionals were more likely to undecided about the statement “The presence of asbestos in a building does not automatically result in worker exposure if the asbestos is managed properly” than maintenance workers and the comparison group (p = 0.008). Professional employees were more likely to agree with the statement that “I would not work at a hospital if I knew that asbestos was present in the building” than the other two groups (p = 0.0001).
Table 37

Distribution of Respondents by Responses to Statements reflecting possible Attitudes towards Asbestos

<table>
<thead>
<tr>
<th>STATEMENTS</th>
<th>SA (%)</th>
<th>A (%)</th>
<th>U (%)</th>
<th>D (%)</th>
<th>SD (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since asbestos-related diseases take many years to develop, workers should not be concerned about these diseases (N=208)</td>
<td>2.88</td>
<td>2.88</td>
<td>1.44</td>
<td>33.17</td>
<td>59.62</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>The presence of asbestos in a building does not automatically result in worker exposure if the asbestos is managed properly (N=207)</td>
<td>6.28</td>
<td>56.52</td>
<td>14.49</td>
<td>18.36</td>
<td>4.35</td>
<td>0.0080</td>
</tr>
<tr>
<td>Asbestos in any form or condition found in a building should be removed immediately (N=207)</td>
<td>23.19</td>
<td>46.38</td>
<td>14.98</td>
<td>12.56</td>
<td>2.42</td>
<td>NS*</td>
</tr>
<tr>
<td>Workers without adequate PPE can work with asbestos without being harmed (N=207)</td>
<td>0.97</td>
<td>5.80</td>
<td>4.35</td>
<td>46.86</td>
<td>42.03</td>
<td>NS</td>
</tr>
<tr>
<td>Appropriate warning signs should be put up in areas of the hospital where asbestos is located (N=206)</td>
<td>49.03</td>
<td>45.15</td>
<td>3.88</td>
<td>1.46</td>
<td>0.49</td>
<td>NS</td>
</tr>
<tr>
<td>Every hospital where asbestos is present should have an asbestos policy and control program in place (N=206)</td>
<td>47.09</td>
<td>50.00</td>
<td>1.94</td>
<td>0.49</td>
<td>0.49</td>
<td>NS</td>
</tr>
<tr>
<td>There should be periodic medical examination of workers who may be exposed to asbestos fibers (N=207)</td>
<td>52.66</td>
<td>44.93</td>
<td>1.93</td>
<td>-</td>
<td>0.48</td>
<td>NS</td>
</tr>
<tr>
<td>Workers should not be punished if they refuse to wear PPE when working with asbestos (N=207)</td>
<td>3.86</td>
<td>19.81</td>
<td>13.53</td>
<td>44.44</td>
<td>18.36</td>
<td>NS</td>
</tr>
<tr>
<td>I would not work at a hospital if I knew that asbestos was present in the building (N=206)</td>
<td>4.85</td>
<td>11.17</td>
<td>28.64</td>
<td>51.46</td>
<td>3.88</td>
<td>0.0001</td>
</tr>
<tr>
<td>Hospital workers in Jamaica should be educated about asbestos (N=206)</td>
<td>57.28</td>
<td>41.75</td>
<td>0.49</td>
<td>-</td>
<td>0.49</td>
<td>NS</td>
</tr>
<tr>
<td>I want to know more about asbestos (N=207)</td>
<td>49.28</td>
<td>49.76</td>
<td>-</td>
<td>0.48</td>
<td>0.48</td>
<td>NS</td>
</tr>
<tr>
<td>I would not wear PPE for asbestos if required to (N=207)</td>
<td>0.97</td>
<td>2.90</td>
<td>1.45</td>
<td>54.59</td>
<td>40.10</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS= Not Significant
Maintenance Workers

Table 38

*Frequency Distribution of PPE provided, Practices, and Training of Maintenance Workers in Relation to Asbestos*

<table>
<thead>
<tr>
<th>Parameters relating to asbestos</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heard about asbestos:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>41</td>
<td>87.23</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>12.77</td>
</tr>
<tr>
<td>Disturb suspected ACM on the job:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23</td>
<td>56.09</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>43.91</td>
</tr>
<tr>
<td>Provided with PPE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>24</td>
<td>58.54</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>41.46</td>
</tr>
<tr>
<td>PPE provided:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coverall/Gowns/Protective clothing</td>
<td>14</td>
<td>58.33</td>
</tr>
<tr>
<td>Respirator</td>
<td>8</td>
<td>33.33</td>
</tr>
<tr>
<td>Dust mask</td>
<td>5</td>
<td>20.83</td>
</tr>
<tr>
<td>Boots</td>
<td>4</td>
<td>16.67</td>
</tr>
<tr>
<td>Hard hat</td>
<td>3</td>
<td>12.50</td>
</tr>
<tr>
<td>PPE usually worn on the job:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>24</td>
<td>58.54</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>41.46</td>
</tr>
<tr>
<td>“Street clothing” worn on job sometimes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>29.27</td>
</tr>
<tr>
<td>No</td>
<td>29</td>
<td>70.73</td>
</tr>
<tr>
<td>Ever participated in removal of suspected ACM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>7</td>
<td>17.07</td>
</tr>
<tr>
<td>No</td>
<td>34</td>
<td>82.93</td>
</tr>
<tr>
<td>Received training on asbestos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4</td>
<td>9.76</td>
</tr>
<tr>
<td>No</td>
<td>37</td>
<td>90.24</td>
</tr>
</tbody>
</table>
Six (12.77%) of the maintenance workers interviewed had never heard of asbestos. Approximately 56% of maintenance workers who had heard of asbestos reported having had to disturb materials during routine work that they suspected contained ACM. However these workers were not very specific in terms of the frequency with which suspected ACM was disturbed during routine work at the hospitals. Responses such as “sometimes”, “not very often”, and “very often” were given. Twenty four (58.54%) of the maintenance workers reported that they were provided with PPE for work while the remainder (41.5%) were not provided with any PPE. The PPE provided for maintenance workers are listed in Table 34. Coverall/Gowns/Protective clothing was the PPE most frequently provided followed by respirator. Twelve (29.3%) maintenance workers reported wearing “street clothing” while performing their job.

Seven of 41 (17.0%) maintenance workers reported having participated in the removal of suspected ACM from hospital buildings while 34 (83.0%) had never participated in any such work. Three buildings were named by maintenance workers as areas from which suspected ACM was removed. These were the maintenance department, boiler room and pathology department. The ceiling, boilers, corridor and steam pipes were named as specific locations from which suspected ACM was removed. It was reported that the suspected ACM removed was collected by municipal waste collector/ certified asbestos waste disposal agency for disposal. The seven maintenance workers reported wearing PPE during the removal of the ACM and the PPE worn included protective clothing and respirator.

With respect to training on asbestos, 4 (9.7%) reported participating in training programs on asbestos while 37 (90.3%) had not benefited from any training on asbestos.
Training was reportedly conducted at each of the two hospitals where the questionnaires were administered, one other hospital and a bank in Kingston over the period 1998-2002. The training received was rated as “good to excellent” at these places.

Focus Group Discussions

Two FGD were held, one at each hospital. At hospital “R” 11 employees who were the heads for various professional and non-professional departments were invited to participate and one individual declined the invitation. Six of the 10 individuals (60.00 %) participated; two sent apologies while nothing was heard from the remaining two prospective participants. At hospital “A” 5 (50.00%) of the 10 invitees participated. Overall, 11 (55.00%) of the 20 individuals who consented, participated. Personal contact and telephone calls were made to remind persons of the date and time of each discussion. The discussions were held in very comfortable air-conditioned conference rooms at the hospitals. The seating arrangement ensured that all participants faced each other. The discussion was guided by a set of questions decided on by the PI. A research assistant took notes and tape-recorded the proceedings at both FGD.

Several themes emerged from the discussions such as general occupational safety and health (OSH) concerns of participants at the hospitals at which they worked, ability of participants to identify and describe ACM, use of asbestos, asbestos exposure and health effects, asbestos ban, PPE for asbestos exposure, disposal of ACM, asbestos policy for hospitals, control program for asbestos at hospitals, and post FGD actions that would be taken by participants. Details relating to each theme are provided below.
Occupational Safety and Health (OSH) Concerns of Participants

At the start of each focus group discussion, all participants were asked to list the major OSH problems existing at each hospital. They were told that they could mention problems specific to their departments or general OSH problems at the hospitals. The problems mentioned were:

- Inadequate facilities for the disposal of hazardous chemicals
- Emissions from incinerator on hospital compound
- Inadequate facilities for the disposal of sharps
- Poor maintenance of hospital buildings
- Exposure to asbestos
- Exposed electrical wiring
- Use of formaldehyde
- Ineffective PPE for work with formaldehyde
- Exposure to communicable diseases
- Lack of knowledge on how to handle mercury spills and disposal of mercury
- Frequent water lock-offs and leaking roofs

Most of the OSH concerns of participants were unrelated to asbestos. The exposure to asbestos at hospitals was mentioned by three participants, two from hospital “R” and one from hospital “A”.

Awareness of Asbestos at Hospital/Description of ACM

When asked if they were aware of asbestos being present at the hospital at which they worked, four participants indicated they were aware while the remaining seven were
unaware. Participants from both hospitals were aware that ACM was present in the buildings. All participants indicated that they would not be able to definitively identify ACM if it was present in their work area. Participants were asked if they could give a general description of any building material that they would suspect to contain ACM. They described ACM as “white”, “fibrous”, “flaky”, and “looks like ceiling material”. Most participants could not offer any description of ACM. The descriptions given for ACM by participants were general and vague and could be descriptive of other building materials.

*Use of Asbestos*

Most participants were unaware of the use of asbestos in building construction. The participants mentioned only one use of asbestos and that was insulation.

*Exposure Routes/Health Effects of Asbestos*

Most of the participants were able to give at least one route of exposure for asbestos. Exposure routes mentioned were inhalation, ingestion, and dermal absorption. More than half of the participants named inhalation as the most common route of exposure to asbestos. When asked if they thought that asbestos was present elsewhere in the country, all answered in the affirmative. None of the participants knew the PEL for asbestos. Most participants were able to name one or more of the established health effects of asbestos. Health effects alluded to by participants were lung cancer, asbestosis, mesothelioma and “respiratory illness”.
Asbestos Ban in Jamaica

The question on whether asbestos was banned in Jamaica elicited varying responses. Three participants seemed quite sure that asbestos was banned; two were emphatic in stating that there was no asbestos ban on in Jamaica, while the remaining six were unsure. This question was hotly debated and in the end all agreed that if asbestos was not banned then the government should step in and institute a ban. The fact is that the use of asbestos is not banned in Jamaica; only its importation.

PPE for Asbestos

All participants agreed that given the hazardous nature of asbestos, workers who may be exposed should be provided with appropriate PPE. Some seemed quite unsure as to exactly what PPE was recommended. Some participants stated that respirators should be provided but none knew exactly what type of respirator was recommended. A few were convinced that a respirator was needed that would filter out the tiny asbestos particles. A few recommended a face mask but could not differentiate between a face mask and a respirator. Another form of PPE recommended was a coverall.

All participants were unanimous in their expression that some form of penalty should be instituted against workers who fail to wear the PPE provided by management. Some felt that some workers have to be protected against themselves. One participant recommended a system in which if a worker felt that he has a right not to wear PPE on the job then he should be required to sign a document waiving his rights to claim compensation in the event he developed an asbestos-related disease. All participants felt that training on asbestos should be provided for workers who may be exposed.
Disposal of ACM

All participants felt that asbestos waste should not be disposed of with or in the same manner as domestic/municipal solid waste. Participants felt that no burning of ACM should take place. They recommended a system of disposal managed by persons with the relevant training and expertise and one in which the ACM was containerized and buried at a specially selected site for that purpose.

Control Program

All participants felt that a control program was needed at every hospital where asbestos was present. When asked to suggest the components of such a control program the following responses were proffered:

- Provision of PPE
- Education program- All participants felt that ongoing education programs were needed to educate workers about the risks posed by asbestos and the need for workers to protect themselves. Educational programs should cover what asbestos was, routes of exposure, asbestos-related diseases, signs and symptoms of diseases, use of PPE, and prevention and control measures. Participants agreed that appropriate warning signs should be placed in all areas of the hospital where ACM was present.
- Pre-employment medical examination of workers
- On the job periodic medical examination
- Environmental sampling (air and dust)
- Compensation for workers who develop asbestos-related disease on the job.
Asbestos Policy

All participants agreed that an asbestos policy was needed in hospitals with asbestos. When asked to elaborate on what such a policy should cover, the following suggestions were offered: Education/training of employees about asbestos, PPE for asbestos, signage in areas with ACM, risk assessment in hospitals with asbestos, periodic assessment of the environment and mitigation measures for asbestos.

Recommendations Made by Participants

Participants made the following recommendations to deal with the current situation at the hospitals:

- Removal of ACM from hospitals
- Education of workers
- Protection of workers
- Use of alternatives to asbestos
- Sampling and testing of the environment
- Encapsulation of ACM

Actions Participants Plan to Take After FGD

When asked what immediate actions they would take following the FGD, the participants said among other things they would learn more about asbestos; find out if their offices were near to areas with ACM or contained any ACM; and the level of exposure. All participants wanted to know more about asbestos and its health effects. When quizzed whether the FGD discussion had made them more fearful of asbestos, they
said “no” and conceded that the sessions had made them more sensitized and aware about asbestos and its potential health hazards.
CHAPTER 4
DISCUSSION

This study was approved by the IRB at UAB and the Ethics Committees of the JMOH and the UWI/UHWI in Jamaica. In the case of the UAB IRB there was continuous monitoring of the project as the PI had to submit progress reports and have his protocols renewed on an annual basis. To obtain approval for the initial protocol and subsequently, annual renewals the PI had to take and pass the online course “Collaborative IRB Training Initiative (CITI) in the protection of human subjects in research”.

This study utilized several approaches to garner relevant data. There was a preparatory phase in which the PI became certified to conduct air sampling an analysis using PCM. Field and laboratory personnel at the JMOH and other agencies were trained to conduct building inspections for asbestos and to collect and analyze bulk and air samples utilizing PLM and PCM, respectively. A survey of 30 Jamaican hospitals was conducted and bulk samples were collected and analyzed by PLM resulting in the identification of those hospitals with ACM. Personal air and area air samples were subsequently collected utilizing approved protocols in two of the largest hospitals with ACM utilizing three groups of hospital employees selected randomly. Fibers meeting the criteria for asbestos were found in some air samples. A subset of samples containing fibers was subjected to TEM to confirm if the fibers were asbestos. Two hundred and seventy seven hospital employees stratified by work performed responded to an
interviewer administered questionnaire. In addition two focus group discussions with HODs and supervisors as participants were held at the two hospitals.

Strengths of the Study

This was the first study of its kind to be conducted in Jamaican hospitals where bulk samples and air samples were collected and analyzed by an accredited laboratory to determine the presence of ACM and airborne asbestos fibers thus enabling us to determine if hospital employees were at risk from airborne asbestos exposure. This study is an example of a truly collaborative effort between the SCGH, the DSCOSH and the Department of Environmental Health Services at UAB along with the JMOH, the RHAs, and the Department of Community Health and Psychiatry at the UWI in Jamaica to address an existing health concern in hospitals. The study allowed for the transfer of technology with the training of local personnel to assist the JMOH in managing the asbestos pollution problem in hospitals. This study also provides information which can be used by the JMOH to address concerns about ACM in hospitals in a rational and decisive manner.

Limitations of the Study

One aspect of the training program on PLM analysis did not materialize. The PLMs rented from the Geology/Geography Department at the UWI lacked Central Stop Dispersion Staining Objectives which are indispensable for the identification of specific types of asbestos in bulk samples. This robbed the trainees from benefiting from this vital aspect of PLM analysis of bulk samples. This problem with the microscope was only
discovered at the start of the training and by then it was too late to get replacements from
the US.

The response of the SCGH to the request of the Jamaican MOH was meant to
build capacity in field and laboratory personnel to undertake building inspections, collect
bulk and air samples, and analyze the samples to determine the presence of ACM and the
asbestos fibers, respectively. The failure of the JMOH to procure laboratory equipment
such as PCMs to enable trained personnel to participate in sample analyses prevented the
inclusion of more hospitals with ACM in phase of the project dealing with analysis of air
samples.

One-fifth of respondents had never heard of asbestos and so their interviews had
to be terminated at that point. This led to a reduction in the number of completed
questionnaires available for analysis thus contributing to some degree of information
bias.

Impact of Asbestos Training Program

The training program on asbestos hazard identification/train the trainer impacted
positively on participants’ knowledge. This is evidenced by the mean score on the pre-
test (56%) increasing to 78.5% after participants were exposed to the lectures and field
visit. This represented an increase of 40% in knowledge about asbestos. Results of the
pre/post-test clearly indicate that the participants had some knowledge about asbestos
prior to the training but that the training was effective in increasing the knowledge of
course participants. The performance of participants on the post-test for the course on
air/bulk sampling and analysis was commendable given the fact that none of the
laboratory personnel had ever been exposed to PLM and PCM analytical methods. It was envisaged that the lab personnel would undertake preliminary analysis of air and bulk samples collected but this did not materialize. Unfortunately, the trained laboratory personnel have not been able to practice their new skills and it can be expected that with the passage of time much of what was learnt may be forgotten. The JMOH should be implored to procure the laboratory equipment that will enable the workers trained to be able to play an ongoing role in asbestos abatement and control. There is no laboratory in the country which is equipped or accredited to undertake analysis of asbestos bulk and air samples on a commercial scale. The JMOH NPHL has the potential to be the first laboratory in Jamaica with trained personnel to conduct the analyses alluded to. It is a fact that asbestos abatement in other buildings takes place in the country. Standard requirements for asbestos abatement include pre- and post-abatement asbestos air sampling. It could not be ascertained if air sampling was always a feature of abatement projects and certainly if it was, the analysis of these samples would take place abroad at great costs. The JMOH NPHL could therefore become the site at which local air samples are analyzed thus reducing cost to contractors and contributing revenue to the JMOH. Over time the laboratory could apply for accreditation from a reputable international agency/institution.

The participants were pleased with the training programs as indicated by the favorable rating accorded them. They reported their likes and dislikes about the program and these should be taken into consideration if future training programs are contemplated. A direct expenditure of US$15,000 was spent by the SCGH on the training program. However, when one considers the contributions of the DSCOSH and the Departments of
Environmental Health Sciences and Community Health and Psychiatry at UAB and UWI respectively, the true cost was nearer to US$20,000 (approximately J$1.3M). In the future any request for training or other assistance to the SCGH should be carefully evaluated and guarantees put in place to ensure that in-country partners meet their agreed obligations.

**Hospital Asbestos Bulk Sampling**

The analysis of bulk samples indicated potential risk of asbestos exposure in Jamaican hospitals. Sixteen (16) hospitals (61.5%) were found to have ACM. The three principal types of asbestos were found namely chrysotile, amosite, and crocidolite. Chrysotile was the most commonly found type at the hospitals and this was not surprising given the fact this type of asbestos is found in more than 90% of ACM found in buildings in the US and elsewhere. In a study by Kahwa et al (1999) asbestos was found in several of the Jamaican hospitals included in this study. A report on the findings was submitted to the JMOH. It therefore means that the JMOH knew of asbestos being present in some of the hospitals since 1999 but did not undertake any investigations. What makes the matter untenable is that in most hospitals where asbestos was found the asbestos was used as TSI for boilers and steam pipes which have long being abandoned and derelict serving no useful purpose whatsoever. In these cases, there can be no justification for exposing workers to this potential hazard. This situation requires a proactive response from the JMOH to have immediate removal and safe disposal of the ACM on structures which have long become obsolete. In one case ACM was found on boilers in an abandoned boiler house on one hospital compound and on another
compound old boilers with ACM were abandoned in the yard. These two situations have implications for community exposure if asbestos fibers were to become airborne.

Most of the ACM was found at two of the largest hospitals in boiler rooms and on steam pipes which were functional. In these cases the asbestos if not already disintegrated was serving a useful purpose but given the general poor condition of the ACM the same proactive approach by the JMOH recommended should be followed to prevent potential future exposures. The storage of ACM in bags in the boiler room of one the hospitals for extended periods should be discouraged. Where ACM used for TSI begins to fall in blocks from insulated surfaces then the ACM should be stored in ceiled containers and removed from the facility on a timely basis to a designated hazardous waste disposal site.

At the other hospital, encapsulation of the ACM on sections of steam pipes along a major corridor where ACM was found took place a few months after the study began. We do not know if this was as a direct result of the study being done or if this work was planned in advance of the start up date of the study. While this work was welcomed it was not completed. The JMOH and hospital administrators should be reminded that suitable alternatives to asbestos are available for TSI.

Hospital Air Sampling

This is the first study of its kind to be conducted in Jamaica to determine if employees were exposed to airborne asbestos. Both personal air samples and area samples were collected. Air samples were analyzed initially by PCM. Twenty four or 15% of the air samples tested positive for fibers which fit the criteria for asbestos. The fiber concentrations found were in the range 0.002-0.013 f/cc which was well below
OSHA’s Action Level of 0.01f/cc (in all but one case) and PEL of 0.1f/cc. In HHE performed in hospitals by teams from NIOSH in Barbados and the US in response to requests to investigate possible cases of asbestos exposure the asbestos fiber concentrations were in some cases similar to those of the fiber concentrations found in this study while in other cases OSHA’s Action Level and PEL were exceeded. Unlike this study, it should be noted that in the HHE carried out by NIOSH teams there was some activities going on that could disturb the ACM resulting in fiber release and the potential for workers to be exposed. Yet in most cases the asbestos fiber concentrations were below OSHA’s PEL. In other investigations reported by NIOSH (Tables 10 and 11) where there was building maintenance and asbestos abatement activities in progress results of air sampling analysis revealed that the asbestos fiber concentrations exceeded the OSHA PEL. The reports did not state if any hospital buildings were involved. In the present study there were no activities occurring during data collection that resulted in deliberate disturbance of ACM and evidently even though the ACM found in the hospitals was in very poor condition the disintegration process appeared to be slow and sporadic. This coupled with the excellent natural ventilation in areas where ACM was present could probably explain why fiber concentrations were below detectable limits in most cases. The estimated TWA for the personal air samples was computed and again all concentrations were low or below the LOD. In order to compare the exposure risk of the different groups of workers a job airborne fiber exposure table was developed using half of the concentrations that were below the LOD to represent exposure concentration of those employees (Table 27). For maintenance workers the mean fiber concentration was 0.0018f/cc; for non-maintenance (Group 2) workers, 0.0017f/cc; and professionals
(Group 3), 0.0018 f/cc. Medical technologists had the highest mean fiber concentration (0.0027 f/cc) followed by porters (0.0023 f/cc). Medical technologists were mainly based in their labs and these labs were air-conditioned and at the furthest point from where the ACM was in the case of one hospital.

Only one area sample showed fiber counts above the LOD but which was still very low. The data from these samples can be used on a relative basis to monitor work conditions on a daily basis. A radical increase in area concentrations would signal that work practices needed to be adjusted. While it is difficult to use area samples to measure employee exposure, they are useful in approximating employee exposure especially in work areas where employees may not remain for long to get an 8-hour sample as in the case of hospitals but where exposure may be high. Area sampling has the advantage of using high sampling flow rates for shorter periods which was what was utilized in most cases in this study.

Historically, most asbestos-related diseases are associated with working with ACM, but there have been many documented cases where asbestos exposure and subsequent development of health effects were not due to working directly with asbestos but due to the presence of ACM in the building where their work was performed. It was prudent to ascertain if current fiber exposure in hospitals differed by job category. On the basis of the foregoing, if we assumed the fibers detected in some samples were asbestos then we would conclude that worker exposure was very low or virtually non-existent in most cases. Since this was a pioneering study we wanted to be absolutely sure that airborne asbestos was present in the two large hospitals studied. To do so approximately 50% of samples with fiber counts above the LOD from the analysis by PCM were
subjected to TEM analysis; this is a confirmatory test for asbestos fibers. TEM analysis confirmed that the fibers were not asbestos. So despite the confirmed presence of ACM in the hospitals evidently undergoing disintegration personal air sampling showed that workers were not exposed to airborne asbestos, but the potential remains for future exposure from deterioration of ACM and exposure to other types of fibers exists.

The fibers found in the samples therefore came from other building/insulation materials used. Results from the bulk samples analysis revealed that apart from ACM, other materials were present inclusive of fiberglass, mineral wool, and other synthetic fibers. Some of these materials belong to a group called man-made vitreous mineral fibers (MMVF). They are synthetic, vitreous silicate fibers widely used as a substitute for asbestos as insulation and construction materials. It is postulated that MMVFs produce biological activity in both animal and human lung tissue (Osinubi, Gochfeld, and Kipen, 2000). MMVFs like other fibers may be deposited in the respiratory tract by impaction, sedimentation, interception, and electrostatic precipitation (WHO, 2000). While the health effects of asbestos fibers have been clearly established this is not the case with MMVFs. According to Roggli (1994), the fibers of asbestos tend to split longitudinally, resulting in thinner and longer respirable fibers with greater potency for pathogenicity, whereas the MMVFs tend to split transversely as they are more brittle resulting in shorter fibers of reduced aspect ratio. Long asbestos fibers are cleared less rapidly than short fibers (Morgan & Holmes, 1986). It is thought that MMVFs differ from asbestos fibers in that a smaller proportion of them are respirable and those fibers that are inhaled are less durable than asbestos fibers (Osinubi et al, 2000). Another difference is that unlike asbestos fibers MMVFs have varying degrees of solubility (WHO, 2000). It is postulated
that MMVF activate ROS production resulting in DNA damage, cell injury and ultimately cell death. According to Lockey and Weise (1998) the solubility of MMVF in animal lung tissue indicates that glass fibers are more soluble than rock wool and that refractory ceramic fibers (RCFs) are the most durable MMVF. There is available epidemiologic evidence that MMVF cause malignancy (Osinubi et al, 2000). One of the most convincing studies was a cohort study of mortality of about 25,000 MMVF workers in seven European countries conducted by IARC (Simonata, Fletcher, Cherrie, Anderson, and Bertazzi, 1987). This study found an increase in lung cancer mortality risk (SMR=128) in certain categories of workers. IARC has categorized insulation wools as Class 2b (possibly carcinogenic to humans) and glass fibers as Class 3 (undeterminate as to whether they are carcinogenic) (IARC, 1998). Despite the uncertainties there is convincing evidence that some MMVF, especially RCFs, are capable inducing lung tumors in animals. However, according to Osinubi et al (2000), “at the present time, significant human carcinogenic risk from any inhaled MMVF is neither established nor refuted”. While the OSHA PEL of 0.1 f/cc has been established for asbestos the US standards for RCFs vary. The OSHA standard for RCF is 0.5 f/cc; for the ACGIH it is 0.2 f/cc; ATSDR, 0.03 f/cc; and for NIOSH, the standard is 0.05 f/cc (NIOSH, 2006). On the international scene the standard for RCF in Canada, the Netherlands, and the United Kingdom is 0.5 f/cc, 1 f/cc, and 1 f/cc, respectively (NIOSH, 2006).

While MMVF have been found in personal air samples taken from hospital employees in this study the risk cannot be quantified potential health effects predicted. The concentrations were very small unlike the studies that found associations between
MMVF workers and disease. However the health authorities need to be alerted to the potential for MMVF workers to cause disease among exposed persons.

Asbestos Policy

Despite the widespread presence of asbestos in sections of Jamaican hospitals there is no national asbestos policy or hospital asbestos policy. NEPA, the lead government agency with responsibilities for the environment published a “Proposed Asbestos Management Policy for Jamaica” in April 2002. This document was prepared by the Asbestos Task Force established by NEPA. NEPA disclosed that the proposed policy was established “out of the concern for the extent of the asbestos contamination in Jamaica based on the increase in the number of Environmental Permit applications received for asbestos abatement programs” (NEPA, 2002).

NEPA was contacted to provide information on the criteria used for processing applications for asbestos abatement programs, the number of permits issued and denied annually and the main reasons for denying such permits. We were referred to the “procedures for handling asbestos” which is adopted from the proposed asbestos management policy and describes the procedures, precautions and practices that must be observed by persons involved in asbestos abatement. Precise answers on the number of permits issued/denied and reasons for denying permits were not provided by NEPA. It is perhaps disconcerting that an important policy document as the one referred has remained a “proposal” 5 years after being developed while at the same time NEPA continues to receive and approve applications for asbestos removal. There is no doubt that much ACM is present in the country and we are not surprised that there is no asbestos policy in any of
the hospitals as there is no national asbestos policy to provide guidance to other agencies. We do not subscribe to the notion that hospitals must necessarily await the promulgation of a national policy to develop their own.

We have noted that despite not finding asbestos fibers in personal air samples, almost all the ACM found in the hospitals was friable and in a poor condition indicative of fiber release and this posed a potential exposure risk for employees. The government, NEPA, and hospital administrations need to be proactive to ensure that the exposure of workers to asbestos fibers does not become a future reality. The reported death of a 47 year old surgeon from mesothelioma who worked at a British hospital where asbestos was present should serve as a timely reminder to the Jamaican health authorities (Dyer, 2000).

Questionnaire data

This is the first study of its kind in Jamaica to interview hospital employees to elicit data on knowledge, attitudes and practices with respect to asbestos and its management. A search of the literature did not identify a similar study done elsewhere. In this study 22.4% (62) of the hospital employees interviewed had never heard of asbestos and nearly 64% of those who had heard of asbestos were not aware of asbestos being present at the hospital at which they were employed. This is not surprising as asbestos is not a topic which is covered a lot in the national media. However, this situation is alarming as all respondents worked at hospitals where asbestos was present. Given the hazardous nature of asbestos and the fact that the health authorities have been aware that asbestos was present in several hospitals then the health authorities have to accept some responsibility for not informing employees about the presence of asbestos in the
hospitals. More importantly hospitals have failed to implement the requisite asbestos management/abatement programs in order to avert potential exposure in the future.

Despite the paucity of public information on asbestos in the country, hospital employees exhibited good knowledge on asbestos, its health effects and management. Professional health workers were the most knowledgeable followed by maintenance workers and the group three comprising porters, security guards and sanitation workers, respectively. Concomitantly, several gaps in knowledge pertinent to asbestos were identified. None of the respondents knew the PEL for asbestos and many failed to name appropriate PPE for asbestos. There seems to be some confusion in the minds of respondents as to the difference between a respirator and a dust mask and very few were able to describe the respirator that should be used a PPE for asbestos. Not surprisingly many workers were provided with only dust masks when in some cases proper respirators for asbestos fibers should have been provided and worn. Gaps in knowledge should be addressed by educational interventions.

Respondents displayed an overall positive attitude towards asbestos and the need for proper management within the hospital environment. This type of attitude will guarantee the cooperation of hospital employees with management’s effort to deal decisively with asbestos pollution in the hospitals. There seems to be a great fear of asbestos by some workers. This was evidenced by the expression of approximately 70% of respondents that asbestos in any form or condition found in the hospitals should be immediately removed. This reflects a certain degree of ignorance on the part of most respondents on how to deal with asbestos in a building. The fact is that the mere presence of asbestos in a building does not warrant its immediate removal. Of far greater
importance is the condition of the asbestos. Certainly if the ACM is friable with signs of degradation indicative of fiber release then maybe the best management option may be to remove the ACM by trained personnel. In some cases encapsulation of the asbestos may be an option where the asbestos is serving a useful purpose.

**Maintenance Workers**

Most maintenance workers at both hospitals were aware of asbestos being present in certain areas of the hospitals and a few openly voiced their displeasure about the matter as they felt the hospital management was not doing enough to address the matter. One worker explained that “if it were doctors and nurses having to work where asbestos was located then the matter would have been addressed”. The provision and wearing of PPE was not universal among maintenance workers. Not everyone reported receiving PPE and not every one of those who were supplied reported wearing PPE all the time on the job. What was more disturbing was the inappropriateness of the PPE that was worn in some cases. Workers were observed wearing dust masks in areas where respirators should be worn in the event that asbestos fibers were airborne and they were apparently oblivious to the fact that a dust mask does not afford protection to asbestos fibers. This could reflect possibly ignorance on the part of management personnel who provided the dust masks or a non-caring attitude towards these employees. Very few maintenance workers reported obtaining training on asbestos and this was done more than five years ago. There is an urgent need for continuous training and periodic assessment of knowledge, attitude, and practices in relation to asbestos for this category of staff.
Focus Group Discussions

The focus group discussions were enlightening, cordial, and lively. Participants were very eager to contribute to the discussions and mutual respect was exhibited in all the deliberations. It is commendable that HODs and supervisors were aware of existing occupational safety and health concerns at the hospitals. The OSH concerns highlighted have serious potential health implications and should be addressed urgently by the hospitals’ administration. Only few of the HODs identified asbestos exposure as an OSH problem and were aware of the presence of ACM in the two hospitals. This is unfortunate as if more HODs were aware of this problem they could provide more impetus to efforts to resolve the situation. Participants were not sure if asbestos use was banned in Jamaica and they concluded that if a ban was not in place then the authorities should move swiftly to institute one. Several countries have banned the use of asbestos since 1999. These include Sweden, Denmark, the Netherlands, Finland, Germany, Italy, Belgium, France, Austria, Poland, and Saudi Arabia (Osinubi et al, 2000). Currently the list of countries banning the use of asbestos has risen to 40 (Whitney, 2007; CTV, 2007), excluding the US and Jamaica. What Jamaica has done is to ban the importation of “hazardous materials” and asbestos is included on this list (Rameike, 2007).

Participants were uncertain about the requisite PPE for workers who may be exposed to asbestos and this topic should be an integral part of any educational intervention not only for HOD but the general hospital workforce. Participants were unanimous in agreement that workers who failed to wear PPE for asbestos should be penalized but they could not decide on the punishment that should be meted out. HODs/supervisors would be very instrumental in assisting hospital administrations to
develop and implement an asbestos policy and control programs at the hospitals. The participants seemed to have left the focus group discussions more aware and sensitized about the asbestos and signaled their intention to be vigilant in light of the potential threat from asbestos.
CONCLUSIONS

This study has demonstrated that ACM which is almost exclusively TSI is present in most Jamaican hospitals. The general condition of the ACM is considered to be “poor” and indicative of fiber release. In the majority of cases the ACM found was no longer serving any useful purpose but still remains as a potential hazard for exposure. The JMOH was made aware of asbestos problem in some hospitals some time ago, but did not pursue any investigation.

Some JMOH employees are able to conduct building inspections for ACM, collect bulk and air samples, and conduct PLM and PCM analysis due to the training program implemented, but they lack laboratory equipment to conduct sample analyses.

Based on our study, there were no airborne asbestos fibers with any immediate threat to workers’ exposures. Educational interventions are needed to address gaps in knowledge, attitudes, and practices about asbestos. The development of an asbestos policy for hospitals would serve to allay the fears of workers about asbestos and signal the intention of management to deal decisively with ACM in the hospitals. Abatement of ACM needs to be undertaken in the future.
RECOMMENDATIONS

In light of the findings of the study the following recommendations are made:

1. That the management of hospitals “A” and “R” take steps to address the OSH concerns identified by HODs from both hospitals.

2. That NEPA and the Jamaican government work expeditiously to sign off on the national asbestos policy for the country.

3. That the JMOH and the RHAs in collaboration with hospital employees and their trade unions/professional associations develop and implement a hospital asbestos policy to cover areas similar to those covered by the hospital asbestos policy in the US.

4. That the Jamaican government join the growing international trend and impose a total ban on the use of asbestos in the country.

5. That the JMOH immediately undertake personal and area air sampling in all other hospitals which has ACM to determine if employees are at risk of inhaling airborne asbestos fibers.

6. That the JMOH procure equipment such as PLMs and PCMs and bulk and air sampling equipment to allow employees trained to collect and analyze bulk and air samples to determine the presence of ACM and asbestos fibers. This will prevent having to send samples abroad for analysis and this will save time and money.
7. That the JMOH gives serious consideration to developing the NPHL as the first laboratory in the country to offer PLM and PCM analyses for asbestos. This will generate revenue for the ministry as well as help the ministry to better fulfill their monitoring role of asbestos abatement activities. Business people and other commercial interests will have a local laboratory to perform analyses for ACM and this will save on foreign exchange for these entities.

8. That the JMOH develops and implements a comprehensive education program on asbestos for hospital workers and the general public.

9. That JMOH institutes warning signs in areas of hospitals with ACM to prevent accidental or unauthorized entry to these areas.

10. That the management of Hospital R relocates the present boiler room and incinerator to somewhere more suitable outside the main hospital building. This will serve to avoid insulating the roof of the present boiler room once the asbestos is removed and address other safety issues such as evacuation in the event of a major accident in the boiler room.

11. That the management of hospitals provides appropriate PPE for maintenance and other employees who work in areas where ACM is present. PPE should include protective clothing and respirators approved for protection against asbestos fibers.

12. That a suitable alternative to asbestos be used in hospitals where ACM is currently used as TSI.

13. That the JMOH/Hospital management institute asbestos abatement/management programs in hospitals as a proactive measure against future exposure. This will
require manpower, resources and assistance from national and international agencies.

14. That other government ministries and private sector companies take steps to determine if ACM is present in any of their buildings; determine if workers are at risk of asbestos exposure; and embark on asbestos abatement programs where indicated.
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APPENDIX A

DRAFT ASBESTOS POLICY STATEMENT FOR JAMAICA

“The Jamaican Government recognizes the hazards posed by Asbestos and will ensure the protection of the Jamaican Environment and population from any adverse impact that may be caused by any exposure to Asbestos and Asbestos Containing Material (ACM) fibres. The government through various existing ACTS under the Ministries of Land and Environment, Industry, Commerce & Technology (Trade Act), Health and Labour will effect the following:

1. Control importation by prohibiting the importation of all pure amphibole asbestos, however, non friable Chrysolite and bonded ACM not exceeding 10% asbestos will be allowed through prescribed import application forms.
2. Improve existing inventory systems and introduce new regulations where necessary to obtain a full inventory for ACM in the country especially as related to government occupied buildings, schools and hospitals.
3. This shall include a phased elimination of friable asbestos and ACM depending on its condition, and promote the use of alternatives for asbestos.
4. Provide code of practices for safe handling in the work place, transportation and disposal of ACM waste. Only permitted and licensed entities will be allowed to transport and dispose ACM waste, and this must be done according to the National Asbestos Management Plan and NRCA ACT Section 9
5. Increase public awareness – Existing ACTS allows each order under the ACT to be published once in a daily newspaper. Additionally radio broadcast, and information on air quality including asbestos fibre will be added to the “State of the Environment Report” produced annually.
6. Training for all Jamaicans involved in the handling of ACM shall be the responsibility of the respective stakeholders as defined by the appropriate law.
7. Mandate employers to include asbestos related data in the health records for all persons immediately exposed to asbestos and ACM fibre in their work environment.
8. Penalties will be levied as stipulated in the existing ACTS, in the order of written warning, fines and ultimately imprisonment.”
APPENDIX B

PROCEDURES FOR HANDLING ASBESTOS

Large Scale Operations Asbestos Removal

Workers engaged in removal and handling of asbestos especially if it is friable should take standard precaution to avoid potential health risks. The most important precautionary steps are to wear impermeable gloves, skin covering, eye protection and a high quality respirator. Entry to the working area should be restricted to persons wearing protective clothing and respiratory protection. This restriction should include all visitors. Before asbestos removal, the USEPA recommends posting warning signs, providing removal workers with appropriate protective equipment and enclosing the work area through the use of plastic barriers to prevent contamination of other parts of the building. The use of a negative air pressure system in the room where removal is taking place, to ventilate the room and filter out asbestos fibres as air passes out through special filtering exhausts, is allowed. The exhaust ventilations should be sufficient to maintain a positive flow of air into the enclosure via the entrance. This should be confirmed by the use of smoke generator. Entry to the enclosure should be via a number of air locks (i.e. a series of at least three interlocking chambers) constructed of impervious sheet. These chambers allow for the change over from clean and contaminated clothing and other equipment. Contaminated clothing and equipment should be cleaned by vacuum cleaner inside the contaminated chamber of the air lock. At a minimum, asbestos materials should be wetted with a water and surfactant (if possible) mixture sprayed in a fine mist. Time is allowed between sprayings for complete penetration of the material. All material to be removed should be thoroughly soaked, prior to removal as a 1° (primary) means of control of airborne fibres.

Asbestos, once removed must be containerized for transport and disposal. Recommended containers are 6-mil thick, plastic bags sealed to make them leak-tight. Minimize the void air space in the bags upon sealing, so as to reduce any fibre emissions should the bags burst under pressure. Double bagging, plastic-lined cardboard containers or plastic-lined metal containers provide more thorough containerization. The first and second set of bags should be colour coded to facilitate identification. Asbestos waste slurries can be packaged in leak-tight drums. Plastic linings used in the room should be removed and containerized also. Residual fibres on pipe work should be removed by wet scraping and wire brushing. After that, all surfaces inside the enclosure should be vacuum cleaned using an approved vacuum cleaner. Asbestos debris may be vacuumed using a special vacuum cleaner and the areas should be washed down to remove any remaining fibres. In some cases where surface material is porous, spraying an encapsulating paint or polyvinyl acetate on them will prevent additional release of fibres. The area should then be inspected and
if found satisfactory the enclosure should be dismantled and all used materials disposed of as toxic waste. Asbestos should be disposed of in a facility designed to handle potentially hazardous wastes.

Small Scale Operations Asbestos Removal

Personal protective equipment should be worn wherever there is a risk of contamination of clothing or inhalation of fibres. Wherever possible all operations should be carried out “wet”. The principles and procedures described for large scale operations are applicable but where necessary should be scaled down to meet the local situation. In general, in circumstances where the use of water would unavoidably damage equipment or present a safety hazard, an alternative procedure would be to utilize local exhaust ventilation and collection system designed to capture particulate asbestos released during the removal, or a glove bag system or a leak-tight wrapping which can contain the particulate asbestos.

Asbestos Disposal

All asbestos removed should remain adequately wet until it is collected and containerized in preparation for disposal. All asbestos waste is regarded as a potential hazard and should be disposed of under strict supervision and procedures. All containers should be labeled “DANGER – ASBESTOS – DO NOT INHALE DUST HANDLE WITH CARE” and should be sealed. Vehicles being used to transport the asbestos waste should also take care to have tyres and surfaces kept clear of loose fibres. Disposal of all asbestos material should be at a facility designed to handle potentially hazardous waste. The facility must be approved and operated in accordance with established guidelines.

PLEASE NOTE THAT ALL METHOD STATEMENTS DESIGNED TO KEEP THE RELEASE OF FIBRES TO A MINIMUM, WILL BE PREPARED FOR EMERGENCY WORK ON ASBESTOS-CONTAINING MATERIALS, AND WILL HAVE OBTAINED THE PRIOR APPROVAL OF THE RELEVANT AGENCY (excerpted from the National Environment And Planning Agency (NEPA) Proposed Asbestos Management Policy For Jamaica).
APPENDIX C

IRB APPROVAL LETTER FROM UAB

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56 and ICH GCP Guidelines. The Assurance became effective on November 24, 2003 and expires on February 14, 2009. The Assurance number is FWA0003960.

Principal Investigator: SCARLETT, HENROY
Co-Investigator(s):
Protocol Number: X050622003
Protocol Title: Exposure to airborne asbestos in Jamaican hospitals

The IRB reviewed and approved the above named project on 8-8-07. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.
IRB Approval Date: 8-8-07
Date IRB Approval Issued: 8-8-07

Marilyn Doss, M.A.
Vice Chair of the Institutional Review Board for Human Use (IRB)

Investigators please note:
The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.
APPENDIX D

JMOH ETHICS COMMITTEE APPROVAL LETTER

MINISTRY OF HEALTH
OFFICE OF THE CHIEF MEDICAL OFFICER
Oceana Complex
2-4 King Street
Kingston Jamaica

Tele: 876-967-1628 Fax: 967-1324

No. I&E/AP 2005, November 14

Mr. Henroy Scarlett
Department of Community Health & Psychiatry
University of the West Indies
Mona
Kingston 7

Dear Mr. Scarlett:

Re: Exposure to Airborne Asbestos in Jamaican Hospitals

This serves to inform you that the Advisory Panel on Ethics and Medico-Legal Affairs in the Ministry of Health has reviewed and approved the abovementioned Study which has been assigned the number 63.

Please inform the Ministry of the outcome of the Study.

Yours sincerely

[Signature]
Barrington Wint (Dr.)
Chief Medical Officer
THE UNIVERSITY OF THE WEST INDIES
MONA CAMPUS
Faculty of Medical Sciences
Office of the Dean

Dean: Archibald McDonald, MB BS, FRCS Ed., FACS, DM (Surg) UWI
Professor of Surgery and Emergency Medicine

September 12, 2005

Dr. Elizabeth Delzell, SD
School of Public Health
University of Alabama At Birmingham
Birmingham Alabama USA

Dear Dr. Delzell:

RE: Proposal: Exposure to Airborne Asbestos in Jamaican Hospitals,
ECP 105, 2004/2005

Thank you for submitting the above proposal for review by the UHWI UWI FMS Ethics Committee.

The proposal was reviewed and approved, having met the required ethical standards.

Yours sincerely,

[Signature]

Professor Archibald McDonald
Chairman, UHWI UWI FMS Ethics Committee
APPENDIX F

PERMISSION LETTER FROM JMOH

MINISTRY OF HEALTH
Oceana Complex
2-4 King Street
Kingston Jamaica

Tele: 876- 967-1100 Fax: 9671280

Mrs. Catherine Gregory
Regional Director
South East Regional Health Authority
Dominica Drive
Kingston 5

Attention: Dr. Michelle Harris, Regional Technical Director
Re: Assistance to Mr. Henroy Scarlett, Doctoral Student

Through this medium I am introducing Mr. Henroy Scarlett, a Doctoral student at the University of Alabama at Birmingham. Mr. Scarlett will be conducting research on asbestos and related issues in Jamaican hospitals for his Thesis. The Ministry of Health supports the objectives of Mr. Scarlett’s research. Mr. Scarlett will be in the Island in mid-year to undertake this activity and is requesting permission to interview selected health staff, measure specific parameters in hospitals. He will be working under the supervision of the EHU for the period and will be (assisting the Environmental Health Unit (EHU) in training staff members.

Your extension of the necessary courtesies to Mr. Scarlett in this effort will be appreciated.

Yours truly,

Barry Wint (Dr.)
Chief Medical Officer

/copied Dr. E. Ward – Dir, Disease Prevention & Control
Mr. P. Knight – Dir. Environmental Health Unit (EHU)
APPENDIX G

COPY OF CERTIFICATE – NIOSH 582 EQUIVALENT COURSE TAKEN BY PI

The Environmental Institute

Henroy Scarlett

Has completed coursework and satisfactorily passed an examination that meets all criteria required for the Course

Asbestos in Buildings: Air Sampling and Analysis (NIOSH 582 EQUIVALENT)

May 16-20, 2005
Course Date

May 20, 2005
Examination Date

1604
Certificate Number

Thomas O. Lightfoot - Course Director
Ralph Q. McCarty, Exam Administrator

TEI - 1300 Williams Drive, Suite E - Marietta, Georgia 30066 - (770) 427-3600 - www.tei-atl.com
APPENDIX H
SURVEY PROCEDURES FOR ACM

Initial steps in an ACM survey (The Environmental Institute, 2005)
Survey procedures for sprayed- or troweled-on surface material
Survey procedures for pipe and boiler insulation (The Environmental Institute, 2005)
APPENDIX I

PROTOCOL FOR ASBESTOS BULK SAMPLING IN HOSPITALS

- Consult with laboratory that will analyze the samples before proceeding to take samples.
- A bulk sampling kit will be assembled with the equipment to be used. These include sample vial, plastic bags, spray bottle, label, coveralls, gloves, utility knife, duct tape, pen, and an approved respirator.
- A survey team of 5 members will be selected inclusive of the Principal Investigator. One trained officer will be selected from each of the four Health Regions on the recommendation of the Regional Director or Regional Technical Director. For each sampling operation, the team will comprise at least two members including the Principal Investigator.
- The team will perform a walk-through survey at each hospital of areas suspected of having asbestos. The team will identify all homogenous areas (such as asbestos insulation on pipes) and estimates the number of samples required based on EPA’s guidelines.
- Each sampling location will be labeled and photo-documented.
- Disposable coveralls, approved respirators and disposable gloves will be worn during sampling operations.
- A representative sample of the surface will be obtained.
- The team will take one sample initially of each material. The sample will be sent for laboratory analysis and if positive for asbestos, no further sampling is required from that area. If negative the EPA’s guidelines will be followed: A minimum of three samples for a homogenous material less than 1,000 square feet in area; five samples / 1,000-5,000 square feet; and seven samples for areas greater than 5,000 square feet.
- A spray bottle will be used to wet the surface to be sampled. If the area cannot be wet, an airtight sealed plastic bag will be used as a containment device.
• For friable, reasonably soft material, or pipe insulation- slowly push the sampler into the material with a twisting motion until the entire thickness of the material is penetrated. The representativeness of the coring is the major quality setting factor. Approximately 1-10 grams of material will be obtained per sample for analysis.
• Place the material in the container and cover.
• The team will record the condition of the material (physical assessment) and the potential for future damage (hazard assessment). This information will assist the researcher in categorizing the material in accordance with the EPA’s removal priority response action.
• During the sampling operations the area will be restricted to prevent exposure to other people.
• Label the sample with building number, room number, sample number and date taken.
• Wet paper towels will be used to clean debris from the sample collection device.
• Repair sampler damage: latex paint or caulk dabbed on wet or dry material for friable surface. Tape will be used for repairing core holes left in jacketed insulation.
• Prepare chain of custody form and place it with sample for shipment to the laboratory.
APPENDIX J

CHAIN OF CUSTODY FORM

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>LABORATORY ID #</th>
<th>SIMPLE DESCRIPTION / LOCATION</th>
<th>CONDITION OF SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

SAMPLED BY:          DENT BY:          RECEIVED BY:          ANALYZED BY:          

SIGNATURE / DATE:             SIGNATURE / DATE:             SIGNATURE / DATE / TIME:             SIGNATURE / DATE:             

**NOTE: ALL INFORMATION MUST BE COMPLETED**
APPENDIX K

INFORMED CONSENT FORM FOR PERSONAL AIR SAMPLING

Exposure to Airborne Asbestos in Jamaican Hospitals (Personal Air sampling)

**Sponsor:** The Sparkman Center for Global Health – University of Alabama at Birmingham (UAB).
**Principal Investigator:** Henroy P. Scarlett

**Introduction/Purpose**

You are being asked to participate in a research project on airborne asbestos exposure in Jamaican hospitals. You are one of about 150 hospital employees islandwide aged 18 years and older who has been selected randomly (like the flip of a coin) to participate. The purpose of the study is to determine if hospital employees are at risk of exposure to airborne asbestos and to find out the knowledge and attitudes of employees with respect to asbestos. The investigators will collect bulk samples of building and insulation material as well as air samples to test for asbestos. Questionnaires and focus groups will also be used to collect information for the study.

**Procedures**

*Personal air sampling:* You will be asked to wear a personal air sampling pump with a cassette attached for the duration of a work shift (8 hours). The air sampling pump weighs approximately two pounds and will be attached to your waist band, while the cassette for collecting the air sample will be attached to the pump by a plastic tube and the cassette clipped to your lapel. The pump is battery operated and when it is turned on, a sample of the air that you are breathing will be pulled into the cassette. At the end of the sampling period the cassette will be sent to the laboratory for testing for asbestos fibers. If at any time during the work shift you wish to leave your work area or the hospital compound, the pump will be turned off and removed along with the cassette. On your return the pump and cassette will be re-fitted. The investigators will check the pump every two hours to ensure it is working properly.

**Risks or Discomforts**

The procedures to be used in this study are considered to be safe. The personal air sampling equipment pose no health risks and when fitted properly will not be uncomfortable to wear and should not interfere with the performance of your usual work.

Participant Initials ________
Benefits

You may not personally benefit from your participation in this research; however, your participation may provide valuable information which could be used by the management of your hospital or the Ministry of Health to address any problem(s) associated with asbestos or related issues.

Alternatives

You have the alternative to choose not to participate in this study.

Confidentiality

The information gathered during this study will be kept confidential to the extent permitted by law. However, representatives of the University of Alabama at Birmingham, USA, Ethics Committees of the Ministry of Health, Jamaica and the University Hospital of the West Indies (UHWI) could review your research records and have access to confidential information that identifies you by name. Please understand that we will follow strict rules to protect privacy at all times during and after this study. You will be assigned a unique ID number and only that number will be kept in a locked file in a secure area in the office of the principal investigator at the University of the West Indies, Mona, Jamaica. The coded data will be maintained by the principal investigator for storage and analysis.

The results of the study may be published for scientific purposes, however your identity will not be revealed.

Cost of Participation in Research

There will be no cost to you from participation in the research.

Payment for Participation in Research

You will not be paid for participation in this research.

Research-related Injury

No research-related injuries are anticipated. The UAB has made no provision for monetary compensation in the event of injury resulting from the research.

Participant Initials _______
Withdrawal

You do not have to take part in this research project. Your decision to be in the study is voluntary. If you should change your mind about participating, you are free to withdraw your consent at any time. If you become uncomfortable wearing the personal air sampling equipment, you can ask that it is removed.

New Findings
Any significant new findings that develop during the course of the study that may affect your willingness to continue in the research will be provided to you by Mr. Henroy Scarlett.

Questions
If you have any questions about the research, Mr. Henroy Scarlett will be happy to answer them. Mr. Scarlett’s phone number is 876-894-0636 or 876-927-2476. He is based in the Department of Community Health and Psychiatry at the UWI, Mona, and his email address is henpscar@uab.edu. If you have questions about your rights as a research participant, you may contact Dr Barry Wint, Chief Medical Officer and Chairman of the Ministry of Health Ethics Committee or Professor Archibald McDonald, Chairman of the University of the West Indies/University Hospital of the West Indies Ethics Committee. Dr Wint may be reached at 876-967-1628 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.). Professor McDonald may be reached at 876-927-2556 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.)

Legal Rights
You are not waiving any of your legal rights by signing this consent form.

Signature
Your signature below indicates that you agree to participate in this research. You have been given the opportunity to ask questions about this research project and have received satisfactory answers. You will receive a signed copy of the informed consent. Please print participant name here:

Signature of Participan

Signature of person obtaining consent

Signature of Witness

Date of Signature
APPENDIX L

PROTOCOL FOR PERSONAL AIR SAMPLING

- Consult with laboratory that will do the analyses before proceeding to collect samples
- Leave personal air sampling pumps to charge overnight
- Calibrate personal sampling pump with a representative sampler in line on the day of sampling.

Diagram showing the set-up of equipment for calibration

- Obtain informed consent from participating maintenance workers
- Explain personal sampling procedure to consenting hospital employees
- Remove cap of filter cassette and attach cassette to one end of a piece of flexible plastic tubing; attach the other end of the tube to the pump.
• Attach sampling pump to waistband of hospital employee and fasten the uncapped open-face cassette to the worker’s lapel with the open face oriented downward at an angle of 45°.

• Turn on the pump and record the time.

• Submit at least two field blanks or 10% of total field samples, whichever is greater with each set of samples. Handle field blanks in a manner representative of handling of associated samples in the set. Open field blank cassettes at the same time as other cassettes just prior to sampling. Store top covers from cassettes during sampling period in a closed box or bag.

• Sample at 2 L/min or greater (3,000-10,000L) if necessary.

• Adjust sampling flow rate, Q (L/min), and time, t (min), to produce a fiber density, E, of 100-1300 fibers/mm² for optimum accuracy.

• Check pumps every two hours to ensure proper functioning.

• If workers have to leave the compound or usual work area for lunch or other reasons, turn off and remove pump, noting the time the pump was turned off. On the return of the worker, re-attach and turn on the pump, noting the time.

• At the end of the work shift or when the worker decides to leave, turn off pump and remove the entire sampling train.

• Replace the top covers and end plugs on the cassettes.

• Label each sample and blank.

• Post-calibrate pump.

• Record temperature and pressure at the sampling site.

• Store samples in closed box at room temperature in preparation for shipment to the laboratory.

• Prepare chain of custody form.

• Ship samples in a rigid container with packing material to prevent jostling or damage.
Equipment set-up for personal air sampling
APPENDIX M

PROTOCOL FOR AREA AIR SAMPLING

- Use a high volume sampling pump.
- Calibrate with sampling train in place at the selected sampling location.
- Calibrate to sample at a flow rate of 12 liters/min.
- Place the sampling pump 4-5 feet above the level of the floor away from obstructions that may influence air flow (a table or counter).

Set-up of equipment for area sampling

- Remove cassette cap before pump is activated.
- Plug AC power cord into electrical outlet and turn on the pump.
• Sample for 2-hour periods at approximately 12 liters per minute.
• Record the time the pump was turned on.
• At the end of the designated sampling time, turn off the pump and remove the filter cassette and label it.
• Store cassette in a closed bag until all sampling is concluded for the day
• At the end of sampling, post-calibrate the pump.
• Prepare chain of custody form and ship with samples to the laboratory.
Figure 2 shows a Walton-Beckett graticule as seen through the microscope. The rules will be discussed as they apply to the labeled objects in the figure.

Figure 2. Walton-Beckett graticule with fibers.
These rules are sometimes referred to as the "A" rules.

<table>
<thead>
<tr>
<th>Object</th>
<th>Count</th>
<th>DISCUSSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 fiber</td>
<td>Optically observable asbestos fibers are actually bundles of fine fibrils. If the fibrils seem to be from the same bundle the object is counted as a single fiber. Note, however, that all objects meeting length and aspect ratio criteria are counted whether or not they appear to be asbestos.</td>
</tr>
<tr>
<td>2</td>
<td>2 fiber</td>
<td>If fibers meeting the length and aspect ratio criteria (length $&gt; 5 \times 10^{-6}$ m and length-to-width ratio $&gt; 3$ to $1$) overlap, but do not seem to be part of the same bundle, they are counted as separate fibers.</td>
</tr>
<tr>
<td>3</td>
<td>1 fiber</td>
<td>Although the object has a relatively large diameter ($&gt; 3 \times 10^{-6}$ m), it is counted as fiber under the rules. There is no upper limit on the fiber diameter in the counting rules. Note that fiber width is measured at the widest compact section of the object.</td>
</tr>
<tr>
<td>4</td>
<td>1 fiber</td>
<td>Although long fine fibrils may extend from the body of a fiber, these fibrils are considered part of the fiber if they seem to have originally been part of the bundle.</td>
</tr>
<tr>
<td>5</td>
<td>Do not count</td>
<td>If the object is $&lt; 5 \times 10^{-6}$ m long, it is not counted.</td>
</tr>
<tr>
<td>6</td>
<td>1 fiber</td>
<td>A fiber partially obscured by a particle is counted as one fiber. If the fiber segments emanating from a particle do not seem to be from the same fiber and each end meets the length and aspect ratio criteria, they are counted as separate fibers.</td>
</tr>
<tr>
<td>7</td>
<td>1/2 fiber</td>
<td>A fiber which crosses into the graticule area one time is counted as 1/2 fiber.</td>
</tr>
<tr>
<td>8</td>
<td>Do not count</td>
<td>Ignore fibers that cross the graticule boundary more than once.</td>
</tr>
<tr>
<td>9</td>
<td>Do not count</td>
<td>Ignore fibers that lie outside the graticule boundary.</td>
</tr>
</tbody>
</table>
APPENDIX O

QUESTIONNAIRE - EXPOSURE TO AIRBORNE ASBESTOS IN JAMAICAN HOSPITALS

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
UNIVERSITY OF ALABAMA AT BIRMINGHAM (UAB)
DOCTOR OF PUBLIC HEALTH (DrPH) PROGRAM

EXPOSURE TO AIRBORNE ASBESTOS IN JAMAICAN HOSPITALS

Hello Sir/Madam,
I am a doctoral student in the Department of Environmental Health Sciences at the University of Alabama at Birmingham (UAB) in the United States. I am conducting a study in selected hospitals in Jamaica to determine the exposure of workers to possible airborne contaminants and to assess the knowledge, attitudes and practices of employees with respect to one suspected airborne contaminant. I am requesting that you respond to the questions contained in this questionnaire so that a clear picture may emerge concerning employees’ knowledge, attitudes and practices regarding important exposures in the hospitals. The information you provide may be used to address problems and concerns that may be identified in this study. You are assured that the information you provide will be treated with strict confidentiality.

Thank you.
Henroy P. Scarlett

INSTRUCTIONS: Please complete this questionnaire by writing the responses on the lines provided or by using a tick (✔) where this is more appropriate.

SECTION 1 - DEMOGRAPHIC DATA

1. Assigned ID Code

2. Present occupation

3. Hospital Code

4. Address

5. Telephone number

6. Interviewer
7. Date: Month ___ Day ___ Year ________

8. What is your date of birth? Month___ Day___ Year___

9. Sex
   1. Male ( )
   2. Female ( )

10. How long have you been working at this hospital (Months)? 

11. What is your marital status?  1. Single ( )
   2. Married ( )  4. Separated/ Divorced ( )
   3. Common law ( ) 5. Widowed ( )

12. (a) What is the highest level of education attained?
   1. Primary ( )
   2. All Age ( )
   3. Secondary School ( )
   4. High School ( )
   5. College ( )
   6. University ( )
   8. Other ( )
   Please specify ______________

   (b) Did you complete the program of studies at the level indicated?
   1. Yes ( )
   2. No ( )

   (c) If ‘No’, how many years did you complete? _____________

SECTION 2: KNOWLEDGE ABOUT ASBESTOS

13. Have you ever heard of asbestos?  1. Yes ( )
   2. No ( )
   (NB. If “No”, Interview is discontinued)

14. Are you aware of asbestos being present at this hospital?  
   1. Yes ( )
   2. No ( )

15. What is asbestos usually used for in a building?  
   1. Decoration ( )
   2. Fire protection ( )
   3. Insulation ( )
   8. Other ( )
   Please specify ______________________
   9. Don’t know ( )

16. Is asbestos harmful to human health?  
   1. Yes ( )
   2. No ( )
   9. Don’t know ( )
If 'Yes'; in what way(s)? _________________________________________

17. Can you name any disease(s) caused by asbestos? 1. Yes ( ) 2. No ( )
If 'Yes', give the name of the disease(s)
1. Lung cancer ( )
2. Mesothelioma ( )
3. Asbestosis ( )
4. Pleural plaque ( )
8. Other ( )
Please specify ______________________

18. What is the main way by which asbestos enters the body? (Check one only)
1. Ingestion ( )
2. Through the skin ( )
3. Inhalation ( )
9. Don't know ( )

19. What type(s) of protection should be worn if a worker is exposed to asbestos on the job?
1. Respirator ( )
2. Protective clothing ( )
8. Other ( )
Please specify ______________________
9. Don't know ( )

20. Do you know the occupational exposure limit for asbestos?
1. Yes ( )
2. No ( )
If 'Yes' to the above, what is it? _____________

21. Please answer “True” or “False” to the following statements.

A. Asbestos is a mineral made up of tiny fibers. 1= True 2 = False ( ) ( )

B. White asbestos is the most commonly used form of the mineral. ( ) ( )

C. A smoker who is exposed to asbestos is at increased risk of developing illness. ( ) ( )

D. The use of asbestos is banned in Jamaica. ( ) ( )

E. Trying to remove asbestos from a building can sometimes create a bigger problem than existed before. ( ) ( )

F. Human risk of asbestos disease depends on exposure. ( ) ( )

G. Asbestos-related diseases show several warning signs before they become dangerous. ( ) ( )
H. You have to work directly with asbestos to be at risk from exposure to airborne fibers. ( ) ( )

I. Warning signs are placed at all entrances to asbestos work areas to prevent accidental or unauthorized entry. ( ) ( )

J. If you find any material that you suspect may contain asbestos, it is not necessary to inform your supervisor. ( ) ( )

K. Asbestos waste can be thrown away with regular garbage. ( ) ( )

SECTION C: ATTITUDES TOWARDS ASBESTOS

22. Please indicate how you feel about the following statements by giving one of the listed responses: Strongly Agree = SA; Agree = A; Undecided = U; Disagree = D; Strongly Disagree = SD.

<table>
<thead>
<tr>
<th>Statements</th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Since asbestos-related diseases take many years to develop, workers should not be concerned about these diseases.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>B. The presence of asbestos in a building does not automatically result in worker exposure if the asbestos is managed properly.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C. Asbestos in any form or condition found in a hospital should be removed immediately</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>D. Workers without adequate personal protective equipment (PPE) can work with asbestos without being harmed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>E. Appropriate warning signs should be put up in areas of the hospital where asbestos is located</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>F. Every hospital where asbestos is present should have an asbestos policy and control program in place</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>G. There should be periodic medical examination for workers who may be exposed to asbestos fibers</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>H. Workers should not be punished if they refuse to wear personal protective equipment when working with asbestos</td>
<td>1</td>
<td>2</td>
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<td>5</td>
</tr>
<tr>
<td>I. I would not work at a hospital if I knew that Asbestos was present in the</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
SECTION 4: PRACTICES (Maintenance workers only)

23. a) When carrying out your job, have you ever had to disturb any material that was suspected of containing asbestos?  
   1. Yes ( ) 2. No ( )
   b) If ‘Yes’ to the above, how often? ______________________________

24. a) Are you provided with personal protective equipment?  
   1. Yes ( ) 2. No ( )
   b) If ‘Yes’ to the above, what equipment? ______________________________
   c) Do you usually wear the protective equipment given on the job?  
      1. Yes ( ) 2. No ( )
   d) If ‘No’, why not? ___________________________________________________________________

25. Do you usually work in your street clothes? 1. Yes ( ) 2. No ( )

26. a) Have you ever taken part in removing suspected asbestos containing material from any hospital building? 1. Yes ( ) 2. No ( )
   b) If ‘Yes’ to the above, which building (s)? _____________________
   c) Where in the building (s) was the suspected asbestos material removed? _______________________________________________________
   d) How was the suspected asbestos containing material disposed of?  
      1. Placed in hospital garbage containers ( )  
      2. Left on hospital compound ( )  
      3. Open dumping ( )  
      4. Buried on hospital compound ( )  
      5. Collected by municipal waste collector( )  
      6. Collected by certified asbestos waste Disposal Agency ( )  
      8. Other ( )  
      Please specify___________________________________________
      9. Don’t know ( )
   e) Did you wear protective equipment during the removal operation(s)?  
      1. Yes ( ) 2. No ( )
f) If ‘Yes’ to the above, what protective equipment was worn? ____

27. a) Have you ever participated in any training program on asbestos?
   1. Yes (  )  2. No (  )

   b) If ‘Yes’, where did this training take place? ____________________

   c) When was the last time you participated in a training program?
   ____________________

   d) How would you rate the training program(s)?
   1. Excellent (  )
   2. Good (  )
   3. Average (  )
   4. Poor (  )
   5. Very poor (  )

   THANK YOU
APPENDIX P

INFORMED CONSENT FORM FOR QUESTIONNAIRE ADMINISTRATION

Exposure to Airborne Asbestos in Jamaican Hospitals (Survey interview)

Sponsor: The Sparkman Center for Global Health – University of Alabama at Birmingham (UAB).

Principal Investigator: Henroy P. Scarlett

Introduction/Purpose

You are being asked to participate in a research project on airborne asbestos exposure in Jamaican hospitals. You are one of about 300 hospital employees islandwide aged 18 years and older who has been selected randomly (like the flip of a coin) or because you work in maintenance to participate. The purpose of the study is to determine if hospital employees are at risk of exposure to airborne asbestos and to find out the knowledge, attitudes and practices of employees with respect to asbestos. The investigators will collect bulk samples of building and insulation material as well as air samples to test for asbestos. Questionnaires and focus groups will also be used to collect information for the study.

Procedures

This study will include a survey interview: You will be asked to answer questions contained in a questionnaire concerning your personal history, knowledge, attitudes and practices with respect to asbestos. The administration of the questionnaire will take approximately 15-20 minutes.

Risks or Discomforts

The procedures to be used in administering this questionnaire are considered to be safe and pose no health risks.

Benefits

You may not personally benefit from your participation in this research; however, your participation may provide valuable information which could be used by the management of your hospital or the Ministry of Health to address any problem(s) associated with asbestos or related issues.

Participant Initials ________
Alternatives

You have the alternative to choose not to participate in this study.

Confidentiality

The information gathered during this study will be kept confidential to the extent permitted by law. However, representatives of the University of Alabama at Birmingham, USA, Ethics Committees of the Ministry of Health, Jamaica and the University Hospital of the West Indies (UHWI) could review your research records and have access to confidential information that identifies you by name.

Please understand that we will follow strict rules to protect privacy at all times during and after this study. You will be assigned a unique ID number and only that number will associated with the information you provide. The ID numbers and matching names will be kept in a locked file in a secure area in the office of the Principal Investigator at the University of the West Indies, Mona, Jamaica. The coded data will be maintained by the principal investigator for storage and analysis.

The results of the study may be published for scientific purposes, however your identity will not be revealed.

Cost of Participation in Research

There will be no cost to you from participation in the research.

Payment for Participation in Research

You will not be paid for participation in this research.

Research-related Injury

No research-related injuries are anticipated. The UAB has made no provision for monetary compensation in the event of injury resulting from the research.

Withdrawal

You do not have to take part in this research project. Your decision to be in the study is voluntary. If you should change your mind about participating, you are free to withdraw your consent at any time. If you feel uncomfortable answering the questions in the questionnaire you can asked that the interview be stopped.

Participant Initials ______
New Findings

Any significant new findings that develop during the course of the study that may affect your willingness to continue in the research will be provided to you by Mr. Henroy Scarlett.

Questions

If you have any questions about the research, Mr. Henroy Scarlett will be happy to answer them. Mr. Scarlett’s phone number is 876-894 0636 or 876-927-2476. He is based in the Department of Community Health and Psychiatry at the University of the West Indies, Mona and his email address is henpscar@uab.edu. If you have questions about your rights as a research participant, you may contact Dr Barry Wint, Chief Medical Officer and Chairman of the Ministry of Health Ethics Committee or Professor Archibald McDonald, Chairman of the University of the West Indies/University Hospital of the West Indies Ethics Committee. Dr Wint may be reached at 876-967-1628 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.) Professor McDonald may be reached at 876-927-2556 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.)

Legal Rights

You are not waiving any of your legal rights by signing this consent form.

Signature

Your signature below indicates that you agree to participate in this research. You have been given the opportunity to ask questions about this research project and have received satisfactory answers. You will receive a signed copy of informed consent.

Please print participant name here:

[Signature of Participant]

[Month] / [Day] / [Year]

[Date of Signature]

[Signature of person obtaining consent]

[Month] / [Day] / [Year]

[Date of Signature]

[Signature of Witness]

[Month] / [Day] / [Year]

[Date of Signature]
February 20, 2007

Dear …………………

You are cordially invited to be a participant in a Focus Group Discussion on a topic to be announced on the day of the discussion. The discussion is scheduled to be held on Thursday, March 1, 2007 at 2:00 pm in Conference Room 1 in the Office of the Dean, Faculty of Medical Sciences, UWI. The session will last for approximately 80-90 minutes. You are one of ten (10) persons who have been invited to participate. The discussion is the final part of the research project I have been conducting at the hospital over the last year. In keeping with the requirements of the UWI/UHWI and MOH Ethics Committees, participants will be asked to give informed consent and the relevant document will be available on March 1st.

I wish to express my gratitude to you and your staff for the tremendous support and cooperation given to my research efforts to date and I look forward to your participation in this important discussion.

Sincerely,

-----------------------
Henroy P. Scarlett (henpscar@uab.edu; henroy.scarlett@uwimona.edu.jm)
Lecturer/Principal Investigator

Telephone: (876) 927-2476
            (876) 927-1752
            (876) 927-1660-9 ext.2267

Fax: (876) 977-6346
Email: dchp@uwimona.edu.jm
APPENDIX R

INFORMED CONSENT FORM FOR FOCUS GROUP DISCUSSION

Exposure to Airborne Asbestos in Jamaican Hospitals (Focus groups)

Sponsor: The Sparkman Center for Global Health – University of Alabama at Birmingham (UAB).

Principal Investigator: Henroy P. Scarlett

Introduction/Purpose

You are being asked to participate in a research project on airborne asbestos exposure in Jamaican hospitals. You are one of about 18 hospital employees islandwide aged 18 years and older who has volunteered to participate in a focus group. The purpose of the study is to determine if hospital employees are at risk of exposure to airborne asbestos and to find out the knowledge, attitudes and practices of employees with respect to asbestos. The investigator will collect bulk samples of building and insulation material as well as air samples to test for asbestos. Questionnaires and focus groups will also be used to collect information for the study.

Procedures

This study will include two Focus Group discussions. A focus group is type of interview with a small number of carefully selected people brought together to discuss an important topic. You will be asked to participate in a focus group discussion to explore issues relating to asbestos and its control. The focus group will bring together 7-9 persons who will sit and discuss freely issues related to asbestos in a comfortable environment. The focus group discussion will take approximately 1½-2 hours.

Risks or Discomforts

The procedures to be used in conducting the focus group discussion are considered to be safe and pose no health risks.

Benefits

You may not personally benefit from your participation in this research; however, your participation may provide valuable information which could be used by the management of your hospital or the Ministry of Health to address any problem(s) associated with asbestos or related issues.

Participant Initials _______
Alternatives

You have the alternative to choose not to participate in this study.

Confidentiality

The information gathered during this study will be kept confidential to the extent permitted by law. However, representatives of the University of Alabama at Birmingham, USA, Ethics Committees of the Ministry of Health, Jamaica and the University Hospital of the West Indies (UHWI) could review your research records and have access to confidential information that identifies you by name.

Please understand that we will follow strict rules to protect privacy at all times during and after this study. You will be assigned a unique ID number and only that number will be associated with the information you provide. The ID numbers and matching names will be kept in a locked file in a secure area in the office of the principal investigator at the University of the West Indies, Mona, Jamaica. The coded data will be maintained by the principal investigator for storage and analysis.

The results of the study may be published for scientific purposes, however your identity will not be revealed.

Cost of Participation in Research

There will be no cost to you from participation in the research.

Payment for Participation in Research

You will not be paid for participation in this research.

Research-related Injury

No research-related injuries are anticipated. The UAB has made no provision for monetary compensation in the event of injury resulting from the research.

Withdrawal

You do not have to take part in this research project. Your decision to be in the study is voluntary. If you should change your mind about participating, you are free to withdraw your consent at any time.

Participant Initials ________
New Findings

Any significant new findings that develop during the course of the study that may affect your willingness to continue in the research will be provided to you by Mr. Henroy Scarlett.

Questions

If you have any questions about the research, Mr. Henroy Scarlett will be happy to answer them. Mr. Scarlett’s phone number is 876-894-0636 or 876-927-2476. He is based in the Department of Community Health and Psychiatry, UWI, Mona, and his email address is henpscar@uab.edu. If you have questions about your rights as a research participant, you may contact Dr Barry Wint, Chief Medical Officer and Chairman of the Ministry of Health Ethics Committee or Professor Archibald McDonald, Chairman of the University of the West Indies/University Hospital of the West Indies Ethics Committee. Dr Wint may be reached at 876-967-1628 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.) Professor McDonald may be reached at 876-927-2556 (Monday through Friday, between the hours of 8:30 am and 4:30 pm.)

Legal Rights

You are not waiving any of your legal rights by signing this consent form.

Signature

Your signature below indicates that you agree to participate in this research. You have been given the opportunity to ask questions about this research project and have received satisfactory answers. You will receive a signed copy of informed consent.

Please print participant name here:

__________________________
Signature of Participant

__________________________
Signature of person obtaining consent

__________________________
Signature of Witness

Month     Day     Year
Date of Signature

Month     Day     Year
Date of Signature

Month     Day     Year
Date of Signature
APPENDIX S

PROTOCOL FOR FORMATION AND CONDUCTING FOCUS GROUP DISCUSSION

• The Principal Investigator (PI) will identify the issues to be explored in the discussions.
• Formulation of objectives relating to issues identified.
• The PI will develop a set of questions to provide direction for the discussions.
• The PI will identify the types of people who may be able to provide answers.
• Each focus group will comprise 6-9 persons.
• Participants to be selected will be heads of departments or supervisors.
• Focus group discussions will be held after all questionnaires are administered.
• Persons identified as potential participants will be sent a letter of invitation outlining the purpose of the discussion and what the results may be used for; the time, date and venue will also be included. Prospective participants will be assured of confidentiality. Telephone calls and personal contact will be used to remind those who responded positively to the invitation.
• A meeting room will be arranged. This room will be quiet, comfortable and free from outside distractions.
• Participants will sit around a table to ensure that they can see each other without having to turn around.
• Light refreshment will be provided.
• The facilitator/moderator (PI) will direct the discussion without being a part of it.
• The facilitator will create a relaxed and informal atmosphere conducive to free and spontaneous expression of feelings and views about asbestos.
• Open-ended questions will be used to generate discussion.
• All members of the group will be encouraged to participate.
• No one will be allowed to dominate the discussion.
• Each discussion will last for 60-90 minutes.
• The discussion will be tape-recorded (with the permission of the group).
• At the end of the discussion the facilitator will thank the group for attending and participating in the discussion.
APPENDIX T

SCHEDULE FOR COURSE ON ASBESTOS HAZARD ASSESSMENT/TRAIN THE TRAINER

University of Alabama at Birmingham/Ministry of Health, Jamaica: Asbestos Hazard Assessment /Train the Trainer Course
Venue: University of Technology, Jamaica (Off-site Campus, 21 Slipe Pen Road) Tuesday, July 19, 2005

Day 1: Tuesday, July 19, 2005
Facility Assessment

8:00 - 8:30 Registration
8:30 - 9:00 Opening Ceremony:
- Chairman – Henroy Scarlett
- Greetings – Mr. Peter Knight – Director, EHU, JMOH
- Greetings – Representative from NEPA
9:00 - 9:30 Pre-test
9:30 - 10:00 Introduction
A. Purpose of the Program
B. History of Asbestos
10:00 - 10:30 Health Effects
10:30 - 10:45 Break
10:45 - 12:00 Types of Asbestos and its uses
12:00 - 1:00 Lunch
1:00 - 1:30 Terms & Definitions
1:30 - 2:30 Inspecting for Friable and Non-Friable ACM
2:30 - 2:50 Break
2:50 - 4:30 Condition Assessment

Day 2: Wednesday, July 20, 2005
Facility Assessment

8:30 - 9:30 Response Actions
9:30 - 12:00 Air Monitoring and Calibration (Hands On)
12:00 - 1:00 Lunch
1:00 - 2:00 Personal Protective Equipment
2:00 - 3:00 Bulk Sampling Procedures
Day 3: Thursday, July 21, 2005
Facility Assessment

3:00 - 4:00  Presentation by Professor Kahwa
4:00 - 4:30  Discussion

8:30 - 9:00  Field trip instructions
9:30 - 12:00  Survey Field Trip
12:00 - 1:00  Lunch
1:00 - 2:00  Field Trip Discussion
2:00 - 3:00  Course Review
3:00 - 4:00  Post-Test
4:00 - 4:30  Final Discussion

Day 4: Friday, July 22, 2005
Trainer the Trainer: Safe Work Practices

8:30 - 10:30  Control Measures
10:30 - 11:30  Personal Protective Equipment (Respirators & Fit Testing)
11:30 - 12:00  Film Costal Video (Controlling Exposure) VHS
12:00 - 1:00  Lunch
1:00 - 1:30  Cleaning Up Small Spills and Debris
1:30 - 2:15  Glove Bag Method (5 Minute Demonstration Video)
2:15 - 2:45  Break
2:45 - 3:30  Small Scale Removal (5 Minute Demonstration Video)
3:30 - 4:30  Questions and Class Discussion
APPENDIX U
PRE-TEST/POST-TEST

UAB/MOH ASBESTOS TRAINING PROGRAM – JULY 19-22, 2005
FACILITIES INSPECTION FOR ASBESTOS CONTAINING MATERIALS
PRE-TEST/POST-TEST

Name: ________________________________

Time allowed: 45 minutes

Instruction: For each of the following items place a circle around the letter which indicates the best response

1. Cigarette smoking:
   a) causes collapse of the macrophages
   b) increases the production of lysozymes
   c) damages the cilia
   d) may cause mesothelioma

2. Epidemiological studies have shown that exposure to asbestos:
   a) may cause fibrosis of the lung which can be minimized by discontinuing exposure
   b) may cause pleural plaque fibrous thickening of the lining of the chest cavity
   c) has been linked to a rare form of cancer called mesothelioma
   d) all the above

3. The dose-response effect means that:
   a) occupants in buildings with ACM will most likely contract mesothelioma
   b) insulation workers who are non-smokers are at higher risks of having mesothelioma than smokers
   c) exposure to asbestos enhances the carcinogenic effects of other materials
   d) the greater the exposure the higher the risks
4. Building drawings showing beams, columns, bearing walls and foundations would typically be identified by what letter?
   a) A
   b) S
   c) H
   d) E

5. A building is a combination of what four basic building systems?
   a) controls, plumbing, mechanical, electrical
   b) architectural, controls, mechanical, electrical
   c) architectural, HVAC (mechanical), plumbing, electrical
   d) controls, electrical, mechanical, structural

6. Asbestos in plumbing systems is typically:
   a) for the purpose of temperature control on pipe runs and fittings.
   b) found on equipment which heat or chill water and/or maintain water at a stable temperature.
   c) limited to consumed and circulated water systems when used in insulation.
   d) a and b.

7. Working drawings, specifications, shop drawings and submittals:
   a) are excellent resources and may identify ACM by specification.
   b) should be made available to inspectors.
   c) may or may not reflect the building as it was constructed.
   d) all of the above.
8. Signs containing the words: CAUTION --ASBESTOS-- HAZARDOUS DO NOT DISTURB WITHOUT PROPER TRAINING AND EQUIPMENT:
   a) should be displayed at each regulated area and at all approaches to regulated areas.
   b) should be displayed where airborne concentrations of asbestos exceed the regulations.
   c) should be placed immediately adjacent to any friable and non-friable ACM as well as suspected ACM located in routine maintenance areas.
   d) all of the above.

9. An asbestos awareness training program:
   a) should be developed for all employees who are exposed to airborne concentrations of asbestos at or above regulations.
   b) should be developed for all maintenance and custodial employees
   c) is recommended for all current employees
   d) a & b

10. Which type of respirator has the lowest protection factor?
    a) Powered air-purifying (PAPR) helmet type.
    b) Air-purifying, full face mask with high efficiency filters.
    c) Air-supplied, continuous flow mask.
    d) Air-purifying, half mask with high efficiency filters.

11. Which type of respirator has the highest protection factor?
    a) Half mask with HEPA filters.
    b) Full face mask with HEPA filters.
    c) PAPR helmet type with HEPA filters.
    d) PAPR tight fitting mask with HEPA filters.

12. Asbestos is:
    a) naturally occurring mineral
    b) paper by-product
    c) a very tough form of fiberglass
    d) not a health hazard in its natural form
13. The most common type of asbestos is:
   a) Actinolite
   b) Tremolite
   c) Chrysotile
   d) Crocidolite

14. During the sampling process the proper type of personal respiratory equipment that should be worn is:
   a) a proper fitting high efficiency surgical mask.
   b) no protection is needed if the sample area is properly misted and the sample carefully collected.
   c) a type J respirator.
   d) a full or half-face mask with high efficiency disposable filters.

15. Laboratories selected to perform bulk sample analysis must:
   a) participate successfully in the QC program.
   b) have a microscopist with a BS in geology.
   c) be capable of producing sample analyses in 24 hours.
   d) there are no minimum requirements.

16. Inspecting a building for ACM is:
   a) a complex task and requires a great deal of planning and coordination.
   b) often difficult due to the variety of building types and building materials.
   c) sometimes incomplete because of poor planning.
   d) all of the above.

17. One of the first tasks an inspector should do when performing a building survey is:
   a) collect bulk samples.
   b) identify homogeneous materials and functional areas.
   c) make a physical assessment of the material.
   d) none of the above.

18. Clear, well kept records of asbestos related activities are important so that:
   a) lawyers can better use the information in court.
   b) building owners and users can accurately communicate building information to others and to each other.
   c) Government officials can audit them better.
   d) none of the above.
19. Building owners should:
   a) Remove all ACM as soon as financially feasible
   b) Inform occupants of presence and location of ACM
   c) Inform occupants of the need to avoid disturbing ACM
   d) B & C

20. Laboratory analyses of the split quality assurance samples should:
   a) not disagree on the presence or absence of asbestos.
   b) not disagree on the type of asbestos.
   c) A and B
   d) agree on the percent of asbestos within 2%.

21. To select sample locations:
   a) Study building as built drawings
   b) Interview persons familiar with building (owner, maintenance personnel, etc.)
   c) Inspect building thoroughly
   d) All the above

22. The purpose of quality assurance program for bulk sampling is:
   a) to make sure that you have enough samples for the selection area.
   b) to check on analytical variability within the same lab or between labs.
   c) to make sure that the correct statistical number of samples have been collected.
   d) to serve as a back up in case a sample is lost or mislabeled.

23. As part of an Inspection a Building Inspector should do all of the following except:
   a) Inspect the building for friable materials and materials of products which are likely to contain asbestos.
   b) Perform analysis on samples to determine the presence of asbestos.
   c) Delineate homogeneous areas and develop a sampling plan for bulk samples or assume material to be suspect.
   d) Collect information of the physical condition and location of all ACM.

24. The primary means by which material is deemed friable is:
   a) Comparing ratios of asbestos and non-asbestos minerals in an analyzed sample.
   b) By visual assessment of its condition.
   c) By touching the substance.
   d) By analyzing the results of air monitoring tests.

25. An assessment is necessary for:
   a) All material assumed to be ACM.
b) All friable ACM identified.
c) Any object observed next to ACM.
d) a and b.

26. Which of the following is not a major classification of suspect building materials?
   a) Surfacing material
   b) Cementeous products
   c) Thermal system insulation
   d) Miscellaneous materials

27. The difference between a damaged and a significantly damaged material is:
   a) Subjective, though based on % of damage.
   b) Water or physical damage.
   c) Friability or non-friability.
   d) Calculated using an approved algorithm.

28. TSI on pipes, tanks, boilers, etc. is considered friable:
   a) anytime it contains asbestos.
   b) if it has been damaged.
   c) if it is more than 10 years old.
   d) if it had been repaired.

29. Collecting bulk samples in a random manner
   a) makes findings statistically more accurate
   b) covers up areas where damage may occur due to collection damage
   c) makes the job much easier
   d) none of the above

30. Asbestos, a naturally occurring mineral, is found in:
   a) Thermal insulation products
   b) Acoustical materials
   c) Flooring covering materials
   d) All the above plus many more products
31. The best approach to handling public, employee, and building occupant relations when dealing with asbestos building inspections and related work involves three principles:
   a) Bring it up early
   b) Tell the truth
   c) Communicate with all affected parties
   d) All the above

32. Inspectors should have the following key items of information to be included in the inspection report:
   a) list of identified homogenous materials.
   b) physical assessment data.
   c) laboratory analysis.
   d) program for informing workers and building occupants of ACM locations.

33. The Building Inspector's report should include what types of information?
   a) Field data (i.e. sampling areas, functional areas, assumed ACM, etc.)
   b) Laboratory analysis results.
   c) Physical assessment data.
   d) All of the above.

34. A homogeneous sampling material is one that:
   a) has friable material of the same color.
   b) has friable and non-friable material that look the same.
   c) contains material that is uniform in texture, color and appears identical in every other aspect (including age).
   d) is strictly used for quality assurance sampling.

35. Which of the following should be included in the sampling drawing in the Survey Report?
   a) Description of area (building name, address, room(s) #, etc).
   b) Dimensions and scale.
   c) Name of inspector and date of inspection.
   d) All of the above.
36. The recommended number of bulk samples to be collected per homogeneous sampling area of surfacing material is:
   a) Four
   b) Nine
   c) Three
   d) Seven

37. The minimum number of bulk samples to be collected for a homogeneous sampling material of surfacing between 1,000 and 5,000 square feet is:
   a) Three
   b) Seven
   c) Nine
   d) Five

38. Selection of sample locations is best done by:
   a) using your personal experience and judgement.
   b) look for old wet spots and deterioration.
   c) collect minimum number of samples evenly throughout or use a random sampling scheme.
   d) ask the asbestos program manager to show you the most likely location.

39. Asbestosis is a disease
   a) caused by a scarring and stiffening of the lung by significant exposure to asbestos fibers
   b) which can be caused by a single exposure
   c) which typically takes 15-30 years after exposures to detect
   d) a & c

40. Asbestosis left undisturbed and contained
   a) is a great insulation and possesses little or no hazard
   b) should be removed immediately
   c) should be properly abated in the event of disturbance by renovation or significant disturbance
   d) will always remain in good condition
APPENDIX V

TRAINING EVALUATION FORM

UAB/MOH ASBESTOS TRAINING PROGRAM – JULY 19-29, 2005

TRAINING EVALUATION FORM

Course Objectives and Content

<table>
<thead>
<tr>
<th>Panel</th>
<th>Poor</th>
<th>Fair</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course objectives were clearly stated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Course objectives were achieved</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Topics presented were relevant to your work</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</tr>
<tr>
<td>The course was structured in a logical way</td>
<td>1</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>The course was easy to follow</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>The course was interesting and enjoyable</td>
<td>1</td>
<td>2</td>
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</tr>
</tbody>
</table>

Course Presentation

<table>
<thead>
<tr>
<th>Panel</th>
<th>Poor</th>
<th>Fair</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were the concepts explained clearly?</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>Were you encouraged to actively participate during the course?</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>Were your individual questions/problems discussed to your satisfaction?</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>How would you rate the presentation style of the trainer?</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>How would you describe the trainer’s knowledge of the subject?</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>Was the course well-paced?</td>
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<td>2</td>
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</tbody>
</table>
**GENERAL**

<table>
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<tr>
<th></th>
<th>Poor</th>
<th>Fair</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you feel you have gained new skills and knowledge?</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Would you recommend the course to others?</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Do you believe the skills you have learned will help you improve your performance on the job?</td>
<td>1</td>
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</tr>
<tr>
<td>Are the course materials easy to read?</td>
<td>1</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>Will you be able to use the course materials as a reference?</td>
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</tr>
<tr>
<td>Do you think the venue is suitable?</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Did you like the lesson time frame?</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Were your expectations met?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</tr>
</tbody>
</table>

Any additional comments on the course strengths or weaknesses?

- What did you like most about the course?
- What did you like least about the course?
- What suggestions would you make for improvement(s)?

THANK YOU
APPENDIX W

LABORATORY METHODS FOR ASBESTOS PCM AIR SAMPLES (NIOSH 582) AND PLM BULK SAMPLES (NIOSH 9002)


Instructor: Mr. Harold Jones

Agenda

Monday, July 25, 2005

9:00 - 9:30  Course Introduction

9:30 - 10:00  Phase Contrast Microscope
Reagents, mounting equipment

10:00 - 10:15  BREAK

10:15 - 12:00  Fiber concentration calculations
Fiber counting rules (A rules only)
Air sample prep and mounting technique

12:00 - 1:00  LUNCH

1:00 - 2:45  Calibration and quality control
Reading air samples & recording calculations

2:45 - 3:00  BREAK

3:00 - 4:30  Reading air samples and recording calculation

4:30 - 5:00  Comparing calculations with standard results
Tuesday, July 26, 2005

9:00 - 10:00  Mounting air samples for analysis
10:00 - 10:15 BREAK
10:15 - 12:00  Calibration and quality control
12:00 - 1:00  LUNCH
1:00 – 2:45  Reading air samples & recording calculations
2:45 - 3:00  BREAK
3:00 - 4:30  Reading air samples & recording calculations
4:30 - 5:00  Comparing calculations with standard results

Wednesday, July 27, 2005

9:00 - 9:30  Background information on Asbestos
9:30 - 10:00  Stereomicroscopic Analysis of Asbestos
10:00 - 10:15 BREAK
10:15 - 12:00  Stereomicroscopic Laboratory
12:00 - 1:00  LUNCH
1:00 – 1:45  Polarized Light Microscope set-up
1:45 – 2:15  Identification of Asbestos by PLM
2:15 – 2:45  Definitions of PLM terms
2:45 – 3:00  BREAK
3:00 – 5:00  Asbestos Identification Laboratory
Thursday, July 28, 2005

9:00 - 9:15  Opening Comments/Review
9:15 - 10:00  Dispersion Staining Theory and Application
10:00 - 10:15  BREAK
10:15 - 11:00  Friable and non-friable ACBM
11:00 - 12:00  Bulk sample Examination Methods
12:00 - 1:00  LUNCH
1:00 - 1:45  Quantification Techniques
1:45 - 2:30  Condenser and Objective lens alignment
2:30 – 2:45  BREAK
2:45 – 5:00  Bulk Sample Examination Laboratory

Friday, July 29, 2005

9:00 - 9:15  Condenser and Objective lens alignment
9:15 - 10:00  Bulk Sample Examination Laboratory
10:00 - 10:15  BREAK
10:15 - 12:00  Bulk Sample Examination Laboratory
12:00 - 1:00  LUNCH
1:00 - 2:30  Bulk Sample Examination Laboratory
2:30 - 2:45  BREAK
2:45 - 4:30  Bulk Sample Examination Laboratory
4:30 - 5:00  Final Quiz
APPENDIX X

FINAL EXAM ON PLM AND PCM

UAB/MOH ASBESTOS TRAINING PROGRAM – JULY 25-29, 2005
LABORATORY METHODS – PLM and PCM
FINAL EXAM

July 29, 2005

1) Which of the following is not a name for asbestos?
   a. actinolite
   b. amosite
   c. crocidolite
   d. serpentine
   e. chrysotile

2) If you collected a sample of 1220 liters of air at a flow rate of 2.5 liters per minute, how long did the sample run to the nearest 10 minutes?
   a. 560
   b. 320
   c. 120
   d. 490
   e. 240

3) What is an example of an isotropic mineral?
   a. quartz
   b. gypsum
   c. glass
   d. tremolite

4) If you collect a sample of two (2) liters of air in 29 seconds, what is the flow rate in liters per minute?
   a. 2.8
   b. 4.3
   c. 3.7
   d. 4.1
   e. 2.1
5) Which asbestos type has a negative sign of elongation?
   a. amosite
   b. chrysotile
   c. actinolite
   d. tremolite
   e. crocidolite

6) When the refractive index of a mineral is equal to the index of the refractive index oil, the mineral under the microscope will become
   a. fuzzy
   b. opaque
   c. transparent
   d. invisible
   e. reflective

7) Which of the following is the correct order for setting up the phase contrast microscope: 1) focus on the sample 2) center on the phase ring 3) center the field iris
   a. 1,2,3
   b. 2,1,3
   c. 3,2,1
   d. 1,3,2
   e. 2,3,1

8) Which of the asbestos minerals exhibits pleochroism in plane polarized light?
   a. chrysotile
   b. tremolite
   c. actinolite
   d. crocidolite
   e. anthophyllite

9) The OSHA standard for asbestos requires that in order to be counted, an asbestos fiber (under PCM) must be longer than
   a. 5 micrometers
   b. 2 micrometers
   c. 2.5 micrometers
   d. 1 micrometer
   e. 0.5 micrometers
10) What are the dispersion staining colors displayed for chrysotile under central stop using 1.55 refractive index oil?
   a. perpendicular - golden yellow, parallel - blue
   b. perpendicular - blue, parallel - magenta
   c. perpendicular – pale yellow, parallel – blue-gray
   d. perpendicular – vary pale blue, parallel – yellow
   e. perpendicular – magenta, parallel – blue

11) Name 3 “clues” to identify asbestos types of fibers with the use of a PLM microscope. (Three points)

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12) How are bulk samples of asbestos quantified and reported by the analyst?
   a. weight
   b. visual estimate
   c. size
   d. color

13) What is the extinction angle of Chrysotile asbestos?
   a. 90 degrees
   b. 45 degrees
   c. 30 degrees
   d. 60 degrees

14) What is the asbestos type designated for Amosite?
   a. serpentine
   b. amphiboles
   c. wavy
   d. undulating
15) What refractive index liquid is used for identifying Amosite asbestos?
   a. 1.55
   b. 1.68
   c. 1.605
   d. 1.250

16) What type of asbestos fibers are most often found in building materials?
   a. Crocidolite
   b. Amosite
   c. Chrysotile
   d. Anthophylite

17) Where is asbestos not used in the following building materials?
   a. concrete
   b. fireproofing material
   c. vinyl floor tiles
   d. glass windows

18) Which of the following fiber are isotropic?
   a. cellulose
   b. tremolite
   c. fiberglass
   d. chrysotile

19) Which of the following forms of asbestos is mined only in South Africa?
   a. Chrysotile
   b. Anthophylite
   c. Tremolite
   d. Amosite

20) Amphibole asbestos types of fibers have what morphological characteristic?
   a. straight fibers
   b. wavy fibers
   c. undulating fibers
   d. flat fibers
21) What is the most important consideration in making filter mounts?
   a. Cleaning the slide before mounting
   b. Avoiding having air bubbles under the cover slip
   c. Don’t disturb the filter
   d. Proper labeling of the slide

22) The two chemicals necessary for asbestos air samples mounting are:
   a. Hydrochloric acid and acetone
   b. Triacetin and acetone
   c. Serpentine and amphibole
   d. Sulfuric acid and nail polish

23) What is the proper diameter of the Walton-Beckett graticule?
   a. 100 microns
   b. 385 microns
   c. 22 microns
   d. 0.00785 microns

24) What is the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for asbestos?
   a. 0.01 f/cc
   b. 1.0 f/cc
   c. 0.1 f/cc
   d. 0.5 f/cc

25) When performing a PCM fiber count, we must count a minimum of:
   a. 100 fields
   b. 20 fields
   c. 100 fibers
   d. 20 fibers

26) If a field blank yields greater than 7 fibers in 100 fields, you should report:
   a. Possible contamination
   b. Overloading of the filter
c. Poor quality of the filter
d. Sampling error

27) If a pump with a flow rate of 40 lpm runs for ½ an hour, what volume of air would be collected?

a. 12,000 liters
b. 20 liters
c. 120 liters
d. 1,200 liters

28) Which of the following about PCM is true?

a. PCM will identify the type of asbestos fiber present
b. PCM analysis is more expensive than TEM
c. PCM does not identify the type of asbestos fiber present
d. PCM uses a magnification of greater than 100X