# Exposure to Airborne Asbestos in Jamaican Hospitals

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***ABSTRACT***

***Objective:*** *Asbestos is an established human carcinogen and has been identified at 16 of 26 Jamaican hospitals surveyed. We sought to determine if hospital employees are exposed and if current asbestos exposure in Jamaican hospitals differed by job category.*

***Method:*** *At two of the largest hospitals with more than 10 permanent maintenance workers and where over 67% of bulk samples analysed contained asbestos, three groups of employees selected by stratified random sampling participated in a personal air sampling study for asbestos. One hundred and thirty-two personal air samples and 32 area samples were collected and analysed for asbestos fibres utilizing phase contrast microscopy (PCM) and transmission electron microscopy (TEM).*

***Results:*** *Twenty-four (14.6%) air samples had fibre counts above the limit of detection (LOD) for the analytical method (PCM), ranging from 0.002 f/cc to 0.013 f/cc. The fibres met the dimensional characteristics of asbestos fibres. There was no difference in the median fibre concentration to which the groups of employees were exposed. Further testing of samples which had fibre counts above the LOD using TEM confirmed that the fibres were not asbestos.*

***Conclusion:*** *Despite not finding asbestos fibres in the air samples, most of the asbestos containing building material (ACBM) found in the hospitals was friable and in a poor condition indicative of fibre release. We recommend an ongoing monitoring programme for airborne asbestos fibres in hospitals until an abatement programme can be undertaken by the regulatory agencies in the country.*

**Keywords:** Asbestos, exposure, Jamaican hospitals, personal air sampling

# Exposición al Asbesto Suspendido en el Aire en Hospitales de Jamaica

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***RESUMEN***

***Objetivo:*** *El asbesto, también llamado amianto, es un carcinógeno humano conocido, y ha sido identificado en 16 de 26 hospitales jamaicanos investigados. El presente trabajo tuvo por objeto determinar si los empleados del hospital están expuestos al asbesto, y si la exposición actual de asbesto en hospitales jamaicanos difiere según la categoría del trabajo.*

***Método:*** *En dos de los hospitales más grandes con más de 10 obreros de mantenimiento permanentes y dónde más del 67% de las muestras a granel analizadas contenían asbesto, tres grupos de empleados seleccionados por muestreo aleatorio estratificado participaron en una investigación de muestreo de aire personal en busca de asbesto. Ciento treinta y dos muestras de aire personal y 32 muestras de área fueron recogidas y analizadas en busca de fibras de asbesto, utilizando microscopía de contraste de fases (MCF) y microscopía electrónica de transmisión (MET).*

***Resultados:*** *Veinticuatro (14.6%) muestras de aire tuvieron un conteo de fibras por encima del límite de detección (LDD) para el método analítico (MCF), que fluctuaba de 0.002 f/cc a 0.013 f/cc. Las fibras correspondían a las características dimensionales de las fibras de asbesto. No hubo diferencias en la concentración mediana de las fibras a la que los grupos de empleados estaban expuestos. Pruebas posteriores con las muestras que arrojaron conteos de fibras por encima del LDD usando la MET, confirmaron que las fibras no eran de asbesto.*

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***Conclusión:*** *A pesar de que no se encontraron fibras de asbesto en las muestras de aire, la mayor parte de los materiales de construcción que contienen asbesto (ACBM) hallados en los hospitales eran friables y estaban en mal estado, dando ya señales de desprendimiento de fibras. Se recomienda un programa de monitoreo de fibras de asbesto suspendidas en el aire en los hospitales hasta que pueda emprenderse un programa de eliminación de las mismas por parte de las agencias reguladoras del país.*

**Palabras claves:** Asbestos, exposición, hospitales de Jamaica, muestreo de aire personal

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## INTRODUCTION

The term asbestos is a generic one referring to six types of naturally occurring mineral fibres. Asbestos fibres exhibit properties such as incombustibility, thermal stability, resistance to biodegradation, chemical inertia toward most chemicals and low thermal conductivity (1). Asbestos is an established human carcinogen (2). Globally, an estimated 125 million people are still occupationally exposed to asbestos (3). About 100 000 deaths annually worldwide are due to asbestos (4). Occupational exposure to asbestos could be responsible for 5−20% of lung cancers and 80−90% of pleural mesothelioma, in men in industrialized countries (1). The incidence of pleural mesothelioma in these countries is 1−1.5/100 000 in men and 0.5/100 000 in women (5). The risk of cancer is positively correlated with cumulative exposure. There is no threshold below which there is no increased risk of respiratory cancer (1). There is now sufficient evidence to suggest that asbestos also causes cancer of the larynx and of the ovary (6).

Potential sources of occupational and environmental asbestos exposure include asbestos-containing products, asbestos removal, asbestos in public buildings and family members of persons occupationally exposed, asbestos production and transport (7). The level of exposure to asbestos in North America is dependent on location and occupational exposure is the greatest, followed by neighbourhood/ domestic exposure, exposure in urban areas and rural/ background exposure (8).

Asbestos fibres vary with respect to size (length and diameter) and chemical composition. Fibre diameter is the most important factor determining penetration and deposition in the lungs. Thin fibres have the greatest inhalation potential and may be deposited very deep in the lungs. Long (≥ 8 µm in length) and thin (≤ 1.5 µm in width) asbestos fibres are thought to pose the greatest cancer risks (1, 9). However, short, thin, asbestos fibres appear to contribute to the causation of human malignant mesothelioma (10).

In humans, the nose effectively filters out compact fibres longer than 5 µm (11, 12) or these fibres are eliminated by the mucociliary transport, translocation to lymph nodes, migration, diffusion and dissolution in body fluids (11, 13) and for particles shorter than 5 µm there is peripheral deposition in the lung (11). Inhaled asbestos fibres that reach the respiratory bronchioles are engulfed by macrophages and transformed to asbestos bodies. The presence of "asbestos bodies" in sputum is indicative of asbestos exposure but not necessarily indicating a pathological process (11). The lung parenchyma is the main storage compartment for asbestos fibres (14).

### Jamaican situation

Two asbestos factories operated in Jamaica in the past (15). Asbestos was first reported in Jamaica hospitals about ten years ago (16). A recent survey conducted in 26 Jamaican hospitals found asbestos containing building material (ACBM) in 16 [61.5%] (17). The types of asbestos fibres identified in the ACBM were chrysotile, amosite and crocidolite. Other materials in the ACBM were fibreglass, mineral wool, cellulose, binder, synthetic fibres and calcium carbonate minerals.

The condition of asbestos in a building influences a worker's potential exposure. Maintenance workers and others in hospitals are potentially exposed to asbestos (16−17). Historically, most asbestos-related diseases are associated with working with ACBM. However, there are documented cases where exposure and asbestos-related conditions occurred as a consequence of working in a building where asbestos was present instead of working actively with asbestos (18−21). The aim of the study was to determine if asbestos exposure was occurring in Jamaican hospitals and if the exposure differed by job category.

## METHODS

Two of Jamaica largest hospitals, "X" and "Y" were selected for this study. A recent study found that 23 (67.6%) of 34 bulk samples collected from these institutions contained asbestos (17). Maintenance workers were of prime interest in the study, and only the larger hospitals where asbestos was identified, and which had 10 or more maintenance workers qualified for inclusion. The study protocol was approved by the Institutional Review Board (IRB) at the University of Alabama at Birmingham and the Ethics Committee of The University of the West Indies/University Hospital of the West Indies and the Ministry of Health and Environment, Jamaica.

Hospital X is a type "A" public/private hospital which is among the most technologically advanced on the island. It has over 400 beds and was constructed in the 1950s. Hospital Y, built in the 1970s is also a type "A" public institution with over 500 beds. Both hospitals serve as referral facilities for secondary and tertiary services. The staff complement at both hospitals is about 1000.

A recently updated lists of hospital employees served as the sampling frame. The general approach to subject selection was stratified random sampling at each hospital. We selected subjects for personal air sampling randomly from each of three job groups. The three job groups, defined on the basis of their potential for exposure to asbestos were maintenance workers, other non-professional workers and professional workers. Maintenance workers, considered as the group with the most potential for exposure to asbestos fibres, comprised boiler operators, pipe fitters, electricians, plumbers and carpenters. Other non-professional workers, considered to have low potential for exposure, were comparable to maintenance workers in terms of sociodemographics and period of employment. This group included male porters, sanitation workers and security guards. Professional workers, also presumed to have low potential for exposure, included professional caregivers (doctors and nurses), laboratory workers (medical technologists, laboratory technicians), radiographers and pharmacists. Doctors, nurses and medical technologists were further stratified by the department/ward where they worked and participants were randomly chosen. This group of employees, although of higher socio-economic status than the other two groups was included as it was important to ascertain their exposure to airborne asbestos because they comprised the majority of hospital employees.

A sampling protocol developed by the United States of America (USA) National Institute for Occupational Safety and Health (NIOSH) (22) was utilized and 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. 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.

NIOSH Method # 7400 (23) was used as the sampling and analytical method (SAM). The sampling procedure was explained to each participant and informed consent was obtained. Each sampling pump was calibrated before and after monitoring with a cassette in line at approximately 2 L/min. Samples were collected at flow rates of approximately 2 L/min. Samplers were attached to each participant and worn continuously during all work and rest operations. The sampling strategy employed was a full shift single sample measurement for eight hours for the 8-hour standard of 0.1 fibre/cc. Samples were collected from each group of employees 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 then two different maintenance workers were sampled each day for five days. The samplers worn by employees were checked at regular intervals to rule out malfunctioning. Workers who left the hospital during lunchtime had their pump turned off, removed and re-fitted on their return. At the end of sampling, cassettes and filters were handled in a manner to prevent contamination and labelled to indicate date, pump serial number, flow rate, start and ending time.

A total of 132 personal air samples were collected from both hospitals during the period July 10, 2006, to January 18, 2007. A field blank was submitted for approximately every ten samples in the batch collected. The samples and chain of custody forms were shipped to Safety Environmental Laboratories Inc., Birmingham, USA, for analysis. This laboratory is accredited by the American Industrial Hygiene Association (AIHA).

Thirty-two area samples were taken with a pump, tubing and filter cassette placed at breathing zone height at some stationary locations within the hospitals. Area sampling was done to estimate the existing airborne asbestos fibre concentration inside work areas where ACBM was identified but where workers did not necessarily remain for the duration of the work shift, such as boiler rooms. A high-volume sampler collected each sample for two hours at flow rates of approximately 12 L/min. The sampler was calibrated pre- and post-sampling. Samples were analysed by the same laboratory used for personal air samples. The SAM used by the laboratory was NIOSH Method: 7400, Issue 2 – Asbestos and Other Fibres by PCM using the "A" rules (23).

Approximately, 50% of the personal air samples (11 of 23) and the single area sample that tested positive for fibres using PCM were further analysed by Transmission Electron Microscopy [TEM] (24) to confirm if the fibres detected by PCM were asbestos.

Fibre 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. Students' *t*-tests were used to determine whether the mean concentration of fibres varied significantly by group of employees.

A job fibre exposure table was constructed to determine if current fibre exposure in the hospitals differed by job category. Of particular interest was the relation between current fibre 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 were used to characterize the exposure for each group of workers. For fibre concentrations that were below the LOD for the SAM used; we adopted a procedure that assigned one half of the value of the fibre concentrations below the LOD to represent the exposure concentration of each worker whose reading was below the LOD (25). For example, if the fibre concentration was < 0.002 f/cc, 0.001 f/cc was used as the fibre concentration level.

Job group was the unit of analysis. The mean, standard deviation, median and interquartile range of fibre measurements for each of the three major job groups and for subgroups for which an adequate number of samples were obtained, was computed.

## RESULTS

Of the 163 air samples (personal and area), 24 (15%) had fibre concentrations above the LOD ranging from 0.002 f/cc to 0.013 f/cc while 139 (85%) had fibre concentrations below the LOD. One damaged sample was not analysed. Of the 24 samples that tested above the LOD, 23 (96%) were personal air samples. The assumed concentrations for those that measured below the LOD and those above the LOD are given in Table 1. Approximately 83.5% of fibre concentrations were 0.002 f/cc or less. The mean fibre concentration was 1.9 x $10^{-3}$ f/cc of air (SD = 0.0014). The median concentration was 1.5 x $10^{-3}$ f/cc while the range and interquartile range were 0.012 and 0.0005, respectively. Fibre concentrations at hospital X were more likely to be higher than at hospital Y ($p = 0.026$).

Table 1: Frequency distribution of fibre concentrations using one half of the value for those concentrations below the LOD

| Fibre concentration (f/cc) | Frequency | Per cent |
|---|---|---|
| 0.001 | 19 | 11.7 |
| 0.0015 | 93 | 57.1 |
| 0.002 | 24 | 14.7 |
| 0.0025 | 4 | 2.4 |
| 0.003 | 7 | 4.3 |
| 0.004 | 7 | 4.3 |
| 0.005 | 5 | 3.1 |
| 0.006 | 2 | 1.2 |
| 0.009 | 1 | 0.6 |
| 0.013 | 1 | 0.6 |
| **Total** | **163** | **100.0** |

Most of the estimated 8-hour time-weighted average (TWA) for personal air samples provided by the laboratory was below the LOD. All but one of the fibre concentrations were below the Occupational Safety and Health Administration's (OSHA's) Action Level and PEL (permissible exposure limit) of 0.01 f/cc and 0.1 f/cc respectively for asbestos (Table 2).

Table 2: Frequency distribution of estimated 8-hr time-weighted average (TWA) for 131 personal air samples

| Estimated 8-hour TWA (f/cc) | Frequency | Per cent |
|---|---|---|
| < 0.002 | 24 | 18.32 |
| < 0.003 | 84 | 64.12 |
| 0.003 | 12 | 9.16 |
| 0.004 | 8 | 6.11 |
| 0.006 | 1 | 0.76 |
| 0.007 | 1 | 0.76 |
| 0.013 | 1 | 0.76 |
| **Total** | **131** | **100.00** |

Approximately 98% of the hospital employees had estimated 8-hour TWA of ≤ 0.004 f/cc of air. The overall mean estimated 8-hour TWA was 1.85 x$10^{-3}$ f/cc (SD = 0.0013); the median and mode were identical (1.5 x $10^{-3}$ f/cc). The estimated 8-hour TWA at hospital X was 1.7 x $10^{-3}$ f/cc while at hospital Y it was 1.4 x $10^{-3}$ f/cc. For approximately 98% of the samples, the exposure to fibres was considered to be very low/none as fibre concentrations were below the LOD for the SAM and for the other 2%, the exposure was considered low as the fibre concentrations were above the LOD for the method but less than the Action Level of 0.01 f/cc of air.

There was no difference in the median fibre concentration to which the three groups of employees were exposed. Medical technologists had the highest mean level of exposure to fibres (2.7 x $10^{-3}$ f/cc). One member of this group had the highest overall measured fibre concentration [0.013 f/cc] (Table 3).

Further testing of 11 of the 23 personal air samples with the highest fibre counts above the LOD and the only area sample whose concentration was above the LOD by

Table 3: Distribution of airborne fibre exposure (f/cc) by group of hospital workers

| Job Category | Exposure concentration (fibre/cc) Minimum value | Maximum value | Median value | Arithmetic mean |
|---|---|---|---|---|
| **Maintenance workers (Males)** | **0.001** | **0.003** | **1.5 x $10^{-3}$** | **1.8 x $10^{-3}$** |
| **Non-professionals** | **0.001** | **0.007** | **1.5 x $10^{-3}$** | **1.7 x $10^{-3}$** |
| – Male porters | 0.001 | 0.007 | 1.5 x $10^{-3}$ | 2.3 x $10^{-3}$ |
| – Male security guards | 1.5 x $10^{-3}$ | 1.5 x $10^{-3}$ | 1.5 x $10^{-3}$ | 1.5 x $10^{-3}$ |
| – Male sanitation workers | 0.001 | 1.5 x $10^{-3}$ | 1.5 x $10^{-3}$ | 1.4 x $10^{-3}$ |
| **Health professionals** | **0.001** | **0.013** | **1.5 x $10^{-3}$** | **1.8 x $10^{-3}$** |
| – Doctors | 0.001 | 0.006 | 1.5 x $10^{-3}$ | 1.7 x $10^{-3}$ |
| – Nurses | 0.001 | 0.004 | 1.5 x $10^{-3}$ | 1.3 x $10^{-3}$ |
| – Medical Technologists | 1.5 x $10^{-3}$ | 0.013 | 1.5 x $10^{-3}$ | 2.7 x $10^{-3}$ |
| – Pharmacists | 0.001 | 0.003 | 1.5 x $10^{-3}$ | 1.5 x $10^{-3}$ |
| – Physiotherapists | 0.001 | 0.003 | 1.5 x $10^{-3}$ | 1.6 x $10^{-3}$ |

TEM confirmed that fibres detected by PCM were not asbestos.

## DISCUSSION

This is the first study of its kind to be conducted in Jamaica to determine if hospital employees were exposed to airborne asbestos. The strengths of the paper are that we were able to conduct quantitative personal measurements for asbestos exposure. These measurements are considered to be the best measurement of exposure. Also the samples were analysed by an accredited laboratory which gives confidence in interpretation of results. The major weaknesses were that the air sampling was done in only two hospitals and was a one-time exercise and results are not generalizable to the other hospitals.

Initial analysis of air samples by PCM indicated the presence of fibres meeting the criteria for asbestos in 15% of the samples. The fibre concentrations were below OSHA's Action Level of 0.01f/cc (in all but one case) and PEL of 0.1f/cc. However none of the fibres detected were confirmed to be asbestos. Evaluations conducted in hospitals in Barados and the USA using PCM revealed asbestos fibre concentrations similar to fibre concentrations found in this study while in some cases OSHA's Action Level and PEL were exceeded (25−28). In those situations, unlike in our study, active demolition and construction activities were taking place which obviously disturbed ACBM causing fibre release. Also other categories of ACBM such as surfacing materials (ACBM sprayed or troweled on surfaces such as walls, ceilings, and structural members for acoustical, decorative, or fireproofing purposes) and miscellaneous materials (floor tiles, ceiling tiles, roofing felt *etc*.) are widely used in construction in the USA, unlike in Jamaica where ACBM is primarily used as thermal system insulation (TSI). Yet in most cases in investigations in the USA, the asbestos fibre concentrations were below OSHA's PEL. In other investigations reported (1) where there was building maintenance and asbestos abatement activities in progress, results of air sampling analysis revealed that asbestos fibre concentrations exceeded the OSHA PEL. The reports did not state if any hospital buildings were involved. In the present study, there were no demolition/construction activities occurring simultaneously with data collection that could disturb ACBM.

Current levels of asbestosis, mesothelioma and other asbestos-related diseases in Jamaica are unknown but thought to be extremely low. Two cases of asbestosis and five cases of mesothelioma were diagnosed at two hospitals in Jamaica between 1971 and 1995 (29, 30). None of these cases were hospital workers. Evidently, even though the ACBM found in the hospitals was in very poor condition, the disintegration process appeared to be slow and sporadic. This coupled with the fact that asbestos at the hospitals were located in areas that were largely open or isolated from the general workforce and the excellent natural ventilation in hospitals, could probably explain why asbestos fibres were not detected. So despite the confirmed presence of ACBM 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 ACBM and exposure to other types of fibres found in the ACBM exists. The fibres detected in this study more than likely came from materials such as fibreglass, mineral wool and other synthetic fibres which belong to the group called man-made vitreous fibres (MMVF) and are widely used as insulation and construction materials. It is postulated that MMVF produce biological activity in both animal and human lung tissue and there is epidemiological evidence that MMVF caused malignancy (31).

We recommend ongoing monitoring for airborne asbestos fibres in the two hospitals investigated until an abatement programme can be undertaken by the regulatory agencies. While no asbestos airborne fibres were detected at 2 of 16 hospitals with asbestos in this study, we do not know the risk of airborne asbestos exposure in the remaining 14 facilities. We urge the authorities to undertake air sampling in these hospitals to determine if asbestos poses a risk and also to implement abatement activities.

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