Biological and Social Impacts of Naturally Occurring Asbestos in El Dorado County, California

McGill University

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Environmental Research

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Executive Summary

This paper discusses the results of biological and social research regarding naturally occurring asbestos (NOA) in El Dorado County, California. The approach taken was twofold, incorporating both the biological and social components of this issue. First, we sought to determine if there is a biological hazard associated with living in proximity to sites where naturally occurring asbestos is present. We evaluated this by collaborating with several other researchers and furthering their work, which consisted of examining dog lung tissues from El Dorado County. We supplemented their research by examining lung tissues from two control dogs from areas in Québec where NOA is not found: Île-Perrault and Gaspé. We then compared them to the lung tissues obtained from El Dorado County. We found that an increased amount of NOA fibres in dog lungs is representative of the presence of NOA in the environment. From our results it is possible to postulate that dogs may be suitable proxies for the amount of asbestos fibres in human lungs and we conclude that there is evidence of biological hazard associated with living near NOA in the environment we examined.

In the second component of our study, we assessed the perceptions of selected residents of El Dorado Hills, a town located in El Dorado County, on the subject of the presence of naturally occurring asbestos. Previous research in and near this community had focused solely on the perceptions of highly engaged stakeholders in the asbestos issue, including community activists, as well as county, state, and government officials. It did not include

survey of the opinions of the general public of El Dorado County. To assess the opinions of citizens, we distributed surveys directly to residents by traveling to California. The results suggest that a majority of people surveyed believe that there are health risks associated with NOA exposure in this region but that many are unwilling to take action to prevent or minimize their risk.

Introduction

Asbestos is a common term used to denote a group of commercial minerals that have non-metallic, fibrous qualities (Thompson et al, 2002). These minerals are characterized by their high tensile strength, flexibility, low thermal and electrical conductivity, high absorbency, high thermal stability, and natural resistance to acids and bases (Van Orden et al. 2008; Ross et al. 2007). Until the 1970s, asbestos was widely used in the developed world for a variety of products. Its chemical and physical properties and high availability made it a useful and cost-effective material. Although less common today, at one time, the construction of homes, ships, and automobiles depended on the use of asbestos for insulation, pipe coverings, cement, and many other types of industry. Although there is unequivocal evidence that there are health risks associated with asbestos exposure, there is often confusion surrounding these risks because of the complex nature of the subject.

The confusion surrounding asbestos is exemplified by the variety of opinions that exist regarding this term. Martin Harper defines asbestos as "certain minerals that have crystallized in a finely fibrous habit, in bundles of easily separable fibers and/or fibers which are composed of smaller diameter fibrils, and with a hair like elongated shape resembling organic fibers, with exceptionally smooth faces and displaying unusual adamantine or silky luster" (2008). Two general forms of asbestos-containing rocks include serpentine and amphibole (Mahini 2005). Within the serpentine group, there is one form of asbestos, chrysotile, and within the amphibole group there are five officially regulated types: crocidolite, amosite, and when asbestiform tremolite, actinolite,

anthophyllite (Levadie 1984; Swayze et al. 2004). These minerals are differentiated on the basis of their physical and chemical properties. Amphiboles include silicates of calcium, magnesium, iron, sodium, and aluminum, whereas serpentine includes hydrous magnesium silicates (Thompson et al. 2002). Usually the definition of asbestos fibres are based on their chemical structure and aspect ratio (Van Orden et al. 2008), however a universal classification system that could be used to identify a fibre as being "asbestos" is currently lacking (Lowers et al. 2002). As a result, there is still much debate among experts as to whether certain morphological structures in amphibole, serpentine, and other rock types are qualified as asbestos (Meeker et al. 2006). This paper will use the term "asbestos" in a commercial context, and "asbestos fibres" as a term for either commercial or naturally occurring asbestos fibres.

Naturally occurring asbestos (NOA), the focus of this study, is a term used to denote asbestos-containing rock that is observed in its natural state, meaning that it does not apply to asbestos that is mined for commercial purposes (California Department of Conservation 2006; Lee et al. 2008). Natural weathering, erosion, and human activities can disturb the NOA-bearing rocks which release the mineral fibres into the soil, water, air, and thus possibly into the lungs of both people and animals (Bradley et al. 2007; EPA 2008b). In California, it was found that NOA is present in 50 out of the 58 counties (California Department of Conservation 2006). However, the asbestos fibre types that are most prevalent differ in relative frequency from one county to another. Therefore,

because each fibre type is associated with varying degrees of risk to human health, certain counties are of greater concern to researchers than others.

El Dorado Hills, located within El Dorado County, is of particular interest because it is a rapidly-growing community where large amounts of tremolite asbestos have been found in the soil in some areas and in other areas nearby (EPA 2005). Located in part in the Bear Mountain Fault zone, El Dorado County has several fault lines running through it (see Map 1 in Appendix C) making the area geologically predisposed to contain NOA due to the metamorphic nature of asbestos-containing rocks (Stewart 2003). While many California counties contain naturally occurring chrysotile, tremolite, and actinolite, El Dorado County is of concern due to the rapid rate of development relative to other counties with similar issues. Tremolite asbestos is of greatest concern in El Dorado County because of its relative abundance and because it is more associated with mesothelioma at lower exposure levels than other fibre types; specifically, chrysotile.

There are notable differences between the kinds of health effects associated with exposure to NOA when comparing them to occupational exposure. The known risk of developing a disease from NOA exposure has so far been found to be smaller than the risk faced by those who work, or have previously worked with asbestos (Iwatsubo et al. 1998). This is a major problem for residents of El Dorado County, for some may argue that they are not at risk of developing an asbestos-related disease because they do not work with asbestos, and because it is inherently difficult to quantify the health risks due

to the considerable amount of time in which it takes for a disease to develop ("latency"). NOA exposures can be even harder to quantify due to the personal nature of exposure and the frequent unawareness of its presence. While some residents of El Dorado County are not concerned with the presence of NOA in their community, others are trying to change the situation by raising awareness and by requesting the aid of county, state, and federal officials in trying to resolve potential NOA problems.

Description of Clients and Interests

Our clients include Dr. Jerrold Abraham, a professor of Pathology at the State University of New York in Syracuse, in association with Dr. Bruce Case, a Pathology and School of Environment professor at McGill University, as well as a group of El Dorado County residents. In addition to Dr. Abraham and Professor Case, we were in contact with the following people: Chris Anaya, Alice Howard, Lance McMahan, Vicki Summers, and Terry Trent—who are all current or former residents of El Dorado County—as well as Dr. Marci Culley, a psychologist from Georgia State University who has been studying some of the social aspects of the problem in El Dorado County. These particular people are interested in aiding our project either because the issue pertains to their academic research or because of personal concerns relating to NOA in El Dorado County. Dr. Abraham and Dr. Case are performing ongoing research regarding the amount of asbestos fibres found in pet lungs from El Dorado County. Doctors Abraham, Case, and Culley are studying the problem from an outsider's perspective, whereas Mr. Anaya, Ms. Howard, Mr. McMahan, Ms. Summers, and Mr. Trent are involved in the subject as concerned residents or former residents. The concerns of these individuals lie not only with the health hazards of living in such close proximity to a toxic substance, but also with the conflicts surrounding NOA that have arisen in their community.

Background / Literature Review

Biological

Naturally occurring asbestos is a relatively rare phenomenon, and background levels of asbestos in the air are typically very low, ranging from 0.00001 to 0.0001 fibers/mL (ATSDR 2001). While the ambient air concentrations in different parts of El Dorado County may differ greatly, in a study conducted in 2005, the EPA found elevated concentrations of fibres in El Dorado Hills from fixed air sampling. They found even higher levels from activity based sampling, which involves collecting air samples during the simulation of everyday activities (EPA 2005b). Although results depended on location, the highest value that the EPA obtained from fixed air sampling in this region was 0.0017 f/cm^3, and during their activity-based sampling while biking at the same location they obtained a value of 0.0336 f/cm^3 (that is, about a twenty-fold increase over static samples (EPA 2005b)).

Asbestos fibres present in the air can be inhaled and directed through the respiratory tract. They can be deposited on the surface of the airway and swallowed or cleared by mucus. However, if the asbestos fibres make their way to the lungs they may either become lodged in the bifurcations of the tracheobronchial tree or, depending on dimensions, travel towards the alveolar sacs. The lungs have several defences, including mucociliary transport, phagocytosis by macrophages, and lymphatic mediated clearance (Dodson & Hammar 2005). The degree of bio-persistence of asbestos fibres in the lungs is

dependent on fibre properties, such as the length and type. For example, it has been found that longer (>5µm), amphibole fibres are more difficult to eliminate than the shorter serpentine ones (ATSDR 2003). Other factors such as co-exposure to other contaminants such as cigarette smoke and respiratory conditions like asthma can negatively influence the clearance of fibres from the lung (ATSDR 2003).

Exposure to asbestos can lead to several diseases, most predominantly asbestosis, lung cancer and mesothelioma (Doll et al. 1985). Asbestosis is a scarring of the lung tissue which impairs oxygen diffusion to the blood resulting in shortness of breath and crackling-like sounds when breathing. Lung cancer and mesothelioma patients have uninhibited growth of cancer cells resulting in a tumour in the lung tissue or related to mesothelial linings of the pleural or peritoneal cavities, respectively. While the International Labour Organization estimates that 100,000 deaths per year worldwide are a result of occupational asbestos exposure, the rates from naturally occurring asbestos are more difficult to ascertain. Although there are several hypotheses, the mechanisms of asbestos toxicity at the molecular and cellular levels are still unknown.

It has been found that the risk of developing an asbestos-related disease depends on several factors, including the duration and frequency of asbestos fibre exposure (Health Canada 2008). The exposure of those living close to NOA deposits (if they are disturbed and the fibers inhaled); or more certainly for those who work in mines without respiratory protection is increased with respect to both of these variables and therefore these

individuals may face a higher risk of developing a disease. However, even under conditions of high exposure, asbestos-related diseases often take decades to develop. Although an individual may be exposed for years without immediate consequences to their health, the risk of disease increases exponentially as time passes since the initial exposure (Doll et al. 1985; Seidman et al. 1982). Research suggests that long term low-level exposure to NOA may be related to an increased risk of pleural mesothelioma (Pan et al. 2005), while high level exposure, especially in conjunction with smoking, is associated with higher risk of lung cancer (ATSDR 2001).

In addition to morphological features of asbestos fibre such as length, the *type* of asbestos fibre also determines its pathogenicity. For example, exposure to amphibole asbestos types can result in a higher risk of developing mesothelioma than exposure to chrysotile. Tremolite has been associated with mesothelioma due to environmental as opposed to workplace exposure, for it is sometimes an unintended contaminant of other materials like chrysotile, vermiculite, and talc in the mining environment (Ross 1984). For example, studies have shown elevated incidences of mesothelioma in Libby, Montana, where vermiculite workers were exposed to tremolite asbestos (ATSDR 2001); subsequently described more accurately as “Libby Amphibole”. This particular correlation has also been studied in rural Greece, Corsica and Turkey, where naturally occurring tremolite surface deposits have been found or whitewashes containing tremolite have been used to paint interior walls (Dumortier et al. 2002).

As stated previously, several agencies in the area of El Dorado County, including the U.S. Environmental Protection Agency (EPA), have documented the presence of asbestos in exposed soils and ambient air in the County. However, there has been no previous research on the actual uptake of asbestos into lung tissues in this area. Our study is concerned with the relationship between the amount of asbestos fibres in the environment and the quantity found in the lungs. Studies have shown that higher asbestos air concentrations lead to a greater concentration of asbestos fibres in the lungs, hereby referred to as the "lung burden" (Magnani et al. 1998). Several studies in the past have used animals as bio-indicators of asbestos exposure in humans (Glickman et al. 1983; Dumortier et al. 2002). In the more recent study, a $4cm^2$ sample of lung tissue was examined in eight exposed goats and two control goats from Corsica. Elevated levels of tremolite and chrysotile fibres in the lungs of the exposed goats were found, suggesting that animal lung burden can be used as model for human exposure in a given location (Dumortier et al. 2002). Although we are not directly concerned with the occurrence of mesothelioma in the area, our study has direct implications on the resident population and their risk of developing the disease of mesothelioma, since it is associated with tremolite.

Background / Literature Review

Social

Information regarding a number of issues such as NOA regulation, health issues, and methods of minimizing exposure has been made available to residents of El Dorado County on the county's website (http://www.co.el-dorado.ca.us/emd/apcd/asbestos.html) as well as that of the Environmental Protection Agency's (EPA) for El Dorado Hills (http://www.epa.gov/region09/toxic/noa/eldorado/index.html). In spite of these resources, awareness of El Dorado Hills citizens about NOA-related hazards is variable and the issue remains a contentious one. This is demonstrated in the transcripts from meetings between residents and different state and federal agencies that are included on these websites and others. One example is a letter written by Vicki L. Barber, an El Dorado County Superintendent of Schools, on May 11, 2005, which was posted along with other comments on the El Dorado County Office of Education website (http://www.edcoe.org/asbestos/noa.html). In this letter, Ms. Barber requested that State legislators, Chairwoman Ortiz and Senator Cox, make the following information available: the definition of the level of health risk from NOA exposure, the testing methods used to provide reproducible results, the results from analyses conducted in other regions, as well as effective mitigation measures that may be implemented in El Dorado Hills in the near future. She also expressed her disagreement with the large expenditures required to mitigate NOA on the Oak Ridge High School Campus considering that no other communities had been forced to do this in the other 49

California counties in which NOA is present (Barber 2005). These letters reflect the common misunderstanding of the variable risks associated with different fibre types and the resulting sentiment among residents that their community is being "singled out". However, they also indicate that there is concern within the community regarding the lack of information on the subject of NOA.

Helen Baumann, an El Dorado County Supervisor, also wrote a letter to the Chair and Senators in May 2005, which is accessible on El Dorado County's website (http://www.edcoe.org/asbestos/noa.html). She wrote that "regional health studies show that El Dorado County has not had a higher incidence of lung cancer cases than surrounding counties", and that the level of incidence of mesothelioma is not as high as people are making it seem (Baumann 2005). This further demonstrates a misunderstanding of the nature of the health effects associated with asbestos.

In addition to internet sources, media is also likely to contribute significantly to the level of awareness of El Dorado County citizens regarding NOA. The Mountain Democrat newspaper, which has covered the western slope of El Dorado County since 1851, has archived 365 articles about asbestos in El Dorado Hills in total. Many of these articles have been posted on the Mountain Democrat's website (http://www.mtdemocrat.com/) and some demonstrate an attempt to provide readers with a more technical understanding of the issue. For example, one of these articles, titled "Asbestos debate continues", makes reference to the mineral definitions that the EPA used to evaluate the presence of

naturally occurring asbestos in El Dorado Hills and the relation between this mineral and the potential health risks associated with its presence (Sorich 2006).

The Sacramento Bee is another newspaper available to El Dorado County residents in which articles relating to asbestos have been published, such has the article "Oak Ridge has whole new look" written by Michael Allen Jones in August 07, 2008 (http://pubsys.sacbee.com/eldorado/story/1135084.html). This article highlights new construction at Oak Ridge High School and the measures that are "being taken to mitigate potential exposure to NOA on the school site" (Jones 2008).

Other articles, such as the one published in the Magazine *Mother Jones* entitled "Not in Their Backyard" address the opinion of residents and county, state, and federal officials concerning the issue of NOA exposure in El Dorado County and the related health risks (http://www.motherjones.com/news/feature/2007/05/not_in_their_back_yard.html). This article in particular demonstrates the limited knowledge that some individuals had regarding NOA and the variable ways in which residents have responded to this issue. Specifically, it reports that most of the county residents were unaware of the NOA deposits surrounding their community until the mid 1990's when Terry Trent discovered a vein of tremolite in his yard. Although Mr. Trent has since abandoned his property, many people who know about NOA still remain in the area.

A recent article written by Roger Phelps in "The El Dorado Telegraph", published on September 30th, 2008 (http://www.edhtelegraph.com/pub/eldoradohills/landing.html),

highlighted the issue in El Dorado County where "supervisors authorized up to $148,000 additional money for a law firm that represents the County around a long-dormant health-protection issue of airborne asbestos" (Phelps 2008). Dongell, Lawrence and Finney LLP, a law firm based in Sacramento, has transmitted "the concern of the residents to the EPA and ATSDR for failing to properly research the science of naturally occurring asbestos and the potential health risks" (Phelps 2008).

Although these publications do provide some indication of the social nature of the NOA issue in El Dorado County, very little formal research has been conducted with respect to residents' perspectives regarding NOA in this area. To our knowledge, only one publication that addresses this issue currently exists—a study conducted by Dr. Marci Culley from the University of Georgia, titled "Environmental and Public Health Interventions around Naturally Occurring Asbestos: A Community Case Study" (Culley 2007). This paper examines the position taken by the county, state and federal officials as well as community activists regarding NOA in El Dorado County. Although this report provides in-depth accounts of these stakeholders' concerns, it is worth noting that Culley (2007) recognized certain limitations to her research such as the under-representation of the "general population" of El Dorado County (for example, those who are not actively engaged in the issue). It is hoped that the combination and/or comparison of our results with those of Dr. Culley will provide a more holistic view of social perceptions and responses to NOA.

Research Question / Hypothesis

Although we recognize the interrelated nature of the biological and social aspects of asbestos exposure in El Dorado County, for the purposes of our study, these will be treated separately. In the biological section of our research, we were primarily interested in seeing how the level of NOA observed in the lungs of dogs that lived in El Dorado County compared to that of dog lungs from the province of Québec, Canada. We hypothesized that due to the large amount of asbestos found in the air (EPA 2008a), dogs from El Dorado County would have a greater amount of such fibres in their lungs than dogs from Quebec.

We are also interested in looking at how the community of El Dorado Hills, in El Dorado County has responded, and is responding, to the threat of asbestos exposures. Furthermore, we will look into residents' perception of the threats posed by NOA in their immediate environment. We had several hypotheses regarding El Dorado Hills residents' views on NOA. We predicted that individuals would have variable knowledge levels with respect to risks associated with asbestos. We also predicted that people who were more educated or who had a variety of news sources would be more likely to think asbestos is a hazard. Finally, we expected that those who had a good understanding of these risks would be most willing to act to mitigate them.

Biological Section

Methodology

We will attempt to link environmental exposure to naturally occurring asbestos with the amount of asbestos actually retained in the lungs. In the past, examinations of human lungs have been widely used to determine asbestos exposure (Roggli et al. 1986; Hannu et al. 2007). However, there are many difficulties associated with obtaining human lungs including the high monetary cost, the limited number of autopsies performed, as well as complex confidentiality and ethical issues. For these reasons, we used the lungs of deceased pet dogs as surrogates for estimating human lung fibre burdens.

Our research is intended to complement previous research that has been conducted by Dr. Case and Dr. Abraham in which the asbestos fibre burden of four dog lungs from the El Dorado Hills region was analyzed. Of these lungs, three were examined in two separate labs and one was examined only once at one lab. To this existing data, our study added a second analysis of the fourth dog lung in a second lab and an analysis of two more dog lungs from the Province of Quebec which served as controls. These control dog lungs, as well as information about the samples, were provided by Dr. Pierre Hélie, a pathologist from the Université de Montréal. Both samples were taken from the lower lobe, and the dogs were both seven-year-old females. One dog, from the Gaspé Peninsula in Eastern Quebec, died from gastroenteritis, while the other dog, from Île-Perrault near Montréal, died from a bowel infection, specifically necrotic enteritis. Neither dog had a history of

respiratory disease. Although one dog suffered from pulmonary edema, meaning an excess of water in the lungs, it did not affect the quality of our sampling since wax and moisture are removed from the lung samples through standard laboratory procedures, and in fact the starting material – the "wax block" – is dehydrated before it reaches the analytic lab in routine hospital processing. The lung fibre burden analyses of all three lungs—including both control lungs and the lung belonging to the dog from El Dorado—were carried out at the BodyCote environmental lab in Pointe-Claire, Quebec.

The techniques used by a BodyCote lab technician, Mr. Martin Gravelle, for the quantification of asbestos fibres consists of the lung tissue samples being chemically digested, filtered, and evaluated using electron light microscopy. The first step in a lung analysis includes the isolation of the lung parenchyma. The lung tissue was removed from the paraffin wax in which it was preserved by immersing it at 37˚C in xylene for five days. A 5% sodium hypochlorite solution was then added to help chemically digest the biological material. For each sample, an aliquot of the suspended lung/ solution mixture was filtered onto a Millipore™ membrane filter in a known quantity. The samples were then oxidized by a low-temperature oxygen plasma asher, which left only inorganic matter on the filter. This material was then resuspended in distilled, filtered water and filtered through a Nucleopore™ polycarbonate membrane, which was coated with gold to keep inorganic material on the filter while making it visible in the electron microscope, as the beam penetrates gold. The filters were placed on a copper grid containing 200 openings, which was then inserted into the electron microscope. Using a

magnification of 13,500x, all fibres contained in the portion of the lung sample thus examined that were longer than 5µm were counted. The microscope screen has two concentric circles of given diameter depending on the magnification, which were calibrated to determine the length of the fibres. For each lung the measured concentrations were expressed as the number of fibres per gram (f/g) of dried lung. Our detection limit was 34,400 f/g, and samples were counted up to 60 fields, or 60 fibres in x of 60 fields, whichever came first.

The microscope is equipped with an energy dispersive spectrometer which uses X-ray energy dispersion spectra (EDS) to identify each individual type of fibre. Different fibres have unique elemental composition, and using the spectra produced by focusing an electron beam on the fibre allowed us to determine the fibre type (for example, talc, tremolite or chrysotile) by comparing it to a reference spectra. Although we were not involved in the preparation of the samples or the complete analysis, we received an overview of the process during several visits to the lab, and were present during part of the quantification for two of the three lung samples.

Biological Results

The results for Dogs four, five, and six were added to Dr. Bruce Case's previous data which included Dogs one, two, and three, as well as Cats one and two. Data that was previously collected by Dr. Case was of three dogs that all lived in El Dorado County (though for varying amounts of time). Additionally, two cats from El Dorado County had been examined and were previously used as controls. Cat one lived outdoors but was from an area where there is no known NOA. Cat two lived in one of the worst areas of tremolite asbestos in El Dorado County; however, this cat lived indoors in the same general area as Dogs two and four, and therefore presumably did not have as high an exposure level.

In the two control dogs from Quebec (five and six), there were no tremolite (or other) asbestos fibres found via electron microscopy. Thus the concentration in both dogs was below the limit of detection ("not detected" (n.d.)). Another dog from El Dorado County, labelled Dog four, was analyzed and shown to have appreciable levels of tremolite asbestos in its lung tissue (this dog lived in the same household, in a high-tremolite area confirmed as such by the US Geological Survey, as Dog 2). It was analyzed once using electron microscopy and determined to have a concentration 1,031 f/mg of tissue. This number is greater than the average concentration from the three previous El Dorado county dogs from Dr. Case, which showed mean concentrations of 464 f/mg (Dog one), 928 f/mg (Dog two, which lived in the same area as Dog four), and 203 f/mg (Dog three). All of the dogs lived in the El Dorado County region; two lived in exactly the same spot

(dogs two and four) which is an area that had been found to be particularly high in tremolite geologically.

The concentrations of fibres greater than 5μm found in all the specimens' lungs are laid out in Table 1. All three of the animals that were never exposed to areas that have known tremolite asbestos, Cat one (see table 2), Dog five and Dog six, showed no tremolite asbestos fibres in their lungs (see Chart 1). Animals that were exposed to areas with known tremolite asbestos, Dog one, two, three, four (and Cat 2) did show a fibre concentration greater than zero in their lungs (see Tables 3, 4 and 5).

Table 1:

	Exposure (years)	Concentration of fibers > 5μm length (f/mg dry lung)
Cat 1	None	n.d.
Cat 2	9 (indoors)	157
Dog 1	>2	464
Dog 2	>8	928
Dog 3	>10	203
Dog 4	3-5	1031
Dog 5	None	n.d.
Dog 6	None	n.d.

Table 1 *shows the concentration of tremolite asbestos and exposure to known areas of NOA in El Dorado*

(n.d. = below the limit of detection)

Table 2:

Specimen	Concentration (f/mg)
Cat 1	n.d.
Cat 2	154.663
Average	77.332

Table 2 *shows the concentration of tremolite asbestos (f/mg) of El Dorado cats*

Figure 2

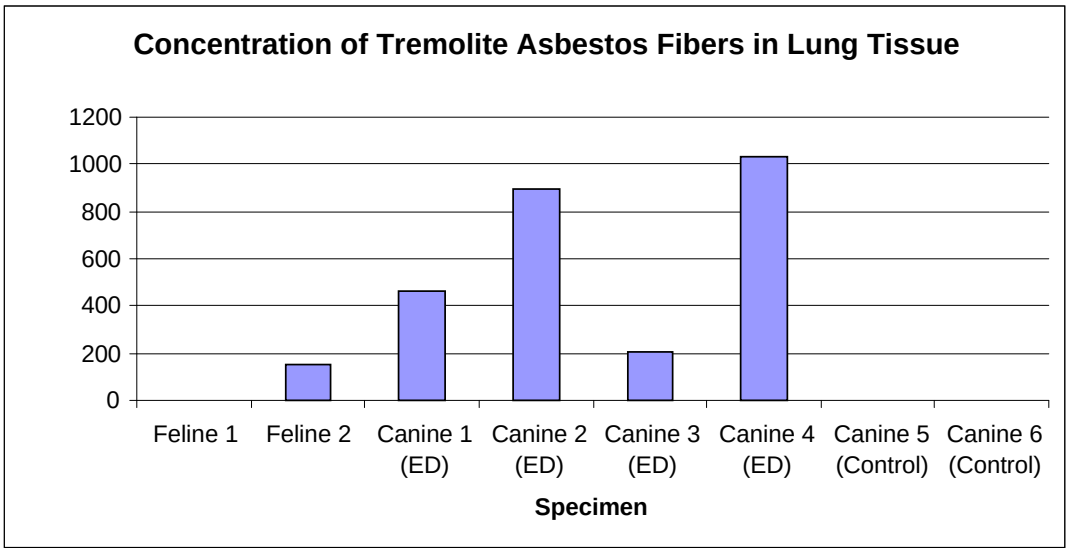

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Figure 2 *shows the concentration of tremolite asbestos fibres in lung tissue in fibers/ mg dry lung > 5 um*

Table 3:

Specimen	Concentration (f/mg)
Dog 1	464
Dog 2	928
Dog 3	203
Dog 4	1031
Average	657

Table 3 *shows the concentration of tremolite asbestos (f/mg dry lung, greater than 5 um length) of El Dorado dogs*

Table 4:

Specimen	Concentration (f/mg)
Dog 5	n.d.
Dog 6	n.d.
Average	n.d.

Table 4 *shows the concentration of tremolite asbestos (f/mg) of Quebec dogs*

Table 5:

Demographic	Concentration (f/mg)
Cats (El Dorado)	77
Dogs (El Dorado)	657
Dogs (Quebec)	n.d.

Table 5 shows the average concentration of tremolite asbestos in El Dorado vs. Quebec

After compiling the data, there were four dogs exposed in El Dorado County, two El Dorado cats, and two Quebec dogs. A t-test with independent estimates of sample variance comparing the El Dorado dogs and the Quebec dogs indicated a statistically significant difference ($p < .05$).

Biological Discussion

The aim of the biological component of this research was to determine whether there was a difference between the concentration of tremolite found in dog lungs from El Dorado

County and those from Quebec. As we expected, the concentration of tremolite was higher in the lungs belonging to the former group of dogs than the latter. Our results demonstrate a significant correlation between the presence of NOA in the area of residence and the amount of fibres found in the lung, for the average concentration of asbestos in the four dog lungs from El Dorado County was 657 f/mg, while the average concentration of Quebec dogs was below the limit of detection ("not detected" (n.d.)). In addition, the difference in asbestos fibres found in the cats can be explained by the fact that the level of exposure was not the same for both cats. One lived in El Dorado County but not where NOA was present (Cat one), while the other spent most of its life indoors, albeit in a high tremolite area.

Our results suggest that there is a relationship between the amount of asbestos fibres inhaled by the dogs and the natural occurrence of asbestos in the environment where they lived. Thus, dogs can be used as efficient bio-indicators for human exposure to amphibole asbestos associated with high-risk asbestos diseases, such as mesothelioma. Several scientists have similarly used lung fibre burden analyses in exposed animals to recognize areas where fibre contamination is a threat (Dumortier et al. 2002; McConnochie et al. 1989; Baris et al. 1987). This is a good way to identify the tremolite exposure "hot spots", given that NOA of various kinds is found in specific geological areas (Meeker et al. 2006).

No fibres were found in the Quebec dog lung tissues analysed. Some studies have reported that there is a higher level of ambient asbestos levels in the air of urban areas in

comparison to rural areas (Bourdes et al. 2000; Case BW et al. 1988). One of the control dogs was from the Montreal suburban area of Île-Perrault. The other dog was from the Gaspé Peninsula, a rural area, and no asbestos was observed in its lung either.

The types of fibre found in the dog lungs from El Dorado County provided us with information on the risk of exposure for the people living in the area. Tremolite fibres were the main type of fibre found in these dog lungs. Because a higher concentration of tremolite is found in dog lungs from this specific area, we may posit that there is a greater risk of human exposure to tremolite in this region as well.

Our results suggest that the duration, the level and the frequency of exposure are important factors which influence the concentration of fibres in dogs and cats lungs. The mean age of the dogs from Quebec is six years and both of these dogs were approximately the same age when they passed away. The age of the dogs is normally linked to the duration of exposure to naturally occurring asbestos if the owner of the dog has not moved. Therefore, the older the dog, the longer it may have been in contact with asbestos fibres and the higher the risks of asbestos fibre inhalation (Doll et al. 1985; Kava 2007). The risk of inhaling asbestos fibres is also related to the frequency of exposure and to the source of exposure. This is clearly exemplified by the fact that although Dog one was only two years old when it died, it had a higher concentration of tremolite in the lungs as a result of having spent its whole life in a high tremolite area. This can be compared to Dog three which was ten years old when it passed away but it spent its life in a lower concentration area and had a lower concentration of asbestos fibres in its lungs.

Dog two had the second highest concentration of tremolite in its lungs, which is consistent with its age, frequency of exposure, and where it lived (Table 1); the same location as Dog four and as Cat two. Dog four, like Dog two, lived in one of the worst tremolite areas (Wild Turkey Drive, near Cothrin Ranch Road) during the first three to five years of its life. After this period, his owner moved with both dogs (two and four). Dog four passed away much later at the age of ten years. In spite of not having been exposed to tremolite in high quantities for the last seven years of its life, when the dog died, his lungs were examined and tremolite fibres were found. This suggests that tremolite fibres have persisted in the dogs' lungs for a long time.

This study has various limitations. First of all, the sample size is small, as only eight animals in total were analysed. Secondly, although the analysis of human lung samples would have provided more directly pertinent information on asbestos exposure and the corresponding risks of asbestos-related disease, it is generally more difficult to sample humans because human samples are often unavailable (Dumortier et al. 2002) due to the increasingly limited number of autopsies achieved. Furthermore, it is expensive and difficult to obtain the funding to do research (although analysis of this nature for animal lung is also expensive), and the approval of ethics committees which are now required in order to perform research on human tissues adds to costs, time, complexity, and the probability of cooperation of volunteers. A contribution of this study is that, like the goats examined by others elsewhere, we have found that pet tissue samples may be more

accessible than human tissues, and they by definition share the same environment as people (Glickman et al. 1983).

The method of analysis can also cause some bias. The sample preparation to analyse tissue with the transmission electron microscope is complicated and can if not done properly introduce errors such as "loss of particles in handling technique, the production of numerous fibres by the splitting of asbestos bundles and the introduction of contamination" (Rogers 1984). However, this analytical technique is very precise for experienced workers as was the case in this study.

In addition, a small piece of dry lung tissue was analysed with a transmission electron microscope (TEM) at a magnification of 13,500X. Extrapolations are made from the data obtained from a small area of the lung about the content of the lung in its entirety; however, according to Rogers (1984) it should be fairly representative. Nonetheless, we saw variations in the number of fibres analysed by two different laboratories (including the one operated by Dr. Abraham for the same animals at the Syracuse, results not shown), and methods differed. For example, the Syracuse laboratory used a scanning electron microscope (SEM) and the other (McGill / BodyCote) used a TEM.

Social Section

Methodology

In order to gain insight into El Dorado County residents' knowledge and attitudes regarding the NOA issue, a survey that addressed this topic was conducted in the El Dorado Hills region. With the funding from the research grant of our supervisor, Dr. Bruce Case, two members of our group (T. Kovach, C. Spina) traveled to El Dorado County to carry out this component of our research.

Procedure

It was determined that due to time constraints, research should be based on non-random opportunity sampling. Specifically, it was decided that the survey would be distributed to individuals in a public location in El Dorado County. Several locations within this county were considered, however permission to conduct the survey in certain areas was difficult to attain since the subject matter of the topic was considered controversial in nature. Ultimately, we received permission to distribute surveys outside of a busy store in a central location in El Dorado Hills. The store in question was a grocery outlet called Nugget Market (see Figure 1 for location). We decided that a grocery outlet was an appropriate location at which to distribute the surveys because it was frequented by a relatively broad range of residents who shared a common need for food. Furthermore, the location of Nugget Market appeared to be a central hub of El Dorado Hills, having several hundred people flowing through during peak hours.

As per the request of Nugget Market's manager, both members were stationed outside each entrance (site 1 & site 2 labelled in Figure 1), which was distanced by about 30 meters. Both entrances were identical and had several outside-type dining areas that most respondents used to complete the two-minute survey. In order to maximize our response rate, the two entrances/exits of the store were manned; therefore most people who frequented the store while we were present were approached.

Figure 1 – Survey distribution locattion, Nugget Market, 4,500 Post St. in El Dorado Hills, CA 95762, with labels of where distribution took place

Source: Google Earth 2008

Survey distribution at this location took place during the weekend of November 15th & 16th, 2008. Surveys were distributed around midday, as this was predicted to be the

busiest time. Specifically, survey distribution lasted five hours on the 15th and six hours on the 16th, totalling eleven hours.

Our two group members distributing the surveys had an oral script prepared to get the attention of people passing by. After of few hours of distributing the surveys, their approach was tailored to be as brief and to the point as possible, since most people kept on with their intended trajectory. Both members approached passers-by with the following greeting: "Excuse me, do you have time to fill-out a survey for a school project"? They chose not to mention the asbestos issue, with the intention of minimizing bias in the survey, as those who felt the issue was over-exaggerated might have declined consideration of participation even before informed consent was possible.

El Dorado Hills, the community in which our survey was distributed, is located within El Dorado County. However, it is important to note that residents of this community are not representative of the greater population of El Dorado County, as the median family income in El Dorado Hills ($97,000) is notably higher than that of the county ($56,000). (http://quickfacts.census.gov/qfd/states/06/06017.html). The results produced by our survey cannot be presumed to portray trends in the county as a whole. Furthermore, in spite of obtaining surveys from 202 respondents from a wide age range, there may be some bias in our survey as a non-random sampling technique was used.

It is important to note that McGill University research protocols require all research regarding the use of humans (in our case, surveying residents of El Dorado Hills), to be approved by an internal Ethics Committee. There were several steps required to ensure that our subjects were treated in an ethical manner so as to gain approval and proceed with this section of our research. Most strongly emphasized was the need for respondents to be made fully aware of the context and use of their responses. That criterion was met by means of a laminated information sheet, intended for reuse, that went along with each survey and stated the purpose and use of our research (see Appendix A).

Questionnaire Design

In order to ensure a coherent and smooth flowing survey, our researchers pre-tested the survey prior to distribution. This simply involved selecting a few non-partisan respondents (for example residents of Quebec, and not El Dorado County) to complete and critique it, thereby allowing us to determine several problems within our query formulations. Knowing that our surveys were to be filled out by potentially rushed individuals, we attempted to make the survey as short and easy as possible to fill out Therefore, fewer than twenty questions were asked, and the majority of questions were closed-ended.

The first section required surveyors to fill-out demographic information so as to determine trends in knowledge and attitudes according to age, gender, etc. The subsequent questions asked whether respondents were aware of NOA and NOA-related

health threats, respectively. These questions required only circle-in agreement or disagreement. Our intent was to use these questions to separate those who were aware of the topic from those who were not. If a person surveyed had never heard of the issue prior to our encounter, their responses were still deemed valuable, as they represented those who were unaware. The remaining closed-ended questions were set up to gain insight on how serious of an issue NOA was perceived to be.

The Likert-scale format was used for the seven subsequent questions. Given the known tension surrounding the NOA issue in El Dorado County, the first two questions in this section asked whether NOA was an issue that had already received too much attention. The next questions were intended to determine the respondents' knowledge level of NOA. Specifically, we wanted to determine whether they were aware that NOA was present in their neighbourhood and whether they knew of the potential long term health risks associated with it. These questions allowed us to determine if there was a correlation between perception of NOA as a health threat and their awareness of its presence.

On the next page were questions with close-ended, descriptive responses. The first two dealt with the respondents' view of how the EPA and county officials handled the NOA matter. Given the recent amount of costly research done within El Dorado County communities, we wanted to assess whether residents felt the steps taken to measure and further mitigate the NOA issue was appropriate. Following this were two questions

asking whether the respondent would be willing to take steps to mitigate the NOA issue in their immediate vicinity, coupled with the concept of 'willingness to pay'. This refers to the theoretical value one would sacrifice so as to exchange the benefits of attaining a good, or in this case, an area relatively free of NOA. This question allowed us to determine the monetary value associated with broad and varying concerns.

In order to determine the respondents' knowledge base, we inquired about their academic background, and separately, their news sources. This was done because we were interested in whether or not there was a correlation between perception of NOA as a health hazard and any given educational background and or source of news. To conclude our survey, we asked an open-ended question to allow respondents to insert their own thoughts on the matter that may not have been covered in the questions. This optional section allowed us to explore further areas not touched upon previously.

Social Results

In all, an n number of 202 respondents was obtained. The ages of those surveyed ranged from 19-85 with a mean age of 47.4 (see Figure 3).

Figure 3:

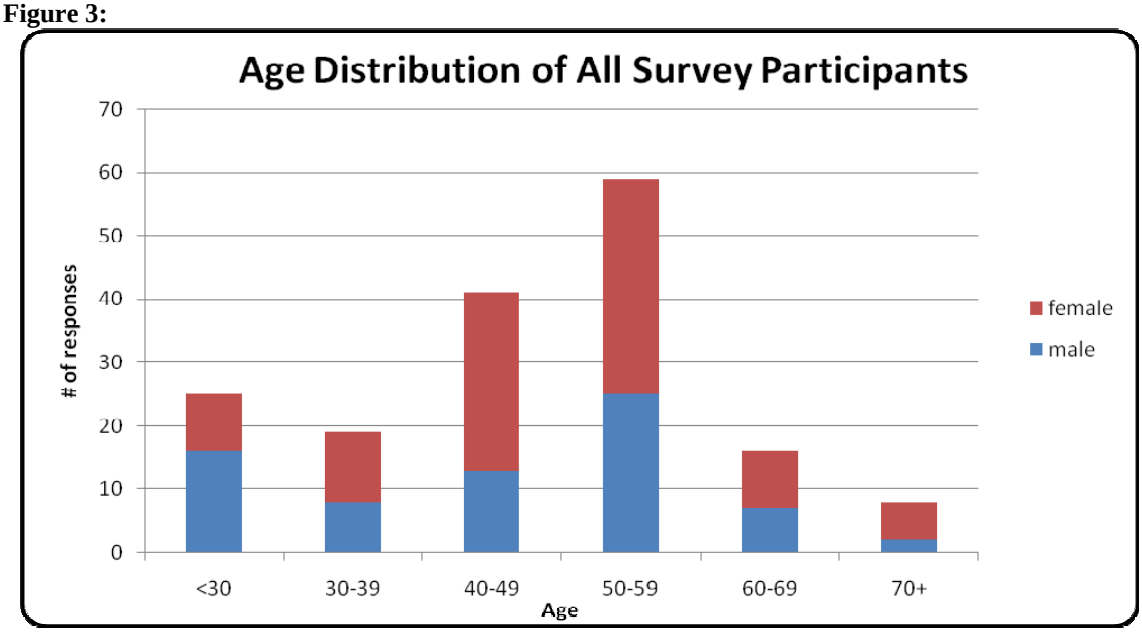

Fig. 3 *shows demographic data of the people that we surveyed; Gender by different age classes.*

The gender ratio of those responding to the survey was slightly skewed toward females, as respondents consisted of 56.4% females *vs.* 43.6% males. Of those, 40% had children who resided at home, and 60% did not. Concerning educational background (the last level of formal education completed): 42% of survey participants completed high school (2.5%), had some college (31.5%), or had completed trade school (7.6%). 58% had either completed a college degree (35%) or had completed postgraduate studies or further (22.8%). Nearly all survey participants (99.5%) had heard of asbestos in some context.

Of all respondents, 69.8% were aware of a potential issue with asbestos in El Dorado County, and 63.4% were aware of specific areas having naturally occurring asbestos deposits.

In an attempt to understand why so many people (30.2%) had not heard of the issue, despite large amounts of publicity and public awareness programs, we looked further into the demographics of those that responded that they never heard of any issue with asbestos in this county. Overall, 79.8% of women were aware of the asbestos issue compared to only 54.3% of men (see Figure 4). The level of unawareness of the asbestos issue was fairly consistent across all age classes (see Figure 5). There were no relationships found between level of formal education and awareness of the naturally occurring asbestos issue.

Figure 4:

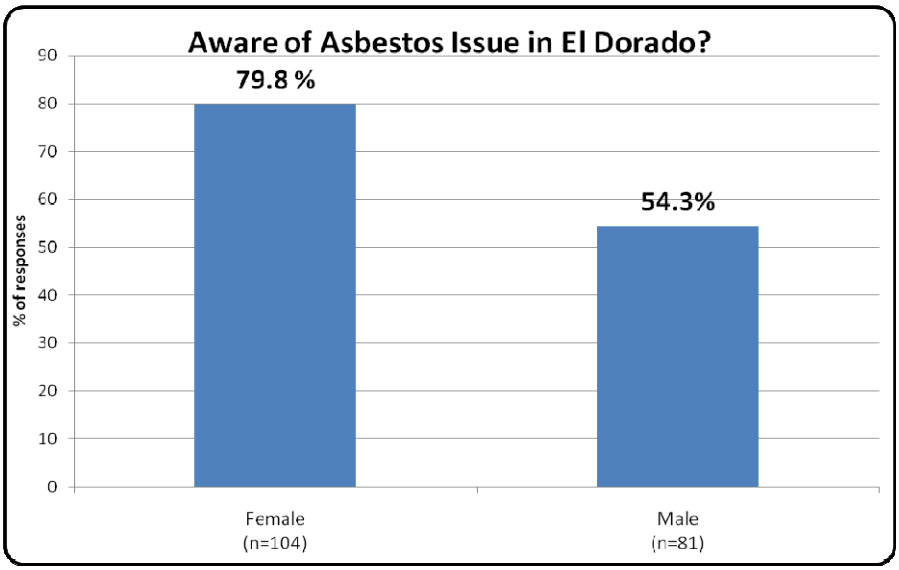

Fig. 4 *shows the response to the question "Have you ever heard of any issue with asbestos in El Dorado County?" based on gender. STATS: z=3.7, P<0.01.*

Figure 5:

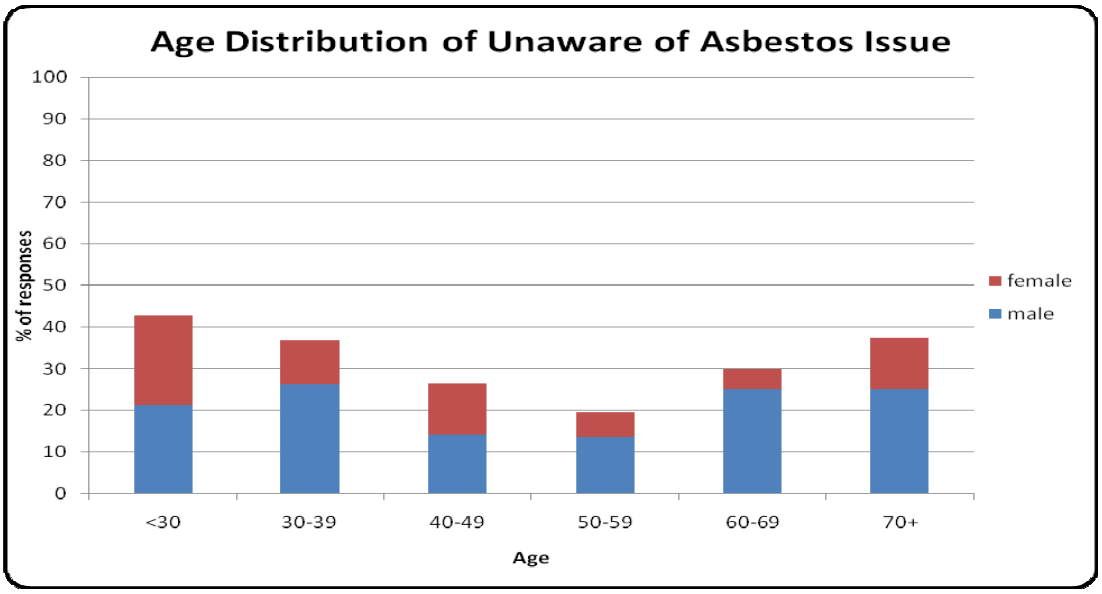

Fig. 5 *shows different age classes listed on the x axis with corresponding % of responses that were unaware of any issue with asbestos in El Dorado County.*

Of those that were aware of the asbestos issue in El Dorado County (percentages based on total number of respondents):

- 63.3% identified this issue as an area of concern.
- 40.3% thought that too much attention had been paid to this issue.
- 36.7% felt that El Dorado County had been unjustly singled out concerning the asbestos issue.
- 30.2% felt that not enough information was available for the proper understanding of the issue.
- 29.2% believed that the EPA's handling of the situation responding was either that the EPA had not done enough (20.4%) or had focused on the wrong issues (8.8%).
- 17.5% were satisfied with how the EPA has handled the situation and 8% felt that the EPA had done too much.
- 30.9% of those surveyed were unsatisfied with how County officials have handled the asbestos situation responding either that elected officials of the County had not done enough (21.3%) or had focused on the wrong issues (9.6%).
- 19.1% were satisfied with how County officials have handled the situation and 7.4% felt that the County officials had done too much.
- Given the choices offered, 32.1% of those responding were not willing to pay anything to remove naturally occurring asbestos from the area, and 33.6% were willing to pay at least $100; A large proportion were undecided (34.3%).
- When asked, "What steps are you willing to take to mitigate the threat of asbestos exposure?", the most frequent response was, "not willing to take any action" (30.5%); 14.9% said they were prepared to move away, 16.9% were willing to close windows, 4.5% would stay indoors, and 8.4% would limit outdoor activities (see Figure 6).

Figure 6:

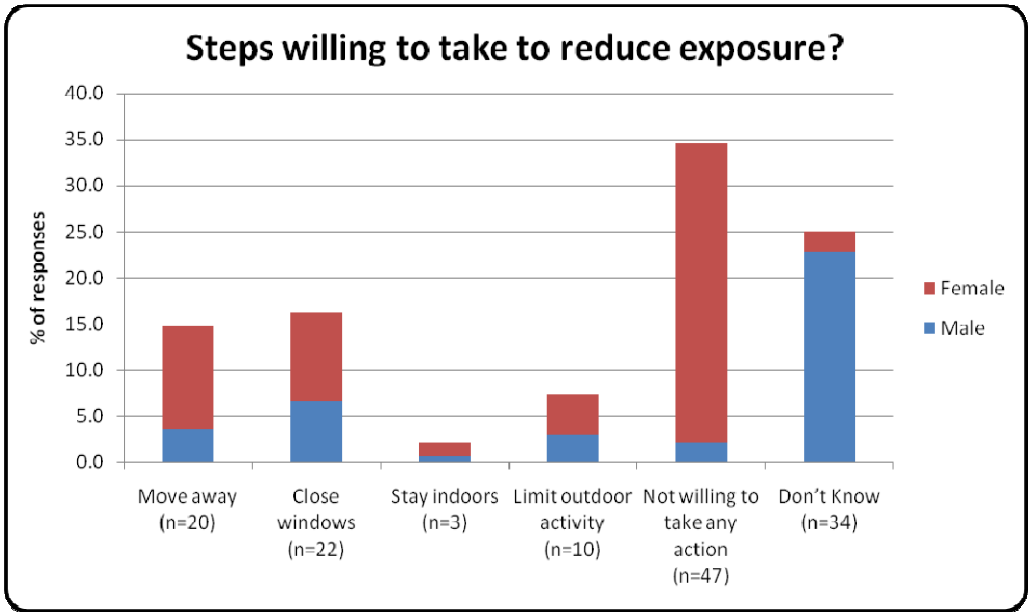

Fig. 6 *shows the responses of the individuals to the question: "What Steps would you be willing to take to reduce exposure to naturally occurring asbestos?" separated by gender.*

We were interested in the responses to the statement: "There are potential long-term health effects related to naturally occurring asbestos exposure." The responses to this statement were based on a Likert scale. We compared these results to see if there was any effect of awareness of health effects vs. how much people would be willing to do to remedy the situation. This was done by comparing the health question responses to the answers given to the following questions: "willingness to pay to remove asbestos hazard" and "willingness to take steps to reduce asbestos exposure". In general, those who were more concerned with health effects were willing to spend more to reduce the hazard (see Figures 7 and 8). We also found that those who were concerned with health effects were more willing to take action to reduce exposure (see Figure 9).

Figure 7:

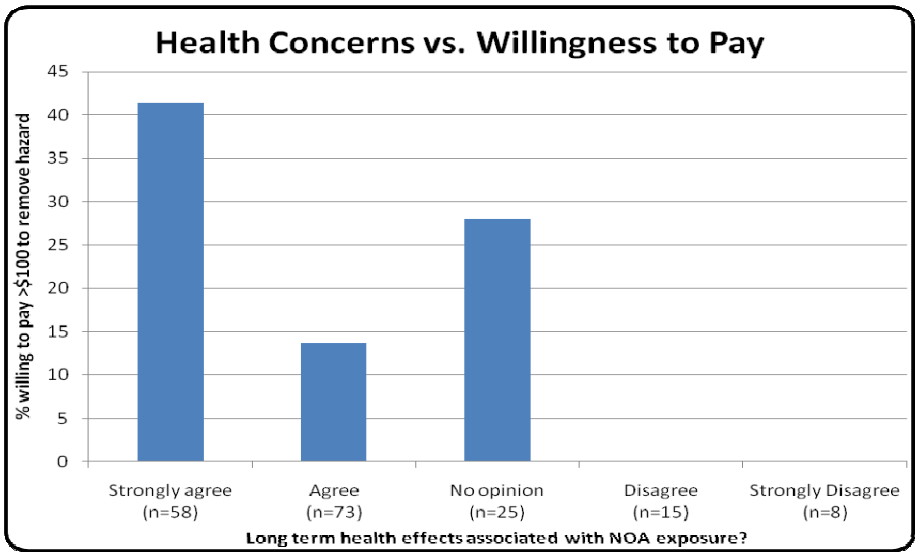

Fig. 7 *compares the responses of two questions: "There are potential long-term health effects related to naturally occurring asbestos exposure." Vs. "How much would you be willing to spend to remove any hazard of naturally occurring asbestos in your area?" STATS: Including all=X^2= 13.8, P <.01, If we omit the choice "Strongly Disagree" because of small sample size=*X^2*=9.6, P<0.05.*

Figure 8:

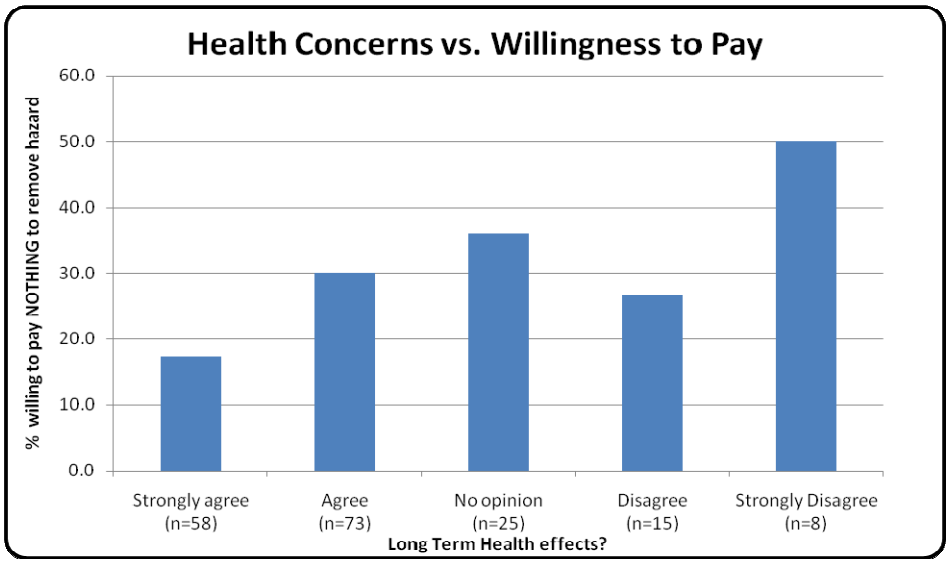

Fig. 8 *compares the responses of two questions: "There are potential long-term health effects related to naturally occurring asbestos exposure." Vs. "How much would you be willing to spend to remove any hazard of naturally occurring asbestos in your area?" STATS*

Figure 9:

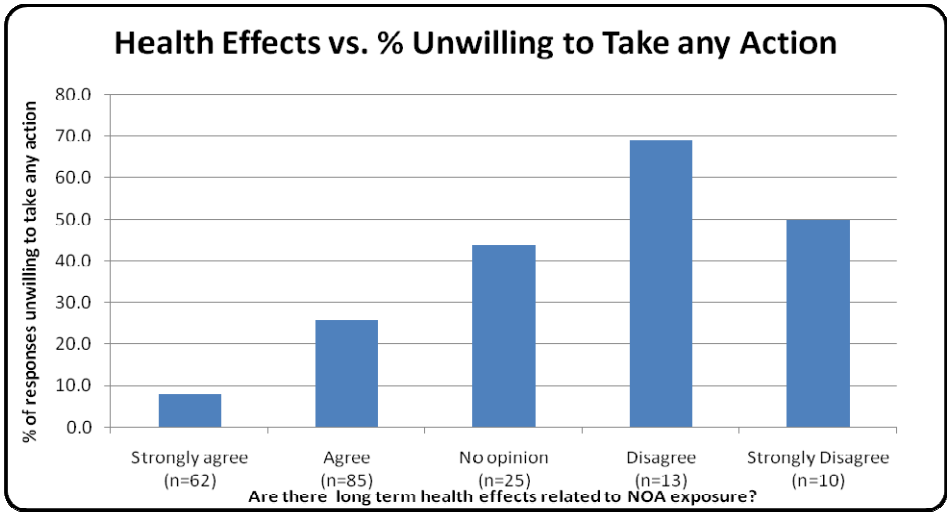

Fig. 9 *compares the responses of two questions: "There are potential long-term health effects related to naturally occurring asbestos exposure." Vs. "What steps would you be willing to take to reduce exposure to naturally occurring asbestos?" This shows that people that disagree with health effects are also more likely to be unwilling to take any action. STATS: Including all=X^2= 29.7, P <.0001, If we Ignore Strongly Disagree because of small sample size=X^2=14.8, P<0.001.*

The statistical analysis used in figures 7-9, were based on the responses of survey participants to Question #11 dealing with health effects. For one example; with Figure 7, 59 people "strongly agreed" that there are health effects related to asbestos exposure. We then asked the question: out of these, how many are willing to pay >$100 to mitigate the asbestos problem? This number was compared to the amount of people answering that they were *not* willing to pay > $100 in the same agreement category. The observed vs. expected frequencies of these responses were analyzed using a chi-squared test for all categories of agreement. Similarly, 58 people who strongly agreed with health effects also answered the willingness to pay question. 24 responded that they were willing to pay > $100 and 34 did not (while the expected frequency by chance would be half and half). This was repeated for all levels of agreement and chi-squared tests performed. Because with chi squared analysis expected values of less than 5 the render the test unstable, the comparison was repeated dropping the column with the lowest values. Both p values are shown below the applicable graphs.

A weak but statistically insignificant relationship was also observed for the number of people who were willing to pay to remove the hazard as a function of the presence of children in the respondent's household (see Figure 10).

Figure 10:

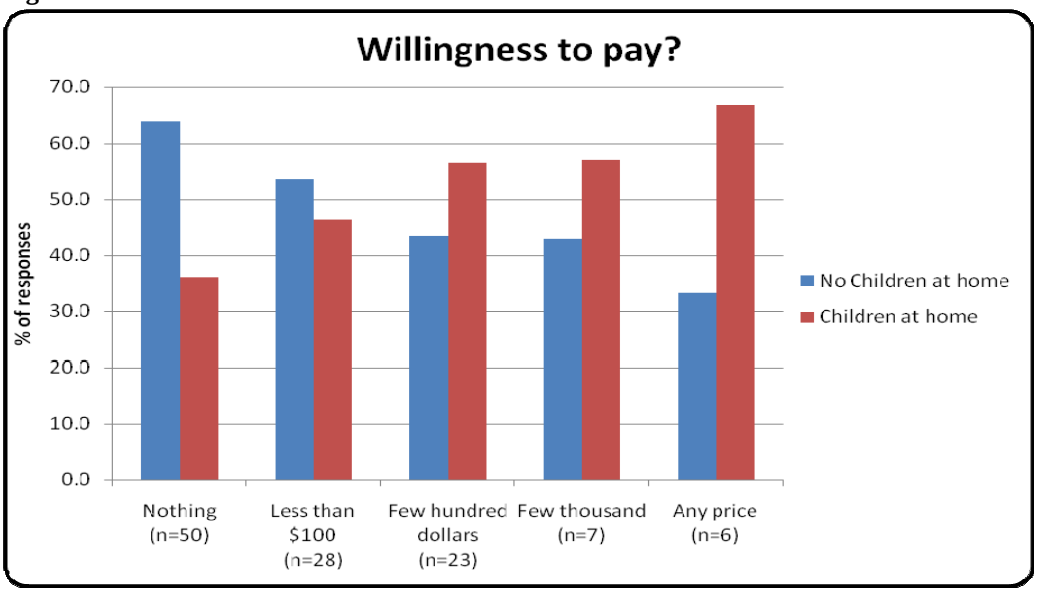

Fig. 10 *shows how people with children at home are more likely to pay for the mitigation of the threat of asbestos exposure. However, due to the small sample size associated with the "Few thousand" and "Any price" answers the results were not statistically significant.*

Social Discussion

The survey that we conducted revealed some important patterns in El Dorado Hills residents' feelings about the presence of naturally occurring asbestos (NOA) in their region. First, our findings confirm that there are variations in residents' awareness of the issue. Notably, 30% of respondents reported that they were unaware of the presence of asbestos in El Dorado County, including the El Dorado Hills community. Among those respondents who were uninformed about the presence of asbestos, it was found that a far greater proportion were male, since approximately 46% of all male respondents and only 20% of female respondents fell into this category. Although responses were also examined according to age and education level, no other demographic groups were overrepresented among those who were unaware of the presence of asbestos in El Dorado County. Although the proportion of respondents who were unaware of the presence of asbestos was quite low, it is this group which is of particular concern because without knowledge of potential for asbestos exposure, no attempts to reduce this exposure would be taken.

When asked whether they believed that there were long-term health effects associated with NOA exposure, 9.4% of respondents replied that they did not know. Although certainty is limited by the small n number obtained, our results suggest a number of patterns in awareness among various demographic categories. It was found that neither gender is greatly overrepresented among those who are unaware of these health effects, as 47% of those who offered this response were male and 53% were female.

Furthermore, unawareness was highest among respondents between the ages of 50-59, an age category that represented 35% of all respondents. Of all those who were not aware of asbestos-related health effects, 44% belonged to this age category.

Awareness of asbestos-related health issues was mirrored in three of the responses to the open-ended survey question which asked respondents for additional comments regarding the asbestos issue. One respondent reported that they hadn't heard of negative issues, while another reported being "unsure [of] what the issue is and if [there is an] effect on health". A third said that they were "not educated on the topic of naturally occurring asbestos [and didn't] know the harmful issue". These responses may indicate that more extensive public education could ensure that all residents of El Dorado Hills were even more knowledgeable about the NOA-related health effects.

In addition to those who were unaware of risks associated with asbestos exposure, the survey results revealed another group of respondents who had heard of these risks but who nevertheless held the belief that they were negligible or unworthy of the time and funding required to reduce exposure. The existence of the latter group was evidenced in the responses to several questions. For example, 11.4% of respondents disagreed or strongly disagreed with the statement that there are long-term health effects associated with NOA exposure.

Responses obtained from two other close-ended questions addressed respondents' opinions regarding the NOA research and mitigation strategies taken by the EPA and the county, respectively. It is likely that those who had heard of the activities of the EPA and the county had also heard about the risks associated with NOA. Therefore, those who responded that the EPA and/or county officials had done "too much" (6% and 5% of respondents, respectively) are likely to be a distinct group of individuals from those who simply did not know about risks associated with asbestos. As an example, one respondent's answer to the open-ended survey question reflected a belief that the health effects related to asbestos exposure were too small to be worthy of taking steps towards mitigation. This respondent stated, "I feel that too much [money] has been spent on NOA and non-naturally occurring asbestos", essentially reiterating the belief that too much had been done by the county and the EPA with regard to mitigating NOA risks.

A lack of knowledge in the presence of potential asbestos-related health risks by some El Dorado County residents has previously been noted in the 2007 study conducted by Marci Culley, which was previously mentioned. This study was primarily based on open-ended interviews with key stakeholders in the NOA issue in El Dorado County. Culley's respondents characterized this refutation of asbestos-related risks as denial, and attributed it to several factors such as the need to justify living in this potentially hazardous region, and the correlated concern with the potential loss of return on investment in property in the area. Culley's research also suggested that that there is a high degree of polarization among El Dorado County residents on the issue of risks

associated with asbestos exposure. Informants in this study reported their conception of the existence of two factions of people: those who are "pro-development"—a category to which those who are "in denial" are implied to belong—and those who are "anti-development".

Our survey results provided evidence of a correlation between individuals' perceptions of risks associated with asbestos and attitudes concerning the development of the county. Specifically, 34% of those who disagreed or strongly disagreed with the assertion that there are long-term health effects associated with asbestos exposure responded that in their handling of the asbestos situation, the EPA had done too much, compared with only 1% of those who agreed or strongly agreed with that there are long term health effects. Because the activities of the EPA had generated negative publicity for El Dorado County, which was perceived as potentially threatening future development of the region, respondents' disapproval of these activities could indicate pro-development attitudes. This supports the existence of the first group of people identified in Culley's research. However, in examining the survey results regarding those who do not deny the health risks associated with asbestos, a more complex picture of residents' knowledge and attitudes is revealed than the one that is suggested by the informants in Culley's research.

Although there are great variations in the way that asbestos-related health risks are perceived by various El Dorado Hills residents, a description of this community as being polarized by this issue is inaccurate in several ways. First, our results suggest that

residents were not uniformly divided by their opinions regarding the health risks posed by NOA. In fact, the vast majority of respondents recognized that there is some degree of risk associated with exposure. Roughly two thirds of residents agreed or strongly agreed that there were health effects associated with NOA exposure. Second, although this group is opposite in their view of the risks associated with asbestos to respondents who do not recognize these risks, their response—or more accurately, their lack of response—to these risks is not strikingly different.

Our results suggest that there is incongruence between individuals' perception of asbestos as potentially harmful and their willingness to take action to reduce these risks. As evidence of this, respondents who had agreed or strongly agreed that there were health risks associated with asbestos exposure made up approximately 52% of respondents who were unwilling to take any actions to minimize exposure and 60% of those who were unwilling to pay any amount to mitigate exposure. This unwillingness to proactively reduce asbestos exposure was previously evidenced by the small size of the group of individuals who were actively engaged in the NOA issue in El Dorado County (Culley, 2007). Together, these trends suggest that those who do not believe that there are potential long-term health risks associated with asbestos exposure are not the only residents who are inactive in proactively protecting themselves and their community against these risks, but that many of those who recognize these risks have a similar pattern of behaviour.

The inaction of El Dorado Hills' residents who do not feel that there is potential for NOA-related health risks can be understood as a direct result of this outlook. However, the inaction of those who do recognize these risks is less evident. Our findings suggest that the primary reason underlying an individual's inaction regarding the asbestos issue is an incomplete understanding of exposure and associated risks. For example, approximately 53% of individuals who strongly agreed with health risks disagreed or strongly disagreed with the statement "there is sufficient information at my disposal for me to understand the asbestos issue". Furthermore, those who strongly agreed that there are potential health effects related to asbestos exposure represented 47% of those who disagreed that enough information was available and 50% of those who strongly disagreed with this statement. Many respondents also reported feeling that they did not have access to enough information in their responses to the open-ended survey question. The following are notable examples of such responses:

> "I went to school in El Dorado as a child. I have no idea if I was exposed to asbestos or how I could find out or what it would mean."
>
> "There should be more info for parents to read up on. You here [sic] about it but I really don't understand some of the health issues."
>
> "I know asbestos is bad but don't know what to do."

These results suggest that although the majority of El Dorado Hills residents are aware of the health risks associated with asbestos, their knowledge is lacking in other areas, for example with regards to the nature of these risks or what steps can be taken towards reducing exposure. These knowledge gaps may be attributable to the challenges faced by

experts in clearly communicating NOA-related risks. Culley asserted that these challenges stem from the complications surrounding NOA risk assessment which include (but are not limited to) the lack of consensus within the scientific community regarding latency periods, what constitutes a dangerous asbestos exposure level, which kinds of fibres pose the most important risks, an unbalanced focus on occupational exposure to asbestos and chrysotile in particular, and problems relating to the direct measurement of exposure (pp. 20-21). Simply put, NOA research is ongoing and therefore the science is still developing. Consequently, residents are likely receiving mixed messages regarding the level of risk associated with NOA. The nature of this communication challenge is further illuminated by an El Dorado County resident who served as an informant in Culley's study.

> "They don't have all the answers, and as far as risk is concerned, they're never gonna have black and white answers, and I don't think that people understand that here. I've been at meetings where parents want to know 'well, uh, is an hour exposure okay, but an hour and one minute…?' They're never gonna get answers like that because that's not the nature of risk."

Another potential reason that many El Dorado Hills residents are not taking any precautionary measures may be due to the discrepancies between the policies regarding NOA in the area and the science regarding NOA. Contrary to studies that suggest that tremolite asbestos can cause mesothelioma at much lower exposure levels than other fiber types (ATSDR 2001), environmental agencies treat all asbestos fibres as equally toxic (Culley, 2007). This is of particular concern in El Dorado County because tremolite

occurs much more commonly than in surrounding regions in which NOA is found (EPA 2005). In spite of the local specificity of this particularly dangerous asbestos fibre type, over 26% of respondents agreed or strongly agreed with the statement that "El Dorado County has been unjustly singled out concerning asbestos". These results suggest that some residents' understanding of NOA-related risks is informed by governmental policies—in this case those that are based on the false assumption that all fibers are of equal hazard—and less closely aligned with the science behind NOA.

In recent years, some steps have been taken to minimize NOA exposure, thereby reducing the gap between NOA policy and science. For example, a number of bylaws have been put in place in recent years in order to mitigate asbestos exposure, including the use of leaf blowers and other devices that may disturb asbestos deposits (Department of Toxic Substances Control, 2004). However, the widespread lack of enforcement of these laws may send out a stronger message to El Dorado County citizens than the bylaw itself—namely that the health risks associated with NOA exposure are negligible. In response to a question regarding how the asbestos issue had been handled, a greater proportion of respondents reported feeling that local officials had not done enough (18%) than those who reported that they had done too much (5%). However, approximately 44% stated that they "did not know", which suggests a lack of critical discernment among residents with regard to the actions taken be the local government.

Our study reveals that beyond the recognition of long-term health effects relating to NOA exposure, El Dorado Hills residents possess an incomplete knowledge base regarding NOA risks. Without a complete understanding of these risks, inaction remains acceptable. However, in light of the mounting scientific evidence that NOA exposure may cause serious health problems among El Dorado County residents several decades into the future, the need for timely and concerted asbestos mitigation efforts on behalf of residents and officials is becoming increasingly harder to dispute. Our study suggests that further education of El Dorado Hills residents should be a fundamental component of stimulating a response on behalf this community, as an awareness of the long term health effects relating to NOA was found to be associated with increased willingness to take action towards reducing exposure. For example, approximately 42% of all respondents who strongly agreed that there were potential long-term health effects associated with NOA exposure were willing to pay over $100 to remove any hazard associated with NOA in their area, compared with only 14% of respondents who agreed with this statement. This implies that if residents could be more strongly convinced of these health effects, a far greater proportion of the population would be willing to invest in attempts to minimize NOA exposure.

Our results also suggest that future education campaigns should target those who either deny or who are unaware of the possibility of long-term health effects associated with NOA. It was found that 0% of respondents who disagreed or strongly disagreed that there was the potential for such health effects were willing to pay over $100 to remove

NOA hazards in their area. Therefore, by educating this group of individuals, a significant amount of progress could be made towards initiating action around the NOA issue. These results were mirrored in the results from the question in which respondents were asked what steps they would be willing to take to reduce their asbestos exposure. For example, of those who strongly agreed that there are potential long-term health effects associated with NOA exposure, 9% responded that they would be unwilling to take any action, compared with approximately 26% of those who agreed with the potential for long-term health effects. Again, this demonstrates that if residents more knowledge, much more action might be taken by residents. Furthermore, of those who disagreed and strongly disagreed that there are potential long-term health effects associated with NOA exposure, a much greater proportion were unwilling to take any action (69% and 50%, of respondents, respectively). This result shows that with a greater understanding of the risks associated with NOA comes a greater willingness to take action to mitigate these risks.

For the question "what steps are you willing to take to reduce exposure to NOA?" the most common responses following "I don't know" (35% of total responses) were "not willing to take any action" (24% of total responses), followed by "move away" (15% of total responses). Therefore, although there are many residents who are less open to making changes in response to this hazard and many who are inactive in protecting themselves due to indecision, there are also many people who are willing to consider making even drastic changes if necessary.

The results from this study provide some insight into a matter on which little was previously known; specifically, the perceptions of residents of El Dorado Hills concerning the NOA in their community. However, we acknowledge several limitations to our results, such as the relatively small sample size and issues relating to sample representativeness. Although the town of El Dorado Hills has a population of 22,200 (http://money.cnn.com/magazines/moneymag/bplive/2007/snapshots/PL0621880.html), only 202 respondents were included in this survey. Furthermore, due to time and financial constraints, the survey was only administered outside of Nugget Market, which introduces strong sampling bias into our survey. Because Nugget Market sells primarily fresh and gourmet food, marketed towards higher income consumers, any lower income residents of El Dorado are likely to be underrepresented in this survey. Because survey distributors did not approach women accompanied by children out of courtesy, it is likely that mothers are underrepresented as well. Therefore, the results obtained cannot be presumed to be entirely representative of the residents of El Dorado, but instead provide a glimpse into the views and opinions of some residents.

It is also likely that certain questions were sensitive to bias, particularly those that addressed individuals' concern with naturally occurring asbestos in their neighbourhood. For example, questions nine and ten asked respondents how much they would be willing to spend and what specific steps they would be willing to take in order to reduce their asbestos exposure. Because these questions could imply that the respondent *should* be

concerned about the issue, and survey respondents often attempt to conform to researchers' expectations, they were deliberately placed at the end of the survey. However, survey administrators noted that several respondents revised their answers to previous questions after having read questions nine and ten.

A number of other questions were of little use due to the small number obtained for a given response. For example, data obtained regarding education and news sources was relatively unhelpful due to the wide range of response options. Primarily very weak correlations were found when relating this data to other responses and, consequently, it went largely unused. Therefore, future research could further examine how these variables relate to residents' attitudes and knowledge of the NOA issue.

Given the nature of the research method used, a number of community-level trends in attitudes and perceptions surrounding the asbestos issue were illuminated. However, this study is limited in its depth as it provides little insight into the psychological dimension of the issue. The results of our survey leave several questions unanswered pertaining to the dilemmas faced by parents raising their children in this community or the more subtle forms of denial regarding the degree of risk associated with NOA that allow residents to justify their continued residence in the area. Furthermore, our survey did not address the source of residents' confusion. For example, do residents understand the difference between tremolite and other kinds of asbestos? This question remains to be answered.

Because growth and development of El Dorado Hills is ongoing, if the asbestos issue were set aside, the community might even be described as thriving. In fact, in 2007, ***CNN Money*** named this town one of the top 100 places to live in the USA (http://money.cnn.com/magazines/moneymag/bplive/2007/snapshots/PL0621880.html). However, given the mounting evidence that suggests that environmental exposure to asbestos is related to a number of health problems, the need for this growing town to begin acting to mitigate asbestos exposure is becoming increasingly urgent. Our results suggest that El Dorado Hills residents' understanding of the issue is still incomplete and this is mirrored in the widespread inaction in regards to asbestos exposure mitigation. Further education of residents about NOA-related health risks is the first step towards initiating action.

Conclusion

Our findings demonstrate a significant correlation between the presence of NOA within residential El Dorado County, and the issue being a cause for concern among residents. The pet dog lung analyses from El Dorado County reinforce the growing amount of NOA fiber / lung burden data in the region. In one dog sampled, exposure to NOA was still evident in large quantity seven years after its owner had moved away from the area - providing further evidence of lung- retained fiber biopersistence. Given the contextual nature of the subject matter, there appears to be a persistent barrier inhibiting transparency between governing bodies and residential awareness. Our exploratory survey demonstrated a large level of confusion in the region studied concerning the issue. Ultimately, the conclusive evidence of the health effects encountered by NOA, should translate into people (governments, citizens, lobbyists) tackling the issue in a swift and serious manner.

This complex issue poses no easy solutions on how to realistically mitigate dangers associated with tremolite deposits in current residential areas. Further mitigation will undoubtedly pit large-scale interests of future development against long-term human health related issues. To date, it appears that the NOA issue has been put aside and the associated risks downplayed. Economically, there is much to be lost if appropriate mitigation is to take place – most notably the further development of high risk areas on hillsides, holding stunning views of expansive virgin hilltops.

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Appendix A
Survey

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Dear Potential Participant,

Enclosed is our survey concerning the possible "Asbestos issue" in El Dorado County. It will take LESS THAN 5 MINUTES TO FILL OUT.

Your responses, should you agree to give them, will serve to gain insight regarding El Dorado County resident views surrounding the asbestos issue.

The research is conducted by a group of seven undergraduate students from McGill University within the 'School of the Environment'.

We thank you greatly for your time: your participation is of great value to our research.

There is no monetary compensation for this survey.

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You may leave answers BLANK if you choose to do so.			
Male[ ] or **Female[ ]**	Age: ___	# of children at home: ___	Zip code: _____
Have you ever heard of asbestos before? **YES [ ] NO [ ]**			
Have you heard of <u>any issue</u> with asbestos in El Dorado County? **YES [ ] NO [ ]**			
Have you personally heard of <u>areas in El Dorado</u> County that have naturally occurring asbestos? **YES [ ] NO [ ]**			

For the remaining questions, circle a response to the right that best fits your agreement with the statement.

Statement	Scale of Agreement					
	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree	Don't Know
1. Asbestos in the environment in and around El Dorado County is an area of concern to me.	1	2	3	4	5	6
2. Too much attention has already been paid to asbestos in El Dorado County.	1	2	3	4	5	6
3. El Dorado County has been unjustly singled out concerning asbestos.	1	2	3	4	5	6
4. There is sufficient information at my disposal for me to understand the asbestos issue.	1	2	3	4	5	6
5. There are potential long-term health effects related to naturally occurring asbestos exposure.	1	2	3	4	5	6

Question	Answer					
6. How has the Environmental Protection Agency (EPA) handled naturally occurring asbestos in El Dorado County?	They have done too much	I am satisfied	They have not done enough	They have focused on the wrong issues	I have no opinion	I don't know
7. How have county officials handled this asbestos issue in El Dorado County?	They have done too much	I am satisfied	They have not done enough	They have focused on the wrong issues	I have no opinion	I don't know
8. What are your news sources? ***(Circle all that apply)***	Local News-papers	Big city and/or national newspapers	Television	Internet	Radio	Other
9. How much would you be willing to spend to remove any hazard of naturally occurring asbestos in your area?	Nothing	Less than a hundred dollars	A few hundred dollars	A few thousand dollars	Any price	I don't know
10. What steps would you be willing to take to reduce exposure to naturally occurring asbestos? ***(Circle all that apply)***	Move away	Close windows	Stay indoors as much as possible	Limit outdoor activities	Not willing to take any action	I don't know
11. Which indicates your current level of education?	Some high school	Completed high school	Some college	Completed College	Trade school	Post-graduate level or further

Any comments concerning the asbestos issue?

Appendix B

Survey Results

QUESTION #1	**GENDER?**	
n=188	Total #	Total %
Female	106	56.4
Male	82	43.6
No Answer	16	

QUESTION #2	**AGE?**					
n=190	Total #	Total %	Male	Female	Male %	Female %
<30	28	14.7	16	9	22.5	9.3
30-39	19	10.0	8	11	11.3	11.3
40-49	49	25.8	13	28	18.3	28.9
50-59	66	34.7	25	34	35.2	35.1
60-69	20	10.5	7	9	9.9	9.3
70+	8	4.2	2	6	2.8	6.2
no answer	14					

QUESTION #3	**Children at Home?**	
n=195	Total #	Total %
YES	78	40.0
NO	117	60.0
no answer	9	

QUESTION #4	**Have you heard of asbestos before?**	
n=202	Total #	Total %
YES	201	99.5
NO	1	0.5
no answer	3	

QUESTION #5	**Have you heard of any issue with asbestos in El Dorado County?**					
n=202	Total #	Total %	Male	Female	Male%	Female%
YES	141	69.8	58.0	73.0	70.7	69.5
NO	61	30.2	24.0	32.0	29.3	30.5
no answer	3					

QUESTION #6	**Have you personally heard of areas in El Dorado County that have naturally occurring asbestos deposits?**					
n=202	Total #	Total %	Male	Female	Male %	Female %
YES	128	63.4	56	63	68.3	60.0
NO	74	36.6	26	42	31.7	40.0
no answer	3					

QUESTION #7	**Asbestos in the environment in and around El Dorado County is an area of concern to me.**					
n=202	Total #	Total %	Male	Female	Male %	Female %
Strongly agree	39	19.3	20	14	17.3	19.2
Agree	76	37.6	40	32	39.5	38.5
No opinion	38	18.8	20	14	17.3	19.2
Disagree	24	11.9	14	7	8.6	13.5
Strongly Disagree	18	8.9	8	9	11.1	7.7
Don't Know	7	3.5	2	5	6.2	1.9
No answer	3					

QUESTION # 8	**Too much attention has already been paid to asbestos in El Dorado County.**					
n=202	Total #	Total %	Male	Female	Male %	Female %
Strongly agree	29	14.4	11	16	13.6	15.4
Agree	33	16.3	16	15	19.8	14.4
No opinion	49	24.3	25	21	30.9	20.2
Disagree	41	20.3	12	27	14.8	26.0
Strongly Disagree	22	10.9	8	10	9.9	9.6
Don't Know	28	13.9	9	15	11.1	14.4
No answer	3					

QUESTION # 9	**El Dorado County has been unjustly singled out concerning asbestos.**					
n=202	Total #	Total %	Male	Female	Male %	Female %
Strongly agree	30	14.9	12	16	14.8	15.4
Agree	25	12.4	12	13	14.8	12.5
No opinion	67	33.2	23	39	28.4	37.5
Disagree	30	14.9	15	13	18.5	12.5
Strongly Disagree	10	5.0	5	1	6.2	1.0
Don't Know	40	19.8	14	22	17.3	21.2
No answer	3					

QUESTION #10	**There is sufficient information at my disposal for me to understand the asbestos issue.**					
n=201	Total #	Total %	Male	Female	Male %	Female %
Strongly agree	31	15.4	10	17	12.3	15.0
Agree	58	28.9	23	33	28.4	29.2
No opinion	24	11.9	13	9	16.0	8.0
Disagree	49	24.4	16	28	19.8	24.8
Strongly Disagree	14	7.0	5	6	6.2	5.3
Don't Know	25	12.4	14	20	17.3	17.7
No answer	4					

QUESTION #11	**There are potential long-term health effects related to naturally occurring asbestos exposure.**					
n=202	Total #	Total %	Male	Female	Male%	Female%
Strongly agree	59	29.2	24	27	29.6	26.0
Agree	75	37.1	22	47	27.2	45.2
No opinion	26	12.9	13	13	16.0	12.5
Disagree	15	7.4	10	5	12.3	4.8
Strongly Disagree	8	4.0	4	3	4.9	2.9
Don't Know	19	9.4	8	9	9.9	8.7
No answer	3					

QUESTION #12	**How has the EPA handled naturally occurring asbestos in El Dorado County?**					
n=197	Total #	Total %	Male	Female	Male%	Female%
Done too much	12	6.1	9	1	1.0	11.7
Satisfied	27	13.7	12	14	13.7	15.6
Not done enough	33	16.8	12	14	13.7	15.6
Focused on wrong issues	13	6.6	4	8	7.8	5.2
No opinion	27	13.7	9	15	14.7	11.7
Don't Know	85	43.1	31	50	49.0	40.3
No answer	7					

QUESTION #13	**How have county officials handled the issue in El Dorado County?**					
n=195	Total #	Total %	Male	Female	Male%	Female%
Done too much	10	5.1	7	1	9.1	1.0
Satisfied	26	13.3	12	14	15.6	13.7
Not done enough	36	18.5	16	13	20.8	12.7
Focused on wrong issues	13	6.7	4	9	5.2	8.8
No opinion	24	12.3	5	17	6.5	16.7
Don't Know	86	44.1	33	47	42.9	46.1
No answer	9					

QUESTION #14	**What are your news sources? (Circle all that apply)**	
n=550	Total #	Total %
Local Newspapers	140	25.5
National newspapers	56	10.2
Television	122	22.2
Internet	112	20.4
Radio	82	14.9
Other	38	6.9

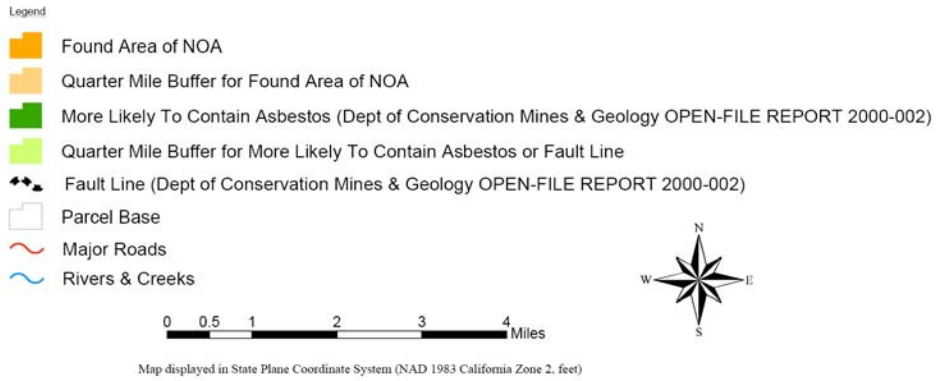
QUESTION #15	**How much would you be willing to spend to remove any hazard of NOA?**					
n=197	Total #	Total %	Male	Female	Male%	Female%
Nothing	52	26.4	20	30	25.6	29.4
Less than $100	28	14.2	14	13	17.9	12.7
Few hundred dollars	26	13.2	13	10	16.7	9.8
Few thousand	9	4.6	6	1	7.7	1.0
Any price	6	3.0	2	4	2.6	3.9
Don't Know	76	38.6	23	44	29.5	43.1
No answer	7					

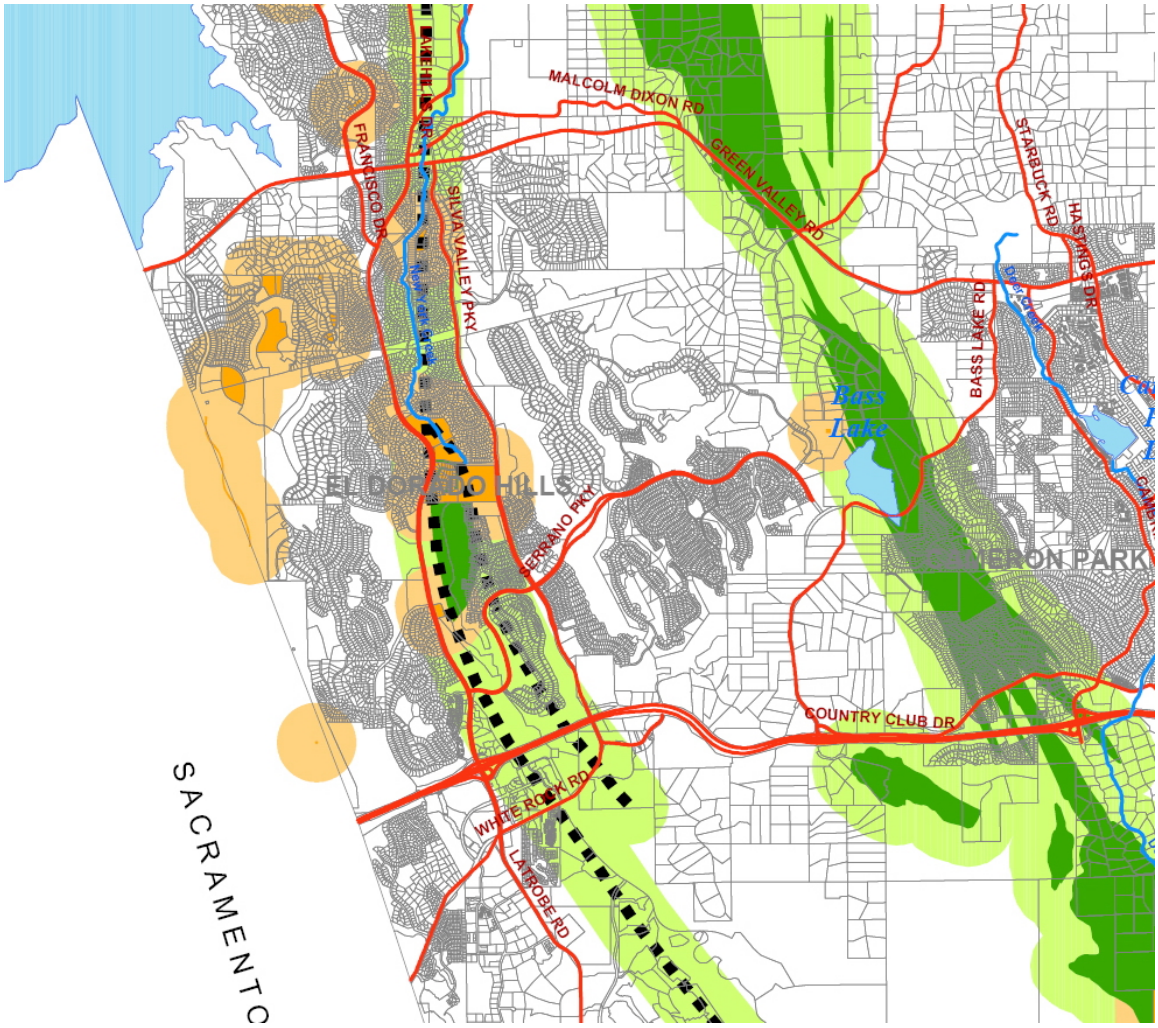
QUESTION #16	**What steps are you willing to take to reduce exposure to NOA?**					
n=215	Total #	Total %	Male	Female	Male %	Female %
Move away	33	15.3	15	18	18.1	16.1
Close windows	29	13.5	10	18	12.0	16.1
Stay indoors	9	4.2	3	4	3.6	3.6
Limit outdoor activity	17	7.9	4	10	4.8	8.9
Not willing to take any action	52	24.2	24	24	28.9	21.4
Don't Know	75	34.9	27	38	32.5	33.9

QUESTION # 17	**Which indicates you current level of education?**					
n=197	Total #	Total %	Male	Female	Male %	Female %
Some High School	1	0.5	0	1	1.0	0.0
Completed High School	5	2.5	3	2	1.9	3.7
Some College	62	31.5	27	33	31.4	32.9
Completed College	69	35.0	26	40	38.1	31.7
Trade School	15	7.6	6	8	7.6	7.3
Post Grad+	45	22.8	20	21	20.0	24.4
No Answer	7					

Appendix C

Map 1: **Detailing western portion of El Dorado County including the El Dorado Hills area and the area to the South which includes Wild Turkey Drive, the area where the animals with highest lung tremolite lived. LEGEND precedes map: Source http://www.co.el-dorado.ca.us/emd/apcd/PDF/Map.pdf**

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WHITE ROCK RD
LATROBE RD
COUNTRY CLUB DR
EL DORADO HILLS
SERRANO PKY
FRANCISCO DR
SILVA VALLEY PKY
MALCOLM DIXON RD
GREEN VALLEY RD
Bass Lake
BASS LAKE RD
STARBUCK RD
HASTINGS DR