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Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

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Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

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An abstract of
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An Abstract of

Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

By

Dianne Alexis

Submitted as partial fulfillment of the requirements for an advanced
Degree from Emory University

**Background:** Occupational exposures to organic solvents on a daily basis can have serious effects on the health and well being of laboratory employees. This study aimed to examine whether safe practices have been adopted among laboratory employees using organic solvents and to investigate if these safe practices were influenced by the knowledge of and the attitude towards harmful effects of organic solvents.

**Methods:** A knowledge, attitude, and practice survey (KAP) was used to collect data about safe laboratory practices. The Analysis of Variance (ANOVA) and Kruskal - Wallis Test were used to examine the association of either, knowledge percent score, practice percent score or attitude percent score of socio-demographic characteristics.

**Results:** 120 questionnaires were administered with an anticipated response rate of 50% (60 responses). Of those asked to participate, 46 of them responded giving an overall response rate of 38.3%. Of the 46 respondents in this study: 14 were males and 32 were females. The majority of the respondents were PhD-educated females with more than 2 years previous work experience.

**Conclusion:** There wasn’t enough evidence to conclude that a greater knowledge of chemical properties and their harmful effects result in better and safer practices.

# Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

**Dianne Alexis**

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Public Health

Rollins School of Public Health
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## List of Abbreviations

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| AIHA | American Industrial Hygiene Association |
| ANOVA | Analysis of Variance |
| ANSI | American National Standards Institute |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| C | Ceiling Limit |
| CDC | Center for Disease Control & Prevention |
| CNS | Central Nervous System |
| CFR | Code of Federal Regulations |
| EHSO | Environmental Health & Safety Office |
| EPA | Environmental Protection Agency |
| IARC | International Agency for Research on Cancer |
| IRB | Institutional Review Board |
| KAP | Knowledge, Attitude and Practice |
| LC50 | Lethal Concentration |
| LD50 | Lethal Dose |
| MSDS | Material Safety Data Sheet |
| NIOSH | National Institute for Occupational Safety and Health |
| NTP | National Toxicology Program |
| OSHA | Occupational Safety and Health Administration |
| PCMR | Proportionate Cancer Mortality Ratios |
| PEL | Permissible Exposure Limits |
| PPE | Personal Protective Equipment |
| PPM | Parts Per Million |
| RTECS | Registry of Toxic Effects of Chemical Substances |
| STEL | Short Term Exposure Limit |
| TLV | Threshold Limit Value |
| TWA | Time Weighted Average |
| WEEL | Workplace Environmental Exposure Limits |

# CHAPTER I

# INTRODUCTION

## 1.1 Overview

Occupational exposures to organic solvents on a daily basis can have serious health effects on the health and well being of laboratory employees. There are certain common sense measures that can be taken in laboratories to prevent or limit these exposures. The harmful effect of organic solvents has been an issue of great concern for environmental and public health professionals for several years; as a result many prevention programs were established to control or reduce unnecessary exposures (Baker 1994, Brautbar & Williams 2002). There is evidence that human exposure to chemicals at levels once thought to be innocuous could have potentially harmful effects. For instance formaldehyde, formalin, and xylene exposures are safety concerns in a pathology laboratory and these chemicals are considered carcinogens by the International Agency for Research on Cancer (IARC 2004 & IARC 2006, Bancroft 2008).

The Occupational Safety and Health Administration (OSHA), IARC and American Conference of Government Industrial Hygienists (ACGIH) enacted a set of safety regulations for formaldehyde, benzene, dichloromethane and xylene for laboratory use. These guidelines were established to limit workers' exposure to solvents in the work place by providing workers with information on safe practices and the use of personal protective equipment (PPE; ACGIH 2001, OSHA 29CFR 1910.1450). The major component of the Laboratory Standards (29CFR 1910.1450, Occupational Exposure to Hazardous Chemicals in the Laboratory) require employers to write and implement a Chemical Hygiene Plan which must be readily available to employees, reviewed at least annually, and updated as necessary (Dapson et al. 2005, OSHA 29CFR 1910.1450).

Formaldehyde also called formalin when available in commercial solutions is a colorless, aqueous solution that has an irritating pungent odor and is classified as an upper respiratory irritant because of its high solubility in water (pathology.med.umich.edu). Concentrations of formalin at levels above 5 parts per million (ppm) in air, are known to irritate mucous membranes of the nose, eyes and throat causing symptoms such as coughing, chest tightness and difficulty breathing (www.osha.gov ). In addition, concentrations of formaldehyde at levels of 25-30 ppm in air are linked to dermatitis, pulmonary edema, pneumonia and bronchial irritation, whereas inhalation of formaldehyde of 100 ppm is dangerous to health leading to death from throat swelling and chemical burns to the lungs (umdnj.edu, Formaldehyde 2004, UMDNJ EOHSS). Long term exposure to formaldehyde has been associated with cancers of the lung, nasopharynx, oropharynx, and nasal passages. Several animal experiments provided evidence of a relationship between nasal cancer in rats and formaldehyde exposure (osha.gov). Formaldehyde exposure commonly occurs through gas-phase inhalation or through liquid-phase skin absorption (Agency for Toxic Substances and Disease Registry, 1999 & (osha.gov).

Xylene is a toxic and hazardous chemical that has numerous health risks including toxic hepatitis and pulmonary edema (selectscience.net, Chang 2006, Buesa 2007, Buesa 2008, Buesa, 2009). The odor threshold for xylene is 1 ppm of air and is considered to have adequate warning properties. Xylene is an irritant of the eyes and mucous membrane at concentrations of 200 ppm (870mg/m3) after 3 to 5 minutes and is a narcotic at high concentrations (Environmental Protection Agency; EPA Health Advisory, 1987, p. 4). Exposures to xylene at 700 ppm in air can be the cause of nausea and vomiting; and extremely high concentrations approximately

10,000 ppm in air could cause loss of consciousness, retrograde amnesia, respiratory failure and death. Xylene liquid or vapor can be easily absorbed by dermal contact, but not as readily as when inhaled or ingested. Based on animal information, xylene is slightly toxic when ingested and ingestion of large amounts can cause irritability, tremors, impaired concentration and short term memory loss (Agency for Toxic Substances and Disease Registry 1999 & OSHA 1910.134).

Benzene is a clear, colorless liquid with a sweet aromatic odor and its odor does not provide sufficient warning of its hazard. It has an odor threshold level of 4.7 ppm in air and exposures to levels of 20,000 ppm in air, for 5 to 10 minutes, may result in death. Exposures to levels where its odor is recognized may cause euphoria, trouble breathing and irritation in eyes, nose and respiratory tract (Material Safety Data Sheet; www.osha.gov). Chronic exposures to benzene may result in various blood disorders, ranging from anemia to leukemia, liver and kidney toxicity (Material Safety Data Sheet, osha.gov).

Dichloromethane also called methylene chloride is a colorless liquid that may cause severe eye and skin irritation, respiratory tract irritation and central nervous system depression, if employees are exposed to a vapor concentration of 500 ppm after one hour. Dichloromethane is harmful if swallowed or inhaled and is converted to carbon monoxide after absorption, thus yielding increased concentrations of carboxy-hemoglobin in the blood (Material Safety Data Sheet, Dichloromethane ACC# 89820, CAS # 75-09-2). OSHA considers dichloromethane to be a potential occupational carcinogen (osha.gov). However, little is known about workers' knowledge of and attitude towards the effects of organic solvents. This study will seek to determine knowledge and attitudes regarding target laboratory solvents that may lead to safer laboratory practices among workers.

## 1.2 Problem Definition

Organic solvents are found in many research laboratories and are used in the performance of various experiments. They can readily evaporate into the air, so that most occupational exposures occur by inhalation or dermal contact. A study conducted at the Hospital for Sick Children in Toronto found that occupational exposure to organic solvents during pregnancy was associated with increased risk of major fetal malformations (Khattak et. al.1999). Several epidemiological studies have also implicated organic solvents with increases in breast cancer incidence and Non-Hodgkin's lymphoma (Labreche & Glodberg, 1997, Rego 1998). In addition, a Swedish study produced findings of increased risks of malignant melanoma in female laboratory personnel after exposure to organic solvents classified by IARC as being possible carcinogens (Wennborg et al 2001).

Safe practices regarding the use and exposure to organic solvents depend on having an appropriate attitude towards the associated health risks, which is dependent on the knowledge of the harmful effects of organic solvents. This study will seek to examine the underlying determinants that prevent laboratory employees from using safe practices or enabling laboratory managers to develop intervention strategies to improve laboratory safety.

## 1.3 Research Objectives

This study aims to examine whether safe practices have been adopted among laboratory employees using organic solvents and to investigate if these safe practices were influenced by the knowledge of and the attitude towards harmful effects of organic solvents. A survey testing knowledge, attitude and practices (KAP) will be conducted among laboratory employees to find out the prevalence of adequate/good knowledge and appropriate attitude among workers. Safe practices when working with organic solvents should be instrumental in reducing the burden of their harmful effects on workers' health.

## 1.4 Research Questions:

The use of hazardous chemicals such as organic solvents in the laboratory is a necessary part of research. In an effort to ensure the protection of laboratory personnel, OSHA, IARC and ACGIH have promulgated a set of guidelines to limit workers' exposures through safe practices. Safe practices, good attitude and knowledge of organic solvents can contribute to the prevention of over exposure. As a result, the following questions need to be addressed: Does a relationship exist between knowledge of and attitude toward chemical solvent exposures and safer laboratory practices? If so, what is the relationship? What knowledge and attitude parameters most influence laboratory practice and how can we use these data to encourage safer laboratory practices?

## 1.5 Hypotheses

- A greater knowledge of chemical properties and their harmful effects result in better safety practices.

- Higher educational status is positively correlated to knowledge of the effects of the organic solvents.
- Safe laboratory practices are inversely proportional with duration of employment

# CHAPTER II

# LITERATURE REVIEW

## 2.1 Introduction

Laboratories can be places of discovery and learning but they can also be places of danger if proper common-sense precautions are not taken. The use of organic solvents is extremely widespread in laboratories for experimental and routine work, and while the degree of hazard may vary, all solvents should be considered potentially hazardous (Bretherick 1990, Furr 1990, Ridgway et al. 2003). Solvents produce their own individual biological responses and as such, each solvent should be evaluated prior to its use (Bird 1981, Furr 1990).

Exposure to organic solvents can vary depending on work conditions and practices. These exposures can be acute (single dose, high concentration exposures over short periods) or chronic (repeated or continuous over long periods) exposures that may initiate toxic responses or cause changes to the functioning of organs in the body (Occupational Health and Safety 29CFR1910, Furr 1990). However, a certain set of monitoring and working practices are required to prevent adverse health effects (Dimenstein 2009)

### 2.1.2 Relevant Studies

There have been several published studies that focused on occupational exposures to organic solvents and also discussed knowledge, attitudes and practices of workers. The study by Izegbu, Amole, and Ajayi (2006) explored attitudes, perception and practices of workers in laboratories in the two colleges of medicine and their teaching hospitals in Lagos, Nigeria. Their study sought to determine the knowledge, attitude and practice of universal precautions amongst medical laboratory workers. They randomly sent out 300 questionnaires to medical laboratory scientists, doctors, laboratory attendants, laboratory technicians and post graduate students. Their overall response rate was 51.3%. The attitude and practices of laboratory workers were found to be very poor because 45.6% of the respondents ate in the laboratories, 47% of respondents stored food in the refrigerators meant for chemicals and 36.5 % of respondents did not know that tissues fixed in formalin can transmit infection. This study confirmed that the ultimate responsibility for laboratory safety lies with the supervisors who should be committed to improving safe work practices by supplying adequate training programs and the necessary information on universal precautions.

Tak-Sun Yu, Lan Lee and Wai Wong (2005) investigated the prevalence of good knowledge, appropriate attitude and safe practice regarding organic solvents among painting workers in Hong Kong and examined whether safe practices were influenced by the knowledge of and attitude towards the harmful effects of organic solvents. They found that the prevalence of good knowledge, appropriated attitude and safe practice among painters were low; 20.4%, 38.4% and 22.0% respectively. Thus they concluded that appropriate attitude was dependent on having good knowledge and that good knowledge of organic solvents was associated with awareness of relevant legislations. Additionally, safe practice was not dependent on knowledge and attitude but was associated with being informed of safety precautions.

In 2010, Viegas et al conducted a study on the genotoxic effects in occupational exposure to formaldehyde. The study was carried out in Portugal using 80 workers: 50 workers from pathology and anatomy laboratories and 30 workers from formaldehyde-based resins production. Exposure assessment was aimed at measuring the ceiling values of formaldehyde and evaluation of the genotoxic effects was performed by application of micronucleus test in exfoliated epithelial cells from buccal mucosa and peripheral blood lymphocytes. The authors observed that the frequency of micronucleus in peripheral blood nucleus was significantly higher in the group of workers from the pathology laboratories than in factory workers. A positive correlation was also found between years of exposure and micronucleus frequency in peripheral blood lymphocytes and in epithelial cells for workers with long term exposures to formaldehyde.

In 1997, Labreche and Goldberg hypothesized that increases in breast cancer incidence may be caused by occupational exposure to organic solvents. They postulated that organic solvents act directly as genotoxic agents or indirectly through their metabolites. The authors believed that the organic solvents and their metabolites that were stores in the fat tissues of the breast migrate to the breast parenchyma and then transferred to the mammary lobules through continuous apocrine secretions. The detection of many organic solvents in breast milk has supported their hypothesis. In addition, the majority of carcinomas occur in the ducts of the breast and some organic solvents have been shown to produce mammary gland cancers in experiments on rodents.

Burnett et al conducted a study in 1999 which examined cancer mortality in healthcare science technicians. They used mortality data from death certificates collected between 1984 and 1995 in the National Occupational Mortality Surveillance Database. They calculated the Proportionate Cancer Mortality Ratios (PCMR) for selected cancers among female health and science technicians aged 18-90 years old at time of death. They found that among clinical laboratory technologists, Non-Hodgkin’s lymphoma mortality was higher among women aged 18-64 years old. The authors concluded that the increase incidence of cancer could be related to chemical exposures in the work place.

## 2.2 Handling of Chemicals

Protection of laboratory employees from exposures to hazardous chemicals depends on the handling of these chemicals in laboratories. Before using any chemical, laboratory employees should be familiar with the characteristics associated with that particular chemical and this reference source is a material safety data sheet (MSDS). The MSDS is a written document that contains information on the health effects of exposure to chemicals. It provides information on the chemical and physical hazard as well as information about safety, handling and storage (Greenberg et al. 1996). The MSDSs are good sources of information for chemicals, and should be kept and readily available in laboratories to be used before handling any hazardous chemicals (MSDS: translinknet.be, 29CFR 1910.1200, 1450)

Laboratories should be appropriately equipped for the handling of hazardous chemicals, in that hazardous chemicals should only be handled in chemical fume hoods (Horowitz et al 1971). In addition laboratory employees should also be equipped with the correct type of personnel protective equipment (PPE) or whenever practical, elimination or substitution of the hazardous chemicals by one with similar technical properties should be employed in order to reduce the risk (Paul Anastas et al 1998). Additionally it is important that laboratory personnel avoid or minimize skin contact and inhalation of solvent vapors. After using solvents, employees should wash gloves prior to removal, especially for dichloromethane, and wash hands again prior to eating or drinking (OSHA's Sanitation Standard-29CFR1910.141). However, employees should not eat or drink in the laboratory because chemical and laboratory safety should be an inherent value for every laboratory employee (29CFR 1910.1450)

### 2.2.1 Benzene: Handling and Storage

Benzene is a flammable liquid and should be kept away from heat or areas free of ignition sources. It should also be stored with compatible chemicals, i.e. it should not be stored with oxidizers. Work with benzene should be conducted in a fume hood to prevent exposure by inhalation and splash goggles and impermeable gloves should be worn at all times to prevent eye and skin contact (fscimage.fishersci.com, MSDS No. 1785: 2006)

### 2.2.2 Dichloromethane: Handling and Storage

Dichloromethane is a colorless liquid that has caused adverse reproductive and fetal effects in animals. Employees working with dichloromethane should wash hands thoroughly after use, remove contaminated clothing and wash before reuse. Employees should also avoid contact with eyes, skin and clothing, avoid breathing vapors or mists from dichloromethane and should only use dichloromethane where there is adequate ventilation. Containers with this solvent should be kept tightly closed, away from ignition sources, oxidizing materials and be kept in cool, dry well-ventilated area (sciencelab.com, fscimage.fishersci.com, MSDS CAS # 75-09-2).

### 2.2.3 Formaldehyde: Handling and Storage

Formaldehyde is a colorless, flammable gas at room temperature with a pungent odor and is typically found dissolved in water and methanol solution as formalin. Laboratory employees using formaldehyde should wash hands thoroughly after handling, and avoid contact with eyes skin and clothing.  Employees should also wear suitable protective clothing and in the case of insufficient ventilation, appropriate respiratory equipment.  Containers of formaldehyde should be kept away from ignition sources and stored in cool, dry, well- ventilated areas away from incompatible chemicals (sciencelab.com, MSDS # 18510, SLF 1363).

### 2.2.4 Xylene: Handling and Storage

Xylene is a colorless, flammable liquid with a pungent odor and should be kept away from ignition sources.  Employees working with this solvent should not breathe the fumes, vapor or spray, should wear suitable protective clothing and appropriate respiratory equipment, and also avoid contact with the skin and eyes.  Xylene should be kept away from incompatible chemicals such oxidizing agents (sciencelab.com, MSDS # 1330-20-7)

## 2.3 OSHA Permissible Exposure Limits (PELs)

OSHA sets enforceable Permissible Exposure Limits (PELs) for many chemicals to protect workers against the health effects of exposure.  The PEL is the basis for assessing the acceptability of exposure to hazardous materials such as benzene in the workplace (Allan Ader, 29CFR 1910.1000).  ACGIH has established exposure limit guidelines call Threshold Limit Values (TLVs).  In addition the American Industrial Hygiene Association (AIHA) has developed exposure guidelines known as Workplace Environmental Exposure Limits (WEEL) for chemical compounds that need occupational exposure limits (Zielhuis & Notten 1988, ACGIH, 2007)

There are three types of TLVs for chemical substances:

a) **Time – Weighted Average (TWA)** is the average exposure on the basis of a normal 8-hour day, 40 hour work week schedule to which workers maybe exposed without harmful effects.

b) **Short Term Exposure Limit (STEL)** is defined by ACGIH as the concentration to which workers can be exposed continuously for a short period of time (15 minutes) without suffering from negative health effects such as irritation, chronic or irreversible tissue damage or narcosis.

c) **Ceiling Limit (C)** is the absolute exposure limit that should not be exceeded at any time (Zielhuis 1988)

The PELs for all organic solvents mentioned in this study are reported below:

### 2.3.1 PEL of Dichloromethane (methylene chloride) 29CFR 1910.1052

The current PEL for dichloromethane is 25 parts per methylene chloride per million parts air (25 ppm) at an 8-hour time-weighted average and 125 ppm at a 15 minute STEL. Employers are expected to conduct monitoring of airborne dichloromethane concentrations and periodic dichloromethane exposure monitoring for all tasks where employee exposures are above the action level of 12.5 ppm, 8-hour TWA, or STEL (29CFR1910, 1915, 1926, osha.gov).

### 2.3.2 PEL of Xylene 29CFR 1910.1200

The current PEL for xylene is 100 ppm at an 8-hour TWA concentration. The National Institute for Occupational Safety and Health (NIOSH) recommended PEL for xylene as 100 ppm at a TWA for up to a 10-hour work shift and a 40-hour work week and 200 ppm for 10 minutes at a short-term limit (NIOSH Recommendations, 1988). ACGIH has assigned xylene a TLV of 100 ppm as a TWA for a normal 8-hour work day and a 40-hour work week and a STEL of 150 ppm for periods not to exceed 15 minutes (ACGIH 1988, p42). OSHA and ACGIH limits are based on the chronic effects associated with exposure to xylene, and the NIOSH limit is based on xylene's potential to cause central nervous system depression and irritation of the eyes (osha.gov).

### 2.3.3 PEL of Benzene 29CFR 1910.1028

The current OSHA PEL for benzene is 1 part of benzene per million parts of air at a TWA concentration over an 8-hour work shift; the short-term exposure limit is 5 ppm in any 15-minute sampling period. NIOSH recommends that benzene be controlled and handled as a potential human carcinogen in the workplace and that exposure be reduced to the lowest limit. NIOSH recommended the exposure limit as 0.1 ppm at an 8-hour TWA and 1 ppm as a ceiling in any 15-minute sampling period (oshs.gov). ACGIH has designated benzene as a suspected human carcinogen having an assigned TLV of 10 ppm as a TWA for a normal 8-hour work day and a 40-hour work week (cdc.gov, Centers for Disease Control, NIOSH 1988)

### 2.3.4 PEL of Formaldehyde/Formalin Solutions 29CFR 1910.1048

The (PEL) for formaldehyde and formalin solutions in all workplaces covered by OSHA Act is 0.75 ppm as an 8-hour TWA. This standard includes a 2 ppm for a 15-minute STEL while ACGIH has set a threshold limit value – ceiling (TLV-C) of 0.3 ppm (ACGIH, 2007). OSHA requires monitoring by the employer if the exposure to formaldehyde exceeds the action level of 0.5 ppm or 2 ppm STEL (osha.gov, Dimenstein, IB 2009, OSHA 29CFR 1910.1048)

## 2.4 Effects and lethal doses of chemicals

LC50 (lethal concentration that results in death in 50% of tested species) is a calculated concentration of a chemical in air or water. For the inhalation route LC50 is the concentration of the chemical in air that kills 50% of a defined experimental animal population where time of exposure is any time up to 1 hour when administered to albino rats weighing 200-300 grams each (Washington State Department of Labor and Industries Code 296-839-2005). LC50 is usually expressed in ppm, milligrams per liter or milligrams per cubic meter. LD50 (lethal dose) is a single dose of a chemical that when ingested, injected or applied to the skin of a test animal under controlled laboratory conditions and kills 50% of the test animals. LD50 measures the toxicity of the chemical and is usually expressed in milligrams or grams per kilogram body weight (Registry of Toxic Effects of Chemical Substances (RTECS) (NIOSH).

### 2.4.1 Effects of xylene and lethal doses

**Effects on animals**: xylene exposure produces central nervous system depression and irritation of the eyes and skin in animals. It is fetotoxic and teratogenic in several species of experimental animals when administered by the oral or inhalation routes (RTECS 1989). LC50 in rats of a 4-hour xylene inhalation exposure is 500 ppm, and the oral LD50 is 430 mg/kg (RTECS 1989). Acute dermal toxicity (LD50): >1700 mg/kg for rabbits (MSDS)

**Effects on humans:** xylene is an irritant of the eyes and mucous membranes at concentrations below 200 ppm and is a narcotic at high concentration (AIHA 1978, Proctor, Hughes and

Fischman 1988, Furr AK, 1990). The estimated oral LD50 for humans is 50 mg/kg (EPA Health Advisory, 1987, osha.gov)

### 2.4.2 Effects of benzene and lethal doses

Benzene is considered very toxic and the probable human oral LD50 would be 50-500 mg/kg. Human inhalation of approximately 20,000 ppm (2% in air) would be fatal in 5-10 minutes (Fisher Scientific MSDS Sheet for Benzene). Benzene may cause adverse health effects following exposure via inhalation, ingestion or dermal or eye contact.

**Effects on humans include**: nerve inflammation (polyneuritis) from acute inhalation exposure to benzene, CNS depression and cardiac sensitization. Chronic exposure to benzene has produced anorexia, aplastic anemia and leukemia (US Department of Health and Human Services 1998)

### 2.4.3 Effects of formaldehyde and formalin Solutions and lethal doses

Formaldehyde is moderately toxic by means of skin contact and inhalation and inhalation is the major route of exposure. Exposures measuring 0.1 to 5 ppm in air causes irritation of the nose, eyes, lungs, and throat and acute exposures to concentrations above 25 ppm can cause fatal pulmonary edema. Low toxicity via the oral route; oral dose of 30-100 ml of 37% formalin can be fatal in humans. LD50 oral dose (rats) is 500 mg/kg, LD50 dermal route (rabbits) is 270 mg/kg. LC50 inhalation route for rats is 203 mg/m (2hours) (OSHA 29CFR 1910.1048)

### 2.4.4 Effects of dichloromethane (methylene chloride) and lethal doses

This chemical can cause slight irritation of the nose and throat after exposure to 500 ppm for 1 hour. Headache and dizziness can occur at concentrations as low as 200ppm for 2-3 hours or 986 ppm for 1 hour. In severe cases, dichloromethane has caused unconsciousness, respiratory failure, pulmonary edema and death. It has a low toxicity if ingested based on limited human information and animal studies (IARC)

**Effects on animals**: inhalation in mouse; LC50 =14,400PPM/7h; inhalation in rats: LC50=529gm/m3. Oral route in mouse: LD50= 873 mg/kg and oral route in rats is LD50= 1600mg/kg. The UN National Toxicology Program (NTP) identifies dichloromethane as a carcinogen.

## 2.5 Laboratory Safety and Material Safety Data Sheet (MSDS)

An MSDS is a document that contains information on the potential health effects of exposure to chemicals, or potentially dangerous substances, and on safe working procedures when handling chemical products. The MSDS contains much more information about the chemical than the label and it is prepared by the supplier (Greenberg MI, Clone DC, Roberts JR 1996).

MSDSs are regulated by OSHA Hazard Communication Standard (29CFR 1910.1200) and must provide accurate, clear and concise information to people who use, handle or store hazardous chemicals for a variety of applications. The American National Standard for Hazardous Industrial Chemicals Material Safety Data Sheet Preparation (ANSI Z400.1-2005, made revisions to the standard in 2005 that improved readability, minimized redundancies and reordered the MSDS sections as outlined below:

Section 1- Chemical Product and Company Identification

Section 2- Composition, Information on Ingredients

Section 3- Hazards Identification

Section 4- First Aid Measures

Section 5- Firefighting Measures

Section 6- Accidental Release Measures

Section 7- Handling and Storage

Section 8- Exposure Controls, Personal Protection

Section 9- Physical and Chemical Properties

Section 10- Stability and Reactivity

Section 11- Toxicological Information

Section 12- Ecological Information

Section 13- Disposal Consideration

Section 14- Transportation Information

Section 15- Regulatory Information

Section 16- Additional Information

Employers must ensure that all chemicals have an up-to-date (less than three years) MSDS when they enter the work place. The MSDS must be readily available to the workers who are exposed to the chemical and in the cases of accidents, contaminations or chemical spills, an MSDS can be a “life insurance” for workers handling hazardous substances (translinknet.be).

Greenberg, Clone and Roberts (1996) reviewed MSDSs and suggested that they are important resources for emergency room physicians who need a source of readily available information regarding chemical hazards in the diagnosis and treatment of exposures (Greenberg et al 1996, Annals Emergency Medicine).

## 2.6 Implementing Laboratory Safety Procedures to Reduce Exposures

Occupational exposures to organic solvents can cause adverse health effects. NIOSH has recommended that engineering controls and PPE and clothing be used to reduce solvent exposures to the concentrations specified in the existing OSHA's PEL, NIOSH's recommended exposure limit or ACGIH's threshold limit values. Employers must make every effort to keep exposure concentration below these levels and worker education programs should be instituted to inform laboratory employees about the hazards of exposure and to provide information on safe handling (DHHS-NIOSH Publication N0. 87-104)

### 2.6.1 Exposure Monitoring

A qualified Chemical Hygiene Officer should make periodic surveys of workers exposure to organic solvents. The results of these surveys will determine the extent of exposure and ensure that effective controls are in place (NIOSH Occupational Exposure Sampling Strategy Manual 1977). Laboratory employees' exposures to airborne contaminants should be estimated by 8-hour time-weighted average and short-term (15 minutes) exposures calculated from personal breathing zone samples.

### 2.6.2 Controlling Worker Exposure and Education

Proper maintenance procedures and worker education are good control programs. The methods for limiting exposures to organic solvents are contaminant control, personal protective equipment and chemical substitution. Employers must establish a training program for all employees exposed to hazardous chemicals and this training must be provided at the time of initial assignment and whenever a new hazardous chemical is introduced into the work place. This training should inform the employees about the organic solvents to which they are exposed, potential health risks from exposure, proper use of personal protective equipment and clothing, other methods of control and work practice procedures (OSHA 29CFR. 1910.1200).

### 2.6.3 Contaminant Control

Engineering controls should be used to eliminate the potential for organic solvent exposure in the workplace. Achieving and maintaining reduced concentrations of organic solvents in the workplace depend on exhaust ventilation with appropriate safety designs such as fume hoods. Ventilation equipment should be checked at intervals to ensure adequate performance (ACGIH 1984).

### 2.6.4 Personal Protective Equipment (PPE)

PPE represents the last line of defense against potential exposure and should not be used as a substitute for proper engineering controls and prudent work practices but as an additional measure of protection (Genium MSDS 1988, N0.318) Direct skin contact with organic solvents should be prevented by the use of solvent-resistant gloves, aprons, boots, lab coats and entire work suits depending on the nature of the hazard. Any clothing that becomes contaminated with organic solvents should be removed and discarded or washed before reuse and lab coats must not be taken home for cleaning. In the case of xylene, chemical protective clothing should be chosen on the basis of available performance data and manufacturer's recommendations.

Always wash hands thoroughly before and after glove use and remove gloves as soon as work with hazardous chemicals is completed. Face shields, safety glasses or chemical safety goggles should be worn during the operations with organic solvents whenever the potential for splashing exists. Eye wash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact (osha.gov). Additionally, contact lenses should not be worn if the potential exists for xylene exposure (osha.gov, NIOSH/OSHA Health Guideline 1981, Genium MSDS 1988, No 318).

### 2.6.5 Chemical Substitution

One of the most effective ways to reduce risk of exposure to a hazardous chemical is to eliminate it entirely from the work environment and substitute it with a safer, less hazardous chemical that is capable of performing the same function while being less harmful to one's health (Anastas & Warner 1998).

# CHAPTER III

# METHODOLOGY – SUBJECTS AND METHODS

## 3.1 Background

A study of knowledge, attitude and practices (i.e., KAP survey) of laboratory employees towards organic solvents was conducted at Emory University (Atlanta, Georgia) from January to March 2012. Only workers who were directly involved with the previous organic solvents participated in the study. Participants were recruited online by sending the study consent form, an initiation letter and the survey through emails to laboratory list servers. The link to the online survey was included in the email.

## 3.2 Methods – Study Design, Sample Size and Sampling Method

A KAP survey (Appendix 1) was used to collect data about safe laboratory practices. The questionnaire was divided into five sections with the first section comprised of socio-demographic information and consisted of seven questions; the second section assessed knowledge about organic solvents and consisted of sixteen questions, the third and fourth sections consecutively assessed attitude and safe practices and consisted of seven and eight questions, whereas the fifth section dealt solely with general laboratory safety.

The survey was sent to 120 laboratory employees and 46 of them responded to a structured questionnaire of 44 questions. The survey was conducted using the internet survey tool, Survey Monkey (surveymonkey.com). Information sought included socio-demographic characteristics such as age, gender, educational level, duration of employment, the employee's role in the laboratory, and background on the use of these organic chemicals as part of routine laboratory work. All responses from the survey were exported from Survey Monkey and collected into condensed and expanded spreadsheet versions, then analyzed. The survey data were then cross-tabulated, showing side by side comparisons of demographic variables of each respondent and the association between knowledge, attitude and practices towards laboratory organic solvents (Appendix 4).

## 3.3Ethical Implications

The study was approved by the Institutional Review Board (IRB) at Emory University as an Expedited Approval (Appendix 2) since it posed “less than minimal risk” to participants and fit the regulatory category as set forth in the Federal Register of the Office of Human Research Protections. Ethical requirements included informed consent (Appendix 3) and confidentiality of responses, i.e. responses did not contain any identifying information and survey responses did not contain any subject identifiers. Because the consent form would be the only document linking the participants to the study, a waiver of documentation of informed consent was requested and issued by Emory’s IRB.

## 3.4 KAP Variables

Knowledge about the harmful effects and danger of these organic solvents was sought by asking the laboratory employees about receiving health and safety information from the current employer, provided with information and instructions on use of these chemicals, and awareness of relevant legislation governing the use of these chemicals. Additionally they were asked, whether they attended training courses on these chemicals, the main health hazards associated with these chemicals, the routes of exposures, the symptoms of exposure and the most effective way of controlling exposures. Survey participants must also have chosen whether they had adequate knowledge about any of the organic solvents currently used in the laboratory and to rate their knowledge of safer laboratory practices. There were 16 questions on general knowledge of organic solvents. A correct answer was given a score of "2" and a score of "1" was given for a 'do not know' response. The maximum knowledge score was 106.

A good attitude towards solvents was assessed using a 4-level Likert scale (Wikipedia 2012). There were five positive statements and corresponding scores that respondents choose from; strongly agree (4), agree (3), disagree (2) and strongly disagree (1). In addition there were two negative statements included in the respondents' choices of strongly disagree (4), disagree (3), agree (2) and strongly agree (1). The maximum positive attitude score was 30. Safe laboratory practices towards organic solvents was also explored and this included statements such as, reading labels on containers, wearing appropriate protective gloves, washing hands before eating or drinking, wearing fully covered shoes, being aware of safety precautions and secure storage of outdoor clothing outside of the laboratory area, in cupboards or lockers. There were eight practice statements on organic solvents. A "yes" answer was given a score of '2' and a "no" answer was given a score of '1'. The maximum safe practice score was 26.

## 3.5 Data Analysis

### 3.5.1 Statistical Technique

There were 46 subjects participated in the study. Knowledge, attitude and practice scores (including percent scores) were calculated and treated as continuous variables whilst other variables such as age, gender, pregnant status, education level, duration of employment and the employee's role in the laboratory were treated as categorical variables. Non- parametric analysis was done because of the small sample size and abnormal distribution of scores.

The Analysis of Variance (ANOVA) and Kruskal-Wallis Test were used to examine the association of either the knowledge percent score, practice percent score or attitude percent score of socio-demographic characteristics. The ANOVA and Kruskal-Wallis Test are the standard ways to see the relationships between a continuous variable and a categorical variable. The Spearman Correlation Coefficient was estimated to measure the relationship between (a) knowledge percent score and practice percent score, (b) knowledge percent score and attitude percent score and (c) practice percent score and attitude percent score. The level of significance for the p-values were set at (alpha= 0.05) for all tests (Motulsky 1995). The SAS statistical package V9.2 (SAS Institute Inc, Cary North Carolina) was used for data analysis.

# CHAPTER IV
# RESULTS

## 4.1 Introduction

A detailed description of the results from the analysis of the KAP survey will be presented in this chapter. The categorical and continuous variables will be described as percentages. The levels of good knowledge, appropriate attitude and safe practice towards organic solvents in the laboratories were tested using ANOVA Test, Kruskal-Wallis Test, and the Spearman Correlation Coefficient. ANOVA test was used appropriately to determine whether there was any significant association between knowledge score and socio-demographic characteristics. The Kruskal-Wallis Test was appropriate to determine whether there was any association between practice scores and socio-demographic characteristics and attitude scores and socio-demographic characteristics. Spearman Correlation Coefficient was used to establish the relationship between safe practice and duration of employment.

## 4.2 Findings – Socio-demographic Characteristics

The survey was sent out to 120 laboratory employees via emails with an anticipated response rate of 50% (60 responses). Of, those who were willing to participate, 46 of them responded giving an overall response rate of 38.3%. Of the 46 respondents in the study: 14 were male (30.4%) and 32 were females (69.6%). The participants' socio-demographic characteristics are summarized in Table 1 below. Most of the participants have been employed for more than 2 years (95.7%); are post graduates (45.7%), and are research staff (50%). Additionally, majority of the participants were in the age range of 41-50 years old (34.8%) and

31-40 years old (26.1%) whilst 15.2% were in the under 30 age range and 23.9% in the over 50 age range. The mean knowledge, attitude and practice percent score was 68.07, 68.96, and 83.28 respectively.

**Table 1 Socio-demographic characteristics of participants**

| Variable | Level | N = 46 | % |
|---|---|---|---|
| AGE | 0.under 30 | 7 | 15.2 |
| | 1.31-40 | 12 | 26.1 |
| | 2.41-50 | 16 | 34.8 |
| | 3.over 50 | 11 | 23.9 |
| Gender | Male | 14 | 30.4 |
| | Female | 32 | 69.6 |
| Pregnant | No | 43 | 93.5 |
| | Yes | 3 | 6.5 |
| Duration of employ | <6 months | 1 | 2.2 |
| | < 2 years | 1 | 2.2 |
| | >2 years | 44 | 95.7 |
| Education level | High School | 2 | 4.3 |
| | Bachelor | 15 | 32.6 |
| | Grad | 8 | 17.4 |
| | Post Grad | 21 | 45.7 |
| Lab Role | Research Staff | 23 | 50.0 |
| | Student | 3 | 6.5 |
| | Supervisor | 10 | 21.7 |
| | Technician | 10 | 21.7 |
| Knowledge Score | Mean | 72.26 | - |
| | Median | 73.50 | - |
| | Minimum | 30 | - |
| | Maximum | 103 | - |
| | Missing | 0 | - |
| Knowledge Percent Score | **Mean** | **68.07** | - |
| | Median | 69.50 | - |
| | Minimum | 28 | - |
| | Maximum | 97 | - |
| | Missing | 0 | - |
| Attitude Score | Mean | 20.70 | - |
| | Median | 21 | - |
| | Minimum | 13 | - |
| | Maximum | 28 | - |
| | Missing | 0 | - |
| Attitude Percent Score | **Mean** | **68.96** | - |
| | Median | 70 | - |

| Variable | Level | N = 46 | % |
|---|---|---|---|
| | Minimum | 43 | - |
| | Maximum | 93 | - |
| | Missing | 0 | - |
| Practice Score | Mean | 21.67 | - |
| | Median | 23 | - |
| | Minimum | 2 | - |
| | Maximum | 26 | - |
| | Missing | 0 | - |
| Practice Percent Score | **Mean** | **83.28** | - |
| | Median | 88 | - |
| | Minimum | 8 | - |
| | Maximum | 100 | - |
| | Missing | 0 | - |

### 4.2.1 Relationship between knowledge percent score and demographic characteristics

The ANOVA test was used to compare good knowledge of the harmful effects of organic solvents between the different variables (age, lab role, pregnant, education level and gender). There was no significant association found between knowledge percent score and socio-demographic characteristics (p-value > 0.05) as seen below in Table 2.

**Table 2 Relationship between knowledge percent score and demographic characteristics**

| | | | Knowledge Percent Score | | |
|---|---|---|---|---|---|
| **Variable** | **Level** | **N** | **Mean** | **Median** | **P-value *** |
| Age | 0.under 30 | 7 | 65.71 | 68.00 | 0.542 |
| | 1.31-40 | 12 | 63.33 | 63.50 | |
| | 2.41-50 | 16 | 69.25 | 70.00 | |
| | 3.over 50 | 11 | 73.00 | 71.00 | |
| Lab Role | Research Staff | 23 | 69.61 | 73.00 | 0.840 |
| | Student | 3 | 64.00 | 68.00 | |
| | Supervisor | 10 | 64.60 | 67.00 | |
| | Technician | 10 | 69.20 | 64.00 | |
| Pregnant | No | 43 | 68.02 | 70.00 | 0.949 |

| | | | Knowledge Percent Score | | |
|---|---|---|---|---|---|
| **Variable** | **Level** | **N** | **Mean** | **Median** | **P-value *** |
| | Yes | 3 | 68.67 | 61.00 | |
| Duration of employment | < 6 months | 1 | 82.00 | 82.00 | 0.666 |
| | < 2 years | 1 | 73.00 | 73.00 | |
| | >2 years | 44 | 67.64 | 69.00 | |
| Education level | High School | 2 | 73.50 | 73.50 | 0.385 |
| | Bachelor | 15 | 72.87 | 77.00 | |
| | Grad | 8 | 61.00 | 56.00 | |
| | Post Grad | 21 | 66.81 | 70.00 | |
| Gender | Male | 14 | 71.43 | 72.50 | 0.364 |
| | Female | 32 | 66.59 | 68.50 | |

* P-value is calculated by ANOVA test.

### 4.2.2 Relationship between attitude percent score and demographic characteristics

To compare appropriate attitude regarding the harmful effects of organic solvents between different variables (age, lab role, pregnant, duration of employment and gender) the Kruskal- Wallis Test was used to calculate the p- vlaue. There was no significant association found between attitude percent scores and socio-demographic characteristics (Kruskal- Wallis Test, p-value > 0.05) as seen below in Table 3

**Table 3 Relationship between attitude percent score and demographic characteristics**

| | | | Attitude Percent Score | | |
|---|---|---|---|---|---|
| **Variable** | **Level** | **N** | **Mean** | **Median** | **P-value *** |
| Age | 0.under 30 | 7 | 64.29 | 67.00 | 0.452 |
| | 1.31-40 | 12 | 69.17 | 70.00 | |
| | 2.41-50 | 16 | 68.13 | 70.00 | |
| | 3.over 50 | 11 | 72.91 | 70.00 | |
| Lab Role | Research Staff | 23 | 68.57 | 70.00 | 0.421 |
| | Student | 3 | 63.33 | 67.00 | |
| | Supervisor | 10 | 72.20 | 75.00 | |

| Variable | Level | N | Attitude Percent Score Mean | Median | P-value * |
|---|---|---|---|---|---|
| | Technician | 10 | 68.30 | 70.00 | |
| Pregnant | No | 43 | 68.88 | 70.00 | 0.820 |
| | Yes | 3 | 70.00 | 67.00 | |
| Duration of employment | < 6 months | 1 | 70.00 | 70.00 | 0.458 |
| | < 2 years | 1 | 77.00 | 77.00 | |
| | > 2 years | 44 | 68.75 | 70.00 | |
| Education level | High School | 2 | 60.00 | 60.00 | 0.279 |
| | Bachelor | 15 | 68.80 | 70.00 | |
| | Grad | 8 | 69.50 | 68.50 | |
| | Post Grad | 21 | 69.71 | 70.00 | |
| Gender | Male | 14 | 68.14 | 70.00 | 0.626 |
| | Female | 32 | 69.31 | 70.00 | |

* P-value is calculated by Kruskal-Wallis test.

### 4.2.3 Relationship between practice percent score and demographic characteristics

To compare safe practice regarding the harmful effects of organic solvents between the different variables (age, lab role, pregnant, duration of employment, education level and gender) the p- value was calculated by the Kruskal- Wallis Test. The age of the participants was marginality significantly associated with safe practice percent score (p=value = 0.059). None of the other socio-demographic characteristics were significantly associated to safe practice percent score as seen in Table 4

**Table 4 Relationship between practice % score and socio-demographic characteristics**

| Variable | Level | N | Practice Percent Score Mean | Median | P-value * |
|---|---|---|---|---|---|
| Age | 0.under 30 | 7 | 88.14 | 88.00 | **0.059** |

| | | | Practice Percent Score | | |
|---|---|---|---|---|---|
| Variable | Level | N | Mean | Median | P-value * |
| | 1.31-40 | 12 | 76.92 | 85.00 | |
| | 2.41-50 | 16 | 82.25 | 85.00 | |
| | 3.over 50 | 11 | 88.64 | 92.00 | |
| Lab Role | Research Staff | 23 | 84.70 | 88.00 | 0.879 |
| | Student | 3 | 88.33 | 88.00 | |
| | Supervisor | 10 | 86.10 | 86.50 | |
| | Technician | 10 | 75.70 | 82.50 | |
| Pregnant | No | 43 | 82.93 | 88.00 | 0.617 |
| | Yes | 3 | 88.33 | 88.00 | |
| Duration of employment | < 6 months | 1 | 88.00 | 88.00 | 0.496 |
| | < 2 years | 1 | 92.00 | 92.00 | |
| | > 2 years | 44 | 82.98 | 88.00 | |
| Education level | High School | 2 | 77.00 | 77.00 | 0.972 |
| | Bachelor | 15 | 85.20 | 88.00 | |
| | Grad | 8 | 78.25 | 88.00 | |
| | Post Grad | 21 | 84.43 | 85.00 | |
| Gender | Male | 14 | 85.36 | 88.00 | 0.981 |
| | Female | 32 | 82.38 | 88.00 | |

* P-value is calculated by Kruskal-Wallis test.

### 4.2.4 Relationship between duration of employment and safe practice

Knowledge, attitude and practice percent scores were treated as continuous variables. There was no correlation between knowledge and safe practice percent score, knowledge and attitude percent score and safe practice and attitude percent score with duration of employment. The Spearman Correlation Coefficient, p –value = 0.2097, 0.1806 and 0.811 respectively as seen in Table 5.

**Table 5 Relationship between duration of employment and safe practice**

| Variables | Spearman CC * | P-value |
|---|---|---|
| Know. % score & Pract. % score | 0.18847 | 0.2097 |
| Know.% score & Att. % score | 0.20093 | 0.1806 |
| Pract. % score & Att. % score | 0.03622 | 0.8111 |

*: Spearman correlation coefficient

### 4.2.5 Distributions of knowledge, attitude and safe practice percent scores

Based on graphical and numerical methods, the knowledge percent score was normally distributed (Shapiro-Wilk; W=0.984; p-value =0.752), while both safe practice (Shapiro-Wilk W= 0.636; p-value<0.0001), and attitude percent scores (Shapiro-Wilk W=0.948; p-value= 0.038) were not normally distributed. The histograms for knowledge, safe practice and attitude percent scores are shown in Figures 1-3 respectively.

*Figure 1 Histogram of Knowledge Percent Score*

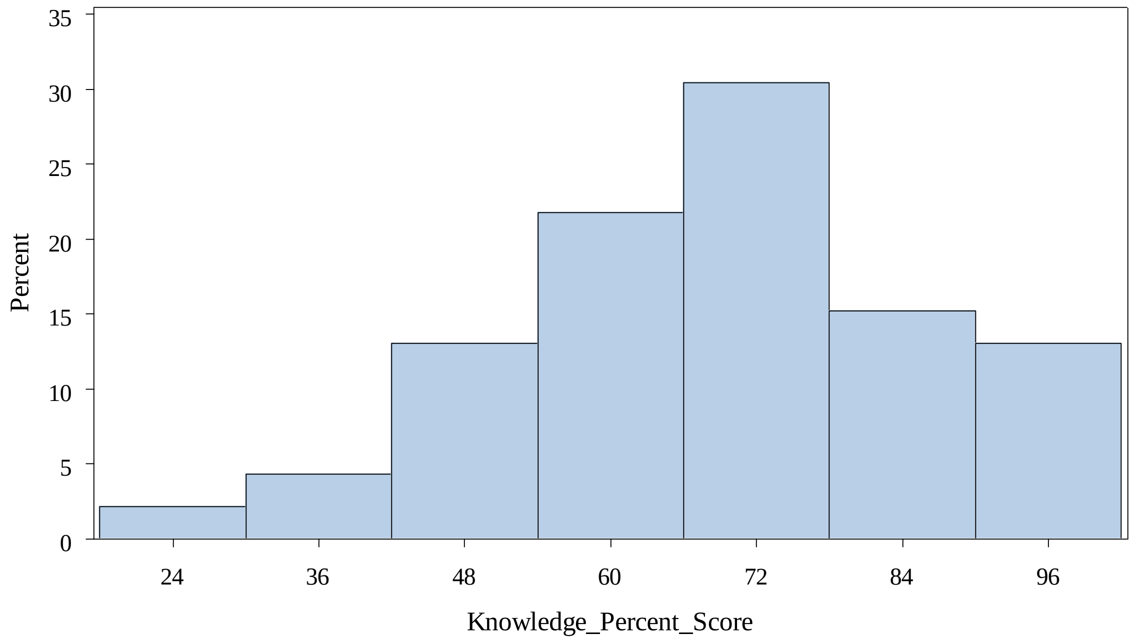



*Figure 2 Histogram of Attitude Percent Score*

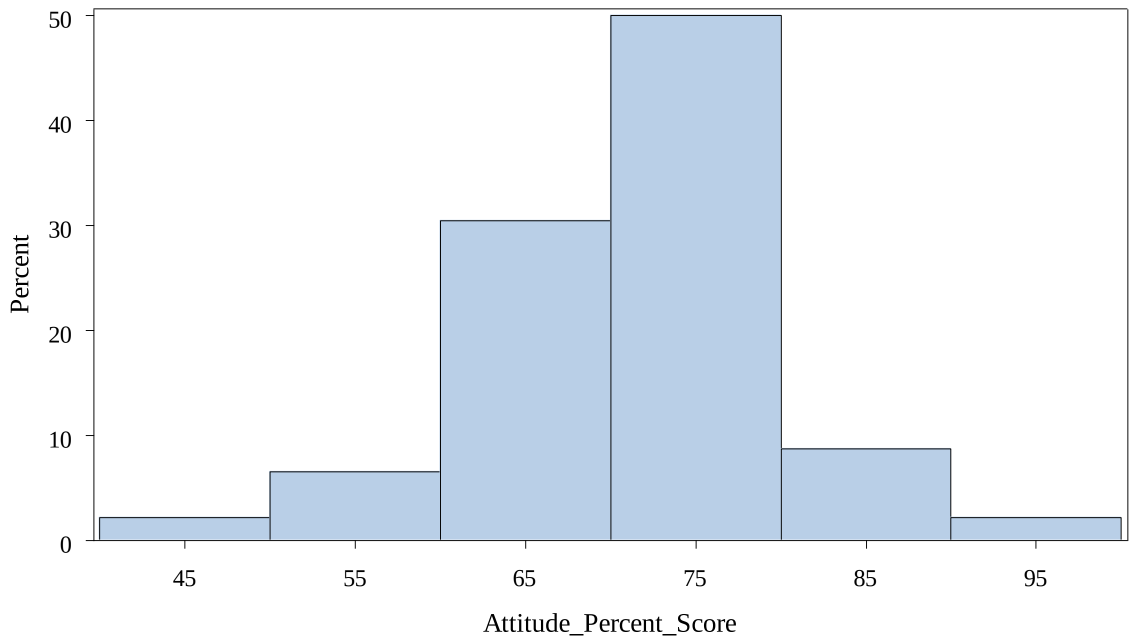
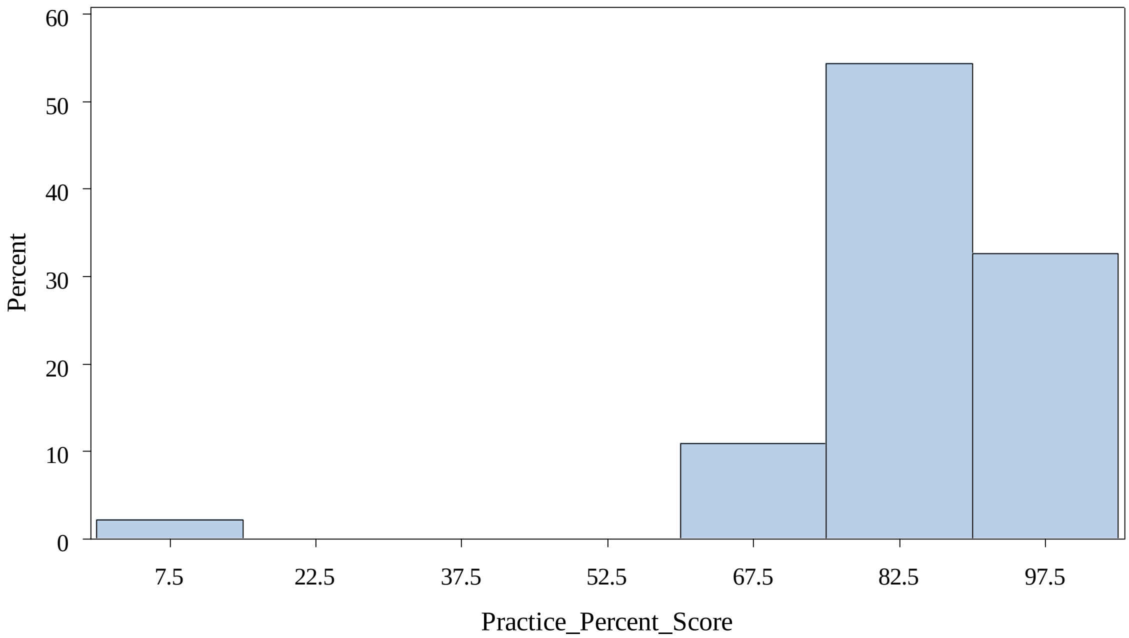


*Figure 3 Histogram of Practice Percent Score*




## 4.3 Summary

The majority of respondents were highly educated so they should have possessed good knowledge about organic solvents; however only 21.7% (10/46) possessed a high degree of knowledge (percent score of 80-100%) despite an excellent safe practice score. Appropriate attitude towards organic solvents was relatively low 6.5% (3/46). A safe practice score of 80-100% was attained by 76% (35/46) of respondents. Safe practice towards organic solvents was marginally significant among 7 respondents under 30 years old which does not reflect true practice.

# CHAPTER V
# DISCUSSION

### 5.1 Introduction

A KAP survey was conducted to investigate knowledge, attitudes and practices toward occupational exposures to chemicals (organic solvents) in laboratories on the campus of Emory University. The result showed female predominance in respondents with a 69.6% compared to males 30.4% and a predominance of 34.8% of respondents are in the age range of 41-50 years old. 45.7 % of the respondents are PhD-educated. This is because 50% of the respondents are research staff and needed the highest levels of education in order to be successful in their chosen field.

## 5.2 Summary of Study

Millions of laboratory employees are exposed to organic solvents on a daily basis while performing research. The prevention of occupational exposures requires a thorough knowledge of and appropriate attitude towards the effects of these solvents. A KAP survey was conducted among laboratory workers to find out the prevalence of good knowledge and appropriate attitude among them.

The mean score for knowledge, attitude and safe practice was 72.26, 20.70 and 21.67 respectively. There was no significant association between either knowledge, or attitude percent and socio-demographic characteristics. However, only age was marginally significantly associated with safe practice (p-value =0.059) which can be considered as approaching significance. None of the previously stated hypotheses were found to be statistically true after being tested.

## 5.3 Conclusions

There is insufficient evidence to support the relationships that were hypothesized which were: (a) a greater knowledge of chemical properties and their harmful effects result in better safer practices, (b) higher educational status is positively correlated to knowledge of the effects of the organic solvents and (c) safe laboratory practices are inversely proportional with duration of employment. However, given the lack of distribution of safety scores, we cannot conclude the opposite is true either. Further analysis is necessary with a broader distribution of scores in order to fully assess the validity of the study hypothesis.

## 5.4 Limitations

A major limitation of the study was the low response rate of the survey. Seventy-four employees refused to participate in the study which is more than half of the anticipated responses. Some non-respondents may have thought that they had good knowledge about organic solvents and neglected to complete the survey or saw the survey as a nuisance, or did not have time to complete the survey. A pilot test of the survey might have improved the survey and the response rate. If I could replicate this study, I would have done a pilot test and extend the time of research.

Knowledge of organic solvents was low, although there was no absolute scale to compare the scores, but the laboratory community should have probably known the answers to the facts that they were tested on. The overall relative scores suggested that some training may be needed to raise their awareness.

Although the response rate was not great, it was good enough. A higher response rate would have given the study more power (the bigger n is the more power given to the study) for statistical purposes and generalizability. More females responded to the survey than males because the laboratory community is more populated with women. This survey could have included a broader array of educational levels to give a better picture of the knowledge, attitudes and practices of the population at Emory University.

**5.5 Implications**

Good research seeks to add to knowledge and suggests areas where additional exploration may be needed. This study represents a single survey, however even thought it did not prove the hypotheses, it still has value and raises important questions for future inquiry.

A previous study conducted by Tak-Sun Yu et al (2005) concluded that “safe practice did not depend on knowledge and attitude, but was positively associated with being informed of safety precautions and being supplied with chemical information from supervisors”. In this study, safe practice was marginally associated with 7 respondents under the age of 30 years old. This suggests that younger participants were more aware of the safety regulations and could be students or newly hired laboratory technicians who may have recently attended a lab safety training program.

The Environmental Health and Safety Office (EHSO) at Emory University conduct online research laboratory safety training every month, annual laboratory self-inspection and validation inspection for 30% of the spaces. Despite all the measures that are in place questions still remain about employee's attitudes towards safe practices in the laboratories. Some supervisors and researchers are aware of poor attitudes and safety practices in their laboratories such as the general reluctance by some employees to wear PPE, lab coats or storing bottles of organic solvents inappropriately with acids or alkalis. Good laboratory safety relies on more regular inspections by EHSO so more laboratories can respond by adopting safer practices.

### 5.6 Recommendations

This study showed that safer practice was a significant factor with the younger respondents. In order to attain good knowledge and appropriate attitude regarding chemicals in the laboratories, supervisors could adopt a buddy system for cross training younger employees and new hires. The experienced and knowledgeable employee portraying appropriate attitude and safe practices towards hazardous chemicals, can serve as orientation mentor for younger employees thus accomplishing positive goals for the laboratory.

EHSO can also extend the Self – Inspection Checklist to include more than 12 items and conduct validation inspections for all laboratories on campuses at Emory University instead of only 30% of spaces. In addition EHSO should develop better innovative and safety programs geared towards enhancing knowledge, attitudes and safe practices instead of using the same recycled programs over and over again. Safe or sustainable practices towards organic solvents may only be attained if EHSO was committed to informing laboratory managers about substituting hazardous organic solvents to safer options.

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# Appendices

## APPENDIX I: KAP SURVEY

## Knowledge, Attitude and Practice Survey

**Survey Objective: To determine knowledge and attitude regarding target laboratory solvents (formalin, formaldehyde, benzene, dichloromethane and xylene that may lead to safer laboratory practices.**

### Demographic information

**1. How old are you?**

a. □ Under 30
b. □ 31 – 40
c. □ 41 – 50
d. □ over 50

**2. What is your gender?**

a. □ male
b. □ female

**3. If female, are you pregnant?**

a. □ Yes
b. □ No

**4. What is the highest level of education you have completed?**

a. □ High School
b. □ College/ Bachelor's Degree
c. □ Graduate Degree
d. □ Post Graduate Degree

**5. How long have been working in the laboratory?**

a. □ less than 6 months
b. □ between 6 months and 2 years
c. □ more than 2 years

**6. What is your role in the laboratory?**

a. □ Supervisor
b. □ Research Staff
c. □ Technician
d. □ other (please specify) ______________________

**7. Have you been using these chemicals routinely as part of your laboratory work? (Please check all the apply)**

□ **formalin,**
□ **xylene,**
□ **formaldehyde,**
□ **benzene,**
□ **dichloromethane,**

**None of these** □---------------------------- Thank you for your time. There is no need for you to complete the rest of the questions.

**8. Have you ever received any health and safety information from your current employer?**

Yes □------------------------------------------ Go to question 9
No □------------------------------------------Go to question 11

**9. If yes, what format did this take? (Please check all those that apply)**

a. □ company orientation training
b. □ additional health and safety training session
c. □ a demonstration on how to use personal protective equipment
d. □ a leaflet or information sheet
e. □ online training
f. □ posters / signs on the wall

**10. Did this information include any of the following? (Please check all that apply)**

a. □ the potential health hazards from using organic solvents
b. □ how to use personal protective equipment properly
c. □ how to clean up organic spills properly
d. □ chemical hazards
e. □ employers' responsibilities for your health and safety

**11. How long ago did you receive the information (Check one)**

a. □ less than 6 months ago
b. □ between 6 months and 2 years ago
c. □ more than 2 years ago

**12. Have you ever received any health and safety training on any of the organic solvents you currently use from a previous job?**

a. □ Yes
b. □ No

**13. Are you aware of the relevant legislation governing the use of any of the organic solvents you currently use in the laboratory?**

a. □ Yes
b. □ No

**14. Do you feel you have adequate knowledge about any of the organic solvents you currently use in the laboratory?**

a. □ Yes
b. □ No

**15. Rate your knowledge about safer laboratory practices. Check one**.

a. □ none at all
b. □ a bit
c. □ more or less
d. □ quite a bit
e. □ very high

**16. Organic solvents can harm your body through……. Check all that apply**

a. □ ingestion
b. □ inhalation
c. □ dermal contact
d. □ through contact with your eyes
e. □ do not know

**17. What are the potential health hazards associated with formalin and formaldehyde? Check all that apply.**

a. □ can cause occupational asthma
b. □ may cause sensitization by skin contact
c. □ can be toxic if swallowed
d. □ can cause cancer in humans
e. □ can affect fertility
f. □ may cause eye irritation

**18. Which of the following are possible symptoms of being exposed to high levels of xylene? Check all that apply**.

a. □ headaches and dizziness
b. □ nausea and vomiting
c. □ irritation of nose, eyes and throat
d. □ skin sensitization
e. □ nervous system effects
f. □ may cause reproductive effects
g. □ can cause cancer in humans

**19. What are the main health hazards associated with breathing in benzene? Check all that apply.**

a. □ depression of the central nervous system
b. □ drowsiness and dizziness
c. □ headaches, tiredness and nausea
d. □ loss of coordination, confusion, and in extreme cases, unconsciousness
e. □ skin sensitization
f. □ eye irritation
g. □ cause cancer in humans
h. □ may affect reproductive organs

**20. What are the main health hazards associated with breathing in dichloromethane. Check all that apply.**

a. □ slight irritation of nose and throat, skin and eyes
b. □ headaches, dizziness, nausea, inability to concentrate and reduced coordination
c. □ unconsciousness and respiratory failure
d. □ may cause cancer in humans
e. □ slight feto-toxicity
f. □ pulmonary edema, death

**21. The hazard symbol**  **is displayed on all organic solvents. Does this mean that these solvents are?**

a. □ dangerous to the environment
b. □ corrosive
c. □ harmful or an irritant
d. □ toxic
e. □ do not know

**22. The most effective way of controlling your exposure to formalin, formaldehyde and xylene is to switch to low fume hoods to reduce your laboratory's footprints.**

a. □ true
b. □ false
c. □ do not know

**ATTITUDES**

**23. Do you think that exposure to organic solvents has any harmful effects to health?**

a. □ Yes
b. □ No

**24. People worry more than necessary about the hazards associated with formaldehyde.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**25. Given the opportunity, I would use further measures to help protect my health when using the organic solvents mentioned in this survey.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**26. I think the risks associated with formalin and xylene, are sufficiently controlled in my workplace.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**27. I can help protect my health and safety when using benzene and dichloromethane by making slight changes to the way I work.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**28. I think the organic solvents mentioned in this survey are safe as long as they are handled and used in the correct.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**29. I see no reason why I cannot eat or drink in the laboratory.**

a. □ strongly agree
b. □ agree
c. □ disagree
d. □ strongly disagree

**PRACTICE**

**30. Do you read labels on containers of organic solvents?**

a. □ □ Yes
b. □ □ No

**31. Do you wear gloves when working with organic solvents?**

a. □ □ Yes
b. □ □ No

**32. Do you wash hands before eating or drinking after work?**

a. □ □ Yes
b. □ □ No

**33. Is eating, drinking and application of cosmetics prohibited in the laboratory?**

a. □ Yes
b. □ No

**34. Are appropriate protective gloves available and worn?**

a. □ Yes
b. □ No

**35. Do all laboratory staff wear fully covered shoes, confine long hair and avoid loose clothing?**

a. □ Yes
b. □ No

**36. What safety precautions should you be fully aware of when working with the organic solvents in this survey? Check all that apply.**

a. □ wear safety goggles or safety glasses at all times
b. □ ensure that the gloves you use are appropriate to the specific risk
c. □ do not wear lab coats in break rooms, cafeterias and restrooms.
d. □ do not take your lab coats home to wash
e. □ always wear the lab coat that has been provided and see that it is properly fastened.

**37. Is there provision for the secure storage of outdoor clothing out of the laboratory area, or in secure cupboards/ lockers within the area?**

a. □ Yes
b. □ No

**GENERAL LABORATORY SAFETY**

**38. Where required, is access to the lab restricted to authorized persons only?**

a. □ Yes
b. □ No

**39. Are all chemicals labeled, including hazard symbols where appropriate?**

a. □ Yes
b. □ No

**40.  Are Material Safety Data Sheets available for all hazardous substances used in the lab?**

a. □ Yes
b. □ No

**41.  Are reagents and solvents stored in suitable closed vessels, within fire-resistant cupboards, cabinets or bins containing spill trays?**

a. □ Yes
b. □ No

**42. Is an eyewash fountain and emergency shower present, functioning and unobstructed?**

a. □ Yes
b. □ No

**43.  Are emergency procedures and emergency phone numbers clearly posted on all laboratory doors?**

a. □ Yes
b. □ No

**44.  Is there a person, with appropriate experience and knowledge, designated to deal with spills/leaks involving organic solvents or other hazardous substances?**

a. □ Yes
b. □ No

******Questions from this survey was adapted and formatted from "Embalmers Knowledge Assessment, Attitudes and Risk Perception" Questionnaire conducted by University of Aberdeen and Institute of Occupational Medicine Research Report and KAP survey conducted by Tak-Sun Yu et al (2005)**

Tak-Sun Yu, I.,  Nga, L.L., Wong, T.W. (2005) Knowledge, attitude and practice regarding organic solvents among printing workers in Hong Kong.   J. Occup. Health 47: 305-310

Creely, K.S., Leith, S., Graham, M.K., Cowie, H.A., et al (2003). Effective communication of chemicals. Hazard and risk information using a multimedia safety data sheet. Prepared by the University of Aberdeen for the Health and Safety Executive 2003 Report 072. http://www.hse.gov.uk/research/rrpdf/rr072.pdf

# APPENDIX II: EXPEDITED IRB APPROVAL

EMORY UNIVERSITY | Institutional Review Board

TO: Dianne Alexis
Principal Investigator

DATE: January 30, 2012

RE: **Expedited Approval**
IRB00054658
Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

Dear Dianne Alexis,

Thank you for submitting a new application for this protocol. This research is eligible for expedited review under 45 CFR.46.110 and/or 21 CFR 56.110 because it poses minimal risk and fits the regulatory category F[7] as set forth in the Federal Register. The Emory IRB reviewed it by expedited process on 01/27/2012 and granted approval effective from **01/27/2012** through **01/26/2013**. Thereafter, continuation of human subjects research activities requires the submission of a renewal application, which must be reviewed and approved by the IRB prior to the expiration date noted above. Please note carefully the following items with respect to this approval:

- Protocol Document (Version: 12/20/2011)
- KAP suvey
- Recruitment E-mail
- ~~Waiver of signature~~
- Informed Consent form (Version: 12/19/2011)

Any reportable events (e.g., unanticipated problems involving risk to subjects or others, noncompliance, breaches of confidentiality, HIPAA violations, protocol deviations) must be reported to the IRB according to our Policies & Procedures at www.irb.emory.edu, immediately, promptly, or periodically. Be sure to check the reporting guidance and contact us if you have questions. Terms and conditions of sponsors, if any, also apply to reporting.

Before implementing any change to this protocol (including but not limited to sample size, informed consent, study design, you must submit an amendment request and secure IRB approval.

In future correspondence about this matter, please refer to the IRB file ID, name of the Principal Investigator, and study title. Thank you

Steven J. Anzalone
IRB Analyst Assistant
*This letter has been digitally signed*

CC:

## APPENDIX III: INFORMED CONSENT

| | | |
|---|---|---|
| Study No:IRB 00054658 | *Emory University IRB*<br>IRB use only | Document Approved On: «ApproveDate»<br>Project Approval Expires On: **«ExpireDate»** |

**Emory University**
**Consent to be a Research Subject**

**Title**: Occupational Exposures to Chemicals (Organic Solvents) in Laboratories

**Principal Investigator:** Dianne Alexis

**Funding Source:** There is no funding available for this study

### Introduction

You are being asked to be in a research study. This form is designed to tell you everything you need to think about before you decide to consent (agree) to be in the study or not to be in the study. **It is entirely your choice. If you decide to take part, you can change your mind later on and withdraw from the research study. You can skip any questions that you do not wish to answer.**

Before making your decision:

- Please carefully read this form or have it read to you
- Please ask questions about anything that is not clear

You can take a copy of this consent form, to keep. Feel free to take your time thinking about whether you would like to participate. By signing this form you will not give up any legal rights.

### Study Overview

Every day many laboratory workers are exposed to chemical agents in their work place, which implies a risk for workers' health and well being. For instance formaldehyde, formalin and xylene exposures are safety concerns in a pathology laboratory and are considered carcinogens by the International Agency for Research on Cancer. Short term exposures to benzene and dichloromethane cause loss of coordination, confusion and unconsciousness (American Conference of Government Industrial Hygienists). The purpose of this study is to examine whether safe practices have been adopted among laboratory workers using organic solvents and to see if safe practices were influenced by the knowledge of and the attitude towards harmful effects of organic solvents as well as other factors.

### Procedures

You will complete a survey, which will take 10- 15 minutes to complete. The survey includes a series of questions related to your knowledge and attitude regarding target laboratory solvents. The survey will address variables including demographics, safe practices, personal protective equipment, occupational exposure and its control. The survey will be conducted online via survey monkey and your responses will be automatically compiled in a spreadsheet that cannot be linked to you. The results of this study will be used for educational purposes only.

## Risks and Discomforts
No risks or discomforts are anticipated for taking part in this study. You will be exempt from answering questions about chemicals you do not use. If you feel uncomfortable with a question, you can skip the question or withdraw from the study. If you decide to quit at any time before you have finished the survey, your answers will NOT recorded.

## New Information
It is not possible that the researchers will learn something new during the study about the risks of being in it.

## Benefits
You will be contributing to the knowledge on the safe practices of working with organic solvents and be instrumental in reducing the burden of the harmful effects of organic solvents on workers health.

## Compensation
You will not be offered payment for being in this study.

## Confidentiality
Your responses to the questionnaire will be kept completely confidential and will not contain any identifying information. Data will be collected without use of subject identifiers. Although you were recruited from a list of e-mail addresses of laboratory workers, your survey answers will not link to your email address or in any other way link to you.

## Costs
There are no costs, research or standard of care related, associated with this study. There will be no costs to you for participating in this study. You will not be charged for any of the research activities**.**

## Withdrawal from the Study
You have the right to leave a study at any time without penalty.

## Contact Information
Contact Dianne Alexis at (404) 232-9292:

- if you have any questions about this study or your part in it,
- if you have questions, concerns or complaints about the research

Contact the Emory Institutional Review Board at 404-712-0720 or 877-503-9797 or irb@emory.edu:

- if you have questions about your rights as a research participant.
- if you have questions, concerns or complaints about the research.

- You may also let the IRB know about your experience as a research participant through our Research Participant Survey at http://www.surveymonkey.com/s/6ZDMW75.

## Consent

By continuing on with this survey, you are giving your informed consent to participate in this study. No documentation will be obtained specifically with your personal information.

## APPENDIX IV: SUMMARY OF DATA

| Column1 | AGE | Gender | Pregnant | Education level | Duration of employ | Lab Role | Know. Score | MKS | % Score | Attitude Score | MAS | % Score 2 | Practice Score | MPS | % Score 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 31-40 | F | N | Grad | 2 yrs + | Supervisor | 73 | 106 | 69 | 22 | 30 | 73 | 21 | 26 | 81 |
| **2** | 31-40 | F | N | Grad | 2 yrs + | Student | 53 | 106 | 50 | 16 | 30 | 53 | 22 | 26 | 85 |
| **3** | over 50 | F | N | Grad | 2 yrs + | Supervisor | 58 | 106 | 50 | 23 | 30 | 77 | 24 | 26 | 92 |
| **4** | over 50 | F | N | Bachelor's | 2 yrs + | Supervisor | 83 | 106 | 78 | 19 | 30 | 63 | 24 | 26 | 92 |
| **5** | 41-50 | F | N | Post Grad | 2 yrs + | Research Staff | 79 | 106 | 75 | 19 | 30 | 63 | 20 | 26 | 77 |
| **6** | 41-50 | F | N | Post Grad | 2 yrs + | Supervisor | 47 | 106 | 44 | 19 | 30 | 63 | 24 | 26 | 92 |
| **7** | 41-50 | F | N | Post Grad | 2 yrs + | Supervisor | 69 | 106 | 65 | 23 | 30 | 77 | 22 | 26 | 85 |
| **8** | 41-50 | F | Y | Bachelor's | 2 yrs + | Research Staff | 65 | 106 | 61 | 25 | 30 | 83 | 20 | 26 | 77 |
| **9** | 41-50 | F | N | Bachelor's | 2 yrs + | Technician | 103 | 106 | 97 | 22 | 30 | 73 | 24 | 26 | 92 |
| **10** | under 30 | F | N | Bachelor's | 2 yrs + | Student | 72 | 106 | 68 | 20 | 30 | 67 | 24 | 26 | 92 |
| **11** | 41-50 | F | N | Post Grad | 2 yrs + | Research Staff | 30 | 106 | 28 | 15 | 30 | 50 | 16 | 26 | 62 |
| **12** | 41-50 | F | N | Bachelor's | 2 yrs + | Technician | 52 | 106 | 49 | 21 | 30 | 70 | 20 | 26 | 77 |
| **13** | over 50 | F | N | Post Grad | 2 yrs + | Research Staff | 97 | 106 | 92 | 21 | 30 | 70 | 24 | 26 | 92 |
| **14** | over 50 | F | N | High School | 2 yrs + | Technician | 63 | 106 | 59 | 18 | 30 | 60 | 24 | 26 | 92 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **15** | 41-50 | M | N | High School | 2 yrs + | Research Staff | 93 | 106 | 88 | 18 | 30 | 60 | 16 | 26 | 62 |
| **16** | over 50 | F | N | Post Grad | 2 yrs + | Research Staff | 65 | 106 | 61 | 22 | 30 | 73 | 23 | 26 | 88 |
| **17** | over 50 | M | N | Bachelor's | 2 yrs + | Research Staff | 102 | 106 | 96 | 21 | 30 | 70 | 22 | 26 | 85 |
| **18** | 41-50 | M | N | Post Grad | 2 yrs + | Research Staff | 71 | 106 | 67 | 21 | 30 | 70 | 23 | 26 | 88 |
| **19** | under 30 | F | N | Bachelor's | 2 yrs + | Supervisor | 42 | 106 | 40 | 13 | 30 | 43 | 23 | 26 | 88 |
| **20** | under 30 | M | N | Bachelor's | 2 yrs + | Research Staff | 85 | 106 | 80 | 21 | 30 | 70 | 23 | 26 | 88 |
| **21** | 31-40 | F | N | Post Grad | 2 yrs + | Technician | 61 | 106 | 58 | 21 | 30 | 70 | 16 | 26 | 62 |
| **22** | 41-50 | M | N | Post Grad | 2 yrs + | Research Staff | 75 | 106 | 71 | 21 | 30 | 70 | 22 | 26 | 85 |
| **23** | over 50 | F | N | Grad | 2 yrs + | Research Staff | 86 | 106 | 81 | 19 | 30 | 63 | 24 | 26 | 92 |
| **24** | 41-50 | F | N | Post Grad | 2 yrs + | Supervisor | 89 | 106 | 84 | 20 | 30 | 67 | 21 | 26 | 81 |
| **25** | 31-40 | M | N | Post Grad | 2 yrs + | Student | 78 | 106 | 74 | 21 | 30 | 70 | 23 | 26 | 88 |
| **26** | 31-40 | M | N | Post Grad | 2 yrs + | Research Staff | 59 | 106 | 56 | 21 | 30 | 70 | 22 | 26 | 85 |
| **27** | 41-50 | F | N | Bachelor's | 2 yrs + | Technician | 73 | 106 | 69 | 21 | 30 | 70 | 20 | 26 | 77 |
| **28** | over 50 | F | N | Post Grad | 2 yrs + | Supervisor | 96 | 106 | 91 | 26 | 30 | 86 | 22 | 26 | 85 |
| **29** | 31-40 | F | N | Post Grad | 2 yrs + | Research Staff | 49 | 106 | 46 | 21 | 30 | 70 | 18 | 26 | 69 |
| **30** | 41-50 | M | N | Bachelor's | < 6 mos. | Research Staff | 87 | 106 | 82 | 21 | 30 | 70 | 23 | 26 | 88 |
| **31** | under 30 | M | N | Bachelor's | 2 yrs + | Technician | 82 | 106 | 77 | 19 | 30 | 63 | 24 | 26 | 92 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **32** | 31-40 | F | N | Grad | 2 yrs + | Technicia n | 62 | 106 | 58 | 20 | 30 | 67 | 2 | 26 | 8 |
| **33** | 31-40 | F | N | Grad | 2 yrs + | Research Staff | 77 | 106 | 73 | 21 | 30 | 70 | 23 | 26 | 88 |
| **34** | under 30 | M | N | Post Grad | 2 yrs + | Research Staff | 64 | 106 | 60 | 21 | 30 | 70 | 23 | 26 | 88 |
| **35** | 31-40 | F | N | Post Grad | 2 yrs + | Research Staff | 80 | 106 | 75 | 20 | 30 | 67 | 22 | 26 | 85 |
| **36** | 31-40 | M | N | Post Grad | 2 yrs + | Research Staff | 40 | 106 | 38 | 21 | 30 | 70 | 24 | 26 | 92 |
| **37** | over 50 | F | N | Bachelor's | 2 yrs + | Supervis or | 75 | 106 | 71 | 24 | 30 | 80 | 19 | 26 | 73 |
| **34** | over 50 | M | N | Post Grad | 2 yrs + | Research Staff | 74 | 106 | 70 | 20 | 30 | 67 | 24 | 26 | 92 |
| **39** | 41-50 | F | Y | Post Grad | 2 yrs + | Research Staff | 98 | 106 | 92 | 20 | 30 | 67 | 26 | 26 | 100 |
| **40** | under 30 | M | N | Bachelor's | 2 yrs + | Technicia n | 62 | 106 | 58 | 17 | 30 | 57 | 20 | 26 | 77 |
| **41** | under 30 | F | N | Bachelor's | 2 yrs + | Technicia n | 82 | 106 | 77 | 24 | 30 | 80 | 24 | 26 | 92 |
| **42** | 41-50 | M | N | Post Grad | 2 yrs + | Research Staff | 88 | 106 | 83 | 23 | 30 | 77 | 22 | 26 | 85 |
| **43** | over 50 | F | N | Grad | 2 yrs + | Supervis or | 57 | 106 | 54 | 28 | 30 | 93 | 24 | 26 | 92 |
| **44** | 31-40 | F | N | Post Grad | < 2 yrs. | Research Staff | 77 | 106 | 73 | 23 | 30 | 77 | 24 | 26 | 92 |
| **45** | 41-50 | F | Y | Grad | 2 yrs + | Research Staff | 56 | 106 | 53 | 18 | 30 | 60 | 23 | 26 | 88 |
| **46** | 31-40 | F | N | Bachelor's | 2 yrs + | Technicia n | 95 | 106 | 90 | 22 | 30 | 73 | 23 | 26 | 88 |