Original Article

Formaldehyde Fume Exposure Pattern in Anatomic Pathology Laboratories in Nigeria

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Abstract

Background: Formaldehyde, widely utilized in anatomic pathology laboratories, has been classified as a carcinogen, yet its exposure patterns in laboratory practice in Nigeria has been scarcely studied. **Aim**: The study aimed to evaluate exposure patterns in selected anatomic pathology laboratories in Nigeria. **Method**: Four laboratories from northern parts of Nigeria were selected for the study. The short-term exposure limits/levels (STEL) in parts per million (ppm) were calculated for 15-minute intervals for the period of surgical cut-up daily for 5-working days. Average values for each laboratory were then documented. **Result**: The average STEL ranged from as low as 0.002 ppm to as high as 1.6 ppm in the laboratories studied and was influenced by concentration of formaldehyde used in specimen preservation, and to some degree, ambient temperature, and humidity during surgical cut-up. **Conclusion**: There is a need for anatomic pathology laboratories to constantly monitor the levels of formaldehyde emissions in their workspaces and the need to educate clients of the laboratory on the ideal formaldehyde concentration for tissue fixation and the dangers of concentrated formaldehyde usage.

Keywords: Formaldehyde; exposure; laboratories; hazard

INTRODUCTION

Formaldehyde is a colorless, pungent chemical used in several industries. In histopathology, it is used for routine tissue fixation, embalming bodies and museum mounting. Formaldehyde permissible exposure limit (PEL) in the workplace is 0.75 parts per million (ppm) measured as an 8-hour time-weighted average (TWA) and short-term exposure limit (STEL) of 2 ppm during a 15-minute period.[1]

Short-term hazardous effects include burning sensations in the eyes and airways; nausea; and skin irritation while the most burdensome long-term effect is susceptibility to cancer.[2] The aim of this study was to evaluate exposure patterns in anatomic pathology laboratories in Nigeria.

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METHODOLOGY

The study was conducted in the anatomic pathology laboratories of three government-owned teaching hospitals, (named laboratories A, B and C) and that of a private
laboratory (Laboratory D) in northern Nigeria. The study was conducted in the surgical cut-up rooms of each of the laboratories. Because surgical cutups do not extend for up to 8 hours at a time, rather than calculate the standard 8-hour time weighted average (TWA), the short-term exposure limits/levels (STEL) were calculated for 15-minute intervals in *X*mg/m^3 converted to (*X*) x 0.814 parts per million (ppm) [3] for the period of surgical cut-up.

The readings were taken daily for 5- work days (Monday to Friday) for the duration of gross tissue examination in the surgical cut-up rooms. The highest and average levels were then recorded for each day. In addition to measuring the formaldehyde concentration, ambient temperature and humidity were also documented during the study periods.

A Fourier transform infrared spectrometric (FTIR)-based device with sensitivity from 0 – 5 ppm was deployed for the readings and can detect concentrations up to 5 ppm every 3 minutes to 2 hours. The device was placed in the vicinity of the personnel doing the surgical cut-up as closely as possible to be representative of the actual amount of fumes being experienced (figure 1).

RESULTS

The average surgical cut-up times for Laboratory A was about 2 hours; for Laboratory B it was about 1 hour 30 minutes; for Laboratory C it was about 2 hours and for Laboratory D it was about 1 hour 45 minutes.

Figure 1: Fourier transform infrared spectrometric (FTIR)-based device showing a read out during surgical cut-up.

Table 1: Shows pattern of formaldehyde fume exposure in the 4 laboratories.

Day of the week	Laborator A (HCOH in ppm)	Laboratory B (HCOH in ppm)	Laboratory C (HCOH in ppm)	Laboratory D (HCOH in ppm)
Day 1	0.5	0.2	1.5	1.0
Day 2	1.6	0.01	0.16	1.6
Day 3	0.6	0.5	0.1	0.7
Day 4	1.6	0.002	1.1	1.1
Day 5	0.5	0.07	0.4	1.2
Ventilation	Fair	Fair	Fair	Good
Use of PPE	Yes; but no goggles	Yes; but no goggles	Yes; but no goggles	Yes; but no goggles
Temperature	27 – 30C	25 – 30C	21 – 27C	27 – 30C
Humidity	34 – 48%	6 – 30%	28 – 29%	34 – 48 %
Average STEL	0.97	0.16	0.66	1.12

HCOH= Formaldehyde; ppm= parts per million; Ventilation: determined by presence of extractor fans and window sizes; PPE= personal protective equipment; STEL= short term exposure limit.

Laboratory A had 1 extractor fan and 1 window while the other laboratories had no extractor fans, but each had at least 2 large windows with thoroughfare ventilation.

The short-term exposure levels (STEL) recorded (as shown in Table 1) ranged from 0.5 – 1.6ppm and an average of 0.97ppm in Laboratory A; 0.002 – 0.5ppm and an average of 0.16ppm in Laboratory B; 0.10 – 1.5ppm and an average of 0.66ppm in Laboratory C and 0.7 – 1.6ppm and an average of 1.12ppm in Laboratory D.

There was no statistically significant inter- or intra-laboratory recognizable pattern of exposure. However, exposure levels relatively reflected ambient relative humidity and temperature. These ranged in temperature from 25C to 30C and humidity from 6% to 48%. It was difficult to conclude on these due to difficulty in measuring the formaldehyde concentration used for each specimen.

DISCUSSION

The short-term exposure limit/level (STEL) for the laboratories ranged from as low as 0.002 ppm to as high as 1.6 ppm (average range from 0.16 – 1.12). The upper limit of this is very close to the 15-minute exposure limit of 2 ppm. Nevertheless, this is too high considering that 0.5 ppm is the lower end of the permissible exposure limit (PEL) at which a worker is expected to be evacuated from the offending source.[1] A similar study in an anatomy laboratory concluded on the need for real time formaldehyde exposure monitoring after it recorded values ranging from 0.45 – 1.08 ppm in the laboratory.[4]

Surgical cut-up rooms in all the laboratories studied are well ventilated and thus, the absence of a pattern in the levels of formaldehyde fume exposures rather reflects the concentration of formalin fixatives being used by hospitals sending specimens to the laboratories. Private hospitals were found to more frequently utilize concentrated formalin solution for tissue fixation than the public tertiary hospitals. This may explain the consistently higher values reported from the private laboratory (Laboratory D) involved in this study. Other factors observed in this study which appear to affect the patterns of exposure were the ambient temperatures and humidity during surgical cut-up. The lower temperatures and relative humidity recorded in 2 of the laboratories were associated with lower exposure levels compared to the other 2 with higher ambient temperatures. Parthasarathy et al[5] established the effects of these in their study which showed that a 10°C increase in temperature increased formaldehyde emissions 1.9–3.5 times, and that a 35% increase in relative humidity increases the emissions by a factor of 1.8–2.6.

Though the personnel conducting the surgical cut ups wore protective clothing, no goggles were worn and as such could not be protected against burning sensations in the eyes; face masks were ineffective against the fumes. Thus, the personnel reported symptoms including burning sensations in the eyes, nose, and throat. These are found to occur when formaldehyde present in the air exceeds 0.1 ppm.[1] While most personnel working in anatomic pathology laboratories nationwide have also experienced these short term effects at one time or the other, the long term effects such as arrhythmias, asthma, atherosclerosis, stroke, congestive heart failure, and neurodegenerative diseases, all of which have also been associated with chronic formaldehyde exposure, have been poorly but need to be studied nationally.

The Environmental Protection Agency (EPA), in 1987, first classified formaldehyde as a probable human carcinogen. However, the International Agency for Research on Cancer (IARC) and then the National Toxicology Program of the United States of America in its 12th Report on Carcinogens, as far back as 2011 have classified formaldehyde as a Group 1 carcinogen.[6, 7] Its carcinogenicity, based on animal studies, has been attributed to direct genotoxicity as well as qualitative chromosomal translocations especially in the nasal mucosa cells of chronically exposed individuals.[8] This may explain the increased linkage with Nasopharyngeal carcinoma; and based on the effect of formaldehyde on bone marrow stem cells, increased linkage with leukemia and Hodgkin lymphoma.[9, 10]

A panacea to this problem of inappropriate utilization of formaldehyde by hospitals from which surgical specimens emanate is, perhaps, to organize seminars on how to appropriately handle surgical specimens. Such talks may be held during continuous medical education (CME) programs organized by various branches of Nigeria Medical Association (NMA). A complementary approach may be to reach out to the facilities, either identified as usually sending specimens in concentrated formalin, or avail them the opportunity of sending their staff for training on how to prepare ideal fixatives or assist them in preparing the solution after they have procured the raw materials.

Personnel working in anatomic pathology laboratories should also be trained on optimum handling of formaldehyde-containing solutions as well as provision of adequate personal protective equipment. Though, the ideal practice for handling formaldehyde-containing fluids is under a hood; while this may be impracticable in most anatomic pathology laboratories, there is need to ensure adequate ventilation and provision of extractor fans in surgical cut-up rooms.

In conclusion, there is a need for anatomic pathology laboratories to constantly monitor the levels of formaldehyde emissions in their workspaces and the need to educate end users of the laboratory on the ideal formaldehyde concentration for ideal tissue fixation and the dangers of concentrated formaldehyde usage as well as safety precaution with handling and usage.

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