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Economic, human and environmental health benefits of replacing formaldehyde in the preservation of corpses

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ABSTRACT

Formaldehyde has been prominent in preserving biological tissues since the nineteenth century. Despite being admittedly harmful to health and to the environment, it is still widely used. The Morphology Department of the University of Brasília - Brazil, applied the rethink, reduce, reuse, recycle and responsibility methodology to their activities in an effort to protect the health of laboratory workers and users, save resources and reduce damage to the environment. Here we evaluate the results obtained a decade after the implementation of this proposal (2005–2015). Formaldehyde was replaced by alcohol and glycerol solutions in corpse conservation. Over five thousand dollars in public funds that would have been destined to buying preserving substances were saved annually, and over a hundred thousand liters of water that would have been contaminated and thrown into the sewage system were spared. The environment used to implement the study was improved and anatomical parts kept for study had their lifespan extended. It is noteworthy that such simple adjustments could cause pronounced changes in laboratory activities. We would avoid contaminating billions of liters of water and it would be possible to save millions if similar practices were implemented in all educational institutions having similar routines.

1. Introduction

The technical basis for preserving human bodies joins the initiatory and sacred knowledge of ancient civilizations, amongst which ancient Egypt, located in the north of Eastern Africa, stands out. There, effective practices for embalming bodies were developed so that the dead rulers, who were considered to be gods, could be reunited with other deities, according to their civilization's religious beliefs. (Wilkinson, 2010). Scientific progress has benefited very little from this knowledge, due to the difficulty in deciphering the hieroglyphs.

Morphological studies usually begin with a stage of preservation of biological tissues, first avoiding their decomposition. The conservation process can be defined as a process that prevents the action of the putrefaction agents that act in biological tissues, stopping the enzymatic mechanisms and fixing them in the state they were in when they were first preserved (González and Castro, 1989).

The cadaver is the main element of the anatomic study when it comes to preservation of biological material (Didio, 1986; Rodrigues and Franco, 2011). Ethics and standards must be observed for the use of cadavers, due to important cultural aspects of man's relationship with death (Rodrigues, 2010).

The decomposition of corpses begins in the digestive tract, because of the micro fauna existing in the intestinal lumen. Nervous tissue, especially the central nervous system, also deteriorates quickly, which hinders the acquisition of organs for studies and research.

Some substances (e.g., alcohol) have been used by anatomist Steven Blankaart (1650–1704) in intravascular injections. This technique was consecrated when it was used by Guillermo Hunter in methods and techniques for fixation, dehydration, staining and morphological preservation (1718–1783). The use of alcohol became popular among anatomy scholars between the XVIII and XIX centuries, but there are controversial narratives concerning who started this practice (Laskowski, 1886; González and Castro, 1989). It has accompanied anatomists for centuries – not only for its partly reversible influence on living but also on non-living tissues (Hammer et al., 2012). Ethanol, also called ethyl alcohol, is an organic chemical, clear colorless liquid

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with a characteristic vinous odor (Pubchem, 2017b).

Glycerin was discovered in 1779 by the Swedish chemist Carl Wilhelm Scheele (1742–1786), with Carlo Giacomini (1840–1898), enthusiastically advocatingits application in preserving the nervous system, from 1884 on. In 1867, Laskowski (1841–1902) and Brissaud (1852–1909) presented a combination of glycerin, alcohol and carbolic acid in an international seminar, and introduced the technique in the anatomy museum in Vienna (González and Castro, 1989). This technique enabled the inclusion of cadavers and parts with large volumes of biological tissue.

Glycerol (1, 2, 3-propanetriol) is a colorless, odorless, viscous liquid, derived from both natural and petrochemical feedstocks. It contains three hydrophilic alcoholic hydroxyl groups, which are responsible for its solubility in water and its hygroscopic nature. The expressions glycerin or glycerin generally refer to a commercial solution of glycerol in water of which the principal component is glycerol (Pagliaro and Rossi, 2008).

1867 was a milestone in the history of morphological sciences, since the German chemist August Wilhelm V. Hoffmann (1818–1892) identified formaldehyde (formalin, methanal etc), an universal chemical agent for fixing biological tissues, as discovered in 1859, by Aleksander Butlerov (1828–1886). Twenty-five years later J. Blum implemented the aqueous solution of formaldehyde in zoological studies (Blum, 1893; González and Castro, 1989). The use of formaldehyde was popularized from the nineteenth century on for its low cost and high power of tissue penetration. In this setting, alcohol, formaldehyde, glycerin, various acids, sodium, potassium, paraformaldehyde, methyl salicylate, benzyl benzoate, xylene, and other chemicals have been used as fixers and preservers isolatedly or combined amongst themselves (González and Castro, 1989; Rodrigues, 2010).

Formaldehyde is a natural component of ambient air. Anthropogenic sources are usually the major contributor to the high levels of formaldehyde in populated regions, since ambient levels are generally $< 1\ \mu g/m^3$ in remote areas. Outdoor air concentrations of formaldehyde in urban environments (about 0.16 ppm) are more variable and depend on local conditions (IARC, 2006).

Gaseous formaldehyde, recognized as one of the most abundant aldehydes found in urban areas, was detected in São Paulo, the largest industrialized region of Latin America with a highly polluted atmosphere, at a concentration of 46.3 ppbv (Montero et al., 2001).

The evidence indicates that formaldehyde is not carcinogenic by the oral route, taking into consideration that the occurrence in drinking water is at concentrations well below those ones of public health concern. Due to this, according to the World Health Organization, it is not considered necessary to set a formal guideline value for formaldehyde (WHO, 2011).

In the XX century, concerns over the use and disposal of preservation solutions and the impacts on the environment and on the health of human and animals populations have emerged. In the workplace, laboratory and industrial practices that use chemicals in routine activities are detrimental to the health and well-being of workers (Goldblatt, 1955; Goldstein and Eijkemans, 2005; Hassim and Hurme, 2010; Laboratory, 2011).

According to the Globally Harmonized System of Classification and Labeling of Chemicals (UN, 2011), formaldehyde is a dangerous product since it is corrosive to metals (H290), a liquid fuel (H227), toxic if swallowed (H301), toxic in contact with the skin (H311), fatal if inhaled (H330) and can cause cancer (H350). Ingesting formaldehyde may cause bloody vomit and abdominal pain, with a high chance of perforation in the esophagus and stomach walls, shock and damage to the kidneys and death (Indukern, 2008).

The Brazilian NR-15 (operations and unhealthy activities - 115.000-6) establishes an exposure of up to 1.6 ppm in 48 h per week (considered as a maximum unhealthy degree). However, the Occupational Safety and Health Administration has set a limit for a worker exposure, as an 8-h time weighted average, of airborne concentration at 0.75 ppm (OSHA, 2011).

For more details and information concerning to formaldehyde properties, uses, toxicity, human health effects, medical treatment, animal studies, pharmacology, environmental fate and exposure, occupational exposure standards, etc see (INCA, 1996–2017; WHO, 2005; IARC, 2006; WHO, 2010; OSHA, 2011; WHO, 2011; HDSB, 2015; NIOSH, 2016).

This study aims to present the results of a decade of changes in the technical and scientific activities of the Morphology Area of the University of Brasília – UnB, made to foster care for the environment, the welfare of workers, to reduce spending and to properly fulfill norms.

2. Materials and methods

2.1. Institutional characteristics

Technical activities or support activities which assist in human anatomy lessons at UnB began in 1962. The morphology area (MA) was created with the initial goal of teaching human anatomy to Medical, Nursing and Physical Education courses. Its scope was expanded and it was moved to the College of Health Sciences until the Faculty of Medicine (FM/UnB) was created, with its users being students of several courses (medicine, nursing, pharmaceutical sciences, nutrition, dentistry, physical education, performing arts, languages, etc.).

The technical area of this activity sector focuses on reproducing knowledge, scientific production, technical training focused on human resources, university extension, and circulation of scientific knowledge produced for both the internal public and the community.

The MA/UnB has been a partner to elementary and high schools in the Federal District and its surroundings since the beginning. Therefore, young people and their teachers are users of the services provided to the community by the continuous and temporary projects such as for example, courses, scientific events, and specific activities planned to meet the regional demands.

2.2. Methodological characterization

This was a qualitative descriptive study and can be defined as a historical and organizational research (Triviños, 1987; Demo, 2000). The initial problem focused on the technical and scientific activities that have always supported the actions of the FM//UnB MA. Therefore, over a decade (2005–2015) of activities was analyzed and evaluated.

The actions that implied the execution of laboratory practices such as sampling, preservation, conservation, and restoration of biological tissues derived from human cadavers received for teaching and scientific research were and are governed by Law 8.501, November 30, 1992. Handling was initially (until 2010) governed by the Ordinance of the Public Ministry of the Federal District and its Territories (*Ministério Público do Distrito Federal e Territórios; MPDFT*), No. 01, of March 1, 2006, and currently by Ordinance MPDFT No. 01, June 23, 2010, which revoked the former.

The cadavers at FM/UnB underwent a change in their preservation technique, in which the aqueous 10% formaldehyde solution was substituted by dry conservation techniques. For this purpose, the routine solutions applied for the preparation and the conservation of bodies was alcohol or bi-distilled glycerin based - Giacomini's (González and Castro, 1989; Ferreira, 2013) modified technique. This step was important for the transition from previous the preservation technique with formalin to the dry techniques. The use of formaldehyde as a fixative and conservative solution was reduced during the first 90 days of the beginning of corpse preservation process. Other less handled parts of the Human Anatomy Museum continued to be kept in formalin solutions.

Another point in question was the disposal of solid waste generated when processing cadavers, both in regard to the laboratory preservation techniques, as to the waste generated during the preparation of the