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Metalworking Fluid Exposure and Consequences on Skin Health in a Metal Machining Factory: Review Article

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Abstract

Metalworking fluids (MWFs) are a variety of substances can be used during machining of metals such as cutting, turning, grinding, milling and drilling. National Institute of Occupational Safety and Health (NIOSH) in United States of America has stated that MWFs available in different forms such as straight oil (neat oil), soluble oil (emulsifiable oil), semisynthetic MWFs, and synthetic MWFs and during the machining processes worker can be exposed to MWFs through skin contact and inhalation. MWFs in machining factory allow significant bacterial growth in the fluids and aerosols which cause dermatological and respiratory adverse health effects among exposed workers. skin diseases that MWF exposure can cause various morphology of skin disorders such as skin scaling or dryness. Semi-quantitative dermal exposure assessment methods (DREAM) in both occupational and epidemiological survey. The prevention of the health effects of MWF on skin systems would probably by enhancing the awareness of the workers towards the health effects of MWF and the appropriate safety methods need to apply regularly all along their working time.

Keywords: Metalworking fluid; DREAM; Metal Machining.

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1. Introduction

Metalworking fluids (MWFs) are a variety of substances can be used during machining of metals such as cutting, turning, grinding, milling and drilling. MWFs provide lubrication, cooling to the metal pieces during the machining and help to carry away the small debris such as swarf and fine metal particles that were generated by the machining of the metal. According to Health and Safety Executive (HSE), MWFs can help to increase the machining performance and extend the life of the cutting tools in addition to providing corrosion protection for the workpieces (HSE, 2011).

National Institute of Occupational Safety and Health (NIOSH) in United States of America has stated that MWFs available in different forms such as straight oil (neat oil), soluble oil (emulsifiable oil), semisynthetic MWFs, and synthetic MWFs and during the machining processes worker can be exposed to MWFs through skin contact and inhalation (NIOSH 2012). Skin contact can occur when workers dip their hands into the fluid or handle tools or equipment covered with the fluid without using any personal protective equipment (PPE) such as gloves and aprons while inhalation exposure results from breathing MWFs mists or aerosols in the air. Respiratory exposure can occur when the fluid splash from the machine leaving MWF aerosols suspended in the workers' environment and inhaled by the workers especially if the workers were not wearing the proper personal protective equipment and the lacking local exhaust ventilation to remove the MWF aerosols. The levels of the exposures were directly related to the close proximity of the workers from the machine or the speed and pressure of the machine (Fishwich *et al.* 2015; NIOSH, 2012; NIOSH, 1998).

Perkins & Angenent (2010) have stated that water-based MWFs in machining factory allow significant bacterial growth in the fluids and aerosols which cause dermatological and respiratory adverse health effects among exposed workers.

Kurpiewska, J. Liwkowicz, J. Benczek, K. (2011), Kütting *et al.* (2010), Cherrie and Semple (2010) and Roff *et al.* (2004) have reported that dermal exposure to water-based Metalworking fluids through direct or indirect skin contact lead to skin health effects that vary from simple redness to severe vesicles and ulcers. There was a shortage in a number of related studies on exposure to metalworking fluids in Malaysia (Jabbar et al, 2017).

From the identified papers, studies meeting the following eligibility criteria were selected: Metal-working fluids, studies on occupational exposure to MWFs and the adverse health effects on skin health of workers in the metal machining industry. A case study, cross-sectional, and review papers were selected.

2. MWF Effects on Skin Health

The skin was a complex multilayered tissue with a large surface area exposed to the environment. The outer layers, the *stratum corneum*, can provide as much as 80% of the resistance to absorption to most ions as well as solutions and was considered as the primary barrier to prevent penetration that consists primarily of dead keratin-filled keratinocytes embedded in the extracellular lipid matrix. However, the skin was permeable to many toxicants and dermal exposure to chemicals can result in severe systemic toxicity (Hodgson, 2004).

Maizura, *et al.* 2015, HSE (2011), and Cherrie and Semple (2010) have reported that all types of MWFs water-based or oil-based can cause irritation of the skin and dermatitis. The water-based MWF cause skin irritation also due to the microbes which survive on the fluid in addition to the toxic biocidal that usually added to water-based MWF to kill the microbes.

Improper handling of MWFs provides a good environment for the growth bacteria and fungi can cause skin disorders among workers (Awoslka-Olumo *et al.*, 2003).

Lillienberg et al. (2008) and De-Joode et al. (2005) have stated that the workers in the production section of metal machining factories were susceptible to dermal exposure to MWF. Those workers in exposed group were highly susceptible to skin disorders such as skin redness, skin itching, skin dryness and/or skin scaling. Similarly, Wiszniewska & Walusiak-Skorup (2015) have stated that MWF was found to be the most common cause of occupational contact dermatitis.

Johansen, Frosch & Lepoittevin, (2011) and De-Joode *et al.* (2005) have reported that most occupational skin diseases were due to an irritant or allergic contact dermatitis and irritant contact dermatitis was commonly associated with exposure to MWF. Lillienberg *et al.* (2008) and De-Joode *et al.* (2005) have stated that the workers in the production section of metal machining factories were susceptible to dermal exposure to MWF.

Johansen, Frosch & Lepoittevin (2011) stated in their book on skin diseases that MWF exposure can cause various morphology of skin disorders such as skin scaling or dryness.

The water-based metalworking fluid dermal exposure can lead to skin disorders due to dual effects of chemical exposure and also biological exposure when the microbes used the MWF as a media to live and contact with the skin can produce skin disorders (Maizura *et al.* 2015).

Ladou (2007) has stated that patch testing was the most important diagnostic test for occupational skin disease and this because nearly 90% of occupational skin diseases were contact dermatitis and although irritant and allergic dermatitis can be similar clinically, differentiation can be done only by patch testing. In

addition to patch testing, fungal, bacterial, and viral smears and cultures, biopsies, and prick testing in case if allergic contact dermatitis was suspected. Brown (2004) has stated that occupational contact dermatitis had an appreciable impact on the economy of patients. Pesonen *et al.* (2015) have reported that the risk of occupational dermatitis among metal and machine operator workers who use MWF in daily basis was 2.06 compared to the unexposed.

3. Skin Health Assessment

A study was conducted in Poland between January and September 2007 to assess the skin health status of a group of 581 healthcare workers, 181 metal factory workers, and 91 food services workers. A self-reported questionnaire was used to assess the skin condition, partly based on the Nordic Occupational Skin Questionnaire NOSD-2002. This questionnaire still used in projects in Nordic countries and recommended to assess the skin conditions of hands and/or forearm for estimating the scale of contact dermatitis in population (Kurpiewska, Liwkowicz, and Benczek (2011). Shamout and Adisesh (2016) stated that, for NOSQ questionnaire, the sensitivity 70.3%, specificity 99.8%, positive predictive value 96.3%, and negative predictive value 98.5%. However, the questionnaire was unable to differentiate between allergic contact dermatitis and irritant contact dermatitis.

4. Skin Exposure Assessment

De-Joode *et al*. (2003) stated that skin exposure to chemical and biological hazards can be assessed by using structured semi-quantitative dermal exposure assessment methods (DREAM) in both occupational and epidemiological survey; this model systematically describes the transport of contaminant mass from exposure sources to the surface of the skin through three main exposure routes: emission, deposition, and transfer.

- Emission involves mass transport of substances by direct release from a source onto skin or clothing, such as exposure by splashes, or immersion of hands into a liquid
- Deposition on skin or clothing describes mass transport from the air. In this case, the contaminant mass is first released into the air and subsequently deposited on skin or clothing.
- The transfer is defined as the transport of mass from contaminated surfaces onto skin or clothing, e.g. skin contact with surfaces or working tools that have been previously contaminated with an agent.

In a study conducted by De- On another hand, De-Joode *et al.* (2005) have assessed the reliability of DREAM and reported that DREAM can be applied reliably to estimate both potential and actual skin exposure to wide range of chemicals in different occupational industries where workers were handling a liquid chemical. From the available references, the DREAM was a valid and reliable method to estimate the

skin exposure. Lesmas Fabian *et al.* (2014) have carried out a research to evaluate the effectiveness different methods to estimate the dermal exposure in developing countries and founded that DREAM was the most appropriate method as compared to other methods PHED (pesticide handlers' exposure database) and RISKOFDERM (risk assessment to chemicals).

5. Water-based MWF Microbial Contamination and its Effects on Skin Health

Maizura *et al.* (2015) have conducted a study in Malaysia in metal machining factory to study the water-based MWF and the level of contamination with the microbes and have found that there was contamination with a different form of bacteria from gram-negative as *Pseudomonas aeruginosa*, *E. coli*, and *Klebsiella pneumoniae.* Trafny *et al.* (2015) have found that the MWF were contaminated with several species of *Enterobacteriaceae* as *Pseudomonas* and these findings support our study findings. NIOSH (2012) which studied an aircraft factory and reported that bacteria and fungus were isolated from MWF and the dermal exposure can lead to skin disorders due to chemical and biological exposure. Dilger *et al.* (2005) have concluded that different bacteria can be survived in MWF and with time they become resistant to biocides in the same time the workers who were exposed to MWF can be exposed to these bacteria that can cause skin irritation and complaints among exposed workers. Veillette *et al.* (2004) have tracked the microbes in the MWF for 6 months and identified different forms of microbes as bacteria such as *Pseudomonas aeruginosa*, *E. coli*, and *Staphylococcus aureus*. Awosika-Olumo *et al.* (2003) have concluded that improper handling of MWF can provide an appropriate environment for microbes' growth and the workers who were exposed to MWF can suffer from different skin disorders.

Brown (2004) has stated that occupational contact dermatitis had an appreciable impact on the economy of patients. Pesonen *et al.* (2015) have reported that the risk of occupational dermatitis among metal and machine operator workers who use MWF in daily basis was 2.06 compared to the unexposed.

6. Prevention of Skin Disorders

Skin disorders as an occupational disease are preventable and there were studies showed that prevention is achievable as reported by Kütting *et al.* (2010), and Simpson *et al.* (2003), However, another study Holness and Kudla (2012) have stated that there were gaps in the prevention programs for work-related skin diseases. Trafny *et al.* (2015) have recommended that good hygiene practices were needed to prevent the adverse health consequences on the workers. Cohen and White (2006) have recommended when exposure to MWF is exceeding 2 mg/m^3 the engineering control, administrative control, and health surveillance are required to protect the health of the MWF exposed workers. Alfonso *et al.* (2015) have recommended that action must be taken to reduce the exposure and protect the workers. Kutting & Drexler (2003) have stated that there was

lack of evidence on the effectiveness of skin care methods in the workplace. Therefore, the evidence-based recommendation of skin protection methods and how to use and frequency to use where needed. Abia *et al.* (2016) have stated the awareness of workers towards the chemical hazards in the workplace can enhance the knowledge and subsequently improve the occupational health status of the workplace. Joshi *et al.* (2016) have concluded in occupational field periodic training and awareness programs on occupational health and safety should conduct to improve and update the knowledge and awareness of the workers about the occupational hazards in their workplace. Nielson *et al.* (2010) and Dilger *et al.* (2005) have recommended further studies to test the effectiveness of intervention method to prevent the occupational diseases due to the exposure to hazardous materials in metal machining industries.

7. Conclusion and Recommendation

Exposure to MWF and its contaminants Cr, Ni, and Microbes would lead to adverse health on skin systems. The prevention of the health effects of MWF on skin systems would probably by enhancing the awareness of the workers towards the health effects of MWF and the appropriate safety methods need to apply regularly all along their working time.

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