Health Impact of Exposure to Copper and Zinc Among Workers in A Metal Die Casting Foundry in 10th Ramadan City

Thesis Submitted for partial fulfillment of MSc degree of occupational and environmental medicine

By

Haithum Amin Salloum

M.B., B.Ch.

Faculty of Medicine, Ain Shams University.

Under Supervision Of

Prof. Dr. Ahmed Essmat El-Sayed Shouman

Professor in Dep. of Community, Environmental & Occupational Medicine.

Faculty of Medicine, Ain Shams University

Dr. Waleed Salah El-din Ahmed

Lecturer in Dep. of Community, Environmental & Occupational Medicine.

Faculty of Medicine, Ain Shams University.

Dr. Doaa Mahmoud El-hosseiny

Lecturer in Dep. of Community, Environmental & Occupational Medicine.

Faculty of Medicine, Ain Shams University.

Faculty of Medicine
Ain shams University
2018

I am still learning

Michelangelo at his 80

Acknowledgement

First and Foremost, I would like to thank Allah Almighty for always being there when I needed him the most for his blessings to my effort to reach this far.

I would like to express my deepest appreciation and profound gratitude to ***Prof. Ahmed Essmat El-Sayed Shouman***, Professor of Community, Environmental & Occupational medicine – Faculty of Medicine – Ain Shams University for his candid supervision and spectacular leadership to this project until it is completed.

I would like also to thank and show appreciation to ***Dr. Waleed Salah El- Din Ahmed***, Lecturer in Community, Environmental & Occupational Medicine – Faculty of Medicine – Ain Shams University for his sincere support throughout this thesis. He showed real partnership with shared principle to do our best.

I would like also to thank and appreciate ***Dr. Doaa Mahmoud El-Housseiny***, Lecturer in Community, Environmental & Occupational Medicine – Faculty of Medicine – Ain shams University for her endless help and support. She was there for me day and night advising and guiding proactively.

Haithum Amin

List of Contents

Title Page No.

List of Tables

Table No.	Title	Page No.

List of Figures

Fig. No.	Title	Page No.

List of Abbreviations

Abb.	Full term
ACGIH	American Conference of Governmental Industrial Hygienists
ATSDR	Agency for Toxic Substances and Disease Registry
BMI	Body Mass Index
CO2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
CuO NPs	Copper Oxide Nanoparticles
DHHS	Department of Health and Human Services
ECI	European Copper Institute
EPA	Environmental Protection Agency
GI	Gastrointestinal
HS	Highly Significant
HSE	Health and Safety Executive
ICA	International Copper Association
IFC	International Finance Corporation
IQR	Interquartile range
IZA	International Zinc Association
K_3EDTA	Tripotassium Ethylenediaminetetraacetic Acid
MAC	Maximum Allowable Concentration
MFF	Metal Fume Fever
NADCA	North American Die Casting Association
NIOSH	National Institute for Occupational Safety and Health
NJDHSS	New Jersey department of Health and Senior Services
NS	Non-Significant
OECD	Organization for Economic Co-Operation and Development
OHS	Occupational Health and Safety
OSHA	Occupational Safety and Health Administration
PEFR	Peak Expiratory Flow Rate
PPE	Personal Protective Equipment
RDAs	Recommended Dietary Allowances
SGRQ	Saint George Respiratory Questionnaire
SPSS	Statistical Package for the Social Sciences

UV	Ultraviolet
WHO	World Health Organization
Zn	Zinc

Abstract

Introduction: Little information is present regarding health impact of copper and zinc exposure among metal die casting workers in one of Egyptian foundries. **Aim of the work:** 1-To measure blood zinc and copper levels among the studied groups, 2- To measure the prevalence of respiratory hazards among exposed workers and their impact, 3-To identify other health problems due to copper and zinc exposure such as anemia and respiratory disorders, and lastly 4) To correlate such problems with blood copper and zinc levels. **Participants and Methods:** A comparative cross-sectional study was conducted among 60 male workers, 30 of them were the exposed group involved in processes like melting. The other 30 were chosen from the administrative departments in the same foundry as the reference group. All workers were interviewed using questionnaire for occupational history, respiratory and other symptoms. Blood samples were taken to measure serum copper and zinc, hemoglobin (Hb), and white blood cells counts (WBCs). Ventilatory functions were assessed too. **Results:** The study showed no significant difference in the levels of blood copper and zinc among the studied groups. However, symptoms related to copper and zinc toxicity were significantly more prevalent among the exposed group, like respiratory symptoms, symptoms regarding skin, throat and eye irritation, metallic taste in the mouth and exhaustion. Symptoms suggestive of metal fume fever including flue like symptoms, arthralgia, fever, and leukocytosis were more prevalent among the exposed workers, but without significant difference. There was no significant correlation between copper and zinc blood levels and other findings such as; Saint George Respiratory Questionnaire scores, Peak Expiratory Flow Rate scores, mean Hb, and WBCs level. **Conclusion:** Although there was no significant difference in blood copper and zinc levels among the studied groups, exposed workers were complaining of different symptoms, one of which was respiratory symptoms that had a

significant impact on their social and psychological functioning.

Introduction

Die casting is one of the oldest methods used to shape metals. The metal or metal alloy is melted, then poured into a prepared mold and allowed to cool. The molded piece is then removed from the mold and processed further by one or more of a great variety of processes ***(Woodard et al, 2006)***.

Die casting has many applications being used in many manufactures including automobile industry, business machines, and toys ***(Rajput, 2007)***.

The four principal metals, with different alloy compositions, that are commonly hot- or cold chamber die cast are aluminum, zinc, magnesium and copper-base alloys ***(Laukli et al, 2004)***. In die casting industry, workers are exposed to metals through inhalation of fumes of molten metals, skin contact, and even ingestion ***(NOHSC, 1989)***.

Zinc, which is one of the components used in this industry, can affect the health of workers. Its normal blood range is 50–100 μg/dl, while the toxic manifestations are seen when the oral intake is more than 1000 mg/day ***(Vasudevan et al, 2011)***.

Acute Toxicity is usually seen in welders due to inhalation of zinc oxide fumes and results in metal-fume fever which is; an acute 24– to 48–hour illness characterized by

influenza–like symptoms including fever, chills, sweating, weakness, headaches, muscle aches, and dryness of mouth and throat ***(ACGIH, 1999)***.

Sturgis et al, revealed that two workers developed metal fume fever as a consequence of acute inhalation (10–12 minutes) of 600 mg zinc/m^3 as zinc oxide ***(Sturgis et al, 1927).*** Chronic toxicity may cause gastric ulcer, pancreatitis, anemia, nausea, vomiting and pulmonary fibrosis ***(Vasudevan et al, 2011)***. The reproductive system may be affected too, and the developing fetus may be damaged ***(NJDHSS, 2008)***.

Copper is considered to be a respiratory irritant. Its normal blood level is 70–150 μg/dl ***(Vasudevan et al, 2011)***. In humans, inhalation of copper fumes has been shown to induce irritation of the upper respiratory tract, associated with metal fume fever ***(ACGIH, 1999)***.

Chronic health effect due to occupational exposure to copper fumes may include general malaise, anorexia, nausea, vomiting, and hepatomegaly. Contact dermatitis, pulmonary granulomas, and pulmonary fibrosis have also been described ***(Warrell et al, 2003)***. It also causes permanent skin & hair color changes ***(NIOSH, 1981)***.

Roberts et al, found that workers exposed to chronic copper dust exposure, at concentrations ranging from 111 to

464 mg/m^3, suffered from neurological changes, digestive disorders, and pulmonary complications ***(Roberts et al, 2015).***

Foundries in Egypt started to face problems since the application of the environmental law, which put special conditions for the waste products and emissions from the different industries, as foundries are less compatible with that law; Foundries spaces became restricted, As a result; pressure increased on this industry causing many labors to migrate to other professions or forming random non licensed groups away from supervision, producing products that are unapproved, and harmful to health ***(Chamber of metallurgical industries, 2015)***.

The present study is to investigate the health aspects of foundry workers, since this group of population attracted the attention of few previous researches in Egypt.

Aim of the work

Research hypothesis

Workers in metal die casting have higher blood levels of zinc and copper than control group, with more respiratory and health problems related to these exposures.

Goal of the study:

Health promotion of Egyptian workers in metal die casting foundries.

The objectives of the present study

1. To measure the blood level of zinc and copper among metal die casting workers and compare it with matched controls.
2. To measure the prevalence of respiratory hazards among those exposed workers in the foundry.
3. To identify other health problems such as anemia, gastric ulcers, and contact dermatitis, that may result from zinc and copper exposure among metal die casting worker.

Chapter 1

Copper and Zinc Historical Background, prosperities, Uses, and Sources & Life Cycle in The Environment

Historical background: *Copper & Zinc through Ages*

- **The Ancients**:

Copper (Cu) has fascinated humankind for centuries .it has been known since ancient times. It was first used by the Sumerians and Chaldeans of Mesopotamia somewhere 5000 and 6000 years ago. These early peoples developed considerable skill in fabricating copper, the rudiments of craftsmanship spread to the river-dwelling people of Egypt. Evidence shows that bronze pots, mixing trays, copper razors, copper arrows and quivers, together with prehistoric Sumerian copper spearheads have successfully survived the test of time ***(Copper Development Association, 2017).***

Zinc was used by Greeks and Romans in ancient times, but it was not as popular as copper or iron, as it boils away at a lower temperature than is required to be extracted from its ore, so ancient smelting techniques were not up to the task of isolating it. Nevertheless, archaeologists have found a handful of zinc artifacts, including a sheet of zinc from Athens that dates back to 300 B.C ***(Pappas, 2015).***