OCCUPATIONAL EXPOSURE TO NICKEL, CADMIUM AND COPPER AMONG WORKERS IN JEWELRY MANUFACTURING

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Abstract

Introduction: working in jewelry expose**s** workers/technicians to certain heavy metals as either in production process or cleaning processes. Heavy metals include Nickel, Cadmium And Copper.

Study objectives: we conducted the present study to satisfy the following objectives: to estimate the prevalence of toxicity for Nickel, cadmium and copper among jewelry workers in Jordan, and to correlate the study variables with the toxicity level and route of exposure.

Methodology: study design is cross-sectional. The target population is all jewelry technicians who work in the jewelry shops in Jordan. A convenient sample of 50 jewelry technicians were selected from those available in Amman, the capital of Jordan. A special questionnaire was prepared to collect data from participants. The first set of questions in the questionnaire determined the demographic data of the participants such as age, gender, smoking habits, type and place of occupation, and duration of employment. The second set of questions included working type, job type, use of personal protective equipment such as mask, gloves and lab-coat, diseases such as sensitivity, urinary tract infection, the perception of participants for occupational dangers associated with their job, and the frequency of jewelry

melting. Urine samples were taken from participant who agreed to participate in the present study. The concentrations of heavy metals (Cadmium, Copper and Nickel) were analyzed by atomic absorption spectrophotometer (AAS).

Findings: the study included 47 male workers with average age of 31.7 years. The concentrations of Cadmium, Copper and Nickel were higher in study participants compared with control participants. Exposure to Cadmium was significantly higher among workers compared with control (12.65 µg/l, 4.66 µg/l; P 0.001). Exposure to both Nickel and Copper was not statistically significant (P > 0.05).

Conclusion: workers in jewelry are exposed to heavy metals Cadmium, Copper and Nickel and Cadmium exposure is more apparent. Exposure to Copper and Nickel seems to have other routes as indicated by control group.

Keywords: Occupational exposure, jewelry, Nickel, Cadmium, Copper

Introduction

Jewelry is viewed as a form of personal decoration or adornment. It is manifested as necklaces, rings, brooches, earrings and bracelets. Several materials as gemstones, precious metals or shells are involved in the production of jewelry. The choice of such materials depends on cultural differences and the availability of the materials. Jewelry is usually appreciated due to its material properties, its patterns or for meaningful symbols (Olivier, Jayne Wallace, 2009).

The processing of jewelry manufacturing utilizes copper plating either directly or as a base metal for silver and other precious substances. A precious metal is known as being rare, naturally occurring metallic chemical element that has high economic value. From a chemical point of view, the precious metals are less reactive than most elements, have high luster, are softer or more ductile, and have higher melting points than other metals (Kutlu, 2005).

Two categories of jewelry industry include: genuine jewelry production from valued metals as gold, silver and platinum; and costume jewelry production. Tin and lead are mixed before molding and plating with valued metals (Kulmala, 2006).

Nickel is one of the most common causes of allergic contact dermatitis (Burrows and Adams, 1990). The condition has been seen in various occupations including hairdressers, nickel platters, and jewelers. Once a worker is sensitized to nickel, the sensitivity persists after the exposure is removed. Inhalation is thought to be the major route of exposure to nickel and nickel compounds (Proctor et al., 1991). Inhalation exposures have been linked with lung cancer and nasal sinuses in workers employed in

nickel refineries and smelters (Mastromatteo, 1994). Other health effects due to nickel inhalation exposures include nasal irritation, damage to the nasal mucosa, perforation of the nasal septum, loss of smell, pneumoconiosis, and allergic asthma (Snow SN, Costa, 1992).

Various effects due to exposure to cadmium have been reported to involve many organs and systems. Acute adverse effects due to overexposure to cadmium have been reported. Currently, in most occupational settings, chronic effects are of greater concern. It has been shown that the main symptom is respiratory distress due to chemical pneumonitis and edema. High exposure level of cadmium (40–50 mg/m3 for 1 hour) was shown to cause death (Proctor et al., 1991). The current cadmium tolerable intake standard established by the Joint Expert Committee on Food Additives (JECFA) of WHO is 25 micrograms per kilogram of body weight per month (mg/kg bw-mo). Average cadmium intakes are about 5 mg/kg bw/ mo (http://www.cadmium.org/pg).

Chronic occupational exposure to cadmium is likely to be associated with an increased occurrence of lung cancer, kidney damage, and chronic obstructive lung disease (WHO, 1992). It is believed that the kidney is the organ most sensitive to the toxic effects of cadmium and kidney damage due to cadmium exposure occurs when cadmium accumulates in the kidneys. This damage is progressive over time and is irreversible reaction. Chronic lung injury also develops in workers in relation to the period and level of exposure. But the effects on the lung occur quite slowly. The exposure level at which these effects occur is unknown Anyhow, the define level of exposure linked with lung damage is thought to be above that which causes kidney damage (NIOSH, 1992). According to the National Institute for Occupational Safety and Health (NIOSH), cadmium is considered to be a potential human carcinogen (NIOSH, 1984a). Both of lung and prostate cancers have been of concern. Although the evidence linking overexposure to cadmium with lung cancer is strong, the evidence linking cadmium exposure with prostate cancer is weaker (Thun et al., 1991).

In humans, inhalation of copper fume has been shown to induce irritation of the upper respiratory tract, metallic or sweet taste, and discoloration of the skin and hair. Copper fume exposure is associated with metal fume fever, 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).

There are many types of jewelleries including a large number of metal jewelleries with and without a content of precious metal. There is a great potential associated with jewelleries to release substances such as heavy metals that have health risks. Furthermore, it has been reported that there is a problem with the content of large amounts of lead in what is called

cheap jewelleries. This problem was taken seriously when a 4 year old boy (in united states of America USA) died due to accidentally swallowing of a heart-shaped piece of jewellery containing above 99% lead (Berg, 2006).

Gold is known by its chemical and physical properties. It is a soft, flexible, lustrous. It has a yellow color. Gold can resist corrosion. Gold has been utilized in jewelry making and decorations and as a cosmetic ingredient since the ancient times (Merchant, 1988). Because the pure metal is soft in nature, it is required to use gold alloys to make jewelry, apparatus and coins (Voet and Wolff, 1996).

Methods and Subjects

Study Design

The study design for the present study is cross sectional. Cross sectional design are concerned with gathering data from all participant at the same time point interval.

Study Population

The present study targeted technicians working in jewelry industry in Jordan and was conducted for determination of selected heavy metal levels in urine. These heavy metals included cadmium, copper and nickel. The target population is all jewelry technicians who work in the jewelry shops in Jordan. A convenient sample of 50 jewelry technicians were selected from those available in Amman, the capital of Jordan. All technicians in jewelry shops who were working in the selected setting were included in the study.

Data Collection

The groups involved in this study consisted of 47 jewelry technicians. All of them were from the capital city, Amman, Jordan, all of them were males. Jewelry technicians from Irbid City rejected to participate in the present study.

As a control group, the individuals that were involved in this study were 34 persons revising King Abdulla teaching Hospital for general checking.

All the subjects were willing to participate in the study, and signed a consent form of the protocol of the study and it was explained to each one of them by researcher that the sample they will give will be used for research purposes. The consent form had been approved and certified by the Human Researcher committee at Jordan University of Science and Technology.

Samples Collection

Questionnaires were filled by the participants. In addition to that, the researcher collected urine samples from jewelry technicians and the control group.

Questionnaire

The first set of questions in the questionnaire determine the demographic data of the participants under this study includes age, gender, smoking habits, type and place of occupation, and duration of employment. The second set of questions included working type, job type, use of personal protective equipment such as mask, gloves and lab-coat, diseases such as sensitivity, urinary tract infection, the perception of participants for occupational dangers associated with their job, and the frequency of jewelry melting.

Urine Samples

The participants were provided with urine containers and asked to give urine samples. After that, sample were kept frozen in deep refrigerator at -70 C until the time of analysis.

Sample Analysis for Heavy Metals

The concentrations of heavy metals (Cadmium, Copper and Nickle) were analyzed by atomic absorption spectrophotometer (AAS) which allow for the measurement of a wide range of concentrations of metals in biological samples. The AAS consist of a Flam Atomic Absorption Spectrometry (F-AAS) (Shimadzu, AA-6300, Tokyo, JAPAN) fully equipped for flame (air acetylene), and a Graphite furnace atomization (GFA-AAS) (Shimadzu, EX7, Tokyo, JAPAN).

The samples were analyzed using the spectrophotometer placed at the Princess Haya for biotechnology.

Statistical Analysis

The data obtained from analysis the urine of the subject investigated in this study regarding the concentration of the heavy metals and the associated factors demographically and environment of work were analyzed statistically by multivariable analysis and Mann–Whitney test using statistical package for the social sciences SPSS (version 16, SPSS, an IBM Company, Chicago, USA). p- value of ≤ 0.05 was considered statistically significant in the result presented of the study.

Results

Demographic Characteristics of Participants

As shown in table 1, all participants were males. About 57% of participants were less than secondary education level, about 60% were married, all of them were Jordanians, and about 47% were smokers (table 1).

Table 1: general characteristics of participants

Variable	Frequency (N)	Percentage (%)
Sex:		
Males	47	100
Females	0	0
Educational level:		
Less than secondary	27	57.44
Secondary and more	20	42.56
Marital status:		
Single	19	40.4
Married	28	59.6
Nationality:		
Jordanian	47	100
Non-Jordanian	0	0
Smoking:		
Yes	22	46.8
No	25	53.2

The results also showed that the mean age for participants was 31.7 years (SD $\pm$ 9.1), the monthly income was 339 Jordanian dinar (SD $\pm$ 168) and experience years mean was 13.78 years (SD $\pm$ 7.44) (table 2).

Table 2: other characteristics of participants

Variable	Mean	Standard deviation (SD)
Age (years)	31.7	9.1
Income (per month)	339	168
Experience years	13.78	7.44

Occupational Characteristics of Participants

As shown in table 3, about 96% of participants were technicians in jewelry industry. About 98% of jewelry technicians work in more than one type of jewelry. Fifty one percent of participants reported the presence of diseases which included allergy (91.6%), asthma (4.2%) and cardiovascular diseases (4.2%). The majority of jewelry technicians reported never use of safety protection tools(78.7%). The results also showed the majority of participants are aware of occupational hazards (78.7%). The jewelry technicians reported their usual exposure to vapors from metals during working. About 25% were always exposed, about 21% reported that they were mostly exposed while slightly higher than the half (53.2%) reported sometimes. About 36% of participants reported having hand sensitivity. The

results showed that the participants were frequently melting jewelry and about 55% melting jewelry more than twice a day (table 3).

Table 3: Occupational variables of participants

Job nature:	**Frequency (N)**	**Percentage (%)**
Manufacturing	45	95.7
Sales	2	4.3
Type of jewelry:		
Gold	1	2.1
Gold and others	46	97.9
Diseases:		
Yes	24	51
No	23	49
Type of disease		
Allergy	22	91.6
Asthma	1	4.2
cardiovascular	1	4.2
Using of protection tools:		
Mostly	3	6.4
Sometimes	7	14.9
Never	37	78.7
Perception of occupational hazard:		
Yes	37	78.7
No	10	21.3
Exposure to evaporation		
Always	12	25.5
Mostly	10	21.3
Sometimes	25	53.2
Hand sensitivity:		
Yes	17	36.2
No	30	63.8
Frequency of jewelry melting/ day		
Once	15	31.9
Twice	6	12.8
More than twice	26	55.3

The Presence of Heavy Metals in Urine Samples of Jewelry Technicians

The mean concentration of cadmium in the urine samples of jewelry technicians is 12.65 (± SD 11.12) (µg/l) and among controls is 4.66 (± SD 2.27) (µg/l). this variation is statistically significant (p value 0.001). The mean concentration of nickel in the urine samples of jewelry technicians is 93.07 (± SD 51.62) (µg/l) and among controls is 69.15 (± SD 38.72) (µg/l). this variation is not statistically significant (p value 0.071). The mean concentration of copper in the urine samples of jewelry technicians is 20.14

(± SD 9.38) (µg/l) and among controls is 17.72 (± SD 9.52) (µg/l). this variation is not statistically significant (p value 0.490) (table 4).

Table 4: the concentration of heavy metals in urine sample of jewelry technicians and controls

Variable-study	Mean (µg/l)	SD (µg/l)	Variable-control	Mean (µg/l)	SD (µg/l)	P value
Cadmium	12.65	11.12	Cadmium	4.66	2.27	0.001
Nickel	93.07	51.62	Nickel	69.15	38.72	0.071
Copper	20.14	9.38	Copper	17.72	11.50	0.409

The Relationship Between Heavy Metal Concentration with Age and Experience

As shown in table 5, the variation between heavy metal concentrations and age is statistically significant for Cd, Cu and NI (p value 0.000, 0.003, 0.000 respectively). It is also significant for experience except for Cd (p value 0.990) while it is for Cu and Ni (p value 0.000).

Table 5: the relationship between heavy metal concentration with age and experience

Heavy metal	Mean (µg/l)	SD (µg/l)	Variable	Mean (years)	SD (years)	P value
Cd	12.65	11.12	Age	31.73	9.28	0.000
Cu	23.45	13.11	Age	31.73	9.28	0.003
Ni	113.58	58.86	Age	31.73	9.28	0.000
Cd	12.65	11.12	Experience	13.71	7.58	0.990
Cu	23.45	13.11	Experience	13.71	7.58	0.000
Ni	113.58	58.86	Experience	13.71	7.58	0.000

Discussion

Introduction

The present study was conducted to investigate the health aspects of jewelry technicians since this group of population did not attract the attention of previous research especially in Jordan. The objectives of the present study included the estimation of the prevalence of toxicity for Nickel, cadmium and copper among jewelry workers in Jordan and the correlation of the study variables with the toxicity level and route of exposure.

The study results showed that there was a significant exposure to cadmium among jewelry technicians compared with control group (p value 0.001). The jewelry technicians are exposed significantly to cadmium because of the release of cadmium through jewelry processing. The data of the present study also showed that the occupational exposure to cadmium is associated significantly with age (p value 0.000) but not with experience results (p value 0.990). It is plausible to explain the significant association between exposure to cadmium and age since more exposure is expected to increase with age. It is difficult to explain the non significant association

between experience years and exposure to cadmium (p value 0.990). Taken together, the exposure to cadmium comes from other resources in addition to jewelry processing. Generally around 10% of cadmium exposure from the surrounded air in non smoking persons (Vahter et al., 1991) and from water (Olsson et al., 2002). In smoker persons , the cigarette smoking is the major source of exposure to cadmium and lead to elevate in the plasma cadmium level and this depend on the type of cigarette and it varies according to the type of tobacco (Järup et al., 1998).

The study results did not show a significant variation between exposure to copper between study and control groups (p value 0.409). The results also showed significant association between copper with each of age and experience years (p value 0.000 for each). Anyhow, the mean concentration of copper in the present study is 23.45 ug/l is less than the reported mean for copper 39 μg/g (Van et al., 2008). Copper exposure cannot be considered according to our data to due to occupational environment.

The results did not show a significant variation between jewelry technicians and control group (p value 0.071). The results also showed that there was a significant association between the exposure to nickel with age and experience (p value 0.000 for each). These findings do not reflect the facts associated with the multi involvement of nickel in industrial use. Nickel is one of the most common causes of allergic contact dermatitis (Burrows and Adams et al., 1990). The condition has been seen in various occupations including hairdressers, nickel platters, and jewelers. Once a worker is sensitized to nickel, the sensitivity persists after the exposure is removed. Inhalation is thought to be the major route of exposure to nickel and nickel compounds (Proctor et al., 1991). Inhalation exposures have been linked with cancer of the lung and of the nasal sinuses in workers employed in nickel refineries and smelters (Mastromatteo, 1994).

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