INVESTIGATING THE RELATIONSHIP BETWEEN MENTAL RETARDATION AND LEAD INTOXICATION

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Abstract

Introduction: There has been a debate in literature to correlate lead (Pb) poisoning with mental retardation since lead can be involved in developmental stage and induce brain damage; in particular, children under age of 10 years.

Study objectives: To determine blood Pb levels among mentally retarded patients at Jerash Center for Welfare and Rehabilitation and to correlate clinical study variables with blood Pb levels.

Methodology:

Study design and setting: Cross-sectional experimental study design. The present study was conducted at Jerash Center for Welfare and Rehabilitation. A convenient sample of 90 participants was included in the present study. Blood Pb level was analyzed at Princess Haya Center for Biotechnology using Atomic Absorption Spectrometry.

Results: The(mean ± Sd) concentration of Pb is 0.6 ± 2.7 μg/dl. There was a significant relationship between age and blood Pb level (p value < 0.001). The results showed that more blood Pb concentrations were associated with mental retardation and physical impairment. More blood Pb levels were detected among mental retardation cases in irbid.

Conclusion: Although most cases of mental retardation were associated with undetectable blood Pb levels, it is still important to take into account the possibility of involvement of lead among mentally retarded patients.

Recommendations:

1- In the present study, 90 cases out of 230 resident cases in Jerash Center for Welfare and Rehabilitations were included in the study for Pb analysis. It is recommended to carry out the analysis of blood for the all cases.

2- It is also recommended to carry out analysis for other heavy metals such as chromium for patients.

3- To adopt policies and measures to decrease the exposure of children to Pb and other toxic heavy metals. Measures include removing of paint chips from houses and controlling the behavior of children to inhibit ingestion of things with potential content of heavy metals through hand to mouth behavior such as soil (controlling pica behavior).

Keywords: Lead (pb), mental retardation, heavy metal toxicity

Introduction

The term disability is defined as: "the functional limitation within the individuals caused by physical, mental, or sensory impairments and can be developmental in origin or acquired" (Tesini, 1994).

Individuals with disabilities, according to the definition given by the WHO (1980), have a disadvantaged condition that arises from a deficiency or disability, which restricts their fulfillment of a role, that is normal or within the normal limit of a human being.

Types of Disabilities

Physical Impairment

Physical impairment, which is defined as loss of voluntary movement in a part of the human body, is caused by disease or injury anywhere along the motor-nerve path from the brain to the muscle fiber and may result from injury, poisoning, infection, haemorrhage, occluded blood vessels, or tumors (British Society for Disability and Oral Health, 2000). Several types of paralysis include monoplegia, hemiplegia, paraplegia or quadriplegia. Another form of Physical impairment is called cerebral palsy which is a disorder of movement and posture that is due to a non-progressive abnormality of the immature brain. This disability is usually associated with muscle weakness, stiffness, or paralysis; poor balance or irregular gait; and uncoordinated or involuntary movements. Individuals with physical impairment may have reduced ability for self care and mobility problems which

affect their ability to reach oral dental services and consequently their use of oral dental care (British Society for Disability and Oral Health, 2000).

Learning Disability

According to (UK Department of Health, 1998), learning disability was described as "a significant impairment of intelligence and social functioning acquired before adulthood".

Learning disability was also defined as a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself as an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations (Individuals with Disabilities Education Act, 1990).

Developmental Disabilities

Developmental disabilities include cerebral palsy, Down syndrome, mental/and physical disability, autism, seizure disorders, hearing and visual impairments, congenital defects, and even social or intellectual deprivation. They are identified in early childhood and usually persist throughout an individual's life. Such conditions may be associated with special health care Down's syndrome include learning and developmental disabilities, emotional disturbances, vision and hearing impairments, diabetes, asthma, genetic and hereditary disorders with orofacial defects, or HIV infection (National Maternal and Oral Health Resource Center, 2000).

Mental/and Physical Disability

Mental/and physical disability is used to be visualized as a multidimensional term. It refers to significantly sub average general intellectual functioning, existing concurrently with deficits in adaptive behavior and manifested during the developmental period (Grossman HJ, 1973). It was also defined as a condition characterized by the faulty development of intelligence, which impairs an individual's ability to learn and to adapt to the Down's syndrome of society. An individual is classified as having mild mental/and physical disability if his or her IQ score is 50-70; moderate retardation, IQ 35-50; severe retardation, IQ 20- 35; and profound retardation, IQ below 20-25 (Reichard, 2001).

Down syndrome (Trisomy 21) is a birth defect associated with an autosomal chromosome abnormality and is the most commonly known single cause of mental/and physical disability (Nunn JH, 1987).

Learning difficulties, abnormalities in immune response related to the increased prevalence of periodontal disease, short fingers, large palms, small but broad feet, are also reported in patients with Down syndrome (Brown RH, 1980).

Prevalence of Disability

Disabilities have been reported to affect a wide range of the population of all ages and social classes. The prevalence of individuals with disabilities varies throughout the world. In the United States (U.S.), approximately 11 million children and adults in the U.S. have a disabling condition (Weddell JA, 2000).

Estimations from the United Kingdom (UK) showed that over 6 million people were identified as disabled and about 360,000 children had disabilities. The prevalence of learning disability was about 2% of the UK population (Department of Health, 1998).

Storhaug (1997) estimated that 3 to 3.5% of children in the Nordic countries aged 0-15 years have a chronic disease or a long-standing disability. In Sweden, the number of children aged 0-19 years who were severely disabled was estimated as 1.5%. The prevalence of mental/and physical disability in the Nordic population was estimated to be 1-3%.

In industrialized countries, by school age the prevalence of cerebral palsy (CP) has remained reasonably constant at about 0.2% in live births (Paneth, 1984). The overall prevalence of cerebral palsy CP has for many years remained fairly constant at 0.14 - 2.4% (Stanley, 1993). The incidence of cerebral palsy in the U.S., for all ages is 0.15 to 0.3% (Weddell, 2000).

Kuwait has a higher prevalence of Down's syndrome than that reported to European western countries. The incidence was 0.171, 0.174, 0.221 and 0.232% per live births in the years 1997, 1998, 1999 and 2000 respectively (Al-Awadi SA, 2002).

The Relationship between Lead and Mental Retardation

It has been claimed since a long time that there is a possibility to establish a causal relationship between lead intoxication and mental retardation (Moncrieff, 1964). It was suggested that lead was a greater factor in producing mental retardation and the estimation of lead in the blood was the only certain way of demonstrating excessive exposure to lead. It was believed that a blood lead level of over 36 μg/100 ml 36 microgram per 100 ml was an indication of intoxication (Moncrieff, 1964).

In another study conducted by Kumar (1998), blood lead levels were measured by atomic absorption spectrometry in 82 children suffering from various neurological disorders (cerebral palsy 42, seizure disorders 35, acute encephalopathy of unknown origin 5) and in 28 healthy children, aged 1 to 12 years. The results showed mean blood Pb levels were 11.96 ± 10.97 μg/dl in control children and 17.65 μg/dl in children with neurological disorders. A significant number of control children as well as those who had neurological disorders were

found to have blood Pb concentrations of more than 10 μg/dl. Blood Pb levels were, statistically, elevated in children with cerebral palsy compared to controls.

It has been shown that the burden of Pb toxicity is greatly underestimated because most cases of lead poisoning are clinically unapparent (Kumar, 1998). Recent studies point to the possibility that Pb can cause cognitive and behavioral deficits in children even at low levels of exposure and some of these effects may be irreversible (Cuonunins, 1992). Furthermore, children with neurological disorders have to be evaluated for Pb poisoning, either because Pb may cause these disorders or these conditions may be associated with increased lead ingestion and/or absorption (Committee on Environmental Health, 1993). Anyhow, exposure to Pb of children with preexisting neurological handicaps have been associated with serious consequences for them, and this due to further impair their residual cognitive, motor, or behavioral abilities. The environment of many developing countries is shown to be heavily contaminated due to unrestricted use of lead in industry and automobile fuel. This, in turn, poses a significant health hazard for children (Kumar, 1998).

Other researchers showed that Pb toxicity results from the ingestion of paint chips, house dust, ink, Pb items, and soil contaminated with lead. Furthermore, Pb has deleterious effects on both cognitive and emotional functioning. Therefore, Pb exposure may result in further brain damage and cause behavioral disturbances in those with mental retardation (Boris, 1996; Johnson, 1994; Piazza, 2000).

There is scarcity of information on blood Pb levels in common neurological disorders in children in Jordan. Therefore, this study provides us with a good opportunity to study this problem.

Trends in Preschool Lead Exposure, Mental Retardation, and Scholastic Achievement

Rick Nevin (2009) focused on racial differences and blood Pb concentrations in the preschool age and found less blood Pb levels in Hispanic group. Researchers have investigated the relationship between MR and Pb poisoning since 1940s (Byers and Lord, 1943). Other researchers as Marlowe, 1995; David.,1976, 1982, reported that Pb poisoning was associated only with childhood blood lead above 60 mg/dL.

Several later studies reported an inverse relationship between blood lead and IQ and academic achievement (US Centers for Disease Control and Prevention, 1991; Lanphear, 2005; Miranda, 2007).

Canfield (2003) showed that higher blood Pb to be associated with a large loss in IQ. He also showed that preschool blood lead of 10 mg/dL was associated with a loss of 7.4 IQ points relative to children with blood lead of 1mg/dL.

Sources of Blood Lead

Several sources attribute to increase blood lead such as lead paint chip ingestion, lead in paint and gasoline and inhaled air lead (US Environmental Protection Agency, 1986). According to Meyer and Mitchell (1943), the lead share of USA pigments fell from near100% in 1900 to 35% by the mid-1930s. Furthermore, the USA forbidden lead paint after 1977, but 80% of pre-1940 and 46% of 1940–1959 homes still had some interior lead paint in1999 (Jacobs, 2002).

Blood Lead Levels in Children with Neurological Disorders

Kumar (1998) evaluated blood Pb levels using atomic absorption spectrometry in 82 children suffering from various neurological disorders (cerebral palsy 42, seizure disorders 35, acute encephalopathy of unknown origin 5) and in 28 healthy children, aged 1 to 12 years. The results showed that mean blood Pb levels were 11.96 ± 10.97 μg/dL in control children and 19 ± 17.65 μg/dL in children with neurological disorders. A significant number of control children as well as those who had neurological disorders were found to have blood Pb concentrations of $\geq$ 10 μg/dL and $\geq$20 μg/dL, the cut-off limits for lead poisoning and medical evaluation, respectively. Blood Pb levels were, statistically, elevated in children with cerebral palsy compared to controls. Children with pica behavior exhibited higher blood Pb concentrations.

Study Hypothesis

In the present study, it is hypothesized that the target population are exposed to Pb significantly compared with control group. It is also hypothesized that the state of mental retardation is significantly with lead exposure.

Study Objectives

1- To determine the levels of Pb among the mentally retarded patients.

2- To correlate the levels of Pb with clinical variables in the study.

Methods and Subjects

Study Design

The present study adopts an experimental cross sectional design approach to collect information about patients with neurological abnormalities.

Study Setting

There is one center in Jordan specialized with treatment and rehabilitation of mentally and physically people called Jerash Center for Welfare and Rehabilitation, Jordan.

Sampling size and Technique

Clinical Data

The clinical and demographic data for participants were obtained from participants files. The following variables were investigated: gender, degree of disability, cause underlying disability, type of disability, age and place of residency.

Data were collected for 90 participants where it was possible to obtain blood samples from participants. This type of data collection from participants is called convenient sampling technique.

Lead Measurement

The concentration of lead was analyzed by atomic absorption spectrophotometer (AAS) which allow for the measurement of a wide range of concentrations of metals in biological samples. The atomic absorption spectrophotometer 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 Center for Biotechnology.

Statistical Analysis

The data obtained from analysis of the blood of the subject investigated in this study regarding the concentration of the heavy metals and the associated factors demographically and environment of work were presented as: frequency, percentage and T 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

The data of the present study shows that all cases presented are associated with severe degree of disability. Three reasons underlie the disability cases in broad terms, about 54.4% of cases are without apparent reasons, about 14% of cases are due to inheritance reasons while about 31% of cases are due to miscellaneous reasons. In the coming tables, causes of disability will be more explored with details. Three types of disability have been shown to cover study participants. Most of cases (72.20%) have severe mental retardation, about 27% of participants have severe mental retardation accompanied by physical impairment, only one case has autism in addition to severe mental retardation. About 57% of patients have their ages $\leq$ 30 years. Study participants are from various areas in Jordan. About 33% of participants are from Amman, about 17% from Irbid, about 16% from Jeresh, followed by about 13% from Mafraq. The other cases are varied in other regions in Jordan (Table 1)**.**

Table 1: Demographic characteristics of participants.

VARIABLE	NUMBERN OF CASES	PERCENTAGE
Severity degree:		
- Severe	90	100
- Non severe	0.0	0.00
Cause of disability:		
Unknown	77	85.6
Inheritance	13	14.4
Type of disability		
- Severe MR	65	72.20
- Severe MR, autism	1	1.10
- Severe MR, physical impairment	24	26.7
Age (years)		
≤30	51	56.7
> 30	39	43.3
Place of residence		
- Amman	30	33.3
- Irbid	15	16.7
- Jerash	14	15.6
- Mafraq	12	13.3
- Balqa	10	11.1
- Zarqa	4	4.4
- Ajloun	3	3.3
- Aquaba	1	1.1
- Ma'an	1	1.1

Detailed Causes of Disability

For about 54% of cases of disabilities, there are no apparent causes. For about 12.23 % of cases, disability was underlying by diseases. Both of inheritance and oxygen insufficiency have the same contribution as reasons for disability (10% for each). In 3 cases (3.33%), chromosomal defects have been identified. Two cases were due to falling accidents, and other two cases were due to diseases affecting mother during pregnancy. The remaining cases were sporadic (Table 2).

Table 2: Detailed causes of disability

Cause	Frequency	Percentage
Unknown	49	54.4
Born hanging	1	1.1
Chromosome defects	3	3.3
Congenital	1	1.1
Disease	11	12.2
Preterm delivery	1	1.1
Falling accident	2	2.2
Hard delivery	1	1.1
Inheritance	9	10
Mother's diseases during pregnancy	2	2.2
Oxygen insufficiency during delivery	9	10
Traffic accident	1	1.1

Lead Level Concentration Range among Participants

Most of cases (81.1%) were associated with lead concentration of 0.0 ug/dl. In about 6% of cases, lead concentration was in the range of 0.1-≤1 μg/dL, about 4% of cases lie in the range of 1-≤ 2 ug/dl, about 7% of cases lie in the range of 2-≤ 5 μg/dL, and about 2% of cases have > 5 ug/dl. The mean concentration of lead is 0.6 ±2.16 μg/dL (Table 3).

Table 3: Lead level concentration range among participants.

Lead concentration (ug/dl)	Frequency	Percent
0.0	73	81.1
0.1-≤1	5	5.55
1-≤ 2	4	4.44
2-≤ 5	6	6.66
> 5	2	2.22
Mean: 0.60± 2.2		

The Correlation Between Age and Lead Concentration

The data showed that participants in age group 18-22 years had no detectable concentrations of lead, for the age group 23-27 years, lead concentration increased up to 2.67μg/dl, sharp increases in lead concentrations up to13.37 μg/dl were scored in the age group 28-32 years, lead levels of participants in the age group 33-38 years showed lower values (up to 2.59 μg/dL) compared with the previous age group. The highest level of lead (14.15 μg/dL) was observed in the age group 39-42 years and in the age group > 42 years, the lead levels declined to 1.94 μg/dL (Table 4).

Table 4: The correlation between age and lead concentration**.**

Age group	Number of cases	Lead concentration range(ug/dl)
18-22	13	0
23-27	28	0-2.67
28-32	15	0-13.37
33-38	21	0-2.59
39-42	7	0-14.15
> 42	6	0-1.94

The Concentration of Lead by Place of Residency

Patients from Irbid have been associated with the highest lead concentration 1.25± 3.64 μg/dL, followed by patients from Jeresh 0.962±3.57 μg/dL, Ajloun 0.650±1.12 μg/dL, Balqa 0.610±1.24 μg/dL, Amman 0.348±1.07 μg/dL, Zarqa 0.143±0.285 μg/dL and Mafraq 0.126 ±0.435 μg/dL (Table 5).

Table 5: Lead level by place of residency.

Place of residence	Lead level Mean (μg/dL)	CI 95% (lower-upper)	SD	SE
Ajloun	0.650	-2.14- 3.43	1.12	0.65
Amman	0.384	-0.015-0.784	1.07	0.20
Balqa	0.61	-0.28-1.49	1.24	0.39
Irbid	1.25	-0.78-3.26	3.64	0.94
Jeresh	0.962	-1.09-3.02	3.57	0.954
Mafraq	0.126	-0.15-0.402	0.435	0.126
Zarqa	0.143	-0.311-0.596	0.285	0.143

The Concentration of Lead by Type of Disability

The results showed that cases with severe mental retardation accompanied by physical impairments have more lead concentration 1.57 ±3.87 ug/dl compared to severe mental retardation 0.250± 0.80 ug/dl (Table 6).

Table 6: The concentration of lead by type of disability**.**

Type of disability	Lead level Mean (μg/dL)	CI 95% (lower-upper)	SD	SE
Severe MR	0.250	0.049- 0.443	0.80	0.099
Severe MR with physical impairment	1.57	-0.063-3.21	3.87	0.97

The Concentration of Lead by Cause of Disability

The concentration of Pb by cause of disability is the highest for falling group of patients 2.43 ±3.44 μg/dL, followed by cause of inheritance 1.88 ±4.64 (μg/dL, unknown reasons 0.650 ±2.04 μg/dL, and oxygen insufficiency 0.022 ±0.06 μg/dL (Table 7).

Table 7: Lead level by cause of disability.

Cause of disability	Lead level Mean (μg/dL)	CI 95% (lower-upper)	SD	SE
Unknown	0.650	0.062- 1.24	2.04	0.292
Falling	2.43	-28.50-33.38	3.44	2.43
Inheritance	1.88	-1.70-5.45	4.64	1.55
Oxygen insufficiency	0.022	-0.029-0.74	0.06	0.022

Discussion

The present study was conducted in the view of the fact that there is a debate in literature if there is a possibility to establish a causal relationship between Pb intoxication and mental retardation (Moncrieff, 1964). The trends in research depended primarily on determining Pb toxicity in the blood samples of mentally retarded patients. It was hypothesized that Pb to be a great factor in producing mental retardation and blood Pb levels over 36 μg/dL were considered an indication of intoxication (Moncrieff, 1964). The debate continues in literature since other researchers as Marlowe, 1995; David.,1976, 1982, reported that Pb poisoning was associated only with childhood blood Pb above 60 μg/dL. The debate has continued over the time and the literature has emerged more recent findings when several later studies reported an inverse relationship between blood Pb and IQ and academic achievement (US Centers for Disease Control and Prevention, 1991; Lanphear, 2005;

Miranda, 2007). Other studies showed that preschool blood Pb of 10 μg/dL decreased IQ points relative to children with blood Pb of 1 μg/dL (Canfield, 2003).

The results of the present study showed that the mean concentration of blood Pb level 0.6 ± 2.2 μg/dL. The present findings are less than that reported in other studies. In his study, Ashok Kumar (1998) reported that children with neurological disorders had 19 ± 17.65 μg/dL. Although the results for blood Pb level in the present study are low, it is still possible to explain neurological disorders among patients and the study findings agree with other studies in which the decline in IQ at even the lowest levels of Pb exposure was reported (Canfield, 2003; Bellinger and Needleman, 2003; Lanphear, 2005).

The results revealed a significant relationship between age and blood Pb concentration (p value < 0.001). These results implied that age is an important factor in increasing exposure to Pb and also revealed that the exposure to lead may due to a long time that could be associated with the disability.

The results presented in Table 5 and Figure 2 showed Irbid City to have more lead concentrations compared with other areas in Jordan. No research studies have been identified in this regard, up to the best knowledge of the researcher, to investigate the lead concentration in different areas in Jordan. We cannot, based on these findings, claim that Irbid City has more or less lead concentrations compared with other areas. The same idea is applied on other areas in Jordan. It is possible to assume that selective increased lead concentration may reflect the access to Jerash center and accordingly the variations appear.

The results showed increased Pb concentration in cases with severe mental retardation accompanied by physical impairment compared with severe mental retardation without the involvement of physical impairment. The present findings agree in general guidelines with other findings reported by other researchers as Kumar (1998) who showed elevated blood Pb levels in children with cerebral palsy, and those findings reported by Yuan (2010) in which it has been reported that mental retardation is the most common disability of childhood and the incidence of MR is about 1-3 % of all children.

The results presented in Table 7 and Figure 4 demonstrated that the highest concentration of Pb was associated with falling accidents followed by inheritance, and unknown cases. These findings open the door for various hypothesis such as the involvement of Pb in falling accidents was the reason for falling and indirectly resulted in inducing the disability. However, since Pb has no any biological role in the body and it has been associated with neurological abnormalities as previously stated (Kumar, 1998; Yuan Liu, 2010), it is not surprising to find such findings.

Inheritance ranks the second as a cause of disability associated with Pb concentration. It is plausible to claim that disability has come through developmental stage more than by inheritance. This point of view has been derived from other studies. Several researchers have addressed Pb involvement as a neurotoxin substance with respect to neurodevelopment disorders. It was shown that lead has the ability to cross the placenta beginning at 12 weeks of gestation, and then accumulates in fetal tissues (Baghurst, 1992; Tong, 1998; Wasserman, 1994; Wasserman, 1997). Furthermore, Sullivan and Krieger (2001) indicated that both pregnant women and children have more tendency to absorb more ingested Pb (up to 70% is absorbed) than the general adult population (20% absorbed).

The results also indicated unknown cases of disability to associate with blood level concentration. These findings also open the door for screening patients with disability.

Conclusions

1- The mean lead concentration among patient with mental retardation at Jerash Center for Welfare and Rehabilitation is 0.6 $\pm$ 2.2 μg/dL. Most cases with severe mental retardation have undetectable blood lead levels.
2- Mental retarded cases associated with the highest blood level concentrations are from Irbid City.
3- Mental retardation cases accompanied by physical impairment have more blood Pb concentrations compared to mental retardation cases without the involvement of physical impairment.
4- Blood Pb concentrations are higher in falling accidents followed by inheritance cases and unknown reasons for mentally retardation cases.
5- The study findings showed increased exposure to Pb with time.

Recommendations

1- In the present study, 90 cases out of 230 resident cases in Jerash Center for Welfare and Rehabilitations were included in the study for Pb analysis. It is recommended to carry out the analysis of blood for the all cases.
2- It is also recommended to carry out analysis for other heavy metals such as chromium (Cr) for patients.
3- To adopt policies and measures to decrease the exposure of children to Pb and other toxic heavy metals. Measures include removing of paint chips from houses and controlling the behavior of children to inhibit ingestion of things with potential content of heavy metals through hand to mouth behavior such as soil (controlling pica behavior).

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