The Zamfara Lead Poisoning Episode in Nigeria: an Indication for Children’s Environmental Toxicology and Micronutrient Centre

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Abstract

Recent reports indicate that 1/3 of Africa’s disease burden is attributable to environmental hazards. Nigeria is clearly at the threshold of industrialization and one of the oldest known prices of industrialization is poisoning by various chemical agents. The diagnosis of chemical poisoning is poorly understood and often ignored in the developing countries in favour of the perceived more important infectious states. Lead poisoning is the oldest and one of the most well-known of the industrial (chemical) diseases. The recent Zamfara lead poisoning episode in Nigeria was a very severe case of lead toxicity in a community of illegal miners in two villages, Bukuyou and Anka in Zamfara State, Nigeria, which unleashed one of the most unprecedented outbreaks of lead poisoning in human history. The resultant morality put at a conservative estimate of about 400 children within a very short period, aside from the morbidity, raises very serious concern. The health care delivery system in Nigeria could not offer any meaningful assistance in terms of adequate diagnostic capacity. This episode has revealed that the pace of industrialization and the level of preparedness of the nation’s health care system are disconnected. Instructively, the experience makes it a priority for the nation’s biomedical laboratory service to be repositioned or restructured to enable it detect most industrial diseases and toxic substances common in progressively industrializing nations. Toxicological service must be made a prominent arm of the service. Additionally, all known mining regions should be linked to centres providing toxicological investigations for surveillance. There is the need for a national survey of blood lead levels preferably combined with nutritional assessment as nutritional status may modify chemical toxicity and emphasis should be on children owing to the greater susceptibility this group. There is also the need to establish an agency to study various aspects of the toxic effects of lead and other toxicants along with micronutrients in Nigeria, comparable to the Agency for Toxic Substances and Disease Registry (ATSDR) in the United States.

Keywords: Children, Industrialization, Lead poisoning, Micronutrients, Toxicology, Zamfara [This paper is essentially from a public lecture delivered at the 2011 World Biomedical Laboratory Science Day, organized by the Medical Laboratory Science Council of Nigeria at Merit House, Maitama District, Abuja].

Introduction

For too long, the emphasis of most developing countries has justifiably been on infectious diseases. A growing body of evidence indicates that environmental hazards are contributing a sizable proportion to the disease burden in industrializing countries. The world Health Organization (WHO) has reported that about one-third of Africa’s disease burden is attributable to environmental hazards (Prüss-üstün and Corvalán, 2006). The major contributing risk factors to environmental disease burden on the continent are traditional environmental health hazards such as lack of access to safe water, indoor air pollution from solid fuel combustion, and lack of sanitation and hygiene. However, with notable economic growth the past
decade (World Health Organization, 2008), urbanization and continuing industrialization, modern environmental health hazards (MEHHs) are expected to eventually emerge and perhaps can supersede traditional hazards as critical contributors to environmental disease burden on the continent. The transition to MEHHs is in progress as evidenced by the combination of preindustrial and industrial-era environmental health issues confronting many African communities (WHO, 2002). “Assuring population health and well-being in the near future, therefore will depend not only on how well traditional hazards and risks are managed but also on the degree to which MEHHs and their potential impacts are prevented and controlled”. The WHO (1997) considers MEHHs as products of rapid development in the absence of health and environmental standards and the unsustainable consumption of natural resources. Children, owing to their higher sensitivity to environmental pollutants are usually the most vulnerable victims. The Zamfara lead poisoning episode (profound lead poisoning arising from illegal mining of precious metals, in which children were the main victims) has only served as a vivid confirmation of the apt observation by one of the early environmentalists, Last (1987).

Last (1987) observed that the combination of population pressure, malnutrition and infection has sapped the vitality of nations for generations and that now new problems are being added. These include industrial development, often without the restraining laws, and regulations of the affluent industrial nations which are causing serious environmental damage and occupational diseases. What is often ignored in toxic exposure in resource poor countries is that poor and malnourished populations, particularly children may be more vulnerable to the impacts of MEHHs, given that malnutrition increases susceptibility to toxicological problems (Anetor, 2001; Tillet, 2009). According to the United Nations Industrial Development Organization (UNIDO), Africa’s pollution intensity (pollution generated per unit of production output) is among the highest in the world (UNIDO, 2004; Tillet, 2009).

Nigeria is clearly at the threshold of industrialization and this has a price. One of the oldest known prices of industrialization is poisoning by various chemical agents. The very recent warning of MEHHs by Nweke and Sanders (2009) should be taken seriously and we affirm that their observation is not being alarmist. The itai itai or ouch ouch disease as a result of excessive exposure to cadmium in the Fuchu Toyama prefecture of Japan in which children and women were the main victims is well described in the scientific literature (WHO, 1992; Horiguchi et. al., 2010). Another is Minamata disease, a form of neuropathy from environmental mercury exposure (Dietz, 2009; Karagas et al., 2012). Lead poisoning is the oldest and the most well-known of the industrial diseases and lead is referred to as a prime environmental pollutant or contaminant. Shy (1990) has described the addition of lead to petrol as a scientific mistake of the 20th century. Earlier in 1817, Orfila observed that “if we were to judge of interest excited by any medical subject by the number of writings to which it has given birth, we could not but regard the poisoning by lead as the most important... of all those that have been treated of, up till the present time”.

Lead (Plumbum) is the most serious and widespread poison in our environment, and can cause serious damage to the mental development of young children at relatively low levels, decreasing intelligence quotient (IQ). Taking Lead out of petrol as has been achieved in many countries and recently in Nigeria, has dealt with only one source of exposure (Milestone, 1997). Hazards abound in old leaded paint in homes, schools and workplaces and from old pipes that carry municipal drinking water (Adebamowo, et al., 2007). A lot of lead has been found in the abundant dust surrounding playgrounds where children play. Frankly, soil and dust currently represent potential source of lead and for generations to come, consequently making environmental monitoring a priority and an important strategy for identification and management of plumbism (USDIHHS, 2010).

Lead poisoning is a syndrome caused by the toxic actions of lead which may be seen in individuals whose tissues contain higher than normal (acceptable) levels of lead. Lead in common with other toxic metals, has a variety of toxic actions on protoplasm; the most precisely delineated are on certain enzyme systems and on cell membrane. Clinical lead poisoning has been in the past one of the most important occupational diseases, and it remains a preoccupation even today. (WHO, 2010; McMillin et. al., 2013) The considerable body of scientific knowledge concerning the toxic effects of lead has been enriched in the past decade by significant new knowledge regarding more subtle subclinical effects particularly at the molecular level. Despite all the serious adverse effects of Lead in children, little has been done to regulate exposure among Nigeria children.

This paper attempts to give a broad overview on the consequences of lead exposure using Zamfara as a case in point and advocating a more pragmatic approach to the problem by advocating for an Environmental Toxicology and Micronutrient Centre and its implications for the larger community of
children in Nigeria and other developing or industrializing countries.

**What is Lead, and Why Dear to Man?**

Lead is a soft, dense, blue-gray metal. It is easily malleable. It occurs naturally in the earth’s crust, where it combines with other elements (a contaminant of precious metals that are often mined). Lead is used in many industrial and domestic activities. It is one of a limited class of elements that can be described as absolutely toxic. Indeed one can only talk of acceptable blood lead level as it is recognized to be toxic at all levels.

Lead is used to make batteries and metal mixtures which are used in many industrial and domestic products. It is also contained in some ammunitions, old pipes and their soldered connection, automobile radiators, pewter, pottery, folk medicines, leaded crystal glass, and as a contaminant in trace amounts in many products. Owing to serious health concerns of great international recognition, lead is no longer added to gasoline and many house paints but this is not the case in many Asian countries and in Nigeria (Adebamowo et al., 2007). Inhalation and ingestion of lead and its compounds cause lead poisoning. This basically was what happened in Zamfara as will be elaborated on in this review. It is obvious that all the sources indicated are all within the easy reach of children who, unlike adults are quite undiscerning; play more in dust and are out door most of the time, raising their susceptibility.

It is important to recognize metal toxicity has shifted focus to more subtle, chronic, low-dose effects, in which cause and effect-relationships may not be immediately obvious. This should be borne in mind when managing problems of metal toxicity so that room is left for projection.

**Table 1.0:** Organs and Systems Affected by Lead

<table>
<thead>
<tr>
<th>Systems</th>
<th>Organs</th>
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<tbody>
<tr>
<td>Haemopoeitic system</td>
<td>Kidneys</td>
</tr>
<tr>
<td>Nervous system (central &amp; peripheral)</td>
<td>Bones (mainly repository)</td>
</tr>
<tr>
<td>Reproductive system (male&amp; female)</td>
<td>Gastrointestinal tract</td>
</tr>
<tr>
<td>Immune system</td>
<td></td>
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<tr>
<td>Muscular system</td>
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<td>Auditory system</td>
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<td>Endocrine system</td>
<td></td>
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<tr>
<td>Cardiovascular system</td>
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</table>

It is evident that lead is an indisputable multisystem poison, affecting virtually all the key organs and systems in the body including their organelles (table 1).

**Sources of Lead Exposure**

There are many possible sources of lead. Lead has been widely used in many industrial activities as previously indicated. Some examples are its use in paint, in plumbing, in batteries, and in consumer packaging. Lead is also often released into the environment through industrial operations involving lead, such as mining (as in the situation in Zamfara), smelting, and producing and or recycling lead containing products. All these activities are poorly recognized sources of exposure to lead, particularly for children in the developing countries. One significant source of lead that is hopefully shifting into history has been its use as an additive to gasoline. Painfully however, its place is been taken by paint.

**Blood Lead Levels and Pathological Consequences**

Human exposure to this metal can result in serious pathological consequences if the concentration in the body reaches a critical level. In humans, blood is the most common tissue used for lead analysis and diagnosis of lead poisoning and the medical literature relates the clinical features of lead poisoning to these blood lead levels (BLLs). The majority of human lead exposures occur through the respiratory and gastrointestinal tracts. As much as 50% of the inhaled lead is absorbed from the lungs and enters the circulation while only about 10% may be absorbed through the GIT (McMillin et al, 2013). Thus this tract constitutes an important portal of entry compared to the GIT. The amount absorbed is much higher in children who because of their greater propensity for adventure and outdoor activities take in a lot of air thus increasing their absorption of lead.

The recent report of Shen, (2011) on partnership in translational medicine between China and the United States in which child lead poisoning featured as an example of ‘From Medical Research to Public Health Policy: An Integral Part of ‘Translational Medicine’ is particularly instructive for the Zamfara experience. The figures below show the location of Zamfara state in Nigeria some scenes at the location and related statistics.
Location of Zamfara State in Nigeria and some statistics

Date: March - June 2010
Location: Zamfara State, Nigeria
Casualties: At least 163 dead (very conservative estimate)
355 cases discovered
Figure 1: Scheme Showing Location and Time Line of Lead Poisoning, Morbidity and Mortality Statistics in Zamfara State, Nigeria

Figure 2.0: Burial of contaminated top soil at dump site near Dareta Village, Anka Local Government Area, Zamfara, Nigeria
Source: Vanguard (2010)

Signs and Symptom of Lead Poisoning (Toxidrome)

The signs and symptoms of lead poisoning or toxicity are protean (nonspecific). These may be confused with other common health problems such as malaria, typhoid fever, other bacterial and viral infections frequently seen in many developing countries especially in the tropics (Anetor and Adeniyi, 2001).

Common signs and symptoms of lead poisoning include but not limited to:
- Nausea
- Myelalgia
- Convulsion

- Anaemia
- Infertility
- Miscarriage
- Hypertension
- Headache
- Arthralgia
- Colic
- Wrist drop
- Lead line (blue line in gum)

Diagnosis of Lead Poisoning

As in most clinical entities without uniquely pathognomonic manifestations, the diagnosis of lead poisoning requires critical evaluation of clinical and laboratory data. Diagnosis is commonly divided into clinical and laboratory, with the latter being more definitive. There are many signs and symptoms mimicking lead poisoning such as viral, bacterial and parasitic infections like malaria and typhoid fever as indicated above. This is why clinical diagnosis alone can neither exclude nor confirm lead poisoning and the laboratory diagnosis becomes the main stay of diagnosis of lead intoxication.

Laboratory diagnosis may be either screening or definitive

Screening

Peripheral (arterial) blood and other haem biosynthetic pathway intermediates (discussed below) are often employed.

Definitive

Venous blood lead level is the most useful initial test for recent or ongoing exposure as opposed to past exposures as well as definitive tests. Different tests have been used in the past to evaluate lead exposure and or to gauge the effects of lead exposure (Anetor et al., 2000; McMillin et al., 2013).

Given the greater risk of contamination using the finger-stick method, an elevated BLL obtained through finger-sticking should always be confirmed with venipuncture samples (CDC, 1991; 2004; McMillin et al., 2013). For individuals with high or chronic past exposure periods however, BLLs often under represent the total body burden because most lead is stored in bone and may have normal levels in the blood. Challenge tests (Ca-EDTA chelation tests) may be indicated. Bone lead stores by KX-Fluorescence (Epidemiologic survey) may also be useful. The common facilities required for BLL determination are either, atomic absorption spectrophotometry (AAS) or anodic stripping voltammetry (ASV) or their derivatives. Although in the economically more
advanced countries, inductively coupled plasma mass spectrometry (ICP-MS) are now more commonly used the AAS techniques are still very acceptable and reliable. These scientific equipment are expensive to acquire and maintain by most developing countries. Thus the establishment of some regional centres will be a rewarding approach.

Erythrocyte protoporphyrin (EPP) (haem intermediate) assayed as zinc erythrocyte protoporphyrin (ZPP) was previously considered the best test for screening for asymptomatic toxicity (especially in children). It is however, not sufficiently sensitive at lower BLLs and is not as useful a screening test for lead exposure as previously thought (CDC, 2004).

The activity of delta aminolaevulinic (ALA) dehydratase is often decreased. The inhibition of the activity of delta ALA dehydratase is a sensitive indicator of acute or chronic lead poisoning. The activity of this enzyme decreases with increasing lead levels. The only disadvantage is that it is exquisitely sensitive and remains significantly inhibited even at acceptable levels. Blood lead levels considerably less than 10μg/dl are currently considered normal (ideal BLL is zero) while normal values of ZPP are usually below 35μg/dl. Indeed, there is no threshold (safe level of exposure) for the permanent health effects of lead toxicity (Lampehr et al., 2005). The recent recommendation by the Advisory Council on Childhood Lead Poisoning Prevention approved by the CDC, among others suggested elimination of the term “blood lead level of concern” and that modification to the reference range and that BLLs of 5μg/dl be considered the reference for detecting elevated blood lead levels (CDC, 2012). The EPP level (ZPP) is also elevated in conditions such as iron deficiency anaemia, jaundice, sickle cell disease and other haemolytic states and or anemias.

**Miscellaneous Investigations**

Complete blood count (CBC) may be useful with extensive exposure. In lead - exposed patients, the hematocrit and haemoglobin levels may be slightly to moderately low. Peripheral smears may be normocytic or hypochromic or hypochromic microcytic. Basophilic stippling may be present in significantly prolonged exposure and if the patients zinc level is low (Anetor et al, 2002). These later investigations are not specific to lead exposure and are not as reliable as BLL and EPP. Uric acid excretion and erythropoietin production may also be decreased (Anetor, 2002; Anetor et al., 2005) culminating in elevated uric acid level.

**Diagnosis of Lead at the Primary Care Level**

Since this article focuses on the lead poisoning experience in a rural setting in Zamfara state, Nigeria, it is perhaps appropriate to look at laboratory services at the primary care level. In the absence of facilities for the accurate measurement of lead concentration in blood, a diagnosis of lead poisoning is best made from a careful evaluation of the history and clinical presentation. Nonspecific signs that may point to a diagnosis of lead poisoning include basophilic stippling of red cells due to accumulation of rRNA (McMillin et al., 2013) (in very severe cases in peripheral blood film), which would be present in this case, appearance of blue gum line and wrist drop. Other tests that can be easily conducted at the primary care level that may also assist in the diagnosis of Pb poisoning for prepared minds include: red - cell zinc protoporphyrin (ZPP) concentration and urinary -aminolaevulinic acid excretion (ALA) as well as increased urinary excretion of coproporphrin III; arising largely from the inhibition by lead of ALA-D by competing with zinc as its cofactor. Additionally, by forming covalent bonds with sulfhydryl (-SH) groups, Pb also inhibits the enzyme coproporphyrinogen oxidase which is dependent on free –SH groups for its function (Agbedana and Ayooba, 2006; McMillin et al., 2013). Unfortunately, facilities may not even be available in most Primary Care Centres in Nigeria and indeed most developing countries even though the critical needs are a few chemical reagents and Woods (UV) lamp.

**Radiography**

Abdominal radiographs may show the presence of radiodense Pb foreign bodies in the GIT, helpful only in acute ingestion. Long bone radiographs can show lead line (not recommended for diagnosis, see figure 3) (CDC, 2004). These may raise the index of suspicion in a prepared mind. Ayooba (1979) had already hinted in the late 1970s that with increasing industrialization, clinicians and scientists should be on their guard for cases of toxic nature. This may be consistent with a latter of view by Lauwerys and Hoet (2001).
The International Program on Chemical Safety and Chemical Toxicity (IPCS)

The IPCS is a cooperative programme of the United Nations Environment Programme (UNEP), the International Labour Organization (ILO) and the World Health Organization (WHO). The WHO is the executing agency for the program, which aims to provide internationally evaluated scientific database for countries to develop their own chemical safety measures and to strengthen national capabilities to prevent and treat harmful effects of chemicals and manage chemical emergencies (Flanagan et al., 1995). The IPCS had already anticipated the Zamfara episode and similar events in other developing countries (Flanagan et al., 1995). The provision of services for the diagnosis and management of poisoned patients varies with the level of development of the country. Toxicological services which provide support for diagnosis, prognosis and management of chemical poisoning, in many developing countries, as amply exemplified by the Zamfara experience are very poorly developed if at all existent. There are many simple analytical techniques that do not need sophisticated equipment or expensive reagents even with unsteady electricity supply. Such tests could be carried out in basic laboratories that should be available in all health centres. With appropriate training, Health Centres’ laboratory staff could be trained to provide toxicological services. In our own opinion, what is probably the problem is the lack of will or insufficient awareness. The Zamfara experience has served to bring this to the limelight and made bare what some Nigerians have consistently observed in scientific papers over the years (Anetor and Adeniyi, 2000; Anetor, 2001, Anetor et al., 2002, Anetor et al., 2007)

Second Tier Tests

Second tier tests may include health effects of lead. These essentially include tests based on the biochemical alterations associated with lead poisoning, increased ALA, based on the well-known marked perturbation of the haem biosynthetic pathway with attendant accumulation of some intermediates earlier pointed out (Anetor et al., 2002); increased uric acid (Anetor, 2002) low hematocrit, basophilic stippling in very severe cases also previously indicated may be helpful.

Acceptable Blood Lead Levels: Consideration for Developing Countries

The ideal blood lead level is internationally now unanimously accepted to be zero. This has been confirmed by the precipitous decline in blood lead levels globally. While levels of about 3.0 μg are now known to be average in the general population in most advanced nations, the levels in developing countries still oscillate between 15 and 20 μg/dl (Nriagu et al., 1996). One shudders to recall that in the past levels as high as 40-60 μg were considered acceptable (CDC, 2012). Levels far <10 μg are internationally acceptable currently in many developed countries while levels several fold this still exist in many developing countries including, Nigeria (Nriagu et al., 1996). It should be recalled that in Zamfara, mean levels as high as 153 μg/dl (range 56-331) (Dooyema et al., 2012) were said to have been found in children; no doubt the mortality and profound morbidity. Our studies in Ibadan and Sokoto, Nigeria are instructive (Adeniyi and Anetor, 1999). Sokoto is close to Zamfara state in Nigeria.

In a report preceding the removal of lead from gasoline ‘Lead poisoning in Africa: a silent epidemic’ (Anetor and Adeniyi, 2000) we warned of prevailing lead poisoning on the continent and called on the African Union (AU) to take it seriously. This appeared to have fallen on deaf ears. It is very sad that Nigeria had to resort to panic measures largely executed by agencies outside of the African continent despite early warning.

Lead Poisoning and the Susceptibility of Children

Children confront a wide range of potential hazards in the environment and are especially susceptible to toxic effects because of their developing organ systems, immature biologic defenses and
increased exposure due to small size, diet, behaviour and other factors (National Research Council, 1993; Kilpatrick et al., 2002; Hulla, 2014). Young children are therefore at special risk of environmental lead poisoning because their high metabolic activity enhances susceptibility of vulnerable enzyme systems as well as greater demand for protective micronutrients (Timbrell, 2009; Anetor, 2009). Children also play more outside. Their high metabolic rate implies that the rate of inhalation to take in sufficient oxygen will also be correspondingly higher. Not all aspects of the pathogenesis of lead toxicity are known in children, like in adults lead interferes with essential enzyme systems causing damage to central and peripheral nervous systems (largely through impairment of signal transduction), bone marrow, kidneys and other organs and tissues which are particularly severe in children. Lead poisoning presents clinically in many different ways; including lead encephalopathy, peripheral neuritis, lead colic, nephritis, and anaemia. Acute lead poisoning in children is particularly dangerous, with predominantly neurologic effects, including Korsak’s psychosis and lead encephalopathy (Needleman et al., 1996, McMillin et al., 2013). This may lead to lifelong neurological deficits including poor learning ability. This susceptibility may be accentuated by nutritional deficits, particularly micronutrient deficiency disorders (MDDs) which are common in many developing countries (Shenkin, 2006). This appears of great importance when addressing lead toxicity in nutritionally disadvantaged populations (Apetor et al., 1999; Massadeh et al., 2006).

Prevention of Occupational Lead Poisoning

The prevention of occupational lead poisoning is one of the textbooks illustrations of the principles of industrial hygiene. Education of workers on the importance of cleanliness (washing of hands to get rid of lead dust before eating), and general good housekeeping are known. These were grossly missing in the Zamfara episode. Indeed mining activities were extended to residential homes. This appears of particular import as the nation plans to broaden its revenue base substantially by recourse to the mining sector. The attendant toxicological problems that may arise should be anticipated.

Micronutrients Intervention in Host Resistance to Chemical Toxicity

Nutritional state, though of importance in resource poor countries, has been neglected as an approach to mitigation of chemical toxicity. Nutritional status should be viewed as one of the most important preventive measures available to public health experts in the developing countries where vital micronutrients, particularly Zinc (Zn) (a metabolic antagonist of cadmium and competitor with lead) are deficient (WHO, 2002, Valko et al., 2006; Timbrell, 2009, McMillin et al., 2013). Indeed, Zinc is vital for the function of other important micronutrients such as vitamin A (retinoids) and its deficiency has been reported to be one of the top ten killers in the developing countries (WHO, 2002). The interference of Pb with iron metabolism is also of great importance, it is now believed that the presence of elevated levels of Pb culminates in intracellular iron deficiency, resulting in the replacement of iron with Zn in haem synthesis (Jacobs et al., 1998) leading to ZPP.

It should be recalled that because of the preponderance of cereal base of the diet of residents of the northern part of Nigeria, including Zamfara state, zinc deficiency is very likely to be prevalent. The phytate in cereal may complex zinc making it unavailable in turn affecting the bioavailability of vitamin A. The multiplied immediate and occult pathologic effects are obvious. Adequate zinc level in the body may reduce the consequences of environmental chemicals.

The concept of nutritional modulation of chemical toxicity is an important one for many developing countries owing to its relatively low cost. This should be taken advantage of in industrializing developing countries. The observation by Timbrell (2009) emphasized the resurgence of interest in the relationship of nutritional status to chemical toxicity or drug reaction. Others like Valko et al. (2006) and earlier Peraza et al., (1998) have re-echoed this. This again appeared to have been ignored in Nigeria (Anetor, 2009).

In the specific case of lead toxicity, the weight of evidence suggests that much can be achieved in minimizing the health effects of chemical poisoning now widespread in many developing countries by paying attention to the micronutrients. Zinc is vital for a key enzyme in the haem biosynthetic pathway; delta-aminolaevulinic acid (ALAD) (Anetor et al., 2002; McMillin et al., 2013). This is one of the mechanisms by which lead exerts its toxic effects (Elsenhans et al., 1991). Thus optimum zinc level is protective and reduced level increases susceptibility.

The Zamfara Episode

A community of illegal miners in two villages, Bukuyou and Anka in Zamfara state experienced one
of the most discussed episodes of lead poisoning in human history. This stands out currently as the most
outstanding episode of massive lead poisoning in the
world (Dooymen et al., 2012). It falls among the
classical cases of lead poisoning that we only read
about in books as students. One had thought such cases
were conscribed to history. The Centre for Disease
Control and prevention (CDC) that was invited to
assist described it as “unprecedented”. This, as the
‘Punch’, daily newspaper, Nigeria, (Editorial, 15th
June, 2010) described it as exposing the hollowness of
Nigeria’s health care delivery system. We were
completely helpless. But for CDC, the UN, MSF
(Doctors without Borders) and the Black Smith’s
Institute, the morbidity and mortality put on a
conservative estimate of about 400 would have been a
child’s play. To put it mildly, it was a great national
disgrace that even the apex of the health care delivery
system in Nigeria could not offer any assistance in
terms of diagnosis when contacted by a former Health
Minister. It was very painful to some of us (Scientists)
who after years of clamoring for such services
(toxico logical services), including the then President of
the International Union of Toxicology (IUTOX) (at
the 2007 12th IUTOX congress in Montreal, Canada).

Instructive Message for Biomedicine in Nigeria and
Industrialization
Industrialization is a welcomed development in
any developing or restructuring economy. This
unfortunately is always accompanied by the use and
generation of many toxic substances that are harmful to
humans, animals, plants and the general environment
(Anetor, 2008). Itai itai (Satarug and Moore, 2004;
Horiguchi et al, 2010) and Silent Spring (Carson,
2002) have all previously warned the international
community of the danger of chemicals on human
health, but we failed to heed these warnings. Though
this article is at the moment concerned with the
situation in Zamfara, it should be borne in mind that
environmental contamination with lead occurs in some
urban areas due to emission from factories, smelters
and burning of refuse laden with industrial wastes.
This may cause chronic low-level intoxication, which
is a cause of intellectual impairment in children
(Needleman, 1996; McMillin et al, 2013), ranging
from slight reduction of intelligence quotient (IQ) to
mild mental retardation. The possible contribution of
this to the persistent poor performance of Nigerian
children in major public examinations, such as the
Senior Secondary Certificate Examination and
National Examination Council in Nigeria, is rarely
considered.

How do we proceed from here? We shall restrict
this treatise to biomedicine and scientists in the field
and the government. We must tell ourselves the truth;
the skewed emphasis on communicable disease in
Nigeria and many industrializing or restructuring
countries should be addressed. This is no longer
acceptable. We are now in the industrial era in our
developmental phase. Let us give toxicology the
attention it deserves. Schools, particularly the higher
institutions of learning must give instructions in
toxicology; including undergraduate and post graduate
programs. It should also be noted that chemical
exposure weakens the immune system (immune
paresis) which increases susceptibility to infectious
states that we are at the moment more preoccupied
with (Anetor and Adeniyi, 1998). We should be
concerned about sporadic episodes of chemical
poisoning as submitted by UNEP (2012). There are
many more serious chronic long-term effects that may
take decades to manifest themselves from uncontrolled
exposure to chemicals. Some well-known forms of
such outcomes include developmental defects, cancer
and psychiatric episodes and crime rates (Needleman
et al., 1996; Anetor et al., 2007). There has been much
discussion of chemicals, in the work place and in the
general environment, as causes of cancer (Huff et al.,
1991, Vako et al, 2006). Much of the evidence on this
comes from epidemiology or toxicology or both.
Industrial chemicals of many varieties contain (or are
themselves) chemical carcinogens. Estimates of the
proportion of all cancer attributable to risk factors in
the environment and specifically to occupation have
been a topic of some controversy. An early report by
the joint commission of the National Cancer Institute,
National Institute of Environmental Health Sciences
and National Institute of for Occupational Safety and
Health (IARC, 2003) suggested that 20-40 percent of
all cancers were occupationally related. The
controversy is still raging. A disturbing observation is
that of Tokar et al (2010b) who observed that early life
inorganic lead exposure induces testicular teratoma and
renal urinary preneoplasia.

It is relevant to note the relatively recent
association of Pb with increased human cancer risk
(Antilla et al., 1995; ATSDR 2005b). Silbergeld et al
(2003) has observed that though lead does not appear
to be directly genotoxic in vivo or in vitro, but that lead
may interact with other toxicants to facilitate chemical
carcinogenesis. This is particularly relevant in an
environment with multiple ubiquitous pollutants.
Though the mechanisms are uncertain, several mechanisms have been proposed for lead-associated carcinogenesis, among these are regenerative repair, inhibition of DNA synthesis or repair, generation of ROS with attendant oxidative damage to DNA, substitution of lead for zinc in transcriptional regulators, interaction with DNA-binding proteins, and aberrant DNA expression (Silbergeld, et al., 2000, Qu et al., 2002, Silbergeld et al., 2003). This may not be unlikely as a result of the concomitant endemic MDDs in the affected communities. These are being intensely examined by various research and regulatory agencies earlier pointed out in the advanced countries. The pertinent question therefore is, how prepared is Nigeria as a nation? Do we have similar national functional institutes in Nigeria? Can the National Environmental Standards Regulatory Agency (NESRA) cope alone or are they coping at all?

Conclusion

The Zamfara episode of severe lead poisoning has clearly shown that plumbism is not a disease of the past. It has revealed that the pace of industrialization (low scale or large) and the level of preparedness of the nation’s health care system are disconnected. Instructively, the experience makes it a priority for the nation’s biomedical laboratory service to be repositioned or restructured to be able to detect inevitable industrial diseases and toxic substances common in progressively industrializing nations. Toxicology must be made a prominent arm of the service. Though we are currently concerned about acute Pb poisoning, the long-term (chronic) consequences of lead poisoning and other toxic substances such as neurologic disorders, developmental defects and cancer should however be kept constantly in mind. The probable protective role of micronutrients including chemoprevention strategies should also not be overlooked.

Recommendations

The nation’s biomedical laboratories must be equipped to ensure easy and early diagnosis of lead poisoning; other toxic states or chemical-induced diseases.

All known mining areas should be linked to centres providing toxicological investigations for surveillance—probably under the umbrella of a National Institute of Environmental Health Sciences (NIEHS) (Regional Toxicology Laboratory).

There is need for a national survey of blood lead levels preferably combined with nutritional assessment.

There is the need to establish an agency to study various aspects of the toxic effects of lead and other related toxicants in Nigeria, comparable to the Agency for Toxic Substances and Disease Registry (ATSDR), in the United States.

Provision of facilities and strengthening of laboratories in at least some designated Universities Research Institutes to study the silent epidemic of lead poisoning is highly desirable.

Introduction of courses of instruction in toxicology in schools, including undergraduate and postgraduate courses in the universities and establishment of a standing committee to disseminate information through public enlightenment programmes, emphasizing the adverse effects of lead and other toxicants are desirable strategies.

Owing to the special sensitivity of children, a Children Survey Study is needed, possibly under the auspices of ‘Children’s National Environmental Toxicology and Micronutrient Programme (CNETMP). This may progress to the establishment of a Children’s National Toxicology and Micronutrient Centre.

Finally, other sources of lead to the general population, such as lead in automobile and home paints should also be addressed.

References


Advisory Committee on Childhood Lead Poisoning Prevention (2012). Low level lead exposure harms children: a renewed call for primary prevention. Atlanta CDC, pp.68


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