# AES BIOFLUX

**Advances in Environmental Sciences - International Journal of the Bioflux Society**


## Preliminary indications of blood lead concentrations, among occupationally exposed and non exposed Palestinians


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**Abstract**. Despite the lower rate of exposure to leaded compounds in the past ten years, due to reduced lead petrol concentrations in the ambient air and improvement in environmental control measures, lead poisoning is still an occupational and environmental disease of great concern in public health. The presence of other sources of lead exposure after the ban of leaded gasoline could be a risk factor for elevated blood lead concentrations. In this study blood lead levels (BLL) were screened in both occupationally and non-occupationally exposed groups in the Palestinian Territories by inductive coupled plasma-mass spectrometry (Agilent 7500 ICP-MS). The non-occupationally exposed groups included 18 normal healthy smoker males, 18 non smoker males, and 18 females. Occupationally exposed groups include 25 workers in the assaying and refining of gold and 19 workers in auto-repair garages. Data was analyzed using the statistical computer package (SPSS). Mean blood lead levels of all groups were below the action level according to Centers for Disease Control (CDC) and Occupational Safety and Health Administration (OSHA) (<10 µg/dL). No statistical significant differences were found between workers group and control groups. In the control group, a paired t-test showed a statistically significant difference ($p<0.05$) between the female group and smoker male group. There was no correlation with age for all groups except the female group and auto-repair workers which showed significant correlation ($p<0.05$) with both age and years of work. This could be contributed to differences in genetic make-up, chemical exposure history and age related decreased function of the detoxification processes. Since mean BLL (3.66 µg/dL) of the control group was comparable to economically advantaged countries like USA (1.6 µg/dL) and those with low mean of (1.96 µg/dL) like Jordan, lead is not considered a major environmental pollutant in Palestine and the screening is recommended only at the workers in tasks involving lead.



**Key Words**: Blood lead levels (BLL), occupationally exposed, non-occupationally exposed, Palestinian Territories.


**Introduction**. During the past two decades, major efforts have been made in many countries to minimize exposure to lead, in both, occupational and general environment. Although lead poisoning is rather uncommon in the developed world and cases reported are much milder than past cases, it is still common in developing countries where the preventive measures are poor. Reported blood lead levels (BLL) ranged from a concentration as low as a mean of 1.6 µg/dL in USA (CDC 2005), and 1.96 µg/dL in Jordan (Dabbas & Al-Zoubi 2000), to as high as 287 µg/dL in Islamabad (Khan & Qayyum 2002), and >10 µg/dL, 15.3 µg/dL in Cape Peninsula, South Africa and the Kingdom of Bahrain respectively (Von Schirnding et al 2001; Freije & Dairi 2009).

Efforts to reduce lead in the environment in the USA have resulted in lowering the geometric mean BLL for adults from more than 12 µg/dL to less than 3 µg/dL between 1980 and 1994 and to 1.6 µg/dL between 1999-2002 (CDC 1997; CDC 2005). In a study performed in Barcelona to evaluate the population occurred changes in BLL during the period 1984-1995, results showed that average BLL declined from 18.6 µg/dL in 1989 to 7.8 µg/dL in 1995 (Torra et al 1997). Despite the ban of leaded gasoline, other sources of lead exposure could be a risk factor for elevated blood lead concentrations as indicated by a study done on 1-3 year old Lebanese children. The study showed that BLL mean was 6.6 µg/dL with 14% of children having BLL >10 µg/dL, which was much higher than the prevalence reported among children in economically advanced countries, a fact that was attributed to paternal manual jobs, residence near high traffic area, summer season, using hot tap water for cooking, exposure to kohl and living in older buildings (Nuwayhid et al 2003). However, even though the average BLL has markedly declined, many workers in high-risk industries are still overexposed; thus, the public health objective of the CDC (ABLES) program in USA, as stated in health people 2010, is to reduce the number of persons with BLL >25 μg/dL from work exposures to zero (HESIS 2001).

In Israel, environmental Pb concentrations in soil, plants, water and air are generally low. Blood lead levels measured in the past were considered to be low and not regarded with concern. Traffic policeman in central Jerusalem had BLL of about 12 μg/dL (Foner 1992). Exceptions were traced to specific causes, such as workers in accumulator factories or smelters and plastic factories, and a major epidemic of lead poisoning involving a number of Arab villages was reported in and traced to contaminated flour grounds in village mills (Hershko et al 1984). A study on 317 Israeli children aged 1 month to 10 years between 1998-2000 reported BLL means of 3.2 μg/dL and 2.59 μg/dL in Druze and Jewish respectively (Witt et al 2007). In Palestine, the available published data concerning BLL is only among 2-6 years aged children and 10th grade school students in Jenin district (West Bank). The mean blood lead levels were reported to be 4.2 μg/dL in the West Bank and 8.2 μg/dL in Gaza (Safi et al 2006). In Jenin district the geometric mean of BLL was 0.87 μg/dL, with the highest mean of 1.85 μg/dL found at boys school located near a heavy traffic movement and near an industrial area (Zyoud 2001). An outbreak of lead poisoning in a West Bank Palestinian family from contaminated flour mills was also reported (Richter et al 2000). No published data concerning adult BLL is available; thus, it is important to have surveillance data on occupational and non-occupational exposed populations which may provide an approach for effective environmental control measures if needed.

The aim of this paper is to determine the BLL, measured by ICP-MS in non-exposed healthy adult males and females in the age range of (18-60) years compared to potentially exposed workers in gold assaying and auto repair garages in the West Bank (Palestinian Territories).

## Material and Method.

Peripheral blood samples (5 mL each) of five selected groups (98 samples) of the population were collected by venous puncture using EDTA-K3 blood collection tubes from the period 15$^{th}$ of March 2012 to the 15$^{th}$ of May 2012. Blood samples were stored at 4°C. These groups consisted of three control groups: the female group, the smoker males group, and the non smoker males group. The workers groups included workers in gold assaying and workers in auto repair garages which were collected from Ministry of Economy in Al-Bireh/Ramalla and auto repair garages in Ramalla industrial area respectively in the Palestinian Territories. Control group samples from the age 18-29 were collected from university students in our Aquaculture Research Laboratory, at AL-Quds university where the study was conducted. Those >30, were collected from medical laboratories in the Palestinian Territories. Each of the participating individuals was provided by a structured questionnaire that included age, sex, place of residency, type of work, years of work and potential risk factors of lead exposure (Table 1).

**Blood analyses for lead (Pb)**. Analyses for BLL were conducted by inductive coupled plasma-mass spectrometry (Agilent 7500 ICP-MS), (Agilent Technology, Inc, 2008; Zhang et al 1997; Creed et al 1994). The analysis was carried out within 3 months after sampling. To the 2 mL of blood, 4 mL of Nitric acid (HNO3 69-70% w/w; Merck k GaA, Germany) was added. They were digested in a closed vessel by the microwave method, and the digest was centrifuged, then the supernatant was diluted to 100 mL with dionized water. To each sample 500 μl of internal Standard mix: germanium (Ge), yttrium (Y) and terbium (Tb) at the concentration of 1 ppm in 5% nitric acid was added as an internal standard. The operating conditions were as follows: RF power 1.35 kW, plasma gas 15 L/min, auxiliary gas 1 L/min, carrier gas 1.2 L/min, and sample uptake rate 0.4 mL/min, respectively.

Table 1

Logistic regression analysis: odds ratio (OR) and 95% confidence intervals (CI) for potential risk factors of lead exposure among different groups

| *Risk factors* | *Number of observations* | *OR (95% CI)* |
|---|---|---|
| Working in tasks involving lead | 9 male worker<br>1 non smoker male<br>1 gold assaying worker | 1.25 (0.80-1.96)<br>0.64 (0.13-2.90)<br>0.31 (0.05-1.90) |
| Living near industrial area | 3 smoker male<br>1 gold assaying worker<br>13 garage worker | 0.50 (0.19-1.20)<br>0.21 (0.02-1.70)<br>0.68 (0.43-1.08) |
| Non-plastic domestic water piping | 10 garage worker | 0.55 (0.32-0.90) |

**Calibration blank and quality control**. 5 µg/L, 10 µg/L, 20µg/L, 50 µg/L, 100 µg/L, lead (Pb) standards were prepared from Stock lead standard 1000 µg/mL (contains 1.005 µg/mL of Pb in 0.9 wt% HNO3; D=1.010, Sigma & Aldrich) with deionized water (Figure 1). A reagent blank (4 mL $HNO_3$ 69-70% w/w; Merck k GaA, Germany) was used as a blank for both standards and samples. For quality control, reference material for trace elements in human whole blood was used. The reference material consisted of level 2 (SERO 210205 Pb=336µg/L, and was sup-plied by SERO AS, Billingstad, Norway.

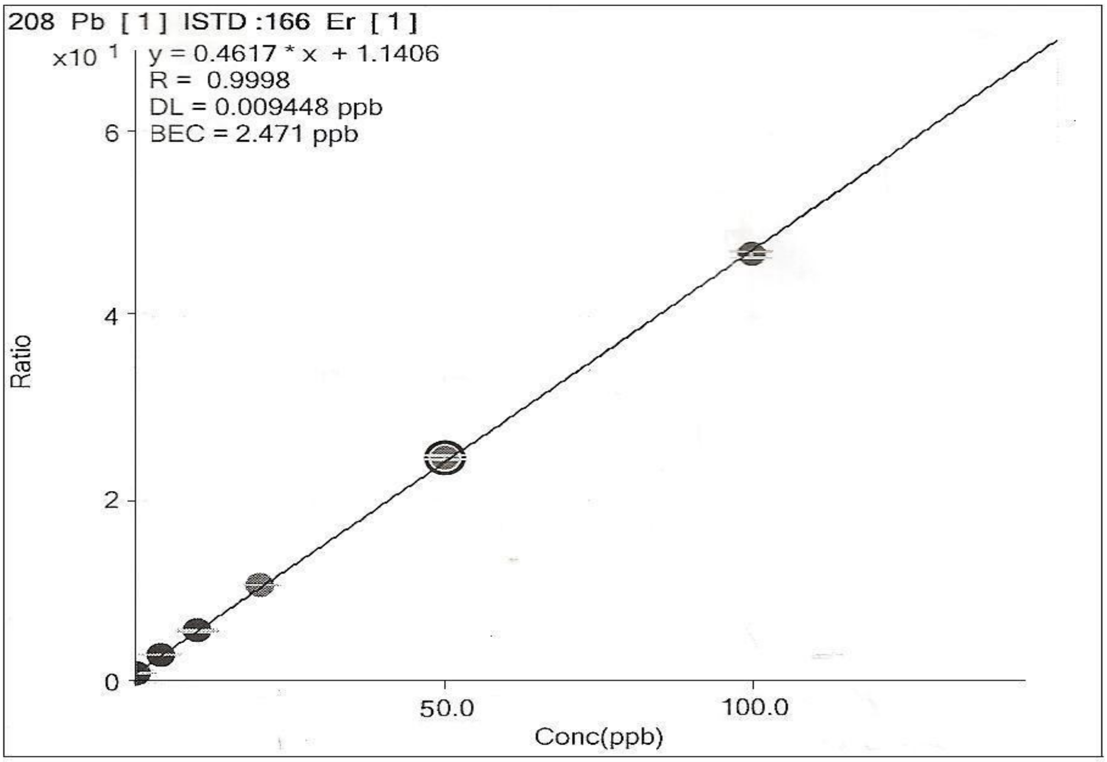


Figure 1. Standard curve of Pb determination in blood.

**Statistical analyses**. Data was analyzed using the statistical computer package (SPSS), including ANOVA test, pair-wise comparison, and a paired t-test between different groups and logistic regression analysis**.** Ranges, means, and correlation coefficient with age and years of work were also calculated.

**Results and Discussion**.

**Blood lead levels BLL in the control group (smoker males, non-smoker males, females)**. In reference to Table 2, the BLL means of control groups (2.90, 4.09, 3.90) were <10 μg/dL, below the action level according to CDC and OSHA. No amount of lead is considered safe, but the CDC has reduced the blood lead concentration above which public health action should be taken to 10 μg/dL, based on the accumulating evidence of lead toxicity at low concentrations (CDC 1991). There was no statistically significant (Table 3) difference (p>0.05) in BLL means (3.66 μg/dL) of control groups compared to economically advantaged countries like USA (1.60 μg/dL) and those with low mean of (1.96 μg/dL) like Jordan. On the other hand, there was a statistical significant difference (p<0.05), with other urban low-income populations, where prevalence of lead poisoning is still high like Pakistan, where means of BLL is 287 μg/dL (Table 3).

Table 2

Blood lead levels (BLL) of the control groups in relation to age and sex

| *No. of individuals* | *Age (year)* | *No. of SM* | *No. of NSM* | *No. of F* | *BLL of SM (μg/dL)* | *BLL of NSM (μg/dL)* | *BLL of F (μg/dL)* |
|---|---|---|---|---|---|---|---|
| 14 | 18-25 | 4 | 5 | 5 | 2.90-4.00 | 0.60-7.20 | 1.33-3.24 |
| 4 | 26-30 | 2 | 1 | 1 | 3.70-3.80 | 4.00 | 1.28 |
| 8 | 31-35 | 2 | 3 | 3 | 3.50-5.10 | 2.60-5.70 | 2.40-3.50 |
| 5 | 36-40 | 2 | 2 | 1 | 3.20-4.70 | 2.90-3.10 | 2.27 |
| 6 | 41-45 | 2 | 2 | 2 | 4.70-4.80 | 4.70-4.80 | 1.50-1.70 |
| 7 | 46-50 | 2 | 2 | 3 | 2.90-5.70 | 3.19-4.40 | 1.75-3.90 |
| 10 | 51-60 | 4 | 3 | 3 | 2.90-4.20 | 2.70-4.30 | 4.70-6.90 |
| Sum: 54 | Range: 18-60 | Sum: 18 | Sum: 18 | Sum: 18 | Range: 2.90-6.20 | Range: 0.60-7.20 | Range: 1.28-6.90 |
| - | - | - | - | - | Mean: 4.09 | Mean: 3.90 | Mean: 2.99 |
| - | - | - | - | - | r:-0.103 | r:-0.056 | r:0.515 |
| - | - | - | - | - | r2:0.011 | r2:0.003 | r2:0.265 |
| - | - | - | - | - | t-v: -0.414 | t-v: -0.223 | t-v: 2.403 |
| - | - | - | - | - | p-v: 0.3421 | p-v: 0.4131 | p-v: 0.0144 |

r - correlation coefficient with age, r2 - the coefficient of determination, t-value - the value of t associated with the calculated value of r, p-value - the corresponding probability, p>0.05 - considered to be statistically not significant, p<0.05 - statistically significant, SM - smoker male, NSM - non smoker male, F – female.

Table 3

Comparison of BLL mean (μg/dL) of control group with means of different countries

| *Statistics* | *Control / USA* | *Control / Jordan* | *Control / Pakistan* |
|---|---|---|---|
| Mean | 3.66 / 1.6 | 3.66 / 1.96 | 3.66 / 287 |
| t-value | 10.95 | 9.05 | -1506.3 |
| p-value | >0.999 | >0.999 | 0.0001 |

Control group - (SM,NSM,F), p>0.5 - statistically not significant, p<0.05 - statistically significant.

These findings agreed well with the fact that environmental lead pollution is not a major problem in our country, since the environment of an industrial and highly populated city is more polluted than the environment of a clean, well planned, less industrial and less populated city. Beside the ban of leaded gasoline, which was considered the major source of environmental inorganic lead exposure, we are not living in a major industrial area, where major industries that deal with lead are found compared to Pakistan, where randomly increasing production of variety of wastes and more than 170 industrial units located in its various sectors exist and are considered the major sources of environmental pollution (Khan & Qayyum 2002). According to our structured questionnaire, most of our samples were from Ramallah city and its villages, but only three males were resident near high traffic or industrial area and little, dealt in tasks that involved lead (10 males), (Table 1), but no one was living in old building or exposed to cosmetic remedy that may contain lead. Although the USA is a highly industrialized country, continuous public health lead education, aggressive environmental intervention and continuous environmental monitoring managed to reduce the geometric mean of general population to 1.6 µg/dL.

**BLL in the workers groups (gold assaying and auto-repair garages)**. Concerning exposed worker groups, they include two groups of workers. The first group was 25 workers, working in the field of assaying and refining gold, at the Palestinian ministry of economy at Al-Bireh/Ramalla. The second group was 19 workers, working in auto repair, collected from car garages, located in the industrial area of Ramalla (Palestinian Territories).

The BLL means of workers groups as indicated by tables 4 and 5 (3.54, 4.02), and ranges (0.40-5.30, 1.20-9.15) were below 10 µg/dL. These levels were below the action level according to CDC and OSHA standards. No significant difference between the means of the control groups and workers groups was observed according to ANOVA test.

During the cupellation method for hallmarking of gold which uses lead foil, technicians may be exposed to toxic lead fumes, thus placing them at high risk of lead exposure (Corti 2001). Not all individuals in the gold workers group were in direct contact with lead, but some were working in official work in the same building, so they were considered as a second hand exposure. Workplace exposure limits and workplace controls affect the BLL, thus measuring airborne lead levels, in order to confirm these results is recommended. According to OSHA, the legal air borne (PEL) is 0.05 $mg/m^3$ averaged over an 8-hour work shift. The more years of exposure at workplace, the greater the risk of high BLL. Results showed no correlation with years of work in gold assaying workers (Table 4), indicating that good workplace controls were considered. In contrast there were correlation between the BLL and years of work in auto-repair garages workers (Figure 2, Table 5).

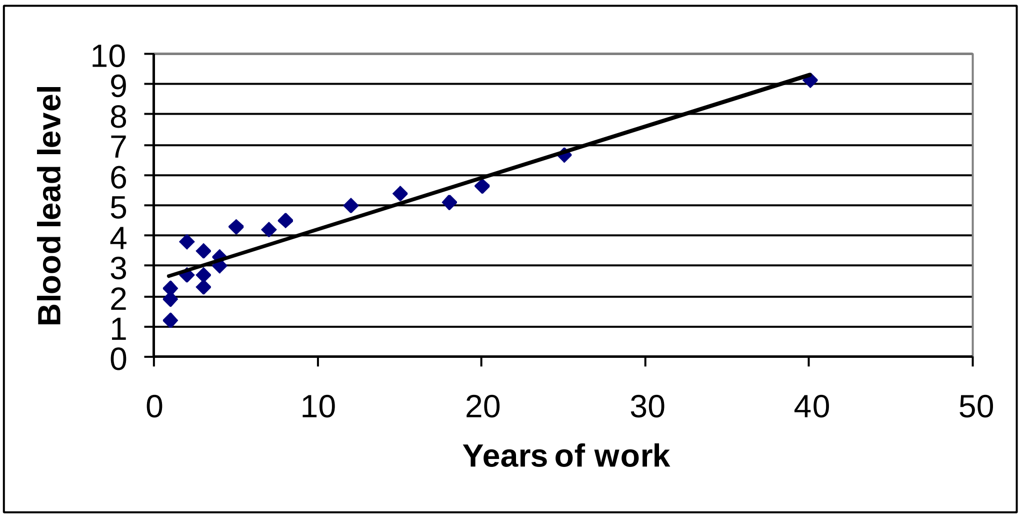


Figure 2. Relation between years of work and BLL among garage workers.

Table 4

Blood lead levels (BLL) of gold assaying workers in relation with age and sex

| *No. of individuals* | *Age( year)* | *No. of SM* | *No. of NSM* | *No. of F* | *BLL of SM (μg/dL)* | *BLL of NSM (μg/dL)* | *BLL of F (μg/dL)* | *Years of work* | *Range: 0.4-5.3* |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 26 - 30 | 5 | 1 | 2 | 2.20 - 4.70 | 4.00 | 3.30 - 4.00 | 3 - 8 | Mean: 3.54 |
| 5 | 31 - 35 | 1 | 1 | 3 | 5.20 | 3.10 | 0.40 - 3.10 | 0.5 - 6 | r: 0.74 |
| 8 | 36 - 40 | 5 | 2 | 1 | 3.30 - 5.30 | 2.20 - 2.90 | 4.40 | 3 - 8 | r2: 0.006 |
| 3 | 41 - 45 | - | 3 | - | - | 1.90 - 5.30 | - | 5 - 6 | t-v: 0.356 |
| 1 | 46 - 50 | - | - | 1 | - | - | 3.20 | 3 | p-v: 0.3619 |
| Sum: 25 | Range: 26-50 | Sum: 11 | Sum: 7 | Sum: 7 | - | - | - | r2= 0.144 | - |
| - | - | - | - | - | - | - | - | r22= 0.012 | - |
| - | - | - | - | - | - | - | - | t2= 0.696 | - |
| - | - | - | - | - | - | - | - | P2= 0.246 | - |

r - correlation coefficient with age, r2 - the coefficient of determination, t-value - the value of t associated with the calculated value of r, p-value - the corresponding probability, p>0.05 - not statistically significant, p<0.05 - statistically significant, r2 - correlation coefficient with years of work, r22 - the coefficient of determination, SM – smoker male, NSM - non smoker male, F – female.

Table 5

Blood lead levels (BLL) of workers in auto-repair garages in relation with age and sex

| *No of individuals* | *Age (years)* | *No. of SM* | *No of NSM* | *BLL of SM (µg/dL)* | *BLL of NSM (µg/dL)* | *Years of work* | *Range: 1.20 - 9.15* |
|---|---|---|---|---|---|---|---|
| 11 | 18 - 25 | 4 | 7 | 1.90 - 4.21 | 1.20 - 3.10 | 1 - 7 | - |
| 5 | 26 - 30 | 4 | 1 | 4.30 - 5.40 | 4.30 | 5 - 18 | Mean: 4.02 |
| 1 | 31 - 35 | - | 1 | - | 5.65 | 0.5 - 6 | r: 0.973 |
| 1 | 36 - 40 | 1 | - | 6.67 | - | 20 | r2: 0.878 |
| 1 | 51 - 60 | - | 1 | - | 9.15 | 25 | t-v: 11.067 |
| Sum: 19 | Range: 18-60 | Sum: 9 | Sum: 10 | - | - | r2 = 0.945 | p-v:_<0.0001 |
| - | - | - | - | - | - | r22 = 0.893 | - |
| - | - | - | - | - | - | t2 = 11.8 | - |
| - | - | - | - | - | - | P = <0.0001 | - |

r - correlation coefficient with age, r2 - the coefficient of determination, t-value - the value of t associated with the calculated value of r, p-value - the corresponding probability, p>0.05 - not statistically significant, p<0.05=statistically significant, r2 - correlation coefficient with years of work, r22 - the coefficient of determination, SM – smoker male, NSM - non smoker male.

Auto-repair garage workers may have been exposed to lead from repairing car exhausts. Previously, tetraethyl lead $Pb(CH_2CH_3)_4$, was added to gasoline and particles of lead and lead oxide are formed on combustion, helping the petrol to burn more slowly and smoothly preventing knocking and giving higher octane ratings. Tetraethyl lead is readily absorbed through the skin and respiratory tract. Lead is released into the environment through lead bromide, a leaded fuel that is absorbed by inhalation (Dietmar 2003). Studies suggested that a decrease of 100 metric tons per day of lead used in petrol is associated with a decrease in mean blood concentrations of 2.14 μg/dL (Lovei 1998). The gradual phase out of leaded gasoline could explain our results since those workers are less exposed to leaded gasoline that was used in older cars manufactured before 1990. Correlation with years of work confirm these results since lead was still added to octane 96 fuel that was used by the older model cars until recently.

Israel banned the sale of 91-octane leaded gasoline in January, 1, 1997 and announced a complete phase out by 2004. Until 1996, Israel market share of unleaded gasoline was 30%, but in December 2003, the Israeli infrastructure ministry issued a legislative order adopting a new standard for 96-octane fuel with a potassium based additive as a replacement for lead, effectively ending the distribution of lead gasoline in Israel by 2004 (IUED 2004). The consequence of gradual phase out of leaded gasoline was a reduction of ambient lead in the atmosphere. A study indicated that air lead levels ranged between 0.2 to 1 $\mu g/m^3$ over the entire trip during peak traffic loads along the main Jerusalem Tel-Aviv highway. These levels were below the 24 hour standards (5 $\mu g/m^3$) and even the monthly standards (1.5 $\mu g/m^3$), thus lead is not considered an important air quality indicator and no continuous monitoring is at present being performed in Israel (Feitelson 2004). Even studies performed between years 1980-1984, when leaded gasoline was in use, showed that environmental Pb concentrations in soil, plants, water and air in Israel are generally low. Lead content of crops was low with highest Pb content of 0.7 μg/g found in unwashed lettuce close to very busy road which was below, the legal limit for Pb in food stuffs (1 μg/g). Lead content of wells, ground water and domestic water is generally low, <10 μg/L, below the maximum allowable amount (50 μg/L) (Regs 1992). From what we previously mentioned, in Palestine, we are totally dependent on Israeli companies for fuel supply. Since leaded gasoline is no longer used in Israel, it is thus not used in Palestine and it is not uncommon to obtain these results.

**BLL of all groups in relation to age and sex**. ANOVA test showed a significant difference between means of the three control groups ($p<0.05$). The alternative Pair-wise comparisons via turkey HSD and paired t-test showed that the difference ($p<0.05$) was between the mean of the female group (2.99 μg/dL) and the smoker males (4.09 μg/dL). Elevated BLL levels in male smokers compared to females could be attributed to smoking habits, since there is evidence that cigarette smoke contains lead and other heavy metals such as cadmium and mercury, which have been shown to have synergistic toxic effects in experimental animals (Fahim & Khare 1980). All females in our study were non-smokers; in addition, they were less exposed to lead from other sources compared to males. According to the questionnaire, all those living near high traffic areas and practice habits that may involve lead were smoking-males. Logistic regression analysis for potential risk factors that may increase blood lead levels (Table 1) show that odd ratios for male smokers living near industrial area and practice hobbies involving lead are 0.5, 1.25 respectively compared to females (OR 0). The odds of an event is the probability of the outcome event occurring divided by the probability of the event not occurring, so male smokers who live near industrial area or practice tasks involving lead had a 0.5 and 1.25 greater odds of having elevated blood lead level than females. Other possible explanations could be that these females were not recently and frequently exposed compared to the male smoker group, as avoiding and removal from exposure to lead, decreases the BLL. Another important genetic determinant of the accumulation of lead in blood is human Amino Levulinic Acid Dehydrase (ALAD) polymorphism. Several white populations express the alleles ALAD1 and ALAD2 with gene frequencies of 0.9 and 0.1 respectively. Results showed that BLL was higher in individuals with ALAD2 allele than

ALAD1. It was hypothesized that ALAD2 subunits bind lead more tightly than ALAD1 subunits, thus affecting the overall pharmacokinetics of lead and BLL. In the male smoker group and female group, genetic polymorphism of ALAD alleles could have attributed to these differences in BLL (Astrin et al 1987).

All groups showed no correlation with age except female group and workers in auto-repair garages where $p<0.05$ was considered statistically significant (Table 2, Figure 3, Table 5, Figure 4).

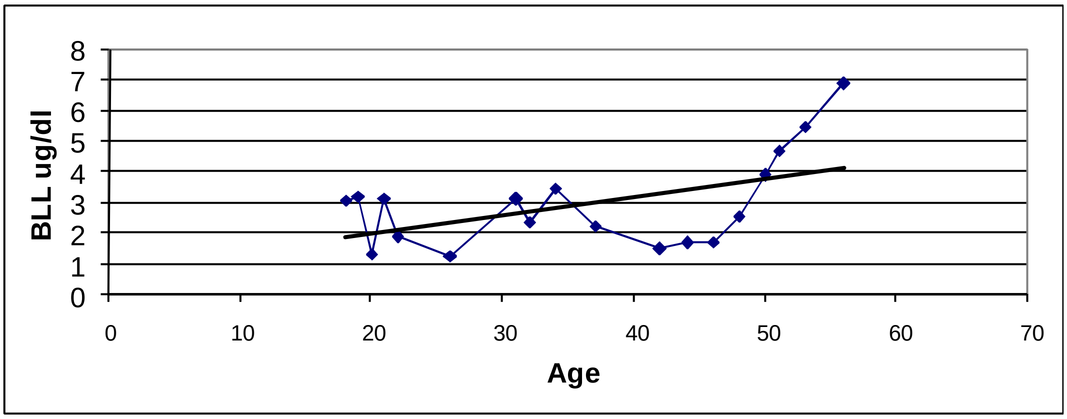


Figure 3. Relation between ages and BLL among females.

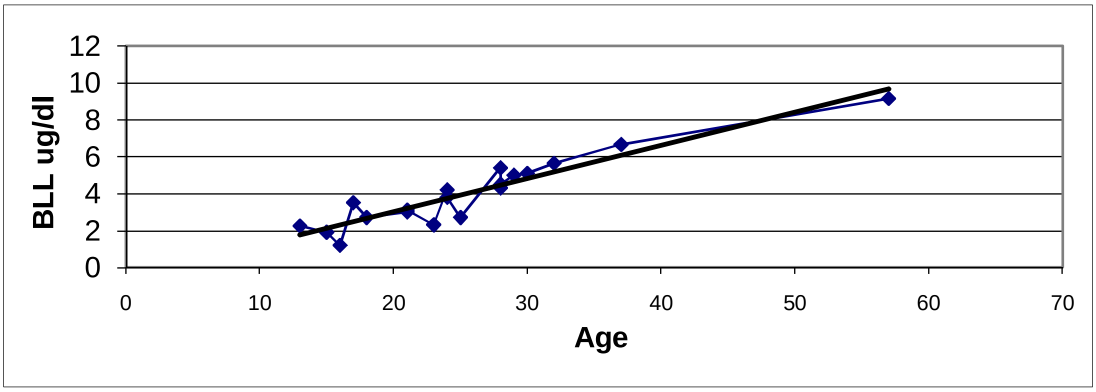


Figure 4. Relation between ages and BLL among garage workers.

Concerning females, increasing BLL with older ages compared to youngers, could be attributed to several factors that make women more susceptible to the toxic effect of lead than men with age (Figure 3). Women tend to show an increased rate of bone lead loss with age relative to men (Drasch et al 1987). In a study done on 2,981 women, a significant increase in BLL was observed after menopause (Silbergeld et al 1988). Furthermore, the rate of lead absorption depends on nutritional status and age of the exposed person. Women with low dietary ingestion of zinc, iron, and calcium especially those with osteoporosis absorb more lead, in addition to the decreased function of the detoxification and excretory processes mainly hepatic and renal with age (Lindeman et al 1985). Another two factors that affects BLL are the genetic-make up and history of chemical exposure. Information about past exposure history for these females is insufficient, thus high chronic past exposure, through living in crowded high traffic area, may have increased total lead body burden accumulating in bone for years t1/2 (25 y), especially when leaded gasoline was still in use. This may have been manifested by increased BLL at older ages when bone demineralization occurs. Genetic-make up related to ALAD polymorphism as previously discussed also influence lead concentrations in blood. Correlation with age in garage workers confirms that cessation from exposure source with time, will decrease BLL as mentioned previously (Figure 4).

It is worth to mention that although BLL reflect the amount of lead currently found in blood and soft tissues, alone is not a reliable indicator of chronic past or current exposure, or total body burden. Lead in blood reflects contributions from current external exposures, as well as from the slow release of lead accumulated in bones over a period, of years, so BLL often under-represent the total body burden, as most of lead is stored in the bone and found at a normal level in blood, unless person is under stressful conditions. Thus when interpreting a person's BLL, we should keep in mind, three key questions, whether the exposure is acute or chronic, recent or remote, and high or low.

**Conclusion**. Mean blood lead levels of all groups were below the action level according to CDC and OSHA (<10 µg/dL). No statistical significant differences were found between workers group and control groups. In the control groups a paired t-test showed statistical significant difference ($p<0.05$) between females and smoker males group, which could be contributed to smoking habit, frequency of exposure and genetic make-up.

No correlation with age for all groups except the female group and auto-repair workers, that showed significant correlation ($p<0.05$) with both age and years of work, which also could be due differences in genetic make-up, chemical exposure history, and age related decreased function of the detoxification and excretory processes. Since mean BLL (3.66 µg/dL) of control groups was comparable to economically advantaged countries like USA (1.6 µg/dL) and those with low mean of (1.96 µg/dL) like Jordan, lead is not considered a major environmental pollutant in Palestine and only screening workers in tasks involving lead is recommended. Finally since air, soil, water, and food are major sources of exposure to the public, they should be screened for Pb content in Palestine, to confirm our results.

**Acknowledgements**. We would like to thank the Deutsche Forschungsgemeinschaft (DFG; German Research Foundation) for buying to Al Quds University an ICP-MS machine. Without this machine this study was impossible.

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Received: 11 September 2012. Accepted: 06 October 2012. Published online: 08 November 2012.
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How to cite this article:
Al-Qutob M., Nashashibi T., 2012 Preliminary indications of blood lead concentrations, among occupationally exposed and non exposed Palestinians. AES Bioflux 4(3):134-145.