ENNS: The French Nutrition & Health Survey
Exposure of the French population to lead - First results
Grégoire FALQ1, Abdelkrim ZEGHNOUN1, Mathilde PASCAL1, Michel VERNAY2, Robert GARNIER3, Didier OLCION4, Katia CASTETBON2, Nadine FRÉRY1

1. French institute for public health surveillance, Environmental Health Department.
2. French institute for public health surveillance, Nutritional Surveillance & Epidemiology Unit (USEN).
3. Poisons centre, Fernand-Widal Hospital, Paris.
4. Laboratory Pasteur-Cerba, Cergy-Pontoise.

Introduction
The French Nutrition & Health Survey (ENNS) was carried out by the French institute for public health surveillance (InVS) in 2006-2007. ENNS was launched in the framework of the National Program on Nutrition & Health implemented in France in 2001. The main objectives of ENNS were to describe food consumption, nutritional status, and physical activity in the general population living in France (adults and children) and to study nutritional and environmental biomarkers.

Few biomonitoring data are available at the national level for pollutants, except lead and dioxins. Thus, ENNS was also designed to estimate levels of heavy metals (lead, cadmium, mercury, arsenic…) and pesticides (organophosphates, organochlorines and pyrethroids) in blood, urine and hair. First results regarding blood lead are presented. The distribution in the population is described and reference values are determined.

Material and Methods
Population and data collection
ENNS is a cross-sectional study carried out in general population included during one year. Participants were sampled using a three-stage probability design (group of towns, dwelling, subject) stratified by geographical areas (8 regions) and degree of urbanization (rural; < 20 000 inh.; 20 000-100 000 inh.; > 100 000 inh.).

Adults were 18-to-74 years old, lived in an ordinary dwelling at least five days per week, were able to understand the stakes of the study, didn’t suffer from a pathology requiring an artificial feeding and gave their consent for participation. Individual characteristics (age, sex, BMI, socio-economic level…), eating habits and environmental exposure (building date of the house, type of drinking water consumption, eating habits, occupational exposure, leisure activities exposed to lead…) were collected through interview and self-questionnaires.

Clinical and biological data
Anthropometric measurements (weight, height, waist and hip circumferences) and biological samples (blood, urine, hair) were collected using standardized procedures at a health center or at home by a nurse. After collection, samples were centrifuged and aliquoted within a maximum of 8 hours and stored at -20°C. Blood lead analyses were carried out in a central laboratory. Acceptable levels of detection, reproducibility, repeatability and uncertainty were defined by InVS.

Statistical analysis
All results were adjusted for survey sampling weights. The CALMAR (CALibration on MARgins) software was used to perform calibration adjustment using a truncated logit method. The French census population was used for the calibration. Calibration variables were sex, age (18-39, 40-59, 60-74 years) and educational level (no certificate, secondary high school, high-school diploma - two-year university degree, bachelor degree or more). The finite population correction (FPC), which can be used in case of sampling without replacement and sampling rate ≥ 0.15, was taken into consideration for the first-stage sampling units. Descriptive statistical analyse (median, percentiles, geometric mean) are presented unadjusted on variation factors (subject characteristics and environmental factors). Reference values are derived in analogy to the IUPAC guideline (around upper bound of the 95% CI of the 95th percentile) [1]. An estimate of the 95th population percentile with its 95% confidence interval was computed and used for reference value proposal. SAS and R software were used for statistical analyse.
Results

Description of the population

2,029 individual blood levels were available for the statistical analysis. Among them, 80 participants had occupational exposure and were removed. The final study sample included 1949 non-occupationally exposed participants. Women and men represented each around half of the study population. The weighted mean age was 45 years. 56% of the population was smoker or past-smoker, 44% had never smoked. 23% of the population was living in houses built before 1948, when lead-based paint was still legally used inside. 24% of the participants took part in renovation works with dust emission in houses built before 1948.

Distribution of blood lead levels

Blood lead levels were consistent with a log normal distribution (Figure 1). Sixty five values (3.3%) were under the limit of quantification and thirty seven values (1.8%) were above 100 µg/L.

Table 1 describes the distribution of the blood lead levels in the French population. Estimates in subpopulations are also presented for sex, smoking status, residence in old dwelling, practice of leisure activities supposed to exposure to lead (i.e. renovation of an old dwelling containing lead paint or/and lead pipe). The median is 26 µg/L and the 95th percentile is 73 µg/L (95% CI [68 - 77]). The 95th percentile is higher for men (85 µg/L, 95% CI [75 - 93]) than for women (58 µg/L, 95% CI [54 - 60]); it is also true for the geometric mean (30.0 µg/L IC95% [28.7 - 31.3] for men against 22.1 µg/L; IC95% [21.2 - 23.0] for women).

Reference values

Based on the preliminary results of this study, it is possible to propose a reference value equal to 75 µg/L for the French population. For men, the reference value is higher than for women (95 µg/L against 60 µg/L). We observed that the higher level in men is partly due physiological characteristic and higher exposition to risk factor such as practice of leisure activities. This observation deserves further studies. The distribution of lead for the French population (Median, GM, P25, P75, P95) were the same whether or nor people with occupational exposure were included. When people with occupational exposure were included.

Comparison with other countries

Distribution of blood lead levels from the population of Germany (18-69 yrs) [2], the Czech Republic (18-58 yrs) [3], and the United States (≥ 20 yrs) [4] are compared to the French levels: the median in France (25 µg/L) is lower than in Germany (31 µg/L) and the Czech Republic (33 µg/L). The 95th percentiles are quite similar in France, Germany and the Czech Republic (respectively 73 µg/L, 71 µg/L and 72 µg/L). Parameters of the distribution from the United States are systematically lower.

Conclusion

Method of the French Nutrition & Health Survey part “Exposure of the French population to lead” and first results have been presented.

The distribution of blood lead levels in France is quite similar to those observed in other European countries. Proposed blood lead reference values for French population are 75 µg/L, 95 µg/L for men and 60 µg/L for women. According to our results, the higher levels observed in men are probably mainly due to practice of leisure activities (i.e. renovation of an old dwelling containing lead paint or/and lead pipe).

Future works will include the determination and the quantification of variation factors explaining average and high blood lead level. Results (geometrics mean) adjusted on these variation factors will be presented and actual level in France will be compared to those of 1996 [5].

Reference


Figure 1 Distribution of blood lead level in the French population

Table 1 Description of blood lead levels and proposed reference value

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>P10</th>
<th>P50</th>
<th>GM</th>
<th>P90</th>
<th>P95</th>
<th>CI P95</th>
<th>Reference value</th>
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<tbody>
<tr>
<td>total</td>
<td>1949</td>
<td>12</td>
<td>25</td>
<td>26</td>
<td>58</td>
<td>73</td>
<td>68 - 77</td>
<td>75</td>
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<tr>
<td>Women</td>
<td>1245</td>
<td>10</td>
<td>23</td>
<td>22</td>
<td>48</td>
<td>58</td>
<td>54 - 60</td>
<td>60</td>
</tr>
<tr>
<td>Men</td>
<td>704</td>
<td>12</td>
<td>29</td>
<td>30</td>
<td>66</td>
<td>85</td>
<td>75 - 93</td>
<td>95</td>
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<tr>
<td>18-39 years old</td>
<td>579</td>
<td>10</td>
<td>19</td>
<td>19</td>
<td>38</td>
<td>48</td>
<td>44 - 62</td>
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<tr>
<td>40-59 years old</td>
<td>947</td>
<td>15</td>
<td>29</td>
<td>29</td>
<td>58</td>
<td>73</td>
<td>66 - 85</td>
<td></td>
</tr>
<tr>
<td>60-74 years old</td>
<td>423</td>
<td>21</td>
<td>39</td>
<td>39</td>
<td>77</td>
<td>99</td>
<td>86 - 115</td>
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<tr>
<td>Smokers</td>
<td>497</td>
<td>12</td>
<td>25</td>
<td>26</td>
<td>60</td>
<td>75</td>
<td>68 - 88</td>
<td></td>
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<tr>
<td>Past smokers</td>
<td>545</td>
<td>15</td>
<td>29</td>
<td>29</td>
<td>63</td>
<td>81</td>
<td>73 - 92</td>
<td></td>
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<tr>
<td>Non smokers</td>
<td>907</td>
<td>10</td>
<td>25</td>
<td>24</td>
<td>50</td>
<td>62</td>
<td>59 - 67</td>
<td></td>
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<tr>
<td>No leisure activities</td>
<td>1249</td>
<td>10</td>
<td>23</td>
<td>24</td>
<td>52</td>
<td>60</td>
<td>58 - 88</td>
<td></td>
</tr>
<tr>
<td>Renovation of an old dwelling</td>
<td>125</td>
<td>14</td>
<td>29</td>
<td>30</td>
<td>65</td>
<td>73</td>
<td>66 - 141</td>
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<tr>
<td>Renovation of an old dwelling and another leisure activity</td>
<td>322</td>
<td>12</td>
<td>29</td>
<td>31</td>
<td>62</td>
<td>84</td>
<td>75 - 105</td>
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<td>Leisure activities (not renovation)</td>
<td>253</td>
<td>12</td>
<td>28</td>
<td>28</td>
<td>73</td>
<td>83</td>
<td>75 - 123</td>
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<tr>
<td>Leaving house build before 1948</td>
<td>490</td>
<td>12</td>
<td>29</td>
<td>31</td>
<td>62</td>
<td>91</td>
<td>81 - 107</td>
<td></td>
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<tr>
<td>Leaving house build after 1948</td>
<td>1347</td>
<td>12</td>
<td>25</td>
<td>25</td>
<td>54</td>
<td>70</td>
<td>66 - 75</td>
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