Evidence of undue lead exposure in Cape Town before the advent of leaded petrol

S. R. Grobler, F. S. Theunissen, L. S. Maresky

Lead concentrations were determined in the exhumed teeth of 28 people who lived in the Cape Town area before the combustion of leaded petrol (i.e. before 1922). The lead content of circumpulpal dentine was analysed by graphite-furnace atomic absorption spectrometry. The mean lead level in the dentine of primary teeth (N = 6) was 109 µg/g, while that in secondary teeth (N = 22) was 315 µg/g. The current lead levels in circumpulpal dentine of Cape Town residents are reported to be 74 µg/g and 16 µg/g for primary and secondary teeth respectively. It was found that lead pollution of the human body during the period 1812-1922 in the Cape Town area was substantially higher than at present. We conclude that the main reasons for this were the widespread use of lead piping and soldering of water tanks, which resulted in a higher incidence of lead poisoning than that attributable to leaded petrol.


Materials and methods

The teeth of 28 people, buried between 1863 and 1922 and exhumed recently, were analysed. The circumpulpal dentine was separated mechanically from the rest of each tooth with the help of a diamond disc cutter. The collected pieces of dentine of each tooth were etched with 1.0M hydrochloric acid to remove contamination; washed with lead-free water, dried, weighed and ashed in nitric acid as described by Keating et al. The lead in the final solution, which contained 5% nitric acid, was determined by means of graphite-furnace atomic absorption spectrometry, basically according to the method of Keating et al.

Results

The average age of the subjects was 43.6 years (SD = 29.3; median = 53.5; range 0.5 - 89 years). Table I shows the circumpulpal lead concentration (µg/g) in the exhumed teeth. The influence of age at the date of death on the lead levels is summarised in Table II. In general the lead concentration...
increased significantly with the age of the donor ($P < 0.05$). The regression line for $y = ax^2$ was 0.73. Fig. 1 summarises the results of various workers and compares them with the result of this study.

Table I. Lead values in the circumpulpal dentine of teeth

<table>
<thead>
<tr>
<th>Age range (yrs)</th>
<th>Lead levels (µg/g dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 - 10</td>
<td>106 (42)</td>
</tr>
<tr>
<td>11 - 20</td>
<td>262 (209)</td>
</tr>
<tr>
<td>21 - 30</td>
<td>219</td>
</tr>
<tr>
<td>31 - 40</td>
<td>173 (89)</td>
</tr>
<tr>
<td>41 - 50</td>
<td>254 (95)</td>
</tr>
<tr>
<td>51 - 60</td>
<td>376 (113)</td>
</tr>
<tr>
<td>61 - 70</td>
<td>354 (108)</td>
</tr>
<tr>
<td>71 - 80</td>
<td>482 (190)</td>
</tr>
<tr>
<td>81 - 90</td>
<td>606 (167)</td>
</tr>
</tbody>
</table>

Table II. Lead accumulation in circumpulpal dentine of excavated teeth in correlation with age at the date of death

<table>
<thead>
<tr>
<th>Age range (yrs)</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 - 10</td>
<td>303.7 µg/g</td>
<td>65 - 122</td>
<td>5</td>
</tr>
<tr>
<td>11 - 20</td>
<td>177.7 µg/g</td>
<td>124 - 503</td>
<td>2</td>
</tr>
<tr>
<td>21 - 30</td>
<td>219</td>
<td>110 - 237</td>
<td>2</td>
</tr>
<tr>
<td>31 - 40</td>
<td>173 (89)</td>
<td>116 - 310</td>
<td>3</td>
</tr>
<tr>
<td>41 - 50</td>
<td>254 (95)</td>
<td>217 - 583</td>
<td>6</td>
</tr>
<tr>
<td>51 - 60</td>
<td>376 (113)</td>
<td>200 - 454</td>
<td>4</td>
</tr>
<tr>
<td>61 - 70</td>
<td>354 (108)</td>
<td>259 - 697</td>
<td>4</td>
</tr>
<tr>
<td>71 - 80</td>
<td>482 (190)</td>
<td>528 - 764</td>
<td>1</td>
</tr>
</tbody>
</table>

Discussion

No difference in the lead content was reported in various studies of deciduous teeth. Bercovitz and Laufer also reported no significant difference in the lead level of different tooth types. However, Rabinowitz et al. reported that differences in lead levels among tooth types are unlikely to reflect physiological factors such as blood supply to teeth or mineralisation rates. These differences are much more likely to depend on age-related, and consequently tooth-related, differences in exposure patterns. Thus, the general level of lead uptake could vary considerably during the various stages of tooth formation and at different time periods. In this study it was not possible to select the type of tooth from the excavated remains because of a lack of availability, while from the above results this also did not seem to be necessary.

Table Mountain served as the main catchment area for the water supply of Cape Town and surrounding areas for many years. Because of the presence of organic material, the water has a high acid content and is also soft (T. W. Timoney, Water Engineers Division, Cape Town City Council (retired) - personal communication). Therefore, a higher than normal dissolution of lead from the lead piping could have been expected. During 1812, the first reticulation system, linking the reservoirs on Table Mountain with Cape Town households was installed; the main pipes were constructed of cast iron while lead pipes linked each household to these. Many homes were equipped with wooden storage tanks, which were lead-lined and had lead-soldered joints in order to render them watertight. Such domestic water supply systems remained in use for over a century, until the Cape Town municipality appointed a special committee to investigate the problem of plumbo solveny in 1931.
In 1914 a report by the medical advisor, Dr J. Anderson, showed that domestic water supplies in Cape Town contained lead in concentrations ranging from 0.05 to 0.4 ppm. Furthermore, raw bulk supplies, allowed to stand overnight in new lead pipes, reached levels of 2.3 ppm. In 1917, samples of domestic water from Cape Town households tested by the State Health Laboratories showed levels ranging between 0.5 and 7.63 ppm. In 1926 three cases of lead-poisoning were reported. In Rosebank, a suburb of Cape Town, lead levels of 5.75 ppm were found. In New Church Street in the city, the level was found to be 0.5 ppm and in nearby Hope Street a level of 4 ppm was recorded. In all three cases, lead poisoning was found. In December 1928, a shop in Sir Lowry Road, equipped for soda water production, showed lead levels of 25.2 ppm. The soda water was prepared in copper tanks with lead-soldered joints. From there it was distributed to other outlets in the city.

Strong representations by Dr J. A. Mitchell (Assistant Medical Officer, Department of Home Affairs and later Secretary of the Department of Health) led to the Cape Town municipality's instituting a thorough investigation in early 1931 by a special committee (Cape Town Archives, 3/CT/34/10). In 1932, a decision was made to establish the first full-scale water treatment works at Constantia. This chemical treatment resulted in a 90% reduction in the leaching of lead into domestic water supplies. By 1938 several other treatment plants had been constructed and all 'Table Mountain's water was treated before it entered the domestic supplies of Cape Town (T. W. Timoney — personal communication). From about that time, lead pipes were gradually replaced by copper in all plumbing systems. However, many old houses in the Cape Town area had lead pipes for much longer, as was found in the District Six area during the 1970s.

In general we found an increase in tooth lead content with age (Table II). This has been reported by various authors.15,17 It must be remembered that lead was analysed in circumpalatal dentine, which is laid down continuously throughout life. A higher correlation between age and lead levels was therefore to be expected. The above reasons could also explain the high standard deviation (Table I). Furthermore, during the collection of circumpalatal dentine, the amount of other dentine which could not be physically separated would vary. Therefore, the lead levels in the circumpalatal dentine could be masked to a greater or lesser extent in different cases.

In this study we analysed the lead levels in the teeth of 6 children under the age of 15 years. The mean lead level was 109 mg/µg. This is markedly higher than the 74 mg/µg reported for children living in an industrialised urban area in Cape Town28 before the reduction of lead in petroleum (Fig. 1). The 74 mg/µg level was attributed mainly to the degree of industrialisation and the petrol lead level of 0.8 g/l at that stage. The average lead level in the teeth of the adults over 15 years is 135 mg/µg (N = 22). This is much higher than the 126 mg/µg reported22 in a person who had been employed continuously as a motor technician in South Africa for 32 years, and who had exhibited signs and symptoms typically manifested by people suffering from lead intoxication. However, an average level of 850 mg/µg in the circumpalatal dentine of unequivocally lead-poisoned persons from Philadelphia and Boston in the USA was reported.22 The lead level in this study (Table I) contrasts strongly with the low level of 2.5 µg/g reported for children in ancient Nubia where there was minimal lead inhalation or ingestion in dentine decreased with age up to an age of about 33 years, after which it stabilised. The Nubian children22 also showed a decrease in lead retention with increased age. There are many factors which may influence the lead levels of circumpalatal dentine, such as the period of exposure, the exposure level, the type of lead exposure and the diet during exposure.

In conclusion this study clearly demonstrates that lead pollution of the human body in the Cape Town area was unacceptably high before the era of the combustion of leaded petroleum. The main cause was the pollution of drinking water by lead plumbing and solder of water tanks.

Finally, the tooth lead levels associated with the combustion of petrol (0.5 to 0.8 g/l) in 1983,1 were substantially lower than those attributable to the lead pollutants in early Cape Town's drinking water supplies.

REFERENCES


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