

# Lead Contact and Poisoning in Barbados Slaves: Historical, Chemical, and Biological Evidence

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LEAD CONTACT AND lead poisoning have received scant attention in discussions of early West Indian societies but are potentially

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important issues in considering the health and medical problems of blacks. Although our discussion focuses on Barbados, the West Indian historical literature strongly suggests that our general findings are applicable to other Caribbean areas and have implications for understanding some of the disabilities of early white populations as well. **In** this paper we also seek to illustrate how bioanthropological and chemical analyses of slave skeletal remains and historical data can complement one another in defining and investigating various dimensions of slave life.

Modern studies treating medical issues in West Indian slave societies have barely discussed lead poisoning in general or its relation to slave morbidity in particular. Although some works state or imply that slaves were affected by lead poisoning, this is usually mentioned only briefly while other studies of British Caribbean slavery do not report lead poisoning at all when discussing slave diseases and health problems (Bridenbaugh and Bridenbaugh, 1972: 193-194; Craton, 1978: 125; Dunn, 1972: 217, 306; Kiple, 1984: 100; Sheridan, 1985: 200).

Various symptoms caused by lead absorption which would be diagnosed specifically today were unrecognized by early West Indian physicians and were undoubtedly hidden in their discussions of other slave diseases. It is clear, however, that a form of lead poisoning, the so-called "dry bellyache," which involved extremely painful intestinal cramps, was widespread in the West Indies during the seventeenth century and for much of the eighteenth. Called "dry" because the cramps were not accompanied by diarrhea but rather by severe constipation, the disease affected whites as well as blacks. It was also common in the British mainland colonies (e.g., Grainger, 1764: 32; Hillary, 1766: 182; Moseley, 1787: 525-540; Salmon, 1693: 854; Aronson, 1983: 38; Guinee, 1972: 283; Eisinger, 1982: 282; Wedeen, 1984: 43).'

Most early West Indian general medical works that mention or discuss the dry bellyache almost universally imply—and sometimes explicitly state—that they are referring only to whites (e.g., Hillary, 1766: 182-200; Hunter, 1785; Quier, 1773; Towne, 1726: 87-98; Trapham, 1679: 129-130; Tryon, 1684: 58-60; Warren, 1740: 32-33; Williamson, 1817: I: 243-245; 2: 20; Wright, 1828: 232). Although slaves are very rarely mentioned, some sources, especially those specifically concerned with slave medical issues, indicate that they were also victims (Cadwalader, 1745: 45; Clark,

1797: 118; Collins, 1811: 232; Dancer, 1801: 103; Grainger, 1764: 34; Hillary, 1766: 182; Moseley, 1787: 525-540; Sloane, 1707: I: cxix, cxx; Thomson, 1820: 42).

For Barbados specifically, all references to dry bellyache are to whites; blacks are not mentioned. However, inferential historical evidence indicates that blacks also suffered from the disease and were thus subject to lead contamination (see below). The nature and degree of such contamination is not ascertainable from this evidence; it only suggests that lead poisoning existed. This qualitative picture is independently supported and quantified by bioanthropological data which provide a more concrete perspective on lead contact and lead intoxication; they also serve as objective checks on the historical sources.

#### PHYSICAL EVIDENCE AND SKELETAL LEAD CONTENT ANALYSIS

Bioanthropological data derive from an analysis of Barbados slave physical remains, part of a skeleton group archaeologically excavated from a slave cemetery at Newton plantation during the early 1970s. During the slave era, Newton typified medium to large-scale Barbados sugar plantations. Although only partially excavated, the cemetery yielded the remains of 104 individuals interred from about 1660 to 1820. As of this writing, the Newton collection constitutes the largest and earliest excavated group of African and African-descended slave remains yet reported from the Caribbean or mainland North America (Handler and Lange, 1978, 1979).

Over the past several years, analyses of the Newton skeletons, particularly the teeth, have yielded information on demographic, pathological, and sociocultural topics. The physical data, when combined with historical information, have enhanced our understanding of the lifeways of Barbados slaves and of the material conditions of their lives; they have also demonstrated the contributions and potential value of physical anthropology and archaeology in dealing with sparsely documented issues relating to Caribbean slave life (see Corruccini and Handler, 1980; Corruccini et al., 1982, 1985, n.d. a, n.d. b; Handler et al., 1982; Handler and Corruccini, 1983, 1986). These earlier analyses of the Newton remains are now extended to issues surrounding lead intoxication.

Lead products in historical and modern societies have exposed

humans to lead quantities that exceed the body's ability to excrete this lead, thus resulting in body lead accumulation. The blood rapidly distributes the absorbed lead and selectively stores it in certain tissues and organs; about 10% of it is ultimately deposited in soft tissues (e. g., brain, liver), many of which are vulnerable to lead's toxic effects. If there is relatively limited exposure to lead and its absorption is not great, the lead is usually eliminated by the kidneys, leaving very little of it in such tissues as bone. On the other hand, with continued absorption the excretion threshold is exceeded, and lead circulating in the blood will then damage vulnerable tissues as well as continue to accumulate in bone. The lead deposited in bone tends to be biologically inert (though slow release with urinary excretion of this lead over a long period of time may damage the kidneys) but may provide some notion of the individual's cumulative lead absorption in the years preceding death.

A trace mineral analysis method, using atomic absorption spectroscopy and developed to measure skeletal lead content, had been successfully applied to several black and white North American colonial populations before its application to the Barbados sample (Aufderheide et al., 1981, 1985; for a technical description of this method see Wittmers et al., 1981).

The analyses of Newton's slaves, based on the skeletal tissue of 48 individuals (from whom a total of 52 samples were removed), yielded a mean bone lead content of close to 118 ppm (parts per million, or micrograms of lead per gram of bone ash). This lead concentration is three to four times that of mainland colonial slave samples and is comparable to mainland colonial whites with known lead exposure (Aufderheide et al., 1981, 1985). This concentration range is also comparable to bone specimens derived from putatively lead-poisoned Romans (Mackie et al., 1975; Waldron et al., 1976). No other New World bone specimen sample demonstrates such a wide range of lead concentration values, from zero to more than 400 ppm. The 95% confidence limits of this mean lead content are from 90.5 to 144.7 ppm. Eighty-one percent of the 21 individuals who died after an estimated age of 30 (when appreciable lead could have accumulated from constant exposure sources) have lead content above 100 ppm.'

In order to evaluate possible relationships between bone lead content and physical or cultural traits, several statistical tests were

conducted. Females showed a higher lead value than males, but this statistical difference may be due to sampling variation and error in sex assignment to poorly preserved skeletons. However, the *variation* in lead content in females is higher than in males. This may reflect greater variation in occupational exposure to environmental lead, as might have occurred among domestic servants as contrasted to fieldworking female slaves. For the Clifts plantation in Virginia, for example, investigators assumed that some female slaves were household servants in order to explain their higher lead values (Aufderheide et al., 1981). Correlation is significant between age at death and lead concentration. The trend is suggested by the increased lead levels by decade of life: age to-19, 58 ppm; age 20-29, 110 ppm; age 30-39, 112 ppm; age 40-49, 136 ppm; age 50-59, 158 ppm. The positive lead content correlations with age support the hypothesis that lead accumulation was a direct consequence of the length of time a slave was resident in Barbados.

#### *Clinical Implications of Skeletal Lead Content*

Information about the quantity of lead in body tissue relative to clinical symptoms of lead poisoning in living populations depends on the literature of modern toxicologic experience (Mahaffey, 1977). Although the amount of lead to which an organ is exposed determines the degree of the organ's impairment and the intensity of the resulting symptoms, in living persons it is not feasible to biopsy bone, brain, or other vital organs to measure their lead content. Thus, except for the occasional use of lead concentration in deciduous teeth and the recent practice of measuring urinary lead excretion after administering a chelating agent (a chemical compound that binds with certain metals causing them to be excreted in the urine), the clinical literature of lead poisoning relates symptoms to the lead level in blood—a much more accessible material.

Until recently measuring both the blood and the bone lead content for the same individual has been difficult because of problems in obtaining a bone sample for chemical analysis in a living person. This difficulty has been overcome by an x-ray fluorescent method which measures bone lead in live individuals whose blood lead level was measured simultaneously. Since modern medical

Table I Frequencies arranged in five groups based on calculated blood lead values for Newton slave skeletons\*

Calculated mean blood lead**	Expected severity of symptoms	Slaves	
		Number	Percent
0-39	None	17	35
4 <sup>0</sup> -79	Mild	18	38
80-119	Moderate	6	13
120-199	Severe	4	8
Over 200	Very severe	3	6

\* Average values were used for twice-sampled specimens.

\*\* Micrograms of lead per deciliter of blood.

experience demonstrates a rough but useful correlation between blood lead concentration and at least certain lead poisoning symptoms (Hernberg, 1980), it becomes possible to predict symptoms of lead toxicity that would have been expected in Newton's living slave population. The x-ray fluorescent method provides a small but useful body of relevant data (Ahlgren et al., 1980; Christofferson et al., 1984; Eastwell et al., 1983; Scott, 1985).

Through regression analysis of such data, using the individual's age (ascertained from the skeletal remains) as the years of lead exposure, the mean blood lead level for each Newton slave was estimated from the measured bone lead concentration. These derived values were then arranged into five groups of blood lead concentration ranges; such groupings have been found clinically useful in establishing the presence or severity of some of the symptoms or signs of lead toxicity (Hernberg, 1980).

Nearly three-fourths of Newton's slaves appear to fall in a range wherein no or only mild symptoms of lead toxicity might have emerged, resulting in little, if any, impairment of their daily activities (Table ). However, a significant fraction of those falling in the "moderate" and "severe" groups would be expected to have suffered from dry bellyache at some time; those in the higher ranges of these groups were probably affected severely and frequently enough to have their work and social activities significantly impaired, possibly with some peripheral nerve defects. At least some in the "very severe" group may well have died of brain toxicity with convulsions and terminal coma.

Lead alters many of the body's chemical systems and ultimately

can impair most organs. Modern medicine recognizes a variety of clinical symptoms and signs of lead poisoning. For purposes of this paper, however, we are particularly interested in those symptoms or signs which are sufficiently overt that they could have been observed in earlier periods and recorded in historical sources. The principal symptoms result from lead's effects on the intestinal tract, peripheral nerves, and brain (see Table 2 for a summary).

*Intestinal tract:* Mild lead poisoning produces appetite loss, nausea, and vomiting, but as lead levels increase the intestine is paralyzed (producing constipation) and then stimulated into painful contractions or abdominal cramps. Higher lead levels may induce spasms of the abdominal wall muscles, generating excruciating pain. Diarrhea is absent from this intestinal disease, hence the historical term "dry bellyache." The presence of intestinal symptoms correlates fairly well with blood lead levels (low calcium diets, probably common among Barbados slaves, enhance lead absorption from the intestinal tract, leading to higher blood and bone lead levels from a given ingested lead dose [Mahaffey et al., 1973; Barltrop and Khoo, 1975; Moore et al., 1978]).

*Nerves:* Lead slows electrical conduction, especially along nerves supplying the muscles that raise wrists and feet. This results in a weak grip in mildly impaired persons. Severely toxic conditions may cause incapacitating paralysis ("palsy") of such muscles, producing a complete inability to lift the wrist or even the foot. Varying degrees of sensory loss may accompany the paralysis, similar to the sensation of one's foot "falling asleep." Close correlation of nerve symptoms with blood lead levels is less well documented, although clinical muscle weakness or paralysis is usually evident only at higher values of lead content.

*Brain:* Children are much more susceptible than adults to the effects of lead toxicity on the brain. Even in children, however, considerable variation in these effects occurs at given blood levels, and predictions listed in Table 2 should be viewed as generalizations. Mildly affected adults or children may show mood or behavioral aberrancies or headaches. The most easily recognized symptoms are convulsions; in severe cases, they can become frequent and prolonged, ultimately producing coma and death (lead encephalopathy).

Such symptoms or signs are among the more obvious and observable effects of lead poisoning, ones that often accompany his-

Table 2 General relationship of blood lead level to severity of three signs or symptoms of lead intoxication

Organ	Sign or symptom	Blood lead level: Micrograms per deciliter				
		0-39	40-79	80-119	120 -199	Over 200
Intestinal tract	Colic	None	Appetite loss; nausea	Vomiting; constipation; colic	Frequent severe colic	Colic with muscle spasm
Nerves	Palsy	None	None	Weakness in extensor muscles	Marked weakness or paralysis	Extensor muscle paralysis common
Brain	Convulsion	None	None	Occasional	Common	Life threatening; coma



torical accounts of dry bellyache (see below). But lead has other, albeit more subtle, toxic effects. For example, even relatively low blood lead levels can produce measurably impaired intellect and mental retardation in children, and lead's interference with hemoglobin formation causes anemia with its accompanying weakness, loss of energy, and shortness of breath. High blood pressure has also been related to lead as well as speech loss, deafness, blindness, visions, and insanity. Even after cessation of exposure, lead may be leached from the bone and excreted in the urine for many years, damaging the kidneys and resulting in fatal renal failure (Betts et al., 1973; Harlan et al., 1985; Lauwers et al., 1986; Nee-dleman et al., 1979; Vermande-Van Eck and Meigs, 1960: 223; Zielhuis, 1975).

In laboratory animals, lead exposure has been shown to decrease fertility, increase stillbirths and miscarriages, cause disturbances in the menstrual cycle, reduce average birth weights and the survival rate of newborns, and produce weak and slowly developing offspring (e.g., Harris et al., 1979; Stowe and Goyer, 1971; Vermande-Van Eck and Meigs, 1960; Weller, 1915; Jacquet, 1977). Although Bell and Thomas (1980: 183), after reviewing the literature, conclude that lead's "full impact on human reproduction remains unresolved," Uzych (1985: 9, 16) has more recently observed that a widely accepted industrial view holds that maternal lead exposure in humans "may seriously jeopardize the health of the unborn child." In addition, he writes, a corpus of data "indicates that paternal lead exposure may adversely affect pregnancy outcome" and cause increases in miscarriages, stillbirths, and post-natal mortality; exposure to lead in males may also "cause decreased fertility . . . and be associated with chromosomal changes." In brief, although more data in this area are needed, available information suggests that human male exposure to lead "may be associated with significant reproductive-related harm."

In summary (cf. Table I), the Newton skeletal lead content suggests that the plantation's living slave population had widespread and significant access to one or more lead sources. The evidence indicates they absorbed this lead in quantities great enough to produce some symptoms or signs of lead poisoning at some time during their lives in perhaps as many as one-third of them, severe enough to interfere with their usual activities at least intermittently in a smaller number, and to threaten or terminate

life in a significant minority. Thus, the Newton skeletal lead concentrations are of such an order to expect that the plantation's slaves, as a population, regularly displayed manifestations of clinical lead poisoning ranging from mild to marked severity. This conclusion is independently and generally supported by the historical evidence which suggests the presence of dry bellyache in Barbados' wider slave population.

LEAD POISONING IN BARBADOS:  
HISTORICAL EVIDENCE

"Called ... by the people of Barbadoes the dry Belly-Ach," wrote Dr. Richard Towne (1726: 87) in the 1720s, "the nervous colick . . . is so popular a disease . . . that it may very justly be reckoned as endemic . . . most people there at one time or other having felt its cruelty"; the dry bellyache was the "most frequent and most fatal species" of a general category of diseases labelled "colicks," i.e., spasmodic abdominal pains. The earliest known direct reference to the disease occurs in 1660, when a colonist reported a "weaknes and feebleness in all my lymbes, being the dreggs of a desperate disease which we call the Belly-ake" (quoted in Bridenbaugh and Bridenbaugh, 1972: 193). Thomas Tryon, who had lived in Barbados during the 1660s, also mentions this "most cruel disease" (1684: 58-59) which reached epidemic proportions by 1695, if not much earlier (Russell, 1695; Dunn [1972: 306] describes an incident in which the dry bellyache "even affected Barbados politics in 1684").

The dry bellyache was "so called from its affecting that part of the body with great costiveness [severe constipation] and pain" (Hughes, 1750: 34). With the first noticeable symptoms, Towne (1726: 88-90) reported, "the belly is seized with an intolerable piercing pain," and during the early phases, which might last a week or two, "the patient is on a perpetual rack, with scarce any remission or pause from pain. . . . The belly continues . . . obstinately costive, very little urine is made, the strength is greatly impaired"; and "the breath stinking very offensively," added Hughes (1750: 34). Based on his experiences in Barbados, Towne (1726: 88) concluded "there is not in the whole compass of infirmities which flesh is heir to, any one that afflicts human nature in a more exquisite degree than this unmerciful torture." In short,

the dry bellyache involved "excruciating torture of the bowels" (Collins, 1811: 232) and was considered, according to Dr. James Clark (a late eighteenth-century resident of Dominica), "the most painful of the diseases to which the inhabitants of the West Indies are liable. . . . The torments of those labouring under this disease are beyond conception, and excite the commiseration of all who attend them" (Clark, 1797: 115-116).

Dr. William Hillary (1766: 183-185), a well-known English physician who practiced in Barbados in the late 1740s and 1750s, provides a detailed and vivid description of dry bellyache (which, to some extent, is based on Towne's [1726: 88-90] earlier description):

It generally seizes the patient with an acute pain at the pit of the stomach, which extends itself down with griping pains to the bowels, which are soon after much distended with wind, with frequent reachings to vomit. . . . The belly usually continues most obstinately costive and the patient discharges but little urine, and that often with pain and much difficulty. . . . The extreme parts of the body are often cold, and sometimes the violence of the pain causes cold clammy sweats, and faintings: their mind is generally much affected, and their spirits sunk very low . . . they become weak, and that weakness increases until those extreme parts [of the arms and legs] become paralytic, with a total loss of motion, though a benumbed sensation often remains. The subtle cause of this disease is sometimes carried . . . to the brain, and produces a stupor, or a delirium; and soon after the whole nervous system is so affected as to produce strong convulsions which too often are followed by death.

In one form or another the symptoms described by Hillary are also reported in other contemporary descriptions of the disease in Barbados, and are also commonly reported for other British mainland and Caribbean colonies (e.g., Hughes, 1750: 34; Cadwalader, 1745: 1-2; Clark, 1797: 115-119; Hunter, 1785; Wedeen, 1984: 24, 43. Eisinger [1982: 280] provides an effective modern description of "colica Pictonum," based on historical accounts).

As indicated above, although some West Indian sources mention black victims of dry bellyache, blacks are not mentioned in the Barbados sources. Inferential historical evidence, however,

suggests that slaves suffered from the disease. This evidence derives from the prevalence of dry bellyache reported for the island during the seventeenth and eighteenth centuries and the facts that no medical accounts explicitly exclude blacks and few specifically mention the race of patients. Moreover, the knowledgeable Griffith Hughes (1750: 34), writing of Barbados in the 1730s and 1740s, noted that the principal victims of dry bellyache were rum distillers, sugar boilers, and plantation overseers; at the time, distillers were generally poor whites, but slaves were also distillers and they also constituted the majority of the sugar boilers (Bennett, 1958: 12; Dickson, 1789: 40-41; Drax, 1755: 47-48; Ligon, 1657: 90-91; Oldmixon, 1741; 2: 154).

Inferential historical evidence, then, and solid physical evidence from the Newton skeletons mutually support one another in pointing to lead poisoning as a major pathology among Barbados slaves.

#### *Possible Sources of Lead in the Newton Skeletons*

The possibility of environmental contamination of archaeological bones always needs to be considered in a skeletal mineral study; however, we can establish no likely factors to suggest post-mortem contamination of the Newton skeletons. All evidence indicates that the bone lead was deposited during the lifetimes of the individuals concerned. What, then, is the most likely source (or sources) of lead in Newton's burials?

Although they focus on white populations, modern historical studies of lead contamination and poisoning in the North American colonies and England offer some clues. Lead could have contaminated a fairly long list of material products such as flour, whitened bread, snuff, hair dyes, certain cosmetics, house paints, glass, tea, pepper and various medicaments, including opiates, which Barbados imported. Although some of these items may have occasionally been used by Barbados slaves, none (with the possible exception of medicines administered by plantation doctors) played a significant role in slave life (e.g., Aronson, 1983: 39-40; McCord, 1954b: 80, 1954c: 123; Wedeen, 1984: 50, 60, 61, 174, 175; Towne, 1726: 120; Handler and Lange, 1978: 291).<sup>3</sup>

Another category of goods which may have affected slaves includes various foods and beverages that were contaminated

by pewter and lead-glazed vessels used for storage, preparation, or serving. In eighteenth-century England, for example, lead-contaminated cider that was stored in lead-glazed vessels, and a variety of other liquids, including wine, could also absorb lead when made or stored in lead-glazed earthenware or other lead-containing vessels such as pewter. Cider and wine were regular English exports to Barbados, as were "leaden ware" and pewter. Slaves, however, usually did not consume such beverages although they may have had occasional access to them. In addition, Barbadian whites used pewter, and such pewter items as "dishes," "pans," "spoons," "flasks," "water plates," "measures," and "pots" of various sizes were found in seventeenth- and eighteenth-century middle and upper socioeconomic level households; the 1781 effects of a coppersmith included 1,038 pounds of "new lead" and 1,304 pounds of "old pewter," also suggesting the extent of lead and pewter usage. However, there is no evidence that such items functioned to any degree in slave households or domestic life (Aronson, 1983: 39-40; Guinee, 1972: 284; McCord, 1953b: 573, 576; Waldron, 1969: 75; Wedeen, 1984: 44, 66; Frere, 1768: 120-121; Oldmixon, 1708; 2: 154-162; Ogilby, 1670: 380. Also, household inventories: see, for example, Recopied Deeds Books, RB 3/5: 96, 374, 451; 3/24: 459; 3/37: 104; and Inventories, Boxes 1780-1786, 1787-1793: *passim*, Barbados Department of Archives).

As in the North American mainland colonies, Barbadians also could have had their water supplies contaminated by lead drains and household gutters. Lacking major rivers and with an irregular distribution of surface springs, islanders largely depended on rainwater. Whites sometimes excavated wells to tap underground springs or streams, but they commonly used cisterns, usually built adjacent to the plantation owner's or manager's house, which collected the rain that funneled through roof gutters. These gutters were of lead, and fragments of them can still be found at some old plantation houses today. Although domestic slaves may have had some access to the rainwater stored in cisterns, most plantation slaves were compelled to use open ponds for their water supplies (Aronson, 1983: 39; Handler and Lange, 1978: 299-300).

Historical sources indicate that Barbados slaves used earthenware in their households. Some of this pottery, either locally made or imported, may have been lead glazed, but no archaeological or historical evidence suggests the extent of its usage. Moreover, de-

spite their use of pottery, the slaves' most common household items were made from organic materials such as calabashes and gourds. Thus, although lead-glazed pottery as a possible contaminant of Newton's skeletons cannot be discounted, its role remains problematical (Handler, 1963a, 1963b; Handler and Lange, 1978: 136-142).

Based on presently available evidence, *rum* appears to be the most likely *major* source (though probably not the only one) of lead contamination among Newton's slaves and, by extension, among Barbados slaves in general.

Abundant evidence exists that consumption of lead-contaminated alcoholic beverages in general can result in lead poisoning, and modern historical studies also suggest that lead poisoning resulting from alcohol consumption was quite common in England, North America, and the British West Indies during the eighteenth century. In particular, rum—much of it "grossly contaminated . . . whether . . . distilled in the West Indies or in New England"—was a major contributor to lead poisoning, a common disorder among North American colonials (McCord, 1953a: 393; cf. 1954c; Aronson, 1983; Eisinger, 1982; Waldron, 1969; Wedeen, 1984: 40, 45, 46, 112).

In the 1670s, Dr. Thomas Trapham (1679: 133) observed similarities in the symptoms of cattle exposed to lead fumes in Derbyshire, England, and those appearing in Jamaican victims of dry bellyache. However, he made no explicit connection between the disease and lead poisoning, and the symptoms of dry bellyache were not established as lead poisoning in the medical literature until the 1760s. Although starting at least a century earlier, West Indian writers on the disease recognized some connection between it and rum, not until the late eighteenth century, not many years after the link between dry bellyache and lead poisoning was made, was the role of rum in producing the disease also identified (Aronson, 1983: 39; McCord, 1953a: 393-396, 399; Wedeen, 1984: 34, 40, 42, 45, 47; Hillary, 1766: 182; Towne, 1726: 89-90; Tryon, 1684: 59-60; cf. Sloane, 1707; I: CV, cviii, cxix; Hughes, 1750: 34, 36).

By the late eighteenth century most physicians writing about the West Indies came to accept the linkage between dry bellyache, on the one hand, and rum and lead, on the other. Although some continued to deny that contaminated rum was a major cause of

the disease (Moseley, 1787: 530-531; Dancer, 1801: 103), the number of sceptics gradually decreased, and modern medical history literature agrees that the rum was contaminated by lead used in distillation machinery, particularly the "worms" and "still heads" (e.g., Eisinger, 1982: 282; Guinee, 1972: 284; McCord, 1953a: 393, 394, 395, 399; Wedeen, 1984: 42).

Distillation machinery involves three major components: a *boiler* (or *still body*) for heating the liquid; a *condensor* which cools the vapor and turns it into liquid again; and a *receiver*, a vessel which collects the distilled liquid. The "worm" was the contemporary name for the condensor, a long spiral tubing; the "still head" (or "still neck") was the boiler part that prevented the liquid's accidental boiling over. England's exports to the West Indies in general, it should be stressed, included large quantities of "boylers, stills, and other useful vessels of copper, lead, and pewter," and until the late eighteenth or early nineteenth centuries West Indian plantation distilleries used copper stills, usually outfitted with pewter or lead "worms" and "still heads" (Thomas, 1690: 11; Miller, 1815: 64; Porter, 1830: 94, 204-206; Hunter, 1785: 235-236; Edwards, 1810: 3: 52; Clark, 1797: 124; Moseley, 1787: 530-531).

Early Barbados inventories of plantation distillery equipment frequently mention "stills and worms" and sometimes specify the material of their manufacture. A 1660 inventory, for example, notes "four copper stills and heads ... [and] four pewter worms"; the "worm being leaded," specifies a 1685 inventory. One in 1789 mentions 1,327 pounds of "old pewter worms"; in the same year another includes "5 leaden worm moulds." Distilleries also contained "cisterns for working of liquor" and "receiving cisterns" that could be iron, or lined with, or made of, lead. A 1746 inventory also lists a "leaden water pump" in the distillery, suggesting what may have been a more widespread pattern (Recopied Deeds Books, RB 3/4: 186, 702; 3/5: 198, 614-615, 879; 3/22: 491-492, 505-506; 3/27: 196; 3/37: 104; Inventories, Boxes 1780-1786, 1787-1793: Hackett, Taylor, Byrrowes; Barbados Department of Archives; Belgrove, 1755: 24-25, 29; Drax, 1755: 78-79).

Lead dissolves fairly easily, particularly in acid solutions which characterize fermentation products. Alcohol in general can not only dissolve substances but also can effectively dissolve lead. Heat facilitates the process. Since distillation involves heating a

liquid, when lead distillation equipment is used (or even copper equipment soldered with lead) the lead is particularly vulnerable to being leached by the acidic fermented solution from the equipment into the liquid (e.g., Eisinger, 1982; McCord, 1954a; Waldron, 1969; cf. Hunter, 1785). These general comments are particularly applicable to rum distillation as it was practiced in colonial America and the early West Indies.<sup>4</sup>

Other aspects of West Indian sugar technology also probably contributed to lead contamination. Dr. John Hunter of Jamaica observed (1785: 236): "In the process of making sugar, the juice of the canes comes frequently in contact with lead." Windmill rollers could be "plated of lead," as a Barbados plantation inventory recorded, and the cane juice was first collected in a lead-lined cistern, or "leaden bed" under the rollers, from which it flowed through a lead pipe, an open lead gutter, or a lead-lined wooden gutter, "exposed to the action of the open air, which is known to corrode lead in some degree," to the boiling house (Hunter, 1785: 236; see also, Edwards, 1810: 3: 38, 40; Miller, 1815: 61; Sheridan 1973: 114-115; and plantation inventories in Recopied Deeds Books, RB 3/4: 186, 702; 3/5: 615-616; 3/22: 505-506; 3/25: 390; Inventories, Boxes 1780-1786, 1787-1793: passim, Barbados Department of Archives).

The boiling house could also contain a "leaden cistern to receive liquor from the mill" and a "leaden gutter" could convey the liquid to the first of the "coppers." Although the large cauldrons, variously called "boilers" or "coppers" —in which the juice was boiled and crystallized—were of copper, they were often lined or "lay'd" with lead; the "coppers" themselves could be set in lead-covered beds. For example, in the late seventeenth century, Henry Drax, a Barbados planter, instructed his manager that in preparing for sugar manufacture, the boiling-house coppers should be "in good repair, and well faced with lead, which must be very thick"; "all the coppers and leaden beds," he stressed, "must be scowered and washed clean." The crystallized sugar, removed from the last and smallest "copper" —the "tayche"—would be placed to cool in a wood or metal vat, which may have used lead, and the residue of sugar crystallization to be used in rum making was conveyed by lead gutters to another reservoir at the still (Drax, 1755: 75-76; Recopied Deeds Books, RB 3/5: 594, 615-



616; 3/22: 505-506; 3/25: 390; 3/37: 104, Barbados Department of Archives; Hunter, 1785: 236; Miller, 1815: 62; Oldmixon, 1708: 2: 152; Hartley 1949: 68-69).

Jamaicans took lead from old worms, combining it with tin to make solder (Hunter, 1785: 240); this custom probably also existed elsewhere in the West Indies. In any case, Barbados plantations apparently commonly used lead solder to repair "boilers" as well as other sugar and rum making equipment. In the mid-eighteenth century a Barbados planter advised that the "metals and utensils" required for a 500 acre plantation should include "10,000 lb. of lead . . . per solder," and early nineteenth-century records of Drax Hall, one of the island's oldest sugar plantations, show repair expenditures for "leading 3 racking coppers," "leading and soldering 5 tayches," "lead making and soldering round the top of a skipping gutter," and "lead soldering round the top of 3 scumming cisterns"; in fact, in 1818 the plantation purchased several "sheets [of] milled lead, 16 ft. by 6 ft." There is every reason to believe that Drax Hall reflected the practices on other Barbadian plantations in the same and earlier periods (Belgrove, 1755: 37-38; Records of Drax Hall, Invoices and Receipts, 1818-1831, Z9/3/1, Z9/3/2, Barbados Department of Archives).

#### RUM IN BARBADOS SLAVE LIFE

"There is more rum made in Barbadoes," an island resident enthusiastically proclaimed in 1710, "than all the sugar plantations in the universe" (Walduck, 1710). Most plantations had distilleries, and from about the mid-seventeenth century slaves (and whites) became heavy rum consumers. "The blacks, both men and women, are very fond of rum," Pinckard (1806; I: 205) observed in 1796. His observation was echoed in earlier as well as later years by other commentators on this "noble intoxicating liquor which the Negroes as well as white servants put too much delight in" and which "servants and slaves ... drink in great abundance" (Thomas, 1690: 17; Ogilby 1670: 380; see also, Anonymous, 1810: 42; Hall, 1924: 13; Hughes, 1750: 36; Hendy, 1833: 34-35). Slavemasters complained about "the excessive use of strong liquor," and although two early laws were designed to curtail slave drinking activities and their access to rum and other alcoholic beverages,

the laws had limited impact (Society for the Improvement of Plantership, 1811: 128; Hall, 1764: 13i; Moore, 1801 : 239; Oldmixon, 1741; 2: 52).

Slaves consumed rum in a number of religious and recreational contexts. In addition, although masters often frowned on rum drinking, especially in social situations they could not easily control, it became a common practice for plantations to allocate small portions of rum (or rum mixed with water) and molasses as part of regular food rations, as special treats, in damp or chilly weather, or even as medicaments (Barbados Assembly, 1818: 42, 43, 47; Barbados Council, 1824: 106, 113; Dickson, 1789: 13; Drax, 1755: 67; Gibbes, 1797: 7; Holder, 1788: 22; Jordan, 1824: 7; Ligon, 1657: 51; Parry, 1789: 14).

In their consumption of rum, slaves (and poor whites) tended to drink "low-wine," the product of the first distillation in the rum-making process and "so strong a spirit" it was easily combustible (Ligon, 1657: 92-93; cf. Edwards, 1810; 3: 55; Miller, 1815: 65). "Low-wine" or "new rum" was observed to have particularly noxious effects, a number of West Indian writers in Barbados and elsewhere considering it to have been a prime cause of the dry bellyache. Hughes (1750: 34, 36), for example, observed how the disease's main victims were those who "immoderately" drank "new hot rum" as well as "very strong punch made exceedingly strong with new rum," and Clark (1797: 118, 125) wrote of Dominica that only the "lower orders" of whites as well as blacks who could not "afford to drink old rum or wine" acquired the disease. Dr. John Hunter (1785: 240, 243-247), a British Army physician stationed in Jamaica in the early 1780s, made comparable observations, noting that rum was often carried directly from the distillery to the market without ageing. He argued that aged rum "loses its noxious qualities in one year" and that a major reason why dry bellyache was decreasing in Jamaica at his writing was that the rum was now "almost always of a good age" (cf. Grainger, 1764: 34; Hillary, 1766: 182; Wright, 1828: 232).<sup>5</sup>

In the mid-eighteenth century, Hughes (1750: 34) remarked that in Barbados the dry bellyache "was formerly much more frequent and fatal than it hath been of late." In the only other later reference to the disease on the island, a British visitor — a naturalist — in the 1780s (who appears to have derived his information from knowledgeable sources) recorded that "the dry belly

ach is more prevalent in Barbados than in the other islands" (Anderson, 1785). Sources for other West Indian areas seem to lack discussions of dry bellyache after the late 1700s, or explicitly report it as "much less frequent than formerly" (Dancer, 1801: 102; also, Clark, 1797: 124; Hunter, 1785: 240; Moseley, 1787: 529-530, 539; Quier, 1773; Williamson, 1817; I: 243; Wright, 1828: 232). By the late eighteenth century, the dry bellyache had also diminished in the mainland colonies (Eisinger, 1982: 280, 282; Guinee, 1972: 283, 284; McCord, 1953a: 393, 398; Wedeen, 1984: 41-42, 43, 47, 59). Thus, there is a consistency in the wider evidence from British America which suggests that, as on the mainland and elsewhere in the West Indies, the dry bellyache had significantly abated in Barbados by the late eighteenth century, although it still may have been more common there than elsewhere in the West Indies.

Although the factors responsible for this decrease are uncertain, changes in rum distilling technology were probably significant. As the knowledge of lead's poisonous effects spread in the late 1700s, lead was increasingly eliminated from distilling machinery and replaced by tin (Hunter, 1785: 239-240; Clark, 1797: 124), and Guinee's (1972: 284) observation for the mainland is undoubtedly also broadly applicable to the West Indies: "The gradual disappearance of lead colic was largely due to cultural, economic and technologic changes in society without significant intervention by the medical profession."

#### SUMMARY AND CONCLUSIONS

As is the case today, rum and rum-based drinks were fundamental to the fabric of Barbadian life several centuries ago; blacks and whites were frequent consumers. It is also quite likely that rum was a *primary* contributor to the dry bellyache, and that, indeed, as in the mainland colonies, "there was a demon in the rum" (McCord, 1953a: 393).

Until very recently Barbados' lower classes principally consumed non-aged white rum. This habit, born of economic reasons, continued a practice established during the period of slavery when slaves and poor whites largely drank "new rum." Even though "new rum" was particularly toxic, if contemporary observers can be believed, in earlier periods all rum was distilled

with lead equipment, and consumers of all socioeconomic levels and racial groups were thus vulnerable to lead contamination.

Historical evidence indicates that both slaves and whites contracted dry bellyache. However, this evidence is insufficient to determine which group was the greater victim. Whites of all class levels seem to have had greater access to alcoholic beverages and other ingested lead than slaves — they even may have had a greater incidence of the dry bellyache. We cannot assert this with certainty because West Indian historical sources, with one exception,<sup>6</sup> omit comparative racial statements and we have no white skeletal materials for analysis. However, the physical evidence from Barbados suggests that lead contamination in the West Indies may have been more extensive among slaves (and whites?) than the historical sources themselves report.

Although we lack white skeletal remains, historical evidence suggests that white lead absorption would not have been less than that of slaves, and was probably greater. In any case, the lead toxicity slaves experienced undoubtedly had a variety of implications for their general health that were unrecognized by contemporary doctors—and hence have not been investigated by modern scholars. If, indeed, we are dealing with a population in general that suffered lead poisoning to some degree this may help to understand and amplify other areas of slave (and white) behavior and pathology that are superficially reported or not reported at all in the historical sources.

In this paper we have argued that the health implications of lead intoxication in Newton slaves and, by extension, Barbados slaves in general, were great enough to have had substantial social, behavioral, and economic effects generally unappreciated by modern scholarship. Moreover, the Barbados evidence, in conjunction with historical evidence from elsewhere, suggests that a similar pattern of pathology also existed in other rum-producing West Indian islands. Evidence of this pattern is present in historical accounts which discuss the dry bellyache (principally its intestinal symptoms), but the evidence is so widely scattered that its significance becomes apparent only when ferreted out and accumulated. The chemical bone lead analysis confirms suggestions in the historical literature concerning lead poisoning in slaves; it also provides quantitation to this evidence and identifies lead as the probable etiology of numerous other symptoms and causes of

death unrecognized by early medical practitioners and later historians who relied on their writings. In brief: A previously unappreciated epidemic of lead poisoning in early West Indian slave societies.

NOTES

- Seventeenth- and eighteenth-century English language medical literature uses the term "dry bellyache" (which seems to have been coined in the West Indies) synonymously with "dry gripes" (apparently mainly employed in the mainland colonies, where it was also called the "West Indian dry gripes"), "colica Pictorum," "lead colic," "nervous colic," and "Devonshire colic." Although "dry bellyache" was not the only term used in the West Indies (nor was its usage confined to the West Indies), it appears to have been the most common West Indian term and apparently was employed more in the West Indies than elsewhere (see, for example, Cadwalader, 1745: 1-2; Collins, 1811: 232; Clark, 1797: 124; Dancer, 1801: 103; Grainger, 1764: 32, 34; Hillary, 1766: 182; Hunter, 1785; Moseley, 1787: 525-540; Towne, 1726: 87; Thomson, 1820: 42; Warren, 1740: 32-33; cf. Eisinger, 1982: 281 and primary sources quoted in Wedeen, 1984: 24-25, 41, 43, 47, 48; Aronson, 1983: 38, 39; and Guinee, 1972).
- 2 Elsewhere we detail our statistical procedures and present our raw data; we elaborate the test results with respect to bone lead content and demographic characteristics as well as to several sociocultural features. We also discuss the archaeological implications of these results with respect to various dimensions of slave life and the wider problem of the retention, modification, or loss of African customs in the New World (see Corruccini et al., n.d. a).
  - 3 James Clark (1797: 124, 125) of Dominica provides unique information in reporting that dry bellyache's victims included those living in "newly painted houses, or . . . employed in painting with white lead. . . . It has been observed that all house-painters have the disease more or less in the West Indies." It is known that some of Barbados' free blacks were housepainters, and although the island's slave houses were probably unpainted, as with free blacks some slaves were probably housepainters during the eighteenth century (Handler, 1974: 122-124). Slaves valued tobacco. Although archaeological and historical evidence indicates they only used it in cigars and pipes (Handler and Lange, 1978: 133-134), they may have occasionally consumed snuff, a suggestion made by John Gilmore (pers. comm.).
  - 4 As early as 1723, a Massachusetts law recognized that "strong liquors and spirits that are distilled thro' leaden heads or pipes, are . . . unwholesome and hurtful"; it prohibited the use of "leaden heads or worms" and forbade their manufacture from "coarse and bare pewter, or . . . any mixture of lead" (Massachusetts, 1742: 240 -241).
  - 5 Alone among West Indian writers on the subject, Dr. John Quier (1773) who, by his writing in 1773 had practiced for six years in Jamaica, reported that although blacks "in general use great quantities of the newest and

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vilest rum," he never "saw or heard" of any black with dry bellyache; moreover, all persons he ever encountered with the disease were "people of the better sort."

- 6 Dr. James Grainger (1764: 34), a resident of the West Indies, mostly St. Kitts, from late 1759 to 1766, observed that blacks "are oftener tormented with the dry Belly Ach than the whites."

## REFERENCES

- Ahlgren, L., B. Haeger-Aronsen, S. Mattsson, and A. Schatz (1980) "In-Vivo Determination of Lead in the Skeleton After Occupational Exposure to Lead." *British Journal of Industrial Medicine* 37: 109-113.
- Anderson, A. (1785) "Barbados." Ms. 61o. Linnean Society of London.
- Anonymous (181o) *Authentic History of the English West Indies*. London.
- Aronson, S. M. (1983) "Lead and the Demon Rum in Colonial America." *Rhode Island Medical Journal* 66: 37-40.
- Aufderheide, A. C., F. D. Neiman, L. E. Wittmers, and G. Rapp (1981) "Lead in Bone II: Skeletal-Lead Content as an Indicator of Lifetime Lead Ingestion and the Social Correlates in an Archaeological Population." *American Journal of Physical Anthropology* 55: 285-291.
- Aufderheide, A. C., J. L. Angel, J. O. Kelley, A. C. Outlaw, M. A. Outlaw, G. Rapp, and L. E. Wittmers (1985) "Lead in Bone III: Prediction of Social Correlates from Skeletal Lead Content in Four Colonial American Populations (Catoctin Furnace, College Landing, Governor's Land, and Irene Mound)." *American Journal of Physical Anthropology* 66: 353-361.
- Barbados Assembly (1818) *The Report from a Select Committee of the House of Assembly, Appointed to Inquire into the Origin, Causes, and Progress of the Late Insurrection*. Barbados.
- Barbados Council (1824) *A Report of a Committee of the Council of Barbadoes, Appointed to Inquire into the Actual Condition of the Slaves in this Island*. London.
- Barbados Department of Archives (various dates) *Recopied Deeds Books; Inventories, Boxes; Hackett, Taylor, Byrrowes, and Records of Drax Hall*.
- Bartrop, D. and H. E. Khoo (1975) "Nutritional Determinants of Lead Absorption," in D. Hemphill (ed.) *Trace Substances in Environmental Health IX*. Columbia: University of Missouri: 369-376.
- Bellgrove, W. (1755) *A Treatise Upon Husbandry or Planting*. Boston.
- Bell, J. U. and J. A. Thomas (1980) "Effects of Lead on Mammalian Reproduction," in R. L. Singhal and J. A. Thomas, (eds.) *Lead Toxicity*. Baltimore and Munich: Urban and Schwarzenberg: 169-185.
- Bennett, J. H. (1958) *Bondsmen and Bishops: Slavery and Apprenticeship on the Codrington Plantations of Barbados, 1710-1838*. University of California Publications in History 62. Berkeley and Los Angeles.
- Betts, P. R., R. Astley, and D. N. Raine (1973) "Lead Intoxication in Children in Birmingham." *British Medical Journal* 1: 402-406.
- Bridenbaugh, C. and R. Bridenbaugh (1972) *No Peace Beyond the Line*. New York: Oxford University Press.

*Lead Poisoning in Barbados Slaves 421*

- Cadwalader, T. (1745) *An Essay on the West-India Dry-Gripes*. Philadelphia.
- Christoffersson, J. O., A. Schutz, L. Ahlgren, B. Haeger-Aronsen, S. Mattsson, and S. Skerfving (1984) "Lead in Finger-Bone Analyzed in Vivo in Active and Retired Lead Workers." *American Journal of Industrial Medicine* 6: 447-457.
- Clark, J. (1797) *A Treatise on the Yellow Fever, as it Appeared in the Island of Dominica . . . to which are Added Observations on . . . Some Other West Indian diseases*. London.
- Collins, Dr. (1811) *Practical Rules for the Management and Medical Treatment of Negro Slaves, in the Sugar Colonies*. London. (1st ed. 1803).
- Corruccini, R. S., A. C. Aufderheide, and J. S. Handler, and L. E. Wittmers (n.d.) "Patterning of Skeletal Lead Content in Barbados Slaves." Unpublished manuscript, submitted to *Archaeometry*.
- Corruccini, R. S. and J. S. Handler (1980) "Temporomandibular Joint Size Decrease in American Blacks: Evidence from Barbados." *Journal of Dental Research* 59: 1528.
- \_\_\_\_\_ and K. P. Jacobi (1985) "Chronological Distribution of Enamel Hypoplasias and Weaning in a Caribbean Slave Population." *Human Biology* 57: 699-711.
- Corruccini, R. S., K. P. Jacobi, J. S. Handler, and A. C. Aufderheide (n.d.) "Implications of Tooth Root Hypercementosis in a Barbados Slave Skeletal Collection." Unpublished manuscript, submitted to the *American Journal of Physical Anthropology*.
- Corruccini, R. S., J. S. Handler, R. Mutaw, and F. W. Lange (1982) "Osteology of a Slave Burial Population from Barbados, West Indies." *American Journal of Physical Anthropology* 59: 443-459.
- Craton, M. (1978) *Searching for the Invisible Man*. Cambridge: Harvard University Press.
- Dancer, T. (1801) *The Medical Assistant; or Jamaica Practice of Physic*. Kingston, Jamaica.
- Dickson, W. (1789) *Letters on Slavery*. London.
- Drax, H. (1755) "Instructions for the Management of Drax-Hall and the Irish-Hope Plantations [ca. 1670]," in W. Belgrave (ed.) *A Treatise Upon Husbandry or Planting*. Boston: 51-86.
- Dunn, R. S. (1972) *Sugar and Slaves: The Rise of the Planter Class in the English West Indies, 1624-1713*. Chapel Hill: University of North Carolina Press.
- Eastwell, H. D., B. J. Thomas, and B. W. Thomas (1983) "Skeletal Lead Burden in Aborigine Petrol Sniffers." *Letter to the Editor, The Lancet* 2: 524-525.
- Edwards, B. (1810) *The History, Civil and Commercial, of the British Colonies in the West Indies*. 3 vols. Philadelphia.
- Eisinger, J. (1982) "Lead Wine: Eberhard Gockel and the Colica Pictonum." *Medical History* 26: 279-302.
- Frere, H. (1768) *A Short History of Barbados From its First Discovery and Settlement to the End of the Year 1767*. London.
- Gibbes, P. (1797) *Instructions for the Treatment of Negroes, Etc. Etc. Etc.* London.

- Grainger, J. (1764) *An Essay on the More Common West India Diseases*. London.
- Guinee, V. F. (1972) "Lead Poisoning." *The American Journal of Medicine* 52 (3): 283-288.
- Hall, R. (1764) *Acts, Passed in the Island of Barbados*. London.
- (1924) *A General Account of the First Settlement and of the Trade and Constitution of the Island of Barbados, Written in the Year 1755*. E. M. Shilstone (ed.) Barbados.
- Handler, J. S. (1963a) "Pottery Making in Rural Barbados." *Southwestern Journal of Anthropology* 19: 314-334.
- (1963b) "A Historical Sketch of Pottery Manufacture in Barbados." *Journal of the Barbados Museum and Historical Society* 30: 129-153.
- (1974) *The Unappropriated People: Freedmen in the Slave Society of Barbados*. Baltimore: Johns Hopkins University Press.
- Handler, J. S. and R. S. Corruccini (1983) "Plantation Slave Life in Barbados: A Physical Anthropological Analysis." *Journal of Interdisciplinary History* 14: 65-90.
- (1986) "Weaning Among West Indian Slaves: Historical and Bioanthropological Evidence from Barbados." *William and Mary Quarterly* 43: 111-117.
- Handler, J. S. and F. W. Lange (1978) *Plantation Slavery in Barbados: An Archaeological and Historical Investigation*. Cambridge: Harvard University Press.
- (1979) "Plantation Slavery on Barbados, West Indies." *Archaeology* 32: 45-52.
- Handler, J. S., R. S. Corruccini, and R. J. Mutaw (1982) "Tooth Mutilation in the Caribbean: Evidence from a Slave Burial Population in Barbados." *Journal of Human Evolution* 297-313.
- Harlan, W. R., J. R. Landis, R. L. Schmouder, N. G. Goldstein, and L. C. Harlan (1985) "Blood Lead and Blood Pressure. Relationship in the Adolescent and Adult U. S. Population." *Journal of the American Medical Association* 253: 530-534.
- Harris, W. A., T. E. Harden and E. B. Dawson (1979) "Apparent Effect of Ascorbic Acid Medication on Semen Metal Levels." *Fertility and Sterility* 32: 455-459.
- Hartley, H. M. (1949) "Of the Produce of the Plantations," in F. J. Klingberg (ed.) *Codrington Chronicle: An Experiment in Anglican Altruism on a Barbados Plantation, 1710-1834*. University of California Publications in History 37: 63-84. Berkeley and Los Angeles.
- Hendy, T. W. B. (1833) *An Attempt to Prove the Fallacy of Inflicting Corporal Punishment to Prevent or to Lessen the Commission of Crime*. Barbados.
- Hernberg, S. (1980) "Biochemical and Clinical Effects and Responses as Indicated by Blood Concentration," in R. L. Singhal and J. A. Thomas (eds.) *Lead Toxicity*. Baltimore and Munich: Urban and Schwarzenberg: 367-399.
- Hillary, W. (1766) *Observations on the Changes of the Air and the Concomitant Epidemical Diseases in the Island of Barbadoes*. London. (1st ed. 1759).



- Holder, H. E. (1788) *A Short Essay on the Subject of Negro Slavery, with Particular Reference to the Island of Barbados*. London.
- Hughes, G. (1750) *The Natural History of Barbados*. London.
- Hunter, J. (1785) "Some Experiments Made upon Rum, in Order to Ascertain the Cause of the Colic, Frequent Among the Soldiers in ... Jamaica, in the Years 1781 and 1782." *Medical Transactions, Published by the College of Physicians in London* 3: 227-249.
- Jacquet, P. (1977) "Early Embryonic Development in Lead-Intoxicated Mice." *Archives of Pathology and Laboratory Medicine* 101: 641-643.
- Jordan, J. W. (1824) *An Account of the Management of Certain Estates in the Island of Barbados*. London.
- Kiple, K. F. (1984) *The Caribbean Slave: A Biological History*. Cambridge: Cambridge University Press.
- Lauwers, M. C., R. C. Hauspie, C. Susanne, and J. Verheyden (1986) "Comparison of Biometric Data of Children with High and Low Levels of Lead in the Blood." *American Journal of Physical Anthropology* 69: 107-116.
- Ligon, R. (1657) *A True and Exact History of the Island of Barbados*. London.
- McCord, C. (1953a) "Lead and Lead Poisoning in Early America: Benjamin Franklin and Lead Poisoning." *Industrial Medicine and Surgery* 22: 392-399.
- \_\_\_\_\_ (1953b) "Lead and Lead Poisoning in Early America: The Pewter Era." *Industrial Medicine and Surgery* 22: 573-577.
- \_\_\_\_\_ (1954a) "Lead and Lead Poisoning in Early America: The Lead Pipe Period." *Industrial Medicine and Surgery* 23: 27-31.
- \_\_\_\_\_ (1954b) "Lead and Lead Poisoning in Early America: Lead Compounds." *Industrial Medicine and Surgery* 23: 75-80.
- \_\_\_\_\_ (1954c) "Lead and Lead Poisoning in Early America: Clinical Lead Poisoning in the Colonies." *Industrial Medicine and Surgery* 23: 120-125.
- Mackie, A., A. Townshend, and H. A. Waldron (1975) "Lead Concentrations in Bones from Roman York." *Journal of Archaeological Science* 2: 235-237.
- Mahaffey, K. R. (1977) "Relation Between Quantities of Lead Ingested and Health Effects of Lead in Humans." *Pediatrics* 59: 448-456.
- Mahaffey, K. R., R. A. Goyer, and J. K. Haseman (1973) "Dose Response to Lead Ingestion in Rats Fed Low Dietary Calcium." *Journal of Laboratory Clinical Medicine* 82: 92-101.
- Massachusetts (1742) *Acts and Laws of His Majesty's Province of the Massachusetts-Bay in New-England*. Boston.
- Miller, G., Jr. (1815) *The Traveller's Guide to Madeira, and the West Indies*. Haddington, Eng.
- Moore, S. (1801) *The Public Acts in Force; Passed by the Legislature of Barbados*. London.
- Moore, M. R., P. A. Meredith, B. C. Campbell, A. Goldberg, and A. Baird (1978) "The Effect of Calcium Glycerophosphate on Industrial and Experimental Lead Absorption." *Drugs Under Experimental Clinical Research* 4: 17-24.
- Moseley, B. (1787) *A Treatise on Tropical Diseases, on Military Operations, and on the Climate of the West Indies*. London.

- Needleman, H. L., C. Gunnoe, A. Leviton, R. Reed, H. Peresie, C. Maher, and P. Barrett (1979) "Deficits in Psychological and Classroom Performance of Children with Elevated Dentine Lead Levels." *New England Journal of Medicine* 300: 689-694.
- Ogilby, J. (1670) *America: Being the Latest and Most Accurate Description of the New World*. London.
- Oldmixon, J. (1708) *The British Empire in America*. 2 vols. London.
- \_\_\_\_\_ (1741) *The British Empire in America*. 2 vols. London.
- Parry, D. (1789) "Extract of a Letter from Governor Parry to the Right Honourable Lord Sydney, August 18, 1788." *British House of Commons Parliamentary Papers* 26: 13-24. London.
- Pinckard, G. (1806) *Notes on the West Indies*. 3 vols. London.
- Porter, G. (1830) *The Nature and Properties of the Sugarcane*. London.
- Quier, J. (1773) "Letter VI. Account of the Bilious Cholic, Called the Dry Belly-Ache," in D. Monro (ed.) *Letters and Essays on the Small-Pox and Inoculation, the Measles, the Dry Belly-Ache ... of the West Indies*. London, 1778: 150-194.
- Russell, F. (1695) "Letter to Lords of Trade and Plantations, 23 March," in *Calendar of State Papers, Colonial Series: America and West Indies 1693-1696* 445. London.
- Salmon, W. (1693) *Seplasmus. The Compleat English Physician*. London.
- Scott, M. (1985) Unpublished Data. Department of Medical Physics, University of Birmingham, England.
- Sheridan, R. (1973) *Sugar and Slavery: An Economic History of the British West Indies, 1623-1775*. Baltimore: Johns Hopkins University Press.
- \_\_\_\_\_ (1985) *Doctors and Slaves: A Medical and Demographic History of Slavery in the British West Indies, 1680-1834*. Cambridge: Cambridge University Press.
- Sloane, H. (1707) *A Voyage to the Islands Madera, Barbados, Nevis, S. Christophers and Jamaica*. London.
- Society for the Improvement of Plantership in the Island of Barbados (1811) *Minutes*. Liverpool.
- Stowe, H. D. and R. A. Goyer (1971) "The Reproductive Ability and Progeny of F, Lead-Toxic Rats." *Fertility and Sterility* 22: 755-760.
- Thomas, D. (1690) *An Historical Account of the Rise and Growth of the West India Colonies*. London.
- Thomson, J. (1820) *A Treatise on the Diseases of the Negroes as They Occur in the Island of Jamaica*. Jamaica.
- Towne, R. (1726) *A Treatise of the Diseases Most Frequent in the West Indies*. London.
- Trapham, T. (1679) *A Discourse on the State of Health in the Island of Jamaica*. London.
- Tryon, T. (1684) *Friendly Advice to the Gentlemen Planters of the East and West Indies*. London.
- Uzych, L. (1985) "Teratogenesis and Mutagenesis Associated with the Exposure of Human Males to Lead: A Review." *The Yale Journal of Biology and Medicine* 58: 9-17.

*Lead Poisoning in Barbados Slaves 425*

- Vermade-Van Eck, G. J. and J. W. Meigs (1960) "Changes in the Ovary of the Rhesus Monkey After Chronic Lead Intoxification." *Fertility and Sterility* 11: 223-234.
- Waldron, H. A. (1969) "James Hardy and the Devonshire Colic." *Medical History* 13: 74-81.
- Waldron, H. A., A. Mackie, and A. Townshend (1976) The Lead Content of Some Romano-British Bones. *Archaeometry* 18: 221-227.
- Walduck, J. (1710) "Letter to J. Petiver." Sloane Manuscripts 2302. British Library.
- Warren, H. (1740) *A Treatise Concerning the Malignant Fever in Barbados and the Neighboring Islands*. London.
- Wedeen, R. P. (1984) *Poison in the Pot: The Legacy of Lead*. Carbondale: Southern Illinois University Press.
- Weller, C. V. (1915) "The Blastophthoric Effect of Chronic Lead Poisoning." *Journal of Medical Research* 33: 271-293.
- Williamson, J. (1817) *Medical and Miscellaneous Observations Relative to the West India islands*. 2 vols. Edinburgh.
- Witmers, L. E., Jr., A. Alich, and A. C. Aufderheide (1981) "Lead in Bone I: Direct Analysis for Lead in Milligram Quantities of Bone Ash by Graphite Furnace Atomic Absorption Spectroscopy." *American Journal of Clinical Pathology* 75: 80-85.
- Wright, W. (1828) *Memoirs of the late William Wright*. Edinburgh.
- Zielhuis, R. L. (1975) "Dose-Response Relationships for Inorganic Lead: I. Biochemical and Hematological Responses." *International Archives of Occupational Health* 35: 1.