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Lifestyles, Diets, and Native American Exposure Factors Related to Possible Lead Exposures and Toxicity

Stuart Harris (Confederated Tribes of the Umatilla Indian Reservation) and
Barbara L. Harper (AESE, Inc.).

Abbreviated Title: Native American Diets and Exposure Factors

Corresponding author:

Stuart G. Harris
Confederated Tribes of the Umatilla Indian Reservation,
Special Science and Resources Program,
P.O. Box 638,
Pendleton, OR 97801

SGH: 541/966-2408 (v), stuartharris@ctuir.com
BLH: 509/967-5174 (v), bharper@amerion.com

ABSTRACT

Lead exposure is still a national concern, and it is possible that Native Americans who live on reservations and pursue traditional lifestyles may be at higher risk through both their unique exposure profiles and potentially greater sensitivity. A major component of the exposure assessment is the diet. For tribal members, traditional lifestyles that include native foods, medicines, and traditional practices have evolved and proven to be the most healthful over many thousands of years of co-existence with the ecology. However, a completely traditional diet may not be fully available for a variety of reasons, so one must also consider the adverse health consequences caused by the loss of healthy native foods and medicines, contamination of remaining native foods, the inability to practice one's religion, and the possibly lower quality of the substitute diet. Health evaluations of lead exposure on reservations should therefore consider at least two types of diets in addition to the typical suburban diet: (a) traditional diets composed of native foods and medicines that would result in increased exposure if the plants and animals are contaminated, and (b) disadvantaged or commodity food diets that result in widespread vitamin and mineral deficits of the sort known to increase absorption of and response to lead. Additional exposure to lead might come from reservation housing which is often older, although the prevalence of lead based paint on reservations is unknown. The degree of physiological response could also be affected by widespread exposures to other neurotoxins (such as mercury and PCBs in fish), underlying disease patterns, and genetics. Although each of these factors is plausible, their prevalence singly or in combination is unknown. Any correlation between these risk factors and blood lead levels on reservations is also unkown. This paper begins to address these gaps by discussing the range of traditional and current diets that may exist among tribes and methods for developing a whole-lifestyle exposure scenario that is appropriate for an individual tribe. Some of these factors discussed in this paper may not apply to the large population of Native Americans who live in urban situations.

Key Words: Native American, subsistence diet, cultural, lead (Pb), risk

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INTRODUCTION

When estimating lead exposures to tribal members through the use of models, their overall activity and exposure patterns must be understood well enough to be put into the format required by the exposure model (e.g., the IEUBK model or CERCLA exposure scenarios). Dietary exposures are a critical element of exposure models and need to be examined in some detail, especially for Native Americans. However, our eventual goal as tribal technical staff is not primarily to increase precision about a single exposure pathway such as diet, but rather to increase overall understanding about multipathway exposures, the possibility that tribal populations may also be more physiologically sensitive, and the effects of environmental contamination on the entire environmentally-based lifestyle.

Any exposure model, whether it is the IEUBK or standard CERCLA exposure scenarios, needs to be specifically derived for the population to which it is applied. The process for developing tribally-appropriate exposure scenarios centers around understanding key aspects of traditional lifestyles for the particular tribe. The range of specific lifestyles and exposure factors will vary widely from tribe to tribe because each tribe's culture is a unique product of its own history, watershed, food sources, and homeland. Therefore specific dietary and activity patterns will vary as widely as climate and resources vary. Although every tribe has a different culture, traditions, and religious practices, many of these lifestyles are environmentally oriented and generally result in higher environmental contact rates. Furthermore, this range of traditions and lifestyles exists within a varying context of tribal government sovereignty, federal trusteeship obligations, treaty law, and religion. It is important to begin with a basic understanding of these laws and principles.

GENERAL PRINCIPLES

Maintaining a homeland with a clean functioning ecosystem where past, present, and future generations may live is a dominant feature of tribal integrity, health, religion, and everyday life. Tribal Nations are fundamentally concerned with protecting these features, and draw on their sovereign status to do so. The sovereign status of tribal governments means that the tribal governments should be accorded *at least* the same status as state governments. Many tribal governments are full service governments providing services from sidewalks to street signs, housing to healthcare. Tribes are increasingly obtaining authority to administer and enforce environmental laws, and are actively protecting their

resources both on and off reservations. For those tribes that have treaties with the United State government, the most basic tenet of the Treaties, under the Cannons of Construction of constitutional law, is that Treaties were intended to protect the resources on which the traditional religious lifestyle and community health depend. The term sovereignty also refers to self-determination, which is of paramount importance and is part of the reason that assimilation into the dominant society is so strenuously resisted. If traditional practices have to be reduced because environmental contamination makes them unsafe, the culture is diminished. People will often knowingly continue to use contaminated resources rather than give up their culture and religion, which means that a different approach to education and health care intervention is needed.

Our job as tribal employees is to help protect tribal rights, natural and cultural resources, individual and community health, and traditional lifestyles. These lifestyles and the resources on which they depend are protected by treaty (for many but not all tribes), religious freedom laws, federal trusteeship obligations, and modern environmental legislation. Risk assessment in Indian Country must therefore start with an understanding that the legal (ARAR) landscape is more complex than in non-tribal Superfund or regulatory situations. This legal landscape includes but is not limited to Treaties, CERCLA, National Historic Preservation Act, NEPA, American Indian Religious Freedom Act, RCRA, Clean Water Act, Safe Drinking Water Act, Endangered Species Act, and Executive Orders on consultation, environmental justice, and sacred lands. Because the specific ARAR landscape depends on the individual tribal situation and affected resources, each Tribal Nation must be consulted before starting a regulatory or remedial action that involves reservation lands, ceded lands, public lands with tribal historic use, or other lands that contain or could affect tribally-important resources. Focused health intervention studies would also benefit from a better understanding of tribal history and context so pitfalls such as assuming that it is acceptable to simply give up a cultural practice in order to prevent exposure can be avoided.

TRADITIONAL HOLISTIC LIFESTYLES

Traditional lifestyles are part of an ancient tribal heritage, and this lifestyle is still practiced by many more people than suburban society realizes. Knowing how to gather, prepare, and use native foods and medicines is not an option or preference, but is required as part of living a traditional religious life. Tribal religious practices are recovering from years of prohibition, and tribal heritage is increasingly recognized as a very important part of recovering from "post-colonial traumatic stress syndrome" and preserving community integrity and personal and community health (Duran and Duran, 1995). Evaluating impacts to tribal health requires knowledge of more than just dietary practices (Thornton, 1998).

Because these traditional lifestyles are so closely bound to every aspect of the environment, any species is likely to be used in many ways, either directly in the diet as food or medicine or as an item of cultural or religious significance, as well as being an integral component of an ecosystem. Even if cultural items do not contribute a direct

exposure, their loss could affect the practice of the traditional religion, thus causing human stress that could in turn affect response to toxicants. For instance, a resource at location A might be required to gather food at location B in order to conduct a ceremony at location C. Thus, while diet is a major exposure pathway, risk managers must realize that breaking a dietary exposure pathway by denying access to a resource or area is likely to have health and religious consequences of its own. We recommend that any exposure or dietary study of Native Americans that is done to support a remedial action or intervention should have four parts: estimating exposure through the diet and other routes, understanding the consequences of contamination on natural and cultural resources and their use, and understanding the consequences of breaking a nutritional and traditional religious link in order to reduce or avoid exposure, as well as a consideration of the health effects in a population whose health and nutritional status may already be impaired to a greater or lesser degree.

EXPOSURE SCENARIOS BASED ON HOLISTIC LIFESTYLES

Suburban exposure scenarios reflect relatively few pathways and environmental contact, but tribal lifestyles are inseparable from the environment. Unlike suburban exposure scenarios, every element of a traditional lifestyle is intertwined with the environment through health, food, medicine, religion, education, and/or social activities, to name some of more obvious linkages. Traditional duties and therefore exposure patterns are also often age- and gender-specific. Although conventional federal risk management goals are often focused on a single resource (e.g., groundwater) or location (e.g., a contaminated hotspot), tribal perspectives are likely to be protection of an entire ecosystem, watershed, or lifestyle.

One example of a subsistence exposure scenario based on the lifestyles of three tribes and developed from within those tribes (Umatilla, Walla Walla, and Cayuse) has been published (Harris and Harper 1998). The process for developing the subsistence scenario involved substantial preparation and knowledge of the community (and in this case actual enrollment in the tribe). In addition to demonstrating accountability and integrity (a form of informed consent), we also developed informal rules for protecting confidentiality and intellectual property rights. Because these scenarios were developed solely within the tribe, there was no internal institutional review board (IRB) available, but our personal training in biomedical ethics and IRBs enabled us to follow the intent of the IRB process and obtain an equivalent review at the tribal policy level before proceeding. Tribal members do not regard their lives as objects of anthropological study to which academics have rights of access for scientific reasons (as reflected in bioprospecting, genome, and repatriation conflicts). They similarly do not regard external IRBs as necessarily suitable for granting permission for biomedical studies of tribal members, while the anthropological community does not even have the equivalent of an IRB process. The "interviews" of community members also delineated what could be revealed and what could not about traditional environmental knowledge, community values, habitat-specific activity patterns and important aspects of the ecology and ecocultural landscape. The interviews also identified families with strong cultural practices. A statistical cross-

section with a small sample size could miss entire families with special skills (such as fishing families who fish for themselves, for ceremonies, and for other members) and who therefore consume non-average diets. These people should not be regarded as statistical outliers with worst-case exposures, but as people living and performing a unique and important community service that requires special protection (or over sampling).

The information from the interviews was summarized in a format for model input (i.e. with exposure frequency and duration, and total dietary amounts of vegetation, meat, and fish). The subsistence scenario also included a sweat lodge pathway, which consists of volatilization of water into a confined space at a certain frequency and duration and which is a primary exposure pathway if the water is contaminated. From a risk management perspective, it must be recognized that use of the sweatlodge is a religious activity, so it is not appropriate to limit the evaluation to contaminants that exceed drinking water standards, or to assume that use of the sweat lodge can be limited as a risk "mitigation" measure. Similarly, the overall exposure scenario uses an exposure duration of 70 years rather than 30 years or less because tribal members are not mobile and cannot leave the homeland which is the source of their sustenance, religion, and history without mental and physical health consequences.

DIETS AND CO-EXISTING RISK FACTORS

We recommend evaluating different types of diets that co-exist among tribal members, rather than a central tendency averaged across a variety of distinct diets (Table 1). The type of survey tool and the targeted information will vary with the risk management goal. For example, current diets might be the focus if the goal is health intervention to combat modern diseases such as obesity, heart disease, or diabetes, but native foods and medicines or a more traditional food ingestion rate might be the focus if a specific resource is contaminated and the goal is to restore full tribal use of that resource.

Some of the recent literature about Native American dietary patterns is presented here. Several papers recognized that the investigator must work within the culture in order to be sensitive enough to get reliable data. Additionally, the investigator must understand the culture well enough to design culturally competent surveys (Teufel 1997), with direct partnerships working the best (Schell and Tarbell, 1998; Harris and Harper, 1997).

1.Cross-sectional dietary surveys. Surveys of current diets are performed most often as part of a disease intervention study, although Broussard et al. (1995) noted that few detailed studies of diet or physical activity levels of contemporary Native Americans have been published. This is improving with the new emphasis on contamination of subsistence foods. Byers (1996) cited the earlier studies of current diets (Wolfe and Sanjur, 1988; Teufel and Dufour, 1990; Brown and Brenton, 1994; Russell et al., 1994; Nobmann et al., 1992; Story et al., 1986) as part of a Native American cancer conference, and found modern reservation diets to be high in fat and low in fruits and

vegetables. Zephier et al. (1977) studied the modern diets of 10 tribes in relation to cardiovascular disease, and found generally high fat, low fiber diets, with older participants eating better presumably because they made a conscious effort to do so. The Exposure Factors Handbook (EPA, 1997) contains additional current dietary information. Some of these studies were performed on reservations, while others were designed to extract a racial subset of the general national dietary data and may or may not have focused on actual reservation conditions. More and more information about the relation of diabetes to modern diets and exercise levels is appearing, and this is shedding light on the composition and healthfulness of traditional diets. Additional papers on specific nutritional status are appearing, and are helping to fill data gaps.

While cross-sectional surveys are certainly appropriate to use where intervention for a health condition is the goal, it may miss entire classes of people who are more traditional, people who are quite well off or the poorest, those who do not have telephones or means to travel to health clinics (where participants are often recruited), or those who lack confidence in western medicine. There are also a number of factors that may skew a participant's answer, such as a belief that revealing confidential information about native plants and medicines could have adverse consequences, or the potential for losing a resource to commercial interests once it is identified (echinacea is a case in point[1]).

2. Surveys of traditional/subsistence diets are found primarily in the anthropology literature, which was not searched for this paper, although more papers are appearing in the biomedical literature recently. There are several definitions of "subsistence," and the term has been applied both to living completely off the land and to recreational sportsmen who eat what they catch or kill (Endter-Wada, 1966). Byers (1966) surveyed the anthropology literature, and concluded that traditional or subsistence diets were generally low fat and high fiber, although this is generally discussed qualitatively rather than on a nutritional or caloric basis. Harris and Harper (1997) investigated traditional diets consumed by tribal members who were recognized by themselves and by others as being "traditional," and estimated the caloric content, which compared well with earlier caloric estimates of the same diet (Hunn, 1990). It is important that more information about traditional diets be published in the medical literature because there are indications that a return to native diets is effective in some cases of diabetes (Norrell, 1998; deGonzague et al., 1999; many others) and other diseases, but care must be taken to avoid exploitation of this information by commercial interests, or revealing tribal proprietary information.

3. Modern reservation conditions are among the poorest in the country, although this varies considerably. While a few tribes have benefited substantially from gaming,

[1] An example of echinacea over-harvest can be found at http://www.billingsgazette.com/region/980801_reg004.html. This article also states that the "Fort Berthold Indian Reservation in North Dakota passed a tribal law forbidding harvests after zealous digging rendered the once-abundant plant a rarity."

and many others have been able to make some improvements in their social and health infrastructure, unemployment is still extremely high and living conditions extremely poor on many reservations. This is also reflected in reservation diets, which are often vitamin and mineral deficient. A Navajo HANES report showed that the diet tended to be low in fruits and vegetables, high in fat, and below RDA for several vitamins and minerals, including calcium and iron (which would affect lead absorption)(Ballew, 1997). Hopi students had diets that were high in fat and low in calcium, zinc, and Vitamin D (Brown and Brenton, 1994). Wolever et al. (1997) reported that Ojibwa-Cree diets were high in fat, low in fiber, and had a high prevalence of inadequate Vitamin A, Ca, Vitamin C, and folate. Montana reservations also had diets low in greens, fruits, and vegetables (Nelson et. al., 1997), as did Pima Indians (Smith et al., 1996). Adams (1995) equated reservation diets with tryptophan deficiency. The federal government (as required by Treaties with many tribes) supplies government surplus or "commodity" food to reservations, and the nutritional quality of a commodity food diet may vary widely depending on what is chosen individually and can contain high fat, high salt, and low fiber. The modern item, fry bread, had its origins in original commodity food distributions, when Indian agents often stole everything except lard, flour and salt, so fry bread has a cultural meaning relating to survival (Cajete, 1999) and will not be given up.

4. Partial or targeted dietary surveys can be found in the literature and may be initiated as a response to a specific research project or a specific incident of contamination. Many of these studies suggest research needs with respect to lead exposure in Native Americans. For instance, lactose intolerance is widespread among American Indian adults, which could result in calcium deficiency and therefore increased absorption of lead if exposure were to occur (Goyer, 1997; Crowe and Morgan, 1996). Although a higher milk intake during pregnancy results in lower lead levels in cord blood (Rotherberg et al., 1996), if the mother is lactose intolerant she would ingest less milk during pregnancy and possibly buy or serve less milk to her children. If this same mother has accumulated a higher bone lead level that is mobilized during pregnancy (Hernandez-Avila et al., 1998; Gulson et al., 1999), the children could be at higher risk. Historically, lead in bone (Patterson et al., 1991; Erickson et al., 1991) and teeth (Kuhnlein and Calloway, 1977) was much lower than it is now; so there would not have been a lactose intolerance and calcium-lead issue except perhaps in special cases of using lead pigments.

Chan et al. (1995) studied subsistence ingestion rates of seal, beluga, caribou, and other foods, including organs and animal parts, due to known contamination by heavy metals. They found that many individuals had high heavy metal intakes, including lead, and also noted that some individuals received much higher doses due to overall dietary practices. Many other studies like this are now appearing in the literature. These are important because they may help determine whether there is an interaction between nutritional status (calcium and Vitamin D in particular) and lead absorption. For instance, Native populations from both northern (Haworth and Dilling, 1986; Gessner et al., 1997; Waiters et al., 1999) and southern (Brown and Brenton, 1977)

regions have been found to be deficient in Vitamin D, which is involved with calcium in lead absorption (Moon, 1994; Fullmer, 1997). Because there are genetic influences in lead absorption related to the Vitamin D Receptor gene and other genes (Onalaja and Claudio, 2000; Schwartz et al., 2000), and because one of the variants of the Vitamin D Receptor protein (Gc locus) is associated with Type 2 diabetes and glucose tolerance and insulin resistance (Baier et al., 1998; Szathmary, 1987), there may be a genetic situation regarding insulin metabolism that affects lead absorption that did not reach physiological levels of concern when lead exposure was much lower..

Many other reports exist for specific foods, most often fish. Recent attention has centered on omega-3 polyunsaturated fatty acids (PUFA). Many medical studies have shown beneficial effects of PUFA, particularly for heart disease. Since fish provided (and continue to provide) the major protein source for some tribes (including the Columbia River tribes such as the Umatilla, Walla Walla, and Cayuse tribes) for thousands of years, the relation of traditional diets to modern health is particularly close. At least one report has been published showing elevated omega-3 PUFA among Alaskan Eskimos (Parkinson et al., 1994). It is clear that traditional or subsistence levels of fish consumption are beneficial, but fish are more and more often contaminated. Egeland and Middaugh (1997) discussed "balancing" the health benefits of eating fish contaminated with mercury without considering the cultural importance of eating fish. Tenenbaum (1998) said that "indigenous populations in the Arctic are the most affected by contamination of their traditional food sources…[but] changing to a more modern diet may be even worse for these people's health." This is true not just because the quality of the replacement diet may be poorer, but also because fish may be a cultural resource and an essential part of the religion. If the optimization of eating fish or not eating fish is based solely on probability of a clinically and statistically significant health affect, significant impacts are missed. What part of a culture are people supposed to give up in order to avoid exposure? Immigrants suffer mental and physical ailments, and social isolation and the loss of stable religious affiliations may herald health declines (Bower, 1998), and tribal reservations suffer similar conditions on an ongoing basis.

For lead exposure, the diet may not be the only source of lead. For Native Americans, other factors may also put them at risk of increased exposure or increased response (Table 2), although systematic studies have not been done. Health status information in Native Americans is sparse. For example, there was only a single article indexed in MedLine from 1994-1998 about blood lead levels in Native Americans, American Indians, reservations, or tribes, and that article stated that the "CDC lead-screening questionnaire failed to efficiently identify those children with lead toxicity," referring to a study conducted on the Navajo reservation (Kazal, 1997). The only other citation was a case of gasoline sniffing.

It is known that factors that enhance risk of lead exposure are low SES, old housing[2], low dietary intake of calcium, iron and zinc (Goyer 1996), and each of these conditions is

[2] Tribal housing is often older, and the prevalence of lead paint is a concern but is unknown. EPA has several pilot projects underway to determine if lead paint is a problem on reservations (E Avant, EPA Region 5, personal communication).

present to a greater or lesser degree on reservations. Other studies identify similar risk factors, but have not looked specifically at Native American populations (Kraft and Scheberle, 1995; Pirkle et al., 1998).

RISK CHARACTERIZATION AND RISK MANAGEMENT ISSUES

Risk characterization from our perspective means more than estimating the probability of overt health effects or the probability of a certain percentile of children exceeding a particular blood lead level. To us, risk characterization means looking at both the exposure and the sensitivity (risk = exposure x sensitivity), as well as the risk to the entire lifestyle if places or resources are contaminated. We refer to this as "eco-cultural-health" risk management. If we consider just the human exposure element, there are some perspectives that need to be considered (remembering that each sovereign tribal government makes its own health and environmental policy decisions).

One issue is the level of protection that is set as the goal or identified as acceptable. Using dose-based models such as the IEUBK does not necessarily mean that any amount of exposure or environmental degradation is acceptable either as new (permitted) releases, residual (post remediation) contamination, or non-point-source exposure (e.g., general municipal water and sediment concentrations). In other words a tribe may not agree that protecting 95% of children to a blood lead level of 10 ug/dl is the correct risk management goal. Since NHANES III showed that today's blood levels in clean suburban settings is 2.8 ug/dl (Flegal and Smith, 1995; Brody et al., 1994; MMWR, 2000), there is no a priori reason why a tribe should accept 5% of children exceeding 10 ug/dl, particularly since the current exposure limit for Pb has no margin of safety and "blood lead levels as low as 10 ug/dL can adversely affect the behavior and development of children" (MMWR, 1997).

Since EPA has not developed either a Reference Dose (which would include a safety factor) or a cancer slope factor for lead, it cannot be included in cumulative risk assessments. In addition, the MCL[3] may not be protective enough for tribal children who are vitamin and mineral (calcium) deficient. Concentration benchmarks and standards were seldom developed with such combinations of risk factors in mind, and need to be reevaluated specifically for tribal situations. If exposures to other neurotoxins is occurring, both individual and community impacts must be evaluated. A unit of selection could also be the community's gene pool or neuronal pool. A neurological deficit in even one person could impair the intergenerational transfer of knowledge, which could cause a cumulative detriment to hundreds of people or the whole tribe.

HUMAN SUBJECTS RESEARCH and RISK COMMUNICATION

There are many complex issues regarding the study of Native Americans, their cultures

[3] MCL refers to Maximum Contaminant Level, the term for enforceable limits of individual contaminants in drinking water.

and eco-cultural resources, and issues of human sampling. There are issues of intellectual property that extend beyond the well-known intellectual property rights pertaining to sacred sites or confidential cultural or religious practices (all of the information about traditional practices including subsistence foods is the intellectual property of the tribe, and some of it will simply never be released). Because few tribes have Institutional Review Boards (IRBs) that review human subjects research, they are generally at a disadvantage with respect to control over the data, control over human biological samples, and so on, regardless of the external review that has been done by university or Indian Health Service IRBs. State departments of health may do studies with no IRB review at all. Tribal research codes are still rare, and may or may not have considered human, ecological, and cultural research as a total package. Therefore, there are many constraints on doing the research to fill these data gaps and test this hypothesis.

There have been several books and papers published on cross-cultural counselling, cross-cultural nursing and health care provision, and a few on cross-cultural risk communication. While the literature on providing culturally appropriate health care (including native healers along with western healers), the risk communication literature has not dealth with this issue yet.

CONCLUSION

Communicating risk management concepts to reduce lead exposure within Native American Tribes requires a fundamental understanding of the community, resource base, and culture. Many times reasearchers lacking this fundamental knowledge will simply follow the standard protocols and "check-off" lists. Designing the research statement without this understanding may result in overlooking critical cultural components of the community. If the keystone community member(s) who know the cultural process needed for day to day subsistence survival is/are overlooked, then the evaluation of the pathways to exposure resulting from cultural use of a contaminated resource may not be reflected in the risk manager's decision process. Evaluating lead exposure must take into account more than simply a suburban exposure scenario. The evaluation must also consider unique combinations of factors that affect exposure, bioavailability, and response to the neurotoxicity and other effects of lead. Even questionnaires designed to predict lead exposure using survey techniques may not be suitable for Native American populations and living situations (Kazal, 1997).

This type of risk management is not a simple communication or study design problem. Indeed, risk communication is only part of the solution, and can address only those asepcts of the problem that are more wessternized (such as the house paint issue). Risk communication techniques such as fish advisories can be somewhat effective in reducing consumption of a contaminated resource (Fitzgerald et al., 1995), but risk communication and risk management must be tailored to be culturally sensitive (Van Oostdam et al., 1999; Harris, 2000). Risk management may follow a process of balancing costs, benefits and impacts. However, we propose that instead of dollars as the fulcrum,

risk ethics becomes the primary driver for balancing cost, benefits, and impacts from the perspective of the affected people. We recommend that this concept be more fully explored by professional societies, and that fellowships in risk ethics be established.

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Table 1. Types of diets that might be selected according to the risk management goal

Type of Dietary Survey	**Typical Driver or Goal**
1. Current diets evaluated with cross-sectional dietary surveys; may be on or off-reservation.	Health intervention for specific diseases, often within a specific group based on age, gender and so on; market basket surveys.
2. Fully traditional diet with subsistence exposure scenario	Protection of treaty rights and religion; remedial goals for final ROD; multi-generation protection of small gene pools
3. Modern reservation conditions - poverty and commodity foods (high fat, low fiber)	Correction of specific nutritional deficits; Socioeconomic or public health evaluation
4. Partial or targeted dietary survey; may be triggered by contamination of a particular food, place, or resource, or by a specific research question.	Key factors related to specific genetic (ethnopharmacology) makeup (e.g., milk intake rate related to lactose intolerance); Identification of specific contaminated food source (e.g. mercury or PCBs in fish)

Table 2. Additional potential sources of lead exposure for Native Americans

Other potential co-exposures to Lead	**Rationale**
Older housing	Reservation housing is often older and in poorer condition; unknown rates of lead-based paints
Lead shot and fishing weights	Poverty may force handmade uses
Pigments (decorative)	Lead and cinnabar-based pigments with dermal absorption and bone storage (Ghazi, 1994)
Use of animal bones or bone meal	Degree of use, degree of lead storage all unknown
Sediment	Mining sediments heavily laden with lead are moving down the Columbia River and other waterways
Agricultural lead-arsenate	Non-point source runoff from old orchards
Airborne deposition	A primary pathway of exposure for herbivores (Kalas et al., 2000)
Site-specific soil and fish contamination	Many mining and other Superfund sites contain lead; many fish populations contain lead
Co-exposures to other neurotoxins	Mercury and PCBs in fish – unknown cumulative effects