Uranium Legacy Impacts on Health of Residents: DiNEH Project Update

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DiNEH Project research is reviewed and approved by

- ***Navajo Nation Human Research Review Board*** **to ensure compliance with Navajo Nation Law, Respect for Navajo Culture and Protection of Navajo People, and by the**
- **University of New Mexico Human Research Review Board, and**
- **Peer-Reviewed by the National Institute of Environmental Health Sciences of NIH**

Data presented reflect support from the following 20 chapters of the Eastern Agency of the Navajo Nation

- **Baca/Prewitt/Haystack, Becenti, Cassamero Lake, Church Rock, Crownpoint, Coyote Canyon, Iyanbito, Lake Valley, Littlewater, Mariano Lake, Nahodishgish, Ojo Encino, Pinedale, Pueblo Pintado, Smith Lake, Standing Rock, Thoreau, Torreon/Star Lake, Whitehorse Lake, White Rock**

We thank the 1050 members of those chapters who have participated in this research to date.

What are health concerns about uranium?

- **Uranium damages kidneys**
  - **Higher the dose, more likely there will be damage**
  - **Caused by chemical properties of the metal, NOT by radiation**

30 % of Navajos lack access to regulated water (compared to 0.6% of US as a whole, 12% for all tribes)

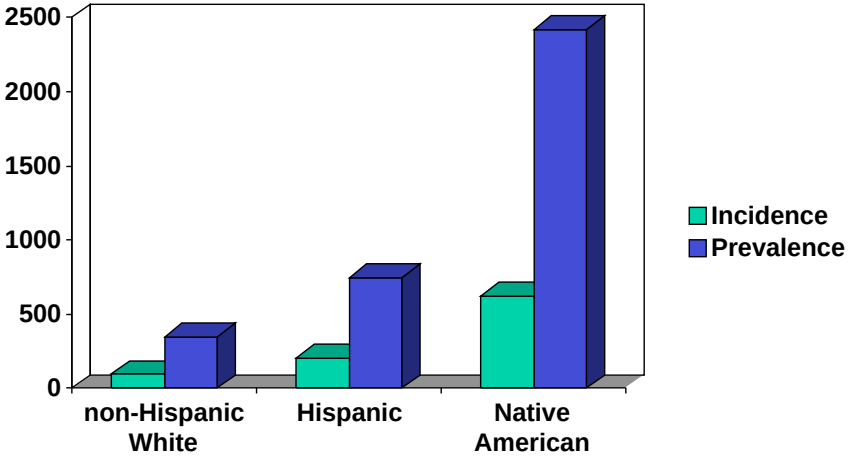
- **New Mexico populations already at risk**
  - **High prevalence of diabetes & kidney disease**
  - **Early onset, increased severity**
  - **No studies in at-risk communities, or in children**

- **Significant exposure potential**
  - **Uranium & other heavy metals (also damage kidneys)**
  - **Naturally occurring and anthropogenic (human activity) sources**
  - **Soil, surface water, drinking water, plant/animal uptake**

Children playing in contaminated arroyo, Church Rock, NM

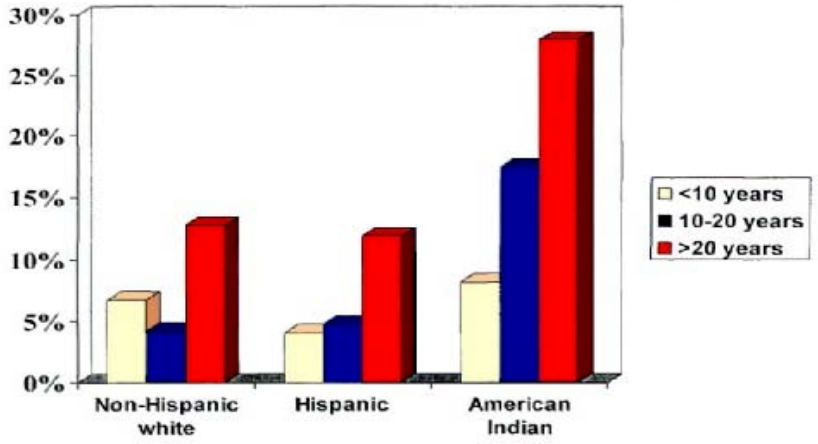
Health Disparities May Increase Sensitivity in At-Risk Populations: Two Examples

End Stage Renal Disease Disparities by Ethnicity/Race–NM (2000) (per million; age adjusted)



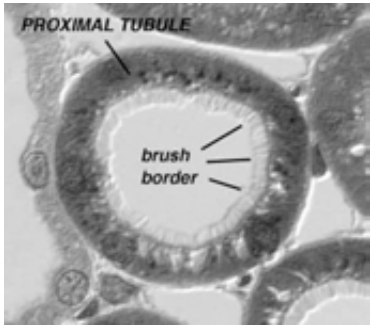
Prevalence of Pneumoconiosis in Underground Miners by Ethnicity/ Race Indicate Increased Sensitivity in American Indians

(non-malignant respiratory disease, e.g. fibrosis from deposition of particles)



Major Concerns

Other Research Findings



- **Linkage between heavy metals, hypertension, diabetes, kidney disease**
  - **Lead linked to increased kidney disease in people with diabetes (VA Normative Aging Study) and hypertension (NHANES)**
  - **Recent laboratory studies show mechanisms for this effect (Tseng on arsenic/diabetes)**
  - **ATSDR showed biomarkers of exposure-related kidney damage persist after exposure stops in diabetics, but not in healthy individuals. Diabetes progression is accelerated.**
- **Recent in vitro data also link uranium, as a metal, to cancer**
  - **AFFRI (Miller); U of A (Ingram & Briehl); France (Théibault et al.,)**
- **Results of medical monitoring at DOE's Fernald Uranium Processing Facility (Ohio):**
  - **2-4X higher rates of kidney diseases in those living within 5 mi. (not at-risk population)**
  - **Uranium primary exposure concern, but also radon, plutonium and other radionuclides**
  - **Also doubling of kidney cancer and melanoma, increased prostate cancer**

Don't Regulatory Standards Protect Health?
Evolution of health protective standards/guidelines

- **Groundwater limits have decreased by approximately an order-of-magnitude each decade since 1950 as scientific understanding improves**

- **Based on UNM/CEHP recommendation, NM WQCC decreased by >2 orders of magnitude 2003 (5 mg/L to 0.030 mg/L)**

- **Decision challenged and upheld by appellate decision (2006)**
  - *"the Commission properly amended the standard …, credible scientific data existed in the record to support its action."* The opinion further documented that the lowered standard was supported to be more protective of the public's health "*particularly because the state has a high Native American and Hispanic population, which is especially susceptible to those effects*".

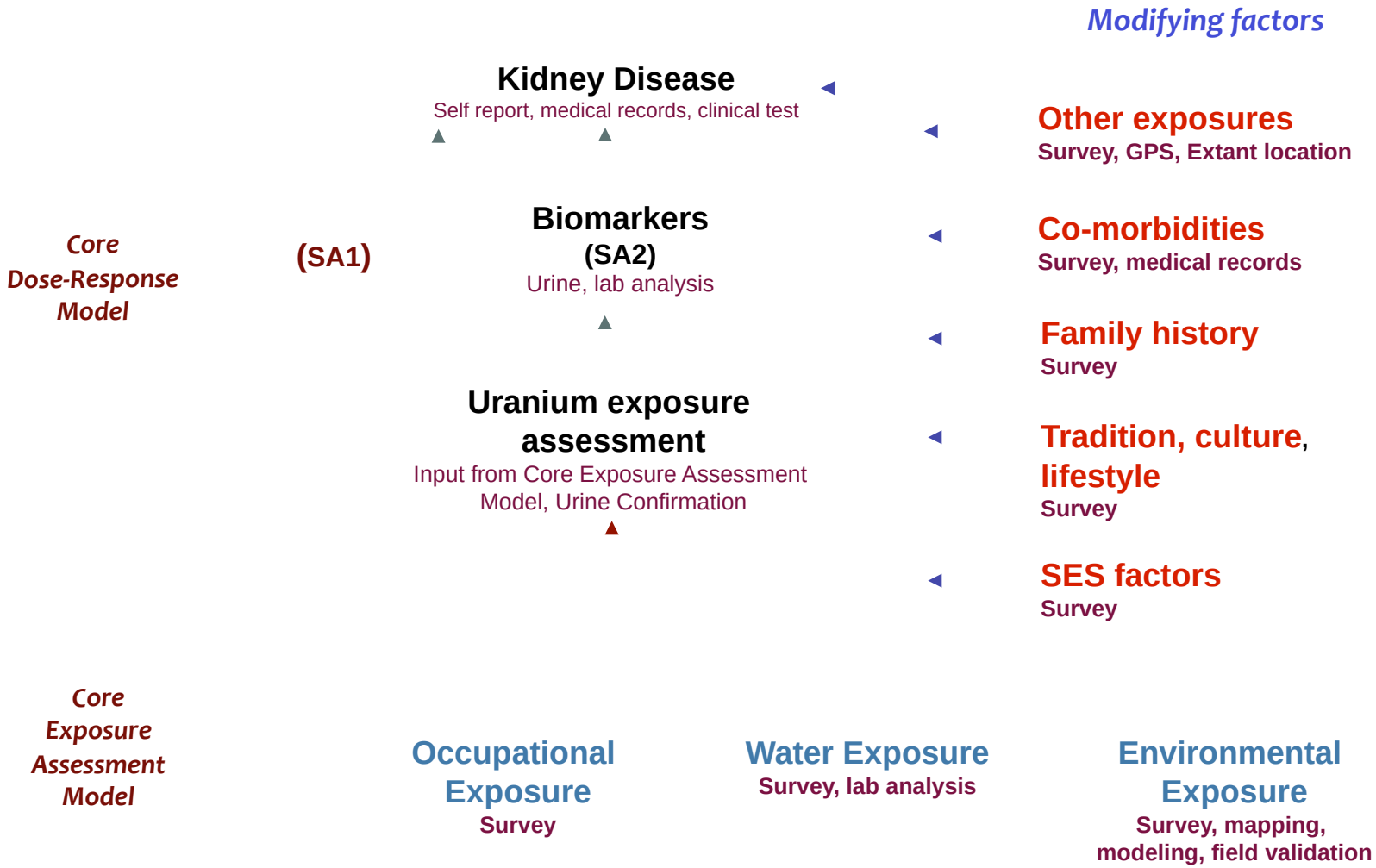
DiNEH Project

- **First community health assessment in uranium-impacted communities**
  - **Specifically in a population at risk for kidney disease**
- **Funded by National Institute of Environmental Health Sciences**
  - **Collaboration with 20 Chapters in Eastern Navajo Agency, Crownpoint Service Unit of I H S, Southwest Research and Information Center, University of Texas. PI at UNM-HSC**
- **Most comprehensive community-based assessment**
  - **Includes a range of mine-impacted and non-impacted chapters**
  - **Comprehensive assessment of exposure, health, land use practices, and known risk factors**
  - **Relies on convergent validity, multilevel modeling, replication**
  - **Disease assessment from self-report, medical records, clinical screens, biomarker assays**

Multilevel model

Replication, Convergent Validity, Field Validation, Exposure confirmation

Kidney Risk Multi-level Model—Structure



DiNEH Exposure Data

Water

	DiNEH Project (October 2003 thru August 2009)
# Water Sources Sampled	108
# Water Sources Exceeding at Least 1 Primary MCL	17
USEPA Primary MCLs Exceeded (# water sources with exceedances in parentheses)	As (7), F (2), Gross Alpha (4), Hg (2), NO_3 (2), Pb (1), Radium-226+228 (2), Se (5), U (9)

Urine uranium (n=22 only at this time)

Urine-Uranium Comparisons (ug U/g Cr)			
STUDY →	DiNEH Kidney Study (n=22)	NHANES (2001-2002)	NMDOH Biomonitoring
Participants →	Residents near mines	National survey	Volunteers
Median	0.0441	0.007	0.026
3rd Quartile	0.0818	0.014	0.058
95th %ile	0.3562	0.040	0.354

Current status of DiNEH research

- **Survey (self-report) data**
  - demographics, water- and land-use practices, environmental and occupational exposure, and health status
  - completed for >1000 residents of 20 Eastern Navajo chapters
- **Water data not yet quantitatively integrated into modeling**
  - only yes/no for exposure

Year	# of Surveys	Analysis	Result
2007	300	qualitative/bar graphs	indicated hypertension, kidney disease, diabetes, and autoimmune disease increased as the number of mines in a chapter increased
2008	535	logistic regression. Model developed on random sample of 330, validated through prediction of remaining cases (deLemos thesis)	Analyzed kidney disease as an outcome. Showed living in proximity to mines was a significant predictor of disease, as well as commonly thought of risk factors like comorbidities, family history of the disease, obesity, age, and education. Autoimmune disease not modeled.
2009	890	logisitic regression and Bayesian Model Development	Replicated proximity as a significant predictor of hypertension, kidney disease, and diabetes. Proximity is best predictor of autoimmune disease.

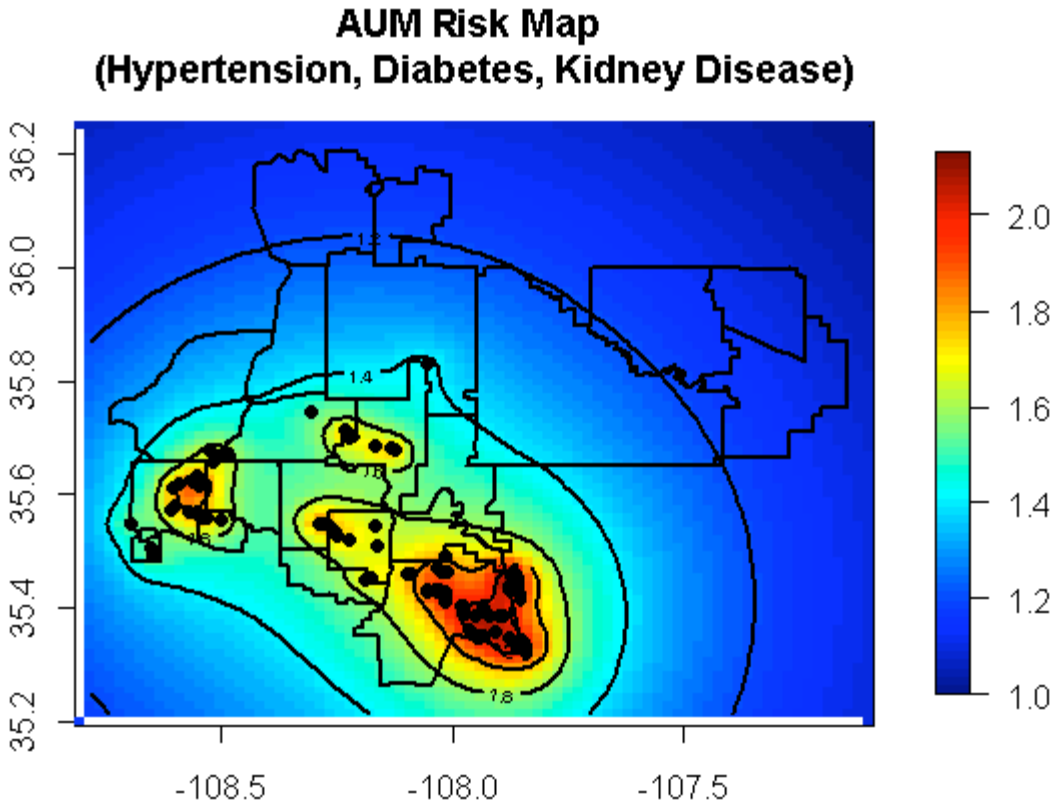
Current refinement of our understanding

- **Best predictor: proximity to mine waste features weighted by areal surface of feature**
  - **In other words -- for two mines of equal size, value is greater for closer mine, but a big waste pile 10 miles away may be less important than several smaller features within 1 mile of a home.**
  - **Why proximity rather than self-reported exposure?**
    - **19-25% of respondents are unaware of whether or not they live near mines**

Can You Tell These are Abandoned Uranium Mines?

Preliminary Analysis: Proximity to AUM Features Is a Significant Predictor of Hypertension, Diabetes and Kidney Disease

- **Conditional models (n=890): proximity is a significant predictor of each disease, the 3 are linked to each other and improving the ability to predict any one improves the ability to predict the other two**
- **Family history of disease, obesity, age, and level of education are also significant predictors**
- **"Proximity" is calculated as the log of the sum of the inverse distances to all AUM features in the study area, weighted by the surface area of each feature**



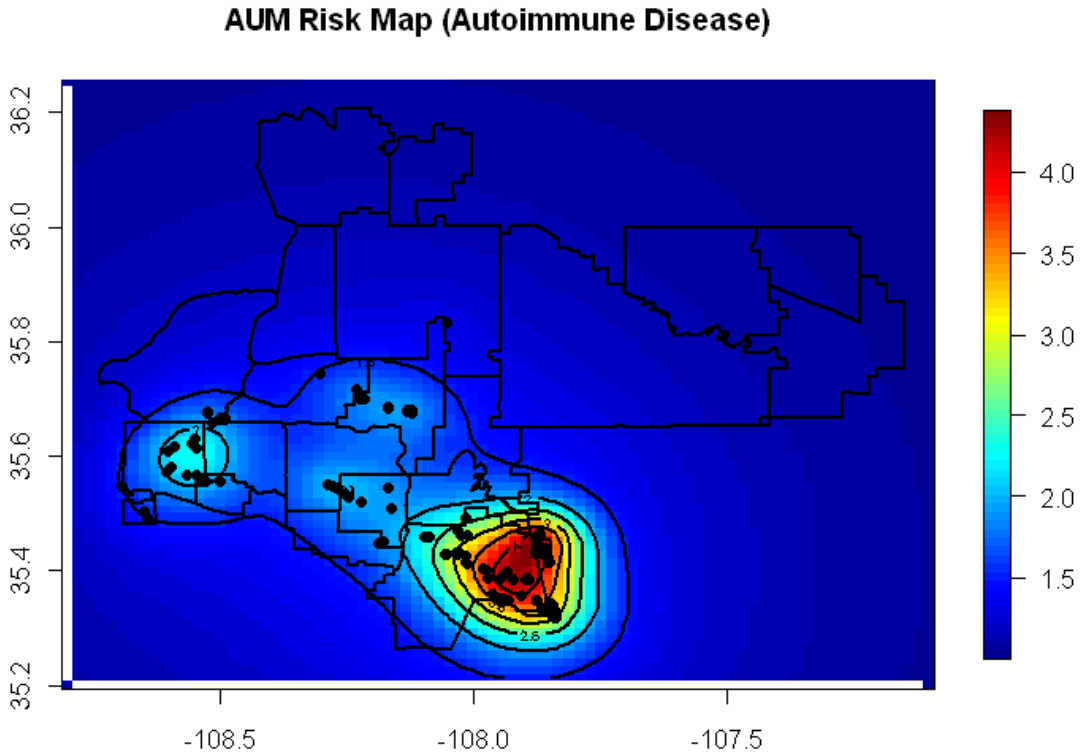
Axes indicate latitude (y) and longitude (x). Black circles represent locations of mine features. Color scale on right indicates scale of increasing odds ratios for diseases based on value of the weighted proximity variable. Map shows two distinct regions where odds of increased disease are increased more than 2-fold because of proximity to mines.

Preliminary Analysis: Proximity to AUM Features Is a Significant Predictor of Autoimmune Disease

- **"Proximity" is calculated as the log of the sum of the inverse distances to all AUM features in the study area, weighted by the surface area of each feature**
- **Autoimmune disease reported less frequently in males**
- **Age, BMI, level of education, and self-reported exposure to AUM features not significant predictors**
- **Results consistent with estrogenic effects of U (Raymond-Whish)**

AUM Model Summary Statistics

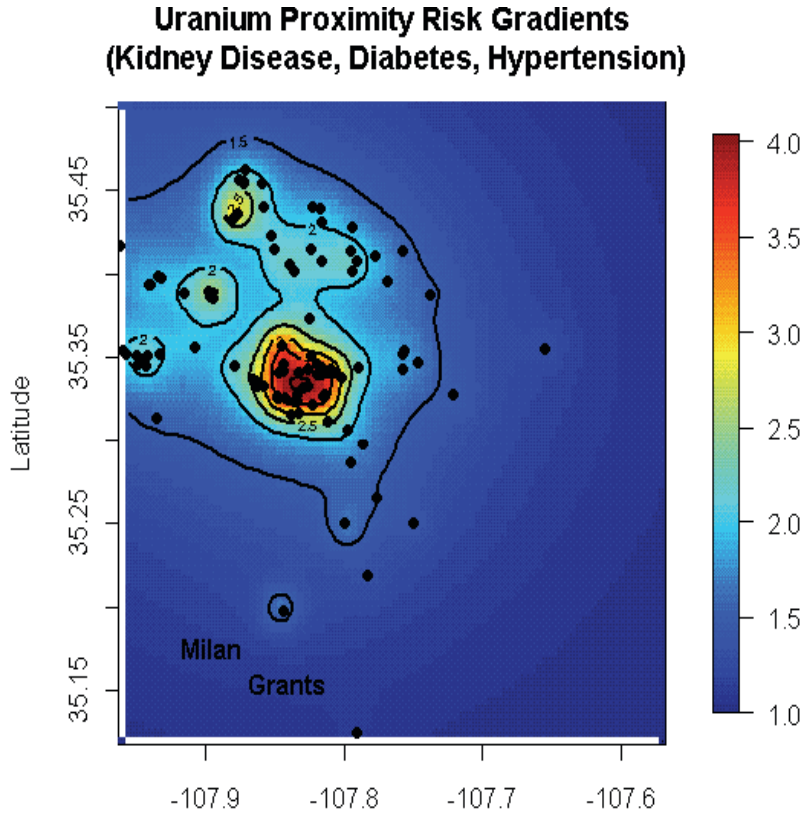
	Estimate	Std. Error	z value	Pr(>|z|)	Odds Ratios		
					Estimate	95% Confidence Interval	
(Intercept)	-3.63	0.31	-11.59	<0.0001			
Gender (Male)	-0.86	0.41	-2.08	0.0372	0.42	0.28	0.64
AUM Proximity	1.41	0.44	3.21	0.0014	4.12	2.65	6.41



Axes indicate latitude (y) and longitude (x). Black circles represent locations of mine features. Color scale on right indicates scale of increasing odds ratios for disease based on value of the weighted proximity variable. Map shows a distinct region where odds of autoimmune disease are increased more than 4-fold because of proximity to mines.

What Do DiNEH Results Tell Us About Other NM Communities?

- Current analysis is based on self-reported data for the DiNEH study area on Eastern Navajo *only*
- If these results are generally applicable, they may provide a significant predictor of disease in other communities in New Mexico
- Model validation more efficient process than model development
- For example, the map at right shows an illustration of the range of odds ratios that might be predicted for the San Mateo Basin communities
- (***NOTE: this is an illustration of uranium-proximity risk gradients based ONLY on location of abandoned mines, NOT weighted by surface area of the features as in the DiNEH predictors***.)



Black circles represent locations of mine features. Color scale on right indicates scale of increasing odds ratios for disease based on the number of mines only. Map shows a distinct region where odds ratios are increased more than 4-fold because of proximity to mines. Higher Ors reflect substantially higher density of features than in DiNEH study area.

What it has taken to get these results

- **>$2.5 million in research support**
- **6 yrs of research design, data gathering, analysis**
- **Staff of 14 plus substantial in-kind support and collaboration**
- **Multidisciplinary technical/professional team**
  - **Toxicology, Navajo language/culture, geochemistry, hydrology, public health, mining/milling history, clinical care and laboratory analysis, statistical modeling, geospatial analysis, Bayesian analysis, exposure assessment, outreach and risk communication**
- **Collaboration with multiple agencies**
  - **Navajo Nation: NNEPA, NNAML, NNDOH, NNDWR**
  - **New Mexico: NMDOH, NMED, NMEMNR**
  - **US: USEPA, ATSDR, IHS, ACE**

Questions not yet addressed

- **Additional exposures from living in contaminated structures identified through 5-Year Plan**
  - **Health risks associated with U plus decay chain radionuclides**
    - **Structure exposure adds to proximity exposures**
  - **Radon in homes may be primary toxicant (lung cancer)**
  - **Radium also identified**
  - **Need to evaluate multiple potential outcomes in those individuals**
- **Outcomes of combined exposures (either by source or by toxicant)**
  - **E.g. structures + proximity + drinking water; uranium + arsenic + mercury**
- **Remainder of DiNEH Project scope**
  - **Clinical assessments**
  - **Laboratory biomarker analyses**
  - **Follow-up on other potential disease endpoints**
    - **Autoimmune disease (link to U from DiNEH analysis and parallel to other metal exposures)**
    - **Cancers (continuing community concern, supported by in vitro laboratory work at AFFRI, in France, and NAU/U of A)**
    - **Reproductive and developmental outcomes (Shields et al., 1992)**
- **Whether results generalize to other populations**

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