



Uranium and other heavy metals in *Ovis aries* (Dibé)

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Research Question

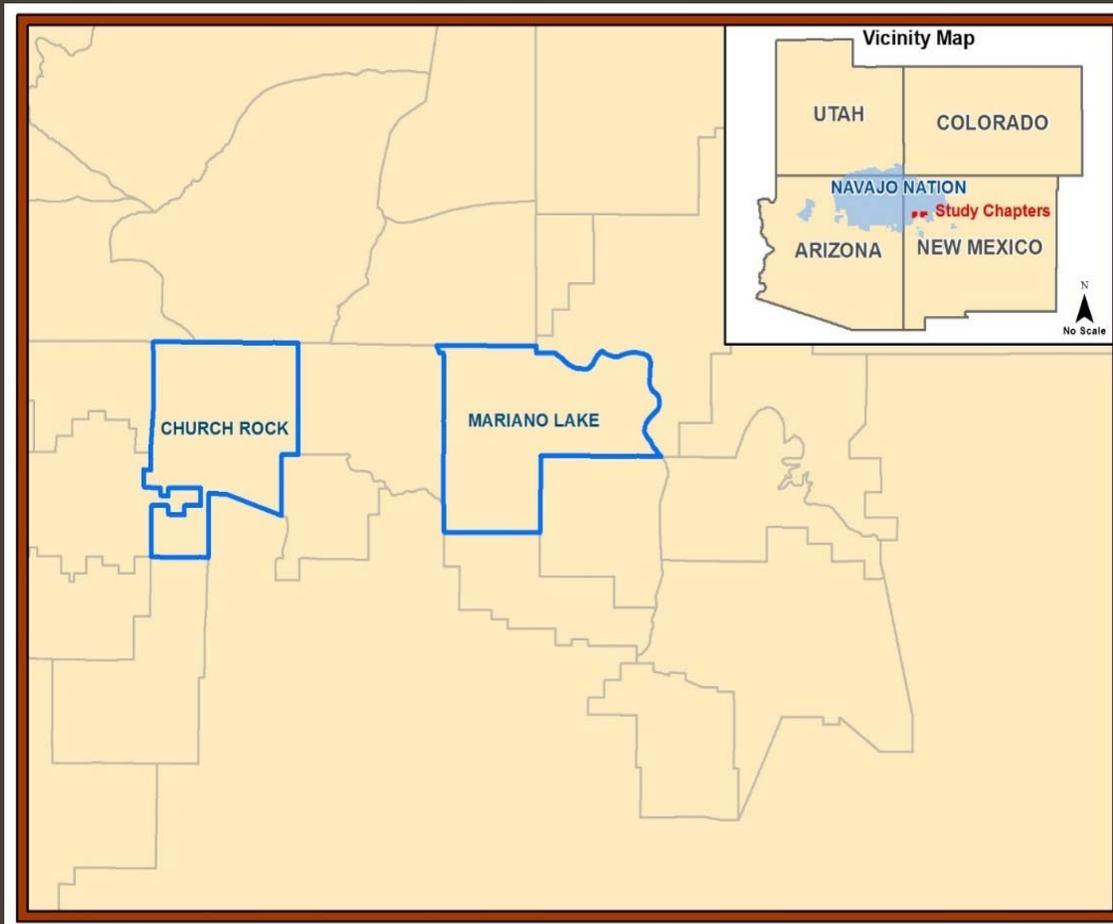
- Is locally harvested food contaminated on the Diné reservation in northwestern New Mexico?
- Harvested foods: the primary meat staple (sheep meat), forage for sheep, water, and soil.



[Xe]6s ⁻⁴ neodymium 144.2	promethium (147)
92 U [Rn]7s ² 5f ³ 6d ¹ uranium (238)	93 Np [Rn]7s ² 5f ⁴ 6d ¹ neptunium (237)



Study Area



 Diné Nation Study Chapters: Churchrock & Mariano Lake.



Study Findings

Demographics

Gender	66% Male
Age	M=58.7 ± 2.9
Education	50% HSE/GED
Current Residence Yrs.	38% 40-49y, 25% 50-59y
Language preference	63% Both, 25% Diné

Sheep Protein Information

Overall meat intake from sheep alone	35%
Number of meals containing sheep products consumed per week	Once a week
Sheep parts consumed	100% leg muscle, liver, lung, kidney, intestine, soup bone.
Years of consumption of sheep parts	52.3 + 10.8 yrs.

Sheep Water Heavy Metal Standards for Upper Limits of Potentially Toxic Contaminants

Heavy Metal	Upper Limits of Potentially Toxic Contaminants
Arsenic (As)	200 µg/L ²
Cadmium (Cd)	10-50 µg/L ²
Lead (Pb)	50-1000 µg/L ^{1, 2}
Selenium (Se)	50 µg/L ²
Vanadium (V)	100 µg/L ^{2,3}

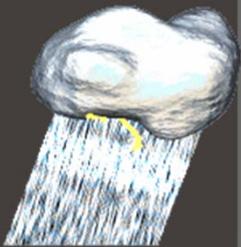
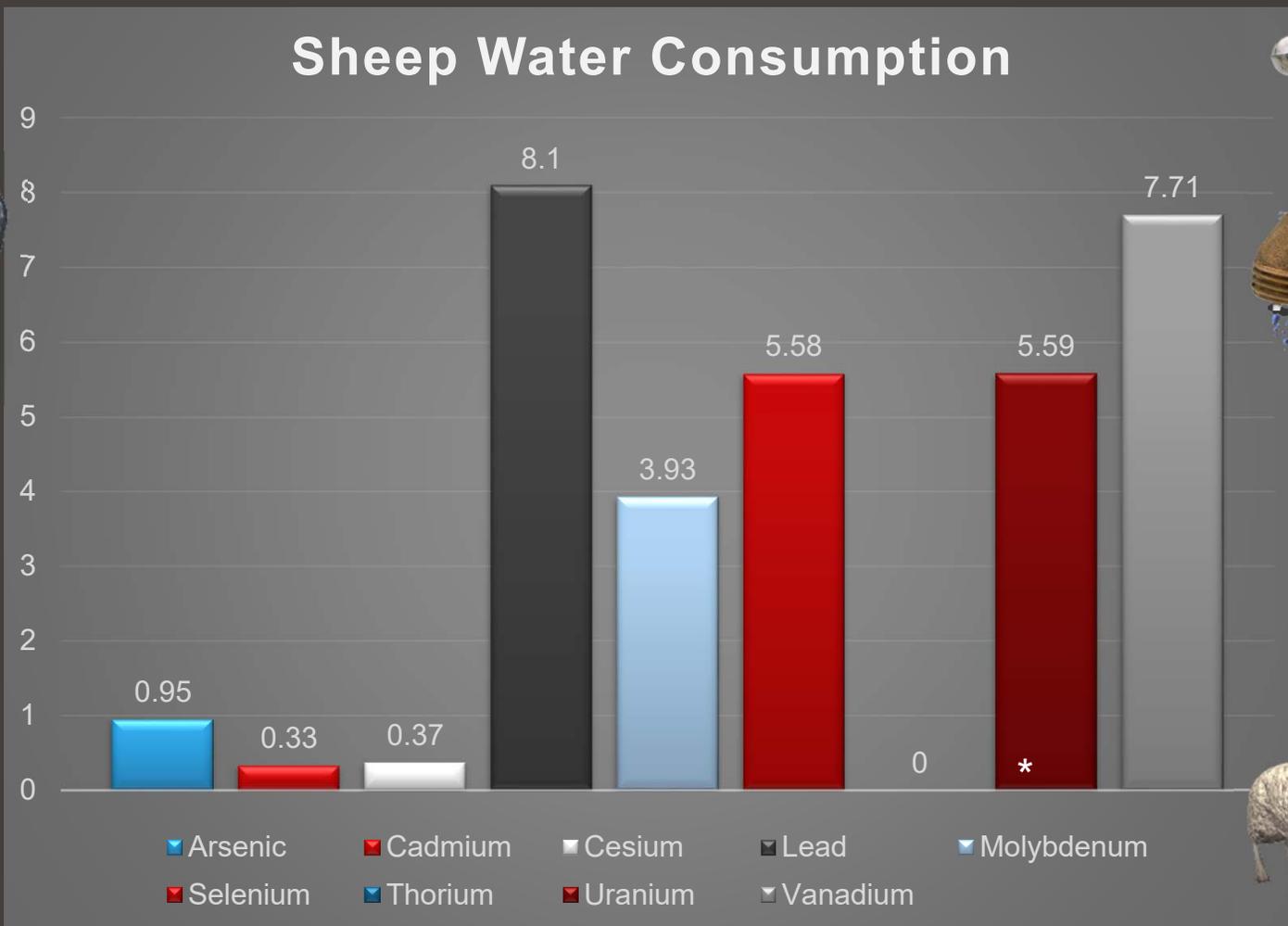


¹NRC 2005; ²Pugh, 2002; ³Paterson et al., 1986



FINDINGS

Sheep Water Consumption



µg/L



National Primary Drinking Water Regulations, 2009

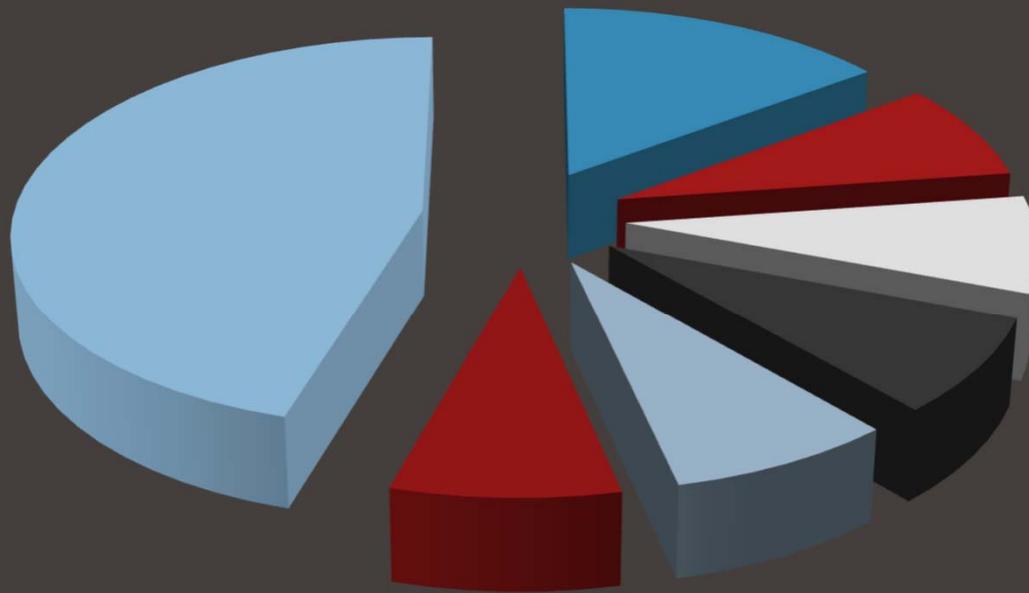
Heavy Metal	Maximum Contaminant Levels (MCLs)
Arsenic (As)	10 µg/L ¹
Cadmium (Cd)	5 µg/L ¹
Lead (Pb)	15 µg/L ¹
Selenium (Se)	50 µg/L ¹
Uranium (U)	30 µg/L ^{1,2}

¹US EPA & ²Navajo Nation EPA

THERE IS NO STANDARD FOR CESIUM, MOLYBDENUM, THORIUM OR VANADIUM



Sheep Forage Types



- 15% *P. smithii* ¹
- 8% *A. hymenoides* ²
- 8% *A. purpurea* ³
- 8% *M. replens* ⁴
- 8% *P. jamesii* ⁵
- 8% *S. cryptandrus* ⁶
- 46% *B. gracilis* ⁷

COMMON NAMES

- | | |
|---------------------------------|----------------------------|
| ¹ Western wheatgrass | ⁵ Galletta |
| ² Indian ricegrass | ⁶ Sand dropseed |
| ³ Purple three awn | ⁷ Blue grama |
| ⁴ Creeping Muhly | |



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Sheep Forage Heavy Metal Maximum Tolerable Concentrations (MTC)

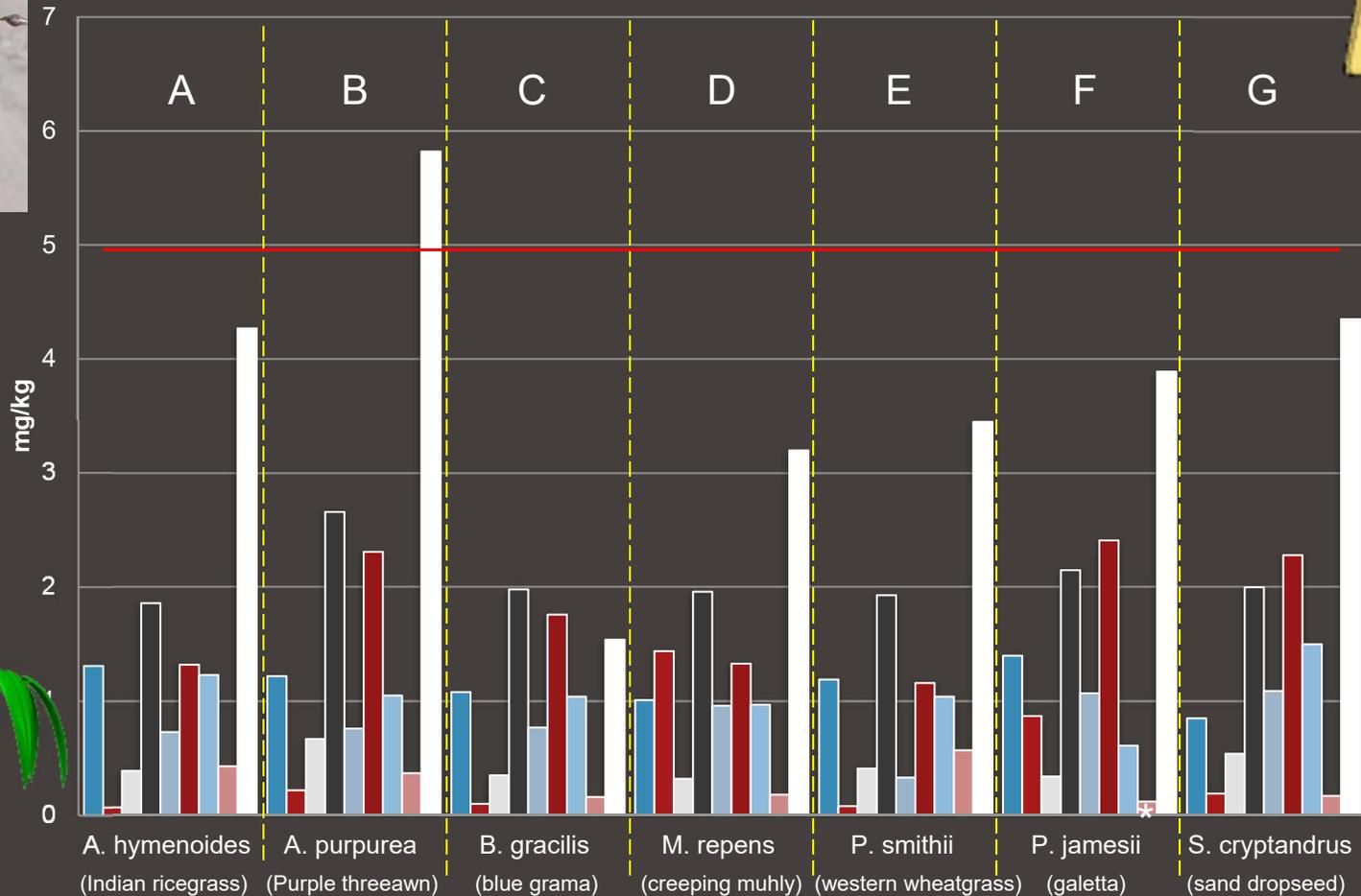
Heavy Metal	Max Tolerable Concentrations
Arsenic (As)	30 mg/kg of diet ^{5,†}
Cadmium (Cd)	10 mg/kg DM diet ¹
Lead (Pb)	100 mg/kg diet DM ¹
Molybdenum (Mo) ^{2,3}	5 mg/kg diet DM ^{5,†}
Selenium (Se)	5 mg/kg DM ⁴
Vanadium (V)	50 mg/kg diet DM ^{1,†}



¹NRC 2005; ²NRC 1985; ³NRC 1975; ⁴Pugh, 2002; ⁵Dreesen & Williams, 1982, NRC 2007†
DM: Dry Matter

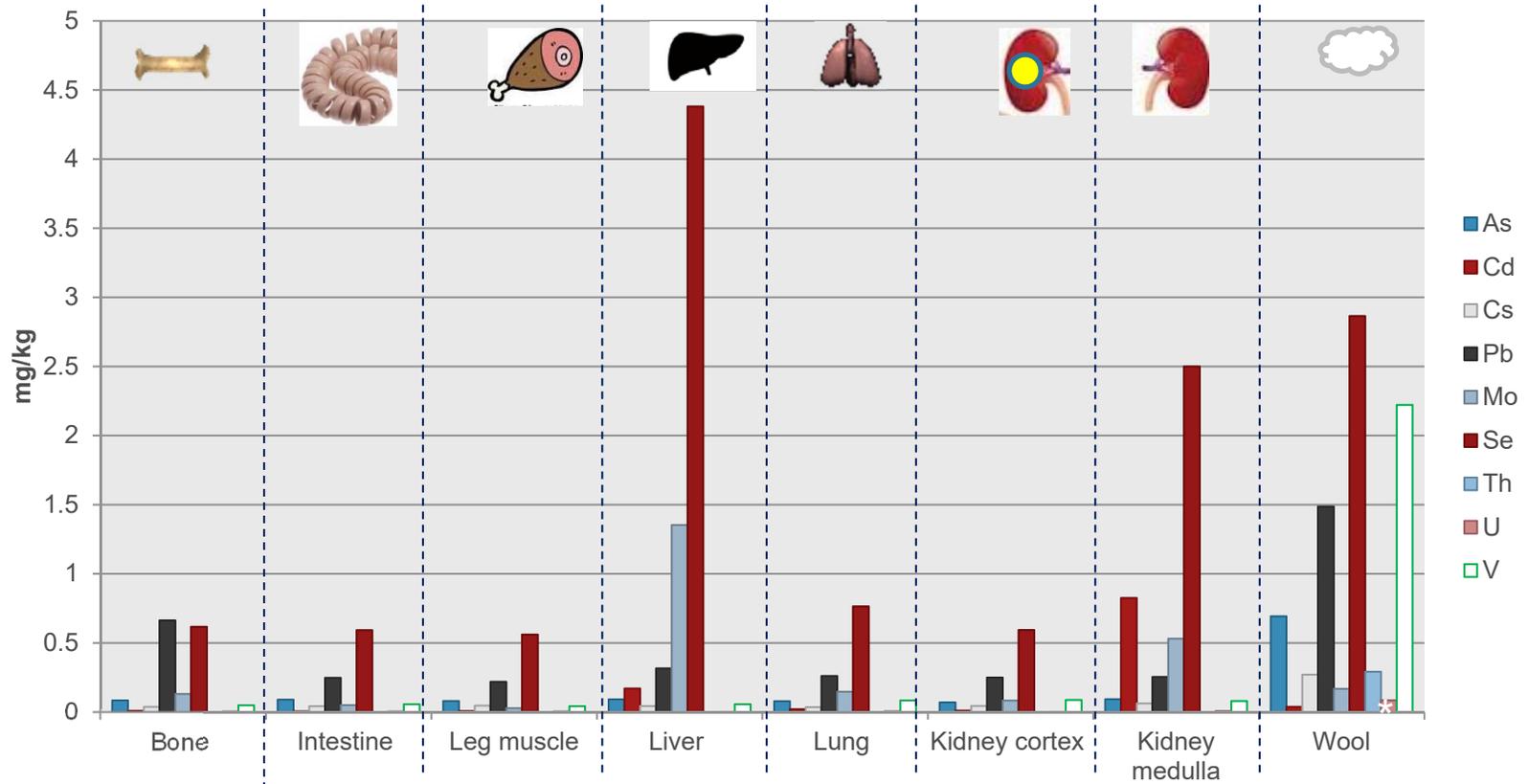


HM Concentration Levels in Forage





HM Concentration Levels (mg/kg) in Sheep Parts



Human Dietary Standards for Heavy Metals

Food HM Provisional Tolerance Weekly Intake (PTWI)

Heavy Metal	Provisional Tolerance Weekly Intake (PTWI)
Arsenic (As)	15 µg/kg Body Weight (BW) ¹
Cadmium (Cd)	7 µg/kg BW ^{1,2}
Lead (Pb)	25 µg/kg BW ^{1,3}

Reference Dietary Intake (RDI), Recommended Dietary Allowance (RDA), Upper Intake Limit (UL)

Heavy Metal	RDI / RDA / UL
Selenium (Se)	RDI: 55 µg/day UL: 400 µg/day ¹
Molybdenum (Mo)	RDA: 45 µg/day UL: 2,000 µg/day
Vanadium (V)	UL: 1,800 µg/day ^{1,3}

¹FAO/WHO 1989; ²JECFA, 2003; ³WHO 1999

THERE IS NO FOOD SAFETY RDI, RDA OR TUL FOR CESIUM, THORIUM OR URANIUM



Summary of the dietary exposure of the target study population to heavy metals from sheep meat protein and organ consumption representative of one day per week.

Heavy Metal	Weekly Intake (µg/kg BW ¹)	PTWI ² (µg/kg BW ¹)	% of PTWI	Once a Week Intake (µg)	RDI ³ or RDA ⁴ or UL ⁵ (µg/day)	% of RDI or RDA or UL
As	1.64	15	10.9	--	--	--
Cd	2.98	7	42.5	--	--	--
Pb	6.2	25	24.8	--	--	--
Mo	--	--	--	92.34	RDA: 45 UL: 2000	205 4.6
Se	--	--	--	392.26	RDI: 55 UL: 400	713 98
V	--	--	--	8.2	UL: 1,800	0.46

¹ Body Weight (reference weight 60 kg); ² Provisional Tolerable Weekly Intake; ³ Reference Dietary Intake; ⁴ Recommended Dietary Allowance; ⁵ Tolerable Upper Intake Level.



Summary

1. Because of low study participation the sample size for samples like sheep were small (N=3) and the study findings should be used with caution; a study with larger samples is recommended

2. There was no samples from the “low” impact areas, samples collected were only from “high” impact areas because of low study participation

3. Greater HM in forage roots vs. above ground plant parts

4. ***SHEEP PROTEIN***: No toxic HM levels in sheep water (most participants used regulated H₂O). Elevated Se levels in some forage (half of MTC) and was seen also in sheep liver, kidney, & wool. No symptoms reported in sheep or flocks, sheep may have adapted to elevated Se levels in forage. Uranium low levels.





Summary

5. Continue to use regulated water sources and avoid unregulated water and areas where soil is contaminated with uranium.
6. Continue monitoring harvested foods, do a study that collects human biological exposure levels.
7. Diversify diet and consume sheep protein that has lower Se (liver) and Cd concentration levels.
8. The food intake calculations are based on adults only and we need further research for those that may be sensitive to heavy metal exposure.





Questions

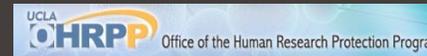
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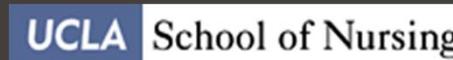
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Dissertation Committee

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Supplement Slides

