ENVIRONMENTAL JUSTICE: UNIQUE EXPOSURE PATHWAYS AND DISPROPORTIONATE EXPOSURES IN LOW INCOME, MINORITY, NATIVE AMERICAN, AND OTHER POPULATIONS: OUTLIERS MATTER

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BACKGROUND
Environmental Justice Issue

- Environmental hazards, exposures, and risks are not uniformly distributed
- Multiple biologic and social risk factors intersect, placing some people at high risk,
- Low income, minority status, and age may create unique exposure circumstances that place some individuals groups at disproportionately high risk

OBJECTIVES

- 1) Review exposure pathways and distributions normally examined by risk assessors.
- 2) Identify and discuss populations with high end exposures and unique exposure pathways
- 3) Provide a framework for identifying unique pathways and outliers

Transformation of EPA Risk Assessment Approaches

Old	New
Single Source	Multiple Sources
Single Media-focused	Multi-media Focused
Single Pathway	Multiple Pathways
Single Route of Exposure	Multiple Routes of Exposure
Single Endpoint	Multiple Endpoints
	Community Cumulative Risk
Central Decision-making	Community-based Decision-making
Command and Control	Flexibility in Achieving Goals
One-Size-Fits-All Response	Case-Specific Responses
Single Stressor Risk Reduction	Holistic Reduction of Risk

From EPA 1997, 2000, 2007

IDENTIFICATION OF COMMUNITY

↓

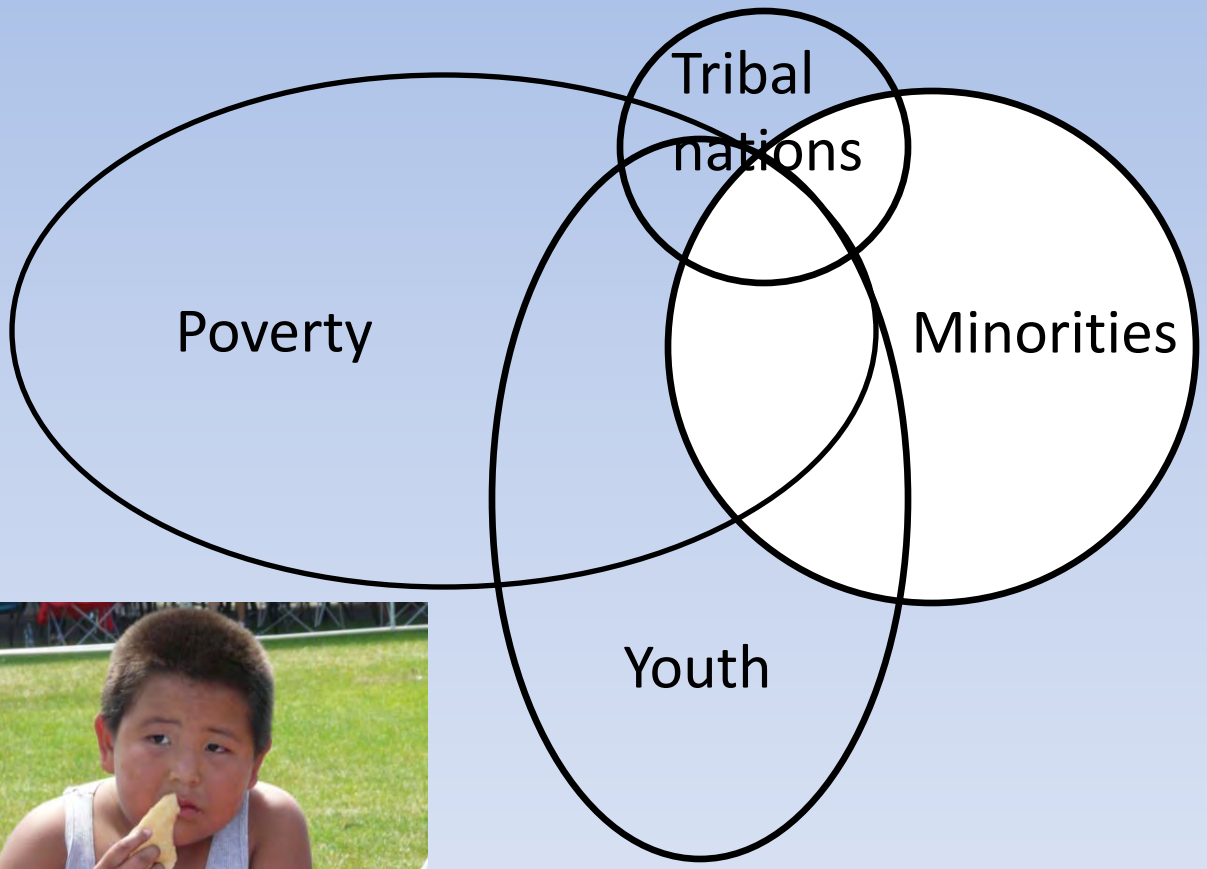
Tools and Methods

information, strategies, exposure models, data bases, analytic methods, GIS

↓

EPA's Risk Paradigms

Intersecting Vulnerability Attributes



STAKEHOLDERS

Psychosocial Stress

Inadequate health care/access

Exposure to noise

Exposure to violence

+

Education

Minority status

Income

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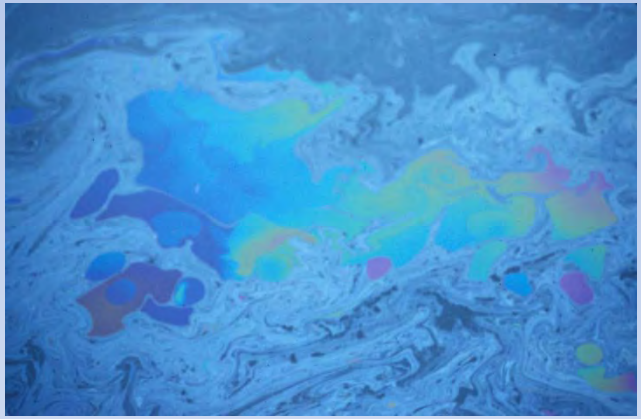


Modify effects of chemicals

INTERACTIONS AMONG RISK FACTORS

National Databases

Community instigated

IDENTIFICATION

Literature Case studies

Recognized Populations

RISK ASSESSMENTS: TRADITIONAL VERSUS ENVIRONMENTAL JUSTICE RISK ASSESSMENTS

Cumulative risk assessment for multiple hazards

Traditional risk assessment examines exposure to a given contaminant (e.g. lead, mercury, PCBs), including one or several exposure pathways (top), but environmental justice communities are often exposed to multiple contaminants, with multiple pathways that lead to complex, cumulative exposures

Exposure Matrix
Pathways of Exposure

	AIR	WATER	SOIL/DUST	FOOD
Inhalation	MAJOR ROUTE	Showering (volatiles)	MAJOR ROUTE	
Ingestion	Deposition on food	MAJOR ROUTE	MAJOR ROUTE toddlers also	MAJOR ROUTE
Dermal		Some organics through showers or swimming	Some organics from muds and slurries	

Main Pathways of Exposure for Human Risk Assessment.

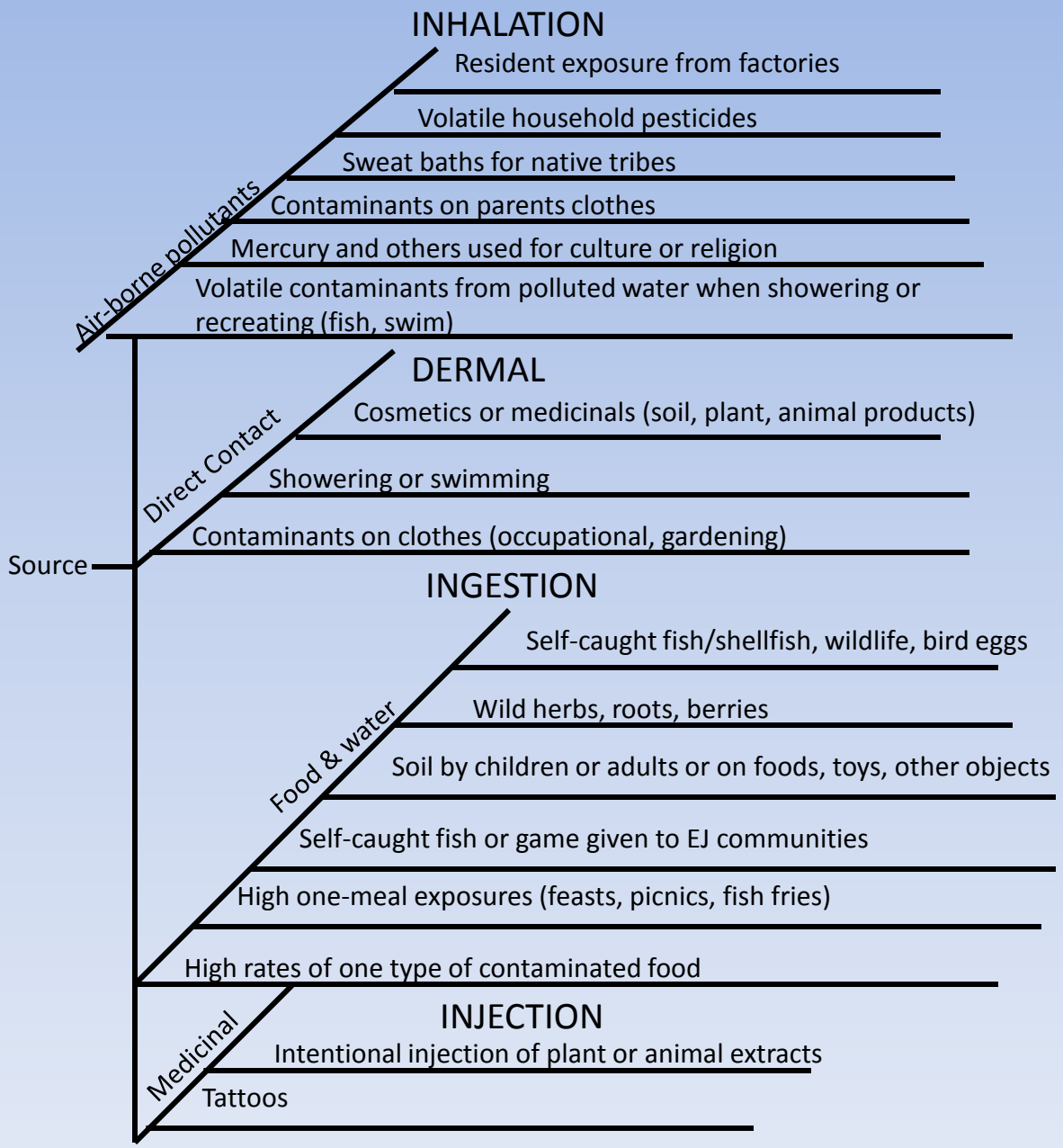
Receptor

Source → pathway → Route of Exposure

Source

- Air-borne Pollutants → Inhalation
- Direct Contact → Dermal
- Food and Water → Ingestion
- Medicinal → Injection

Expanded Conceptual Approach



Air-borne pollutants

INHALATION

Resident exposure from factories

Contaminants on parents clothes

Volatile household pesticides

Sweat baths for native tribes

Mercury and others used for culture or religion

Volatile contaminants from polluted water when showering or recreating (fish, swim)

INGESTION

Food & Water

Self-caught fish/shellfish, wildlife, bird eggs

Wild herbs, roots, berries

High one-meal exposures
(feasts, picnics, fish fries)

Self-caught fish or game given to EJ communities

Soil by children, adults, foods, toys & other objects

High rates of one type of contaminated food

Direct Contact

DERMAL

Cosmetics or medicinals (soil, plant, animal products)

Showering or swimming

Contaminants on clothes (occupational, gardening)

Medicinal

INJECTION

Intentional injection of plant or animal extracts

Tattoos

Potentially Unique Exposure Pathways Developed for Environmental Justice Communities

Consumptive Uses (Ingestion)

- Daily and seasonal consumption patterns
- Wild-caught or gathered foods
- Unusual commercial foods or herbs
- Commercial foods vs. wild foods by biota species and parts
- Daily and seasonal preparation patterns for wild foods or unusual commercial foods
- Unusual consumption patterns by group, age, gender, or season
- Intermittent of high exposures: single meal or single day consumption [feasts, fish fries, socials]
- Inadvertent consumption patterns

  (e.g. children eating dirt)
- Geophagy (deliberate soil ingestion)

TYPES OF FACTORS TO CONSIDER

Hunting

- Preparation for hunting
- Hike to hunting site
- Canoe or boat to site
- Conducting scouting trips
- Setting traplines
- Building blinds
- Capturing or killing prey
- Field dressing of meat
- Hauling our food
- Butchering
- Drying or smoking
- Preparing hides or skins
- Returning remains to nature
- *Are products for food, drink, implements, medicine, cosmetics, or ceremonies
- *What are the terrain types or aquatic conditions?
- *Are game butchered on site or brought back to land or to a village?
- *What are the exertion levels, and time spent in each activity?
- *What are the total pathways of each activity (inhalation, dermal, ingestion)

TYPES OF FACTORS TO CONSIDER

Fishing

Preparations for fishing
Canoe or boat to site
Hike to collecting site
Building piers
Making/repairing nets
Making/repairing poles
Construct drying racks
Fishing activity itself (from shore or boat)
Cleaning or storing fish
Drying & storing fish
Returning remains to nature
*What are the products involved?
*What are the terrain types to get there,
and the aquatic conditions for fishing?

http://www.salem-news.com/stimg/april072008/columbia_basin.jpg

*Are fish butchered on site or brought back to camp or a village?
*Are there gut contents of consideration
*What are the exertion levels and time spent in each activity?
*What are the total pathways of each activity?

Maintenance and Cosmetic Uses

- Tribal sweat baths
- Sand or soil or plant material for maintenance or cosmetics
- Usual commercial materials for cosmetics
- Unique substances for cultural practices (eg. mercury)
- Temporal patterns:

  daily & seasonal,

  frequency, duration

Medicinal, Religious and Cultural Uses

- Types of medicine and healing practices
- Species, types, seasonality and exposure from herbs or other medicines
- Potential roles of commercial medicinals in relation to self-gathered herbs
- Types and frequencies of religious events or ceremonies
- On-site, non-consumptive uses, (eg. Vision Quests or Dream Quests)
- Folk/Cultural Medicines (i.e. Ayurvedic, mercury)
- Temporal patterns: daily & seasonal, frequency, duration
- Lifestyle exposures: alcohol, tobacco, pharmaceutical

Cultural uses of Mercury

- Mercury---elemental
  - Widely available in ***"botanica"*** stores
  - In northeast cities primarily Afro-Caribbean
  - Global issue: mercury used also among Asian Indian, Andean Indians etc
- Superstitious & good luck
  - Sprinkled in new cars and on new babies
  - Carried In pocket to bring "love"
- Quasi-religious practices and healing
- Residual mercury may affect subsequent tenants

Examples

Asian Herbal Medicines	lead	(64% of samples)
(Ayurvedic)	mercury	(64%)
(Ernst 2002)	arsenic	(41%)
	cadmium	(9%)
Chinese medicines	mercury	
(Ernst & Thompson 2001)	cadmium	
	arsenic	
	copper	
	thallium	
Mexican medicines	azarcon	
(Bose et al. 1983)	lead	

Azarcon

Eco-cultural Dependency Webs and Eco-cultural Attributes as Exposure Pathways

Occupational exposures

- Unique exposures and co-exposures
- Take-home exposures

Non-point source exposures (inhalation)

- Air pollution
- Traffic and roadways
- Hazardous waste sites/landfills

Building-related exposures (inhalation, ingestion)

- Housing age and condition
- School age and condition
- Pesticides, lead, mold
- Residences above or next to small industrial sources

  Residences as workplaces (solvents, ceramics, recycling)

Unique Pathways
Examples of high-end exposures

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Environmental Justice

- Original conception
  - Poor or minority neighborhoods clustered around exposure sources
  - Industries, hazardous waste sites, etc.
- Poor communities singled out for LULU's
  - LULUs=locally unwanted land uses
- Poor people could only afford contaminated neighborhoods
- Increasingly EJ applies to groups that may be spatially dispersed

NJ is a poster child for fenceline residences

SOME SPECIAL POPULATIONS covered in our paper

- **Native Americans**
- **Farms, farmers, farm workers and farm neighbors**
- **Migrant Workers**
- **Urban Poor: unemployed, underemployed**
- **Urban gardeners**
- **Conditions of Residences**
- **Conditions of Schools**
- **Conditions of Neighborhoods**
- **Pica and geophagy**
- **Cultural Uses of Mercury**

Children: unique exposures

- Hand to mouth behavior
- Soil ingestion estimates (the risk driver)
- Lead exposure (& housing)
- Pesticide exposure pathways
- Mercury exposure pathways (canned tuna)
- Asthma in urban children

Fish consumption

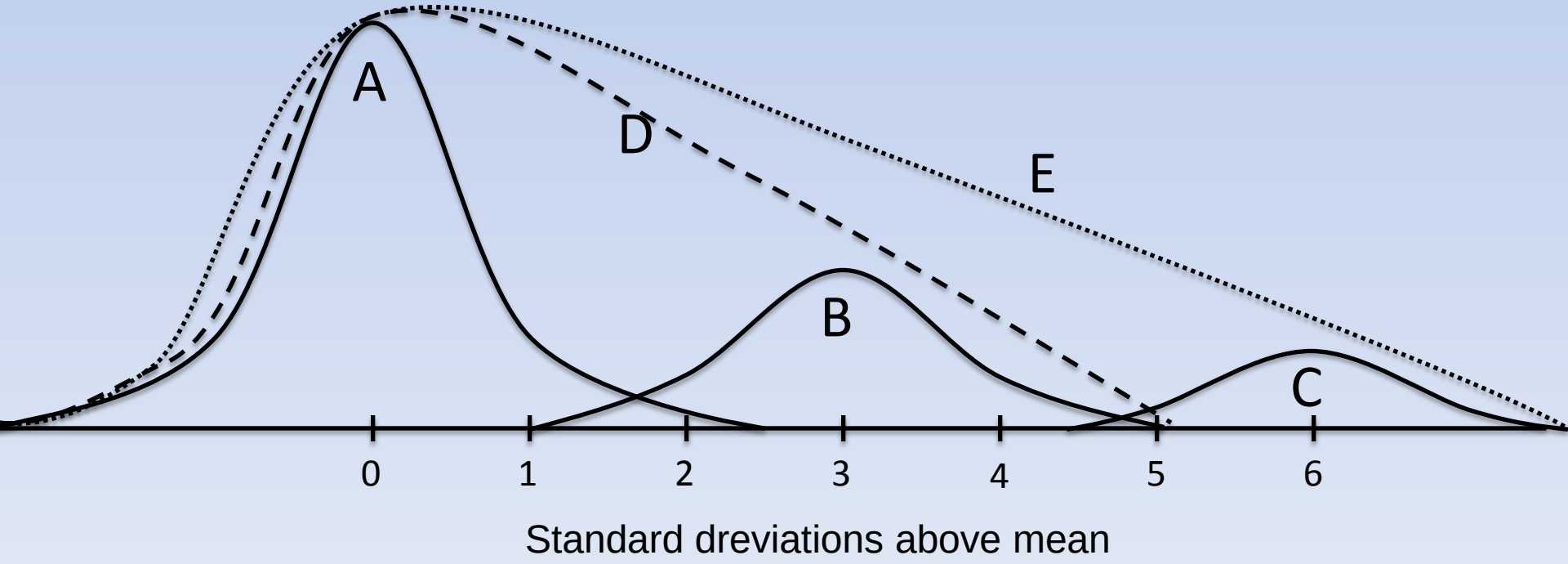
- **Risk assessment default assumptions**
- **High end fish consumers (health reasons)**
- **Recreational fishers**
- **“Subsistence” fishers**
- **Native American scenarios**

Additional pathways & co-exposures

- **Consumptive Resource Use**
- **Non-consumptive Resource Use**
- **Maintenance and Cosmetic**
- **Smoking and demography**
- **Medicinal, Religious and Cultural**
- **Hazardous occupational exposures**
- **Eco-cultural Dependency Webs and Eco-cultural Attributes**

Different Exposure Distributions

A,b,c=‘normal’, d= ‘lognormal’ and e=strongly skewed



Age Specific Estimates of Soil Ingestion by Children(mg/day)

Age	EPA IEUBK defaults	Kimbrough et al. 1984
0-1 year	85	0-9 months=0
		9-18 months=1
1-4 years	135	18-42 months =10000
4-5 years	100	42-60 months =1000
5-6 years	90	100
6-7 years	85	Not specified

Distribution Values for Soil Ingestion

Median soil ingestion value	14 mg/day
Range of median soil ingestion estimates	1-103 mg/day
Median of the upper 95th percentile of the 64 daily ingestion values	252 mg/day
Range of average daily ingestion	1-2268
Median of 64 subjects daily average ingestion	75 mg/day
Upper 95% of the average daily soil ingestion	1751 mg/day

Stanek and Calabrese 1995

Impact on Blood Lead Distribution of Four Different Soil Ingestion Values for Soil Containing 200 ppm of Bioavailable lead

	IEUBK[2] Default of 135 mg/day	Upper 95th percent of median values[1]	Upper 95th percentile of all subjects[1]	Pica at 7.7 g/day
Ingestion value	135 mg/day	258 mg/day	1750 mg/day	7700 mg/day
Geometric mean blood lead (ug/dl)	2.3	3.4	11.3	25
% exceeding 10 ug/dl	0.1%	1%	60%	98%

1=Stanek and Calabrese (1995) 2=EPA Integrated Exposure Uptake Biokinetic Model

Contact Behavior of Infants and Children in Texas.

Videotaping (mean hourly frequency). Mean Events/Hour ± Standard Deviation				
Behavior	**Infants**	**1 yr olds**	**2 yr olds**	**Preschool**
Hand to mouth	19.8 ± 14.5	15.8 ± 8.7	11.9 ± 9.3	22.1 ± 22.1
Object to mouth	24.4 ± 11.6	9.8 ± 6.3	7.8 ± 5.8	10.1 ± 12.4
Food to mouth	10.8 ± 9.0	17.2 ± 14.0	14.7 ± 10.9	15.7 ± 11.8
Videotaping				
% Time on floor		11 ± 10	8 ± 5	9 ± 4

Black et al. 2005

Children's Pesticide Exposure

- Working in fields
- Accompanying parents into fields
- Take-home exposure on clothing
- Cross-contamination of pails
- Household uses of pesticides
- Pesticide residues on foods
- Playing on or with pesticide packaging

Linguistic Problem for Assessment

Percent of farm workers who self-report their English skill levels as "not at all" or "well"

	U.S.-born non-Hispanic		U.S.-born Hispanic		Foreign born Including Mexican Hispanic[1]	
	Speak	Read	Speak	Read	Speak	Read
Not at all	0%	1%	2%	5%	57%	68%
Well	98%	93%	66%	66%	4%	3%

1. There was essentially no difference between Mexican and Central Americans in English skill level

From NAWS 2005

Fish Are Not Created Equal

- Variable Levels of harmful contaminants
- Variable Levels of beneficial Omega-3's
- Variable Levels of microbial contamination
- Variable Desirability (taste, sport)

- Variables a Result of:
  - Fish species
  - Habitat & location
    - General
    - Specific
  - Size & Age of fish

Variety of fish on Adak, Alaska

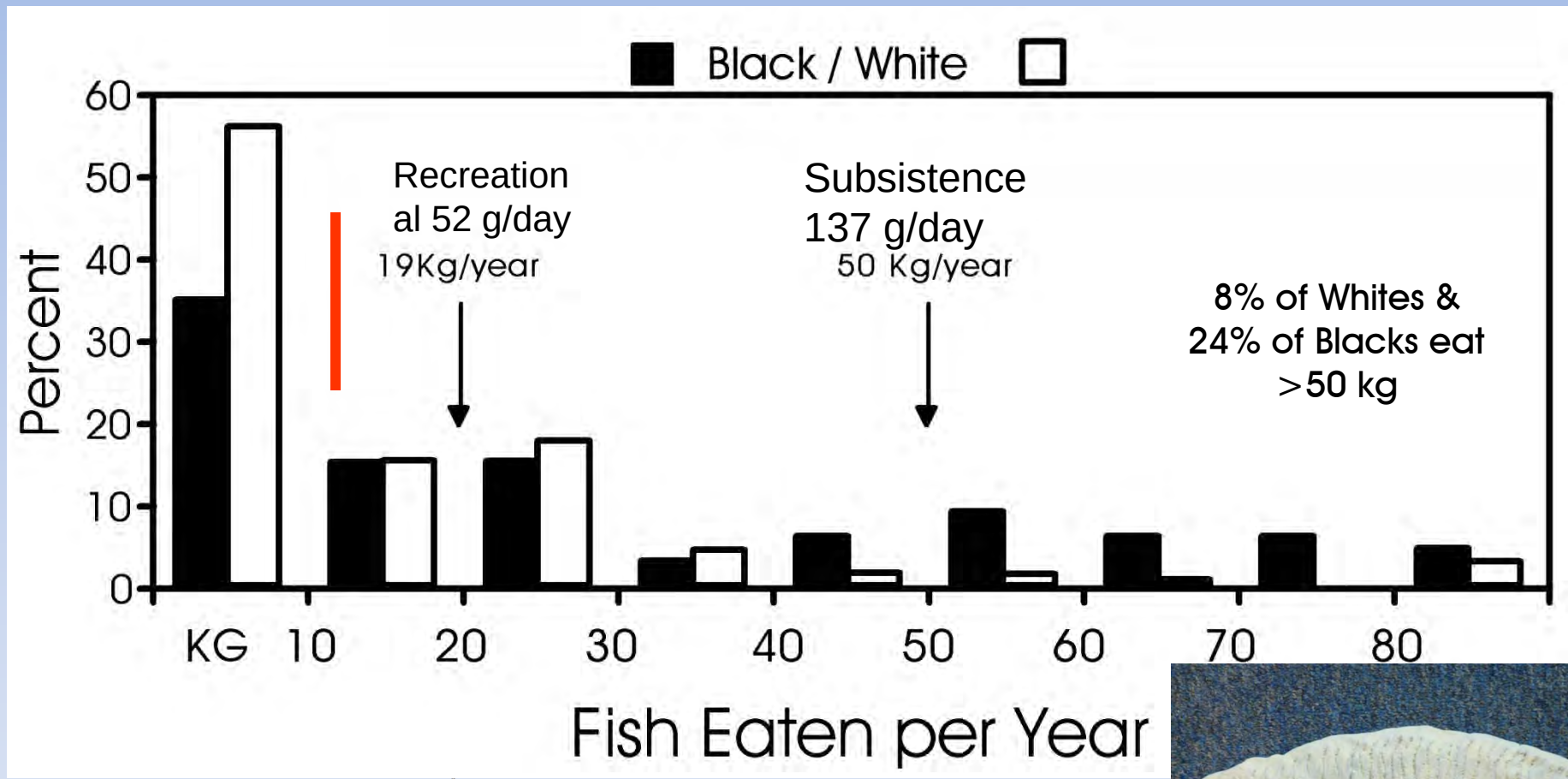
Fishers differ as well

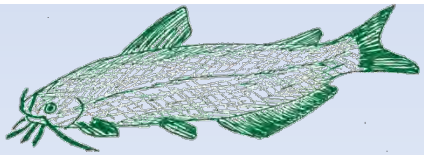
RISK BALANCING FOR FISH

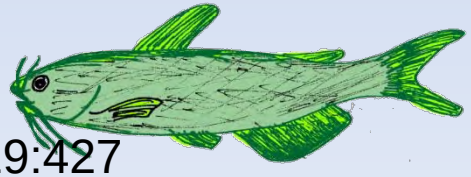
- Low fat protein source
- Locally available in many places
- Omega-3 (PUFAs) & selenium
- BUT
- High methylmercury, PCBs, PFOAs

- Low and moderate consumption: benefit > harm
- High end consumers harm > benefit
  - Modify amount of intake
  - Modify species selected
- CLINICAL OBSERVATIONS---10 MEALS PER WEEK

ENVIRONMENTAL JUSTICE
Fish consumption (kg/year)







Burger et al. 1999 Risk Analysis 19:427

EPA 2008 adult ingestion default (1 meal/wk =32g/day)

Fish (Grams/Day)

140
120
100
80
60
40
20
0

EPA default

Anishinaabe Tribe	Pregnant Inuit	Chippewa	Vietnamese Immigrants	Hispanic	White
DeWeese et al. 2009	Muckle et al. 2001	Peterson et al. 1994.	Cavan et al. 1996	Bienenfeld et al. 2003	Burger and Campbell 2008

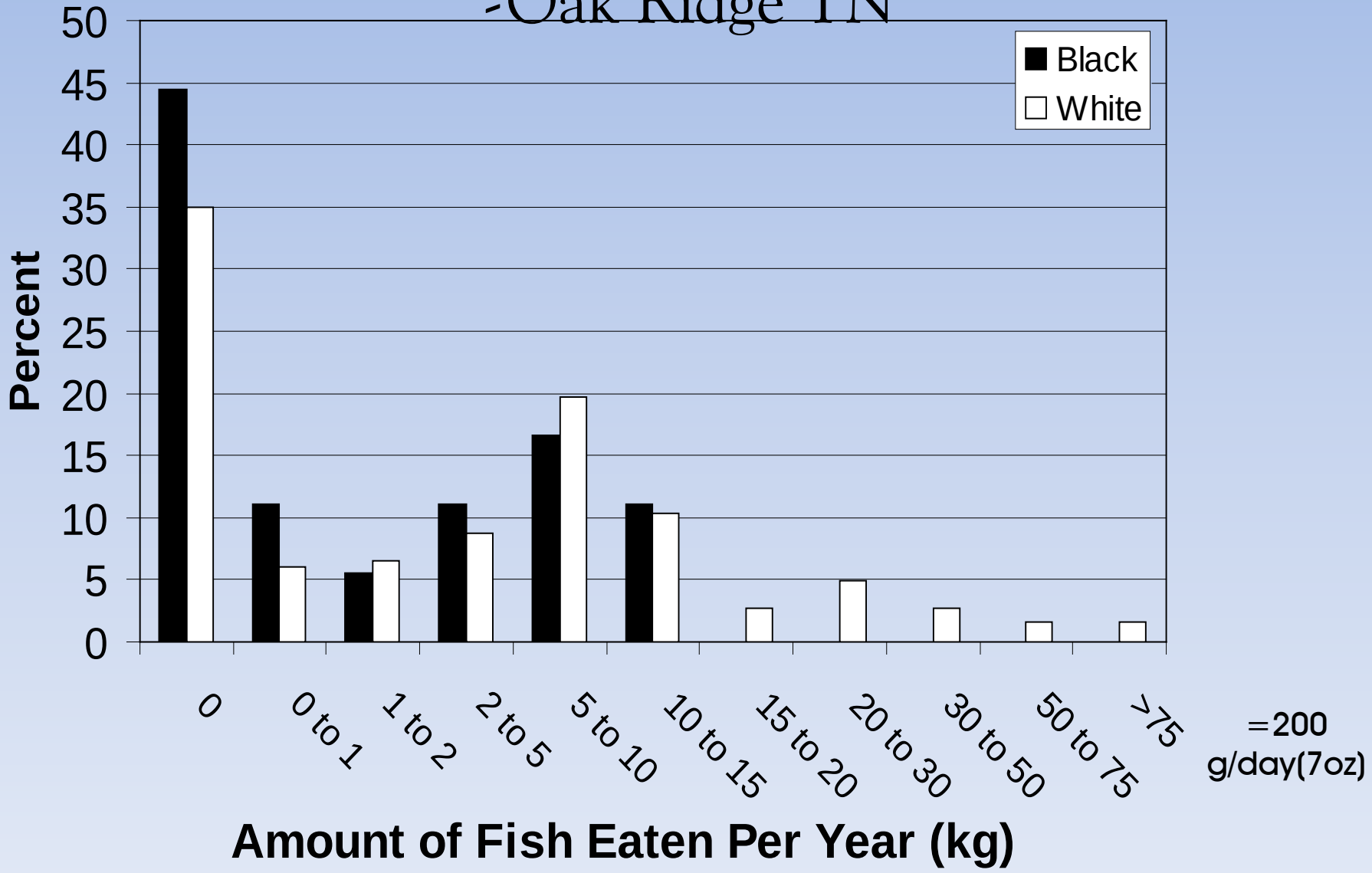
EXPOSURE DATA FOR ADULTS BY PERCENTILE: SOUTH CAROLINA

Age	Sample Size	% Who Eat	Grams/person/day Mean (Range)	Median	75th %	90th %	95th %	99th %
Wild-caught Fish								
32 & under	145	77	32.6 (0.63-412)	14.2	37.6	66.5	123	216
33 to 45	159	77	71.3 (7.52-902)	18.8	67.6	177	354	590
over 45	150	78	44.0 (0.35-538)	20.0	44.4	100	164	286
Wilcoxon X^2			*3.86 (NS)*					

Hitting the High-end

HIGH END CONSUMERS AREN'T ALWAYS MINORITY OR SUBSISTENCE---

-Oak Ridge TN



TYPE	Daily intake Grams/day	Kg/year	Daily Intake of MeHg for a fish with 0.3 ppm (ug/day)	Daily MeHg per kg body wgt (assume 70kg)
MINORITY				
Delaware (KCARD 1994)	Black = 15 Asian = 6 Hispanic = 3	5.5 2.2 1.1	4.5 1.8 0.9	.06 .03 .01
Michigan (West et al. 1992)	Native American=24.3 Black=20.3 Whites = 17.9	8.9 7.4 6.5	7.3 6.1 5.4	.10 .09 .08
San Francisco Bay, Ca (Moya 2004)	Black = 27 Chinese = 28 Filipino = 33 Pacific Is =38 Asian = 22 Hispanic = 22	9.9 10.2 12.0 13.9 8.0 8.0	8.1 8.4 9.9 11.4 6.6 6.6	.12 .12 .14 .16 .09 .09
New Jersey (Burger 2002a)	Asian = 52 Hispanic = 41 White = 27 Black = 23	19.0 15.0 9.9 8.4	15.6 12.3 8.1 6.9	.22 .18 .12 .10
South Carolina (Burger et al. 2001)	Black male=70 Black female=48 White male=38 White female=26	25.6 17.5 13.9 9.5	21.0 14.4 11.4 7.8	.30 .21 .16 .11
SanDiego Bay, CA (Moya 2004)	Asian = 82 Filipino = 50 Hispanic = 24 Caucasian = 11	29.9 18.3 8.8 4.0	24.6 15.0 7.2fs 3.3	.35 .21 .10 .05
Asian and Pacific Islanders, Washington (Sechena et al. 2003)	117.2	42.8	35.2	.50

Published Data on Fish Consumption Reported for Native Americans

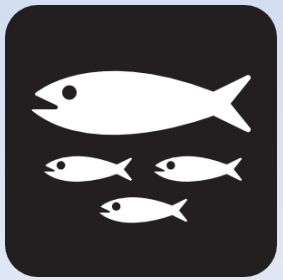
TYPE	Average Daily Intake Grams/day	Kg/year	Daily MeHg Intake for a fish with 0.3 ppm (µg/day)	Daily MeHg per kg body wgt (assume 70kg)
EPA population	6.5	2.4	1.9	.03
EPA Default (EPA 2000)	17.5	6.4	5.2	.08
EPA 2008 8 oz/wk = 32g/day	32	11.8	9.6	.14
EPA for subsistence fishers)(EPA 2000)	142.4 (165.5)	51.8 (60.2)	42.6	.61
Amerindians – (and Currie 1993	Men – 19 Women – 14	6.9 5.1	5.7 4.2	.08 .06
Native American – (West et al.1992)	24.3	8.9	7.3	.10
Tulalip and Squaxin Tribes, , Toy et al. 1996)	60.72[a]	22.2	18.2	.26
Columbia River () tribes (CRITFC 1994)	63.2	23.1	19.0	.27
Anishinaabe, (DeWeese et al. 2009)[b]	15.1 (Dec) 121.1 (April)	5.5 44.2	4.5 36.3	.06 .52
– median for 1950s (Walker and Pritchard 1999)	350	128	105	1.5
(99th percentile) (CRITFC 1994)	389	142	117	1.7
CTUIR traditional rate (Harris and Harper 1997)	454	156	136	1.9
Historic[c] Yakama (Harper and Harris 2008, Harper et al. 2008)	620	226	186	2.7

Both fish and shellfish.
Calculated from high rate for April for the tribe (X 227 g/meal).
refers to what tribal members ate historically before contamination and other factors both suppressed the fish populations and rendered the fish high in contaminants such that fish consumption was lowered.0

Traditional Subsistence or Lifeways Consumption Patterns (g/day)

TRIBE	Fish/shellfish	Game/Meat	Vegetable	Other
Yakama Nation, Washington	150	245	264	
Elmo Pomo,	200	200	1103	36
Washoe Tribe	200	220	1906	40
coastal	514	286	404	148
CTUIR	620	125	1225	125
High fish diet High game	1060 250	150 935	1600 1600	

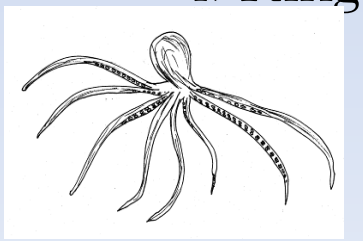
8 ounces = 226grams

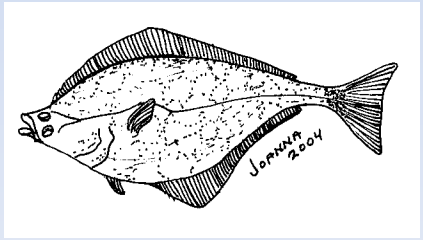


Harper et al. 2008

ALEUTIAN ISLAND FOOD SURVEY RESULTS

1. Villagers regularly use 59 kinds of wild resources
2. Villagers used 19 kinds of fish, 13 kinds of marine invertebrates, 12 kinds of birds and eggs, and 11 kinds of mammals (includes Sea Lion)
3. Households used an average of 23 kinds of wild resources
4. 95 % gave away some of their catch
5. Percent of all households using:
    a. Sockeye Salmon = 95%
    b. Halibut and Cod = 95%
    c. Octopus = 90%
    d. Chitons = 85%
    e. Dolly Varden = 75%
    f. King Crab = 75%





Direct Exposure from Confederated Tribes of the Umatilla Indian Reservation

Direct Pathway	Default Suburban	Rural Gardener	Subsistence Forager
Inhalation (m^3/day)	20m^3	25m^3	30m^3
Drinking water ingestion (L/day)	2L/d	3L/d	3L/d + 1 L for sweat lodge
Soil ingestion (mg/d)	50-100 mg/d	300 mg/d	400mg/d
Exposure frequency days/year	Up to 365 days	Up to 365 days	365 days/24 hrs
Exposure duration	30 years	70 years	70-75 years
Body weight	70 kg	70 kg	70 kg

Exposure Information Needed from Dietary Studies to Allow Adequate Risk Assessment

Consumption patterns

- Number of meals per week (mean, median, maximum, percentiles up to 99)
- Size of the meals (mean, median, maximum, percentiles up to 99)
- Composition of those meals (species of fish, game, plant, herb)
- Parts eaten (for fish, shellfish and game)
- Size of the fish eaten (means, range)
- Method of cooking (and skin off or on)

Individual status

- Age, gender, ethnicity
- Pregnancy or child-bearing age
- Nutritional status
- Other compromising characteristics

Exposure Duration

- Lifetime exposure
- Acute or peak exposure (many meals in a short period of time)

Temporal patterns

- Differences in consumption patterns by age group
- Differences in consumption patterns by season (and month)
- Differences in consumption patterns by changing mores[a]
- Total years of exposure

Precautionary Action

- More research is always needed
- More research will always be wanted
- But the words *"more research is needed should not be used as an excuse for failure to take actions."*
- We need to invoke precaution while our science base is maturing.
- Link to the national POLLUTION PREVENTION initiative (P2)
- International Environmental Justice
  - Our hazards are being exported to poor communities in other countries

INTERACTIONS AMONG PROXIMATE RISK FACTORS

INTERACTIONS AMONG RISK FACTORS

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