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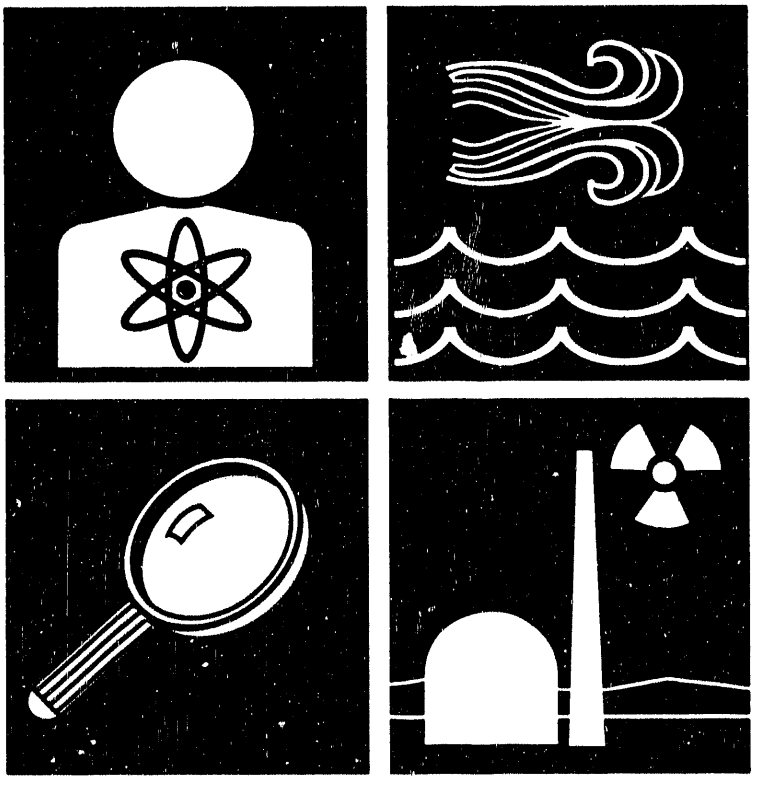
Methodology for Reconstruction of Historical Food Consumption Estimates

D. M. Anderson

May 1992



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METHODOLOGY FOR RECONSTRUCTION OF HISTORICAL FOOD CONSUMPTION ESTIMATES

Hanford Environmental
Dose Reconstruction Project

D. M. Anderson

May 1992

Letter report for the
Technical Steering Panel

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

SUMMARY

This letter report was written to provide the food consumption methodology to be used in the Hanford Environmental Dose Reconstruction (HEDR) Project beyond Phase I (which ended in July 1990). Phase I efforts were judged by the Technical Steering Panel to be adequate for use in preliminary dose estimates, but greater precision is now required for consumption estimates of food types that are dominant contributors to dose.

In Phase I (Callaway 1992), baseline food consumption estimates (grams per day) for 10 primary food types in the original 10-county study region were derived from the 1977-1978 National Food Consumption Survey (USDA 1983). Callaway (1992) developed food consumption ratios to project these estimates into the past (1945) using other U.S. Department of Agriculture (USDA) sources of food consumption information. The baseline estimates were multiplied by the 1945:1977 ratios to produce consumption estimates for 1945 (e.g., see Appendix A). This ratio backcasting method used in Phase I to project consumption estimates from 1977 back to 1945 will be refined using additional USDA data to improve and document the acceptability of the ratios for deriving backcast consumption estimates. The number of food types and population groups will be expanded to provide more disaggregated estimates of food consumption. Food consumption estimates will be developed for 1945, 1951, and 1957.

A database of individual diets will be created from which daily diets will be randomly selected for use in the dose model to calculate doses for reference individuals. Existing data on historical food consumption patterns in the expanded 19-county HEDR Project study region will continue to be evaluated for reliability in adjusting nationwide consumption estimates for use in the HEDR Project study region. Much of the existing data comes from local surveys of varying degrees of quality and completeness, and some may prove unreliable for verifying estimates derived in this work.

Resolution, precision, and acceptability of the estimates will be improved from those used in Phase I. This letter report describes activities that will be conducted by the Food Consumption Subtask of Task 06 during

FY 1992 and FY 1993. Results of these activities will be reported in the Task 06 final report due in 1993 (Milestone 0602C, Food Consumption Report, General Population).

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INTRODUCTION

The primary objective of the Hanford Environmental Dose Reconstruction (HEDR) Project is to develop estimates of radiation doses that individuals could have received from operations of the Hanford Site since 1944, with descriptions of the uncertainties inherent in such estimates.

Part of the dose estimation process involves identifying pathways by which people could have been exposed to radionuclides. One of these exposure pathways is ingestion of food products that may have been contaminated by radionuclides released from Hanford-Site facilities (PNL 1991). Thus, estimates of food consumption are required to reconstruct the dietary patterns of individuals during Hanford releases from the 1940s and 1950s. Specifically, consumption estimates and related distribution statistics are required inputs to dose modeling efforts as described by Napier et al. (1992), and as specific input parameters in the dose model code (Ikenberry et al. 1992). Milk and leafy vegetables are particularly important pathways for ingestion of radionuclides (Napier 1991).

Estimates of food consumption for a limited geographical area were provided for Phase I of the HEDR Project in Callaway (1992). After Phase I ended in July 1990, the geographical study area was expanded to include 19 counties surrounding Hanford.[a]

This report describes the methodology that HEDR staff at the Pacific Northwest Laboratory developed for use in estimating food consumption for the expanded study region. The report completes Milestone 0602B (Shipler 1992) for the HEDR Project. This letter report describes activities that will be conducted by the Food Consumption Subtask of Task 06 during FY 1992 and FY 1993. Results of these activities will be reported in the Task 06 final report due in 1993 (Milestone 0602C, Food Consumption Report, General Population). The methodology is designed to obtain reliable estimates of the diets

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(a) Counties are Adams, Asotin, Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Spokane, Walla Walla, Whitman, and Yakima in Washington, and Gilliam, Morrow, Sherman, and Umatilla in Oregon.

of reference individuals living in the 19-county HEDR region with resolution by age, sex, geographic region, and other factors relevant to dose estimation for 1945, 1951, and 1957, years for which air releases of radionuclides were high relative to other time periods (PNL 1991).

METHODOLOGY

This section summarizes the methodology used in Phase I of the HEDR Project to estimate food consumption, and describes the current methodology.

PHASE I CONSUMPTION ESTIMATES

In Phase I, the 1977-1978 National Food Consumption Survey (NFCS) individual food intake data were used as baseline consumption estimates. Secondary sources of food consumption estimates (USDA 1965a, 1975, and 1985) were used to develop ratios of food consumption, 1965:1977 and 1945:1977. The 1977-1978 NFCS consumption estimates were multiplied by the ratios to provide an estimate of consumption in 1965 and 1945, backcasted from 1977 raw data. A general concern raised in the comments on the Phase I food consumption report (Callaway 1992) was the need for greater precision in the food consumption estimates. Ten food types were derived from the aggregation of the 3,725 groups for which individual intake data were collected in the 1977-1978 NFCS. The mean daily gram intake of each of the 10 food types was reported for each population subgroup or cell (age, sex, season, etc.). Most of the standard deviations reported for these means were larger than the means themselves. This problem was common across all cells, regardless of sample size, and is partially explained by the wide variation in food consumption among individuals on any given day.

CONSUMPTION RATIOS

The ratio backcasting method used in Phase I to estimate historical levels of food consumption in the HEDR study area (Callaway 1992) will be validated using other secondary sources of consumption trend data (USDA 1955, 1965b, and 1972). Specifically, concerns about ratios estimated for consumption of leafy green vegetables will be addressed. For example, the Phase I results indicated that the 1945:1977 ratio of leafy vegetable consumption was 1.55 (Callaway 1992). Technical Steering Panel (TSP) reviewers indicated that the inverse should be expected (Callaway 1992, Appendix D). However,

preliminary analysis of available trend data (USDA 1965b) indicates that the Phase I backcasting ratios are generally reliable for estimating consumption, with some fine tuning required. For historical context, World War II was ending in 1945. Part of the war effort involved the planting of "victory gardens." These gardens served to augment the domestic food supply with home-produced food, while freeing commercial quantities of fruits and vegetables for military consumption.

For post-Phase I work, similar ratios will be developed to backcast from 1977 to 1949, 1951, and 1957. With assistance from Task 08 (Statistics), the degree of uncertainty that these ratios introduce into consumption estimates will also be assessed (see the example provided in Appendix A).

POPULATION GROUPS

Population groups or cells refer to the specific groupings of survey respondents according to age, sex, race, and geographic location (see Appendix C). In Phase I, TSP reviewers indicated that because of insignificant differences in consumption estimates among various population subgroups, further collapsing of subgroup categories would be desirable (Appendix D of Callaway 1992). This was found to be true for milk, but significant differences are expected to exist across age/sex groups for others of the revised food types to be used for post-Phase I work (see Appendix B). TSP reviewers also commented that finer resolution of population groups might be needed to more precisely measure the food intake of infants and adults. Age groups for post-Phase I analysis will be consistent with those presented in Napier et al. (1992, Table 2.1).

Urban and rural geographic distinctions will continue to be included. Based on preliminary analysis of available United States Department of Agriculture (USDA) trend data, it is apparent that consumption differs depending on whether food was purchased or nonpurchased. Therefore, this distinction will be added to assist in determining home-produced or local consumption, and thus the geographic source of the food consumed. Race groups will include

white, black, hispanic, and other nonwhite.[a] Distinctions will continue to be included in the analysis for spring, summer, fall, and winter seasons. It should be noted that, as in Phase I, because of the large number of population groups being considered, individual population cells may not have a sufficient number of observations to make meaningful estimates in all cases. For example, if the NFCS data contain only 10 observations of rural females, ages 10-14, who ate nonpurchased spinach, the reliability of an estimate that represents all rural females, ages 10-14, is less than if there were 50 such observations.

DISTRIBUTION INFORMATION

The 1977-1978 NFCS individual intake data (USDA 1983) will be aggregated from 3,725 seven-digit food types to 74 food types (see Appendix B). Histograms and accompanying univariate statistics will be calculated and reported for each population subgroup (e.g., urban, female, over 20 years, black, nonpurchased food). These statistics will include the number of observations, mean, median, range, percentiles, standard deviation, and standard error for each cell, as well as the histogram showing the distribution of grams of food consumption per day.

DATABASE OF INDIVIDUAL DIETS

Future food analysis work will involve creating a database of individual diets (DID) to be used by Task 07 (Environmental Pathways and Dose Estimates) when estimating doses for individuals. The concept is to create a source of seasonal dietary information based on the HEDR Project food types and the individual intake data from the NFCS. Each individual observation in the NFCS data will have the reported consumed foods aggregated to the 74-type level. This information, in addition to all demographic information available, will form one record in the DID. Each column in the DID will represent one of the HEDR Project food types, and each row will represent an individual of a given age, sex, region, and socioeconomic classification (see example in Appendix A).

(a) Native American food consumption estimates are being studied in a separate HEDR subtask (0605, Native American Data).

Using the DID for a particular season, the dose model will be able to randomly select from daily diet information for specific representative individuals. This information will be provided to Task 07 to allow the reconstruction of a possible chain of daily diets for specific individuals for a month or more in time. This approach avoids the need for between-food correlation matrices. These correlations will be included automatically because daily diets, rather than individual foods, will be randomly selected.

However, this approach does not control for correlation of food consumption among days or for regular food eating cycles. This problem will be addressed to some extent by stratifying or dividing the database by selected food consumption patterns exhibited to form strata or divisions that contain similar types of individuals. Additionally, NFCS data from the 1977-1978 survey are provided for three consecutive days per individual. Correlations between days 1 and 2, 1 and 3, and 2 and 3 will be calculated to identify any between-day correlations over the three-day period. If strong between-day correlations are present, then attempts will be made to incorporate these correlations into time sequences of daily diets that are generated from the DID. Daily diets from the appropriate strata will be sampled to generate a time sequence of diets. The sequences of daily diets will be reviewed by nutrition experts to evaluate their credibility and reliability in representing actual eating habits. Based on nutritionist evaluation, changes in the approach will be made as needed to improve reliability.

VERIFICATION WITH PREVIOUS WORK

The USDA conducted the only decennial comprehensive surveys of food consumption on a national level in 1955, 1965, 1977-1978, and 1985. The 1955 NFCS data provide only household-level information (not by individual) and are not a useful source for checking the reliability of estimates of consumption by individuals for the 1945-1955 period. NFCS individual food intake data were collected during the spring of 1965. The 1977-1978 NFCS effort provided an increase in detail and volume of individual intake data collected above that of the 1965 NFCS. The 1985 NFCS was targeted to measure food consumption of low-income households and single mothers in particular.

The 1977-1978 NFCS data set will be used to develop baseline estimates of consumption to which backcasting ratios will be applied. The 1965 NFCS data set will serve to verify an estimated consumption ratio for 1965. If it is determined that other secondary sources of consumption data, such as the 1955 NFCS, can provide per capita consumption by food type, then they will also be used to verify backcasting ratios and consumption estimates.

DATA QUALITY OBJECTIVES

Future work will produce refined estimates of food consumption to be used as inputs to the dose model. Data quality objectives for this work build on those presented in Shipler (1992, p. 7.4).

Accuracy - The estimation of likely daily diets over time will be evaluated by nutritionists to assess accuracy. Uncertainties and sources of error that diminish accuracy will be characterized with assistance from Task 08.

Precision - Frequency distributions of consumption data will be calculated by food type (Appendix B) and population group (Appendix C). Associated means, medians, percentiles, standard deviations, and standard errors will be reported for each group. Precision also will be assessed by comparing food consumption estimates to known consumption estimates derived from independent data sources.

Completeness - Food consumption estimates and daily diets will be developed for all dose-relevant food types and population groups using the entire 1977-1978 NFCS data set. As in Phase I, detailed results will be presented for fresh dairy categories and leafy dark green vegetable categories. Analytical results for other food types will be presented in summary detail.

Representativeness - The selected food types will represent the likely foods produced and consumed in the HEDR Project region during the time period being considered and that are believed to be dominant contributors to radiation dose.

Reliability - This work will produce estimates of consumption that are acceptable and consistent with available secondary data sources such as USDA trend data. Estimates should withstand peer review.

Comparability - Estimated backcasting ratios will be refined to incorporate sources of historic consumption data. Resolution of the consumption estimates will be improved from Phase I by expanding the number of food types from 10 to 74, allowing a greater distinction between types of food.

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APPENDIX A

EXAMPLE OF RATIO BACKCASTING TO 1945 AND DATABASE OF INDIVIDUAL DIETS

APPENDIX A

EXAMPLE OF RATIO BACKCASTING TO 1945 AND DATABASE OF INDIVIDUAL DIETS

Steps

- Identify per-capita food consumption estimates for 1945 from secondary data in terms of grams consumed per day for each food type.
- Use 1977-1978 National Food Consumption Survey (NFCS) individual intake data as the base, per-day, food consumption estimate for each food type.
- Divide the USDA per capita food consumption in 1945 by the USDA per capita food consumption in 1977 to get a ratio (1945:1977).
- Multiply the base-level (1977-1978) consumption estimate from survey data by the 1945:1977 ratio to get estimated consumption in 1945.
- Provide an estimate of uncertainty associated with the estimated ratio.

Summary: Food consumption estimates for 1945, 1951, and 1957 will be projections of the 1977-1978 NFCS sample back to the respective years using food consumption ratios.

BACKCASTING EXAMPLE

Lettuce

Year	Per-Capita Consumption (lb)	Source[a]
1945	13.7	USDA Agriculture Statistics
1951	14.9	USDA Agriculture Statistics
1957	17.1	USDA Agriculture Statistics
1965	19.5	USDA Agriculture Statistics
1977	22.7	USDA Agriculture Statistics

Year	Ratio
1945	13.7/22.7 = 0.6035
1951	14.9/22.7 = 0.6564
1957	17.1/22.7 = 0.7533
1965	19.5/22.7 = 0.8590

Uncertainty Check

The 1965 example estimate of 19.5 lb of lettuce from trend data is acknowledged to include poundage of all lettuce sales, and therefore includes lettuce waste. To partially quantify the uncertainty introduced by including food waste, we can compare 19.5 lb to an example estimate from the 1965 NFCS data that includes only consumed (eaten or drunk) food of 16.9 lb. This results in an estimate of the amount of food waste included in the 1965 ratio of 2.6 lb, or 13.3%. This means that the food consumption ratio estimated from data that includes food waste over estimates the amount of food actually consumed by approximately 13.3%, assuming that food waste as a proportion of actual consumption remained relatively stable over the 1945-1965 period.

EXAMPLE: > 20 year-old, nonmetropolitan, white, female

1977 NFCS data might indicate a mean daily consumption of lettuce of 1000 grams or 2.2 lb.

Estimated average daily consumption by study year for this population cell would be

1945	0.6035 • 1000 g = 603.5 g
1951	0.6564 • 1000 g = 655.4 g
1957	0.7533 • 1000 g = 753.3 g
1965	0.8590 • 1000 g = 859.0 g

(a) Sources and numbers are for example purposes.

Example Database of Individual Diets

#	Sex	Age	Region	$Food_1$ grams	$Food_2$ grams	$Food_3$ grams
1	F	11	Urban	8.8	436.9	3.5
2	M	2	Rural	5.4	123.0	27.5
3	M	24	Urban	10.7	1034.4	0.6
4	F	23	Urban	1.0	965.6	25.9
5	M	65	Rural	8.7	788.6	34.2
6	F	8	Urban	6.8	41.9	12.9
7	M	18	Urban	10.8	366.7	88.0
8	F	47	Rural	6.2	870.8	23.1
9	M	7	Urban	10.8	0.0	53.1
10	M	12	Urban	3.0	319.1	34.7

APPENDIX B

FOOD TYPES

APPENDIX B

FOOD TYPES

FOOD

Dairy Products

1 Fresh milk
2 Cheese
3 Cottage cheese
4 Other cheese
5 Ice cream and other frozen desserts
6 Baby formula and canned milk products
7 Dried milk products
8 Goat milk

Fresh Vegetables (including fresh-cooked)

9 Green peas
10 Corn
11 Asparagus
12 Tomatoes
13 Snap beans
14 Cabbage
15 Lettuce
16 Spinach
17 Cauliflower
18 Celery
19 Broccoli
20 Carrots
21 Green onions
22 Other onions
23 Beets
24 Turnips, rutabagas
25 Squash, pumpkin
26 Cucumbers
27 Green peppers
28 Lima beans
29 Leafy vegetables, Not Elsewhere Classified
30 Other fresh vegetables, Not Elsewhere Classified

Canned and Frozen Vegetables

31 Spinach
32 Leafy vegetables, Not Elsewhere Classified
33 Tomatoes
34 Peas

35 Snap beans
36 Corn
37 Asparagus
38 Other canned/frozen vegetables

Other Vegetables

39 Dried vegetables
40 Fresh white potatoes
41 Fresh sweet potatoes
42 Processed potatoes
43 Vegetable juices

Fruits

44 Apples
45 Pears
46 Strawberries
47 Other berries
48 Sweet cherries
49 Melons
50 Grapes
51 Apricots
52 Peaches
53 Plums (Italian prunes)
54 Other noncitrus (banana and pineapple included in Other)
55 Noncitrus fruit juices (banana and pineapple included in Other)

Fresh Meat

56 Beef
57 Pork
58 Chicken
59 Other poultry
60 Game meat
61 Game poultry
62 Cured pork
63 Lunchmeat
64 Other fresh meat products
65 Eggs

Fresh Seafood

66 Local fish
67 Other fish
68 Shellfish
69 Other seafood

Grain Products

70 Flour and prepared mixes
71 Bread, rolls
72 Other bakery products

Other

73 Mixtures
74 All other foods

APPENDIX C

POPULATION GROUPINGS

APPENDIX C

POPULATION GROUPINGS

Age/Sex

1 All < 1 year
2 All 1 to 4 years
3 Male 5 to 9 years
4 Female 5 to 9 years
5 Male 10 to 14 years
6 Female 10 to 14 years
7 Male 15 to 19 years
8 Female 15 to 19 years
9 Male ≥ 20 years
10 Female ≥ 20 years
11 Pregnant female

Geographic

1 Urban
2 Suburban
3 Nonmetro

Race

1 White
2 Black
3 Hispanic
4 Other

Purchased

1 Purchased food
2 Nonpurchased food

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