The Arizona Border Study

An Extension of the
Arizona National Human Exposure Assessment Survey (NHEXAS)Study
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Quality Systems and Implementation Plan for Human Exposure Assessment

The University of Arizona
Tucson, Arizona 85721

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Standard Operating Procedure **SOP-IIT-A-7.0**

Title: Calculating Ingestion Exposure, Estimating Ingestion Exposure, the Indirect Method of Exposure Estimation

Source: The University of Arizona

U.S. Environmental Protection Agency
Office of Research and Development
Human Exposure & Atmospheric Sciences Division
Exposure & Dose Research Branch

STANDARD OPERATING PROCEDURE FOR CALCULATING INGESTION EXPOSURE ESTIMATING INGESTION EXPOSURE, THE INDIRECT METHOD OF EXPOSURE ESTIMATION

This Standard Operating Procedure (SOP) uses data that have been properly coded and certified with appropriate QA/QC procedures by the University of Arizona NHEXAS team.

Objective

Estimate the ingestion exposure using consumption values from the 4-Day period Diet Diary Questionnaire and residue concentration data from the Total Diet Study (TDS) database.

Exposure Calculation

The equation used to calculate the indirect daily ingestion exposure for each person is as follows:

$$E_{T,D} = \frac{\left[\sum_i C_i \times W_{i,D}\right]}{BW} \qquad (4\text{-}1)$$

where $E_{T,D}$ is the total daily ingestion exposure to all chemical residues found in the food items consumed by each subject during day D, mg/kg.day.

D is the day for which the exposure is calculated. There are 4 days in the Diet Diary Questionnaire.

C_i is the concentration of the chemical residue, chlorpyrifos or diazinon, in the food item i consumed by each subject during day D, mg/kg. Three C_i values will be used: $C_{i,max}$, $C_{i,min}$, and $C_{i,avg}$.

$W_{i,D}$ is the weight of the food item i consumed by each subject during day D, kg.

BW is the body weight of each subject, kg.

The equation used to calculate the indirect weekly ingestion exposure for each person is as follows:

$$E_{T,W} = \frac{\left[\sum_i C_i \times W_{i,W}\right]}{BW} \qquad (4\text{-}2)$$

where $E_{T,W}$ is the total weekly ingestion exposure to all chemical residues found in the food items consumed by each subject, mg/kg.week.

C_i is the concentration of the chemical residue, chlorpyrifos or diazinon, in the food item i consumed by each subject during the 4-day period, mg/kg.

$W_{i,W}$ is the total weight of the food item i consumed by each subject for one week. This value is based on the extrapolation of the 4-day period value. The extrapolation is done by multiplying a factor of 7/4 to the total weight of the food item consumed during the 4-day period. The unit is kg.

BW is the body weight of each subject, kg.

The consumption unit used in the Diet Diary questionnaire is "serving". This unit has to be converted to kilograms. The conversion is explained in SOP#8.

The minimum, maximum, and average concentration values of chemical residue in the food items are obtained from the Total Diet Study (TDS) database, which are integrated in the Dietary Exposure Potential Model (DEPM).

Variable List

Variable	Description
HHID	Household I.D.
AZCODE	The food code used in the Diet Diary Questionnaire
DAY1SERV	Number of servings of each food item on day1.
DAY2SERV	Number of servings of each food item on day2.
DAY3SERV	Number of servings of each food item on day3.
DAY4SERV	Number of servings of each food item on day4.
KG	Conversion factor for converting the unit of each food item from servings to kg. The unit is kg/serving.
BW	Body weight of each subject, kg.
FDMASS-D1	The mass of each food item consumed on day 1, kg.
FDMASS-D2	The mass of each food item consumed on day 2, kg.

Variable	Description
FDMASS-D3	The mass of each food item consumed on day 3, kg.
FDMASS-D4	The mass of each food item consumed on day 4, kg.
FDMASS-WK	The cumulative mass of each food item consumed in one week, kg.
CH_MIN	Minimum value of the concentration of chlorpyrifos in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.
CH_MAX	Maximum value of the concentration of chlorpyrifos in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.
CH_AVG	Average value of the concentration of chlorpyrifos in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.
DI_MIN	Minimum value of the concentration of diazinon in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.
DI_MAX	Maximum value of the concentration of diazinon in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.
DI_AVG	Average value of the concentration of diazinon in each food item obtained from the Total Diet Study (TDS) data in the Dietary Exposure Potential Model (DEPM), mg/kg.

Variable	Description
CH-MINEX-D1	The minimum daily ingestion exposure to chlorpyrifos in each food item on day 1, mg/kg.day.
CH-MAXEX-D1	The maximum daily ingestion exposure to chlorpyrifos in each food item on day 1, mg/kg.day.
CH-AVGEX-D1	The average daily ingestion exposure to chlorpyrifos in each food item on day 1, mg/kg.day.
CH-MINEX-D2	The minimum daily ingestion exposure to chlorpyrifos in each food item on day 2, mg/kg.day.
CH-MAXEX-D2	The maximum daily ingestion exposure to chlorpyrifos in each food item on day 2, mg/kg.day.
CH-AVGEX-D2	The average daily ingestion exposure to chlorpyrifos in each food item on day 2, mg/kg.day.
CH-MINEX-D3	The minimum daily ingestion exposure to chlorpyrifos in each food item on day 3, mg/kg.day.
CH-MAXEX-D3	The maximum daily ingestion exposure to chlorpyrifos in each food item on day 3, mg/kg.day.
CH-AVGEX-D3	The average daily ingestion exposure to chlorpyrifos in each food item on day 3, mg/kg.day.
CH-MINEX-D4	The minimum daily ingestion exposure to chlorpyrifos in each food item on day 4, mg/kg.day.
CH-MAXEX-D4	The maximum daily ingestion exposure to chlorpyrifos in each food item on day 4, mg/kg.day.
CH-AVGEX-D4	The average daily ingestion exposure to chlorpyrifos in each food item on day 4, mg/kg.day.

Variable	Description
DI-MINEX-D1	The minimum daily ingestion exposure to diazinon in each food item on day 1, mg/kg.day.
DI-MAXEX-D1	The maximum daily ingestion exposure to diazinon in each food item on day 1, mg/kg.day.
DI-AVGEX-D1	The average daily ingestion exposure to diazinon in each food item on day 1, mg/kg.day.
DI-MINEX-D2	The minimum daily ingestion exposure to diazinon in each food item on day 2, mg/kg.day.
DI-MAXEX-D2	The maximum daily ingestion exposure to diazinon in each food item on day 2, mg/kg.day.
DI-AVGEX-D2	The average daily ingestion exposure to diazinon in each food item on day 2, mg/kg.day.
DI-MINEX-D3	The minimum daily ingestion exposure to diazinon in each food item on day 3, mg/kg.day.
DI-MAXEX-D3	The maximum daily ingestion exposure to diazinon in each food item on day 3, mg/kg.day.
DI-AVGEX-D3	The average daily ingestion exposure to diazinon in each food item on day 3, mg/kg.day.
DI-MINEX-D4	The minimum daily ingestion exposure to diazinon in each food item on day 4, mg/kg.day.
DI-MAXEX-D4	The maximum daily ingestion exposure to diazinon in each food item on day 4, mg/kg.day.
DI-AVGEX-D4	The average daily ingestion exposure to diazinon in each food item on day 4, mg/kg.day.
CH-MINEX-WK	The minimum weekly ingestion exposure to chlorpyrifos in each food item, mg/kg.week.
CH-MAXEX-WK	The maximum weekly ingestion exposure to chlorpyrifos in each food item, mg/kg.week.
CH-AVGEX-WK	The average weekly ingestion exposure to chlorpyrifos in each food item, mg/kg.week.
DI-MINEX-WK	The minimum weekly ingestion exposure to diazinon in each food item, mg/kg.week.
DI-MAXEX-WK	The maximum weekly ingestion exposure to diazinon in each food item, mg/kg.week.
DI-AVGEX-WK	The average weekly ingestion exposure to diazinon in each food item, mg/kg.week.
FB	Type of food (solid food, beverage, or water)

Variable	Description
CH-MINEXT-D1	The minimum daily ingestion exposure to chlorpyrifos on day 1, mg/kg.day.
CH-MAXEXT-D1	The maximum daily ingestion exposure to chlorpyrifos on day 1, mg/kg.day.
CH-AVGEXT-D1	The average daily ingestion exposure to chlorpyrifos on day 1, mg/kg.day.
Variable	Description
CH-MINEXT-D2	The minimum daily ingestion exposure to chlorpyrifos on day 2, mg/kg.day.
CH-MAXEXT-D2	The maximum daily ingestion exposure to chlorpyrifos on day 2, mg/kg.day.
CH-AVGEXT-D2	The average daily ingestion exposure to chlorpyrifos on day 2, mg/kg.day.
CH-MINEXT-D3	The minimum daily ingestion exposure to chlorpyrifos on day 3, mg/kg.day.
CH-MAXEXT-D3	The maximum daily ingestion exposure to chlorpyrifos on day 3, mg/kg.day.
CH-AVGEXT-D3	The average daily ingestion exposure to chlorpyrifos on day 3, mg/kg.day.
CH-MINEXT-D4	The minimum daily ingestion exposure to chlorpyrifos on day 4, mg/kg.day.
CH-MAXEXT-D4	The maximum daily ingestion exposure to chlorpyrifos on day 4, mg/kg.day.
CH-AVGEXT-D4	The average daily ingestion exposure to chlorpyrifos on day 4, mg/kg.day.
DI-MINEXT-D1	The minimum daily ingestion exposure to diazinon on day 1, mg/kg.day.
DI-MAXEXT-D1	The maximum daily ingestion exposure to diazinon on day 1, mg/kg.day.
DI-AVGEXT-D1	The average daily ingestion exposure to diazinon on day 1, mg/kg.day.
DI-MINEXT-D2	The minimum daily ingestion exposure to diazinon on day 2, mg/kg.day.
DI-MAXEXT-D2	The maximum daily ingestion exposure to diazinon on day 2, mg/kg.day.
DI-AVGEXT-D2	The average daily ingestion exposure to diazinon on day 2, mg/kg.day.
DI-MINEXT-D3	The minimum daily ingestion exposure to diazinon on day 3, mg/kg.day.
DI-MAXEXT-D3	The maximum daily ingestion exposure to diazinon on day 3, mg/kg.day.
DI-AVGEXT-D3	The average daily ingestion exposure to diazinon on day 3, mg/kg.day.
DI-MINEXT-D4	The minimum daily ingestion exposure to diazinon on day 4, mg/kg.day.
DI-MAXEXT-D4	The maximum daily ingestion exposure to diazinon on day 4,

Variable	Description
	mg/kg.day.
DI-AVGEXT-D4	The average daily ingestion exposure to diazinon on day 4, mg/kg.day.
CH-MINEXT-WK	The minimum weekly ingestion exposure to chlorpyrifos, mg/kg.week.
CH-MAXEXT-WK	The maximum weekly ingestion exposure to chlorpyrifos, mg/kg.week.
CH-AVGEXT-WK	The average weekly ingestion exposure to chlorpyrifos, mg/kg.week.
DI-MINEXT-WK	The minimum weekly ingestion exposure to diazinon, mg/kg.week.
DI-MAXEXT-WK	The maximum weekly ingestion exposure to diazinon, mg/kg.week.
DI-AVGEXT-WK	The average weekly ingestion exposure to diazinon, mg/kg.week.

Procedure

The procedure explained next is for estimating unweighted exposure. Weighted exposure estimates can be obtained by using the SUDAAN program. The unweighted exposure estimates, with corresponding sampling weights, will be used as the program's inputs. The sampling weights used will be calculated and adjusted according to the processes explained in details in SOP # 9 and 10.

The procedure for the unweighted exposure estimation in this SOP is the following:

1. In SPSS, create a file called **PAGE IRN1 WITH BW CORRECTED**, which contains the following variables: ***HHID, DAY1SERV, DAY2SERV, DAY3SERV, DAY4SERV, AZCODE,*** and ***BW***. ***BW*** is obtained from the Baseline Questionnaire, while all other variables are obtained from the Diet Diary Questionnaire.
2. In Excel, create a file called **IIT CONVERSION WITH TDS VALUES**, with the following variables: ***AZCODE, FB, KG, CH_MIN, CH_MAX, CH-AVG, DI_MIN, DI_MAX,*** and ***DI_AVG***. This file contains, for each food item, the conversion factor (servings to kg) and the concentration values (minimum, maximum, and average) for chlorpyrifos and diazinon. The conversion factors are obtained from **IIT CONVERSION**, see SOP #8. The concentration values are obtained from **TDS RESIDUAL VALUES FROM DEPM CH AND DI 2**, which are originally from the TDS database integrated in the DEPM.
   Due to the fact that the food items used in NHEXAS' Diet Diary Questionnaire are not exactly the same as those in the Total Diet Study, an identical or similar food item in the TDS file must be identified for each food item in **IIT CONVERSION** that has no exactly matched food item. For those food items which are not possible to be matched, the average of the minimum, maximum, and average concentration values of all food items in the TDS will be used for the minimum, maximum, and average concentration values of each of these food item.
3. In SPSS, merge **PAGE IRN1 WITH BW CORRECTED** with **IIT CONVERSION WITH TDS VALUES**. Save the merged file as **PAGE FOR EXPOSURE CALCULATION INDIRECT**. Calculate daily and weekly

exposure to each chemical in each food item using equation 4-1. See spreadsheet format of this file shown below.

4. Create a file called INGESTION EXPOSURE INDIRECT, which contains the daily and weekly exposure to each chemical. See spreadsheet format of this file shown below.

Spreadsheet Format

In PAGE FOR EXPOSURE CALCULATION INDIRECT:

Column	Variable
1	***HHID***
2	***AZCODE***
3-6	***DAY1SERV, DAY2SERV, DAY3SERV, DAY4SERV***
7	***KG***
8	***FDMASS-D1***, calculated from ***DAY1SERV*** × ***KG***
9	***FDMASS-D2***, calculated from ***DAY2SERV*** × ***KG***
10	***FDMASS-D3***, calculated from ***DAY3SERV*** × ***KG***
11	***FDMASS-D4***, calculated from ***DAY4SERV*** × ***KG***
12	***FDMASS-WK***, calculated from (***FDMASS-D1*** + ***FDMASS-D2*** + ***FDMASS-D3*** + ***FDMASS-D4***) × (7/4)
13-15	***CH_MIN, CH_MAX, CH_AVG***
16-18	***DI_MIN, DI_MAX, DI_AVG***
19	***BW***
20	***CH-MINEX-D1***, calculated from (***FDMASS-D1*** × ***CH_MIN***)/***BW***
21	***CH-MAXEX-D1***, calculated from (***FDMASS-D1*** × ***CH_MAX***)/***BW***
22	***CH-AVGEX-D1***, calculated from (***FDMASS-D1*** × ***CH_AVG***)/***BW***
23	***DI-MINEX-D1***, calculated from (***FDMASS-D1*** × ***DI_MIN***)/***BW***
24	***DI-MAXEX-D1***, calculated from (***FDMASS-D1*** × ***DI_MAX***)/***BW***
25	***DI-AVGEX-D1***, calculated from (***FDMASS-D1*** × ***DI_AVG***)/***BW***
26	***CH-MINEX-D2***, calculated from (***FDMASS-D2*** × ***CH_MIN***)/***BW***
27	***CH-MAXEX-D2***, calculated from (***FDMASS-D2*** × ***CH_MAX***)/***BW***
28	***CH-AVGEX-D2***, calculated from (***FDMASS-D2*** × ***CH_AVG***)/***BW***
29	***DI-MINEX-D2***, calculated from (***FDMASS-D2*** × ***DI_MIN***)/***BW***
30	***DI-MAXEX-D2***, calculated from (***FDMASS-D2*** × ***DI_MAX***)/***BW***
31	***DI-AVGEX-D2***, calculated from (***FDMASS-D2*** × ***DI_AVG***)/***BW***
32	***CH-MINEX-D3***, calculated from (***FDMASS-D3*** × ***CH_MIN***)/***BW***
33	***CH-MAXEX-D3***, calculated from (***FDMASS-D3*** × ***CH_MAX***)/***BW***
34	***CH-AVGEX-D3***, calculated from (***FDMASS-D3*** × ***CH_AVG***)/***BW***
35	***DI-MINEX-D3***, calculated from (***FDMASS-D3*** × ***DI_MIN***)/***BW***

Column	Variable
36	***DI-MAXEX-D3***, calculated from (***FDMASS-D3*** × ***DI_MAX***)/***BW***
37	***DI-AVGEX-D3***, calculated from (***FDMASS-D3*** × ***DI_AVG***)/***BW***
38	***CH-MINEX-D4***, calculated from (***FDMASS-D4*** × ***CH_MIN***)/***BW***
39	***CH-MAXEX-D4***, calculated from (***FDMASS-D4*** × ***CH_MAX***)/***BW***
40	***CH-AVGEX-D4***, calculated from (***FDMASS-D4*** × ***CH_AVG***)/***BW***
41	***DI-MINEX-D4***, calculated from (***FDMASS-D4*** × ***DI_MIN***)/***BW***
42	***DI-MAXEX-D4***, calculated from (***FDMASS-D4*** × ***DI_MAX***)/***BW***
43	***DI-AVGEX-D4***, calculated from (***FDMASS-D4*** × ***DI_AVG***)/***BW***
44	***CH-MINEX-WK***, calculated from (***FDMASS-WK*** × ***CH_MIN***)/***BW***
45	***CH-MAXEX-WK***, calculated from (***FDMASS-WK*** × ***CH_MAX***)/***BW***
46	***CH-AVGEX-WK***, calculated from (***FDMASS-WK*** × ***CH_AVG***)/***BW***
47	***DI-MINEX-WK***, calculated from (***FDMASS-WK*** × ***DI_MIN***)/***BW***
48	***DI-MAXEX-WK***, calculated from (***FDMASS-WK*** × ***DI_MAX***)/***BW***
49	***DI-AVGEX-WK***, calculated from (***FDMASS-WK*** × ***DI_AVG***)/***BW***

In INGESTION EXPOSURE INDIRECT:

Column	Variable
1	***HHID***
2	***CH-MINEXT-D1***, calculated from the summation of ***CH-MINEX-D1*** for each subject.
3	***CH-MAXEXT-D1***, calculated from the summation of ***CH-MAXEX-D1*** for each subject.
4	***CH-AVGEXT-D1***, calculated from the summation of ***CH-AVGEX-D1*** for each subject.
5	***CH-MINEXT-D2***, calculated from the summation of ***CH-MINEX-D2*** for each subject.
6	***CH-MAXEXT-D2***, calculated from the summation of ***CH-MAXEX-D2*** for each subject.
7	***CH-AVGEXT-D2***, calculated from the summation of ***CH-AVGEX-D2*** for each subject.
8	***CH-MINEXT-D3***, calculated from the summation of ***CH-MINEX-D3*** for each subject.
9	***CH-MAXEXT-D3***, calculated from the summation of ***CH-MAXEX-D3*** for each subject.
10	***CH-AVGEXT-D3***, calculated from the summation of ***CH-AVGEX-D3*** for each subject.
11	***CH-MINEXT-D4***, calculated from the summation of ***CH-MINEX-D4*** for each subject.
12	***CH-MAXEXT-D4***, calculated from the summation of ***CH-MAXEX-D4*** for each subject.
13	***CH-AVGEXT-D4***, calculated from the summation of ***CH-AVGEX-D4*** for each subject.
14	***CH-MINEXT-WK***, calculated from the summation of ***CH-MINEX-WK*** for each subject.
15	***CH-MAXEXT-WK***, calculated from the summation of ***CH-MAXEX-WK*** for each subject.
16	***CH-AVGEXT-WK***, calculated from the summation of ***CH-AVGEX-WK*** for each subject.
17	***DI-MINEXT-D1***, calculated from the summation of ***DI-MINEX-D1*** for each subject.
18	***DI-MAXEXT-D1***, calculated from the summation of ***DI-MAXEX-D1*** for each subject.
19	***DI-AVGEXT-D1***, calculated from the summation of ***DI-AVGEX-D1*** for each subject.
20	***DI-MINEXT-D2***, calculated from the summation of ***DI-MINEX-D2*** for each subject.
21	***DI-MAXEXT-D2***, calculated from the summation of ***DI-MAXEX-D2*** for each subject.
22	***DI-AVGEXT-D2***, calculated from the summation of ***DI-AVGEX-D2*** for each subject.
23	***DI-MINEXT-D3***, calculated from the summation of ***DI-MINEX-D3*** for each subject.
24	***DI-MAXEXT-D3***, calculated from the summation of ***DI-MAXEX-D3*** for each subject.
25	***DI-AVGEXT-D3***, calculated from the summation of ***DI-AVGEX-D3*** for each subject.
26	***DI-MINEXT-D4***, calculated from the summation of ***DI-MINEX-D4*** for each subject.
27	***DI-MAXEXT-D4***, calculated from the summation of ***DI-MAXEX-D4*** for each subject.
28	***DI-AVGEXT-D4***, calculated from the summation of ***DI-AVGEX-D4*** for each subject.
29	***DI-MINEXT-WK***, calculated from the summation of ***DI-MINEX-WK*** for each subject.
30	***DI-MAXEXT-WK***, calculated from the summation of ***DI-MAXEX-WK*** for each subject.
31	***DI-AVGEXT-WK***, calculated from the summation of ***DI-AVGEX-WK*** for each subject.