USE OF A FOOD CONSUMPTION MODEL TO ESTIMATE HUMAN CONTAMINANT INTAKE

ARLETTA BELOIAN
Food and Drug Administration 200 C Street, S.W., Washington, D.C.

(Received 23 December, 1981)

Abstract. A mathematical model is proposed for estimating daily contaminant intake by multiplying three variables related to consumption, from three independent consumption surveys. With lead as an example, the product of the three variables typified the mean and increasing intakes among infants 0–5 months, children 6–23 months and children 2–5 yr of age. Limitations implicit to the approach and the variables were discussed. Daily mean lead intake increased between the three respective age groups, 15, 59, and 82 lag lead. When intake was expressed on a body weight basis (μg lead/kg BW), the rate of daily lead exposure for children 6 to 23 months (6.1) and 2 to 5 yr (5.6) of age was similar but both were higher than the rate for the 0–5 month infant (2.7 μg kg⁻¹ BW). The 90th percentile daily dietary lead intake for 0–5 month infants was double their mean intake and for children 6 months to 5 yr was one and a half times their corresponding mean intakes. Food sources which contributed to the daily lead intake of the infant differed from those for the two groups of older children.

1. Introduction

The Scientific Committee of the Food Safety Council (1980) in a report entitled ‘Proposed System for Food Safety Assessment’, proposes several key factors necessary for toxicological safety assessments. Human exposure to chemicals in food is one of the key factors in making those assessments. Since human exposure is not a static affair, it must be constantly monitored and regulatory authorities must be prepared to act if exposure levels increase drastically. The Food Safety Council report states that whatever method is used to assess potential toxicity of a food ingredient, average intake figures simply are not good enough for toxicological evaluations. Present methods do not allow us to estimate true consumption by small subsets of eaters who are the individuals with the food ingredient in their dietary intake. Therefore, the Food Safety Council recommends, where possible, that toxicity tests be oriented and potentially extrapolated from experimental animals against some multiple of the 90th percentile consumption by man.

In 1975, Mahaffey (1978) measured the variability of dietary lead in children’s diets and found the levels ranged between 12 and 505 μg lead daily. The 79 children were 6 months to 3 1/2 yr of age, all lived in the Washington, D.C. area, were black and came from low-income households. Duplicate samples of foods consumed by the children were collected for four days and the composites analyzed for lead content. Drinking water was included in the composites. The average dietary lead intake for the children was 105 μg lead per day; their median intake was 85 μg lead per day.

The purpose of this paper is to propose and describe a modified approach for estimating human daily contaminant intake from survey data on food intake among individuals in the United States. The approach uses a mathematical model for consist-
tenency when working with large and complex food consumption survey databases. The
intents are to quantify average intakes and the increasing intakes among percentiles of
the individuals and to identify and give relative rank to the probable sources for a
contaminant from the individuals' diets.

Since the food consumption model was not developed specifically for contaminants,
it's evolution will be reviewed through three stages of its development when used with
food additives. Some of the limitations encountered with the approach and estimates of
food additive intake will also be described.

The food consumption surveys which provided data on the variables used in the
approach will be described and some of the limitations of those survey data discussed.

Lastly, data produced using the model will be presented for infants 0–5 months,
children 6–23 months and children 2–5 yr of age. Estimates and food sources of the
dietary lead data will target the age groups of concern among the infants and children
and provide rationales for their identification. The paper will conclude with quantitative
estimates of daily lead intake and daily lead exposure per kilogram bodyweight and the
estimates at increasing percentiles among each of the three age groups of infants and
children.

2. The Model and Its Variables

In the model approach, the product of the three variables yields an estimate for each
individual's daily intake, shown in Table I.

TABLE I

| The following formula describes the calculation for intake estimates of a substance in food (i): |
| Daily substance intake per person = \[ \frac{\sum_{i=1}^{n} (E_i \times C_i \times S_i)}{N} \] |
| where |
| \( E_i \) = Number of times (eating occasions) the \( i \)th food is consumed in \( N \) days, |
| \( C_i \) = Substance concentration of the \( i \)th food, |
| \( S_i \) = Food serving size (in grams), as a constant value within age limits, of the \( i \)th food; and |
| \( N \) = Number of days of dietary records for each person |

At present three separate data sources are used to obtain values needed for intake
calculations. In Table II the variables are typified for the contaminant, lead.

TABLE II

| For Example: |
| The variables in the formula are described for estimating lead intake, where |
| \( E_i \) = Number of eating occasions a food such as fresh green beans or canned green beans is
consumed (in 14 days); |
| \( C_i \) = Mean lead concentrations (in ppm) in fresh green beans or in canned green beans; |
| \( S_i \) = Food serving size (in grams), as a constant value within age limits, of the \( i \)th food; and |
| \( N \) = 14 days. |