Uncertainty in Total Diet Studies

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Total Diet Studies

• Measurement of *average* intakes of multiple contaminants and nutrients
  • Pooled samples from *typical consumption* after food prepared and cooked in the standard way
  • Cost-effective
  • Analysis of overall trends over time
TDS in the UK

- Carried out since 1966
  - Once every 3 years
- Wide variety of chemical substances monitored
  - Vary between years according to specific toxicological concern, policy questions
  - Exposure assessment to assess trends over time

The Aim

To provide, on a continual basis, **analytical samples representative of the average UK diet**. This was required for the FSA food surveillance program, in particular, the monitoring of pesticides, radionuclides and other potential chemical contaminants in the food supply.
## Composite food groups

119 categories of foods, combined into 20 groups for analysis

<table>
<thead>
<tr>
<th>Bread</th>
<th>Other cereals</th>
<th>Carcase meats</th>
<th>Offals</th>
<th>Meat products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>Fish</td>
<td>Oils and fats</td>
<td>Eggs</td>
<td>Sugars and preserves</td>
</tr>
<tr>
<td>Green vegetables</td>
<td>Potatoes</td>
<td>Other vegetables</td>
<td>Canned vegetables</td>
<td>Fresh fruit</td>
</tr>
<tr>
<td>Fruit products</td>
<td>Beverages</td>
<td>Milk</td>
<td>Dairy products</td>
<td>Nuts</td>
</tr>
</tbody>
</table>

Separated into groups likely to contain substances, and those consumed in large quantities
Sampling strategy

Expenditure and Food Survey (UK’s household survey) used to estimate relative proportion of each food category within a group.

Foods purchased at two-weekly intervals, locations selected to represent the UK as a whole.

Food samples prepared according to domestic practice and combined in appropriate quantities to form a homogenous sample (estimate average intake) for each of the 20 groups.

Each group analysed for chemicals, such as nutrients and contaminants.

Exposure estimated by combining data on the concentration of a chemical in each food group with information on the distribution of individuals’ food consumption patterns (data from NDNS). Mean or high percentile consumption.
Replicate sample measurements (multiple compounds) from TDS sample

Representative cooked and pooled TDS sample (mixed species, individual fish + processed fish products)
Replicate sample measurements (multiple compounds) from TDS sample

Additional information per sub-category

Representative cooked and pooled TDS sample
(mixed species, individual fish + processed fish products)
<table>
<thead>
<tr>
<th>Element</th>
<th>Average intake for all population groups (µg/kg bw/day)</th>
<th>Groups with excess intake (µg/kg bw/day)</th>
<th>Health based guidance values (µg/kg bw/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>23.2</td>
<td>None</td>
<td>160 (EVM safe upper limit); 500 (JECFA PMTDI)</td>
</tr>
<tr>
<td>Germanium</td>
<td>0.03</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Indium</td>
<td>0.35</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td>0.13</td>
<td>None</td>
<td>3.6 (JECFA PTWI)</td>
</tr>
<tr>
<td>Manganese</td>
<td>87.5</td>
<td>None</td>
<td>200 or 150 (elderly) (EVM)</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.07</td>
<td>None</td>
<td>0.23 (JECFA PTWI)</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2.4</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Nickel</td>
<td>4.7</td>
<td>Pre-school children (4.6); Elderly (free living) (8.2)</td>
<td>12 (WHO); 4.3 (EVM)</td>
</tr>
</tbody>
</table>
Food consumption (% contribution by sub-population and TDS food group)

Men drink more ‘alcoholic drinks’ and less water than others

Fruit and veg: men and young women similar patterns. Older women similar to vegetarians

Most vegetarians avoid meat
Mercury (% contribution to exposure) by sub-population and food group

But are food groups independent, within individuals?

Fish, dairy products

Grain
Males, % consumption

Females, % consumption
Uncertainties

• Consumption data *(NDNS Diaries)*
• Variation in *combinations* of foods consumed is not well captured in the survey
  • Especially rarely consumed combinations
• Model choice for usual intakes?
  • Parametric methods available to account for this uncertainty and include correlations between foods
Uncertainties

- Consumption data (Food and Expenditure Survey)
- Household diet only – excludes eating out
- No alcohol

<table>
<thead>
<tr>
<th></th>
<th>Contribution to household diet as purchased</th>
<th>Loss/gain in preparation and cooking (%)</th>
<th>Estimated average weight of food as eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Kg/person/day)</td>
<td>(to nearest 5%)</td>
<td>(Kg/person/day)</td>
</tr>
<tr>
<td>Bread</td>
<td>0.107</td>
<td>0</td>
<td>0.107</td>
</tr>
<tr>
<td>Miscellaneous Cereals</td>
<td>0.123</td>
<td>+ 5</td>
<td>0.129</td>
</tr>
<tr>
<td>Carcase meat</td>
<td>0.033</td>
<td>- 40</td>
<td>0.020</td>
</tr>
<tr>
<td>Offal</td>
<td>0.001</td>
<td>- 35</td>
<td>0.001</td>
</tr>
<tr>
<td>Meat products</td>
<td>0.081</td>
<td>- 25</td>
<td>0.061</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.035</td>
<td>- 45</td>
<td>0.019</td>
</tr>
<tr>
<td>Fish</td>
<td>0.022</td>
<td>- 35</td>
<td>0.014</td>
</tr>
<tr>
<td>Oils and fats</td>
<td>0.022</td>
<td>0</td>
<td>0.022</td>
</tr>
<tr>
<td>Eggs</td>
<td>0.013</td>
<td>- 10</td>
<td>0.013</td>
</tr>
<tr>
<td>Sugar &amp; preserves</td>
<td>0.058</td>
<td>0</td>
<td>0.058</td>
</tr>
<tr>
<td>Green vegetables</td>
<td>0.043</td>
<td>- 30</td>
<td>0.030</td>
</tr>
<tr>
<td>Potatoes</td>
<td>0.126</td>
<td>- 15</td>
<td>0.107</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>0.106</td>
<td>- 15</td>
<td>0.090</td>
</tr>
<tr>
<td>Canned vegetables</td>
<td>0.041</td>
<td>- 20</td>
<td>0.033</td>
</tr>
<tr>
<td>Fresh fruit</td>
<td>0.111</td>
<td>- 25</td>
<td>0.083</td>
</tr>
<tr>
<td>Fruit products</td>
<td>0.055</td>
<td>0</td>
<td>0.055</td>
</tr>
<tr>
<td>Beverages</td>
<td>0.298</td>
<td>+ 320</td>
<td>1.252</td>
</tr>
<tr>
<td>Milk</td>
<td>0.246</td>
<td>0</td>
<td>0.246</td>
</tr>
<tr>
<td>Dairy products</td>
<td>0.082</td>
<td>0</td>
<td>0.082</td>
</tr>
<tr>
<td>Nuts</td>
<td>0.003</td>
<td>0</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Uncertainties

• Concentration data (sampling uncertainties)
• 119 food samples, 24 sampling locations = 2586 samples, pooled into 20 TDS groups
  • Estimating typical consumption of 20 food types from 119 food types
  • Is shopping list representative of true variation (spatial, temporal, packaging types, brands, source countries)
• Food types with higher variation should ideally have larger samples
• Representative for sub-populations of interest?
Uncertainties

• Concentration data (measurement uncertainty)
• Pooling step
  • High concentrations of individual food samples can be diluted during pooling, processing and cooking
  • Homogenization step important for true average
• To account for ND, samples often reported as
  • zero (lower bound) or
  • LOD (upper bound)
  • Exposures calculated accordingly
• Some concentrations are also reported as below LOQ
• Analytical errors
Measurement uncertainties: non-detects and calibration errors

Values below the limit of detection

Values above the limit of detection, include measurement error
Measurement uncertainties: non-detects and calibration errors

\[ y = 101019x + 94.245 \]
\[ R^2 = 0.9756 \]

\[ y = 171318x - 1013.9 \]
\[ R^2 = 0.999 \]
Exposure models

• Various forms possible
  • Select according to specific question

• Example 1: Overall population intakes (daily average)
  • Expenditure and Food Survey for average consumptions. Updated annually to reflect changing habits

• Example 2: Variation in individual consumption
  • NDNS dietary survey for age groups 1.5-4.5, 4-18, 16-64, 64+ and vegetarians
  • Consider mean and high level (97.5th percentile) consumer

• Both examples use pooled TDS samples
  • Does not account for variation in concentrations of consumed units
Uncertainties

- Food preparation and portion sizes
  - What is typical?
  - Cookbooks and standard recipes used
  - Are sub-populations well represented?
  - What variations should be captured?
  - Cooking utensils vary, these might also have impact on exposure
Uncertainties

• Database: mapping food codes
  • Foods consumed by an individual, in national database coding scheme, have to be assigned to a TDS group.
  • Mixed dishes difficult to categorise

• Risk assessment
  • Guidance values include safety factors

• Data sharing between countries
  • Are TDS samples in one EU country relevant for another?
Uncertainties

- Risk assessment
- Analysis of trends over time, but includes ‘noise’ due to random variation/statistical error

Table 6b. Comparison of population dietary exposures of manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), palladium (Pd), platinum (Pt), rhodium (Rh), ruthenium (Ru), selenium (Se), strontium (Sr), thallium (Tl), tin (Sn) and zinc (Zn) from UK Total Diet Studies 1976 to 2006

<table>
<thead>
<tr>
<th>Year</th>
<th>Mn</th>
<th>Hg</th>
<th>Mo</th>
<th>Ni</th>
<th>Pd</th>
<th>Pt</th>
<th>Rh</th>
<th>Ru</th>
<th>Se</th>
<th>Sr</th>
<th>Tl</th>
<th>Sn</th>
<th>Zn</th>
</tr>
</thead>
</table>
TDS Exposure: 4 year FP7 project led by ANSES

www.tds-exposure.eu

- 19 countries: Belgium, The Czech Republic, Finland, France, Germany, Ireland, Italy, Latvia, The Netherlands, Poland, Portugal, Spain, Sweden, UK, Croatia, Iceland, Turkey, Norway and Switzerland.

- 10 research centres,
- 6 food safety agencies,
- 5 universities,
- 4 National Institutes of Public Health
- 1 SME
Handling Uncertainties

• Part of the EU project TDS-EXPOSURE will assess:
  • Variability and uncertainty in TDS
  • Impact on exposure modelling within TDS
• Capture variability missing from TDS
  • Using more detailed secondary data
• Improving analysis of long-term trends
• Quantify uncertainty
• Results should be implemented in MCRA software
Simulating impact of variation/sampling uncertainty

Concentration: distribution
Number of products: fixed
Relative weights: fixed
Number of shopping trips: fixed
Processing factors: fixed
Relative SD: fixed

Repeat this simulation for assumed set of values/distributions
Summary of main uncertainties

- **Deterministic**
  - Approximation errors due to sampling uncertainty, collecting data and pooling to estimate true mean
  - Measurement uncertainties
  - Definition of typical meal

- **Probabilistic**
  - True distributions for variability are approximated (empirical or parametric)
  - Variability is not represented in TDS concentration, only in *consumption*
  - Linking consumed foods to a TDS food group
Acknowledgments

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  • Hannah Pinchen (IFR)
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