A three-part, mixed effect model to estimate habitual total nutrient intake distribution from food and dietary supplements

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Introduction

Total micronutrient intake →

Generally habitual/usual intake is of interest
e.g. to compare with dietary reference values (EAR, UL)

→ statistical correction for

within-person variation to...

retain between-person variation

Red line: single diary - 23.7% < 1.0 µg vitamin D

Blue line: two diaries corrected for within-person variation - 7.0% < 1.0 µg vitamin D
Objective

Estimation of *habitual (usual) total* vitamin D intake distribution

Guiding principle:

\[
\text{Habitual total intake} = \text{Habitual intake from food} + \text{Habitual intake from dietary supplements}
\]

as a consequence,

habitual (usual) *total* intake is *always greater than or equal to* habitual (usual) intake from either source alone
Objective

• Dutch National Food Consumption Survey – Young Children (DNFCS-YC) 2005-2006

  - N=1279 children ages 2-6 year
  - 2 non-consecutive single-day diaries per child
    - food & dietary supplement intake
    - seasonality; weekend/weekday
  - additional questionnaires
    - past month dietary supplement use (Y/N for several types)

• Dutch Food Composition database (2006, extended version)
• Dutch supplement database
Simplistic approach – ‘first add then shrink’ (AtS)

• add food intake to dietary supplement intake for each day

<table>
<thead>
<tr>
<th>person</th>
<th>day</th>
<th>Observed vitamin D µg/day</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>food</td>
<td>supplement</td>
<td>total</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>4.51</td>
<td>0</td>
<td>4.51</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1.27</td>
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<td>1.27</td>
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<td>2</td>
<td>1</td>
<td>1.97</td>
<td>2.5</td>
<td>4.47</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.93</td>
<td>2.5</td>
<td>3.43</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2.37</td>
<td>0</td>
<td>2.37</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1.48</td>
<td>3.1</td>
<td>4.58</td>
</tr>
</tbody>
</table>

• adjust for within-person variation via ISU-method

Cumulative probability and probability density graphs for habitual vitamin D intake.
Problems applying AtS to vitamin D in DNFCS-YC

- discrete dosages dietary supplements → multiple modes

- episodic consumption of dietary supplements (DS)
  - highly heterogeneous within-person variances
  - DS-users based on additional questionnaire & 2 diaries
    - 19% of DS-users, in none of the diaries DS use
    - 20% of DS-users, one diary DS use
    - 61% of DS-users, both diaries DS use
    - 15% of DS-users both diaries ≠ dosages
Inconsistency in leftmost tail – children 2-3 year

Habitual total intake estimated to be less than habitual intake from food only
‘add then shrink’ is too simplistic

Garriguet (2010)
- Tail inconsistencies can occur quite often
- Proposes separate estimation of habitual intake distributions for users and non-users of dietary supplements

*Advantages*: differences in food intake users/non-users; correlation intake food & DS for users

Bailey *et al.* (2010); Slob *et al.* (2010)
- Propose separate modeling of habitual intake distributions from food and from dietary supplements – “Shrink then add”

*Advantage*: differences in variance components taken into account

New method combines elements of both alternatives
Three-part model – schematic overview

Intake from **food sources**

Intake from dietary supplements (**DS**)
Three-part model – schematic overview

Intake from **food sources**

**Non-users DS**

- Observed amounts from food sources

  Adjust for within-person variation

Intake from dietary supplements (DS)
Three-part model – schematic overview

Intake from **food sources**

Intake from dietary supplements (DS)

**Non-users DS**

Observers amounts from food sources

Adjust for within-person variation

Habitual intake distribution from food sources
Three-part model – schematic overview

**Intake from food sources**
- Observed amounts from food sources
- Adjust for within-person variation
- Habitual intake distribution from food sources

**Intake from dietary supplements (DS)**
- Observed amounts from food sources
- Observed frequency of DS use
- Observed dosage on DS use days

**Non-users DS**

**Users DS**
Three-part model – schematic overview

Intake from **food sources**

- **Non-users DS**
  - Observed amounts from food sources
  - Adjust for within-person variation
  - Habitual intake distribution from food sources

- **Users DS**
  - Observed amounts from food sources
  - Observed frequency of DS use
  - Observed dosage on DS use days

Intake from dietary supplements (DS)

- Observed amounts from food sources
- Observed frequency of DS use
- Observed dosage on DS use days
Three-part model – schematic overview

**Intake from food sources**

- **Non-users DS**
  - Observed amounts from food sources
  - Adjust for within-person variation
  - Habitual intake distribution from food sources

- **Users DS**
  - Observed amounts from food sources
  - Observed frequency of DS use
  - Observed dosage on DS use days
  - Habitual dosage on DS use days

**Intake from dietary supplements (DS)**

- Observed frequency of DS use
- Observed dosage on DS use days
- Adjust for within-person variation

**Correlation**
Three-part model – schematic overview

**Intake from food sources**

- Observed amounts from food sources
- Adjust for within-person variation
- Habitual intake distribution from food sources

**Users DS**

- Observed amounts from food sources
- Observed frequency of DS use
- Observed dosage on DS use days
- Habitual dosage on DS use days
- Correlation
- Adjust for within-person variation
- Habitual intake distribution from food sources
- Habitual intake distribution from DS

**Non-users DS**

- Observed amounts from food sources
- Adjust for within-person variation
- Habitual intake distribution from food sources

Intake from dietary supplements (DS)
Three-part model – schematic overview

**Intake from food sources**

- **Non-users DS**
  - Observed amounts from food sources
  - Adjust for within-person variation
  - Habitual intake distribution from food sources

- **Users DS**
  - Observed amounts from food sources
  - Observed frequency of DS use
  - Observed dosage on DS use days
  - Habitual dosage on DS use days
  - Correlation
  - Adjust for within-person variation
  - Habitual intake distribution from food sources
  - Habitual intake distribution from DS
  - Habitual total intake distribution from food sources and DS

**Intake from dietary supplements (DS)**
Three-part model – schematic overview

Intake from **food sources**

**Non-users DS**
- Observed amounts from food sources
- Habitual intake distribution from food sources
- Adjust for within-person variation

**Users DS**
- Observed amounts from food sources
- Habitual intake distribution from food sources
- Adjust for within-person variation
- Habitual dosage on DS use days
- Observed frequency of DS use
- Observed dosage on DS use days
- Correlation

- Habitual intake distribution from DS
- Habitual total intake distribution from food sources and DS

**Intake from dietary supplements (DS)**

Combines habitual total nutrient intake distribution from **food sources** and **DS**
Three-part model – schematic overview

Intake from **food sources**

- **Non-users DS**
  - Observed amounts from food sources
  - Covariates
  - Adjust for within-person variation and covariates
  - Habitual intake distribution from food sources

- **Users DS**
  - Observed amounts from food sources
  - Covariates
  - Correlation
  - Adjust for within-person variation and covariates
  - Habitual intake distribution from food sources
  - Habitual intake distribution from DS

Intake from dietary supplements (DS)

- Observed frequency of DS use
- Observed dosage on DS use days
- Habitual dosage on DS use days

Combined habitual *total* nutrient intake distribution from *food sources* and *DS*
Inconsistency fixed in leftmost tail – children 2-3 yr

Habitual vitamin D intake (µg/d)
cumulative probability

shrink then add' total (food and dietary supplements)
'shrink then add' food only
Comparison with cut-off points

Proportion of children 2-3 yr with habitual vitamin D intakes below specific cut-off points

<table>
<thead>
<tr>
<th>Method</th>
<th>Cut-off point (µg vitamin D)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Shrink then add</td>
<td>4.6</td>
</tr>
<tr>
<td>Add then shrink*</td>
<td>5.0</td>
</tr>
<tr>
<td>Difference in percent points</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

without imputation and covariates

* original NCI-method
Discussion

Three-part model allows:

- modeling multimodal distributions
  - option other multimodality issues e.g. food fortification

- covariates
  - dietary supplement user or non-user
    (additional questionnaire)
  - demographics
  - nuisance effects (e.g. season, weekend/weekday)
  - differential effects in each of 3 parts

- correlation between probability to use dietary supplements and habitual intake from food sources
Discussion

- imputation or other modeling may be required for (known) users of dietary supplements, without dosage information from diaries
- more detailed information on dietary supplement use over longer time period is warranted
- separating users and non users of dietary supplements may reveal differences in habitual intake distribution from food sources
  - within- and between-person variation
  - mean and percentiles
- three-part model developed from original NCI-method in SAS recently also built in SPADE (Statistical Program to Assess Dietary Exposure)
Conclusion

The proposed three-part model is an improvement for the estimation of total nutrient intake distributions from food and dietary supplements as it:

- allows heterogeneous variances
- retains multimodality
- has no inconsistency in leftmost tail of the distribution
A three-part, mixed effect model to estimate habitual total nutrient intake distribution from food and dietary supplements

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