Changing Models and Methodologies for Food Safety and Nutritional Research in a Digitalized World

ILSI Annual Meeting 2019

Cronan McNamara
Founder & CEO
Disclosure

I am a founder and CEO of Creme Global, an independent data science technology company. Various industry and government partners funded the projects described here.
Digitized World
Digital Density
Digital Density
Exponential Data Growth
Data Science Challenges

Gathering Data

Collect the Data

Structuring, Validating and Sharing

Analysing and Visualising the Data

Developing Predictive Models

Foresight

Insight

Understanding

Gathering Data
01 Use Real World Data

02 Run it through Our Expert Models

03 Provide Actionable Information and Insights
Food Safety & Nutrition Research
Food Safety and Risk Assessment

- Hazard
- Pathway for exposure
- Exposure
  - Risk of Health Effect
  - Sensitivity to Hazard
  - Level of Exposure
- Vulnerability
Exposure / Intake
Exposure/Intake

What do people eat?

What are the nutrient/chemical levels in foods

Population food nutrient intake or exposure risk
Exposure/Intake

Food Consumption Data

What are the nutrient/chemical levels in foods

Population food nutrient intake or exposure risk
Exposure/Intake

- Food Consumption Data
- Nutritional Composition or Chemical Occurrence & Conc. Data

Population food nutrient intake or exposure risk
Exposure/Intake

Food Consumption Data

Nutritional Composition or Chemical Occurrence & Conc. Data

Data Distribution of Population Nutritional Profiles or Chemical Exposure from Food
## Probabilistic Intake Model

**Diary Day 1**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Amount</th>
<th>Substance Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td>40g</td>
<td>0.6%</td>
</tr>
<tr>
<td>x2</td>
<td>500g</td>
<td>0.02%</td>
</tr>
<tr>
<td>x3</td>
<td>200g</td>
<td>1.5%</td>
</tr>
<tr>
<td>x4</td>
<td>90g</td>
<td>0.007%</td>
</tr>
</tbody>
</table>
Probabilistic Intake Model
Probabilistic Modelling

Population Exposure
Probabilistic Modelling

Population Exposure

Lower  Mean  Higher
Probabilistic Modelling

Population Exposure

Lower

Median Consumer Exposure

Higher

cremeglobal
Probabilistic Modelling

Population Exposure

Lower

95th Percentile Consumer Exposure

Higher
Exposure Assessment

Distribution of Exposure in the Population

Frequency

Exposure (mg/kg/day)
Distribution of Exposure in the Population

Exposure Assessment
Exposure Assessment

Distribution of Exposure in the Population

Frequency

Exposure (mg/kg/day)  Reference Dose
Exposure Assessment

Distribution of Exposure in the Population

Frequency

Exposure (mg/kg/day)

Hazard

Reference Dose
Frequency

Distribution of Exposure in the Population

Exposure Assessment

Exposure (mg/kg/day) Reference Dose

Hazard

Susceptibility (Vulnerability)

Reference Dose
Personalised Medicine... Individualised Risk
Food Safety & Nutrition Research in a Digitized World
Food Safety & Nutrition Research

...Data Science Challenge
Food Safety & Nutrition Research

...use all of the Available Data
1. Gather Data
1. Gather Data
2. Structure Data

FS & Nutrition Research
… Data Science Challenge
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data

FS & Nutrition Research

... Data Science Challenge
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling

FS & Nutrition Research
… Data Science Challenge
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling

FS & Nutrition Research
… Data Science Challenge
1. Gather Data
1. Gather Data

...food consumption data
National Food Consumption Surveys
New Digital Data Collection Methods

Country of Residence

- Germany
- Greece
- Ireland
- Netherlands
- Norway
- Poland
- Spain
- U.K. (not Northern Ireland)

New Volunteers

If you would like to have more information about participating in the Food4Me study, please click [here].

Volunteer Login

Email: [Enter Email]
New Digital Data Collection Methods

### Food Frequency Questionnaire (FFQ)

#### Cereal

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Never (0 per month)</th>
<th>1-3 per week</th>
<th>2-4 per week</th>
<th>5-6 per week</th>
<th>Once a day</th>
<th>2-3 per day</th>
<th>4-5 per day</th>
<th>6+ per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forridge, readybreak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals, whole grain e.g. branflakes, barley flakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals, non-whole grain e.g. cornflakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals e.g. muesli, cereal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Bread and Savoury Biscuits

- Potatoes, Rice and Pasta
- Meat and Fish
- Dairy Products
- Fats and Spreads
- Sweets and Snacks
- Soups, Sauces, and Spreads
- Drinks
- Fruit
New Digital Data Collection Methods
### What meals did you have yesterday?

<table>
<thead>
<tr>
<th>Meal</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td>8:00</td>
<td>Home</td>
</tr>
<tr>
<td>Morning Snack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td>13:00</td>
<td>Work</td>
</tr>
<tr>
<td>Afternoon Snack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evening Meal</td>
<td>19:00</td>
<td>Home</td>
</tr>
<tr>
<td>Evening Snack</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New Digital Data Collection Methods

The Brown bread, sliced you had at Breakfast...

What best describes this food
- Brown bread, sliced, toasted
- Brown bread, sliced, untoasted

How many slices did you have?
1

How big was the portion?

The portion size pictures below may not be an exact match for the food/drink you have selected. Please use these pictures to give us an idea of the amount of food/drink you have consumed.
1. Gather Data

...industry data
Secure Data Collection and Anonymization Portals
Example: Fragrance Concentration

- Fragrance Manufacturers
- Consumer Product Companies
Two-Level Concentration
1. Gather Data

...Genomic data
<table>
<thead>
<tr>
<th>Traditionally</th>
<th>With Omics</th>
</tr>
</thead>
<tbody>
<tr>
<td>No use of genetic information</td>
<td>Personalised nutrition and medicine</td>
</tr>
<tr>
<td>Population based risk approaches</td>
<td>Individualised risk approaches</td>
</tr>
<tr>
<td>Bacteria grouped together</td>
<td>Fine-tune predictive models</td>
</tr>
<tr>
<td>Behaviour considered independently</td>
<td>Quantify pathogenic strain variability</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
1. Gather Data

...IoT
Sensor Data in Food Production
- Time
- Temperature
- pH
- Humidity
- Pressure

Smart Agriculture
- Animal monitoring
- Soil communication
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling

Collection
Understanding
Insight
Foresight

FS & Nutrition Research
... Data Science Challenge
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling
2. and 3. Structure, Analyse and Visualise Data
IoT - Creme Global Fridge

Temperature
IoT - Creme Global Fridge

Temperature

Friday
IoT - Creme Global Fridge

Temperature

Loading Drinks into Fridge
IoT - Creme Global Fridge

Enjoying Drinks Party
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling

FS & Nutrition Research

Data Science Challenge
FS & Nutrition Research

… Data Science Challenge

1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling
4. Predictive Modelling
4. Predictive Modelling

...nutritional intake modelling
Reformulation Project

- Impact on consumers
- Two time points
- 600 Products
- Dietary Habits
- 14 Companies

Companies: 600
Products: 14
Market Shares: Two time points
Dietary Habits: 600 Products
Impact on consumers: 14 Companies
Case Study

FDI Creme Global Reformulation Project

Impact and quantification of voluntary reformulation on Irish population

- 14 Companies
- ~600 Products
- Market Shares
- Dietary Habits
- Two time points

Impact on Consumer Intakes of Energy, Fat, Saturated Fat, Sugar and Sodium
Probabilistic Intake Model

Data on Reformulated Products for the two time points

Kantar Worldpanel Market Share Data

Dietary Intake Modelling Platform (Creme Nutrition®)
Validated Population Nutrient Reductions

Sodium -45%
Food4Me Study and Tool

Food Frequency Questionnaire (FFQ)

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Portion size</th>
<th>0-1 per month</th>
<th>1-3 per month</th>
<th>Once a week</th>
<th>Twice a week</th>
<th>2-4 per week</th>
<th>3-5 per week</th>
<th>Once a day</th>
<th>2-3 per day</th>
<th>4-5 per day</th>
<th>6+ per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porridge, ready-to-eat</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Breakfast cereals, wholegrain e.g. bran flakes, barley flakes</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Breakfast cereals, non-wholegrain e.g. corn flakes</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>Breakfast cereals e.g. muesli, muesli cereal</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bread and Savoury Biscuits</th>
<th>Portion size</th>
<th>0-1 per month</th>
<th>1-3 per month</th>
<th>Once a week</th>
<th>Twice a week</th>
<th>2-4 per week</th>
<th>3-5 per week</th>
<th>Once a day</th>
<th>2-3 per day</th>
<th>4-5 per day</th>
<th>6+ per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes, Rice and Pasta</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Meat and Fish</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Dairy Products</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>Fats and Spreads</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>Sweets and Snacks</td>
<td>○</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Sauces, Spreads, and Dressings</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Drinks</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fruit</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Vegetables</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Personalised Nutrition…
3 Approaches of personalisation

- **Personalised nutrition**: interface, tools, feedback preferences, psycho-social factors
- **Individual recommendation for dietary behaviour**: dietary intake, food preferences, lifestyle preferences
- **Basic personal nutritional recommendations**: phenotyping (physical parameters and biomarkers), genotyping (SNP profile)

**Optimal nutrient requirements**

**Biomarkers<>nutrient<>genotype interactions**
Food Frequency Questionnaire (FFQ)

### Cereal

| How often would you have consumed each of the following in the past month? |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Portion size | Never (<1 per month) | 1-3 per week | 2-4 per week | 5-6 per week | Once a day | 1-3 per day | 4-5 per day | 6+ per day |
| Porridge, readybrek | Medium/Large | | | | | | | |
| Breakfast cereals, wholegrain e.g. branflakes, barley flakes | Medium/Large | | | | | | | |
| Breakfast cereals, non-wholegrain e.g. cornflakes | Medium/Large | | | | | | | |
| Breakfast cereals e.g. muesli, cereals | Medium/Large | | | | | | | |

### Bread and Savoury Biscuits

### Potatoes, Rice and Pasta

### Meat and Fish

### Dairy Products

### Fats and Spreads

### Sweets and Snacks

### Soups, Sauces, and Spreads

### Drinks

### Fruit

### Vegetables

### Dietary Habits

---

Save & Exit  Submit FFQ
<table>
<thead>
<tr>
<th>Breakfast Cereals, Wholegrain e.g. Bran flakes, Barley Flakes</th>
<th>Choose your usual portion size for this food group</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="cereal1.png" alt="Cereal Bowl" /></td>
<td><img src="cereal2.png" alt="Cereal Bowl" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Very Small</th>
<th>Small</th>
<th>Small/Medium</th>
<th>Medium</th>
<th>Medium/Large</th>
<th>Large</th>
<th>Very Large</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Breakfast cereals, wholegrain e.g. bran flakes, barley flakes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast cereals, non-wholegrain e.g. corn flakes</td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals e.g. muesli, muesli</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Portion size</th>
<th>Never (0 per month)</th>
<th>1-2 per week</th>
<th>Once a week</th>
<th>2-4 per week</th>
<th>5-6 per week</th>
<th>Once a day</th>
<th>2-3 per day</th>
<th>4-5 per day</th>
<th>6+ per day</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bread and Savoury Biscuits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes, Rice and Pasta</td>
<td></td>
</tr>
<tr>
<td>Meat and Fish</td>
<td></td>
</tr>
<tr>
<td>Dairy Products</td>
<td></td>
</tr>
<tr>
<td>Fats and Spreads</td>
<td></td>
</tr>
<tr>
<td>Sweets and Snacks</td>
<td></td>
</tr>
<tr>
<td>Soups, Sauces, and Spreads</td>
<td></td>
</tr>
<tr>
<td>Drinks</td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
</tr>
<tr>
<td>Dietary Habits</td>
<td></td>
</tr>
</tbody>
</table>

Save & Exit Submit FFG
Volunteer Data

Personal Information
- Name: Smith, John
- Email: johnsmith@cremeglobal.com
- Age: 43
- Gender: Male
- Height: 1.80 m
- Country: Ireland

Status
- Current Status: Accepted
- Feedback Level: Intensity: 3L
- Actions: Remove from Study

Screening Questionnaires
- First Screening Questionnaire: 2012-07-06 08:26:26
- Second Screening Questionnaire: 2012-07-06 08:36:33

Participant Consent Form
- Consent Form: 2012-07-06 09:36:33

Food Frequency Questionnaires
- FFQ ID: 11
  - Title: Preliminary FFQ
  - Description: Preliminary FFQ
  - Time Point: Screening
  - Status: Completed
  - Date Started: 2012-07-06 16:19:23
  - Date Completed: View Report

K-Bioscience Data

Vita Data
# Nutritional Intake

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Daily Intake (Food &amp; Supps)</th>
<th>Daily Intake (Food Only)</th>
<th>Cereal</th>
<th>Bread &amp; Savoury Biscuits</th>
<th>Potatoes, Rice &amp; Pasta</th>
<th>Meat &amp; Fish</th>
<th>Dairy Products</th>
<th>Fats &amp; Spreads</th>
<th>Sweets &amp; Snacks</th>
<th>Soups, Sauces &amp; Spreads</th>
<th>Drinks</th>
<th>Fruit</th>
<th>Vegetables</th>
<th>Supplements</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY</td>
<td>260220.00</td>
<td>22020.00</td>
<td>6.0%</td>
<td>1.9%</td>
<td>5.5%</td>
<td>1.2%</td>
<td>1.2%</td>
<td>4.7%</td>
<td>2.1%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>2.4%</td>
<td>2.4%</td>
</tr>
<tr>
<td>KCAL</td>
<td>1104420.00</td>
<td>1104420.00</td>
<td>6.8%</td>
<td>1.9%</td>
<td>5.5%</td>
<td>1.2%</td>
<td>1.2%</td>
<td>4.7%</td>
<td>2.1%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>2.4%</td>
<td>2.4%</td>
</tr>
<tr>
<td>TOTAL FAT</td>
<td>38.98</td>
<td>38.98</td>
<td>3.0%</td>
<td>4.2%</td>
<td>0.3%</td>
<td>1.2%</td>
<td>1.2%</td>
<td>2.0%</td>
<td>4.4%</td>
<td>2.0%</td>
<td>4.6%</td>
<td>2.0%</td>
<td>2.3%</td>
<td>2.3%</td>
</tr>
<tr>
<td>SAT FAT</td>
<td>16.40</td>
<td>16.40</td>
<td>1.5%</td>
<td>2.7%</td>
<td>0.8%</td>
<td>1.1%</td>
<td>2.1%</td>
<td>2.2%</td>
<td>4.3%</td>
<td>2.2%</td>
<td>2.4%</td>
<td>1.9%</td>
<td>2.1%</td>
<td>2.1%</td>
</tr>
<tr>
<td>TRANS</td>
<td>0.47</td>
<td>0.47</td>
<td>-</td>
<td>-</td>
<td>8.2%</td>
<td>2.1%</td>
<td>2.2%</td>
<td>2.0%</td>
<td>2.0%</td>
<td>2.0%</td>
<td>-</td>
<td>-</td>
<td>2.3%</td>
<td>2.3%</td>
</tr>
<tr>
<td>HYDRO FAT</td>
<td>19.98</td>
<td>19.98</td>
<td>3.4%</td>
<td>2.2%</td>
<td>1.1%</td>
<td>1.2%</td>
<td>2.1%</td>
<td>2.2%</td>
<td>4.5%</td>
<td>2.5%</td>
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</table>
Section 3a: Your Nutrient Profile

This section of the report shows your average daily intake for selected macronutrients, fibre, vitamins and minerals in comparison to the Institute of Medicine international recommendations for your age and gender.

For more information on any of the nutrients listed above click here or check the nutrients section on your personal login page on the Food4me website.

To return to the start of your report, click here.
Outcomes: Energy Intake

- Energy Intake (Kj/day⁻¹)

Control Group (L₀)
Personalised Nutrition Group (L₁+L₂+L₃)
Level 1 "Diet"
Level 2 Diet + Phenotype
Level 3 Diet + Phenotype + Genetic
Outcomes: Healthy Eating

Index

![Graph showing Healthy Eating Index for different groups: Control Group (L0), Personalised Nutrition Group (L1+L2+L3), Level 1 “Diet” (L1), Level 2 Diet + Phenotype (L2), Level 3 Diet + Phenotype + Genetic (L3).](image-url)
Food Safety & Nutrition Research in a Digitized World
Food Safety & Nutrition Research

...use all of the Data
Food Safety & Nutrition Research

...Data Science Challenge
Food Safety & Nutrition Research

Data Science is a Team Sport
Food Safety & Nutrition Research

...Collaborate
## My Data

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Total  €7,545,625 +/- €329,829
P25 - p75  €7,304,535 to €7,771,941

The below histogram shows the spread of values of the total Pipeline value prediction (in €).
1. Gather Data
2. Structure Data
3. Analyse / Visualise Data
4. Predictive Modelling

FS & Nutrition Research

… Data Science Challenge

cremeglobal
Changing Models and Methodologies for Food Safety and Nutritional Research in a Digitalized World

Key Takeaways
Changing Models and Methodologies for Food Safety and Nutritional Research in a Digitalized World

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2. Use Digital Tools to Gather & Access Data
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