Dietary exposure of the Italian population to food contaminants: the national Total Diet Study 2012-2014

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Dietary exposure to trace elements and radionuclides: the methodology of the Italian Total Diet Study 2012-2014

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Abstract

This article presents the methodology of the Italian Total Diet Study 2012-2014 aimed at assessing the dietary exposure of the general Italian population to selected non-essential trace elements (Al, inorganic As, Cd, Pb, methyl-Hg, inorganic Hg, U) and radionuclides (^{40}K, ^{134}Cs, ^{137}Cs, ^{90}Sr). The establishment of the TDS food list, the design of the sampling plan, and details about the collection of food samples, their standardized culinary treatment, pooling into analytical samples and subsequent sample treatment are described. Analytical techniques and quality assurance are discussed, with emphasis on the need for speciation data and for minimizing the percentage of left-censored data so as to reduce uncertainties in exposure assessment. Finally the methodology for estimating the exposure of the general population and of population subgroups according to age (children, teenagers, adults, and the elderly) and gender, both at the national level and for each of the four main geographical areas of Italy, is presented.

Key words
- metals
- arsenic
- radioisotopes
- exposure assessment
- food safety
- total diet study

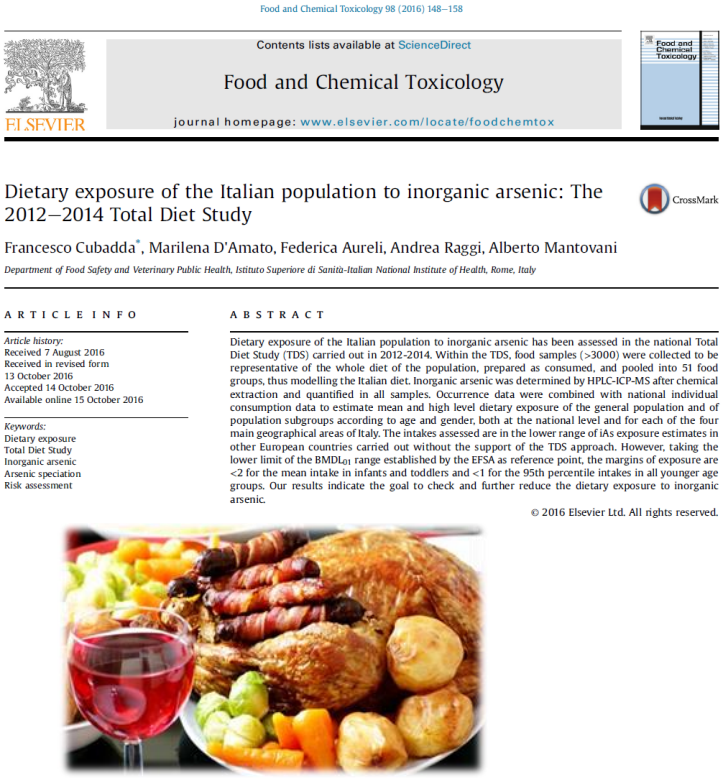
INTRODUCTION

Trace elements are chemical substances taken up at trace levels from the diet. Whereas essential trace elements are nutrients needed in very minute quantities for the proper growth, development, and physiology of the organism (e.g. iron, copper, zinc, iodine, selenium, molybdenum), dietary exposure to non-essential elements such as cadmium, lead or mercury is of concern [1-3]. Environmental sources are the main contributors to contamination of food with metals and other non-essential elements. Even though they are ubiquitous and thus naturally present in the diet, higher levels may occur as a result of environmental pollution from industrial and other anthropogenic activities.

Non-essential elements may enter the food chain at any point during growth and harvesting, through to storage and processing, including packaging. Food is the major contributor to exposure of the general popu-

Certain food groups are known to accumulate some trace elements naturally and, consequently, they can contain relatively high concentrations of these ones. For example, fish and shellfish are known to accumulate mercury in the toxic form of methylmercury. Wheat takes up cadmium whereas rice accumulates arsenic largely in the toxic form of inorganic arsenic. It is to be noted that other food items such as fish and seafood contain very high concentrations of arsenic, but it occurs as organic species of lower or negligible toxicity. Therefore, for risk assessment of arsenic speciation data are needed in order to characterize the presence of the toxic inorganic form [4, 5]. Also in the case of mercury speciation is important, since methylmercury is considerably more toxic than inorganic mercury [5, 6].

Another element of concern is aluminium, which is found in food as a result of its natural occurrence in the environment, contamination from various sources



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Dietary exposure of the Italian population to inorganic arsenic: The 2012–2014 Total Diet Study

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ABSTRACT

Dietary exposure of the Italian population to inorganic arsenic has been assessed in the national Total Diet Study (TDS) carried out in 2012-2014. Within the TDS, food samples (>3000) were collected to be representative of the whole diet of the population, prepared as consumed, and pooled into 51 food groups, thus modelling the Italian diet. Inorganic arsenic was determined by HPLC-ICP-MS after chemical extraction and quantified in all samples. Occurrence data were combined with national individual consumption data to estimate mean and high level dietary exposure of the general population and of population subgroups according to age and gender, both at the national level and for each of the four main geographical areas of Italy. The intakes assessed are in the lower range of iAs exposure estimates in other European countries carried out without the support of the TDS approach. However, taking the lower limit of the $BMDL_{01}$ range established by the EFSA as reference point, the margins of exposure are <2 for the mean intake in infants and toddlers and <1 for the 95th percentile intakes in all younger age groups. Our results indicate the goal to check and further reduce the dietary exposure to inorganic arsenic.

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7-8 March 2017

Total Diet Studies

*Total Diet Studies (TDSs) are designed to produce a solid base for population **dietary exposure assessment** to chemicals and its potential impact in public health*

A Total Diet Study (TDS) consists in:

- **Selection** of foods commonly consumed
- Random **purchase** of foods at retail level
- **Processing** the food as usually consumed
- **Pooling** and **homogenising** the prepared food items into representative food groups
- **Analysis** of the pooled samples for the substances of interest

efsa European Food Safety Authority

World Health Organization

JOINT GUIDANCE OF EFSA, FAO AND WHO Towards a harmonised total diet study approach: a guidance document. *EFSA J* 2011;9(11):2450-515

Guidelines for an harmonised Total Diet Study approach

Reference:

European Food Safety Authority (EFSA), Food and Agriculture Organization (FAO), World Health Organization (WHO).

2011.

Towards a harmonised total diet study approach: a guidance document.

EFSA J 9(11):2450

efsa European Food Safety Authority

World Health Organization

EFSA Journal 2011; 9(11):2450

JOINT GUIDANCE OF EFSA, FAO AND WHO

Towards a harmonised Total Diet Study approach: a guidance document[1]

European Food Safety Authority (EFSA), Parma, Italy[2, 3]

Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

World Health Organization (WHO), Geneva, Switzerland

ABSTRACT

tds ▶ exposure

TDS Exposure project (4 years, concluded in January 2016) fostered harmonisation of the TDS approach at the pan-European level

KEY WORDS

Total Diet Study, Dietary Exposure, Contaminants, Nutrients, Harmonisation

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[2] Correspondence: datex@efsa.europa.eu

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Essential principles of a Total Diet Study

TDSs are designed to cover the **whole diet** and to **measure** the **amount** of each chemical substance of interest **ingested by the population** living in a country over their **lifetime**, using average and high-level consumption data as appropriate for the substances being assessed (**chronic dietary exposure**)

Essentials principles of a TDS:

1. Representative of the whole diet
2. Pooling of foods
3. Food analysed as consumed

Exposure through drinking water and water used in cooking is considered in the TDS approach

EFSA J 2011;9(11):2450-515

Italian TDS 2012-14

- Launched by Italian Ministry of Health
- Coordinated by Istituto Superiore di Sanità

Reference:

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ORIGINAL ARTICLES AND REVIEWS

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This ...resents the methodolo... ...an Total ... 2014 aimed at ass... ...dietary exposure ... ...elected non-essenti... ...ts (Al, inor... ...Hg, U) and radionu... ...^{137}Cs, ^{90}... ...t, the design of the sa... ...standard... culinary ...

Key words
• metals
• ... isotopes
• ...posure assessment
• food safety
• total diet study

ORIGINALLY LAUNCHED FOR
trace elements and element species, and radionuclides
THEN EXTENDED TO
mycotoxins, dioxins and PCBs, and micronutrients

...accumulate some ...ently, they can ...f these ones. ...own to accumulate ...thylmercury. Wheat takes ...ulates arsenic largely in ...It is to be noted that ...food contain very ...curs as organic ...or negligible ...erefore, for ...arsenic speciation data ...needed in order to ch... ...e the presence of the toxic inorganic form [4, 5]. A... ...n the case of mercury speciation is important, since methylmercury is considerably more toxic than inorganic mercury [5, 6].

Another element of concern is aluminium, which is found in food as a result of its natural occurrence in the environment, contamination from various sources, leaching from food contact materials and the use of aluminium-containing food additives [7, 8]. As regards

ubiqu... levels ... from i... ...other ant... ...ic activities. Nor... ...elements may ...ter the food chain at any ...uring growth and harvesting, through to storag... ...d processing, including packaging. Food is the major contributor to exposure of the general (non-occupationally exposed) population, although other routes may also be significant for specific elements.

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Italian TDS 2012-14: the methodology (1)

Target population

Two genders and five age classes, i.e. infants and toddlers (<3 y), children (3-9.9 years), teenagers (10-17.9 years), adults (18-64.9 years) and elderly people (≥ 65 years)

Geographical variation

4 cities were selected to represent the **four main geographical areas of Italy**:
Milan (North-West), Bologna (North-East), Rome (Centre), Bari (South and Islands)

D'Amato et al. 2013. Ann Istit Super Sanità 49:272
Cubadda et al. 2016. Food Chem Toxicol 98:148

Italian TDS 2012-14: the methodology (2)

Food list

The most widely consumed foods by adults and/or children (consumer rate of at least 5%) were selected

Foods were grouped so that commodities known to:

•*be susceptible to contamination (e.g. offal, crustaceans and molluscs, spices and herbs) or*

•*represent major exposure sources (e.g. rice)*

were kept separate, as were foods which are consumed in large quantities (e.g. bread, pasta).

The **core foods (n = 51),** grouped into **13 categories,** covered about **99.7% of the whole diet** of adults and children

D'Amato et al. 2013. Ann Istit Super Sanità 49:272
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Italian TDS 2012-14: food sampling and sample preparation

❑ Food Sampling

- The **> 3000 elementary food items** making up the 51 core foods bought at retail in 4 selected cities, from November 2012 to July 2014
- Specific **retail outlets** (e.g. hyper and supermarkets, traditional markets, bakeries, etc.) selected **according to consumer habits**
- **Fruit and vegetables** sampled during two **different seasons**

Seasonality covered

❑ Sample preparation and analysis

- Individual food samples prepared and cooked according to **normal consumer practices**
- Samples then pooled in 204 samples, i.e. the **51 core foods** representative of the population diet, obtained **for each** of the four main **geographical areas**
- Samples were freeze-dried (except for water and some other matrices) to enable **long-term storage** and successive analysis for other chemicals later on
- Sensitive analytical methods used: negligible number of results <L
- **Absence of left-censored data reduced uncertainty in exp**
  LB-UB)
- **Inorganic arsenic** was measured in all food groups by HPLC-IC

NOVEL
First TDS where inorganic arsenic is measured

Chemical substances: >50 individual chemicals measured

Non-essential elements

Al, Cd, Pb, MeHg and Inorganic-Hg, [illegible], U

Radionuclides

^{40}K, ^{134}Cs, ^{137}Cs, ^{90}Sr

Dioxins & PCBs

PCDDs (7), PCDFs (1[illegible]ors)

Mycotoxins

9 individual my[illegible] T2, HT2, ZEA, CIT)

Micronutrients

Essential tra[illegible]others), *ongoing*

For toxic substances, in all cases, exposure was lower compared to EFSA estimates:

CORRECT!

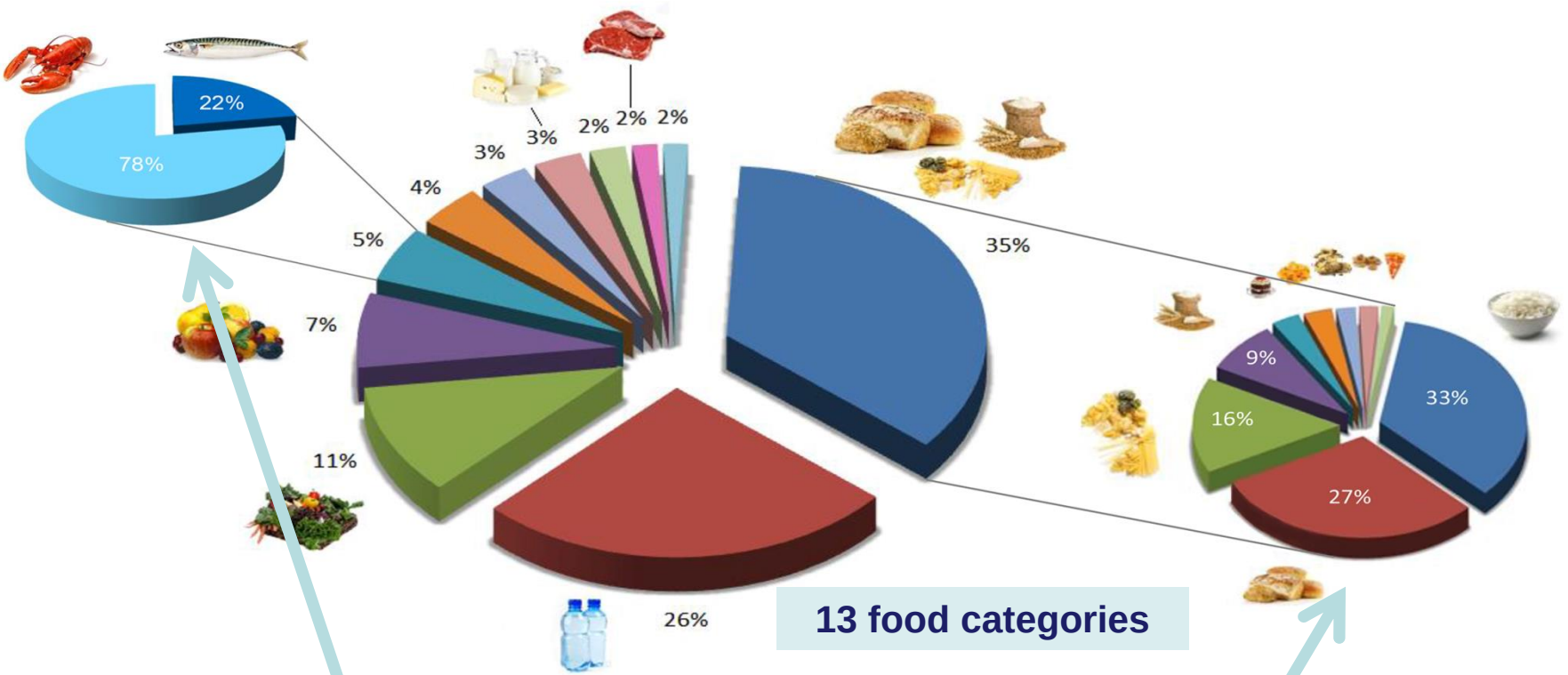
EFSA APP[illegible]OACH SHOULD NOT UNDE[illegible]TIMATE EXPOSURE, TDS PRO[illegible] MORE ACCURATE DATA

Risk characterization:

Average intake of toxic chemicals is <HBGV (TWI, BMDL), but MOEs are sometimes very small and sensitive population groups/high consumers may exceed the HBGVs

Exposure assessment: contribution of food categories and single food items

Example: exposure to inorganic arsenic



Contributors to the dietary exposure of the Italian population to inorganic arsenic.

13 food categories

The category *'Fish and seafood'* split into the 2 constituting core foods

The category *'Cereals and cereal products'* split into the 9 constituting core foods

Cubadda et al. 2016. Food Chem Toxicol 98:148

Conclusions

- **The Italian national TDS covered:**

- Average and high level (P95) exposure for total population and consumers only
- Exposure to contaminants and intake of (micro)nutrients
- Two genders and fiveage classes
- Geographical variation (4 main geographical areas of Italy)
- Seasonal variation (fruit & vegetables)
- 51 core foods
- Water as both food and cooking medium
- Long-term storage of samples (successive analysis for other chemicals later on)
- Element chemical species: inorganic As comprehensively measured and not estimated for the first time in a TDS

- **The exposure of toxic chemicals and the intake of nutrients has been assessed for the Italian population (incl. sub-groups) and the relevant risk characterized**