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## Standardized Map of Iodine Status in Europe

Ittermann, T., Albrecht, D., Arohonka, P., Bílek, R., Dahl, L., Castro, J. J., Filipsson Nyström, H., Gaberšček, S., Garcia-Fuentes, E., Gheorghiu, M., Hubalewska-Dydejczyk, A., Hunziker, S., Jukic, T., Karanfili, B., Koskinen, S., Kusic, Z., Majstorov, V., Makris, K., Markou, K., ... Völzke, H. (2020). Standardized Map of Iodine Status in Europe. *Thyroid : official journal of the American Thyroid Association*. <https://doi.org/10.1089/thy.2019.0353>

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# 1 **Standardized Map of Iodine Status in Europe**

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90 **Abstract**

91 **Background**

92 Knowledge about the population's iodine status is important, because it allows adjustment of  
93 iodine supply and prevention of iodine deficiency. The validity and comparability of iodine  
94 related population studies can be improved by standardization, which was one of the goals of  
95 the EUthyroid project. The aim of this study was to establish the first standardized map of  
96 iodine status in Europe by using standardized UIC data.

97 **Methods**

98 We established a gold-standard laboratory in Helsinki measuring UIC by inductively-coupled  
99 plasma-mass spectrometry. A total of 40 studies from 23 European countries provided 75  
100 urine samples covering the whole range of concentrations. Conversion formulas for UIC  
101 derived from the gold-standard values were established by linear regression models and  
102 were used to post-harmonize the studies by standardizing the UIC data of the individual  
103 studies.

104 **Results**

105 In comparison to the EUthyroid gold-standard, mean UIC measurements were higher in 11  
106 laboratories and lower in 10 laboratories. The mean differences ranged from -36.6% to  
107 49.5%.

108 Of the 40 post-harmonized studies providing data for the standardization, 16 were conducted  
109 in schoolchildren, 13 in adults and 11 in pregnant women. Median standardized UIC was <  
110 100 µg/L in 1 out of 16 (6.3%) studies in schoolchildren, while in adults 7 out of 13 (53.8%)  
111 studies had a median standardized UIC < 100 µg/L. Seven out of 11 (63.6%) studies in  
112 pregnant women revealed a median UIC < 150 µg/L.

113 **Conclusions**

114 We demonstrated that iodine deficiency is still present in Europe, using standardized data  
115 from a large number of studies. Adults and pregnant women, particularly, are at risk for  
116 iodine deficiency, which calls for action. For instance, a more uniform European legislation  
117 on iodine fortification is warranted to ensure that non-iodized salt is replaced by iodized salt  
118 more often. In addition, further efforts should be put on harmonizing iodine related studies  
119 and iodine measurements to improve the validity and comparability of results.

120

## 121 **Introduction**

122 The iodine status of regions is assessed by median urinary iodine concentrations  
123 (UIC) determined in representative samples of populations. National iodine  
124 fortification programs are initiated and modified based on such studies. According to  
125 the World Health Organization (WHO), a region is iodine sufficient if the median UIC  
126 is  $\geq 100 \mu\text{g/L}$  in non-pregnant populations (1). Based on this criterion, worldwide  
127 maps of country-specific iodine status are drawn (2, 3). Laboratory methods for  
128 measuring UIC, however, are heterogeneous hampering the comparability of iodine  
129 monitoring studies (1). In a recent ring trial in Germany consisting of 300 samples,  
130 variations of up to 50% were observed between different UIC laboratory methods.  
131 These findings emphasize the need for standardization of iodine monitoring status as  
132 well as UIC measurements ensuring valid estimates of the iodine status in  
133 populations (4).

134 Besides the standardization of iodine monitoring studies, it will be necessary to  
135 harmonize fortification programs. In Europe, iodine fortification programs differ  
136 according to type of regulations (mandatory vs. voluntary iodine fortification), amount  
137 of iodine used, and chemical form (iodine vs. iodate) (5, 6). The variety of iodine  
138 fortification programs within Europe is a challenge for companies acting on the global  
139 market. In consequence, large parts of Europe can be seen as mildly to moderately  
140 iodine deficient with only 27% of European households having access to iodized salt  
141 (7). Around 350 million citizens are exposed to iodine deficiency being at higher risk  
142 for developing neurodevelopmental anomalies, since iodine deficiency remains as an  
143 important yet preventable cause of brain damage (7). In contrast, the “Global  
144 Scorecard of Iodine Nutrition 2017” provided by the Iodine Global Network (IGN)  
145 shows that large parts of Europe are adequately supplied by iodine (2). This

146 discrepancy may be explained by a lack of standardization of iodine measurements  
147 used for the IGN scorecard. Furthermore, iodine status is reported at the national  
148 level in the IGN map, but, particularly in countries with voluntary iodine supply,  
149 median iodine levels may differ substantially between subpopulations and regions  
150 within the respective country. Therefore, harmonized monitoring studies and UIC  
151 measurements as well as the consideration of regional and population differences,  
152 are of great importance when evaluating and monitoring the effectiveness of  
153 fortification programs. In our study, we aimed to standardize European iodine  
154 monitoring studies with respect to these considerations in order to establish a valid  
155 map of the iodine status in European populations.

## 156 **Material and Methods**

157 Within the framework of the EUthyroid consortium, we collected data on iodine status  
158 from 48 European studies using the EUthyroid data exchange system (8). Information  
159 on data owner, study design (population-based, volunteers or patients), study  
160 population (children, adults or pregnant women), year of data collection, blood  
161 sampling, urine collection, and laboratory methods were collected from each study.  
162 Details of the included studies can be found in Supplementary Table 1. The  
163 maximum number of studies, for which UIC were analyzed in one laboratory, was  
164 three. The study region was assessed using the EU-recommended “Nomenclature of  
165 Territorial Units for Statistics” (NUTS) system, which classifies each European  
166 country by five hierarchical levels (9). For each study participating in the cross-lab  
167 comparison, the relevant ethics approval was obtained and each study followed the  
168 declaration of Helsinki.

169 The individual studies were post-harmonized by standardizing the UIC data. For this  
170 purpose, we established a gold-standard EUthyroid laboratory at THL in Helsinki,



171 where UIC was measured with inductively coupled plasma – mass spectrometry  
172 (ICP-MS) using an Agilent 7800 ICP-MS system (Agilent Technologies Inc., Santa  
173 Clara, CA, USA). One-hundred µl of urine was extracted using ammonium hydroxide  
174 solution. Iodine was scanned on  $m/z = 127$  and tellurium was used as internal  
175 standard. The National Institute of Standards and Technology (NIST) reference  
176 standard materials SRM2670a (with certified mass concentration value) and  
177 SRM3668 Level 1 and Level 2 were used to ensure accuracy of urinary iodine  
178 determinations. Coefficient of variation (CV) of control samples was  $2.9\% \pm 0.8$  during  
179 the course of the study. The laboratory participates regularly successfully in the  
180 external quality assessment scheme “Ensuring the Quality of Urinary Iodine  
181 Procedures” (EQUIP) organized by the Centers for Disease Control and Prevention.

182 For standardization of the UIC data from the individual studies, each partner was  
183 asked to send 75 spot urine samples to the EUthyroid gold standard laboratory. This  
184 number was a priori determined by a power analysis, accounting for the variation of  
185 UIC measurements. Since the distribution of UIC varies according to current iodine  
186 supply of the respective study region, it is not useful to determine one strict cut-off to  
187 define these marginal areas. Instead the cut-offs should be determined study-specific  
188 based on distributional characteristics. To detect deviations at either end of the UIC  
189 distribution, the low and the high end were oversampled. Thus, samples were  
190 selected the following way:

- 191 • Between 0 – 5<sup>th</sup> percentile – 12 samples
- 192 • Between 5<sup>th</sup> percentile – 25<sup>th</sup> percentile – 13 samples
- 193 • Between 25<sup>th</sup> percentile – 50<sup>th</sup> percentile – 13 samples
- 194 • Between 50<sup>th</sup> percentile – 75<sup>th</sup> percentile -13 samples
- 195 • Between 75<sup>th</sup> percentile – 95<sup>th</sup> percentile – 13 samples

- 196       • Between 95<sup>th</sup> percentile – 100<sup>th</sup> percentile – 11 samples

197   Based on the comparisons, we calculated mean deviations  $\pm$  1.96 standard  
198   deviations in % by Bland & Altman plots. Correlations between two laboratory  
199   methods were assessed by linear regression (10). Conversions formulas derived  
200   from linear regression models were established and applied to the original studies.  
201   We also re-calculated formulas using Passing-Bablok regression for all laboratories  
202   and found no substantial differences to our findings when applying these formulas to  
203   the study data (data not shown).

204   Out of the 48 studies, eight studies were not able to submit samples to the EUthyroid  
205   laboratory resulting in a total number of 40 standardized studies from 23 European  
206   countries. Standardized UIC were calculated as median for each of the studies and  
207   plotted on the European map. Data analyses were conducted using Stata 15.1 (Stata  
208   Corporation, College Station, TX, USA). Maps were generated in ArcGIS  
209   (Environmental Systems Research Institute (ESRI), ArcGIS Release 10.3.1,  
210   Redlands, CA, USA).

## 211   **Results**

212   In comparison to the gold-standard EUthyroid laboratory, UIC measurements were  
213   on average higher in 11 laboratories and lower in 10 laboratories (Table 1). The  
214   mean differences ranged from -36.6% to 49.5%. Correlations of UIC to the gold-  
215   standard EUthyroid laboratory were  $\geq 0.9$  for 9 laboratories (42.9%), 0.8 – 0.9 for 5  
216   laboratories (23.8%), 0.7 – 0.8 for 3 laboratories (14.3%), and  $< 0.7$  for 4 laboratories  
217   (19.0%). Conversion formulas used for generating standardized UIC values are given  
218   in Table 1.

219 Of the 40 standardized studies from 23 countries, 16 (40.0%) were conducted in  
220 schoolchildren, 13 (32.5%) in adults and 11 (27.5%) in pregnant women. Table 2  
221 shows the median standardized UIC for all 40 studies and in Figure 1 the median  
222 standardized UIC are printed on the European map. Studies are presented  
223 depending on the exact study region (status is not extrapolated to the national level)  
224 and very small study regions are highlighted by circles for better visibility. In  
225 population monitoring of iodine status using UIC, schoolchildren have been least  
226 impacted by thyroid medication (11), therefore preference has been given to studies  
227 carried out in schoolchildren. Thus, the UIC data have been selected for each country  
228 in the following order of priority: data from the most recent nationally representative  
229 survey carried out in (i) schoolchildren, (ii) adults, (iii) pregnant women. In the  
230 absence of recent national surveys, subnational data were used in the same order of  
231 priority.

232 European maps of standardized UIC in school children, adults and pregnant women  
233 are displayed in Figures 2 – 4 on the country level. Median standardized UIC was <  
234 100 µg/L in 1 out 16 (6.3%) studies in schoolchildren, while in adults 7 out 13 (53.8%)  
235 studies had a median standardized UIC < 100 µg/L. In tendency, countries from  
236 Eastern Europe were better supplied by iodine than Northern and Western European  
237 countries. Seven out of eleven (63.6%) studies in pregnant women revealed a  
238 median standardized UIC < 150 µg/L. In some countries median UIC differed strongly  
239 across subpopulations. Especially in Latvia, but also in Germany, Switzerland, Spain,  
240 Czech Republic, and Macedonia schoolchildren had higher median UIC than adults.

## 241 **Discussion**

242 We observed substantial differences in UIC measurements between different  
243 laboratories. These results show that standardizing UIC measurements is important

244 when comparing results. Looking for example at the population-based German adults  
245 studies DEGS (nationwide, 2011), SHIP-Trend (North-East Germany, 2012), and  
246 KORA (South Germany, 2008), the range of non- standardized median UIC varied  
247 substantially and were between 44  $\mu\text{g/L}$  and 158  $\mu\text{g/L}$ . Even though voluntary iodine  
248 fortification in Germany can lead to regional differences in iodine status, such large  
249 differences were not expected and do not seem plausible. However, different  
250 laboratories were responsible for the UIC measurements in the latter studies and we  
251 previously demonstrated larger differences in UIC measurements across these  
252 laboratories (4). While UIC measurements by Sandell-Kolthoff reaction were quite  
253 comparable to UIC measurements by the gold-standard ICP-MS for one laboratory,  
254 there were substantial differences in UIC for the other two laboratories using Sandell-  
255 Kolthoff reaction compared to the ICP-MS method (4). Thus, we believe that a  
256 potential explanation for the differences across the laboratories is the use of different  
257 digestion methods (4). Particularly, a not sufficient amount of the oxidizing digestion  
258 acid may result in elevated UIC measurements. After standardizing data from the  
259 European studies using the gold-standard EUthyroid laboratory, the median UIC  
260 were less variable, ranging between 51  $\mu\text{g/L}$  and 93  $\mu\text{g/L}$ , which indicates that  
261 Germany is currently mild to moderately iodine deficient.

262 Our standardized UIC data shows that mild-to-moderate iodine deficiency is still  
263 common in the adult population and in pregnant women in Europe, according to  
264 WHO criteria (1). Schoolchildren, on the other hand, are mostly iodine-sufficient,  
265 according to this study. Compared to children and adolescents, adults are likely to  
266 obtain less iodine from the diet because of lower consumption of milk products, the  
267 main source of dietary iodine in many countries (12-14). This, together with larger  
268 urine volumes in adults compared to schoolchildren (15) or amount of liquids

269 consumed, may explain the higher frequency of adult studies with median UIC < 100  
270 µg/L compared to studies in schoolchildren.

271 Pregnant women represent a specific subgroup of the general population. During  
272 pregnancy, iodine demand is higher and iodine clearance in the kidney increases,  
273 which is taken into account in the WHO pregnancy population cut-off for sufficient  
274 iodine supply (150 µg/L) in UIC (1). Pregnant women are recommended to take  
275 iodine supplementation in some countries (16), which hampers the comparison  
276 between iodine status in pregnant women and other populations in a study region.  
277 Furthermore, physiological changes during pregnancy and the fact that sample  
278 collection from pregnant women is sometimes performed in conjunction with  
279 ultrasound measurements, when they are advised to drink more water, leads to a  
280 higher dilution of the urine samples and in consequence to lower UIC (17). For these  
281 reasons, monitoring studies in pregnant women should not be used to characterize  
282 the iodine status of the general population and should be assessed separately from  
283 monitoring studies in children and adults. Our data demonstrates that pregnant  
284 women are particularly affected by iodine deficiency in Europe, emphasizing the  
285 importance of monitoring studies and an improved iodine status in this vulnerable  
286 subgroup.

287 Our standardized UIC data shows iodine deficiency in 53.8% of all adult studies, but  
288 iodine deficiency in only 6.3% of studies in schoolchildren. The 2017 iodine  
289 scorecard of the IGN indicates only two European countries as iodine deficient, but in  
290 the IGN scorecard, the iodine status of all countries with data is based on studies in  
291 schoolchildren, with the exception of Finland (2). WHO recommends monitoring of  
292 UIC in school-age children as a proxy for the general population (1). Although WHO  
293 also defines adequate iodine intake in adults as a median UIC value  $\geq 100$  µg/L (1),

294 the scientific basis for this threshold is weak (18). Future research to define a  
295 functional UIC cut-off value for adults indicating iodine deficiency would be valuable.

296 For the IGN scorecard, studies were not standardized, which may also be an  
297 explanation for the differences to our map. Another potential source of variation when  
298 comparing iodine surveys is the use of iodine-creatinine ratios (ICR). ICR has the  
299 advantage that UIC measurements are standardized to dilution of the urine samples,  
300 but the measurement error of ICR is larger than for UIC, because two biomarkers are  
301 set into context. In large populations the effect of the dilution of urine samples should  
302 cancel out. In a recent study it was reported that a study size of 500 individuals is  
303 needed to determine the iodine level of a population with a precision of 5% (19).  
304 Thus, we recommend to analyze UIC instead of the ICR in larger population studies.  
305 In pregnant women, however, ICR data is useful, because of the large variation in the  
306 dilution of urine during pregnancy.

307 Iodine supply appears to be better in Eastern European countries compared to  
308 Western or Northern European countries. This may be due to the fact, that in Eastern  
309 Europe iodine fortification programs are obligatory and well monitored, whereas in  
310 the rest of Europe iodine fortification programs are mostly voluntary (6).

311 The major strength of our study is that we, for the first time, present standardized  
312 data on iodine status for Europe. For standardization of each laboratory we used a  
313 sufficient number of samples (n=75) covering the whole range of UIC Our  
314 standardization approach was not ideal, because it was based on post-harmonization  
315 of data from existing studies. However, it yields a general view of the current iodine  
316 status across Europe, and indicates that pre-harmonized studies are needed, as well  
317 as actions to improve iodine intake in certain population groups. The main limitations  
318 imitations of our study arise from differences of the monitoring studies included, for

319 example in recruitment procedures (population-based or not), size of study (ranging  
320 from 74 to 14,641 study participants) or timing of sample collection. Furthermore,  
321 subnational UIC surveys should be interpreted with caution. These surveys are  
322 commonly carried out to provide a rapid assessment of population iodine status, but  
323 due to a lack of sampling rigor, they may over- or underestimate the iodine status at  
324 the national level. Even though schoolchildren are the ideal population, they are not  
325 representative for adult populations, because adolescents and adults are expected to  
326 have a lower UIC due to differences in diet. Particularly, the consumption of milk  
327 varies significantly between these subpopulations.

328 In the EUthyroid project we standardized the data from European iodine monitoring  
329 studies and demonstrated that iodine status is generally adequate in schoolchildren  
330 but iodine deficiency may still present in adults and pregnant women. An  
331 improvement of the iodine supply in Europe is hampered by different national  
332 legislations leading to a disproportionate use of iodized salt in processed food  
333 production (6). Therefore, a more uniform European legislation on iodine fortification  
334 is required. The standardized European map of UIC is an important milestone to  
335 provide the robust evidence to encourage stakeholders to improve and harmonize  
336 legislations towards Europe and beyond. In future studies, much more effort should  
337 be put on harmonizing the procedures used in iodine monitoring studies, beginning  
338 from the planning phase and including sample collection procedures and UIC  
339 measurements, to improve the validity and comparability of iodine studies.

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345 **Literature**

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**Supplementary Table 1. Description of the involved studies**

<b>Country</b>	<b>Year</b>	<b>Study population</b>	<b>Iodine measurement</b>	<b>Reference</b>
Croatia	2014 – 2016	Simplify study – population-based sample of 200 children, 227 adults and 202 pregnant women	Sandell-Kolthoff reaction (Wawschinek modification)	(1)
Cyprus	2014	Sample of 121 adults recruited from hospitals and advertisements	ICP-MS	
Czech Republic	2006	Study in Zdar nad Sazavou – population-based sample of 302 children and 288 adults	Sandell-Kolthoff reaction subsequent to dry alkaline	(2)
Finland	2017	FinHealth 2017 Study – Nationally representative survey, subsample with 1542 adults (Findiet 2017 Survey)	ICP-MS	
Germany	2003 – 2006	KiGGS study – nationwide population-based study in 14,641 children and adolescents	Sandell-Kolthoff reaction with ammonium persulfate digestion	(3)
Germany	2008 - 2012	SHIP-Trend – population-based study in 4287 adults	Sandell-Kolthoff reaction (Wawschinek modification)	(4)
Germany	2008 – 2011	DEGS – nation-wide population-based study in 7022 adults	Sandell-Kolthoff reaction with ammonium persulfate digestion	(5)
Germany	2006 – 2008	KORA-F4 – Population-based study in 2999 adults	Sandell-Kolthoff reaction (Wawschinek modification)	(6)
Germany	1997 – 2001	SHIP-0 – population-based study in 4260	Sandell-Kolthoff reaction	(7)

Country	Year	Study population	Iodine measurement	Reference
Greece	2012 – 2015	adults Representative sample of 1135 pregnant women	(Wawschinek modification) Sandell-Kolthoff reaction with ammonium persulfate digestion	(8)
Hungary	2018	One randomly-selected school including 110 children	Sandell-Kolthoff method adopted to microplate	
Hungary	2016	GS16 – 190 randomly selected pregnant women in week 16 of pregnancy	Sandell-Kolthoff method adopted to microplate	
Northern Ireland and Republic of Ireland	2014 – 2015	901 schoolgirls aged 14-15 years	Sandell-Kolthoff reaction with multiplate persulphate digestion	(9)
Northern Ireland (UK)	2014 – 2015	240 pregnant women recruited from maternity hospital	Sandell-Kolthoff reaction with multiplate persulphate digestion	(10)
Italy	2016	100 school children from Tuscany	ICP-MS	
Latvia	2010 – 2011	Study of 915 school children from 46 randomly-selected schools	Sandell-Kolthoff reaction with ammonium persulfate digestion	(11)
Latvia	2013 – 2014	Study of 743 pregnant women recruited by gynecologists from all regions	Sandell-Kolthoff reaction with ammonium persulfate digestion	(12)
North Macedonia	2016	Population-based sample of 1167 school children aged 8 – 10 years	Sandell-Kolthoff reaction with ammonium persulfate digestion	
North Macedonia	2017	Sample of 593 pregnant women recruited by advertisement	ICP-MS	
Montenegro	2016	Population-based sample of 406 school children	Sandell-Kolthoff reaction with ammonium persulfate digestion	

Country	Year	Study population	Iodine measurement	Reference
Norway	2015	FINS-TEENS –Randomized study of 457 adolescents aged 14 – 15 years from 8 secondary schools	ICP-MS	(13)
Poland	2017	Survey on iodine nutrition within the the National Health Programme including 1000 schoolchildren and 300 pregnant recruited on a voluntary basis	Sandell-Kolthoff reaction	
Portugal	2010 – 2011	Sample of 4390 school children and 4107 pregnant women recruited voluntarily	Colorimetric method	
Romania	2015 – 2016	Sample of 317 pregnant women recruited from ambulatory care	Sandell-Kolthoff reaction with ammonium persulfate digestion	
Serbia	2018	74 children with thyroid disease recruited from ambulatory care	Chemiluminescent microparticule immunoassay	
Slovenia	2017	Sample of 292 women of reproductive age	Sandell-Kolthoff reaction with ammonium persulfate digestion adopted to microplate	
Spain	2010 – 2011	Tirokid study – Population-based sample of 1750 children	Sandell-Kolthoff reaction (Benotti & Benotti modification) with chloric acid digestion	(14)
Spain	2008 – 2010	Di@bet.es – Population-based study in 4383 adults	Sandell-Kolthoff reaction (Benotti & Benotti modification) with chloric acid digestion	(15)

<b>Country</b>	<b>Year</b>	<b>Study population</b>	<b>Iodine measurement</b>	<b>Reference</b>
Sweden	2006 – 2007	National sample of 866 school-aged children	Sandell-Kolthoff reaction (Pino modification)	(16)
Sweden	1987 – 2001	Swedish Obese Subjects (SOS) Study – 565 obese subjects choosing bariatric surgery	Sandell-Kolthoff reaction (Pino modification)	(17)
Sweden	2006 – 2011	Karlstad-Uppsala-Study – Population-based study in 459 pregnant women	Sandell-Kolthoff reaction (Pino modification)	(18)
Switzerland	2015 – 2016	National representative study in 727 school children, 345 women of reproductive age and 358 pregnant women	Sandell-Kolthoff reaction (Pino modification)	(19)
Turkey	2016 – 2017	Sample of 165 high school and vocational school students aged 15 – 22	Sandell-Kolthoff reaction with ammonium persulfate digestion	

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**Table 1.** Laboratory comparisons to the EUthyroid central lab for urinary iodine concentrations (UIC)

Laboratory	Difference in UIC; % Mean (1.96*SD)	Correlation	p <sub>int</sub>	p <sub>slope</sub>	Conversion formula
1	-0.1 (14.7)	0.99	0.925	0.356	-0.23 + 1.01*UIC
2	-18.2 (53.2)	0.98	0.667	<0.001	-0.90 + 1.16*UIC
3	-15.5 (75.8)	0.98	0.022	0.458	17.44 + 0.98*UIC
4	13.0 (27.0)	0.97	<0.001	0.040	-29.2 + 1.04*UIC
5	-2.6 (49.7)	0.95	0.836	0.225	-1.05 + 1.04*UIC
6	32.3 (32.9)	0.95	0.074	<0.001	15.71 + 0.66*UIC
7	3.4 (37.2)	0.95	0.892	0.179	0.91 + 0.97*UIC
8	5.5 (79.2)	0.93	0.287	0.972	-5.65 + 1.00*UIC
9	14.5 (27.3)	0.92	0.693	<0.001	2.39 + 0.86*UIC
10	12.4 (44.4)	0.89	0.363	<0.001	5.02 + 0.83*UIC
11	-15.9 (143.9)	0.87	0.337	0.124	9.48 + 0.93*UIC
12	34.7 (89.9)	0.83	<0.001	<0.001	-67.37 + 1.54*UIC
13	49.5 (63.1)	0.82	0.163	<0.001	-6.61 + 0.63*UIC
14	30.0 (51.1)	0.82	0.096	0.161	-27.27 + 0.93*UIC
15	10.9 (83.2)	0.77	0.824	0.723	-6.39 + 0.98*UIC
16	-25.4 (74.3)	0.76	0.017	0.938	-89.08 + 1.92*UIC
17	-36.4 (62.0)	0.76	0.952	<0.001	-0.91 + 1.51*UIC
18	-18.4 (101.9)	0.68	<0.001	<0.001	68.21 + 0.63*UIC
19	4.4 (83.7)	0.62	0.042	0.009	20.94 + 0.80*UIC
20	-36.6 (131.8)	0.57	<0.001	<0.001	80.08 + 0.59*UIC
21	-16.5 (139.7)	0.50	<0.001	<0.001	49.23 + 0.53*UIC

Mean and standard deviations (SD) derived from Bland & Altman plots; correlations and conversion formulas from linear regression models; p<sub>int</sub> and p<sub>slope</sub> are the p-values derived from the regression model for the intercept = 0 and the slope = 1. p<0.05 indicates significant difference.

**Table 2.** Standardized median urinary iodine concentrations (UIC) in European monitoring studies

Country	Year	Number of individuals	Standardized median UIC in µg/L (95%-CI)	Standardized inter-quartile-range of UIC in µg/L
<b>Studies in school children</b>				
Croatia	2016	200	222 (209; 235)	179 – 282
Czech Republic	2006	302	210 (194; 225)	103 – 294
Germany	2006	14641	113 (111; 115)	61 – 169
Hungary	2018	110	254 (231; 276)	163 – 337
Northern Ireland and Republic of Ireland	2015	901	110 (104; 116)	71 – 162
Italy	2016	100	134 (126; 143)	114 – 162
Latvia	2011	915	102 (93; 111)	34 – 194
North Macedonia	2016	1167	216 (208; 224)	149 – 291
Montenegro	2016	406	181 (168; 193)	124 – 248
Norway	2015	457	98 (93; 103)	69 – 135
Poland	2017	1000	121 (116; 126)	82 – 168
Portugal	2011	4390	107 (106; 108)	94 – 156
Serbia	2018	74	187 (170; 204)	132 – 239
Spain	2011	1750	179 (174; 184)	121 – 246
Sweden	2007	866	127 (122; 132)	95 – 166

Country	Year	Number of individuals	Standardized median UIC in µg/L (95%-CI)	Standardized inter-quartile-range of UIC in µg/L
Switzerland	2016	727	152 (146; 158)	115 – 201
<b>Studies in adults</b>				
Croatia	2016	227	178 (163; 193)	111 – 222
Cyprus	2014	121	99 (87; 111)	71 – 150
Czech Republic	2006	288	105 (101; 108)	83 – 191
Finland	2017	1542	96 (93; 100)	62 – 146
	2012	4287	65 (63; 66)	36 – 103
Germany	2011	7022	51 (49; 52)	26 – 82
	2008	2999	93 (90; 96)	58 – 136
	2001	4260	72 (70; 73)	41 – 107
Slovenia	2017	292	73 (63; 83)	38 – 151
Spain	2010	4383	121 (118; 124)	79 – 179
Sweden	2001	565	132 (123; 140)	71 – 204
Switzerland	2016	345	103 (87; 120)	63 – 184
Turkey	2017	165	116 (110; 121)	89 – 145
<b>Studies in pregnant women</b>				
Croatia	2016	202	157 (147; 167)	114 – 196
Greece	2015	1135	118 (114; 123)	79 – 180

<b>Country</b>	<b>Year</b>	<b>Number of individuals</b>	<b>Standardized median UIC in µg/L (95%-CI)</b>	<b>Standardized inter-quartile-range of UIC in µg/L</b>
Hungary	2016	190	144 (126; 161)	89 – 276
Latvia	2013	743	39 (35; 44)	16 – 75
North Macedonia	2017	593	177 (161; 192)	90 – 265
Poland	2017	300	113 (101; 126)	64 – 188
Portugal	2011	4107	104 (103; 105)	65 – 155
Romania	2016	317	159 (142; 177)	99 – 243
Sweden	2007	459	114 (105; 123)	73 – 162
Switzerland	2016	358	156 (135; 177)	81 – 325
Northern Ireland (UK)	2015	240	66 (54; 79)	32 – 113

CI = confidence interval calculated by bootstrapping with 500 repetitions

**Figure 1.** Standardized European map of median urinary iodine concentrations (UIC); studies have been selected for each country in the following order of priority: most recent study in (i) schoolchildren, (ii) adults, (iii) pregnant women; grey shadings indicate “no data available”

**Figure 2.** Standardized European map of median urinary iodine concentrations (UIC) in school children; grey shadings indicate “no data available”

**Figure 3.** Standardized European map of median urinary iodine concentrations (UIC) in adults; grey shadings indicate “no data available”

**Figure 4.** Standardized European map of median urinary iodine concentrations (UIC) in pregnant women; grey shadings indicate “no data available”









