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Iodine deficiency among Belgian pregnant women not fully corrected by iodine-containing multivitamins: a national cross-sectional survey

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Abstract

Low iodine intake during pregnancy may cause thyroid dysfunction in pregnant women and their newborn. In the present study, iodine status among a nation-wide representative sample of Belgian pregnant women in the first and third trimester of pregnancy was determined, and determinants of iodine status were assessed 1 year after the introduction of bread fortified with iodised salt. The women were selected according to a multistage proportionate-to-size sampling design. Urine samples were collected and a general questionnaire was completed face to face with the study nurse. The median urinary iodine concentration (UIC) among pregnant women (*n* 1311) was 124·1 μg/l and 122·6 μg/g creatinine when corrected for urinary creatinine. The median UIC in the first trimester (118·3 μg/l) was significantly lower than that in the third trimester (131·0 μg/l) but significantly higher than among non-pregnant women (84·8 μg/l). Iodine-containing supplement intake was reported by 60·8 % of the women and 57·4 % of the women took this supplement daily. The risk of iodine deficiency was significantly higher in younger women, in women not taking iodine-containing supplements, with low consumption of milk and dairy drinks and during autumn. Women with a higher BMI had a higher risk of iodine deficiency but the risk was lower in women who reported alcohol consumption. The median UIC during pregnancy indicates iodine deficiency in Belgium and some women are at a higher risk of deficiency. The current low iodine intake in women of childbearing age precludes the correction of iodine deficiency in pregnant women supplemented with multivitamins containing 150 μg iodine as recommended.

Key words: Iodine deficiency: Belgium: Pregnant women

Pregnancy induces fundamental changes in thyroid function and iodine metabolism leading to thyroid stimulation[1]. The stimulation of the thyroid gland during pregnancy stems from the rise of oestrogen concentrations resulting in an increase of serum thyroxin-binding globulin, an increase in the renal clearance of iodide, the iodide transfer to the fetus, the direct stimulation of the thyroid by the human chorionic gonadotrophin and finally resulting in changes in the peripheral metabolism of maternal thyroid hormones under the influence of the placenta. Iodine-sufficient pregnant women meet their thyroid hormone requirement by increasing the thyroid iodide intake, maintaining a plentiful store of iodine in the thyroid. In iodine-deficient women, this adaptive mechanism fails to maintain adequate iodine stores, which can lead to thyroid dysfunction in the pregnant women and their newborn. Some studies have suggested that mild iodine deficiency during pregnancy may impair neuropsychological development[2] and psychomotor[3] development in the offspring, preventing them from reaching their full intellectual potential[4]. However, the impact of mild-to-moderate maternal iodine deficiency on cognition of the offspring is still unclear as few controlled intervention studies have measured long-term clinical outcomes[5]. Correction of mild-to-moderate iodine deficiency via supplementation in primary school children was found to improve cognitive and motor function[6].

Despite a worldwide successful implementation of iodine supplementation programmes over the last decades, iodine deficiency remains a public health problem in Europe[7,8]. According to the WHO, the median urinary iodine concentration (UIC) among pregnant women within the range 150–249 μg/l is indicative of iodine sufficiency[9]. Although, since 2003, the number of European countries in which

Abbreviation: UIC, urinary iodine concentration.

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iodine deficiency remains a public health problem decreased from twenty-three to fourteen[10], it is a matter of concern that iodine deficiency has reappeared in countries thought to have sufficient iodine intake, such as the UK[11]. Several surveys have indicated that Belgium is affected by mild iodine deficiency, and that this represents a substantial economic burden to the Belgian healthcare system[12–14]. Consequently, optimising iodine intake was chosen as a priority in the nutritional policy of the Belgian Ministry of Health.

An agreement was signed between the bakery sector and the Ministry of Health in April 2009, to encourage the fortification of bread with iodised salt (voluntary fortification)[15].

A recent national survey on iodine status in Belgian school-aged children has shown a median UIC of 113·1 and 84·8 μg/l among their mothers, indicating iodine sufficiency among the children and suggesting that the voluntary fortification of bread with iodised salt may have contributed to the optimisation of iodine intake in school-aged children but not in the adult population[16].

The aim of this first national representative study was to assess iodine status among pregnant women in Belgium during the first and third trimester of pregnancy, and to examine the determinants of iodine status in a mild iodine-deficient area, 1 year after the introduction of bread fortification with iodised salt.

Methods

Sampling

The target population of the survey comprised all pregnant women in Belgium during the first or third trimester of pregnancy in the period of the survey from September 2010 to June 2011. The women were selected according to a multistage proportionate-to-size stratified sampling design. Because some population-based data suggest that the prevalence of iodine deficiency is higher in the south than in the north of the country[17,18], the hospitals were stratified by region. A thirty-cluster survey was performed in both regions with at least twenty women per cluster, as recommended[19]. A sample size calculation based on an estimated 70 % prevalence of UIC <150 μg/l[13], a 95 % CI for the true prevalence of UIC <150 μg/l, a design effect of 2 and an absolute precision of 5 % resulted in a sample size of 645 women per region (1290 women, in total) or about twenty-two women per hospital: eleven in the first trimester and eleven in the third trimester of pregnancy.

In each region, the hospitals were ordered by province and size based on the number of deliveries during the past year and sixty clusters of four hospitals were selected using systematic sampling while accounting for the number of deliveries in order to have enough replacement hospitals in case

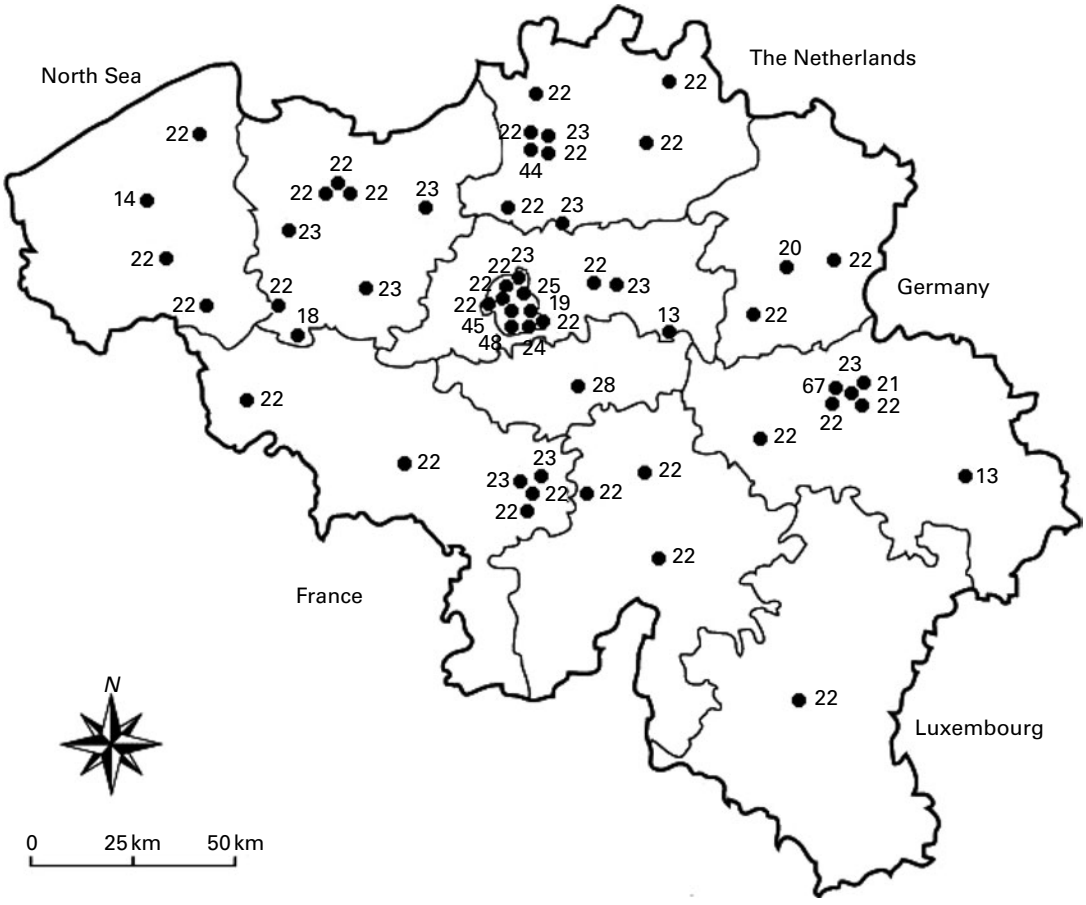

Fig. 1. Geographical distribution of the fifty-five hospitals visited in Belgium and the number of pregnant women (*n* 1311) investigated by site (national survey on the iodine status of pregnant women, Belgium 2010–11).

hospitals refused to participate. Of these sixty clusters, thirty clusters were randomly selected and within each cluster, the first hospital was invited to participate. In each hospital, all gynaecologists were invited to participate in order to level out a possible gynaecologist effect.

Data collection

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the medical ethical committee of the Erasme Hospital in Brussels. Written and verbal informed consent was obtained from all pregnant women. The fieldwork took place between September 2010 and June 2011. Urine samples were collected and a general questionnaire about sociodemographic and socio-economic characteristics, smoking and alcohol-drinking behaviour, thyroid diseases, use of iodine-containing supplements, consumption frequency of seaweed, fish and seafood, eggs, milk and dairy drinks, yoghurt, cottage cheeses and cheeses, consumption quantity of fish and seafood, milk and dairy drinks, yoghurt, cottage cheeses and cheeses, usual number of slices of bread consumed per d and use of iodised household salt was completed face to face with the study nurse. For one hospital (*n* 23 women), certain questions (mainly nationality, ethnicity and education level) needed to be omitted from the questionnaire upon decision of the ethical committee of this particular hospital. BMI was obtained from weight and height recorded by the gynaecologist during the first consultation for women in both the first and third trimester of pregnancy.

There were sixteen categories to report education level and they were recoded into six categories: secondary education or lower; higher education; university or higher; other education; no education; not known.

Analysis of samples

All urine samples were frozen and kept at −80 °C until analysis. UIC were measured in duplicate at Erasme Hospital using a modification of the Sandell–Kolthoff reaction with spectrophotometric detection[20]. The sensitivity of the assay was 12 μg/l. The Erasme laboratory participated successfully in the Program to Ensure the Quality of Urinary Iodine Procedures of the US Centers for Disease Control and Prevention[21]. Urinary creatinine was determined by a colorimetric method based on the Jaffe reaction[22].

Statistical analyses

Statistical analyses were carried out using STATA 10.1 (StataCorp). As UIC is not normally distributed, non-parametric methods were used. Differences in UIC between regions, trimesters and age groups were explored using the two-sample Wilcoxon rank-sum test or the Kruskal–Wallis equality-of-populations rank test. The odds of having a UIC lower than 150 μg/l *v.* an optimal iodine status were estimated by multiple logistic regression while controlling for age, trimester of pregnancy, region, BMI, smoking behaviour, alcohol consumption, use of iodine-containing food supplements, use of iodised household salt, bread consumption, fish consumption, milk and dairy drink consumption, education level, ethnicity and parity.

Results

Among the 1311 pregnant women participating in the survey, 214 were from Brussels, 640 from Flanders and 455 from Wallonia (Fig. 1). For two women, the region was missing. The mean age of women was 28·5 (SD 5·1) years (*n* 1305) and was similar in all three regions. For 1307 women, a general questionnaire was available. The mean BMI of women was 24·4 (SD 5·1) kg/m^2. More than 20 % of the women in the sample were from non-Caucasian origin and more than 50 % of the women included had a lower education level. Of all women included, 15 % smoked during pregnancy and 12 % reported having drunk alcohol during pregnancy (Table 1).

There were 640 women in the first trimester of pregnancy while 666 were in the third trimester of pregnancy and two were in the second trimester of pregnancy. For 41·7 % of the

Table 1. Characteristics of the pregnant women included in the study (Belgian national survey on micronutrient status in pregnant women, 2010–11)

(Number of participants and percentages, *n* 1311)

Characteristics	%	*n*
BMI (kg/m^2)		
Underweight	5·7	73
Healthy weight	59·2	763
Overweight	22·1	285
Obese	13·1	169
Ethnicity		
White/Caucasian	73·6	965
Asiatic	2·5	33
African (black)	4·9	64
North African	13·4	176
Hispanic	0·9	12
Not known	4·7	61
Education level		
Secondary education or lower	54·5	715
Higher education	27·2	357
University or higher	14·9	195
Other education	0·2	3
No education	0·7	9
Not known	2·4	32
Smoking		
Yes	16·8	220
During past 4 weeks	15·4	202
No	82·9	1087
Not known	0·3	4
Drinking alcohol		
Yes	20·4	267
During past 4 weeks	11·5	151
No	78·5	1029
Not known	1·1	15
Supplement use during pregnancy	76·2	999
Iodine supplements	60·8	797
Daily iodine supplements	57·4	746
Iodine supplements during the first trimester	50·9	326
Daily iodine supplements during the first trimester	49·0	312
Iodine supplements during the third trimester	70·4*	469
Daily iodine supplements during the third trimester	65·7*	432

* Values were significantly different from those of the first trimester ($P<0·001$).

Table 2. Distribution of urinary iodine concentrations (UIC, μg/l and μg/g creatinine) in pregnant women (*n* 1299) (national study on iodine status among pregnant women in Belgium, 2010)

(Mean values and standard deviations; medians, inter quartile ranges (IQR), percentages and 95 % confidence intervals)

	All women		Wallonia		Flanders		First trimester		Third trimester	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
n	1299		452		633		631		663	
Age (years)	28·5	5·1	27·9	5·5	28·8	4·7	28·3	5·1	28·8***	5·1
Gestational weeks	22·2	12·5	22·1	12·8	22·4	12·3	9·9	2·8	34·1	3·6
UIC (μg/l)										
Median	124·1		117·2		125·1		118·3		131·0***	
IQR	72·6–212·8		67·8–199·6		72·9–204·6		69·6–192·5		74·5–235·3	
95 % CI	118·3, 131·0		108·7, 129·2		117·2, 134·2		110·0, 126·8		123·3, 140·0	
< 150 μg/l	59·3		63·7		58·4		62·2		56·5	
< 100 μg/l	37·8		40·2		37·6		40·2		35·4	
< 50 μg/l	11·5		13·4		10·5		13·4		9·8	
UIC:creatinine (μg/g creatinine)										
Median	122·6		112·0		124·2†††		106·2		139·6***	
IQR	75·2–208·4		70·1–198·4		82·1–200·7		71·1–177·4		81·9–232·5	
95 % CI	115·4, 128·9		102·0, 125·3		115·3, 129·5		99·2, 112·6		129·1, 152·7	
Iodine supplements (%)										
Before pregnancy	12·0		9·5		15·7‡‡‡		12·6		11·5	
First trimester	43·3		46·4		35·5		37·3		49·1	

*** Mean values were significantly different from the first trimester ($P<0·001$).
††† Mean values were significantly different from Wallonia ($P=0·040$).
‡‡‡ Mean values were significantly different from Wallonia ($P<0·001$).

women, this was their first pregnancy, and 45·6 % of the women had been pregnant before. For the other women, this information was missing. Nearly 4·0 % of the women had had a miscarriage at least once. Interestingly, 77·6 % of the women stated that their pregnancy was planned. Of all women included, thirty-six (2·7 %) reported suffering from a thyroid disease: eighteen suffered from hypothyroidism; four from hyperthyroidism; six from goitre or nodules; one from thyroiditis; the disease was unspecified for the other women.

The median UIC among the pregnant women was 124·1 μg/l and even lower when corrected for urinary creatinine (122·6 μg/g creatinine). Of all pregnant women included, 59·3 % had a UIC below 150 μg/l, 37·8 % had a UIC below 100 μg/l while 18·4 % had a UIC above 249 μg/l and 3·7 % of the women had a UIC above 500 μg/l. The median UIC in the first trimester of pregnancy was significantly lower than that in the third trimester (118·3 and 131·0 μg/l, respectively). These differences were even more pronounced when the UIC was corrected for urinary creatinine (106·2 and 139·6 μg/g creatinine, respectively; Table 2). Compared with pregnant women, the median UIC in women of childbearing age was significantly lower, even when the UIC was corrected for urinary creatinine (Fig. 2).

The median UIC in Flanders and Wallonia were not significantly different. However, the UIC values corrected for urinary creatinine were significantly lower in Wallonia than in Flanders (112·0 and 124·2 μg/g creatinine, respectively; Table 2). The median UIC was highest in the oldest age group (>31 years, 132·2 μg/l), and lowest in the youngest age group (≤26 years, 116 μg/l) ($P<0·001$).

Most of the women reported taking iodine-containing multivitamins during pregnancy (Table 1). The percentage of women taking iodine supplements was significantly higher in the third than in the first trimester of pregnancy. The majority of women started taking iodine supplements during pregnancy and only 12 % of them started taking iodine supplements before pregnancy (Table 2). There were no differences among the regions in the use of iodine-containing supplements and the frequency of intake; however, in Flanders, the percentage of women starting to take iodine supplements before pregnancy was significantly higher than in Wallonia.

Of all women included in the survey, 87·2 % reported using non-iodised salt or sea salt, while 11·2 % reported using

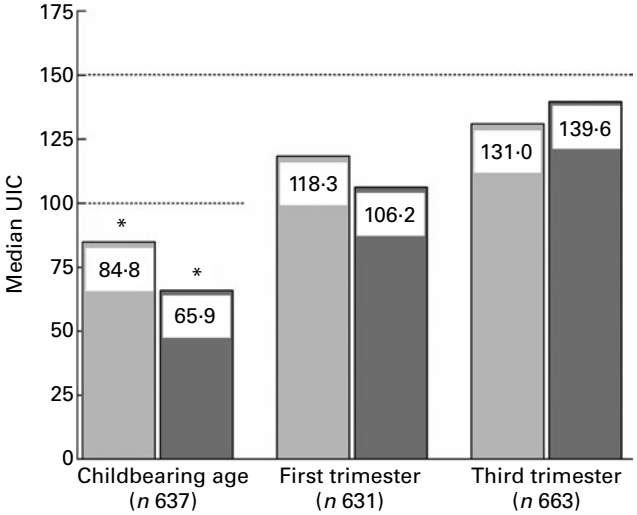

Fig. 2. Median urinary iodine concentration (UIC) (in μg/l (▥) and μg/g creatinine (■)) in women of childbearing age[16] and during the first and third trimester of pregnancy in Belgium. The upper horizontal dotted line represents the lower threshold indicating iodine deficiency in pregnant women (150 μg/l). The lower horizontal dotted line represents the lower threshold indicating iodine deficiency in women of childbearing age (100 μg/l). * Median UIC values were significantly different from those of the first and third trimester pregnant women ($P<0·001$).

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iodised household salt and 1·6 % reported using a combination of iodised and non-iodised salt.

The risk of iodine deficiency was investigated by logistic multivariate analysis (Table 3). The risk of iodine deficiency was significantly higher in younger women, in women not taking iodine-containing supplements and in women consuming milk and dairy drinks less frequently. In addition, the risk of iodine deficiency was significantly higher in autumn compared with winter. When a second model was constructed to asses the risk of iodine deficiency using the UIC values corrected for urinary creatinine, BMI, trimester of pregnancy and alcohol consumption appeared as determinants of iodine status (Table 4). The risk of iodine deficiency was higher in women with a higher BMI and women in the first trimester of pregnancy. Pregnant women who reported alcohol consumption during pregnancy had a lower risk of iodine deficiency (Table 4). Age, use of iodine-containing supplements, milk and dairy drink consumption frequency and season remained as determinants of iodine status in pregnant women as in the first model using uncorrected UIC values.

Discussion

The present results indicate that pregnant women in Belgium are iodine deficient based on the median UIC, as recommended by the WHO. Although about 60 % of pregnant women reported taking iodine-containing multivitamins during pregnancy, the median UIC did not reach the lower recommended threshold of 150 μg/l, indicating iodine sufficiency in pregnant women. More than 50 % of urine samples had a UIC below 150 μg/l.

As this is the first national survey on iodine nutrition in Belgian pregnant women, the evolution of iodine status over time cannot be accurately estimated. However, a previous small-scale study in Brussels in 1990 reported a median UIC of 56 μg/l in pregnant women[1]. The median UIC reported in the present national survey was 124·1 μg/l, suggesting that iodine intake in pregnant women has increased over time. However, unlike the population of school-aged children[16], iodine intake remains insufficient in some pregnant women. Other studies have also shown that despite the optimal median UIC in school-aged children, the median UIC in their mothers, in pregnant women or weaning infants may indicate iodine deficiency[23,24].

The median UIC was significantly higher in the third trimester compared with the first trimester or with women of childbearing age. The increase in UIC during pregnancy can be attributed to the intake of iodine-containing supplements. The percentage of women taking iodine-containing supplements was lower in the first trimester than in the third trimester of pregnancy. The failure of iodine supplements to optimise iodine intake in pregnant women stems from the

Table 3. Risk of iodine deficiency during pregnancy in Belgium (urinary iodine concentration (UIC) < 150 μg/l, *n* 1229)
(Odds ratios and 95 % confidence intervals)

	No. of subjects	No. of women with UIC < 150 μg/l	OR	95 % CI	*P* for trend
Age (years)			0·97	0·95, 1·00	0·027
Region					0·062
Flanders	632	373	1		
Brussels	213	113	0·90	0·63, 1·30	
Wallonia	452	290	1·31	1·00, 1·71	
Use of iodine-containing supplements					< 0·001
No	509	373	1		
Yes	788	403	0·37	0·29, 0·48	
Use of salt					0·732
Use of non-iodised salt	1122	676	1		
Use of iodised salt	146	89	1·20	0·82, 1·76	
Use of iodised and non-iodised salt	21	8	0·48	0·19, 1·22	
Frequency of milk and dairy drink consumption					< 0·001
Never	166	112	1		
Less than once per month	40	32	1·89	0·79, 4·50	
1–3 d per month	38	26	1·08	0·49, 2·40	
1 d per week	46	29	0·92	0·44, 1·92	
2–4 d per week	143	90	0·84	0·50, 1·39	
5–6 d per week	50	29	0·56	0·28, 1·14	
Once per d	655	376	0·63	0·43, 0·93	
Two to three times per d	139	73	0·47	0·29, 0·78	
More than three times per d	12	6	0·34	0·10, 1·24	
Ethnicity					0·063
White	954	584	1		
Asian	33	11	0·36	0·17, 0·77	
African (black)	64	36	0·78	0·45, 1·36	
North African	173	100	0·88	0·62, 1·27	
Hispanic	12	5	0·64	0·19, 2·16	
Season					0·010
Winter	469	269	1		
Spring	383	225	1·02	0·76, 1·37	
Summer	93	55	1·41	0·86, 2·30	
Autumn	350	226	1·46	1·07, 1·99	

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Table 4. Risk of iodine deficiency during pregnancy in Belgium (urinary iodine concentration (UIC) < 150 μg/g creatinine, *n* 1202)
(Odds ratios and 95 % confidence intervals)

	No. of subjects	No. of women with UIC < 150 μg/g creatinine	OR	95 % CI	*P* for trend
Age (years)			0·90	0·86, 0·94	0·001
Use of iodine-containing supplements					< 0·001
No	509	412	1		
Yes	788	370	0·21	0·16, 0·29	
Frequency of milk and dairy drink consumption					< 0·001
Never	166	108	1		
Less than once per month	40	32	2·25	0·89, 5·72	
1–3 d per month	38	29	2·47	0·97, 6·27	
1 d per week	46	29	0·97	0·43, 2·17	
2–4 d per week	143	86	0·86	0·50, 1·48	
5–6 d per week	50	30	0·73	0·33, 1·63	
Once per d	655	379	0·70	0·46, 1·06	
Two to three times per d	139	78	0·59	0·34, 1·01	
More than three times per d	12	7	0·60	0·15, 2·34	
Ethnicity					0·414
White	954	571	1		
Asian	33	11	0·32	0·13, 0·76	
African (black)	64	40	0·77	0·41, 1·43	
North African	173	117	1·27	0·84, 1·91	
Hispanic	12	7	1·19	0·33, 4·24	
Season					0·034
Winter	469	274	1		
Spring	383	228	0·91	0·65, 1·27	
Summer	93	50	1·21	0·72, 2·03	
Autumn	350	229	1·38	0·98, 1·94	
First pregnancy					0·113
Yes	542	320	1		
No	750	459	0·27	0·05, 1·42	
Age × first pregnancy					0·049
Yes	542	320	1		
No	750	459	1·06	1·00, 1·12	
Trimester					0·017
First trimester	631	429	1		
Third trimester	663	351	0·73	0·55, 0·95	
BMI (kg/m^2)			1·05	1·02, 1·08	0·001
Alcohol consumption during pregnancy					0·033
Yes	264	141	1		
No	1018	635	1·51	1·07, 2·12	
Frequency of fish consumption (fatty fish)					0·392
Never	192	136	1		
Less than once per month	187	115	0·80	0·47, 1·34	
1–3 d per month	496	287	0·64	0·42, 0·99	
1 d per week	290	160	0·66	0·41, 1·07	
2–4 d per week	112	72	0·87	0·47, 1·63	
Once per d	10	7	2·07	0·34, 12·62	
Two to three times per d	2	1	1·04	0·06, 18·41	
Frequency of fish consumption (other fish)					0·209
Never	225	152	1		
Less than once per month	224	137	0·71	0·44, 1·14	
1–3 d per month	504	305	1·02	0·68, 1·53	
1 d per week	269	142	0·57	0·36, 0·90	
2–4 d per week	64	38	0·86	0·42, 1·74	
Once per d	3	2	0·28	0·01, 6·85	

fact that iodine deficiency was probably present before pregnancy as suggested by the median UIC of 84·8 μg/l in women of childbearing age[16]. During pregnancy, the daily thyroid hormone and iodine requirement increases because of the increase in the renal clearance of iodine and because of the transfer of iodine to the fetus, aggravating therefore a pre-existent iodine deficiency. There are only a few studies with enough power to classify median UIC by trimester of pregnancy and even fewer studies comparing UIC with UIC of women of childbearing age[25].

In iodine-deficient areas, the median UIC during pregnancy remains constant or even decreases in the absence of iodine-containing supplements[26,27]. In areas with iodine sufficiency, the UIC during pregnancy increases and the median UIC is generally above 150 μg/l[28,29]. The iodine status in pregnant women in Belgium depicted a situation in which the recommendations to take iodine-containing supplements work relatively well as UIC are higher in the third trimester of pregnancy. However, because of the inadequate low iodine intake before

pregnancy, the daily administration of 150 μg iodine is not sufficient to reach iodine sufficiency during pregnancy.

This situation illustrates the importance of monitoring the iodine status of pregnant women even when iodine supplements are routinely given to pregnant women.

Many factors may affect urinary iodine excretion during pregnancy. Obviously, the most important is iodine intake and whether or not iodine supplements are given. In the case of iodine sufficiency before pregnancy and in the absence of systematic iodine supplements, median UIC is likely to remain unchanged during pregnancy as suggested by a study from Switzerland[24].

Because glomerular filtration rate increases during pregnancy, the UIC:creatinine ratio, which minimises the variation due to dilution and urine volume, may be more appropriate than UIC expressed as μg/l to assess iodine intake in pregnant women. However, there are only a few studies comparing UIC:creatinine during pregnancy with a sufficient number of subjects in the first and third trimester of pregnancy to really conclude[30,31]. In Belgium, the UIC:creatinine ratio in women of childbearing age and among women in the first trimester of pregnancy was lower than the UIC expressed in μg/l. By contrast, in the third trimester, the UIC:creatinine ratio was higher than the uncorrected UIC. These findings are consistent with a study from an iodine-sufficient area from Japan showing lower median UIC:creatinine during the first trimester and higher during the third trimester compared with UIC not corrected for urinary creatinine[30].

The current iodine status, particularly during early pregnancy, is a matter of concern as most of the women in Belgium are iodine deficient when they become pregnant and they remain deficient during pregnancy, even if the iodine status improves during the third trimester. The exacerbation of iodine deficiency during pregnancy may lead to maternal hypothyroxenaemia and enhanced stimulation of the thyroid gland[32].

Thyroid volume of mildly iodine-deficient pregnant women and their newborn increases during pregnancy as shown in a study performed in Belgium[32] and other European countries[33]. In addition, goitrogenesis during pregnancy can be prevented by iodine supplementation during pregnancy[34]. Furthermore, brain maturation of the fetus needs thyroid hormones.

However, fetal thyroid secretion occurs only during the second trimester of pregnancy; therefore, maternal thyroxine is the only source of thyroid hormones during the first trimester. Interestingly, several epidemiological studies and some clinical studies have reported an association between intelligence quotient and maternal mild iodine deficiency during pregnancy[35–37].

The median UIC increased with the age of the pregnant women, probably because of the fact that older pregnant women are better informed about food supplements or because of a previous pregnancy. Iodine status was significantly higher in Flanders than in Wallonia based on UIC:creatinine. This finding corroborated a previous study among another Belgian population group[17]. The model investigating the risk of iodine deficiency was explained by the use of iodine-containing supplements and the consumption of milk and dairy drinks. Dairy products are the main source of iodine in Belgium as in many other industrialised countries[38]. No significant associations were found between an optimal iodine status and fish intake. There were no significant differences in iodine status among pregnant women from different ethnic origin and socio-economic status, as shown previously in Brussels[39].

The risk of iodine deficiency was higher in autumn than in winter as reported in other European countries[40,41]. The variation of iodine intake with season has been attributed to variations of the iodine content in milk. During the winter months, cattle are housed indoors and fed with iodine-containing food.

When the UIC:creatinine ratio was used in the multivariate analysis, all the determinants associated with iodine status in the first model using the uncorrected UIC values remained significantly associated with iodine status. Interestingly, the second model using the UIC:creatinine ratio yielded new determinants of iodine status: BMI and alcohol consumption. Pregnant women who reported alcohol consumption had a lower risk of iodine deficiency. This is the first time that such an association is reported in pregnant women. In a study among adults from Denmark, an association between a reduced prevalence of goitre and solitary nodules and alcohol consumption has been reported[42]. Finally, the higher risk of iodine deficiency in women with a higher BMI may also explain the association between thyroid function and BMI in a mildly iodine-deficient area[43].

These associations have not been reported before, probably because this is the first study gathering at the same time enough statistical power, detailed nutritional questionnaires and a correction of UIC for urinary creatinine. Alcohol intake may relate to creatinine or an imprecision of the creatinine correction with a different alcohol intake[44].

The association between BMI and iodine could be caused by differences in creatinine rather than iodine excretion. This is plausible as a higher BMI associates with a higher muscle mass and hence a higher creatinine clearance[45].

The current policy in Belgium to optimise iodine status implemented since 2009 is based on the fortification of bread with iodised salt and the use of iodised table salt. This policy is voluntary and, currently, only 44 % of bread is fortified with iodised salt (source: ESCOSALT). In addition, the use of iodised table salt remains low in Belgium; only 37 % of households use iodised salt[16]. The use of iodised salt among pregnant women was even lower, although, in the present survey, the use was self-reported and some misreporting may have occurred. The current voluntary strategy seems, however, to work well for school-aged children as shown previously[16] but not for the adult population. To optimise the iodine status in pregnant women, an increase of iodine intake in women of childbearing age is necessary in order to reach a daily intake of 150 μg iodine well before pregnancy. This objective may be reached by increasing the number of bakers using iodised salt in the production of bread and by increasing the utilisation of iodised instead of non-iodised table salt by the general population.

The study has several limitations. The individual iodine intake could not be determined as only one spot urine sample was collected for each woman. The use of iodised salt among pregnant women was self-reported and no salt sample was collected to determine the iodine content. In addition, although hospitals were selected using a proportionate-to-size stratified sampling design; women in each hospital were included until quotas were reached. Finally, the number of women who refused to participate in the study was not recorded. The main strengths of the study were the nationwide representative sample, the high response rate of hospitals and the fact that women of lower socio-economic classes were not under-represented in the present study as is the case in many other studies.

In conclusion, iodine-containing multivitamins taken during pregnancy increase urinary iodine excretion in Belgian pregnant women, underlying the necessity to promote iodine supplements ideally starting before pregnancy. However, despite the fact that about 60 % of pregnant women reported taking iodine supplements, the median UIC during pregnancy indicated iodine deficiency. Furthermore, some groups of women are at a higher risk of iodine deficiency. The current low iodine intake in women of childbearing age in Belgium precludes the correction of iodine deficiency in pregnant women supplemented with multivitamins containing 150 μg iodine as recommended. The iodine status in women of childbearing age needs to be increased in order to meet the iodine requirement during pregnancy. A more generalised use of iodine-containing multivitamins during pregnancy, iodised instead of non-iodised table salt and bread fortified with iodised salt is necessary to optimise the iodine intake in women of childbearing age and in pregnant women.

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