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Trends in food consumption and nutrient intake in Germany between 2006 and 2012: results of the German National Nutrition Monitoring (NEMONIT)

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Abstract

The German National Nutrition Monitoring (NEMONIT) is a longitudinal and nationwide study to assess changes in food consumption and nutrient intake in Germany. A sample of 1840 participants (baseline age: 14–80 years) was drawn from the nationally representative German National Nutrition Survey (NVS) II (2005–2007). The participants have been interviewed by telephone annually since 2008. Food consumption was assessed by two 24-h recalls in the NVS II and the 4 years of NEMONIT (2008–2012/2013), respectively. Energy and nutrient intakes were calculated using the German Nutrient Database 3.02. Diet quality was evaluated using the Healthy Eating Index-NVS (HEI-NVS) II. Time trends were analysed by generalised estimating equation. Consumption of fruit/fruit products and fruit juice/nectar among men and women decreased, whereas consumption of water, soft drinks and coffee/tea increased over the 6-year period. Furthermore, increased consumption of confectionery and animal fats was observed among women. HEI-NVS II did not change since NVS II in both sexes. There were no changes in energy and protein intakes, but carbohydrate intake declined while fat intake increased over time. Regarding micronutrients, a decreasing intake of thiamin, riboflavin and vitamin B_6 was observed in both sexes, but intake of Mg, Fe and niacin increased among women over time. In conclusion, food consumption and nutrient intake remained relatively stable between 2005–2007 and 2012/2013 within this German cohort. A few favourable and unfavourable changes were observed. Compared with national dietary guidelines, consumption of food of plant origin remained too low and consumption of meat/meat products remained too high in Germany.

Key words: Food consumption: Nutrient intake: Trends: Germany: Nutrition monitoring

The German National Nutrition Survey (NVS) II provides representative data on food consumption of the German population[1]. In 2005–2007, German men and women aged 14–80 years did not consume enough foods of plant origin and ate too much meat/meat products in comparison with dietary guidelines. For example, the consumption of vegetables was about half of the nationally recommended amount. The maximum recommended consumption of meat/meat products was exceeded by men, whereas women were in the upper range of the recommendations. Regarding non-alcoholic beverages, men and women met the recommended amount of at least 1·5 litres/d, primarily through the consumption of water. The NVS II results highlight that the German population consumes a diet that only partially meets the national food-based dietary guidelines.

However, food consumption may have changed in the last few years caused by factors such as changed consumer attitudes and behaviour as well as public health policies and programmes[2,3]. In order to gain insights into the developments regarding food consumption and nutrient intakes of the German population, the German National Nutrition Monitoring (NEMONIT) was initiated in 2008. NEMONIT is a longitudinal survey collecting data on an annual basis from a sample of participants recruited from the NVS II.

Thus, the objectives of the present study were as follows: to investigate changes in food consumption and nutrient intakes of a German cohort between 2005–2007 and 2012/2013; to analyse whether observed changes were caused by period effects or by age effects; and to compare results with those of nutrition surveys in other European countries.

Methods

Study design and participants

NEMONIT is a longitudinal study that is based on the NVS II[1]. NVS II participants who completed one or two 24-h recall interviews and did not refuse to take part in further surveys were asked to participate in NEMONIT (Fig. 1). After excluding individuals who refused or did not respond, 2749 participants from NVS II were recruited for NEMONIT for annual assessments of their food consumption and nutritional behaviour. In addition, data on socio-demographic characteristics, health aspects and

Abbreviations: GEE, generalised estimation equation; HEI-NVS II, Healthy Eating Index-German National Nutrition Survey II; NEMONIT, German National Nutrition Monitoring; SES, socio-economic status.

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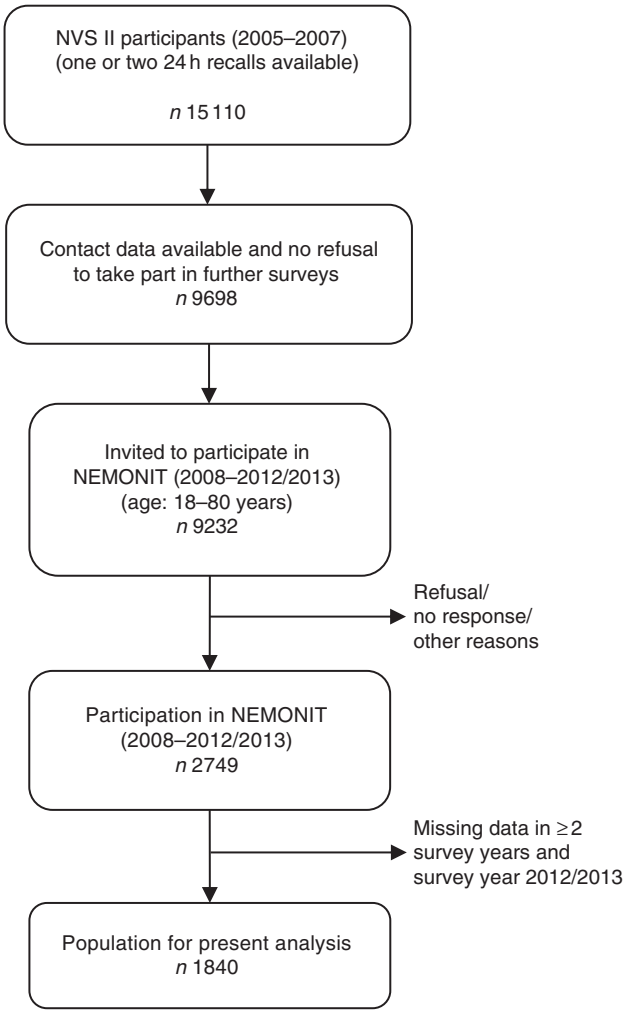

Fig. 1. Flow chart of the study population. NVS II, German National Nutrition Survey II. NEMONIT, German National Nutrition Monitoring.

lifestyle were collected. In the present study, data from NVS II (2005–2007) and 4 NEMONIT survey years (2008–2012/2013) are presented. Analyses included either individuals who participated in the NVS II and in least three of the four NEMONIT study years or participants from whom dietary information was available at least at baseline (NVS II) and the fourth NEMONIT survey year (2012/2013). At baseline, the study population consisted of 1840 participants who were 14–80 years old.

The surveys were approved by the German Federal Data Protection Office. Respondents were informed in detail about the study objectives and interview procedures as well as the handling of data records and analyses under pseudonymous conditions. It was made clear that participation was on a voluntary basis and could be terminated at any time. Participants provided informed written or verbal consent.

Dietary intake

Data on food consumption and nutrient intake were collected in each survey year using two 24-h telephone recall interviews (EPIC-Soft[4,5], re-named GloboDiet in 2014), which were conducted on randomly drawn non-consecutive days (at least 1 week apart). Dietary assessment for each study year was carried out in four waves through the year. Household measurements, standard units and a picture booklet providing photographed portion sizes for various foods and dishes were used to assist participants to indicate the consumed amount of food. The picture booklet is an excerpt from the original EPIC-Soft picture book. Intake of each food item was calculated as the average intake of both recall days. Food items were categorised into twenty-three food groups. Nutrient supplement intake was not included.

The calculation of energy and nutrient intakes for all survey years was based on the German Nutrient Database 3.02[6].

Healthy Eating Index

The Healthy Eating Index-NVS (HEI-NVS) II[7] adapted to 24-h recalls was used to evaluate the quality of participants' diets. Participants' consumed amounts of food groups were compared with the food-based dietary guidelines of the German Nutrition Society[8] and macronutrient intakes were compared with the national reference values for nutrient intake[9]. The HEI-NVS II is composed of ten components (Table 1). Each of the ten components is given a maximum score of 10 points, except for the components fruit/fruit products and vegetables (max. 15 points). The total HEI-NVS II score ranges from 0 to 110 points. High HEI-NVS II scores indicate intakes close to the recommended ranges or amounts.

Socio-demographic characteristics

Age, place of residence and socio-economic status (SES) were assessed by a computer-assisted telephone interview (CATI). Participants' places of residence were aggregated to regions (north, south, east and west). SES encompassed education (five categories ranging from no qualification to baccalaureate; additional points for vocational training and university education), net household income (on a monthly basis, nine categories from <750 € to 5000 € or higher) and employment status of the principal earner of the household (eight categories ranging from unskilled worker to executive employee/senior official)[10].

Statistics

Statistical analyses were performed using SAS (version 9.2; SAS Institute Inc.). NEMONIT participants were compared with non-participants (n 12 086) to analyse whether the differences in demographic characteristics of participants and non-participants may have biased the study results. The Mann–Whitney U test was used to detect differences in age between participants and non-participants. The prevalences of categorical variables were compared using χ^2 tests.

Daily food consumption and nutrient intake data for each survey year are expressed as mean and the corresponding 95 % CI, although data were not normally distributed. This presentation was chosen because rarely consumed foods such as fish often have median intakes of zero, and the applied regression model provides estimates of the mean. Median food consumption and nutrient intake data are provided in the online

Table 1. Components of the Healthy Eating Index-NVS II* and adapted dietary recommendations†

Food groups/nutrients	Recommendation
Fruit and fruit products‡	250 g/d
Vegetables‡	400 g/d
Bread, cereals/cereal products and potatoes	350–560 g/d
Milk, dairy products and cheese	2 portions/d; 1 portion = 200–250 g milk/milk products or 50–60 g cheese
Fish, fish products and seafood	150–220 g/week
Meat, meat products and sausages	<300–600 g/week
Eggs	≤3 eggs/week (≤180 g/week)
Alcohol (ethanol)	Men: ≤20 g/d and women: ≤10 g/d
Fat	Maximum 30 % energy intake
Non-alcoholic beverages	≥1·5 litres/d

NVS II, German National Nutrition Survey II.
* According to Wittig & Hoffmann[7].
† According to German Nutrition Society[8,9].
‡ Consideration of one glass of fruit or vegetable juice as a substitute for one portion of fruit or vegetables.

Supplementary Tables S1–S3. A bivariate generalised estimation equation (GEE) model was used to calculate $P_{\text{for trend}}$ for the period between 2005–2007 and 2012/2013. Time in years since baseline (baseline: 0 value) was modelled as a continuous variable and an unstructured working correlation structure was assumed. GEE, an extension of the quasi-likelihood approach, assumed no distribution of response observations and described how the mean response of the population is related to the covariates (population-averaged interpretation)[11].

To analyse whether observed longitudinal changes in food consumption and nutrient intake may have arisen from age, period and/or cohort effects, a multivariate GEE model was used following the method of Jacobs *et al.*[12]. In this model, current age at each study year, time (in years since baseline) and interaction of age and time were included. The age coefficient estimates between-person differences in food consumption/nutrient intake per year of age (cross-sectional age effect). The time coefficient estimates the change in food consumption/nutrient intake per year excluding inter-person differences in age (age-matched time trend), whereas the age-by-time-interaction represents the cohort effect that has evolved since the initial observation (variation in food consumption/nutrient intake in specific ages over time).

The GEE analyses showed that the interaction term of age and time was often not significant or was very small compared with the other regression coefficients, and inclusion of the interaction term did not result in a smaller quasi-likelihood under the independence model criterion value. For this reason, the age-by-time-interaction was suppressed in the model, assuming that cohort effects are minimal. In the present study, the cross-sectional age effect was therefore interpreted as an estimate of the age effect and the age-matched time trend as a measure of period effect.

Level of significance was set at $P < 0{\cdot}05$ (two-sided).

Results

Sample characteristics

Baseline characteristics of the study sample are shown in Table 2. There was a higher percentage of women in the cohort, and men had a higher SES than women.

Table 2. Characteristics of the study sample at baseline (NVS II, 2005–2007) (Numbers and percentages; mean values with their standard errors)

	Men	Women
n	778	1062
%	42·3	57·7
Age in years		
Mean	50·1	48·6
SE	0·6	0·5
Age groups (%)		
14–34 years	15·9	16·7
35–50 years	32·7	38·6
51–64 years	31·4	29·4
≥65 years	20·0	15·3
Region (%)		
North	17·9	16·6
South	31·6	31·0
West	33·7	33·9
East	16·8	18·5
Socio-economic status (%)		
High	33·3	22·2
Upper middle	32·4	35·6
Middle	24·0	30·0
Lower middle/low	10·3	12·2

NVS II, German National Nutrition Survey II.

Compared with non-participants, NEMONIT participants were older (49·3 *v.* 45·8 years; $P < 0{\cdot}001$) and had a higher percentage of women (57·7 *v.* 54·7 %; $P = 0{\cdot}014$) at baseline. Furthermore, NEMONIT participants showed a higher SES than non-participants (high SES: 26·9 *v.* 17·3 %; $P < 0{\cdot}001$). There was no significant difference with regard to region.

Trends in food consumption and Healthy Eating Index-German National Nutrition Survey II

Between 2005–2007 (baseline) and 2012/2013, only a few changes in food consumption were observed (Table 3(a) and (b)). Consumption of fruit/fruit products decreased in both men and women, whereas animal fat consumption increased. An increase in confectionery consumption was also observed in women and an increased consumption of eggs was seen in men. Furthermore, men and women increased their non-alcoholic beverage consumption over time. This increase was

Table 3. Food consumption (g/d) and HEI-NVS II scores in men (*n* 778) and women (*n* 1062) over the study period (Mean values and 95 % confidence intervals)

	Baseline (NVS II)		Follow-up periods (NEMONIT)									
	November 2005–January 2007		July 2008–August 2009		August 2009–August 2010		August 2010–September 2011		January 2012–February 2013		Estimated average change over the study period*	
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI		P_{trend}*
(a) Men												
Bread	164	158, 170	168	161, 175	159	153, 166	155	149, 161	163	156, 170		0·185
Cereals and cereal products	71	65, 76	74	67, 81	79	71, 87	76	69, 83	74	68, 81		0·142
Pastries	70	65, 76	63	57, 68	69	62, 75	72	66, 79	66	60, 71		0·534
Vegetables	136	129, 144	125	117, 132	134	126, 142	133	126, 141	136	128, 143		0·932
Potatoes and potato products	72	67, 78	74	67, 80	80	73, 86	73	67, 79	67	62, 72		0·441
Fruits and fruit products	174	161, 188	169	154, 184	174	158, 190	158	144, 172	144	132, 157	−25	<0·001
Fats and oils	29	27, 30	30	28, 32	29	27, 31	31	29, 33	29	28, 31		0·347
Animal fats	15	13, 16	15	13, 17	15	13, 16	17	15, 18	16	14, 17	+1	0·022
Vegetable fats	13	12, 15	14	13, 15	13	12, 14	13	12, 15	12	11, 14		0·300
Milk, dairy products and cheese	207	193, 221	188	173, 202	193	177, 210	193	179, 208	195	182, 209		0·133
Eggs	13	11, 14	16	14, 18	15	13, 17	15	13, 17	15	13, 17	+2	0·031
Meat, meat products and sausages	146	139, 153	148	139, 156	156	148, 163	149	141, 158	144	137, 152		0·748
Fish, fish products and seafood	20	17, 24	24	20, 28	23	19, 27	23	19, 27	23	19, 26		0·284
Confectionery	57	53, 61	61	57, 66	59	54, 63	59	55, 64	56	52, 61		0·800
Non-alcoholic beverages												
Water	903	847, 959	854	799, 910	953	893, 1014	986	928, 1045	1004	947, 1061	+115	<0·001
Coffee/tea (black/green)	587	556, 618	685	648, 723	696	658, 733	702	665, 740	673	638, 707	+90	<0·001
Herbal tea/fruit tea	155	133, 177	153	128, 178	163	137, 189	159	134, 183	149	126, 173		0·980
Fruit juice and nectar	214	189, 239	159	138, 181	164	141, 186	156	134, 177	137	119, 155	−76	<0·001
Soft drinks	129	108, 150	117	94, 141	121	96, 146	125	101, 150	120	97, 143		0·436
Alcoholic beverages												
Beer	294	261, 328	284	249, 319	299	264, 334	285	250, 321	257	226, 287		0·082
Wine and sparkling wine	70	61, 80	70	59, 81	81	69, 93	73	62, 84	68	57, 79		0·762
HEI-NVS II score	67	66, 68	67	66, 68	67	66, 68	67	66, 68	67	66, 68		0·735
(b) Women												
Bread	118	115, 122	120	116, 124	119	114, 123	120	116, 124	114	110, 118		0·167
Cereals and cereal products	61	56, 65	60	55, 65	63	59, 68	58	53, 62	58	54, 63		0·590
Pastries	60	55, 64	60	56, 65	60	56, 65	59	55, 63	59	55, 64		0·689
Vegetables	143	137, 149	140	133, 147	147	141, 154	144	137, 151	140	134, 146		0·882
Potatoes and potato products	58	55, 62	61	57, 65	57	53, 61	62	58, 66	59	55, 63		0·642
Fruits and fruit products	202	191, 213	198	186, 210	193	180, 206	184	173, 196	179	167, 190	−25	<0·001
Fats and oils	18	17, 19	19	18, 20	19	18, 20	22	21, 23	20	19, 21	+3	<0·001
Animal fats	9	8, 10	10	9, 11	10	9, 11	12	11, 13	12	11, 13	+3	<0·001
Vegetable fats	9	8, 9	9	8, 10	8	8, 9	9	8, 10	8	7, 9		0·328
Milk, dairy products and cheese	202	191, 212	203	191, 215	212	200, 224	206	195, 217	187	176, 198		0·254
Eggs	12	11, 13	13	12, 15	12	11, 14	12	11, 14	13	12, 15		0·465
Meat, meat products and sausages	86	82, 90	90	85, 94	95	90, 99	94	90, 98	86	82, 91		0·117
Fish, fish products and seafood	16	14, 18	16	14, 19	17	15, 19	18	15, 20	17	15, 20		0·358
Confectionery	50	47, 53	53	49, 56	55	51, 59	56	52, 59	53	49, 56	+4	0·037
Non-alcoholic beverages												
Water	959	916, 1001	961	918, 1003	1006	962, 1050	1025	982, 1068	980	939, 1020	+51	0·020
Coffee/tea (black/green)	560	536, 584	605	577, 633	622	594, 651	646	617, 675	624	597, 651	+74	<0·001
Herbal tea/fruit tea	269	242, 296	258	230, 286	262	233, 291	277	248, 305	299	268, 330		0·225
Fruit juice and nectar	207	187, 227	145	128, 161	134	120, 148	125	109, 141	120	106, 134	−92	<0·001
Soft drinks	63	51, 76	60	46, 74	70	54, 86	71	57, 86	62	48, 77		0·186
Alcoholic beverages												
Beer	57	48, 66	56	45, 67	62	50, 74	47	38, 55	47	36, 58		0·103
Wine and sparkling wine	59	53, 66	58	50, 65	62	55, 70	57	50, 64	57	50, 64		0·515
HEI-NVS II score	69	69, 70	70	70, 71	70	69, 71	70	69, 70	69	68, 70		0·493

NVS II, German National Nutrition Survey II; NEMONIT, German National Nutrition Monitoring; HEI-NVS II, Healthy Eating Index-NVS II.
* Generalised estimating equation.

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caused by the higher consumption of water and coffee/tea (black/green). However, men and women reduced their fruit juice/nectar consumption over the 6-year period. Among the other food groups, there were no significant changes in the consumption of vegetables, meat/meat products and fish/fish products. With regard to the HEI-NVS II score, no significant trend was observed for either sex.

Trends in energy and nutrient intake

For both sexes, no significant changes in total energy intake were observed over the study period, but the relative energy intake from macronutrients changed (Table 4). The energy proportion from carbohydrates decreased among men and women because of the reduced intake of mono/disaccharides over the 6-year period. In contrast, percentage of energy from fat increased for both sexes. In women, intake of SFA, MUFA and PUFA increased, whereas men showed only an increased intake of SFA and MUFA over the years. In addition, an increase in energy intake from proteins was observed among women.

With regard to micronutrients, a significant decrease was observed in thiamin, riboflavin and vitamin B_6 intakes in men and women as well as in folate intake in men (Table 5(a) and (b)). In addition, women showed a higher intake of Mg, Fe and niacin over time.

Age and period effects on food consumption and nutrient intake

Longitudinal changes, presented in Tables 3(a), (b) and 4, were differentiated into age and period effects (Table 6). Food groups and macronutrients are presented when either longitudinal changes or significant age and period effects could be found. An age effect could be observed for most food groups and macronutrients in men and women. For example, consumption of fruit/fruit products and coffee/tea as well as fibre intakes increased with participants' age, whereas consumption of water and soft drinks decreased with age. The multivariate GEE analysis further revealed that most of the changes in food consumption and macronutrient intake, which were observed in the NEMONIT study population (shown in Tables 3(a), (b) and 4), occurred independently of participants' increasing age (period effect), with the exception of animal fats and egg consumption in men and protein intake in women. After taking into account participants' age, significant period effects could also be observed in soft drink consumption (increase) in both sexes, cereal/cereal product consumption (increase) in men as well as meat/meat product consumption (increase) and fibre intake (decrease) in women.

Longitudinal changes in micronutrient intake observed in the bivariate GEE model (Table 5(a) and (b)) were caused by age as well as period effects (data not shown).

Discussion

Trends in food consumption and nutrient intake

Over a 6-year period (2005–2007 to 2012/2013), only a few changes in food consumption and nutrient intakes were observed in the German cohort NEMONIT (age: 14–80 years), a sample drawn from the representative NVS II. In particular, a downward trend could be observed in the daily consumption of fruit/fruit products and fruit juice/nectar, whereas the consumption of certain food groups (e.g. water, coffee/tea, confectionery and animal fats) increased. However, the HEI-NVS II score remained unchanged over the study period. With regard to macronutrients, the results showed an increased intake of fat and a decrease in carbohydrate intake.

In general, differences in food consumption trends were found between male and female participants of NEMONIT. Changes in food consumption occurred more often in women, whereas men showed greater changes compared with women. This may partly be explained by the fact that more women than men participated in NEMONIT, and thus smaller changes in food consumption and nutrient intake could be shown as significant in women.

We compared the present results with the German food balance sheets, which are published annually by the German Federal Ministry for Food and Agriculture[13], because there are no other national survey data available for comparison in relation to food consumption in adults between 2006 and 2012. The decrease in consumption of fruit/fruit products and fruit juice/nectar is consistent with the food balance sheet data. However, the food balance sheet data showed a decline of lower magnitude in fruit juice supply between 2006 and 2012. The results concerning the increase in water, soft drink and coffee/tea consumption are also in agreement with the food balance sheet data. In NEMONIT, no or very minor changes were found with regard to consumption of fish/seafood, milk/dairy products and meat/meat products. Similar trends were shown by the food balance sheets data. In contrast, an increase in daily vegetable supply based on the German food balance sheets could not be observed for the NEMONIT participants.

The longitudinal analysis of the HEI-NVS II showed no significant changes over time. One reason for this result is the unchanged consumption of seven out of ten HEI-NVS II components (e.g. vegetables, fish/seafood and milk/dairy products). Another explanation lies in the method. Regarding the HEI-NVS II score, the favourable increase in non-alcoholic beverage consumption was offset by the simultaneous unfavourable decline in fruit/fruit product consumption and increased energy intake from fat. This finding indicates that the HEI-NVS II is not suitable for pointing out longitudinal trends, because changes in consumption of single food groups may cancel each other out.

Total energy intake remained stable over the 6-year period, whereas the contribution of different macronutrients to energy intake changed. Energy intake from carbohydrates declined, whereas energy derived from fat increased over time. This reflects the observed trends in food consumption. The decrease in mono/disaccharides could be caused by the decreased fruit/fruit product and fruit juice/nectar consumption. Furthermore, the increased SFA intake may be related to the increase in animal fat consumption. Most trends in micronutrients cannot directly be explained by changes in consumption of certain food groups.

Table 4. Energy and macronutrient intakes in men (*n* 778) and women (*n* 1062) over the study period (Mean values and 95 % confidence intervals)

	Baseline (NVS II)		Follow-up periods (NEMONIT)									
	November 2005–January 2007		July 2008–August 2009		August 2009–August 2010		August 2010–September 2011		January 2012–February 2013		Estimated average change over the study period*	P_{trend}*
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI		
Men												
Energy intake (kJ/d)	10 225	10 004, 10 445	10 255	10 011, 10 498	10 422	10 176, 10 667	10 342	10 105, 10 579	9889	9668, 10 111		0·130
Carbohydrate (% energy/d)	45·3	44·7, 46·0	44·2	43·6, 44·9	43·6	42·9, 44·3	43·6	42·9, 44·2	43·5	42·9, 44·2	−1·9	<0·001
Mono/disaccharides (g/d)	123	121, 130	121	116, 126	122	117, 127	122	117, 127	112	107, 116	−8·7	<0·001
Polysaccharides (g/d)	126	123, 129	127	123, 130	127	123, 131	125	122, 128	125	121, 128		0·343
Fibre (g/d)	22·5	21·8, 23·2	22·9	22·2, 23·7	23·2	22·4, 24·0	22·2	21·5, 29·9	22·1	21·4, 22·8		0·425
Protein (% energy/d)	14·5	14·3, 14·7	14·5	14·2, 14·7	14·6	14·3, 14·8	14·5	14·2, 14·7	14·9	14·6, 15·1		0·081
Fat (% energy/d)	34·8	34·3, 35·4	36·1	35·5, 36·7	36·2	35·7, 36·8	36·7	36·2, 37·3	36·7	36·1, 37·3	+2·0	<0·001
SFA (g/d)	42·0	40·7, 43·3	42·7	41·2, 44·2	43·5	42·0, 44·9	44·6	43·2, 46·0	42·8	41·4, 44·3	+1·5	0·020
MUFA (g/d)	31·6	30·6, 32·3	33·3	32·1, 34·4	33·6	32·6, 34·7	33·6	32·5, 34·7	32·0	31·0, 33·0	+1·1	0·030
PUFA (g/d)	12·8	12·3, 13·3	13·5	12·9, 14·0	13·7	13·1, 14·2	13·2	12·7, 13·7	12·8	12·3, 13·3		0·440
Women												
Energy intake (kJ/d)	7837	7695, 7979	7779	7628, 7931	8002	7854, 8150	7981	7838, 8123	7719	7571, 7867		0·812
Carbohydrate (% energy/d)	48·9	48·3, 49·4	47·4	46·8, 48·0	46·6	46·0, 47·2	46·2	45·7, 46·8	45·8	45·2, 46·3	−3·2	<0·001
Mono/disaccharides (g/d)	116	112, 119	108	105, 111	111	108, 115	110	107, 114	102	99, 106	−10·4	<0·001
Polysaccharides (g/d)	99	97, 101	99	97, 101	99	97, 101	99	96, 101	96	94, 98		0·123
Fibre (g/d)	19·9	19·4, 20·4	20·1	19·6, 20·6	20·2	19·7, 20·8	20·0	19·5, 20·5	19·5	19·0, 20·0		0·231
Protein (% energy/d)	14·3	14·1, 14·5	14·6	14·3, 14·8	14·6	14·4, 14·9	14·7	14·4, 14·9	14·6	14·4, 14·8	+0·4	0·003
Fat (% energy/d)	33·8	33·3, 34·3	35·2	34·7, 35·7	35·7	35·2, 36·2	36·3	35·9, 36·8	36·8	36·4, 37·3	+3·0	<0·001
SFA (g/d)	31·5	30·6, 32·4	32·1	31·1, 33·0	33·5	32·5, 34·4	34·3	33·4, 35·2	33·9	32·9, 34·8	+2·8	<0·001
MUFA (g/d)	22·8	22·2, 23·4	24·0	23·3, 24·6	24·7	24·0, 25·4	25·1	24·4, 25·7	24·4	23·8, 25·1	+2·0	<0·001
PUFA (g/d)	9·9	9·6, 10·3	10·5	10·1, 10·9	10·7	10·4, 11·1	10·6	10·2, 10·9	10·5	10·2, 10·9	+0·7	0·002

NVS II, German National Nutrition Survey II; NEMONIT, German National Nutrition Monitoring.
* Generalised estimating equation.

Table 5. Micronutrient intake in men (*n* 778) and women (*n* 1062) over the study period (Mean values and 95 % confidence intervals)

	Baseline (NVS II)		Follow-up periods (NEMONIT)									
	November 2005–January 2007		July 2008–August 2009		August 2009–August 2010		August 2010–September 2011		January 2012–February 2013		Estimated average change over the study period*	P_{trend}*
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI		
(a) Men												
Vitamin A (mg/d RE)	1·63	1·46, 1·80	1·61	1·37, 1·85	1·49	1·29, 1·69	1·56	1·40, 1·72	1·57	1·35, 1·79		0·544
Vitamin D (μg/d)	2·90	2·63, 3·18	3·61	3·15, 4·07	3·69	3·07, 4·32	3·49	3·06, 3·92	3·15	2·82, 3·49		0·062
Vitamin E (mg/d TE)	11·6	11·1, 12·0	11·7	11·2, 12·3	12·1	11·6, 12·6	11·5	11·0, 12·0	11·3	10·8, 11·7		0·551
Thiamin (mg/d)	1·48	1·42, 1·53	1·43	1·38, 1·49	1·46	1·40, 1·51	1·40	1·35, 1·45	1·38	1·33, 1·42	−0·09	0·001
Riboflavin (mg/d)	1·57	1·53, 1·62	1·50	1·44, 1·55	1·50	1·45, 1·55	1·49	1·44, 1·53	1·46	1·41, 1·50	−0·11	<0·001
Niacin (mg/d NE)	36·0	35·1, 36·9	37·2	36·2, 38·2	37·6	36·5, 38·6	37·2	33·6, 38·3	36·5	35·5, 37·4		0·176
Vitamin B_6 (mg/d)	1·77	1·72, 1·82	1·75	1·69, 1·81	1·77	1·71, 1·83	1·72	1·66, 1·78	1·67	1·62, 1·72	−0·08	0·004
Folate (μg/d FE)	238	230, 245	238	229, 247	237	228, 246	232	224, 240	228	221, 235	−8·88	0·035
Vitamin B_{12} (μg/d)	5·78	5·48, 6·07	5·98	4·61, 6·36	5·96	5·63, 6·29	5·95	5·63, 6·27	5·61	5·31, 5·91		0·850
Vitamin C (mg/d)	115	109, 120	111	106, 116	116	110, 122	113	107, 119	107	102, 112		0·106
Ca (mg/d)	893	866, 919	863	832, 893	885	854, 917	896	866, 925	897	868, 925		0·600
Mg (mg/d)	377	369, 386	386	377, 395	394	385, 403	389	381, 398	379	371, 387		0·159
Fe (mg/d)	13·0	12·7, 13·4	13·7	13·3, 14·1	13·9	13·5, 14·3	13·4	13·1, 13·8	13·1	12·8, 13·5		0·229
I (μg/d)†	100	95, 104	105	100, 110	105	99, 110	100	96, 105	102	97, 108		0·537
Zn (mg/d)	11·7	11·4, 12·0	11·9	11·6, 12·2	12·3	12·0, 12·6	12·0	11·7, 12·3	11·7	11·4, 12·0		0·330
(b) Women												
Vitamin A (mg/d RE)	1·39	1·27, 1·51	1·38	1·22, 1·53	1·51	1·32, 1·70	1·46	1·29, 1·63	1·30	1·18, 1·41		0·751
Vitamin D (μg/d)	2·55	2·33, 2·77	2·71	2·34, 3·08	2·67	2·41, 2·94	2·58	2·34, 2·83	2·58	2·33, 2·83		0·951
Vitamin E (mg/d TE)	10·2	9·9, 10·6	10·7	10·3, 11·1	10·6	10·3, 11·0	10·3	9·9, 10·6	10·4	10·0, 10·8		0·546
Thiamin (mg/d)	1·13	1·10, 1·17	1·12	1·08, 1·16	1·13	1·09, 1·17	1·11	1·08, 1·15	1·07	1·04, 1·10	−0·05	0·019
Riboflavin (mg/d)	1·31	1·28, 1·34	1·22	1·18, 1·26	1·24	1·20, 1·28	1·23	1·19, 1·26	1·17	1·14, 1·20	−0·12	<0·001
Niacin (mg/d NE)	26·7	26·1, 27·2	27·7	27·1, 28·4	28·3	27·7, 28·9	28·2	27·6, 28·8	26·9	26·4, 27·5	+0·90	0·006
Vitamin B_6 (mg/d)	1·36	1·32, 1·40	1·36	1·32, 1·41	1·36	1·32, 1·40	1·34	1·30, 1·37	1·28	1·25, 1·31	−0·06	0·004
Folate (μg/d FE)	212	206, 218	220	212, 228	215	208, 222	213	206, 220	208	202, 214		0·455
Vitamin B_{12} (μg/d)	4·27	4·08, 4·46	4·46	4·14, 4·78	4·47	4·23, 4·72	4·75	4·42, 5·08	4·23	4·03, 4·44		0·228
Vitamin C (mg/d)	113	109, 117	118	113, 124	113	109, 118	113	108, 117	109	105, 114		0·162
Ca (mg/d)	807	788, 826	802	781, 823	830	809, 850	824	804, 845	809	789, 829		0·314
Mg (mg/d)	311	306, 317	320	314, 327	323	318, 329	323	317, 329	314	309, 320	+6·60	0·022
Fe (mg/d)	10·7	10·5, 11·0	11·1	10·9, 11·4	11·2	10·9, 11·4	11·1	11·0, 11·4	11·1	10·9, 11·4	+0·42	0·001
I (μg/d)†	87·0	83·7, 90·4	89·5	85·9, 93·1	92·5	88·7, 96·3	90·6	87·0, 94·1	88·1	84·5, 91·7		0·178
Zn (mg/d)	9·12	8·94, 9·30	9·19	8·98, 9·39	9·42	9·22, 9·62	9·51	9·30, 9·71	9·12	8·93, 9·31		0·081

NVS II, German National Nutrition Survey II; NEMONIT, German National Nutrition Monitoring; RE, retinol equivalents (retinol + 1/6 β-carotene); TE, tocopherol equivalents (mainly based on α-tocopherol without considering further vitamin E vitamers); NE, niacin equivalents; FE, folate equivalents (to calculate folate equivalents for enriched foods the factor 1·7 was used).

* Generalised estimating equation.

† Iodised salt and foods made with it were not taken into account.

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Table 6. Estimated cross-sectional age effect and period effect (age-matched time trend) on food consumption and macronutrient intake in men and women (NEMONIT, 2005–2007 to 2012/2013)*

	Men (*n* 778)				Women (*n* 1062)			
Food groups/macronutrients†	Age effect (per year)	*P*	Period effect (per year)	*P*	Age effect (per year)	*P*	Period effect (per year)	*P*
Cereals and cereal products (g/d)	−1·2	<0·001	2·2	0·001	−0·9	<0·001	0·8	0·087
Fruits and fruit products (g/d)	2·2	<0·001	−6·4	<0·001	2·9	<0·001	−7·1	<0·001
Fats and oils (g/d)	0·1	<0·001	> − 0·1	0·893	<0·1	0·077	0·4	<0·001
Animal fats (g/d)	0·1	<0·001	0·1	0·345	<0·1	0·024	0·5	<0·001
Eggs (g/d)	0·1	0·063	0·3	0·085	0·1	0·008	<0·1	0·840
Meat, meat products and sausages (g/d)	−0·7	<0·001	0·9	0·192	−0·2	0·056	0·8	0·049
Confectionery (g/d)	−0·1	0·533	0·2	0·696	−0·4	<0·001	1·1	<0·001
Water (g/d)	−9·4	<0·001	28·4	<0·001	−2·2	0·032	10·8	0·006
Coffee/tea (black/green, g/d)	7·9	<0·001	6·5	0·004	8·0	<0·001	4·4	0·021
Fruit juice and nectar (g/d)	−2·4	<0·001	−10·3	<0·001	−2·8	<0·001	−12·5	<0·001
Soft drinks (g/d)	−6·0	<0·001	4·6	0·011	−2·9	<0·001	4·5	<0·001
Carbohydrate (% energy/d)	−0·05	0·001	−0·27	<0·001	−0·05	<0·001	−0·48	<0·001
Protein (% energy/d)	−0·01	0·244	0·05	0·053	0·02	<0·001	0·03	0·098
Fat (% energy/d)	0·02	0·190	0·32	<0·001	<0·01	0·867	0·51	<0·001
Fibre (g/d)	0·05	0·006	−0·09	0·131	0·06	<0·001	−0·11	0·007

* NEMONIT, German National Nutrition Monitoring. Age and period effects are presented as regression coefficients, generalised estimating equation.
† Food groups and macronutrients are presented when either longitudinal changes or significant age and period effects could be observed.

Effects of ageing of the population and period on food consumption and nutrient intake

In NEMONIT, the same persons were evaluated over a period of time. Therefore, the observed changes are less likely to be the result of differences in the sample characteristics. However, the age of the participants increased over time, and the ageing process causes physiological/physical changes, which can affect food consumption. In order to verify whether the observed changes in food consumption and nutrient intake occurred solely because of the increasing age of the participants (age effect), or whether they simultaneously occur in all age groups caused by external variations (period effect), it is necessary to take into account participants' age in the statistical analyses. The present analysis indicated that the longitudinal changes in food consumption and nutrient intakes observed in NEMONIT were caused by participants' increasing age (age effect) as well as by period effects. For some food groups and nutrients, age and period effect headed in the same direction. For example, participants' ageing contributed to the decrease in fruit juice/nectar consumption over the follow-up period, because fruit juice/nectar consumption decreased across age in every survey year. In addition, a decreased age-matched time trend (period effect) regarding fruit juice/nectar consumption could be observed. The combined effect of age and period resulted in a large decrease in fruit juice/nectar consumption seen in the bivariate GEE analysis including only time as a covariate (Table 3(a) and (b)). In contrast, for some food groups (e.g. soft drinks or fruit/fruit products), age and period had the opposite effect. Soft drink consumption, for instance, was negatively associated with age, but data analysis also showed a time-related increase for this food group. As a result, age and period effect balanced each other out, and therefore significant changes in consumption over time could not be revealed or were weakened in the bivariate GEE analysis. For most food groups and nutrients with detected longitudinal changes, the period effect was slightly larger than the age effect. Overall, the data indicate a need to take account of participants' increasing age in longitudinal dietary analyses. Otherwise population-wide variations over time may be masked by the age effect.

Comparison with other European nutrition surveys

Reported food consumption and nutrient intake trends from other European nutrition surveys differ from those observed in Germany. The UK's National Diet and Nutrition Survey found stable fruit consumption and decreased energy intake among adults (aged 19 years and over) between 2008/2009 and 2011/2012 (assessed by 4-d dietary records)[14]. In addition, fat intake as a percentage of energy intake declined in men aged 19–64 years and in women aged 65 years and over, whereas carbohydrate intake increased. In the French Individual and National Food Consumption Survey (assessed by 7-d dietary records) on men and women aged 18–79 years, increases in overall fresh fruit and vegetable consumption as well as vitamin C and folate intakes were observed (1998/1999 *v.* 2006/2007)[15]. Moreover, a downward trend in meat consumption (only women) and a stable energy intake were reported. The Bus Santé Geneva Study (Switzerland, 1999–2009, participants' age: 34–74 years) showed that intakes of energy, SFA, PUFA, Ca and Fe decreased for both sexes, whereas intakes of carbohydrates (only women) and MUFA increased (assessed by semi-quantitative FFQ)[16]. Overall, other European surveys reveal more favourable trends in food consumption and nutrient intake compared with NEMONIT. However, comparisons should be made with caution. In contrast to NEMONIT, the reported European studies used repeated cross-sectional study designs and did not examine the same cohort over time. Furthermore, the surveys were conducted throughout different time periods among samples of various age ranges using different dietary assessment methods and nutrient databases.

Public health implications

The present study suggests that compliance with national food-based dietary guidelines has not generally improved in German men and women over the study period (2006–2012). The consumption of fruit/fruit products, which was already below the recommended amount at baseline, decreased even more over the six study years. In contrast, meat/meat product consumption remained too high. A balanced diet plays an essential role in maintaining health and preventing nutrition-related chronic diseases such as obesity, diabetes and cancer. These data underscore the need for public health policies, which especially focus on encouraging consumption of fruit/fruit products and vegetables while reducing consumption of meat/meat products and soft drinks.

Limitations and strengths of the study

The following limitations of the present study warrant consideration: the comparison of NEMONIT participants with non-participants indicated a selection bias towards older, female and higher SES class participants. However, the present results are in good agreement with the observed trends documented in the German food balance sheets, assuming a small-to-moderate impact of the selection bias. The assessment of food consumption using two 24-h recalls per study period, which is in accordance with the requirements of the European Food Safety Authority[17] regarding collection of national food consumption data, could be a further limitation of this study. The intake of episodically consumed food such as fish could be underestimated. It also has to be noted that the present study included participants who may have under-reported their energy intake. The degree of under-reporting found at baseline and the follow-up period ranged from 11 to 17 % according to the cut-off points derived by Goldberg *et al.*[18] and Black[19]. However, as the underestimation of episodically consumed foods and the low level of under-reporting occurred systematically in all survey years, trend direction is unlikely to be affected by these biases.

Besides the limitations described above, the present study has several strengths worth noting. With NEMONIT, individual food consumption and nutrient intake were assessed on a longitudinal and nationwide basis. For the repeated evaluation of the same subjects, the same dietary assessment methods and nutrient databases were applied. Therefore, observed trends cannot be attributed to variation in methods or differences in sample characteristics, which often occur in repeated cross-sectional studies. NEMONIT also covers a wide age range, allowing an estimation of population-wide trends in food consumption and nutrient intake.

Conclusions

Food consumption and nutrient intake remained relatively stable between 2005–2007 and 2012/2013 within the nationwide sample of German men and women. A few favourable as well as unfavourable changes were observed. Altogether, in Germany, consumption of food of plant origin remained too low and consumption of meat/meat products was too high. Further assessment of food consumption and nutrient intake of the German population is necessary to evaluate whether the observed trends will continue over the next few years or whether they are temporary fluctuations.

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The authors declare that there are no conflicts of interest.

Supplementary material

For supplementary material/s referred to in this article, please visit http://dx.doi.org/10.1017/S0007114516000544

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