

PAPER

Impact of 'Mad Cow Disease' publicity on trends in meat and total vitamin A consumption in Geneva between 1993 and 2000

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Background: In March 1996, revelations about the possible risk for humans of the 'mad cow disease' epidemic had a sudden impact on the diets of European populations.

Objective: To assess changes in meat and nutrient intakes in adults living in Geneva, Switzerland from 1993 to 2000.

Design: Independent annual cross-sectional surveys (4047 women and 4092 men total).

Main outcome measure: Dietary habits assessed and compared to baseline (January 1993–April 1996) via validated semi-quantitative food-frequency questionnaire.

Results: Women beef abstainers increased from 8.9 to 14.9% in late 1996 ($P < 0.001$) and 13.3% in 1997 ($P < 0.05$); among meat consumers, in late 1996 meat/beef intakes declined –10/–12% (both $P < 0.05$). From 1997 to 2000 most intake levels drifted back toward those at baseline, but chicken intakes were significantly (all $P < 0.05$) greater each year (+19% in 2000 ($P < 0.001$)). Consistent but less dramatic changes were observed among men. From late 1996 until 2000, liver abstention was significantly (all $P < 0.05$) greater (women from 60 to 78%; men from 61 to 73% in 2000; (both $P < 0.001$)). The only nutrient intakes that decreased significantly (all $P < 0.05$) each year from 1997 through 2000 were retinol and total vitamin A women: –22% ($P < 0.001$); –11% ($P < 0.05$) respectively; men: –16% ($P < 0.001$); –10% ($P < 0.05$) respectively, in 2000). Total vitamin A intakes exceeded the dietary reference intake (DRI) for liver eaters (women 185%, men 153%), but were below the DRI for liver abstainers (women 83%; men 66%) in 2000.

Conclusion: The decreases in beef and liver consumption since late 1996 led to the discovery of a long-term disparity in the retinol and total vitamin A intakes of liver eaters vs abstainers.

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Descriptors: beef; diet; liver; retinol; total vitamin A; monitoring; surveillance; human; Mad Cow Disease

Introduction

The Bovine Spongiform Encephalopathy (BSE, also known as 'MadCow Disease') epidemic has been associated with one of

the major food crises in modern European history. Although BSE outbreaks were reported as early as 1986, the disease was not considered a public health threat until March 1996, when the British Government announced that there may be a positive association between BSE and the human Creutzfeldt–Jakob disease (CJD) (Brown, 1996; Butler, 1997). Shortly after that announcement a sudden and unexpected dietary change occurred throughout Europe. The publicity relating meat intake to the risk of developing a novel variant of CJD had a strong impact in Switzerland, which scored second (after the UK) in terms of BSE-affected cattle (300 out of the 1.2 million production cows; Collee & Bradley, 1997).

We are following up our previous report that documented the occurrence of simultaneous short-term

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decreases in meat consumption and retinol intake by the adult population of Geneva, Switzerland immediately following the onset of the BSE crisis (Morabia *et al*, 1999). Our continuing dietary surveillance has permitted us to determine the long-term evolution of retinol consumption between 1996 and 2000 and to explore its impact in population subgroups at high risk of suboptimal intakes of total vitamin A.

The objectives of this paper are to: (1) document the trends in meat intake within the context of the diet of Geneva adults from 1993 until 2000; (2) determine whether the observed changes may potentially influence public health, especially in some high-risk subgroups.

Subjects and methods

The *Bus Santé* project is a long-term, ongoing community health behavior and nutrition survey that has been conducted annually since 1993 (Morabia *et al*, 1997). To our knowledge this is the only European experience of the continuous dietary surveillance of a free-living population over such a long time period. The data reported here were collected from subjects randomly selected throughout 1993–2000 to represent all non-institutionalized residents aged 35–74y from the Geneva population numbering 395 609 people.

Subjects were identified from the residents' register published every year using a standardized procedure. This list includes the first and last name, sex, age, nationality and address of each resident. Random sampling in age–sex-specific strata was proportional to the corresponding frequencies in the population. Vigorous attempts were made to recruit non-responders into the survey. A person who could not be contacted after three mailings and seven telephone calls was replaced using the same selection protocol. A systematic check in the following year's edition of the population register showed that over 90% of 'unreachable' subjects no longer resided in Geneva. Subjects who were contacted but refused to participate were not replaced. Each annual survey was conducted independently, subject participation being uniformly distributed throughout the year. Each participant appeared only once in the database. The overall participation rate was 60%. Each participant completed a self-administered, semi-quantitative food frequency questionnaire (FFQ) at home. This FFQ covered the 4 weeks prior to day of completion. It was developed and tested in the target population (Bernstein *et al*, 1994; Morabia *et al*, 1994). It comprised a list of 80 food items and their serving sizes. Food intake data were converted into daily energy, nutrient and alcohol intakes on the basis of a food composition table, according to gender-specific serving sizes and regrouping and weighting of food items. All participants were invited to visit a mobile epidemiology clinic and to return the completed FFQ which was checked by trained technicians.

Statistical methods

Previous analyses had shown that Genevan diets were very stable from January 1993 to April 1996 (Morabia *et al*, 1999). We therefore grouped, for the purposes of this study, the period from January 1993 to April 1996 into a single (baseline) period before the mad cow disease crisis.

Food groups were defined as follows: *fish* (salmon, fried fish, tuna, lean fish, seafood); *beef* (all types of beef and veal meat (excluding liver)); *pork/lamb* (cooked ham, pork ribs, lamb ribs, stew); *chicken* (not including turkey, duck or other poultry); *liver* (veal, heifer, chicken or pork liver); *cold cuts* (all types of sausages, saveloy, pâtés, pork pie, raw ham, bacon and salami). The latter five food groups (*ie* excluding fish) were further grouped as '*total meat*'. Abstainers from any of these food groups were defined as those reporting not having eaten these foods during the 4 weeks before their interview.

Dietary recommendations are set to provide sufficient amounts for almost all healthy persons (Committee on Dietary Allowances, 1989). The unique energy requirements of each person depend on body composition/size and activity level and are given in ranges (2300–2900 kcal/day for adult men and 1900–2200 kcal/day for women). An energy value of 2900 kcal for men aged 35–50 and 2300 kcal for men older than 50 were used in the calculations. Similarly, 2200 kcal was used for women aged 35–50 and 1900 for women over 50y of age. The nutrient intakes reported in this paper (animal source protein, total fat, retinol, iron and beta-carotene) were selected in addition to total energy because they are commonly found in meat products (Committee on Dietary Allowances, 1989; Mayers, 1993). We also calculated the intake of total vitamin A, which is the sum of retinol (animal sources) and carotenes (plant sources). Total vitamin A intake was computed in retinol equivalents (RE) of beta-carotene because beta-carotene makes up more than 80% of dietary carotenes and contributes double the RE of the other dietary carotenes. In 2001, the Food and Nutrition Board, Institute of Medicine released the results of their study on the requirements for vitamin A by age and gender. The conversion of beta-carotene was changed from a one-sixth unit of retinol, used in the 10th edition of the RDAs, to $\frac{1}{12}$ μ g of beta-carotene equal to 1 μ g of retinol ($RE = \text{retinol intake} + \frac{1}{12} \text{beta-carotene intake}$; Institute of Medicine, 2001; Committee on Dietary Allowances, 1989).

Food group intakes were analyzed after square root (beef, chicken, pork/lamb) or natural log transformation, while nutrient intakes were log-transformed to reach approximate normality. Results are presented after back-transformation to an arithmetic scale. Differences in the proportions of abstainers of specific foods after vs before April 1996 were adjusted for age, education, nationality and current smoking using analysis of covariance and multiple linear or logistic regression.

Monthly trends in the median weekly intakes (including non-consumption) of beef (g) and retinol (μ g), and of the prevalences of beef and liver consumption (%) by gender from January 1993 to December 2000 are presented graphically.

Results

Characteristics of survey participants

Overall 4047 women and 4092 men participated in the study (Table 1). Age, BMI, education, nationality, and current smoking status showed minimal fluctuations in both genders for each survey year.

Trends in dietary intake of Geneva adults from baseline (January 1993–April 1996), until 2000

At baseline, only 1.7% of women and 0.7% of men in Geneva did not eat any meat, and the percentages of total meat abstainers remained small throughout the survey period (Table 2). In 1996, women beef abstainers increased significantly from 8.9 to 14.9% ($P < 0.001$) and to 13.3% in 1997 ($P < 0.05$). The percentages of women/men who avoided liver products over the survey period increased from 59.7/61.4% at baseline to 78.1/73.2% in 2000 (both $P < 0.001$). There was a transient increase in late 1996 of women who did not eat pork or lamb (26.4%, $P < 0.001$), while the corresponding percentages of people who did not

eat either fish or chicken remained stable in both genders (data not shown).

The trends in the median intake of meat among consumers are given in Table 3. The dietary habits of the Geneva population were very stable in the baseline period from 1993, when surveillance began, until April 1996.

At baseline, the median total meat intake for women was 438 g/week. By late 1996, meat intake by women declined –10% and increased +3% in 2000. At the same time, beef and liver intakes by women declined –12% and –14%, respectively. Afterwards, beef intake drifted back toward the baseline level but the declines in liver intake persisted until 1999 before returning to the baseline level in 2000. Chicken intake increased markedly +19% over baseline level in 2000 ($P < 0.001$ for increases in 1998–2000, $P < 0.05$ for 1997). Fish intake remained stable at about 240 g/week over the survey period.

Among men, total meat intake remained stable (616 g/week at baseline). Beef intake decreased –9% in 1997, and then –11% in 2000 (both $P < 0.05$), and liver intake remained low throughout the survey period. Chicken

Table 1 Characteristics of 8139 participants (4047 women, 4092 men), by year of independent survey. Women and men 35–74 y of age, Geneva, Switzerland, 1993–2000

Gender	Variable	1993	1994	1995	1996	1997	1998	1999	2000	Trend P
Women	Number	299	393	461	573	580	585	566	590	—
	Age (mean y)	53	52	50	51	50	50	50	51	0.57
	Body mass index (mean kg/m ²)	24	23	24	24	24	24	24	24	0.54
	University education (%)	32	36	32	36	34	35	38	36	0.70
	Swiss nationality (%)	75	74	72	74	77	76	78	76	0.46
	Current smoking (%)	24	22	28	22	24	22	26	25	0.37
Men	Number	393	363	451	575	558	588	606	558	—
	Age (mean y)	51	53	52	52	51	51	52	52	0.73
	Body mass index (mean kg/m ²)	25	25	25	26	25	26	26	25	0.24
	University education (%)	38	35	33	35	34	37	39	37	0.56
	Swiss nationality (%)	66	71	61	68	71	69	67	72	0.008
	Current smoking (%)	32	29	24	31	27	30	31	28	0.20

Table 2 Percentages of women and men who reported not consuming specific food items during the 4 weeks prior to interview, by time period. Women and men 35–74 y of age, Geneva, Switzerland, 1993–2000 (independent annual surveys)

Gender	Food item	Adjusted ^a proportion of non-consumers					
		January 1993– April 1996	May–December 1996	1997	1998	1999	2000
Women	No meat	1.7	0.8	1.7	1.3	1.9	0.8
	No beef	8.9	14.9**	13.3*	8.7	9.5	9.1
	No pork/lamb	18.5	26.4**	17.9	17.6	18.3	21.1
	No liver	59.7	73.7**	76.0**	74.5**	75.8**	78.1**
Men	No meat	0.7	1.2	1.1	0.4	1.2	0.4
	No beef	5.1	6.0	8.0*	5.4	6.5	4.3
	No pork/lamb	16.6	14.2	15.8	16.0	17.5	18.5
	No liver	61.4	67.4*	70.6**	68.9*	69.8**	73.2**

^aSimultaneously adjusted for age, education, nationality and current smoking.

* $P < 0.05$; ** $P < 0.001$.

Table 3 Median^a intakes (g/week) relative to baseline of specific food items by consumers. Women and men 35 to 74 y of age, Geneva, Switzerland, 1993–2000 (independent annual surveys)

Gender	Food item	Adjusted ^a amount (g/week)					
		January 1993– April 1996 Amount (g/week)	May– December 1996 Percentage change ^b	1997 Percentage change ^b	1998 Percentage change ^b	1999 Percentage change ^b	2000 Percentage change ^b
Women	Meat ^c	438	–10%*	–2%	3%	4%	3%
	Beef	223	–12%*	–9%*	–8%	–2%	1%
	Pork/lamb	94	7%	10%*	3%	3%	12%*
	Liver	36	–14%	–6%	–8%	–11%	3%
	Chicken	119	8%	9%*	17%**	13%**	19%**
	Fish	238	–1%	0%	3%	3%	3%
Men	Meat ^c	616	3%	–2%	4%	2%	–1%
	Beef	350	–7%	–9%*	–1%	–1%	–11%*
	Pork/lamb	111	2%	4%	5%	10%	5%
	Liver	39	–10%	–5%	–13%	–5%	–5%
	Chicken	118	12%*	13%*	11%*	11%*	21%**
	Fish	233	4%	11%	–3%	3%	6%

^aSimultaneously adjusted for age, education, nationality and current smoking.

^bPercentage change compared with the baseline period from January 1993 to April 1996.

^c(Total) meat = (beef, pork/lamb, chicken, liver, cold cuts (not shown)). Sub-medians do not (necessarily) sum to overall median.

* $P < 0.05$; ** $P < 0.001$.

intake increased markedly +21% over baseline level in 2000 ($P < 0.001$, $P < 0.05$ for increases in 1997–1999). As in women, fish intakes in men remained stable at about 240 g/week over the survey period.

Nutrient intakes relative to dietary recommendations

Tables 4 and 5 show some examples of trends in nutrient intakes relative to recommended levels. The median ranges of total energy intake (kcal/day) of women varied less than

Table 4 Median^a (daily) intake of specific nutrients and the percentage of the dietary recommendation for each nutrient. Women, 35–74 y old, 1993–2000; Geneva, Switzerland (independent annual surveys)

Nutrients	Recommended levels	Amount (Percentage of recommended levels)					
		January 1993– April 1996	May– December 1996	1997	1998	1999	2000
Energy (kcal)		1672.0	1613.9	1639.2	1691.0	1721.8	1721.0
Animal proteins (g)	50 g ^b	43.9 (88)	41.8 (83)	42.6 (85)	44.0 (88)	44.1 (88)	45.0 (90)
Total fat (%)	< 30% of energy intake ^c	35.3 (117)	35.1 (117)	35.3 (118)	34.9 (116)	34.4 (115)	35.6 (119)
Iron (mg)	< 50 y, 15 mg ^d	9.7 (65)	9.3 (62)	9.5 (63)	9.8 (65)	10.0 (67)	10.0 (67)
Retinol (µg)	^e						
Liver eaters		959.8	847.3*	922.0	878.6	889.0	952.8
Liver abstainers		272.0	271.7	255.4	256.3	250.9*	263.3
Total		448.4	366.7**	347.7**	352.0**	341.6**	349.7**
Carotene (RE)	^f						
Liver eaters		260.6	257.8	263.4	282.1	262.9	274.8
Liver abstainers		244.8	262.8	251.5	258.1	264.0	276.7*
Total		250.6	261.8	254.4	264.0	264.0	276.5*
Total vitamin A (RE)	700 RE ^g						
Liver eaters		1282.0 (183)	1160.5 (166)	1257.6 (180)	1233.2 (176)	1229.1 (176)	1296.6 (185)
Liver abstainers		558.7 (80)	577.3 (82)	545.1 (78)	551.2 (79)	555.6 (79)	581.7 (83)
Total		776.4 (109)	693.8 (99)*	666.7 (95)**	678.9 (97)*	675.2 (96)*	694.4 (99)*

^aSimultaneously adjusted for age, education, nationality and current smoking.

^bRecommended Dietary Allowance (RDA) is for total protein intake. Animal protein set to 65% of total protein.

^cNot an RDA (< 30% kcal is a recommendation of the American Heart Association).

^dThe Dietary Reference Intake (DRI) for pre-menopausal women is 15 mg/day. The DRI is 10 mg/day for all others.

^eAnimal sources.

^fPlant sources (RE = retinol equivalents).

^gSum of plant and animal sources (RE = retinol equivalents).

* $P < 0.05$; ** $P < 0.001$.

Table 5 Mean^a (daily) intake of specific nutrients and the percentage of the dietary recommendation for each nutrient. Men, 35–74 y old, 1993–2000; Geneva, Switzerland (independent annual surveys)

Nutrients	Recommended levels	Amount (Percentage of recommended levels)					
		January 1993–April 1996	May–December 1996	1997	1998	1999	2000
Energy (kcal)		2135.5	2204.3	2140.3	2174.1	2112.7	2140.8
Animal proteins (g)	50 g ^b	53.6 (85)	55.3 (88)	54.1 (86)	54.9 (87)	54.9 (87)	54.5 (87)
Total fat (%)	< 30% of energy intake ^c	33.9 (113)	33.7 (112)	34.1 (114)	34.1 (113)	33.9 (113)	33.6 (112)
Iron (mg)	10 mg ^d	11.9 (119)	12.2 (122)	11.9 (119)	12.1 (121)	11.8 (118)	12.0 (120)
Retinol (µg)							
Liver eaters		1115.5	1068.2	1066.5	1010.2	1064.4	1045.1
Liver abstainers		326.0	323.0	325.1	327.5	312.4*	315.3
Total		523.8	478.9	461.7*	465.5*	453.0**	437.5**
Carotene (RE)							
Liver eaters		226.9	243.2	229.4	226.7	241.4	272.4*
Liver abstainers		225.7	224.0	226.2	217.4	230.4	232.4
Total		226.4	229.8	227.1	220.2	233.6	242.2*
Total vitamin A (RE)	700 RE ^g						
Liver eaters		1393.4 (155)	1374.2 (153)	1339.1 (149)	1291.4 (143)	1363.3 (151)	1376.2 (153)
Liver abstainers		596.9 (66)	591.7 (66)	592.2 (66)	593.3 (66)	580.1 (64)	593.4 (66)
Total		827.8 (92)	781.1 (87)	754.3 (84)*	757.1 (84)*	751.2 (83)*	746.9 (83)*

^aSimultaneously adjusted for age, education, nationality and current smoking.

^bRecommended Dietary Allowance (RDA) is for total protein intake. Animal protein set to 65% of total protein.

^cNot an RDA (< 30% kcal is a recommendation of the American Heart Association).

^dThe Dietary Reference Intake (DRI) is 10 mg/day for men.

^eAnimal sources.

^fPlant sources (RE = retinol equivalents).

^gSum of plant and animal sources (RE = retinol equivalents).

*P < 0.05; **P < 0.001.

100 kcal over the 5 y post-baseline period, and the energy intakes of men were even more stable. There were only 22% of men and 28% of women who met the recommendation of less than 30% energy intake from fat. Iron intake by women was only two-thirds of the recommendation for pre-menopausal women; iron intakes for men and post-menopausal women appeared to be adequate.

The only nutrient intakes that changed significantly (all $P < 0.05$) after April 1996 were those of retinol and total vitamin A, which decreased in both genders, while the intakes of carotene remained almost constant and then increased in

2000 in both genders, implying that animal sources were responsible for the decreases in total vitamin A. The percentage intake of total vitamin A compared to the Dietary Reference Intakes (DRI) for women decreased from 109% at baseline to 95% in 1997 and then increased to 99% in 2000. For men, these percentages decreased from 92 to 83% over the same period.

Evolution of trends in beef, liver and retinol intakes

Figures 1a,b and 2a,b depict the monthly evolution of population beef intakes and consumption between January

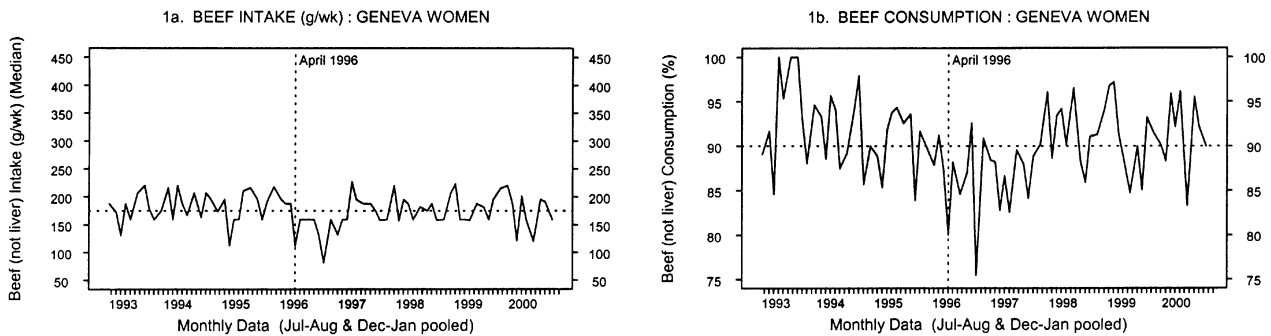


Figure 1 Monthly trends in beef intake (median g/week, excluding liver) and consumption (%) among Geneva women, from January 1993 to December 2000 (independent annual surveys): (a) population beef intake (including nonconsumers); (b) beef consumption.

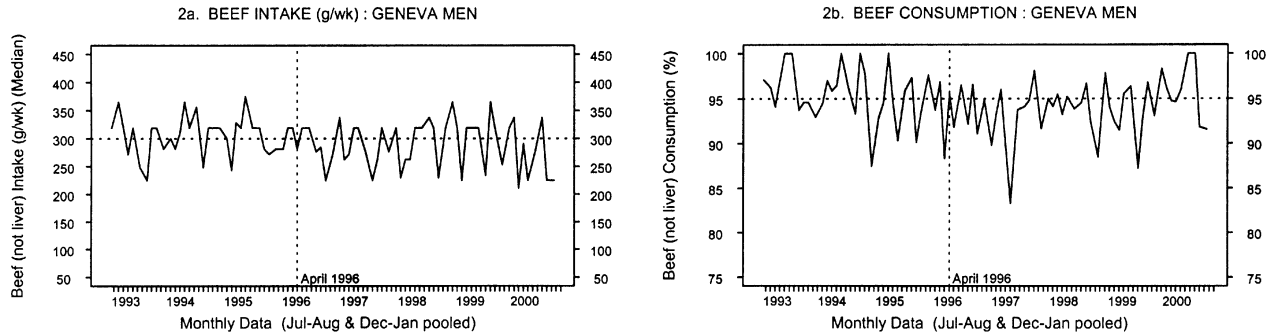


Figure 2 Monthly trends in beef intake (median g/week, excluding liver) and consumption (%) among Geneva men, from January 1993 to December 2000 (independent annual surveys): (2a) population beef intake (including nonconsumers); (2b) beef consumption.

1993 and December 2000 for all women (all men). Among women, beef intake and consumption were stable during the survey period except in autumn 1996. Among men, beef intake did not decrease noticeably until spring 1997 (when beef consumption also fell markedly), after which it remained consistently lower than the baseline level through spring 2000. For both genders (but especially among women) there were sustained decreases in retinol intake from January

1993 to December 2000 (Figures 3a and 4a). Similar decreases in the prevalence of liver consumption were also observed (Figures 3b and 4b).

Dietary assessment of liver consumers vs abstainers

At baseline, 60/61% of women/men abstained from eating liver, and in 2000 these respective percentages had

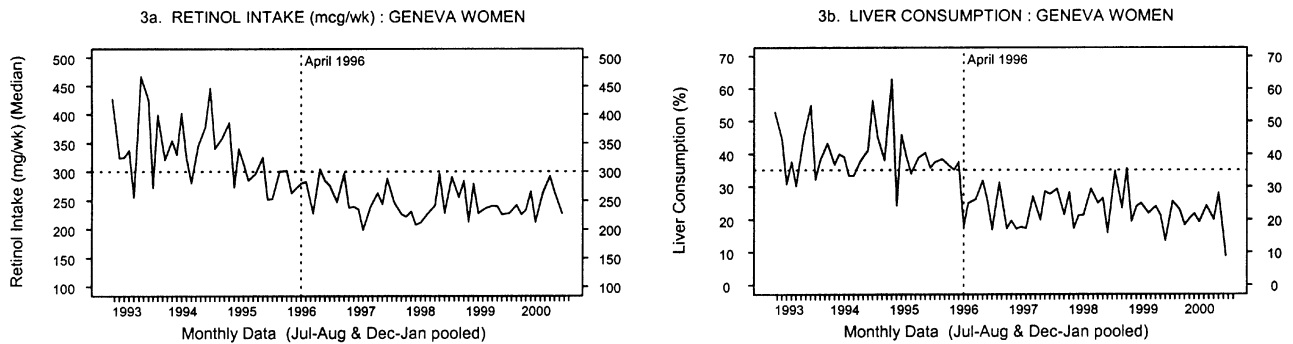


Figure 3 Monthly trends in retinol intake (median mg/week) and liver consumption (%) among Geneva women, from January 1993 to December 2000 (independent annual surveys): (3a) population retinol intake; (3b) liver consumption.

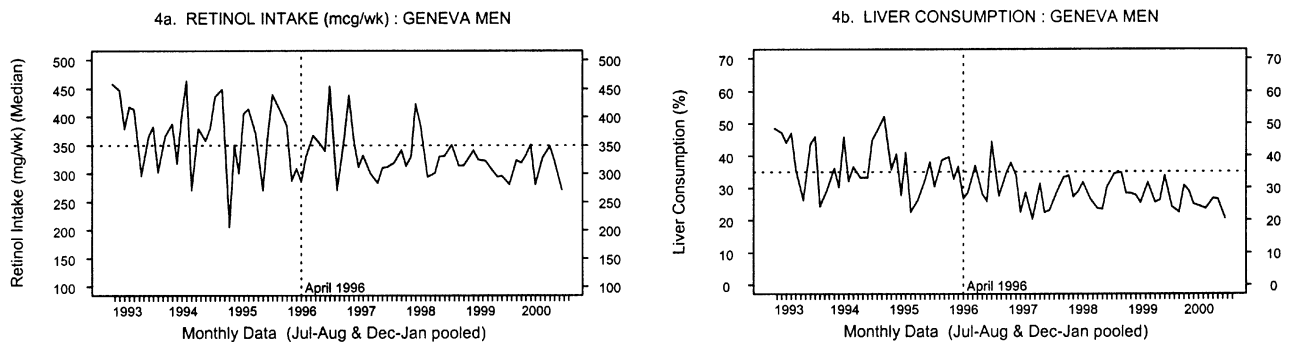


Figure 4 Monthly trends in retinol intake (median mg/week) and liver consumption (%) among Geneva men, from January 1993 to December 2000 (independent annual surveys): (4a) population retinol intake; (4b) liver consumption.

increased to 78/73% (Table 2). Tables 4 and 5 show the nutrient profiles of liver consumers *vs* abstainers. Beta-carotene intake was stable during the survey period for both genders for both subgroups. Retinol intake was at least three-fold greater in liver consumers compared to abstainers. For liver consumers, total vitamin A intake averaged 185% of the DRI for women and 153% of the DRI for men in 2000. In contrast, for liver abstainers total vitamin A intake averaged only 83% of the DRI for women and 66% of the DRI for men.

Discussion

Dietary patterns in Europe before and after 1996

Dietary changes over time in populations are usually gradual in response to food availability, economic pressure or public health campaigns. In the decade before 1996, both food balance sheets and survey data indicated an overall decrease in the consumption of meat in Europe (Moreiras *et al*, 1991; Menotti *et al*, 1999). Beef abstention accounted for much of the observed decline, with drops of -15% in Germany (Winkler *et al*, 2000; Branscheid, 1993), -18% in France (Combris, 1997), and -10% in the UK (Tilston *et al*, 1993). Exceptions were Spain (Artalejo *et al*, 1996), Italy (Zizza, 1997; Beelu *et al*, 1996) and Sweden (Augustsson *et al*, 1999; Anonymous, 1993). Liver was reported to be the major source of total vitamin A in Finland, Italy and Switzerland (Morabia *et al*, 1999; Zizza, 1997). With some exceptions (eg Hungary, Kesteloot, 1999), the decrease in red meat intake was generally accompanied by an increase in poultry intake (Tilston *et al*, 1993; Winkler *et al*, 2000; Branscheid, 1993), as well as greater intakes of fruit, vegetables, fish (Branscheid, 1993; Tilston *et al*, 1993; Moreiras *et al*, 1991; Menotti *et al*, 1999; Winkler *et al*, 2000), and dairy products (Menotti *et al*, 1999; Zizza, 1997).

The diets of adults living in Geneva had been stable during the first three annual *Bus Santé* surveys. Thus, the greater than expected decreases in beef and liver consumption observed after 1996 did not appear to be an extension of the general European trend towards lower meat intake. Large, rapidly occurring changes are usually brought about by catastrophic events such as wars, natural disasters or, as in 1996, by a real or perceived contamination of the food supply. After the mad cow disease crisis, beef, but not liver, consumption levels returned to near baseline values. By 1996–1997, similar declines in beef consumption were also occurring in other European countries. Meat consumption dropped only -2% in France, but beef consumption, which had previously comprised 25% of the meat intake, dropped by more than -11% (Combris, 1997). Except for lamb (-11% decrease), consumption of other meats had increased: poultry $+23\%$ and pork $+5\%$ (Branscheid, 1993; Klipstein-Grobusch *et al*, 1998). In 1996, beef consumption in Slovenia dropped by -16% in fear of exposure to infected meat entering the country illegally (Curk, 1999).

Dietary evolution in Geneva

By 2000, the meat intakes of Geneva adults had returned to baseline levels with the exceptions of $+19\%$ and $+21\%$ increases in poultry intakes by women and men, a -11% decrease in beef intake by men, and continuing declines in liver consumption by women (through 1999) and men.

The only nutrient intake significantly affected between 1996 and 2000 was that of retinol, the animal-derived component of total vitamin A, which steadily decreased in both genders.

Is it conceivable that one food, liver, that was eaten by less than 40% of the population at baseline and by less than 22% of the women in 2000, could have such a large impact on the median intake of total vitamin A in the Geneva population? As in humans, vitamin A is stored in high concentrations in the liver of animals and liver tissue contains a magnitude more vitamin A per gram than any other food. Liver is also rich in many other nutrients, but at lower concentrations than those of vitamin A. Therefore, only a few people decreasing or eliminating liver from their diets can indeed significantly shift the distribution of intake of total vitamin A for the entire population. In addition, there are relatively few foods that provide a significant amount of retinol (liver, whole milk, butter and eggs) or carotene (dark colored fruits and vegetables; Whitney & Rolfes, 1996), whereas most other nutrients are found in abundance in many different foods. Except for the decrease in retinol intake, mainly by women, the dietary patterns of the Geneva population remained stable. As Tables 4 and 5 show, the liver abstainers (60–78% of the population) had consistently lower intakes of total vitamin A than recommended.

It is unlikely that the observed decreasing trends in total vitamin A intakes were due to underestimation by the food frequency questionnaire. The intakes of retinol and beta-carotene have been assessed since 1993 and have proved to be very stable (Morabia *et al*, 1999). Moreover, the food frequency questionnaire developed for this survey tended to overestimate the intakes of retinol and beta-carotene compared with the 24 h recalls against which it had been validated (Morabia *et al*, 1994). However, these survey participants were aged 35–74 and can be expected to have more stable dietary habits than younger adults or children. We cannot therefore extrapolate the present findings to younger generations.

Requirement for total vitamin A

Vitamin A is required for normal vision and plays a role in gene expression, reproduction, embryonic development, immune function and regulation of cell differentiation of epithelial cells (Institute of Medicine, 2001). Carotenes play an additional role as antioxidants independent of their vitamin A activity. Most populations depend on carotenes as the major source of vitamin A.

The first identifiable sign of vitamin A deficiency is night blindness. Vitamin A-related night blindness may be missed

in older people because decrements in vision, including night vision, usually accompany aging (Institute of Medicine, 2001). Many other symptoms including keratosis, and respiratory, gastrointestinal, urinary tract, and other infections are non-specific and can be attributed to a number of causes.

The US Institute of Medicine's Food and Nutrition Board recognizes that many nutrients are actually needed in amounts greater than minimally required to prevent deficiency symptoms for optimum health. However, because of the inherent differences among individuals and their respective health statuses, is difficult to predict how much of a nutrient is required to prevent or delay specific diseases or maintain optimum health (Committee on Dietary Allowances, 1989; Blumberg, 1994; Committee on Diet and Health FaNB, 1989). However, a marginally low intake of vitamin A or carotenes over a period of years, as observed in Tables 4 and 5, may compromise those people with conditions that require higher levels of nutrient intake.

Predicting subgroups at risk for vitamin A deficiency

The recommended amounts of total vitamin A are greater than required for the majority of people in the population (Institute of Medicine, 2001). With 75% of the population (the liver abstainers) consuming between 66% (men) and 83% (women) of the DRI for total vitamin A, it was likely that some subgroups in the population were at risk of deficiency. Using the method of Beaton (1971) (also see Morabia and Costanza (2001), we identified four population subgroups that consistently had levels of total vitamin A intake that put them at high risk in 2000: women aged 35–44, women smokers, men aged 65–74, and men without an educational diploma.

Opportunities for public health education

These data suggest that adults in Geneva should be encouraged to eat more fruit and vegetables, especially if they do not eat liver, dairy products or eggs. The US Department of Agriculture recommends that adults should eat at least five servings of fruit and vegetables per day (Subar & Block, 1990). It is possible for them to get their requirement of vitamin A from fruit and vegetable sources, but many individuals do not do so. They may require a beta-carotene supplement or vitamin A-fortified foods such as milk or cereals to meet their needs (Institute of Medicine, 2001). Public health campaigns should be targeted at the groups at greatest risk. Education and counseling should also be directed at their spouses, since women living in Geneva usually buy and prepare the food for family meals.

Conclusions

We have documented the meat-related dietary changes observed in Geneva from 1993 to 2000. The observed

decreases in beef and liver consumption following the much-publicized Mad Cow Disease crisis in 1996 prompted our enhanced focus on monitoring the trends in meat consumption/intake, which led to the discovery of some long-term disparities in the diets of those who ate liver compared with those who did not. We suggest that a public health education program be targeted at those at greatest risk for total vitamin A intakes below the recommended levels.

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