Alcohol intake and micronutrient density in a population in transition: the transition and health during urbanisation in South Africa (THUSA) study

[a] Serfontein M, BSc [a] Venter C, DSc [a] Kruger A, PhD [b] MacIntyre U, PhD [a] PT Pisa, PhD
[a] Centre of Excellence for Nutrition, North-West University, South Africa [b] Institute of Human Nutrition, University of Limpopo, South Africa
Correspondence to: Dr Christine Venter, e-mail: Christine.Venter@nwu.ac.za
Keywords: population in transition; urbanisation; alcohol consumption; micronutrients; nutrient intake

Abstract

Objective: To investigate the possibility of micronutrient dilution by alcohol in the diets of an adult population in nutrition transition.

Design: A cross-sectional, comparative, population-based study.

Setting: The African population of the North West Province, South Africa.

Subjects: One thousand seven hundred and fifty-seven participants (742 men, 1 015 women) aged 15 years and older from 37 randomly selected sites from rural and urban areas.

Outcome measures: Outcome measures included alcohol consumption at different levels of urbanisation. Nutrient intakes in different alcohol intake categories (abstainers, light-to-moderate, and heavy drinkers) and body mass indices of men and women, separately.

Results: Sixty-one per cent of men and twenty-five per cent of women reported alcohol consumption. Mean daily alcohol consumption of light-to-moderate drinking men (< 30 g per day) and women (< 15 g per day) were 8.3 g and 3.7 g respectively and 80.4 g and 36.6 g for "heavy drinkers", defined as men consuming more than 30 g alcohol/day (18% of the study population) and women who drank more than 15 g alcohol/day (6% of the study population). Sorghum and commercial beer were the most popular alcoholic beverages. Alcohol intake increased from rural to urban middle class, with a shift from sorghum to commercial beer with urbanisation. Men consuming the most alcohol had significantly higher mean intakes of most macro- and micronutrients. For both men and women only the percentage of energy from fat decreased significantly as the alcohol intake increased. The intake of some micronutrients did not meet the Dietary Reference Intake (DRI, Estimated Average Requirement, EAR) at all levels of alcohol consumption. However, the DRIs for pantothenic acid, biotin, magnesium and zinc were met only in men consuming the most alcohol. There was no significant difference in BMI across the different alcohol consumption categories although the total energy intake increased with an increase in alcohol consumption.

Conclusion: In this population in transition, urbanisation increased the consumption of alcoholic beverages. Mean energy intake from alcohol of heavy-drinking men (18.1% of total energy, TE) and women (11.7% of TE) was significantly higher than in the other groups but this did not cause an overall micronutrient dilution effect. It seems that respondents who have the money to buy alcoholic drinks can possibly also afford more healthy and nutritious food.

S Afr J Clin Nutr 2010;23(3)(Supplement 1):S22-S28

Introduction

South Africa is undergoing rapid urbanisation, especially among the African population in their search for a better life in the more affluent urbanised areas.[1] People are moving away from the rural areas to live in and around the cities to improve their socio-economic conditions. Urbanisation causes a shift in food intake with increased intakes of cheaper and more energy dense food and drinks, which are often lacking in micronutrients.[2] Urban areas not only have a greater availability of cheaper unhealthy foods but also higher rates of alcohol consumption.[3] The 2003 South Africa Demographic and Health Survey (SADHS)[4] revealed that 34.1% of urban male residents were current (past seven days) drinkers compared to 20.7% of rural males. Thirty per cent of South African men and 10% of women participating in the 2003 SADHS reported that they were currently drinking alcohol, and in the North West Province current drinking was reported by 44.7% of men and 11.9% of women.[4] Both the type and amount of alcohol consumed are changing. Traditional home-brewed sorghum beer is being substituted with commercial beer, spirits and wine.[5]

Sugary/soft drinks[6] and alcohol consumption[7] may cause micronutrient dilution when consumed at high levels. Light-to-moderate alcohol consumption has been described as healthy.[8] Moderate drinking is described as no more than two to three standard drinks per day.[8] The official definition of a unit of consumption varies from one country to another: from as little as 6.3 g of ethanol in spirits in Austria to as much as 19.75 g in Japan. The British unit is uniformly defined as 8 g, which corresponds to the amount of ethanol in half a pint of beer (3.5% of alcohol by volume). The USA unit, in contrast, is variously defined as 12 g or 14 g.[8] Drinking more than two to three drinks per day (for women and men respectively) may cause micronutrient dilution, either displacing nutrients or interfering with the metabolism thereof.[7] This may lead to deficiencies of micronutrients such as thiamin,[9] vitamins B_6 and B_{12}, folate[10] and antioxidants.[11] Therefore, South Africa has developed guidelines for safe and sensible alcohol consumption[12] to guide people in making the correct choices when consuming alcohol. According to the South African Department of Health,[13] "sensible" drinking means that men should not drink more than three "standard drinks" and women not more than two "standard drinks" per day (defining a standard drink as a can of beer, one tot of spirits, one glass of wine or one small glass of sherry).

Any dietary component that causes micronutrient dilution in the South African population needs urgent attention from health professionals. From a database created by combining the results of numerous dietary surveys of South African adults, the authors concluded that the mean calcium, iron, folate and vitamin B_6 intakes were very low, particularly in women.[14] Mean intakes were lower in rural areas. Fortification of maize meal and wheat flour raised the mean levels of thiamin, riboflavin, niacin, vitamin B_6 and folate above the recommended nutrient intakes (RNIs) but in women the mean iron and calcium intakes remained below the RNIs.[14] Therefore, fortification does not solve all micronutrient deficiencies and deficiencies of calcium, iron, folate and vitamin B_6 are still common in both adults and children.[14]

In the present study data from the Transition and Health during Urbanisation in South Africa (THUSA) survey were analysed to determine the levels of micronutrient dilution caused by alcohol in this community in transition. The THUSA study[15] was undertaken during 1996 and 1998 to compare the prevalence of known risk factors for non-communicable diseases among Africans in the North-West Province at different stages of urbanisation and to provide information for the development of preventive strategies.

Methods

Study design, subject selection and organisational procedures

A statistical model was used to recruit 1 854 "apparently healthy" volunteers, aged 15 years and older, from 37 randomly selected sites from rural and urban areas. The participants were stratified into five levels of urbanisation based on area of residence and type of income as: rural, farm, informal settlement, middle class urban and upper class urban. Pregnant and lactating women, individuals taking chronic medication, and inebriated volunteers were excluded. The study was approved by the Ethics Committee of the Potchefstroom University (now North-West University, Potchefstroom Campus) (Ethics number 4M5-95) and all participants signed an informed consent form after the procedures were explained to them in their own language.

Demographic information, health histories, and dietary intake data were obtained during individual interviews by specially trained, multilingual fieldworkers in the language of a subject's choice, using questionnaires specially designed or adapted and validated for this population. Dietary intakes were measured with a culture sensitive quantitative food frequency questionnaire (QFFQ), which was validated against a seven-day weighed food record and biomarkers,[16] as well as a combination of statistical methods.[17] Reproducibility of the questionnaire was tested on a sub-sample of 144 respondents.[18] Anthropometric measurements (height, weight) were measured by postgraduate biokinetics students, standardised by a level III anthropometrist. Fasting blood samples were drawn by registered nursing sisters from the cephalic vein, using a sterile butterfly infusion set (Johnson & Johnson; 21G, 19 mm) and sterile syringes. Serum was prepared immediately in the field using a Universal 16R™ Hettich centrifuge (Tuttlingen, Germany) with cooling facilities. Serum samples were stored at –20 °C in the field for 2–4 days and later at –84 °C in the laboratory. To verify reported alcohol intakes, the concentration of the liver enzyme gamma-glutamyl transferase (GGT) was determined with the DAX system (discrete analyzer, Technicon DAX 48; Miles Inc Diagnostic Division, Tarrytown, NY, USA).

Nutrient and alcohol intake analysis

Portion sizes reported in household measures were converted to weights. The average daily intake of each food item was calculated in grams from the weight of the portion size and the frequency of consumption. The FoodFinder Dietary analysis programme of the Medical Research Council (MRC) was used for the dietary analyses. The contributions of carbohydrate, protein, fat and alcohol to total energy intakes were expressed as percentages of energy intakes. Alcohol consumption was divided into three levels of intake for men and women separately. Respondents who abstained from alcohol were in Group 1. Men who consumed up to two drinks per day (30 g alcohol per day) and women consuming up to one drink per day (15 g alcohol), which is the average intake recommended by European countries,[19,20] were in Group 2 (light-to-moderate users). Those men consuming more than 30 g and women more than 15 g alcohol per day were in Group 3 (heavy drinkers). This corresponds with Agarwal's definition of heavy drinking.[21]

Statistical analysis

Descriptive statistics were calculated for continuous variables. Differences between mean intakes of strata of urbanisation were tested using the analysis of variance (ANOVA) procedure. Significant F-values were further tested using the TUKEY test for honest significant differences (HSD), with the level of significance set at 0.05. Statistics were done with the Statistica program (StatSoft Inc., Tulsa, OK, USA). Dietary intake, age and body mass index of 1757 volunteers with complete data sets (742 men, 1015 women) were further analysed with the SPSS 15 package (SPSS Inc., Chicago, IL, USA) for this sub-study. Non-parametric partial correlations between alcohol intake and GGT were performed, adjusted for age and BMI.

Results

Obtaining accurate information on alcohol consumption was extremely difficult. Many subjects reported drinking "two or three" cases (12 bottles) of "quarts" (750 mL bottles) of beer over a weekend. Usually men drank together, which made it difficult to know exactly how many bottles or cans were consumed by an individual. The amount of 'homemade' beer was also difficult to quantify. For men, alcohol intake did not correlate statistically significantly with GGT, adjusted for age and BMI ($r = 0.05$, $p = 0.19$). For the women, however, a weak significant correlation ($r = 0.22$, $p = 0.000$) was found. Furthermore, alcohol intake as measured by the QFFQ correlated (Spearman rank coefficient) relatively well ($r = 0.53$, $p < 0.05$) with intake of men and women as measured by a seven-day weighed record completed by a sub-sample of respondents ($n = 74$).[16]

Table I: Daily energy, macronutrient and alcohol intake of men by strata of urbanisation [mean (standard error of the mean)]

	Rural (R)	Farm (F)	Informal settlement (IS)	Middle class urban (MC)	Upper class urban (UC)	Significant differences[a]
	n = 194	n = 109	n = 128	n = 229	n = 83	
	Mean (SEM)	Mean (SEM)	Mean (SEM)	Mean (SEM)	Mean (SEM)	
Energy (kJ)	9 597 (278)	8 913 (371)	9 333 (342)	9 897 (256)	9 818 (425)	R:UC
Carbohydrate (g)	360.5 (11.0)	340 (14.7)	335.0 (13.5)	343.4 (10.2)	315 (16.8)	R:UC
Energy (%)	67.4 (0.67)	67.2 (0.89)	65.5 (0.82)	64.0 (0.62)	57.3 (1.02)	R,F,IS,MC:UC
Protein (g)	65.9 (1.8)	63.6 (2.4)	63.8 (2.2)	66.3 (1.7)	76.9 (2.7)	R,F,IS,MC:UC
Energy %	11.6 (0.15)	12.1 (0.2)	12.0 (0.18)	11.8 (0.14)	13.2 (0.23)	R,F,IS,MC:UC
Animal protein (g)	25.9 (1.1)	28.2 (1.5)	27.2 (1.4)	29.2 (1.0)	44.1 (1.7)	R,F,IS,MC:UC
Plant protein (g)	39.8 (1.2)	35.3 (1.6)	36.3 (1.5)	36.9 (1.1)	32.6 (1.9)	
Fat (g)	54.4 (1.9)	51.1 (2.5)	55.3 (2.3)	63.0 (1.7)	77.3 (2.8)	R,F,IS:MC,UC;MC:UC
Energy %	22.9 (0.51)	22.8 (0.68)	24.3 (0.63)	26.0 (0.47)	30.6 (0.78)	R,F,IS:MC,UC; MC:UC
Alcohol (g)	16.2 (2.7)	10.8 (1.7)	21.0 (3.8)	24.6 (3.4)	12.7 (2.4)	R,F,UC:MC
Energy %	7.5 (0.92)	6.1 (1.18)	7.6 (0.98)	7.9 (0.71)	6.5 (1.4)	
% Drinkers	52	54	69	73	49	
Fibre (g)	19.2 (0.67)	15.6 (0.9)	17.4 (0.82)	18.8 (0.61)	19.7 (1.02)	

[a] Difference significant $p < 0.05$. Strata before colon differ significantly from strata after colon, n = number; SEM = standard error of the mean

Table II: Daily energy, macronutrient and alcohol intake of women by strata of urbanisation [mean (standard error of the mean)]

	Rural (R)	Farm (F)	Informal settlement (IS)	Middle class urban (MC)	Upper class urban (UC)	Significant differences[a]
	n = 290	n = 148	n = 172	n = 292	n = 106	
	Mean(SE)	Mean (SE)	Mean (SE)	Mean(SE)	Mean (SE)	
Energy (kJ)	7 894 (180)	7 961 (253)	7 824 (235)	8 012 (179)	8 523 (297)	
Carbohydrate (g)	308.0 (7.7)	313.0 (10.7)	292.2 (9.9)	283.6 (7.6)	276.0 (12.7)	R,F:MC,UC
Energy (%)	67.0 (0.54)	68.3 (0.75)	64.1 (0.70)	61.5 (0.54)	55.6 (0.89)	R,F:IS,MC,UC; IS:MC,UC; MC:UC
Protein (g)	54.8 (1.3)	54.4 (1.8)	56.9 (1.6)	59.5 (1.3)	69.7 (2.1)	R,F,IS:MC,UC; MC:UC
Energy %	11.4 (0.13)	11.3 (0.18)	11.8 (0.16)	12.1 (0.12)	13.4 (0.21)	R,F,IS:MC,UC; MC:UC
Animal protein (g)	22.2 (0.86)	22.1 (1.21)	25.9 (1.12)	29.1 (0.86)	42.6 (1.43)	R,F,IS,MC:UC
Plant protein (g)	32.4 (0.80)	32.2 (1.13)	30.9 (1.04)	30.2 (0.80)	27.0 (1.33)	R,F,IS,MC:UC; R:MC
Fat (g)	48.7 (1.5)	47.0 (2.0)	52.8 (1.9)	58.8 (1.5)	72.7 (2.4)	R,F,IS:MC,UC; F:IS; MC:UC
Energy (%)	23.6 (0.41)	22.6 (0.57)	25.6 (0.53)	27.7 (0.40)	31.8 (0.67)	R,F,IS:MC,UC; R,F:IS; F:R; MC:UC
Alcohol (g)	2.3 (0.6)	4.4 (0.9)	3.8 (0.8)	2.9 (0.6)	0.6 (1.0)	R,F,IS,MC:UC
Energy (%)	4.6 (0.62)	4.9 (0.84)	4.0 (0.70)	3.4 (0.63)	0.80 (1.17)	R,F,IS,MC:UC
% Drinkers	19	29	35	26	21	
Fibre (g)	15.8 (0.44)	15.4 (0.62)	16.3 (0.58)	17.1(0.44)	17.7 (0.73)	R,F:MC,UC

[a] Difference significant $p < 0.05$. Strata before colon differ significantly from strata after colon, n = number; SEM = standard error of the mean

Sixty-one per cent of men and 25% of women reported alcohol consumption. Alcohol intakes, expressed as intake in grams and as percentage of total energy intake provided by alcoholic beverages (Tables I and II), were very variable. Alcohol intake of women in all strata was low (mean of 2.9 g/day, standard error [SEM] 0.3 g/day) for the drinkers and non-drinkers. Among the males, however, alcohol contributed to between 2.8% and 18.1% of the total dietary energy (mean intake of drinkers and non-drinkers, 18.5 g/day, which equalled about one and a half 'standard drinks' per day). Intakes increased from rural to middle class urban, but people living in upper urban areas (professionals) consumed the least alcohol. Men from the urban middle class had the highest mean intake of alcohol (24.6 g/day) and the highest proportion of drinkers (73%). Men living on farms had the lowest mean intake of alcohol (10.8 g/day). Women living on farms had the highest mean intake (4.38 g/day) but a larger percentage of women from informal settlements reported alcohol consumption (35%). Commercial beer, sorghum beer and home brew were the most popular beverages. With increased urbanisation, the type of beer shifted from sorghum based to commercial beer, as shown in Table III, which depicts the average daily intakes of the ten foods consumed in the largest amounts by male subjects.

Tables IV and V show the alcohol and nutrient intakes as percentages of energy and as absolute intakes for men and women respectively in the different alcohol intake categories. Eighteen per cent of the males consumed more than 30 g per day ("heavy drinkers") whilst only 6% of the women drank heavily (> 15 g per day). Results for the

Table III: Ten foods consumed in largest amounts per male person per stratum per day (n = 338)

Rural		Farm		Informal settlement (IS)		Middle class urban (MU)		Upper class urban (UC)	
n = 78		n = 69		n = 41		n = 71		n = 79	
Food item	Mean (g)	Food item	Mean (g)	Food item	Mean (g)	Food item	Mean (g)	Food item	Mean (g)
Tea (brewed)	346	Milk	375	Commercial beer	286	Tea	317	Commercial beer	237
Milk	158	Tea	364	Tea	270	Commercial beer	268	Tea	168
Sorghum beer	137	Sorghum beer	355	Sorghum beer	221	Milk	188	Milk	142
Maize meal	136*	Maize meal	210	Milk	180	Maize meal	146	Carbonated drink	96
Commercial beer	135	Commercial beer	63	Maize meal	111	Sorghum beer	118	Maize meal	85
Brown bread	96	Diluted cold drink	48	Diluted cold drink	92	Carbonated cold drink	100	Red meat	82
Coffee	92	Sugar	36	Mageu **	43	Brown bread	62	Diluted cold drink	64
Diluted cold drink	63	Carbonated drink	34	White bread	40	Apple	53	Rice	51
Red meat #	48	Corn-on-the-cob	31	Brown bread	40	Rice	50	Brown bread	57
Apple	40	Samp	28	Red meat	35	Red meat	41	Coffee	54

* Maize meal: raw maize meal, # Red meat includes all cuts of beef, mutton and pork and processed meats, ** Amahewu (maheu, mageu, magou, aramrewu) is a traditional non-alcoholic lactic acid-fermented maize drink.[33]

Table IV: Daily nutrient intake, BMI, age and S-GGT of men according to alcohol intake [mean (95% confidence interval)]

Nutrient	DRI (EAR)	Total (n = 747)	Group 1: 0 g/day; n = 286 (38%)	Group 2: 0.1–30 g/d; n = 319 (43%)	Group 3: > 30 g/d; n = 137 (18%)
Alcohol (g)		18.5 (16.5–20.5)	0.0 (-2.8–3.5)[ab]	8.3 (5.3–11.3)[ac]	80.4 (75.7–84.9)[bc]
% E alcohol		4.5 (4.1–5.0)	0.1 (-0.5–0.7)[ab]	2.8 (2.3–3.4)[ac]	18.1 (17.3–18.9)[bc]
Total energy (including alcohol) (kJ)		9 569.4 (9 320.7–9 818)	8 662.4 (8 248.9–9 075.9)[a]	8 986.1 (8 597.1–9 375.1)[b]	12 849(12 255–13 444)[ab]
Total protein (g)	58	65.9 (64.2–67.6)	63.7 (60.9–66.5)[a]	64.7 (62.0–67.0)[b]	76.4 (72.3–80.5)[ab]
% E protein		12.0 (11.8–12.1)	12.0 (11.7–12.2)	12.0 (11.8–12.3)	11.8 (11.4–12.1)
Total fat (g)		58.4 (56.4–60.3)	57.8 (54.8–60.8)	58.7 (55.9–61 5)	62.9 (58.6–67.3)
% E fat		24.9 (24.4–25.5)	25.5 (24.7–26.4[a]	25.3 (24.5–26.1)[b]	22.5 (21.3–23.7)[ab]
Total carbohydrate (g)	100	344.0(333.5–354.5)	327.8 (310.2–345.4)[a]	329.6 (312.9–346.1)[b]	408.3 (383.0–433.6)[ab]
% E carbohydrate		64.9 (64.2–65.6)	64.4 (63.5–65.6)[a]	64.5 (63.5–65.6)[b]	65.1 (65.5–68.8)[ab]
Added sugar (g)		54.1 (50.7–57.6)	54.8 (49.3–60.2)	52.9 (47.8–58.1)	55.3 (47.5–63.2)
% E sugar		9.5 (9.0–10.1)	11.9 (10.9–12.8)[ab]	10.5 (9.6–11.5)[ac]	8.4 (7.0–9.8)[bc]
Fibre (g)	30–38	18.3 (17.7–18.9)	15.2 (8.0)[a]	18.3 (10.0)[b]	21.1 (9.1)[ab]
Vitamin A (µg RE)	625	705.2 (656.5–753.9)	654.6 (582.2–727.1)[a]	710.8 (642.4–779.2)	799.7 (695.3–904.1)[a]
Thiamin (mg)	1.0	1.2 (1.1–1.2)	1.2 (1.1–1.2)[a]	1.6 (1.1–1.2)[b]	1.3 (1.2–1.4)[ab]
Riboflavin (mg)	1.1	1.5 (1.4–1.5)	1.4 (1.3–1.5)[a]	1.4 (1.3–1.5)[b]	2.0 (1.9–2.1)[ab]
Niacin (mg)	12.0	15.2 (14.7–15.7)	12.8 (12.0–13.7)[a]	13.8 (13.0–14.6)[b]	23.2 (21.9–24.4)[ab]
Vitamin B_{12} (µg)	2.0	1.1 (1.1–1.2)	1.0 (0.9–1.1)[a]	1.1 (1.4–1.6)[b]	1.5 (1.4–1.6)[ab]
Vitamin B_6 (mg)	1.1–1.4	5.0 (4.7–5.4)	4.8 (4.2–5.4)	5.0 (4.4–5.5)	5.6 (4.7–6.4)
Folate (µg)	320	223.1 (216.4–229.7)	205.2 (193.7–216.8)[a]	208.1 (197.3–219.0)[b]	295.3 (278.7–311.9)[ab]
Pantothenic acid (mg)	5.0 (AI)	4.3 (4.1–4.4)	3.9 (3.7–4.1)[a]	4.0 (3.8–4.2)[b]	5.5 (5.2–5.8)[ab]
Biotin (µg)	30.0 (AI)	28.7 (27.7–29.7)	26.4 (24.7–28.1)[a]	26.9 (25.3–28.6)[b]	37.7 (35.2–40.2)[ab]
Vitamin D (µg)	5.0–10.0	5.4 (5.1–5.6)	5.6 (5.1–6.1)	5.3 (4.9–5.8)	4.9 (4.1–5.6)
Vitamin E (mg)	12.0	11.7 (11.2–12.1)	11.7 (10.9–12.5)	11.6 (10.9–12.4)	11.8 (10.6–12.9)
Ascorbic acid (mg)	75.0	34.9 (32.1–37.8)	34.1 (30.1–38.2)	34.6 (30.8–38.4)	37.5 (31.7–43.3)
Calcium (mg)	1 000–1 200 (AI)	459.4 (441.1–477.6)	436.0 (405.4–466.7)[a]	443.7 (414.8–472.6)[b]	544.9 (500.7–589.0)[ab]
Iron (mg)	6.0	9.2 (8.9–9.5)	8.8 (8.3–9.3)[a]	8.8 (8.4–9.3)[b]	10.7 (9.9–11.4)[ab]
Magnesium (mg)	350	356.0 (345.0–367.1)	304.7 (285.8–323.6)[a]	322.7 (304.8–340.5)[b]	541.9 (514.7–569.1)[ab]
Phosphorus (mg)	580	1 169.9 (1 138.7–1201.0)	1 043.0 (990.5–1 095.5)[a]	1 087.6 (1 038.1–1 137.2)[b]	1 628.1 (1 552.5–1 703.7)[ab]
Zinc (mg)	9.4	8.9 (8.6–9.2)	8.6 (8.2–9.0)[a]	8.6 (8.2–9.0)[b]	10.2 (9.6–10.8)[ab]
BMI		21.1 (20.7–21.5)	21.3 (20.9–21.7)	20.9 (20.5–21.3)	21.0 (20.4–21.6)
Age		37.8 (36.8–38.7)	34.6 (32.8–36.5)[ab]	39.2 (37.4–40.9)[a]	40.6 (38.0–43.3)[b]
S-GGT (U/l)		55.0 (47.2–62 7)	26.3 (8.5–44.1)[ab]	71.1 (54 5–87.8)[a]	76.1 (50.0–101.7)[b]

a,b,c = means with the same letter differ significantly from one another, p ≤ 0.05; BMI = body mass index; n = number; CI = confidence interval; DRI = Dietary Reference Intake; EAR = Estimated Average Requirement; AI = Adequate Intake; Group 1 = abstainers; Group 2 = light-to-moderate users; Group 3 = heavy users; S-GGT = serum gamma-glutamyl transferase

men show that energy, carbohydrate and fibre intake increased as alcohol intake increased. Male respondents consuming more than 30 g per day also had significantly higher mean intakes of fibre and most micronutrients (vitamin A, thiamin, riboflavin, niacin, vitamin B_{12}, folate, pantothenic acid, biotin, calcium, iron, magnesium, phosphorus and zinc) than non-drinkers, and also more of these nutrients than light-to-moderate drinkers except for vitamin A which was not significantly different. Light- to-moderate drinkers consumed significantly more thiamin than heavy drinkers. Women consuming more than 15 g alcohol per day had higher mean intakes of energy, protein, thiamin, riboflavin, niacin, folate, iron, magnesium, phosphorus and zinc than non-drinkers and more energy, riboflavin, niacin, magnesium, phosphorous and zinc than light-to-moderate drinkers. For both men and women, only the percentage energy from fat was reduced significantly as alcohol intake increased. Although the total energy intake increased with increased alcohol intake, there was no significant difference between the mean BMI of the three groups of men and women.

Mean intakes of vitamin B_{12}, vitamin E, folate, ascorbic acid and calcium were below the Dietary Reference Intake (DRI, Estimated Average Requirement (EAR), Institute of Medicine)[22] for men at all levels of alcohol consumption. Mean pantothenic acid, biotin, magnesium and zinc intake reached the DRI in the group of men consuming more than 30 g alcohol/day but not in the other groups. Women had mean intakes lower than the EAR for vitamin B_{12}, folate, pantothenic acid, biotin, vitamin D, vitamin E, ascorbic acid and calcium at all levels of alcohol intake.

Micronutrient intake data were converted to nutrient density (Tables VI and VII). Nutrient intakes, expressed as a proportion of energy, showed a significant reduction of most micronutrients (vitamin A, thiamin, vitamin B_6, folate, pantothenic acid, vitamin D, vitamin E, calcium and zinc), with the exception of niacin and magnesium, in the case of heavy-drinking men. Expressed per energy unit (4.18 MJ), women who were light-to-moderate drinkers consumed more vitamin A, vitamin D and zinc than the heavy drinkers. Niacin, phosphorus and magnesium intake per energy unit increased in heavy-drinking females. The nutrient densities of vitamin B_6, folate, pantothenic acid, vitamin E and calcium were significantly higher in abstainers than in heavy drinkers.

With regard to food group intakes, female heavy drinkers consumed significantly more chicken, fish, vegetables, potatoes, samp and fat than the non-drinkers, and more chicken, fish, eggs, and fat than the light-to-moderate drinkers (data not shown). The latter consumed

Table V: Daily nutrient intake, BMI, age and S-GGT of women according to alcohol intake [mean (95% confidence interval)]

Nutrient	DRI (EAR)	Total n = 1015	Group 1: 0 g; n = 759 (75%)	Group 2: 0.1–15 g; n = 196 (19%)	Group 3: > 15 g; n = 60 (6%)
Alcohol (g)		2.9 (1.2–4.6)	0.0 (-0.5–0.5)[ab]	3.7 (2.8–4.6)[ac]	36.6 (34.9–38.2)[bc]
% E alcohol		1.0 (0.6–1.3)	0.0 (-0.1–0.1)[ab]	1.5 (1.2–1.7)[ac]	11.7 (11.2–12.2)[bc]
Total energy (including alcohol) (kJ)		8 005.0 (7 791.5–8 218.6)	7 867.7(7 653.5–8 082)[a]	7 990.6(7 569.3–8 411.8)[b]	9 582.4 (8 818.9–10 346.0)[ab]
Total protein (g)	46	57.7(56.2–59.1)	57.3 (55.8–58.9)[a]	58.5 (55.5–61.5)[b]	63.4 (57.9–68.9)[ab]
% E protein		11.9 (11.7–12.0)	11.8 (11.7–12.0)	12.1 (11.8–12.4)	11.9 (11.4–12.5)
Total fat (g)		54.3 (52.7–55.9)	54.2 (52.4–56.0)[a]	55.1 (51.5–58.7)	55.9 (49.5–62.4)[a]
% E fat		25.8 (25.4–26.3)	25.9 (25.3–27.4)[a]	26.3 (25.3–27.4)[b]	23.8 (21.9–25.7)[ab]
Total carbohydrate (g)		296.0 (287.0–305.0)	294.3 (285.0–303.6)[a]	290.9 (272.7–309 2)[b]	317.8 (284.7–350.9)[ab]
% E carbohydrates		63.9 (63.3–64.6)	64.1 (63.3–64.8)	63.1 (61.7–64.5)	65.1 (62.5–67.6)
Added sugar (g)		52.5 (49.6–55.4)	53.3 (49.8–56.7)	50.6 (43.9–57.2)	43.6 (31.5–55.7)
% E sugar		10.7 (10.2–11.1)	12.3 (11.7–13.0)[a]	11.7 (10.4–13.1)[b]	8.2 (5.9–10.6)[ab]
Fibre (g/d)	21–25	16.4 (15.9–16.9)	16.3 (15.8–16.8)	16.4 (15.3–17.4)	17.3 (15.4–19.2)
Vitamin A (µg RE)	625	761.2 (719.4–803.1)	739.0 (687.9–790.0)[a]	862.4 (761.9–962.9)[a]	712.4 (530.1–894.8)
Thiamin (mg)	1	1.1 (1.0–1.1)	1.1 (1.0–1.1)[a]	1.1 (1.0–1.1)	1.2 (1.1–1.3)[a]
Riboflavin (mg)	1.1	1.3 (1.3–1.4)	1.3 (1.3–1.4)[a]	1.3 (1.2–1.4)[b]	1.6 (1.4–1.8)[ab]
Niacin (mg)	12	12.4 (12.0–12.8)	12.1 (11.6–12.5)[a]	12.5 (11.7–13.3)[b]	16.5 (15.0–18.0)[ab]
Vitamin B_{12} (µg)	2	1.0 (0.9–1.0)	1.0 (0.9–1.0)	1.0 (1.0–1.1)	1.0 (0.9–1.2)
Vitamin B_6 (mg)	1.1–1.4	4.8 (4.5–5.1)	4.8 (4.4–5.2)	4.8 (4.1–5.5)	4.4 (3.1–5.7)
Folate (µg)	320	193.2 (187.5–198.9)	190.9 (185.0–196.8)[a]	196.2 (184.7–207.8)	212.9 (191.9–233.8)[a]
Pantothenic acid (mg)	5.0 (AI)	3.5 (3.4–3.6)	3.5 (3.4–3.6)	3.5 (3.3–3.7)	3.8 (3.5–4.2)
Biotin (µg)	30 (AI)	21.7 (20.8–22.5)	21.7 (20.9–22.5)	20.9 (19.2–22.5)	24.0 (21.0–27.1)
Vitamin D (µg)	5–10	4.5 (4.0–4.5)	4.3 (4.1–4.6)	4.1 (3.6–4.6)	4.0 (3.1–5.0)
Vitamin E (mg)	12	10.2 (9.8–10.6)	10.2 (9.8–10.6)	10.2 (9.4–11.0)	11.1 (9.6–12.5)
Ascorbic acid (mg)	75	38.9 (36.5–41.4)	39.4 (36.3–42.4)	40.4 (34.5–46.4)	29.0 (18.2–39.8)
Calcium (mg)	1 000–1 200 (AI)	409.8 (394.1–425.5)	407.9 (390.5–425.3)	409.9 (375.7–444.2)	433.8 (371.7–495.9)
Iron (mg)	6	8.6 (8.3–8.8)	8.4 (8.1–8.7)[a]	8.7 (8.1–9.3)	9.7 (8.7–10.7)[a]
Magnesium (mg)	350	290.3 (280.8–299.8)	280.2 (271.5–306.2)[a]	289.0 (271.8–306.2)[b]	423.0 (391.9–454.2)[ab]
Phosphorus (mg)	580	962.2 (935.4–989.0)	941.7 (915.5–968.0)[a]	961.0 (909.3–1012.7)[b]	1 226.6 (1 132.8–1 320.4)[ab]
Zinc (mg)	9.4	8.0 (7.8–8.2)	7.9 (7.6–8.1)[a]	8.1 (7.6–8.6)[b]	9.2 (8.3–10.0)[ab]
BMI		27.0 (26.6–27.3)	27.1 (26.6–27.5)	26.9 (26.0–27.9)	25.6 (23.8–27.3)
Age		37.8 (36.8–38.7)	37.3 (36.0–38.1)[a]	38.0 (36.0–40.0)	41.8 (38.1–45.5)[a]
S-GGT (U/l)		31.6 (25.0–38.3)	28.0 (24.3–31.8)[a]	30.7 (23.1–37.9)[b]	77.6 (64.1–91 0)[ab]

a,b,c = means with the same letter differ significantly from one another, p ≤ 0.05; BMI = body mass index; n = number; CI = confidence interval; DRI = Dietary Reference Intake; EAR = Estimated Average Requirement; AI = Adequate Intake; Group 1 = abstainers; Group 2 = light-to-moderate users; Group 3 = heavy users; S-GGT = serum gamma-glutamyl transferase

more red meat than the other two groups of women. Heavy-drinking males consumed significantly more rice and less sugar and cold drinks than the other two groups whilst the light-to-moderate drinkers consumed the most milk, cereals and fat. Significantly more sweets (mean 35.9 g/day) and cold drinks (0.5 g) were consumed by the female abstainers compared to heavy drinkers (16.1 and 0.3 g/day, respectively, data not shown). Male abstainers consumed 36.9 g sugar and 0.7 g cold drinks per day compared to 23.4 g and 0.2 g respectively by heavy drinkers ($p < 0.05$).

Discussion

The present study aimed to evaluate whether alcohol intake above 30 g alcohol/day for men and 15 g/day for women causes micronutrient dilution in a community in a country suffering from micronutrient deficiencies and presently in a nutrition transition.[1] SADHS (2003) data revealed alcohol consumption by 44.7% of men and 11.9% of women in the North-West Province,[4] whilst the present study, conducted in 1996 and 1998, revealed that 61% of men and 25% of women drank alcohol. The proportion of both men and women in the country who indicated in the SADHS (2003)[4] that they currently (past seven days) drink was lower than in 1998[3] (45% of men and 17% of women compared to 30% and 10% in SADHS in 2003). The authors of the 2003 survey acknowledge that their results are likely to underestimate the true prevalence of alcohol use in South Africa, given the nature of omnibus surveys and social pressures of women in certain cultures not to drink alcohol.[4] Although the main problem with accurately surveying alcohol consumption has been reported to be due to the stigma related to alcohol use, and its associated behaviours,[22] the correlation (women only) in the THUSA data with GGT, a proxy for alcohol intake, and the correlation of alcohol intake of men and women as measured by the QFFQ, with intake measured by a seven-day weighed record (Spearman rank R = 0.53, $P < 0.001$),[16] seems to indicate that underreporting was not a significant problem. Alcohol intake (absolute intake and % TE) was the highest for men living in middle class urban areas and women living on farms. Beer was the most popular alcoholic drink, and there was a shift from sorghum beer to commercial beer with urbanisation. This finding is in agreement with the findings of Ramphele and Heap[5] and Steyn et al.[24]

A major principle in managing diets is to obtain adequate levels of nutrient intake within the appropriate energy intake needed to maintain or attain healthy body weight. As the proportion of energy from alcohol increases it becomes more difficult to balance the diet in terms of nutrients. The mean intakes of alcohol of the three groups of

Table VI: Daily micronutrient intake of men (per 4.18MJ), according to alcohol intake as a proportion of energy [mean (95% confidence interval)]

Nutrient	Total (n =742)	Group 1: (0 g) (n = 286)	Group 2: (0.1–30 g) (n = 319)	Group 3: (> 30 g) (n = 137)
Energy from alcohol (%)	4.6 (4.2–5.0)	0 (-0.5–0.7)	2.8 (2.3–3.4)	18.1 (17.3–18.9)
Vitamin A (µg/4.18MJ)	327.3 (303.6–351.1)	330.2 (0.5–0.6)	348.0 (315.9–380.1)[a]	273.4 (224.5–322.4)[a]
Thiamin (mg/4.18MJ)	0.5 (0.51–0.53)	0.6 (0.5–0.6)[a]	0.5 (0.5–0.6)[b]	0.4 (0.4–0.5)[ab]
Riboflavin (mg/4.18MJ))	0.7 (0.6–0.7)	0.7 (0.6–0.7)	0.7 (0.6–0.7)	0.7 (0.6–0.7)
Niacin (mg/4.18MJ)	6.6 (6.4–6.7)	6.3 (6.0–6.5)[a]	6.5 (6.3–6.7)[b]	7.5 (7.2–7.9)[ab]
Vitamin B_{12} (µg/4.18MJ)	0.5 (0.4–0.5)	0.5 (0.4–0.5)	0.5 (0.4–0.5)	0.5 (0.4–0.5)
Vitamin B_6 (mg/4.18MJ)	2.4 (2.2–2.5)	2.5 (2.2–2.8)[a]	2.4 (2.2–2.7)[b]	1.9 (1.5–2.3)[ab]
Folate (µg/4.18MJ)	15.7 (14.3–17.0)	16.8 (15.2–18.4)[a]	16.0 (14.5–17.5)[b]	12.4 (10.1–14.7)[ab]
Pantothenic acid (mg/4.18MJ)	1.9 (1.9–2.0)	2.0 (2.0–2.1)[a]	2.0 (1.9–2.0)[b]	1.8 (1.7–1.9)[ab]
Biotin (µg/4.18MJ)	13.1 (12.7–13.6)	13.5 (12.8–14.3)[a]	13.2 (12.5–13.9)	12.1 (11.0–13.2)[a]
Vitamin D (µg/4.18MJ)	2.6 (2.5–2.8)	3.0 (2.7–3.3)[a]	2.7 (2.5–3.0)[b]	1.6 (1.2–2.0)[ab]
Vitamin E (mg/4.18MJ)	5.3 (5.1–5.6)	5.8 (5.5–6.1)[a]	5.5 (5.2–5.7)[b]	3.9 (3.5–4.3)[ab]
Calcium (mg/4.18MJ)	207.9 (200.1–215.7)	217.0 (205.1–228.9)[a]	210.3 (199.1–221.6)[b]	183.3 (166.1–200.4)[ab]
Iron (mg/4.18MJ)	4.1 (4.0–4.2)	4.3 (4.1–4.4)[a]	4.1 (4.0–4.3)[b]	3.5 (3.3–3.7)[ab]
Magnesium (mg/4.18MJ)	154.5 (152.1–157.0)	147.6 (143.6–151.4)[a]	151.7 (148.0–155.4)[b]	175.6 (169.9–181.3)[ab]
Phosphorus (mg/4.18MJ)	518.4 (511.6–525.2)	514.1 (503.0–525.2)	516.5 (515.6–547.7)	531.7 (515.7–547.7)
Zinc (mg/4.18MJ)	4.0 (3.9–4.1)	4.2 (4.1–4.3)[a]	4.1 (4.0–4.2)[b]	3.4 (3.2–3.6)[ab]

a,b,c = means with the same letter differ significantly from one another, $p \leq 0.05$; Group 1 = abstainers; Group 2 = light-to-moderate users; Group 3 = heavy users

Table VII: Daily micronutrient intake of women (per 4.18MJ), according to alcohol intake as a proportion of energy [mean (95% confidence interval)]

Nutrient	Total (n = 1015)	Group 1:(0 g) (n = 759)	Group 2: (0.1–15 g) (n = 196)	Group 3: (> 15 g) (n = 60)
Energy from alcohol (%)	1.0 (0.6–1.3)	0.0 (-0.1–0.1)	1.5 (1.2–1.7)	11.7 (11.2–12.2)
Vitamin A (µg/4.18MJ)	409.6 (389.3–429.9)	403.5 (378.2–428.8)[ab]	463.4 (413.8–513.0)[ac]	310.8 (221.0–400.7)[bc]
Thiamin (mg/4.18MJ)	0.6 (0.5–0.6)	0.6 (0.5–0.6)[a]	0.6 (0.5–0.6)[b]	0.5 (0.4–0.5)[ab]
Riboflavin (mg/4.18MJ))	0.7 (0.65–0.7)	0.7 (0.6–0.7)	0.7 (0.6–0.7)	0.7 (0.6–0.8)
Niacin (mg/4.18MJ)	6.5 (6.4–6.6)	6.4 (6.3–6.6)[a]	6.6 (6.3–6.9)[b]	7.2 (6.7–7.7)[ab]
Vitamin B_{12} (µg/4.18MJ)	0.5 (0.5–0.6)	0.5 (0.5–0.6)[a]	0.6 (0.5–0.6)[b]	0.5 (0.4–0.5)[ab]
Vitamin B_6 (mg/4.18MJ)	2.6 (2.4–2.7)	2.6 (2.5–2.8)[a]	2.6 (2.3–3.0)	1.9 (1.2–2.6)[a]
Folate (µg/4.18MJ)	20.9 (19.7–22.1)	21.5 (19.9–23.0)[a]	21.3 (18.3–24.3)[b]	12.5 (7.1–18.0)[ab]
Pantothenic acid (mg/4.18MJ)	1.9 (1.8–1.9)	1.9 (1.9–2.0)[a]	1.9 (1.8–2.0)[b]	1.6 (1.5–1.8)[ab]
Biotin (µg/4.18MJ)	11.7 (11.4–12.1)	12.0 (11.6–12.4)	11.2 (10.5–12.0)	10.1 (8.7–11.5)
Vitamin D (µg/4.18MJ)	2.4 (2.2–2.5)	2.4 (2.3–2.6)[a]	2.8 (2.0–2.6)[b]	1.6 (1.1–2.1)[ab]
Vitamin E (mg/4.18MJ)	5.5 (5.3–5.6)	5.5 (5.3–5.7)[a]	5.5 (5.2–5.8)[b]	4.6 (4.0–5.2)[ab]
Calcium (mg/4.18MJ)	219.4 (212.8–226.1)	222.5 (214.5–230.4)[a]	215.8 (200.2–231.4)	193.1 (164.8–221.4)[a]
Iron (mg/4.18MJ)	4.5 (4.4–4.6)	4.5 (4.4–4.6)	4.5 (4.3–4.7)	4.2 (3.9–4.5)
Magnesium (mg/4.18MJ)	152.3 (150.2–154.4)	150.1 (147.8–152.4)[a]	150.1 (145.7–154.6)[b]	187.5 (179.4–195.6)[ab]
Phosphorus (mg/4.18MJ)	510.0 (504.2–515.8)	508.9 (502.2–515.6)[a]	506.4 (493.3–519.6)[b]	535.4 (511.6–559.2)[ab]
Zinc (mg/4.18MJ)	4.3 (4.2–4.3)	4.3 (4.2–4.3)	4.3 (4.2–4.5)[a]	4.0 (3.7–4.3)[a]

a,b,c = means with the same letter differ significantly from one another, $p \leq 0.05$; Group 1 = abstainers; Group 2 = light-to-moderate users; Group 3 = heavy users

women (non-drinkers, light-to-moderate drinkers and heavy drinkers) were 0, 3.7 and 36.6 g/day and for the men 0, 8.3 and 80.4 g/day. Recommendations in international food-based dietary guidelines on alcohol intake vary in both quantity, and in quantification (i.e. measured by the percentage of daily energy intake, dL/day or g/day or units). A number of countries suggest a limited alcohol intake but not all of them quantify this recommendation. In general, European countries recommend less than 5% of daily energy intake or 15 g/day and 20 g/day for women and men, respectively.[19] The UK recommends 3–4 units/day for men and 2–3 units/day for women (defining one unit as 8 g alcohol).[20] In the THUSA population, the non-drinkers obtained no energy from alcohol, the light-to-moderate male drinkers 2.8% and heavy male drinkers 18.1%. For light-to-moderate female drinkers alcohol provided on average 1.5% TE and for heavy drinkers 11.7% TE. Therefore, neither the women nor the men who drank heavily complied with the general guidelines for alcohol consumption. It seems therefore reasonable to conclude that alcohol consumption may be a problem in this population in transition, especially among the men, of whom 18% were heavy drinkers as opposed to the 6% of women who were heavy drinkers.

Although the mean energy intake of heavy drinkers (men and women) was significantly higher than in the other groups, the micronutrient density of their diets was not compromised to such an extent that the DRIs were not met. In fact, the diets of the male heavy drinkers met the recommended intakes of pantothenic acid, biotin, magnesium and zinc, which were inadequate in the other groups. This may be due to the higher energy content of their diet (mean energy intake of heavy drinking men was 12849 kJ versus 8662 kJ for abstainers). However, intake of these nutrients (pantothenic acid, biotin, magnesium and zinc) was not particularly low in the secondary data analysis of average South African adult diets made by Steyn et al.[14] It should also be noted that the sorghum and commercial beers made some contribution to the diet with regard to the intake of not only energy but also some micronutrients, such as magnesium, zinc, manganese, riboflavin and niacin, as illustrated in the MRC food composition tables.[25] According to Walmsley et al,[26] light-to-moderate alcohol consumption in older people in the UK is associated with higher intakes of certain nutrients and higher blood concentrations (independent of intake) of some micronutrient status indices, including antioxidants.

Some studies have shown that light-to-moderate alcohol consumers do not substitute alcoholic beverages for food items, but consume alcohol in addition to normal food intakes.[27,28] However, others have shown that substitution in those drinking alcohol does occur.[26] It has been suggested that poorer people are more likely to replace food with alcohol.[29] The present study revealed that the light-to-moderate male drinkers consumed the same amount of energy as the abstainers but more nutritious foods, including cereals, which are nowadays (but not at the time of the study) fortified with zinc, iron, vitamin A and B_6, thiamin, niacin, riboflavin and folic acid. The heavy drinkers (both male and female) consumed significantly more energy but the female heavy drinkers also ate more protein rich foods, vegetables, samp and potatoes. Furthermore, the cold drink intakes of the male and female abstainers were higher than in the other two groups, which might have lowered the nutrient density of their diet, as has been reported by various researchers, including Charlton et al.[6]

One of the major consequences of changes in diet associated with urbanisation is the increased prevalence of obesity in the last decade.[2] In some studies, but not all, alcohol consumers had lower BMI than abstainers, despite their higher total energy intakes.[30,31] Although it has been found that middle-aged men did not substitute alcohol for food, but added alcoholic beverages to the diet, the energy from alcohol (29 kJ per g) increased body weight less than expected, especially in daily alcohol users,[26] and in a follow-up study the same researchers found that alcohol consumers were leaner than abstainers.[27] In the THUSA population more than half of the women were overweight.[32] However, there was no significant difference in BMI across the different alcohol categories despite an increase in energy intake with increased alcohol consumption.

Conclusion

In conclusion, the results of this study were unexpected. The results might have been different if the standard drink were 12 g alcohol, as suggested by the Department of Health for South Africans.[13] However, it seems as if economics may play some role in a population in transition. Those respondents who could afford to buy alcoholic drinks could probably also afford to buy foods that could provide sufficient amounts of micronutrients. This was illustrated in the higher consumption of protein rich foods and vegetables by the small percentage of women who consumed the most alcohol. Overall, the nutrient deficiencies in the diets of the THUSA population were very much the same as those reported by Steyn et al[14] from their database of intakes of South African adults (including the THUSA and other surveys) before national fortification of staple foods. Fortification might have solved some of these deficiencies (such as folate and zinc), especially in the case of the light-to-moderate drinking men who consumed significantly more cereals than the abstainers. The results of the study need to be confirmed in other communities in transition in South Africa, taking into account the increased intakes of fortified nutrients in staple foods.

References

1. Vorster HH. The emergence of cardiovascular disease during urbanization of Africans. Pub Health Nutr 2002;5(1A):239–43.
2. Popkin BM. The nutrition transition in low-income countries: an emerging crisis. Nutr Rev 1994;52(9):285–98.
3. Parry CDH, Plüdderman A, Steyn K, Bradshaw D, Norman R, Laubscher R. Alcohol use in South Africa: Findings from the first demographic and health survey (1998). J Stud Alcohol 2005;66:91–7.
4. Department of Health, Medical Research Council, OrcMacro. South Africa Demographic and Health Survey 2003. Pretoria: Department of Health; 2007.
5. Ramphele MA, Heap M. Health status of hostel dwellers. Part VI. Tobacco smoking, alcohol consumption and diet. S Afr Med J 1991;79(12):717–20.
6. Charlton KE, Kolbe-Alexander TL, Nel JH. Micronutrient dilution associated with added sugar intake in elderly black South African women. Eur J Clin Nutr 2005;59:1030–42.
7. van den Berg H, van der Gaag M, Hendriks H. Influence of lifestyle on vitamin bioavailability. Int J Vitamin Nutr Res 2002;72:53–9.
8. Doll, R. One for the heart: Clinical review. BMJ 1997; 315: 1664–8.
9. Singleton CK, Martin PR. Molecular mechanisms of thiamine utilization. Curr Mol Med 2001;1:197–207.
10. Zhang SM, Willet WC, Selhub J, et al. Plasma folate, vitamin B6, vitamin B12, homocysteine, and risk of breast cancer. J Natl Cancer Inst 2003;95(5):373–80.
11. Ringstad J, Knutsen SF, Nilssen OR, Thomassen Y. A comparative study of serum selenium and vitamin E levels in a population of male risk drinkers and abstainers. A population-based matched-pair study. Biol Trace Elem Res 1993;36(1):65–71.
12. Van Heerden IV, Parry CDH. If you drink alcohol, drink sensibly. SAJCN 2001;14(3):S71–7.
13. Department of Health. South African guidelines for healthy eating for adults and children over the age of seven years. Pretoria: Department of Health; 2004.
14. Steyn NP, Wolmarans P, Nel JH, Bourne LT. National fortification of staple foods can make a significant contribution to micronutrient intake of South African adults. Public Health Nutr 2008; 1(3):307–13.
15. Vorster HH, Venter CS, Wissing MP, Margetts BM. The nutrition and health transition in the North West Province of South Africa: a review of the THUSA (Transition and Health during Urbanisation of South Africans) study. Publ Health Nutr 2005;8(5):480–90.
16. MacIntyre UE, Venter CS, Vorster HH. A culture-sensitive quantitative food frequency questionnaire used in an African population: 2. Relative validation by 7-day weighed records and biomarkers. Public Health Nutr 2000;4(1):63–71.
17. MacIntyre UE, Venter CS, Vorster HH, Steyn HS. A combination of statistical methods for the analysis of the relative validation data of the quantitative food frequency questionnaire used in the THUSA study. Public Health Nutr 2000;4(1):45–51.
18. MacIntyre UE, Venter CS, Vorster HH. A culture-sensitive quantitative food frequency questionnaire used in an African population: 1. Development and reproducibility. Public Health Nutr 2000;4(1):53–62.
19. Nutrition and Food Security Programme. WHO Regional Office for Europe. Food based dietary guidelines in the WHO European region. Denmark: World Health Organization; 2003.
20. International Center for Alcohol Policies. International drinking guidelines. http://www.icap.org/PolicyIssues/DrinkingGuidelines/GuidelinesTable/tabid/204/Default.aspx (Accessed October 13, 2008).
21. Agarwal DP. Cardioprotective effects of light-moderate consumption of alcohol: a review of putative mechanisms. Alcohol & Alcohol. 2002; 37:409–15.
22. Pernanen K. Validity of survey data on alcohol use. In: Gibbons RJ, Israel Y, Kalant H, Popham RE, Schmidt W, Smart RG, eds. Research advances in alcohol and drug problems. New York: John Wiley & Sons; 1974:335–74.
23. Steyn NP, Burger S, Monyeki KD, Alberts M, Nthangeni G. Variation in dietary intake of the adult population of Dikgale. SAJCN 2001;14(4):140–5.
24. Institute of Medicine. Dietary Reference Intakes. Food and Nutrition Board. Washington, DC: National Academy Press, 2003.
25. Langenhoven M, Kruger M, Gouws E, Faber M. Food composition tables. 3rd edition. South African Medical Research Council; 1991.
26. Walmsley CM, Bates CJ, Prentice A, Cole TJ. Relationship between alcohol and nutrient intakes and blood status indices of older people living in the UK: further analysis of data from the National Diet and Nutrition Survey of people aged 65 years and over, 1994/5. Public Health Nutr 1998;1(3):157–67.
27. Mannisto S, Pietinen P, Haukka J, Ovaskainen ML, Albanes D, Virtamo J. Reported alcohol intake, diet and body mass index in male smokers. Eur J Clin Nutr 1996;50:239–45.
28. Mannisto S, Uusitalo K, Fogelholm M, Pietinen P. Alcohol beverage drinking, diet and body mass index in a cross-sectional survey. Eur J Clin Nutr 1997;51:326–32.
29. Klein S, Iber FL. Alcoholism and associated malnutrition in the elderly. Nutrition 1991;7:75–9.
30. Hellerstedt WL, Jeffrey RW, Murray DM. The association between alcohol intake and adiposity in the general population (review). Am J Epidemiol 1990; 32:594–611.
31. Prentice AM. Alcohol and obesity. Int J Obes 1995;19(Suppl 5):S44–S50.
32. Kruger HS, Venter CS, Vorster HH, Margetts BM. Physical activity is the major determinant of obesity in black women in the North West Province, South Africa: the THUSA study. Nutrition 2002;18:422–7.
33. Fritz K. Incorrect information on mageu. SAJCN 2005;18(3):265.