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Micronutrient intake of HIV-infected women in Mangaung, Free State

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Background. Poor nutritional status in HIV/AIDS patients can affect immune function profoundly, leading to faster disease progression and earlier death.

Objective. To determine the micronutrient intake of HIV-infected women in Mangaung.

Design and setting. A cross-sectional study was undertaken in Mangaung, Bloemfontein, Free State.

Subjects and methods. A representative group of 500 pre-menopausal women (25 - 44 years) was randomly selected to participate in the study. Micronutrient intake was determined using a Quantitative Food Frequency Questionnaire (QFFQ). Median micronutrient intakes were compared with the Recommended Dietary Allowance (RDA) or Adequate Intake (AI) values. The prevalence of women with intakes ≤ 67% of the RDA or AI was calculated. Median micronutrient intakes were compared between HIV-infected and uninfected women using non-parametric 95% confidence intervals (CIs) and the Mann-Whitney test.

Results. Sixty-one per cent of women in the younger age group (25 - 34 years) and 38% of older women (35 - 44 years) were HIV-infected. Between 46.6% and 70.7% of all women consumed ≤ 67% of the RDA or AI for calcium, total iron, selenium, folate and vitamin C. At least 25% of HIV-infected women did not meet either the RDA or the AI for vitamins A, D and E. Younger HIV-infected women had significantly higher intakes of calcium ($p = 0.046$), phosphorus ($p = 0.04$), potassium ($p = 0.04$), vitamin B_{12} ($p = 0.01$), vitamin D ($p = 0.03$) and vitamin E ($p = 0.04$) than their HIV-uninfected counterparts. Older HIV-infected women had significantly lower intakes of haem iron ($p = 0.03$), non-haem iron ($p = 0.04$) and selenium ($p = 0.04$) than their HIV-uninfected counterparts.

Conclusions. Insufficient micronutrient intakes are common in both HIV-infected and uninfected women. A well-balanced diet and micronutrient supplementation seem warranted to ensure optimal health and survival, particularly in HIV-infected women.

Africa has a long history of malnutrition.[1] By the turn of the 21st century food insecurity threatened the lives of about 400 million people living in sub-Saharan Africa.[2] In South Africa, poverty and household food insecurity are highly prevalent in poor communities.[3] This scenario has been radically compounded by the emergence of HIV/AIDS.[4]

Good nutrition is fundamental to maintain an optimal immune response.[5,6] There is wide consensus that an inadequate dietary intake may contribute to the poor micronutrient status prevalent in HIV disease.[7] Poor nutrition and HIV/AIDS form part of a typical vicious cycle in which micronutrient deficiencies, malnutrition-related immunosuppression, and oxidative stress lead to faster disease progression and earlier death.[8] Micronutrient deficiencies may prevail even where an adequate supply of macronutrients is available.[9] Results from two South African studies[10,11] confirmed that despite adequate macronutient intakes, inadequate intakes of several micronutrients were observed among HIV-infected blacks. However timely nutritional assessment and intervention can preclude these deficits.[12]

Supportive documented evidence is limited concerning micronutrient intake in HIV-infected women,[6] and micronutrient status of HIV-infected individuals from developing countries.[8] In response to this situation a cross-sectional study was conducted to determine

the micronutrient intake of HIV-infected women in Mangaung, in the Free State province of South Africa.

Methods

Five hundred women from Mangaung, an urban black residential area in Bloemfontein, South Africa, were selected to participate in the study. The respondents were from two built-up areas (Phahameng and Botchabela) and two informal settlements (Joe Slovo and Namibia). Post-pubertal, but pre-menopausal, women were randomly selected from two age groups (25 - 34 and 35 - 44 years respectively), using township maps. The residential plots in the four selected areas were counted and numbered. Namibia had 2 995 plots, Phahameng 1 711, Joe Slovo 1 359 and Botchabela 2 308. A proportionate number of respondents was randomly selected from these plots. The size of the sample was considered representative of the population of Mangaung. Subjects were recruited by trained community health workers, who were given detailed instructions about the recruitment of subjects, as well as a detailed map of 20 of the plots that had to be selected on a weekly basis. The assigned community health workers screened one woman from each plot for eligibility.

The Ethics Committee of the Faculty of Health Sciences, University of the Free State, approved the study (ETOVS No. 02/00). The community health workers explained the content and purpose of the study to possible participants. Subjects provided written informed consent.

HIV status of all the respondents was determined as part of the study, and tests were performed using the HIV-1 and HIV-2 Recombinant Antigens and Synthetic Peptides reagent pack (Abbott, Germany, catalogue no. 3D41-20). Subjects were given the opportunity to indicate whether they would like to receive their HIV test results, or whether the outcome should be withheld from them. All subjects who chose to know the outcome of their test results were referred to a medical practitioner for post-test counselling and, if required, a confirmatory test. The research team was blinded to the outcome of the HIV tests.

Micronutrient intake was determined using a validated Quantitative Food Frequency Questionnaire (QFFQ) that included typical South African foods as well as foods traditionally included in the diet of black inhabitants of the region. The QFFQ was administered during individual interviews by trained interviewers. Three interpreters assisted the interviewers.

The quantities of food items recorded on the questionnaire were converted to weights in grams using the Food Quantities Manual,[13] and the data were processed using the Food Composition Database of the South African Medical Research Council.[14]

Micronutrient intakes were compared with the Recommended Daily Allowance (RDA) and Adequate Intake (AI) values used in the USA.

Statistical analysis

Questions were coded and data processed using the SAS software package.[15] For each age and HIV group, micronutrient intake was reported using medians and percentiles. Categorical data were described using frequencies and percentages. To evaluate clinical relevance, the median micronutrient intake of HIV-infected and uninfected women was compared using non-parametric 95% confidence intervals (CIs), and the statistical significance assessed using the Mann-Whitney test. The prevalence of women with intakes ≤ 67% of the RDA or AI was also calculated and described for each age and HIV status group.

Results

A total of 500 subjects were recruited for the study, of whom 488 were eligible for participation. Four subjects were found to be pregnant during the medical examination, and another 8 subjects did not fit the age requirement and were excluded from the study. Of the 488 subjects, 273 were 25 - 34 years of age and 215 were 35 - 44 years old. The sampling strategy was designed specifically to compare these two age categories in order to render the study results comparable to previous studies performed within the same geographical area. Sixty-one per cent (N = 167) of the younger group (25 - 34 years) (Fig. 1) and 38% (N = 82) of the older group of women (35 - 44 years) (Fig. 2) tested HIV-seropositive. In total 51% of the women (N = 488) eligible for this study tested HIV-seropositive.

Tables I and II show the mineral and trace element intake of women in the two age groups. An analysis of these results shows that both HIV-infected and uninfected women had insufficient intakes of a number of micronutrients. Low median intakes, particularly of calcium, total iron and selenium were observed in the total sample. In both HIV-infected and HIV-uninfected younger women a large percentage consumed ≤ 67% of the RDA or AI for calcium (49.7% and 59.4% respectively), iron (48.5% and 51.9% respectively) and selenium (49.1% and 50.0% respectively). In the older subjects a similar trend was observed for consumption of calcium, iron and selenium.

Tables III and IV list the vitamin intake of the women. The percentage of women with an inadequate fat-soluble vitamin intake was relatively high in the entire sample. Concerning the B vitamins, median intakes of the total sample were generally slightly higher than the RDA or AI, and up to double the RDA or AI. Approximately 30% of the older HIV-infected women consumed ≤ 67% the RDA for vitamin B_6, and more

Table I. Mineral and trace element intake of HIV-infected (*N* = 167) and uninfected (*N* = 106) women aged 25 - 34 years

Nutrient	HIV status	Median	Median difference	95% CI for median difference	*p*-value	RDA/AI	≤67% of RDA/AI (%)
Calcium (mg)	HIV+	679.42	97.37	1.28; 188.04	0.046	1 000*	49.7
	HIV-	533.87					59.4
Chromium (µg)	HIV+	43.60	5.01	-0.94; 11.08	0.098	25*	9.0
	HIV-	35.95					14.2
Copper (mg)	HIV+	1.50	0.15	-0.04; 0.34	0.13	0.9	4.2
	HIV-	1.35					6.6
Iron haem (mg)	HIV+	0.36	-0.006	-0.09; 0.07	0.88		
	HIV-	0.38					
Iron non-haem (mg)	HIV+	3.69	0.28	-0.21; 0.78	0.24		
	HIV-	3.19					
Total iron (mg)	HIV+	12.32	1.04	-0.62; 2.62	0.23	18	48.5
	HIV-	11.84					51.9
Iodine (µg)	HIV+	40.49	2.50	-3.19; 8.63	0.36	150	93.4
	HIV-	39.67					96.2
Potassium (mg)	HIV+	3 024.8	342.30	18.66; 677.01	0.04	2 000	
	HIV-	2 594.0					
Magnesium (mg)	HIV+	388.95	38.09	-5.19; 80.38	0.08	320	9.6
	HIV-	342.31					17.0
Manganese (µg)	HIV+	3 083.4	252.26	-165.97; 635.6	0.23	1 800	4.2
	HIV-	2 776.1					10.4

Table I. (continued) Mineral and trace element intake of HIV-infected (N = 167) and uninfected (N = 106) women aged 25 - 34 years

Nutrient	HIV status	Median	Median difference	95% CI for median difference	p-value	RDA/AI	≤67% of RDA/AI (%)
Sodium (mg)	HIV+	2 708.4	325.47	-18.11; 677.04	0.06	3 000	
	HIV-	2 555.9					
Phosphorus (mg)	HIV+	1 397.0	162.55	2.34; 320.24	0.04	700	1.8
	HIV-	1 206.2					5.7
Selenium (µg)	HIV+	37.04	2.59	-3.14; 8.54	0.39	55	49.1
	HIV-	36.92					50.0
Zinc (mg)	HIV+	10.79	0.81	-0.43; 2.01	0.19	8	7.8
	HIV-	9.89					17.0

* = adequate intake (AI).
= 40 - 69% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.
= > 70% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.

Fig. 1. HIV status of younger women (25 - 34 years).

Fig. 2. HIV status of older women (35 - 44 years).

than half of all women consumed ≤ 67% of the RDA for folate. Median intake of vitamin C for the total sample was much lower than the RDA of 75 mg/day, with the older HIV-infected and HIV-uninfected women showing the lowest median intakes (47.54 mg/day and 43.96 mg/day respectively). More than 46% of all women in the sample consumed ≤ 67% of the RDA for vitamin C.

Younger HIV-infected women had significantly higher intakes of calcium (p = 0.046), phosphorus (p = 0.04), potassium (p = 0.04), vitamin B_{12} (p = 0.01), vitamin D (p = 0.03) and vitamin E (p = 0.04) than uninfected women in the same age group. However, total energy intake of these women was also significantly higher than that of their uninfected counterparts. Older HIV-infected women had significantly lower intakes of haem iron (p = 0.03), non-haem iron (p = 0.04) and selenium (p = 0.04) than their uninfected counterparts.

Discussion

Micronutrients are essential mediators in optimising immune function and deficiencies have been associated with immune impairment in both HIV-uninfected[16] and HIV-infected subjects.[17] In this descriptive cross-sectional study, insufficient intakes of a number of key micronutrients were identified. It should be remembered that while the recommended intake of certain micronutrients was met in this sample, HIV-infected individuals have increased requirements for specific micronutrients.[18]

Earlier studies confirmed that many HIV-infected individuals fail to consume the required intake for at least one,[19] or more micronutrients.[20] In this study about half of the total sample consumed inadequate amounts of calcium, total iron and selenium (Tables I and II). More than 25% of the HIV-infected women

Table II. **Mineral and trace element intake of HIV-infected (*N* = 82) and uninfected (*N* = 133) women aged 35 - 44 years**

Nutrient	HIV status	Median	Median difference	95% CI for median difference	*p*-value	RDA/AI	≤ 67% of RDA/AI (%)
Calcium (mg)	HIV+	681.27	42.56	-66.17; 159.35	0.443	1 000*	48.8
	HIV-	614.16					55.6
Chromium (µg)	HIV+	34.74	-7.53	-15.04; 0.06	0.05	25*	11.0
	HIV-	45.58					12.0
Copper (mg)	HIV+	1.35	-0.10	-0.28; 0.09	0.29	0.9	11.0
	HIV-	1.39					7.5
Iron haem (mg)	HIV+	0.24	-0.07	-0.15; -0.01	0.03		
	HIV-	0.35					
Iron non-haem (mg)	HIV+	3.13	-0.57	-1.11; -0.02	0.04		
	HIV-	3.70					
Total iron (mg)	HIV+	10.59	-0.74	-2.30; 0.91	0.42	18	54.9
	HIV-	11.70					51.9
Iodine (µg)	HIV+	35.12	-2.17	-8.40; 3.93	0.45	150	96.3
	HIV-	38.26					97.0
Potassium (mg)	HIV+	2 689.5	-4.60	-322.32; 318.2	0.97	2 000	
	HIV-	2 783.0					
Magnesium (mg)	HIV+	391.20	3.54	-41.93; 46.76	0.89	320	12.2
	HIV-	363.77					15.0
Manganese (µg)	HIV+	2 803.7	-85.53	-513.71; 317.7	0.68	1 800	11.0
	HIV-	2 818.0					6.0
Sodium (mg)	HIV+	2 282.6	-18.22	-362.37; 325.9	0.91	3 000	
	HIV-	2 332.2					
Phosphorus (mg)	HIV+	1 273.8	-18.33	-158.12; 149.7	0.84	700	2.4
	HIV-	1 296.7					1.5
Selenium (µg)	HIV+	30.42	-6.81	-12.94; -0.46	0.04	55	62.2
	HIV-	38.42					46.6
Zinc (mg)	HIV+	9.15	-0.63	-1.90; 0.56	0.3	8	11.0
	HIV-	10.05					12.0

* = adequate intake (AI).
= 40 - 69% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.
= > 70% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.

Table III. **Vitamin intake of HIV-infected (*N* = 167) and uninfected (*N* = 106) women aged 25 - 34 years**

Nutrient	HIV status	Median	Median difference	95% CI for median difference	*p*-value	RDA/AI*	≤ 67% of RDA/AI (%)
Vitamin A Re (µg)	HIV+	687.30	19.8	-104.2; 144.2	0.77	700	31.1
	HIV-	674.50					29.3
Vitamin D (µg)	HIV+	5.36	0.90	0.12; 1.75	0.03	5*	27.5
	HIV-	4.50					34.0
Vitamin E (mg)	HIV+	16.45	2.21	0.04; 4.38	0.04	15	25.2
	HIV-	14.11					32.1
Vitamin K (µg)	HIV+	126.31	11.31	-10.94; 34.30	0.32	90*	20.4
	HIV-	108.02					22.6
Thiamin (mg)	HIV+	1.72	0.19	-0.02; 0.39	0.08	1.1	7.8
	HIV-	1.46					12.3
Riboflavin (mg)	HIV+	2.09	0.14	-0.15; 0.43	0.35	1.1	4.2
	HIV-	2.00					6.6
Niacin (mg)	HIV+	21.78	2.40	-0.20; 4.94	0.07	14	6.0
	HIV-	18.97					13.2
Vitamin B_6 (mg)	HIV+	1.55	0.15	-0.04; 0.35	0.13	1.3	16.2
	HIV-	1.47					25.5
Folate (µg)	HIV+	252.72	30.04	-1.44; 60.96	0.06	400	53.3
	HIV-	233.82					62.3
Vitamin B_{12} (µg)	HIV+	5.38	1.09	0.26; 1.95	0.01	2.4	6.0
	HIV-	4.18					10.4
Vitamin C (mg)	HIV+	54.10	5.99	-4.08; 15.37	0.25	75	46.1
	HIV-	53.64					49.1
Pantothenic acid (mg)	HIV+	5.90	0.61	-0.08; 1.30	0.09	5*	11.4
	HIV-	5.34					22.6
Biotin (µg)	HIV+	36.42	3.33	-1.62; 8.41	0.197	30*	16.8
	HIV-	31.31					18.9

* = adequate intake (AI).
= 40 - 69% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.

Table IV. Vitamin intake of HIV-infected (*N* = 82) and uninfected (*N* = 133) women aged 35 - 44 years

Nutrient	HIV status	Median	Median difference	95% CI for median difference	*p*-value	RDA/AI	≤ 67% of RDA/AI (%)
Vitamin A Re (µg)	HIV+	593.57	-67.13	-200.32; 68.98	0.34	700	29.3
	HIV-	822.90					23.3
Vitamin D (µg)	HIV+	4.74	-0.02	-0.89; 0.92	0.98	5*	34.2
	HIV-	4.40					39.1
Vitamin E (mg)	HIV+	13.01	-1.82	-4.11; 0.42	0.11	15	39.0
	HIV-	14.13					23.3
Vitamin K (µg)	HIV+	118.16	-20.88	-49.68; 8.29	0.17	90*	22.0
	HIV-	134.00					14.3
Thiamin (mg)	HIV+	1.45	-0.07	-0.26; 0.11	0.44	1.1	9.76
	HIV-	1.50					9.8
Riboflavin (mg)	HIV+	1.73	0.02	-0.30; 0.32	0.94	1.1	7.3
	HIV-	1.78					6.0
Niacin (mg)	HIV+	17.63	-1.31	-3.65; 1.12	0.30	14	12.2
	HIV-	19.06					11.3
Vitamin B_6 (mg)	HIV+	1.22	-0.11	-0.29; 0.08	0.25	1.3	30.5
	HIV-	1.22					21.8
Folate (µg)	HIV+	220.63	-29.73	-64.22; 3.61	0.08	400	70.7
	HIV-	250.70					57.1
Vitamin B_{12} (µg)	HIV+	4.62	-0.04	-0.87; 0.78	0.92	2.4	9.8
	HIV-	4.59					5.3
Vitamin C (mg)	HIV+	47.54	-0.98	-10.67; 8.09	0.82	75	51.2
	HIV-	43.96					54.9
Pantothenic acid (mg)	HIV+	5.08	-0.61	-1.41; 0.12	0.10	5*	18.3
	HIV-	5.67					15.8
Biotin (µg)	HIV+	32.94	-0.75	-5.75; 4.05	0.76	30*	18.3
	HIV-	34.14					15.8

* = adequate intake (AI).
= 40 - 69% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.
= > 70% of the subjects' intake of this nutrient was ≤ 67% of the recommended intake for age.

in the present study did not meet the required intake for vitamins A, D and E (Tables III and IV), while the tendency toward low vitamin C and folate intake was more pronounced. Selenium, iron and vitamins A, E, C[16,21,22] and D[21,22] are vital for a healthy immune system, and even a mild deficiency of one nutrient may alter this.[16] Additionally, toxic free radicals may be neutralised or destroyed by the adequate availability of antioxidants[23] such as selenium and vitamins A, E and C. Consequently, deficiencies of the above nutrients may exacerbate oxidative stress and contribute to abnormalities in immunological or neurophysiological functions[24] in the HIV-infected women in this study. As indicated by Gil *et al*.,[18] the regular ingestion of a variety of fruit and vegetables may beneficially alter the nutritional profile, antioxidant status and immunity of HIV-infected individuals.

Our results support those of American studies showing insufficient micronutrient intake among HIV-infected individuals, with inadequate intakes reported for iron, vitamins A, C and E,[8, 19] selenium, calcium and folic acid.[19, 25] However, the results of this study cannot be generalised to predict the conditions in all African communities,[26] where food availability often differs immensely from that in Western societies. It would therefore be feasible to compare the micronutrient intake of the HIV-infected women in the present study with those of two earlier South African studies.[10,11] In the Free State study by Dannhauser *et al*.[10] conducted in a geographical area similar to ours, lower micronutrient intakes were reported in general. Similar trends of inadequate median intakes were found for vitamins A and C, calcium and iron in their HIV-infected subjects. However, the authors investigated dietary intake in rural and urban HIV subjects of both genders, and a different method of dietary assessment was used. It is furthermore worth mentioning that in the present study only the HIV status of the participants, and not their CD4 cell counts, was determined while other studies assessed dietary intakes of patients in various stages of disease progression.

Similar to the results of the present study, inadequate intakes of calcium, iron, vitamins A and C, and folate were also reported in the Transition and Health during Urbanisation of South Africans (THUSA) study performed in the North West province of South Africa.[11]

Notwithstanding the fact that in the present study younger HIV-infected women consumed significantly more ($p = 0.046$) calcium than uninfected younger women, calcium intakes were generally low in all the women. Financial constraints, plus cultural habits and taboos that regulate milk consumption and the known lactose intolerance of black women, could contribute to a calcium-depleted diet.[27] Non-dairy coffee creamers, which are convenient to use in households without refrigerators, could have contributed to the low calcium intakes in this study. Changes in diet and physical activity typical of urbanisation could increase the risk of osteoporosis,[28] and may also be reflected in the sample.

Iron deficiency is common in Africa, and anaemia appears widely among people living with HIV/AIDS.[29] Older HIV-infected women had significantly lower intakes of haem iron and non-haem iron. These low intakes are problematic as anaemia has been associated with HIV disease progression and increased risk of death.[30] Increased iron intake may therefore be beneficial to improve the prognosis[31] of HIV-infected women.

Selenium and zinc have been studied extensively in the context of HIV infection.[32] There is powerful evidence that deficiencies of both these minerals are prevalent with HIV infection.[10,25,33-36] In the present study we related the low intake of selenium to a core diet of maize products, a poor source of this nutrient. This raises concern, as a deficiency of selenium could be predictive of poor prognosis[37-39] and immune dysfunction,[40] thus increasing mortality.[34,41]

An adequate dietary supply of zinc is associated with sound immune function.[42] Similar to results of the THUSA study,[11] zinc intake of HIV-infected women in the present study was adequate, with only a small percentage of subjects consuming ≤ 67% of the RDA for zinc. In the study by Dannhauser *et al*.[10] about half of the HIV-infected subjects consumed diets containing ≤ 67% of the RDA for zinc.

A prominent feature of the present study is the large number of women with low vitamin C intakes. Low intakes were previously reported for urban black women,[27] HIV-infected women,[6,11] and HIV-infected male and female patients.[10] A corrective diet, including the consumption of more vitamin C-rich food sources by HIV-infected women, could possibly help to reduce the rate of progression to AIDS.[43]

Inadequate folate intake was prominent in the diets of a large percentage of the women in the study. Insufficient folate consumption seems to be a problem among urban and rural blacks in South Africa,[27] HIV-infected women,[11] and also other communities.[6,35] Although folate deficiencies have been associated with impaired immune function,[24] the role of this nutrient in HIV/AIDS infection is not yet clear,[44] with studies showing no relationship between folate deficiency and HIV-related outcomes.[45]

The relatively small percentage of women in the study who had inadequate intakes of thiamin, riboflavin, niacin and vitamin B_{12} is commendable, and fairly consistent with findings of international studies.[6,35] Maize products are a good source of thiamin and maize meal has been enriched with niacin in South Africa for many years,[46] which could possibly explain the

adequate intakes in the present study. Tang *et al*.[43] reported that an increased intake of thiamin, riboflavin, and niacin was associated with a significantly reduced rate of progression to AIDS. However about 30% of the older HIV-infected women had low intakes of vitamin B_6, corresponding with the findings of previous studies.[35] Despite adequate intakes, vitamin B_6 deficiency has been shown to commonly accompany HIV infection,[9] particularly during the early disease stage.[47]

For some nutrients the median micronutrient intakes of HIV-infected women either met or exceeded their respective RDAs or AIs, while for other nutrients intakes were inadequate. Regardless, HIV-infected persons need to increase their intakes of beta-carotene, vitamins A, E, C, B_6, and B_{12}, thiamin, riboflavin, niacin, folate and selenium.[17]

Conclusion

This study provides data on the micronutrient intake of black women in Mangaung. The results underline the urgency for nutritional intervention to approach this aspect of HIV infection in an innovative way, suited to South Africa. Since micronutrient malnutrition can potentially be reversed and requires drastic treatment, the first and foremost goals of nutrition therapy should be to focus on the prevention of these deficiencies and the importance of a well-balanced diet. As the micronutrient requirements of people living with HIV/AIDS are typically higher than those of the general population, micronutrient supplementation seems to be a cost-effective and reasonably easy way to help improve nutritional status in this milieu,[44] and would be warranted in addition to a healthy well-balanced eating plan to ensure optimal health and survival for those patients not qualifying for the antiretroviral programme in South Africa. The legislation on bread and maize flour fortification in South Africa will likely assist in addressing micronutrient deficiencies in this country.[48]

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