European Journal of Clinical Nutrition (2001) 55, 1022–1027

0954–3007/01 $15.00
www.nature.com/ejcn

Original Communication
Serum vitamin E, C and A status of the drug addicts undergoing detoxification: influence of drug habit, sexual practice and lifestyle factors

SK Nazrul Islam[1]*, K Jahangir Hossain[1] and M Ahsan[2]

[1]*Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh; and* [2]*Department of Pharmaceutical Sciences, University of Strathclyde, Glasgow, UK*

Background: The study was carried out on the hypothesis that drug addicts would have reduced vitamin E, C and A status which could be influenced by drug habit, sexual practice and lifestyle factors.
Method: Serum concentrations of Vitamin E, C and A of male drug addicts and cohort controls were analysed, and influence of drug habit, sexual practice and lifestyle factors of the addicts on the vitamin status was assessed. The study was conducted among 253 drug addicts who sought detoxification voluntarily during the period of June 1997 to July 1998 at the Central Drug Addiction Treatment Hospital, Dhaka, and 100 cohort control men. Research instruments were questionnaire and blood specimens. HPLC and spectrophotometric methods were used to determine the vitamin levels in sera of drug addicts.
Results: α-Tocopherol (12.60 ± 3.73 compared with 16.3 ± 3.37 μmol/l; $t = 8.6$, $P = 0.05$), ascorbic acid (21.59 ± 10.5 compared with 38.3 ± 13.62 μmol/l; $t = 10.93$, $P = 0.003$) and retinol (1.15 ± 0.39 compared with 1.33 ± 0.30 μmol/l; $t = 5.28$, $P = 0.048$) in the drug addicts were significantly low as compared to those in the cohort controls. Use of multiple illicit drugs for a longer period of time did result in reduced levels of these vitamins. A significant reduction in retinol concentration was noted among the multiple drug users ($F(2,250) = 3.23$, $P = 0.041$). Duration of addiction had a significant linear correlation with the level of reduction in retinol ($F(2,250) = 3.23$, $P = 0.041$) and α-tocopherol ($F(2,250) = 3.06$, $P = 0.049$). Apart from having a significant negative correlation between number of sexual partners and retinol level ($F(3,247) = 2.65$, $P = 0.049$), sexual practice did not have any influence on the vitamin status of the addicts. Occupation did have a significant effect on the ascorbic acid level ($F(4,248) = 2.46$, $P = 0.046$), but other socioeconomic factors like income, age etc did not influence the vitamin E, C and A levels. Body mass index had a positive linear correlation with the vitamins, but it was significant only with vitamin C ($F(2,250) = 7.06$, $P = 0.001$).
Conclusions: These results could have important implications for providing an antioxidant therapy to drug addicts and thus rehabilitating them into normal life. Risk of HIV infection and transmission (if any) could be reduced or inhibited.
Descriptors: drug addiction; antioxidant vitamins status; drug habit; sexual practice
European Journal of Clinical Nutrition (2001) **55,** 1022–1027

Introduction

It is widely accepted that drug addiction is a societal and health problem worldwide (UNDCP, 1997). It affects every sphere of human life. Young adults' lives are ruined (Islam *et al*, 2000); teenagers experiment with drugs, and use of illicit drugs has soared with the 'baby-boom' generation (Califano, 1998). They are all at high risk of HIV infection (National HIV-AIDS, 1999). Although research into drug abuse is very much to the fore in the Western world, there are few reports regarding drug abuse and antioxidant status. In spite of its fatal consequences worldwide, until recently research on illicit drug use has received little attention in Bangladesh (Morshed, 1996).

Drug addiction impairs nutritional status and immunity (Varela *et al*, 1997a, b). It is well documented that abuse of heroin, cocaine, morphine, marijuana etc induces immuno-nutritional deficiencies (Varela *et al*, 1997a; Thomas *et al*,

*Correspondence: SK Nazrul Islam, Institute of Nutrition and Food Science, University of Dhaka, Dhaka-1000, Bangladesh.
E-mail: snislam@bangla.net
Guarantor: SK Nazrul Islam.
Contributors: SK Nazrul Islam, K Jahangir Hossain and M Ahsan.
Received 7 December 2000; revised 24 April 2001; accepted 28 April 2001

1995; Carr & Serou, 1995; Courssons-Reed *et al*, 1994; Rouveix, 1992), which leads to infection and malnutrition. In addition to affecting food habits (Varela *et al*, 1997a; Himmelgreen *et al*, 1998; Morabia *et al*, 1989) and undermining appetite (Vasko, 1992), the use of illicit drugs leads to malnutrition, which is a composite syndrome of multiple nutrient deficiencies (Chandra, 1997). Cigarette smoking among the addicts may also be responsible for nutritional deficiencies (Marangon *et al*, 1998). There is evidence that lack of immunity, infection and malnutrition are synergistic (Scrimshaw & SanGiovanni, 1997; Solis-Pereyra *et al*, 1997). These all together leave the drug addict in a state of immunonutritional deficiency, and thus susceptible to infectious agents, including HIV (Varela *et al*, 1997a, b). The consumption of fruit and vegetables in drug addicts is lower than general population and they are more inclined to consume food that has a low vitamin content (Himmelgreen *et al*, 1998; Varela *et al*, 1997b; Morabia *et al*, 1989). Therefore, the drug addicts have micronutrient deficiencies, including antioxidant vitamins. Vitamins E, C and A, in addition to their antioxidant functions (Brown *et al*, 1997; Lykkesfeldt *et al*, 1997; Duggan *et al*, 1996), play an important role in the immunity (Chandra, 1997). Deficiencies of these vitamins may contribute to the development of immunodeficiency in the drug addicts (Chandra, 1997; Marcos *et al*, 1997). It is thus in drug addicts, who are at high risk of HIV infection (Islam *et al*, 2000; National HIV-AIDS, 1999), that replication and spreading of the deadly opportunistic HIV would be most likely to occur (Allard *et al*, 1998). HIV-positive patients have also been reported to have an increased oxidative stress and a poor antioxidant defence (Allard *et al*, 1998; Kotler, 1998). In the present study we analysed the serum vitamin E, A and C status of the drug addicts and cohort controls, and attempted to assess the influence of illicit drug habit, sexual practice and lifestyle factors on the vitamin status of the drug addicts. It is the first report to focus on this topic, especially in Bangladesh.

Subjects and methods

Study population

A total of 253 male drug addicts of age 18–45 y were investigated during the period of June 1997 to July 1998. They were principally users of heroin, cannabis, phensedyl (codeine, ephedrine and promethazine), Tidigesic (buprenorphine) and pethedine injections, and sought detoxification therapy voluntarily at the Central Drug Addiction Treatment Hospital, Tejgaon, Dhaka (the only government drug addiction treatment hospital in Bangladesh). Exclusion criteria included medical disorders including a current acute or chronic illness, impaired hepatic or renal functions, cardiac disorders, tuberculosis, cancer, severe asthma, using prescribed medicines, and alcoholism. In addition, readmission within 1 y, and period of addiction less than 1 y were also excluded. One hundred age, height and socio-economic matched healthy non-addicts (not taking any raw tobacco, cigarette etc) men were taken as cohort controls. Research instruments were interviewer administered questionnaire and blood specimens. The questionnaire was developed and pre-tested among the hospitalized drug addicts, who were not included in the study population. To conduct the study, ethical permission was granted by the Director of the Central Drug Addiction Treatment Hospital. After briefing on the perspective of the study and having obtained written consent, information was recorded in the questionnaire and blood specimens collected from each of the individuals.

Serum analysis

A venous blood sample was collected from antecubital vein of each of the case and control subjects. The blood sample was kept undisturbed for at least 60 min and was then centrifuged at 3000 rpm for 10 min. Serum thus extracted was stored at $-20^{\circ}C$ for analysis of retinol and α-tocopherol. Reversed-phase HPLC (LC-10AD, Shimadzu, HPLC 1991, model-7125, Japan) was used for simultaneous determination of retinol and α-tocopherol in the sera, as described by Bieri *et al* (1979). The analytes retinol and α-tocopherol were isolated from the serum by liquid–liquid extraction using n-hexane, concentrated by evaporation under nitrogen stream and reconstituted with HPLC-grade ethanol. The reconstituted sample (50 μl) was injected into chromatography on a C_{18} shim pack CLC-ODS (M) column of diameter 4.6 mm (Shimadzu, LC column, 4.6×250 mm, no. 1256168, Japan) with methanol: water (95:5) mobile phase flowing at 1 ml/min, detector set at one attenuation. The column was re-equilibrated with the mobile phase for 5 min before the next injection. Every sample was injected twice to have replicate chromatographs. Standard analytes were injected for every 25–30 test samples. Retinol and α-tocopherol were detected spectrophotometrically at 291 nm. Standards (retinol, α-tocopherol, retinol acetate and α-tocopheryl acetate) were purchased from Sigma Chemical Co., USA and solvents (HPLC grade) were from Merck (Darmstadt, Germany).

For ascorbic acid analysis, serum, immediately after extraction, was treated with 5% trichloroacetic acid (TCA) and then centrifuged at 3000 rpm for 10 min. The clear supernatant thus obtained was stored at $-20^{\circ}C$ until analysis. The concentration of ascorbic acid in the serum was determined by spectrophotometry using phenyl hydrazine indicator as described by Lowry *et al* (1945). Absorbance was measured against a reagent blank at 520 nm by a Spectrophotometer (UV-1201, UV–vis, Shimadzu, Japan). Every sample was analysed twice to have duplicate readings. Chemicals used in the analysis of serum ascorbic acid were purchased from Merck (Darmstadt, Germany) and Sigma Chemical Co, USA.

Statistical analysis

SPSS software package (version 6.0) was used to analyse the data. Descriptive statistics were calculated for all variables. Values were expressed as percentage and mean ± s.d. Comparison of serum vitamin E, C and A concentration of the drug addicts and non-addict controls were performed by cross table variables and independent sample *t*-test. Analysis of one-way variance (ANOVA) was used to find the effect of drug habit, sexual practice, socioeconomic factors etc on the serum vitamin levels.

Results

Results showed that the serum vitamin E, C and A status of the drug addicts was found to be significantly lowered than those of the non-addict controls (Table 1). The level of α-tocopherol was 12.60 ± 3.73 μmol/l in the drug addicts, while it was 16.3 ± 3.37 μmol/l ($t = 8.6$, $P = 0.05$) in the non-addict controls. Compared to the control value of ascorbic acid (38.3 ± 13.62 μmol/l), it was also significantly low in the drug addicts (21.59 ± 10.5 μmol/l; $t = 10.93$, $P = 0.003$). Results also showed reduced levels of retinol (1.15 ± 0.39 μmol/l; $t = 5.28$, $P = 0.048$) in the addicts compared with those in the non-addict controls (1.33 ± 0.30 μmol/l).

There was a negative correlation between the serum concentrations of vitamins and drug habit. Higher number of illicit drugs used and longer period of addiction resulted in decreased levels of vitamins E, C and A (Table 2). Multiple drug abuse produced a significant reduction in retinol level ($F(2,250) = 4.17$, $P = 0.017$). Duration of drug addiction had a significant linear correlation with the level of reduction in α-tocopherol ($F(2,250) = 3.06$, $P = 0.049$) and retinol ($F(2,250) = 3.23$, $P = 0.041$). Influence of sexual practice on the vitamins is also described in Table 2. The number of sexual partners (in lifetime), use of condoms and STD (sexually transmitted diseases) did not have any particular effect on the vitamin status of the addicts, but multiple sexual partners had a significant negative correlation ($F(3,247) = 2.65$, $P = 0.049$) with the retinol concentration.

Relation of socioeconomic factors and BMI to the vitamin status is outlined in Table 3. Income had a little but insignificant influence on the status of vitamin C and vitamin A. Age did not have any distinct effect. It was shown that occupation had a significant influence on ascorbic acid content ($F(4,248) = 2.46$, $P = 0.046$). However, other socioeconomic factors did not have any influence on vitamins E, A and C status. Body Mass Index (BMI) had a positive linear correlation with the vitamin levels, but it was significant only with vitamin C concentration ($F(2,250) = 7.06$, $P = 0.001$).

Discussion

Since World War II, drug addiction or illicit drug use has relentlessly increased among young adults worldwide. This has arisen as a result of a number factors including outnumbered young adults (imbalance cohort), changes in familial living arrangements, changes in beliefs and values, and in drug markets (Johnson & Gerstein, 1998). As in the developed world, drug addiction is increasing in Bangladesh. It has been recognized as a social, health and also a political problem, and it needs to be addressed urgently. In light of the incidence of fatality associated with drug abuse (National HIV-AIDS, 1999; Califano, 1998; UNDCP, 1997), the present study was undertaken

Table 1 Serum concentrations of vitamin E, C and A of the drug addicts ($n = 253$) and cohort control ($n = 100$)

	Case subject			*Control cohort*			
Antioxidant vitamin (μmol/l)	*Number*	*%*	*Mean ± s.d.*	*Number*	*%*	*Mean ± s.d.*	P-*value*[a]
α-Tocopherol							
< 10.0	65	25.7		2	2.0		$t = 8.60$
10.0–14.9	143	56.5	12.6 ± 3.73	37	37.0	16.3 ± 3.37	$P = 0.05$
15.0–19.9	33	13.0		47	47.0		
20.0–25.0	13	4.3		13	13.0		
> 25.0	02	0.8		1	1.0		
Ascorbic acid							
< 10.0	37	14.6		0			
10.0–19.9	78	30.8	21.59 ± 10.5	8	8.0		$t = 10.93$
20.0–29.0	90	35.6		22	22.0	38.3 ± 13.6	$P = 0.003$
30.0–40.0	32	12.6		27	27.0		
> 40.0	16	6.4		43	43.0		
Retinol							
< 0.50	5	2.0		0			
0.50–0.99	98	38.7		8	8.0		$t = 5.28$
1.00–1.49	97	38.3	1.15 ± 0.39	66	66.0	1.33 ± 0.30	$P = 0.048$
1.50–2.00	44	17.4		24	24.0		
> 2.00	9	3.6		2	2.0		

[a]Significant: $P < 0.05$.
Every sample was analysed twice to have replicate readings.
Descriptive statistics: frequencies; descriptives; crosstabs.
Compare means: independent-samples *t*-test.

Table 2 Effect of drug habit and sexual practice on α-tocopherol, retinol and ascorbic acid levels of the drug addicts ($n = 253$)

Parameter	*% (n)*	*α-Tocopherol (μmol/l)*[a] *mean ± s.d.*	*Retinol (μmol/l)*[b] *mean ± s.d.*	*Ascorbic acid (μmol/l)*[c] *mean ± s.d.*
Number of drugs[1]				
1–2	39.5 (100)	12.9 ± 3.69	1.23 ± 0.43*	21.5 ± 10.3
3	37.9 (96)	12.6 ± 3.84	1.12 ± 0.37*	22.1 ± 11.3
> 4	22.6 (57)	12.1 ± 3.62	1.05 ± 0.32*	20.9 ± 9.5
Period of addiction[2]				
< 5 y	38.7 (98)	13.3 ± 3.57*	1.21 ± 0.42*	22.8 ± 11.0
5–10 y	42.7 (108)	12.3 ± 3.78*	1.12 ± 0.34*	21.1 ± 9.9
> 10 y	18.6 (47)	11.8 ± 3.76*	1.05 ± 0.40*	19.9 ± 10.6
Number of sexual partners[3]				
< 5	37.5 (95)	12.5 ± 4.45	1.21 ± 0.41*	22.0 ± 12.0
5–15	32.5 (82)	12.3 ± 3.51	1.11 ± 0.36*	21.1 ± 10.2
> 15	30.0 (76)	13.2 ± 4.05	1.05 ± 0.32*	20.6 ± 11.0
Condom use[4]	23.7 (60)	12.7 ± 4.16	1.12 ± 0.37	21.5 ± 10.9
No condom use	76.3 (193)	12.3 ± 3.87	1.16 ± 0.42	21.3 ± 12.4
STD[5]				
Syphilis–gonorrhoea	59.3 (150)	12.7 ± 3.47	1.16 ± 0.39	21.7 ± 9.8
No STD	40.7 (103)	12.6 ± 4.09	1.14 ± 0.38	21.4 ± 11.4

*Significant ($P < 0.05$).
[1a]$F(2,250) = 0.917$, $P = 0.40$; [1b]$F(2,250) = 4.16$, $P = 0.016$; [1c]$F(2,250) = 0.27$, $P = 0.76$; [2a]$F(2,250) = 3.06$, $P = 0.048$; [2b]$F(2,250) = 3.27$, $P = 0.041$; [2c]$F(2,250) = 1.09$, $P = 0.336$; [3a]$F(3,247) = 0.897$, $P = 0.443$; [3b]$F(3,247) = 2.65$, $P = 0.049$; [3c]$F(3,247) = 0.527$, $P = 0.664$; [4a]$F(1,251) = 0.370$, $P = 0.53$; [4b]$F(1,251) = 0.39$, $P = 0.533$; [4c]$F(1,251) = 0.01$, $P = 0.917$; [5a]$F(1,251) = 0.007$, $P = 0.935$; [5b]$F(1,251) = 0.16$, $P = 0.689$; [5c]$F(1,251) = 0.057$, $P = 0.811$.
Every sample was analysed twice to have replicate readings.
Compare means: one-way ANOVA (descriptives, ANOVA).

Table 3 Effect of socioeconomic factors on α-tocopherol, retinol and ascorbic acid of drug addicts ($n = 253$)

Parameter	*% (n)*	*α-Tocopherol (μmol/l)*[a] *mean ± s.d.*	*Retinol (μmol/l)*[b] *mean ± s.d.*	*Ascorbic acid (μmol/l)*[c] *mean ± s.d.*
Monthly income US$[1]				
< 100	59.2 (150)	12.8 ± 3.82	1.12 ± 0.40	20.7 ± 10.1
100–200	25.8 (65)	12.6 ± 4.02	1.16 ± 0.34	22.8 ± 10.6
> 200	15.0 (38)	11.8 ± 2.68	1.20 ± 0.43	23.0 ± 11.3
Occupation[2]				
Service	14.2 (36)	12.6 ± 3.90	1.11 ± 0.39	19.9 ± 8.7*
Business	45.1 (114)	12.3 ± 3.72	1.15 ± 0.41	20.5 ± 10.1*
Student	9.1 (23)	13.0 ± 3.57	1.20 ± 0.32	24.7 ± 11.9*
Labourer	11.9 (30)	13.0 ± 3.87	1.15 ± 0.39	20.1 ± 9.1*
Others	19.7 (50)	12.9 ± 3.70	1.15 ± 0.36	24.8 ± 11.8*
Age (y)[3]				
< 25	34.8 (88)	13.1 ± 3.52	1.16 ± 0.37	20.3 ± 9.8
25–30	40.3 (102)	12.3 ± 3.77	1.14 ± 0.42	22.2 ± 11.5
> 30	24.9 (63)	12.4 ± 3.92	1.13 ± 0.37	20.9 ± 9.7
Body mass index[4]				
< 18.5	60.8 (154)	12.5 ± 3.69	1.12 ± 0.34	19.9 ± 10.2*
18.5–25.0	36.4 (92)	12.7 ± 3.72	1.18 ± 0.47	23.7 ± 10.2*
> 25.0	2.8 (7)	14.0 ± 4.80	1.24 ± 0.35	31.1 ± 9.7*

* Significant ($P < 0.05$).
[1a]$F(2,250) = 1.04$, $P = 0.356$; [1b]$F(2,250) = 0.47$, $P = 0.625$; [1c]$F(2,250) = 1.34$, $P = 0.264$; [2a]$F(4,248) = 0.408$, $P = 0.802$; [2b]$F(4,248) = 0.222$, $P = 0.926$; [2c]$F(4,248) = 2,459$, $P = 0.046$; [3a]$F(2,250) = 1.404$, $P = 0.247$; [3b]$F(2,250) = 0.483$, $P = 0.889$; [3c]$F(2,250) = 0.341$, $P = 0.711$; [4a]$F(2,250) = 0.586$, $P = 0.557$; [4b]$F(2,250) = 0.664$, $P = 0.515$; [4c]$F(2,250) = 7.059$, $P = 0.001$.
Every sample was analysed twice to have replicate readings.
Compare means: one-way ANOVA (descriptives, ANOVA).

to investigate the relationship between the levels of vitamins E, C and A in the drug addicts and the extent of influence of their drug habit, sexual practice and lifestyle factors on the status of these vitamins.

Results of the present study showed significant lower concentrations of antioxidant vitamins E, C and A in the drug addicts than those in the non-addict cohort controls (Table 1). It indicated that drug addicts were in antioxidant vitamin deficiency. This is because of the illicit drug use (Varela *et al*, 1997a; Thomas *et al*, 1995) and alteration of food habits (Varela *et al*, 1997a, b; Himmelgreen *et al*, 1998; Vasko, 1992). A partial reduction of the vitamin levels may be also due to cigarette smoking (Marangon *et al*, 1998).

There was a negative correlation between drug habit and antioxidant vitamin status. It was shown in this study that higher number of abused drugs and longer period of addiction resulted in lower levels of the vitamins. As the illicit drug use produces nutritional deficiency (Varela *et al*, 1997a), then use of multiple illicit drugs for a longer period of time may result in greater deficiencies of these vitamins. However, illicit drugs may modulate plasma lipid profiles or the antioxidant level, thus the possibility of synergistic or antagonistic effect of individual illicit drugs on specific antioxidants may need further investigation.

Analysis of sexual practice showed that, although the number of sexual partners had a negative influence on the retinol level, the number of sexual partners and/or condom use did not influence the vitamin E or C status. This is because none of the sexual habits involved biochemical or physiological function. However the effect on retinol status by the number of sexual partners is not understood. It was unlikely that drug addicts who were suffering from sexually transmitted diseases (STD) have had a slightly higher concentration of the vitamin E, A and C than those without STD. Although it is well documented that nutritional deficiency is directly associated with infection (Chandra, 1997; Scrimshaw & SanGiovanni, 1997), the reason for this contrary finding is not clear. However, it may be possibly due to under-reporting of STD.

Investigation into the role of socioeconomic factors on the antioxidant vitamins showed that vitamin C and vitamin A status was influenced little by income, and student drug addicts apparently had a high vitamin status as compared with other occupations. It is generally found that well-off people in third world countries usually consume high amounts of micronutrients-rich green leafy vegetables (FAO, 1997). However, as the drug addicts are in a 'high' or 'sick' or euphoric or semi-stuporus state (Vasko, 1992; Lowinson *et al*, 1992), this explanation is not applicable for the addicts. The BMI of the addicts did have a positive linear correlation with the vitamin status, which is well documented. However, only BMI and occupation had a significant effect on the vitamin C status.

This study revealed that drug addicts had antioxidant vitamin deficiencies, and drug habit (number of drugs and period of addiction) and lifestyle factors had a significant influence on the deficiencies of the antioxidant vitamins. As the antioxidant therapy has been reported to enhance immunity (Jeng *et al*, 1996; Meydani *et al*, 1990) and reduce antioxidant deficiency (Kotler, 1998), this study may indicate a need to initiate antioxidant vitamin therapy to drug addicts, who are at high risk of HIV infection (Islam *et al*, 2000; National HIV-AIDS, 1999), and thus by improving immunity and antioxidant defence systems, replication of HIV may be inhibited (Kotler, 1998). Finally it can be said that the provision of proper detoxification and adequate antioxidant nutrient therapy to the drug addicts may enable their rehabilitation into normal life, and may also reduce the risk of HIV infection and transmission.

Acknowledgements—The authors thank the financial support by the Ministry of Science and Technology, the Government of Bangladesh and are also grateful to the Director, Central Drug Addiction Treatment Hospital, Dhaka, Bangladesh for her kind assistance.

References

Allard JP, Aghdassi E, Chau J, Salit I & Walmsley S (1998): Oxidative stress and plasma antioxidant micronutrients in humans with HIV infection. *Am. J. Clin. Nutr.* **67**, 143–147.

Bieri JG, Tolliver TG & Contignant GL (1979): Simultaneous determination of α-tocopherol and retinol in plasma or red cells by HPLC. *Am. J. Clin. Nutr.* **32**, 2143–2149.

Brown KM, Morrice PC & Duthie GG (1997): Erythrocyte, vitamin E and plasma ascorbic acid cone, in relation to erythrocyte peroxidation in smokers and nonsmokers dose response to vitamin E supplementation. *Am. J. Clin. Nutr.* **65**, 496–502.

Califano Jr JA (1998): Substance abuse and addiction—the need to know. *Am. J. Public Health* **88**, 9–11.

Carr DJJ & Serou M (1995): Exogenous and endogenous opioids as biological response modifiers. *Immunopharmacology* **31**, 59–71.

Chandra RK (1997): Nutrition and the immune system: an introduction. *Am. J. Clin. Nutr.* **66**, 460S–463S.

Courssons-Reed ME, Dykstra LA & Lystle DT (1994): Paviovian conditioning of morphine induced alterations of immune status. *Brain Behav. Immune.* **8**, 204–217.

Duggan C, Colin AA, Agil A, Higgins L & Rifai N (1996): Vitamin A status in acute exacerbation of cystic fibrosis. *Am. J. Clin. Nutr.* **64**, 635–639.

FAO (1997): *Human Nutrition in the Developing World*, ed. MC. Latham FAO Food and Nutrition Series no. 29, 277–282. Rome: FAO/United Nations.

Himmelgreen DA, Perez-Escamilla R, Segura-Millan S, Romero-Daza N, Tansescu M & Sin M (1998): A comparison of the nutritional status and food security of drug-using and non-drug-using Hispinic women in Hartford, connecticut. *Am. J. Phys. Anthropol.* **107**, 351–361.

Islam SN, Hossain KJ & Ahsan M (2000): Sexual lifestyle, drug habit and sociodemographic status of the drug addicts in Bangladesh. *Public Health* **114**, 389–392.

Jeng KCG, Yang CS, Siu WY, Lio WJ & Kuo JS (1996): Supplementation with vitamin C and E enhances cytokine production by peripheral blood mononuclear cells in healthy adults. *Am. J. Clin. Nutr.* **64**, 960–965.

Johnson R & Gerstein DR (1998): Initiation of use of alcohol, cigarettes, marijuana, cocaine, and other substances in US birth cohorts since 1919. *Am. J. Public Health* **88**, 27–33.

Kotler D (1998): Antioxidant therapy and HIV infection: 1998. *Am. J. Clin. Nutr.* **67**, 7–9.

Lowinson J, Ruiz J & Millman R (1992): *Substance Abuse: a Comprehensive Textbook.* eds. J Lowinson, J Ruiz & R Millman, pp 657–674. Baltimore, MD: Williams & Wilkins.

Lowry OH, Lopz JA & Bessey OA (1945): Determination of ascorbic acid in small amount of serum. *J. Biol. Chem.* **160**, 609–615.

Lykkesfeldt J, Loft S, Nielsen JB & Paulsen HE (1997): Ascorbic acid and dehydro ascorbic acid as biomarkers of oxidative stress caused by smoking. *Am. J. Clin. Nutr.* **65**, 959–963.

Marangon K, Herbeth B, Lecomte E, Paul-Dauohin A, Grolier P, Chancerelle Y, Artur Y & Siest G (1998): Diet, antioxidant status, and smoking habits in French men. *Am. J. Clin. Nutr.* **67**, 231–239.

Marcos A, Varela P, Toro O, Lopez-Vidriero I, Nova E, Madruga D, Casas J & Morande G (1997): Interaction between nutrition and immunity in anorexia nervosa: a 1-y follow up study. *Am. J. Clin. Nutr.* **66**, 485S–490S.

Meydani SN, Barklund MP, Liu S, Meydani M, Miller RA, Cannon JG, Marrow FD, Rocklin R & Blumberg JB (1990): Vitamin E supplementation enhances cell-mediated immunity in healthy elderly subjects. *Am. J. Clin. Nutr.* **52**, 557–563.

Morabia A, Fabre J, Chee E, Zeger S, Orsat E & Robert A (1989): Diet and opiate addiction: a quantitative assessment of the diet of non-institutionalized opiate addicts. *Br. J. Addict.* **84**, 173–180.
Morshed SM (1996): *Narcotic control bulletin* **8**, 1–70. Department of Narcotic Controls, Dhaka, Bangladesh.
National HIV-AIDS (1999): *Behavior Change Communication Strategic Implementation Plan for Bangladesh, First Draft Document,* National HIV-AID Committee Bangladesh.
Rouveix B (1992): Opiates and immune function: consequence on infectious disease with special reference to AIDS. *Therapie* **47**, 503–512.
Scrimshaw NS & SanGiovanni JP (1997): Synergism of nutrition, infection, and immunity: an overview. *Am. J. Clin. Nutr.* **66**, 464S–477S.
Solis-Pereyra B, Aattouri N & Lemonnier D (1997): Role of food in the stimulation of cytokine production. *Am. J. Clin. Nutr.* **66**, 521S–525S.
Thomas PT, Bhargana HN & House RV (1995): Immunomodulatory effects of in vitro exposure to morphine and its metabolites. *Pharmacology* **50**, 51–62.
UNDCP (1997): Why world drug report? In *World Drug Report, United Nations Drug Control Programme*, 9–14. New York: Oxford University Press.
Varela P, Marcos A, Santacruz I, Ripoll S & Requejo AM (1997a): Human immunodeficiency virus infection and nutritional status in female drug addicts undergoing detoxification: anthropometric and immunologic assessments. *Am. J. Clin. Nutr.* **66**, 504S–508S.
Varela P, Marcos A, Ripoll S, Santacruz I & Requejo AM (1997b): Effects of HIV infection and detoxification time on anthropometric measurements and dietary intake of male drug addicts. *Am. J. Clin. Nutr.* **66**, 509S–514S.
Vasko ME (1992): Drug abuse and dependence. In *Goth's Medical Pharmacology*, eds. WO Clerk, DE Brater, AR Johnson, 13th edn, pp 336–353. St. Louis, MO: Mosby Year Book.