Vitamin A and vitamin E in human blood

3.* Levels in patients in psychiatric hospitals

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Leitner, Moore & Sharman (1960*a*) reported the results of measurements of vitamin A and carotenoids in the blood of 'normal' adult British subjects during the decade 1948–57. A second paper (Leitner *et al.* 1960*b*) dealt with the vitamin E levels in similar subjects, over the period 1952–7. The mean values for equal numbers of each sex were 158 i.u./100 ml serum for vitamin A, 126 μg for carotenoids, and 1·05 mg for tocopherol. For both vitamin A and carotenoids these means were somewhat higher than values previously found for British subjects, but were slightly lower than values reported from the USA. From about 1950 onwards we observed a steady increase in the mean content of vitamin A. This rise was believed to be due to dietary changes after the relaxation of rationing. It was independent of the change in the magnitude of the international unit of vitamin A, in relation to the antimony trichloride reaction, which occurred in 1950, and to which we drew attention. Our mean for tocopherol was in the centre of the range of values reported by workers in various parts of the world. Comparison of our results with those of other workers, therefore, encouraged us in the view that they might be regarded as typical of the general population of Britain, or at least of the London area.

The inhabitants of psychiatric hospitals make up a high proportion of the hospital population of this country. In common with other hospital patients their choice of food must be less than in the general population, and must to a large extent be governed by the decisions of the catering officers. It seemed to us both interesting and important, therefore, to collect specimens of blood from patients in a psychiatric hospital, and to compare the mean values for vitamin A, carotenoids and vitamin E with those prevailing, at the same time, in the general population. During 1951–4, therefore, blood was taken from patients in a large psychiatric hospital. A preliminary account of the very low levels of carotenoids, and somewhat low levels of vitamin A, found in these subjects has already been given (Leitner *et al.* 1952). Another short communication (Leitner *et al.* 1954) described dietary experiments, in which the carotenoid and vitamin A levels were raised by increasing the ration of vegetables.

In the present paper these early investigations on mental patients, and also studies

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on vitamin E, are described more fully. More recent work, commencing in 1962, is also reported. Its purpose has been (1) to inquire whether low levels of carotenoids and vitamin A still pertain in psychiatric hospitals, (2) to confirm that the levels of carotenoids and vitamin A found by Leitner *et al.* (1960*a*) can be regarded as reasonably typical of the general population in south-eastern England. These recent results have emphasized the regularity in normal subjects of the higher mean for vitamin A in men than in women, and the general absence of this difference in mental patients. A preliminary report of part of our recent work has been given (Sharman, 1963).

EXPERIMENTAL AND RESULTS

Subjects

Mental patients. Specimens of blood were first obtained, over the period March 1951–December 1952, from established patients of Claybury Hospital, a large psychiatric hospital in the London area. Most of these patients had been in the hospital for at least 2 years. Chronic schizophrenia accounted for more than 70% of the diagnoses; the others were subdivided between affective, obsessional or hysterical disorders, paranoid state, senile psychosis and mental deficiency. Most of these states overlapped, either with each other or with schizophrenia.

The question soon arose, however, whether the low levels of vitamin A and carotenoids observed in these patients were associated with their mental illness, or with residence in the hospital. Between April and December 1952, therefore, blood was also collected from new entrants to the hospital, usually within 3 days of their admission. Vitamin A and carotenoid levels were somewhat higher than in the established patients, but were lower than in normal subjects over the same period.

Unfortunately no information was available about the dietary histories of the patients before their entry into hospital. Details about the sources of vitamin A and carotene in the hospital diets, however, were obtained from the catering officers. Adequate amounts of these nutrients were supplied. The inferiority of the blood levels in established as compared with new patients, therefore, could not be explained by a poorly planned diet. It appeared either that the absorption of vitamin A and carotenoids by mental patients became increasingly inefficient with time, or that much of the food supplied in hospital was left uneaten. In order to find out whether the levels in the blood of such patients remain low, even when liberal amounts of carotene are eaten under controlled conditions, experiments were carried out between November 1953 and January 1954. For this purpose large quantities of carotene were given, either in the form of an oily solution of crystalline carotene, or as extra allowances of vegetables rich in carotene. In these experiments specimens of blood were collected before and after the dietary treatment, or at intervals if the treatment was prolonged.

Control subjects. The survey of vitamin A and carotenoids reported by Leitner *et al.* (1960*a*) was carried out for the express purpose of obtaining information on the levels in the blood typical of normal subjects in this country. Blood was collected, by venepuncture, from volunteers who came to one of us (Z.A.L.) for medical examination. Some of them were young men in good health, who were examined for purposes

of life insurance, or for confirming their fitness for employment abroad. Most of the subjects, however, had some complaint, and were examined with a view to diagnosis and treatment. To this extent, therefore, their health was not completely normal. As a compensating advantage, however, it was possible, as a result of the examination, to exclude any subjects who had any systemic disease which made them unsuitable to serve as controls. Confidence that our subjects represented a fair section of the community was increased by the results obtained for the healthy young men included among our subjects. Their mean values for both vitamin A and carotenoids were virtually identical, after due allowance had been made for age, with the mean values found for all the control men throughout the investigation.

There is little or no evidence, as far as we are aware, that the levels of vitamin A and carotenoids in Britain depend upon income or social class. In order to forestall the criticism that the subjects of our survey, as patients of one of us (Z.A.L.), were not typical of the general population, however, we undertook in 1962 a further small survey on specimens of normal blood obtained from the East Anglian Blood Transfusion Service. During the same period we brought our observations at Claybury Hospital up to date by the collection of further specimens. Specimens were also received about the same time from established mental patients and new admissions at Fulbourn Hospital, Cambridge.

Analytical methods

The methods of estimating vitamin A, total carotenoids and vitamin E were as previously described (Leitner *et al.* 1960*a*, *b*). For a few experiments, in which total carotenoids were separated into carotene and xanthophyll fractions, a small absorption column of alumina was used. The extract of total carotenoids in light petroleum was first passed on to the column. Elution with petroleum containing 2% (v/v) of acetone gave a 'carotene' fraction, and by increasing the acetone to 20% (v/v) a 'xanthophyll' fraction was obtained. Both carotene and xanthophyll were measured in μg by reference to a standard curve based on carotene. We thought it unnecessary, for the purpose of roughly estimating the proportions of the two types of pigments, to make allowances for differences between the molecular weights and extinction coefficients of carotene and xanthophyll.

Period 1951–4

Vitamin A and carotenoids in blood. Throughout this investigation, as in our previous work, our results for groups of subjects invariably covered very wide ranges. Mean values for established patients in the psychiatric hospital, for new entrants, and for normal subjects examined over the same periods as controls, are given in Table 1. Findings on the statistical significance of the differences between the means for the various groups are included.

For established patients carotenoid and vitamin A levels were both much lower than in the controls ($P < 0{\cdot}001$ for each in both sexes). For men and women combined vitamin A averaged 121 i.u./100 ml serum for the patients as against 151 i.u. for the controls. For carotenoids the disparity was even greater, with means for both sexes combined of 51 μg/100 ml at Claybury as against 133 μg for the controls.

In new entrants into the hospital both vitamin A and carotenoids were again lower than in the control subjects, although somewhat higher levels were found than in the established patients. For carotenoids the differences between new entrants and controls were significant for both sexes ($P < 0{\cdot}001$) but for vitamin A the difference was only significant for men ($0{\cdot}001 < P < 0{\cdot}01$). For men and women combined vitamin A averaged 134 i.u./100 ml in the new entrants against 152 i.u. in the controls; carotenoids averaged 72 and 136 μg/100 ml respectively.

Table 1. *Mean values for vitamin A and total carotenoids in the blood serum of established mental patients and new entrants at Claybury Hospital, as compared with values for control subjects over the same periods during* 1951–2

Subjects	Period	Sex	No.	Mean age (years)	Carotenoids (μg/100 ml)	Vitamin A (i.u./100 ml)
Claybury, established patients	iii. 51–xii. 52	♂	115	47	46	118
		♀	115	63	56	123
		♂ + ♀			51	121
Controls (A)	iii. 51–xii. 52	♂	217	46	122	164
		♀	156	44	143	137
		♂ + ♀			133	151
Claybury, new entrants	iv.–xii. 52	♂	48	45	72	137*
		♀	34	44	71	130
		♂ + ♀			72	134
Controls (B)	iv.–xii. 52	♂	73	47	128	164
		♀	51	44	144	140
		♂ + ♀			136	152

Significance of the results

		P	
Claybury, established patients *v.* controls (A)	♂	$< 0{\cdot}001$	$< 0{\cdot}001$
	♀	$< 0{\cdot}001$	$0{\cdot}02 < P < 0{\cdot}05$
Claybury, new entrants *v.* controls (B)	♂	$< 0{\cdot}001$	$0{\cdot}001 < P < 0{\cdot}01$
	♀	$< 0{\cdot}001$	$0{\cdot}3 < P < 0{\cdot}4$
Claybury, established patients *v.* new entrants	♂	$< 0{\cdot}001$	$0{\cdot}05 < P < 0{\cdot}1$
	♀	$< 0{\cdot}001$	$0{\cdot}4 < P < 0{\cdot}5$

* For only forty-six patients.

Statistical examination of the relatively small differences found between the levels in established patients and new entrants indicated that the differences in carotenoids were highly significant for both sexes ($P < 0{\cdot}001$). For vitamin A higher levels were found for established patients than for new entrants in each sex, but the differences were not statistically significant. As shown in Table 1 the results for some of our established patients were obtained before the collection of specimens from new entrants was begun. Unlike those previously mentioned, therefore, these comparisons did not refer to exactly the same periods of time.

Routine dietary supplies of vitamin A and carotene. Questions to the catering officers about the diet provided for the patients, and the application of tables compiled by McCance & Widdowson (1946), suggested that the diet was adequate in calories and

protein. Green vegetables were supplied as cabbage, cauliflower, brussels sprouts, spinach, lettuce or other greens. Two issues, each of about 170 g/head, were made weekly in winter, and three or four issues weekly during summer. Root vegetables, other than potatoes, were supplied as swedes, carrots, turnips, parsnips or onions. Two issues weekly of 170 g were allowed for cooking separately, and two further issues of 112–140 g for inclusion in soups. Stewed fruit, 140 g, was supplied once weekly. The allowance of milk was about 425 ml daily, and of butter or margarine 24–28 g daily. From these particulars it appears that the daily supply of preformed vitamin A was 900–1600 i.u., according to the season of the year, and the amount of butter or margarine supplied. An assessment of the carotene supply must be unreliable without information, which was not readily available, about the relative consumptions of the different vegetables. On the assumption that equal amounts of each vegetable were eaten, however, the intake of carotene was about 5000 i.u. daily throughout the year.

The calculated combined carotene and vitamin A supply of 5900–6600 i.u. appears therefore to have satisfied the target of 5000 i.u. considered by the British Medical Association (1950) as being adequate, when supplied as one-third of preformed vitamin A and two-thirds of carotene.

Dosing with carotene. Since the above inquiry indicated that the established patients were allocated adequate amounts of vitamin A and carotene, at least according to standards recommended for normal subjects, it seemed important to find out whether the blood levels would still remain low after the carotene intake had been considerably increased. In preliminary tests of the ability of the patients to absorb carotene, when the intake was increased, four men and one woman were dosed over periods of 11 or 16 days with a solution of β-carotene in arachis oil, 1 mg/ml. A daily dose of 8 ml supplied about 7000 μg of the provitamin daily. Another man received chocolate, containing dried carrot equivalent to a daily dose of about 8000 μg of carotene for 6 days. Specimens of blood were usually collected for analysis about 6 h after the last dose.

The results are given in Table 2. In every instance the level of total carotenoids was substantially increased after dosing. In four of the six subjects that of vitamin A was also increased.

Supplementary vegetables. The preceding experiments indicated that the patients could absorb carotene when it was supplied in massive doses in an easily assimilable form. Further experiments were undertaken to find whether the carotenoid levels could also be raised by increasing the intake of vegetables rich in carotene. For this purpose carrots and spinach were chosen. Allowances of 170 g/head daily of either vegetable were included in the diets of all those members of two wards, one for men and one for women, who could be persuaded to accept them. Measurements of carotene were not made on the batches of vegetables supplied, but from tables (Moore, 1957) the carrots were assumed to contain 12000 μg/100 g, and the spinach 8000 μg. At the beginning of the experiment the two vegetables were supplied on alternate days, which gave a mean daily intake of 17000 μg carotene. Shortage of spinach, however, later necessitated the eating of carrots on most days. Specimens of blood were collected before the supplements were given and on three subsequent occasions.

Table 2. *Levels of carotenoids and vitamin A in the blood serum of mental patients 6 h after the last dose of β-carotene* (1953–4)

Patient	Sex	Age (years)	Date	Daily dose of carotene	Carotenoids (μg/100 ml)	Vitamin A (i.u./100 ml)
J.W.	♀	25	20. vii. 53	None	41	101
			31. vii. 53	None	42	88
			11. viii. 53	7000 μg in oil for 11 days	180	90
S.W.	♂	33	20. vii. 53	None	46	197
			31. vii. 53	None	41	145
			11. viii. 53	7000 μg in oil for 11 days	190	235
T.M.C.	♂	48	20. vii. 53	None	17	118
			31. vii. 53	None	22	139
			11. viii. 53	7000 μg in oil for 11 days	85	144
G.B.	♂	58	23. ii. 54	None	27	96
			10. iii. 54	7000 μg in oil for 16 days	78	147
E.S.	♂	41	2. ii. 54	None	43	72
			23. ii. 54	None	31	151
			10. iii. 54	7000 μg in oil for 16 days	116	252
W.B.	♂	58	25. ix. 53	None	28	109
			30. x. 53	8000 μg as dried carrot for 6 days	104	238

Table 3. *Effect of increasing the vegetable ration on carotenoids (μg/100 ml) and vitamin A (i.u./100 ml) in the blood serum of mental patients* (1953–4)

No. in group	Sex	Mean age (years)	5/6. x. 53		28. x. 53		25/26. xi. 53		8. i. 64	
			C*	A*	C	A	C	A	C	A
With extra vegetables started on 12. x. 53										
28	♂	39	29	119	77	160	107	167	86	156
22	♀	51	44	131	94	151	120	143	103	155
No extra vegetables										
14	♂	46	—	—	—	—	28	122	30	132
14	♀	50	—	—	—	—	53	114	49	150

* C, carotenoids; A, vitamin A.

Table 3 gives the mean levels for vitamin A and carotenoids in groups of twenty-eight men and twenty-two women, from all of whom complete series of blood specimens were collected. In both groups carotenoid concentrations were more than doubled as a result of the supplements. Both before and while the extra vegetables were given higher levels for carotenoids were found in women than in men. The extra vegetables also caused increases in vitamin A concentrations, which were larger in men than in women. As a result, the mean value for vitamin A in men, which before the supplements were given had been lower than in women, was raised so that the gap between the sexes was closed. On one occasion (25 November 1953) a superiority of the mean value for men over that for women, of about the order to be expected in normal subjects, was observed.

Complete series of estimations were not made for control groups. Blood was collected, however, from fourteen men and fourteen women, not given extra vegetables,

on two of the later occasions when specimens were also being taken from the groups given supplements. The mean levels of carotenoids differed little from those previously found in the hospital. The slight rise in the mean vitamin A levels between November and January may possibly have been due to dietary improvements during the Christmas season.

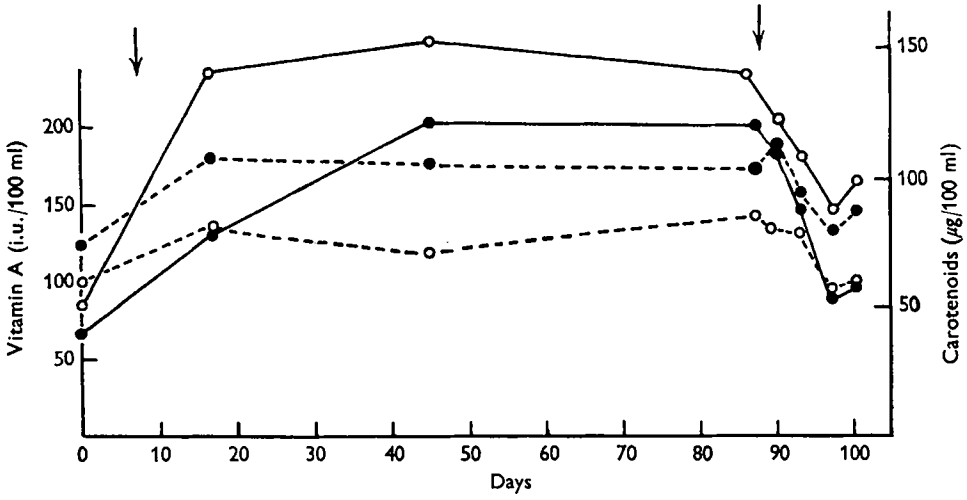

Fig. 1. Mean values for carotenoids and vitamin A in the blood of groups of five men and three women, before, during and after the allowance of extra vegetables, mainly carrots. o—o, women, carotenoids; o---o, women, vitamin A; ●—●, men, carotenoids; ●---●, men, vitamin A; the arrows show the period during which extra vegetables were given.

From five men and three women complete series of blood specimens were collected not only before and during the giving of extra vegetables, but also on four occasions after the vegetable supplements had been withdrawn. Fig. 1 shows the mean levels of carotenoids and vitamin A for each sex. The contents of carotenoids, and to a lesser extent of vitamin A, increased during supplementation. After the vegetables had been withdrawn the levels of both carotenoids and vitamin A declined towards those found before the supplements were given. In the women the increases in carotenoids during supplementation were greater than in men, but this relationship was reversed for vitamin A.

Fractionation of blood carotenoids. Specimens of blood were taken from ten patients, all males, for whom low values for total carotenoids had previously been found. Carotene and xanthophyll fractions were measured separately. The results (Table 4) indicated that in these patients, who had total carotenoid levels of 24–51 μg/100 ml, only a small fraction of the total carotenoids was carotene (3–39%, mean 25%). Similar fractionations were made on blood from two men who had been dosed with carotene, and from three women with moderately high carotenoid levels. In these five subjects, having total carotenoid levels of 67–144 μg, the percentage of carotene was 46–72, mean 61, thus being much higher than in the patients with low total carotenoids.

While these experiments were in progress blood was available from a patient with carotenaemia at Addenbrooke's Hospital, Cambridge. Out of total carotenoids of 568 μg/100 ml the carotene fraction was 83 %.

Table 4. *Separation into carotene and xanthophyll fractions of total carotenoids in the blood serum of mental patients* (1953–4) *and in the blood of a patient with carotenaemia*

Subject	Sex	Age (years)	Carotene (μg/100 ml serum)	Xanthophyll (μg/100 ml serum)	Total carotenoids (μg/100 ml serum)	Carotene (%)
			Low total carotenoids			
E.K.	♂	59	7	17	24	29
G.B.	♂	58	7	20	27	26
? S.	♂	?	7	29	36	19
F.McF.	♂	?	14	22	36	39
E.S.	♂	41	10	27	37	27
G.W.	♂	56	1	38	39	3
T.C.	♂	59	16	25	41	39
W.A.	♂	33	10	32	42	24
R.S.	♂	?	13	32	45	29
S.B.	♂	36	9	42	51	18
					Mean	25
			Higher total carotenoids			
M.D.	♀	56	31	36	67	46
O.M.	♀	25	52	44	96	54
G.B.	♀	44	91	53	144	63
G.B.	♂	58	55	25	80	69*
E.S.	♂	41	92	25	127	72*
					Mean	61
			Carotenaemia			
O.S.	♀	30	470	98	568	83†

* Dosed with carotene.
† From Addenbrooke's Hospital, Cambridge.

Vitamin E in blood. Results for measurements on established patients and new entrants at Claybury and on control subjects are given in Table 5. Results obtained before July 1951 have been excluded, on the grounds that our method of measurement had not been sufficiently standardized. As already stated (Leitner *et al.* 1960*b*), some of our results reported in a preliminary communication (Leitner *et al.* 1952) were open to this criticism. It will be seen that there were only trivial differences between the means for the various groups.

Period 1962–3

Vitamin A and carotenoids in blood. In Table 6 results are given for further specimens of blood collected from mental patients at Claybury and Fulbourn Hospitals. For comparison, values are included for normal blood donors, who were residents of Ipswich, Suffolk; Isleham, Cambs; and Royston, Herts.

The results indicate that low levels of blood carotenoids still pertain among patients at Claybury Hospital, as found in 1951–2. Again the levels for newly admitted patients were only slightly higher than for established patients. Low values for carotenoids

were found in both established and newly admitted patients at Fulbourn Hospital. Less evidence was obtained of low values for vitamin A in mental patients. The only decidedly low value, in fact, was for the male established patients at Claybury.

Table 5. *Mean values for vitamin E in the blood serum of established mental patients and new entrants at Claybury Hospital, as compared with values for control subjects over the same periods* (1951–2)

Subjects	Period	Sex	No.	Mean age (years)	Vitamin E (mg/100 ml)
Claybury, established patients	vii. 51–xii. 52	♂	90	46	1·00
		♀	79	60	1·11
		♂+♀			1·06
Controls, private patients	vii. 51–xii. 52	♂	57	47	1·08
		♀	54	45	1·13
		♂+♀			1·11
Claybury, new entrants	iv. 52–xii. 52	♂	39	46	1·11
		♀	27	46	1·14
		♂+♀			1·13
Controls, private patients	iv. 52–xii. 52	♂	35	48	1·04
		♀	35	47	1·14
		♂+♀			1·09

Table 6. *Mean values for vitamin A and total carotenoids in the blood serum of established mental patients and new entrants at Claybury and Fulbourn Hospitals, as compared with values for control subjects* (1962–3)

Subjects	Period	Sex	No.	Mean age (years)	Carotenoids (μg/100 ml)	Vitamin A (i.u./100 ml)
Claybury, established patients	v. 62–xi. 62	♂	54	52	65	114
		♀	56	51	67	146
		♂+♀			66	130
Claybury, new entrants	v. 62–v. 63	♂	51	42	79	164
		♀	52	41	90	165
		♂+♀			85	165
Fulbourn, established patients	xi. 62–iv. 63	♂	25	58	59	138
		♀	25	46	88	133
		♂+♀			74	136
Fulbourn, new entrants	xi. 62–iv. 63	♂	25	47	67	168
		♀	29	46	77	146
		♂+♀			72	157
Controls*	v. 62	♂	23	43	120	159
		♀	23	40	131	121
		♂+♀			126	140

* Blood samples obtained from the East Anglian Blood Transfusion Service.

DISCUSSION

Low carotenoids and vitamin A in the blood of mental patients. Throughout this investigation the blood of mental patients gave much lower mean values for carotenoids, and usually lower values for vitamin A, than were found in control subjects.

Our mental patients were typified by collections over two periods at one hospital and over one period at another; our controls were two differently selected groups of normal subjects, resident in south-eastern England. For vitamin E there was no significant difference between the mental patients and the controls. Somewhat lower values were always found, for both carotenoids and vitamin A, in patients who had been resident in hospital for 2 years than in newly admitted patients. In certain groups of newly admitted patients the vitamin A levels were normal, but the carotenoid levels were always low.

Between the two stages of our work, begun in 1951 and in 1962, special attention has been given at Claybury Hospital to the provision of liberal supplies of vegetables. As in most other psychiatric hospitals, moreover, the use of tranquillizing drugs has improved the appetites of the patients, to such an extent that obesity has become a common problem. At the most these changes seemed to have caused only a slight increase in blood levels of carotenoids and vitamin A towards the normal range.

The reduction in blood carotene level, as opposed to that of total carotenoids, in mental patients must have been even greater than the values for total carotenoids would, at first sight, suggest. Thus total carotenoids for established patients at Claybury, 1951–2, for both sexes combined were 51 μg/100 ml, as compared with 133 μg for the controls (Table 1). After a deduction has been made for non-carotene pigments, however, according to the values given in Table 4, the value for carotene works out at only 13 μg for the mental patients as compared with 81 μg for the controls.

Absence in mental patients of the usual sex difference in vitamin A levels. In the prolonged investigation reported by Leitner *et al.* (1960*a*) the mean values for blood vitamin A recorded for groups of men were consistently some 20% higher than in women, as originally reported by Kimble (1938–9). For carotenoids a smaller difference was found, in the opposite direction. These sex differences have been confirmed in the further groups of normal subjects examined in the work now described.

In contrast, four of our six groups of mental patients gave means for blood vitamin A which were virtually the same for each sex. In a fifth group (Fulbourn Hospital 1962–3, new entrants) the normal higher mean in men was observed, but in the remaining group (Claybury Hospital, 1962–3, established patients) the mean for women was greater than for men.

Before we conclude that mental patients do not show the usual sex difference in mean vitamin A levels, however, the influence of disparities in the mean ages in the various groups must be taken into account. The widest difference in ages occurred between the groups of male and female established patients at Claybury, during 1951–2 (Table 1). In this comparison the mean age of the men was 47, and of the women 63, with mean vitamin A levels of 118 and 123 i.u./100 ml respectively. This unfortunate divergence in ages arose from the practice, at the hospital, of grouping together in wards patients of the same sex and similar ages. Convenience also indicated that specimens of blood should be collected from a limited number of wards, rather than from all the wards in the extensive hospital. Elderly women, moreover, gave blood samples more willingly than younger women.

In Table 7, therefore, the groups in question have been subdivided according to age. The high mean age for women was obviously due to the inclusion of a high proportion over 69 years old. In both sexes the mean vitamin A failed to show the steady rise up to the age of 60, which was earlier found in control subjects (Leitner *et al.* 1960*a*). This failure, however, may well have been due to the small numbers of patients in each age group. The largest age group, of forty-two women aged over 69, gave a mean of 112 i.u., which was below the mean of 121 i.u. for all the women. This result must raise doubts about the general applicability of our earlier finding (Leitner *et al.* 1960*a*) of a mean vitamin A level for women of this age group which was decidedly above the means for the younger age groups.

Table 7. *Mean values for vitamin A and total carotenoids in the blood serum of established mental patients at Claybury Hospital* (1951–2) *subdivided according to sex and age*

	Men			Women		
Age (years)	No. of patients	Carotenoids (μg/100 ml)	Vitamin A (i.u./100 ml)	No. of patients	Carotenoids (μg/100 ml)	Vitamin A (i.u./100 ml)
Under 30	14	48	125	4	47	134
30–39	23	44	127	8	46	115
40–49	30	45	125	10	44	126
50–59	22	47	104	15	52	143
60–69	19	52	109	36	52	127
Over 69	6	37	91	42	68	112

If we omit from Table 7 results for both men and women over 69 years old, the means for vitamin A in the remaining patients are 119 i.u. for men and 129 i.u. for women. In 1962–3, when precautions were taken that the mean ages for the groups of men and women should be substantially the same, the mean vitamin A for men (mean age 52) was 114 i.u. and for women (mean age 51) it was 146 i.u. In these established mental patients, therefore, the normal tendency for male superiority in the blood vitamin A was replaced by a tendency in the opposite direction. As a reflection of this tendency the mean vitamin A levels in male mental patients, throughout our work, were decidedly below those in the control subjects. The reductions below the control means in female mental patients were trivial, and inconsistent.

Significance of low levels of carotenoids and vitamin A in the blood of mental patients. The values for vitamin A, in all but a small minority of mental patients, greatly exceeded the levels below which faulty dark adaptation is to be expected (Hume & Krebs, 1949). The low mean levels of vitamin A in these patients, therefore, did not imply any widespread deficiency of vitamin A, as assessed on accepted functional standards. Moreover, there is little or no evidence that the presence of carotenoids in the blood, in addition to an adequate level of vitamin A, serves any immediate biochemical purpose. Carotenoid levels (Hume & Krebs, 1949) are greatly influenced by the recent dietary history, and fall rapidly when carotenoids are removed from the diet. Further evidence of this rapid fall after a reduction in the dietary carotenoids has been obtained in our work (Fig. 1). We have no reason to believe, therefore, that the low values for either carotenoids or vitamin A found in mental patients are in

themselves disadvantageous, at least according to present conceptions of the mode of action of vitamin A.

Information about nutritional standards in mental patients, however, is still so scanty that no apology seems needed for the smallness of any addition to our knowledge. Our results have shown not only that mean values for carotenoids, and usually also for vitamin A, are low in mental patients, but that values approaching those for normal subjects may be induced by ensuring that large amounts of carotene are consumed, either in oily solution or in the form of vegetables. Limited evidence suggests that an increased carotene intake also restores the normal superiority of the male level of blood vitamin A over the female.

A likely hypothesis is that the appetite of mental patients for vegetables is poor, and that these are not eaten in amounts typical of normal subjects unless special measures are taken. In the normal subject the higher mean value for vitamin A in men than in women, and the lower one for carotenoids, may imply a somewhat more efficient conversion of carotene into vitamin A in the male than in the female sex. This difference in converting power might in turn be related to the slightly higher basal metabolic rate in men than in women. When the dietary intake of carotene is low the male superiority in converting power will not be given full scope to show its effect, and the usual 20% excess of male over female vitamin A values will diminish or disappear. Comparisons of the blood vitamin A levels of healthy men and women in populations subsisting on diets low in carotene would be of great interest.

An alternative hypothesis, perhaps less probable, is that in mental patients the efficiency of the absorption and conversion of carotene is reduced. Increased quantities of carotene must therefore be given, above the requirements of normal subjects, in order to sustain levels of carotenoids and vitamin A equal to those in normal subjects.

If the first of the above alternatives is accepted it is reasonable to surmise that diets which give rise to low levels of blood carotene will also provide low levels of certain other nutrients. Thus green vegetables, besides supplying carotene, are good sources of calcium, iron and vitamin C. Evidence that the vitamin C intake of the Claybury patients was sometimes defective has been reported elsewhere (Leitner & Church, 1956).

SUMMARY

1. Psychiatric patients, who had resided for at least 2 years in hospital, had much lower mean levels of blood total carotenoids than were found in control subjects. In newly admitted patients carotenoid values were usually slightly higher than in established patients, but were again much lower than in control subjects.

2. Chromatographic analyses indicated that when total carotenoids were low the proportion of carotene to other carotenoids was small. The disparity in blood carotene between mental patients and control subjects must therefore have been even greater than the values for total carotenoids suggested.

3. The blood vitamin A level was also low in some groups of mental patients, but not in others. Evidence was again obtained of lower values in established than in newly admitted patients.

4. In comparisons between groups of male and female control subjects the usual sex difference in blood vitamin A, with the mean for men some 20% higher than for women, was consistently confirmed. In five out of six comparisons between groups of male and female mental patients this difference was absent or reversed.

5. Possibly the absence of the sex difference in blood vitamin A level in mental patients was due to the low carotene levels, which did not allow scope for the display of sexual differences in the efficiency of conversion of the vitamin.

6. Notwithstanding the low levels found in the hospital patients for vitamin A and carotenoids, inquiries about the foodstuffs normally issued indicated that they contained adequate amounts of these nutrients, as demanded by official estimates of the requirements of healthy adults.

7. Dosing of the hospital patients with carotene, or the addition to their diet of liberal extra allowances of vegetables, usually carrots, caused the levels of carotenoids and vitamin A to approach those found in control subjects. After the withdrawal of the extra allowances of vegetables carotenoids and vitamin A soon returned towards their original low levels.

8. Measurement of vitamin E indicated virtually identical mean values in hospital patients, either newly entered or established, and in control subjects.

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