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Nutrition in the Kuru Region

II. A Nutritional Evaluation of Traditional Fore Diet in Moke Village in 1957

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In this paper we present a nutritional evaluation of Fore diet carried out in Moke village of the North Fore in 1957. This survey was performed before significant change in gardening and dietary practices had occurred in the village, which was located adjacent to the newly established government station at the Okapa Patrol Post, and at a time when many women of Moke were dying of kuru (6–8). In an earlier study we surveyed the pattern of kuru death in Moke village (6). In the past ten years, however, there has been a marked change in the pattern of kuru occurrence (1). Kuru has continued to occur in Moke village, even developing in a woman who was one of our studied subjects in the household we had picked for intensive dietary evaluation in 1957. Since marked alteration of Fore gardening practices, food handling and diet has been occurring over the past decade (1, 20), these early data on Fore nutrition are no longer reproducible; new nutritional surveys in the region will encounter markedly altered dietary practices. Few nutritional surveys have been conducted in the New Guinea Highlands at a stage of low acculturation, such as that which prevailed at the time of the study (11, 12). In the preceding paper we have described the usual methods of food preparation used by the Fore (20). The descriptions apply well to Moke village at the time of this survey.

During the year 1957, along with the initial investigation of kuru, an intensive search was conducted for unique items in the Fore diet which might account for the disease on a toxic basis. The possibility that toxic or deficiency factors within the nutritional pattern of the Fore might precipitate or underlie the disease even if they were not the direct cause was entertained, and continuous surveillance of Fore diet and exposure to minerals, plants and animals in their environment was maintained. As the list of foods, medicines, body paints, and smokes used by the Fore was extended, every item discovered was checked for its use by age, sex, and location and, particularly, for its use outside of the kuru region and by kuru victims themselves. No plant, animal or mineral used in diet, medicinally or for cosmetic or smoking purposes was unique to them; all were similarly used by adjacent people who did not suffer from kuru. Only in the cannibalistic consumption of their dead relatives by close kinsmen did the Fore differ from the Moraei Kukukuku people to the east, but other people to the north and west of the Fore likewise practiced this ritual cannibalism as a rite of mourning, without also suffering from kuru.

Nutritional Status of the Fore

Medical study of the Fore people has indicated little clinical malnutrition, except in infants and toddlers subjected to unusual neglect. In fact, malignant

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malnutrition or kwashiorkor in recently weaned infants and toddlers, such as is frequently found in the Chimbu region of the Central Highlands of New Guinea (21), or liver disease of any sort in children, is relatively infrequent as compared to other Highland areas. It is not uncommon for two infants born of the same mother within twelve months or less of one another to be both suckled at the same time with no apparent ill-effect on either child. There are occasional exceptions, however, with malnutrition in infants whose mothers have become ill or who have died of kuru or other causes. Other than such cases, clinical protein and vitamin deficiency states in older children or adults have rarely been seen during a decade of medical study of the area, except in patients chronically ill from some other primary ailment.

During 1957 while our team furnished all medical care and built the only hospital facilities available to the 30,000 natives in the Okapa Administrative District, we saw no more malnutrition than is found in the area today. None of the infant, child, or adult patients who were admitted to the hospital with acute illnesses during the first year of kuru study (1957), and none of the early kuru patients showed signs of dietary deficiency [3]. This is remarkable when compared with the people of many other Highland regions who also have a sweet potato staple diet and who live in a similar environment, but suffer from moderate malnutrition, especially among toddler-aged children, as in Chimbu. However, it was soon apparent that the Fore diet was unusually rich and varied for that of a New Guinea Highland group. Foods in wide variety are plentiful, and there are practically no periods of famine or food shortage, since gardens are large and always productive. Pitpit and sugar cane (both *Saccharum* spp.) and green leafy vegetables largely comprised of *ebia* (*Ruellia* spp.: Family: *Acanthaceae*) form the main supplement to the sweet potato staple, as they do in most other Highland areas; but they are eaten in much larger amounts than has been noted elsewhere (12–14).

Protein sources from meat are unusually plentiful by New Guinea standards. The Fore are wealthy in pigs, which they eat not only on ceremonial occasions, such as weddings, funerals, initiation ceremonies, bride and death payments, etc., but also, when pigs are plentiful, just because they are hungry for pig. Most of the people eat pig for several meals at least once a month, and often more frequently. When pigs are being butchered, the children may take small bits of the viscera to cook and eat themselves while waiting for the meal to be prepared. Among adults there is no special favoritism in food distribution. When pig is cooked there is usually ample for all and enough left over for a second or third meal.

Most of the hamlets are in close proximity to bush land, and, therefore, game such as rodents, small birds, cassowaries, possum, and the tree-climbing kangaroo are often caught. Women and children frequently catch rodents, spiders, larvae, and adult insects, or receive gifts of small game or bird's eggs.

The methods of cooking are particularly conservative of nutriment. Foods are only occasionally boiled in areas where the people have obtained discarded tins and a few pots. This was rare in 1957. The only kitchen utensils

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[3] In later years a few children between the ages of four and nine have been seen with generalized edema resembling the nephrotic syndrome. Some such children have had proteinuria; others have not, and have instead been found with a meningoencephalitis with a mononuclear cell pleocytosis in the cerebrospinal fluid. Strangely, however, serum protein electrophoretic patterns of these latter patients have not shown a more severe albumin deficiency than those of other Fore children. All have recovered quickly on hospital diet (2).

present in most homes are knives, carved wooden plates, and bamboo tubes in which foods are cooked, usually without the addition of water. For the evening meal greens, pitpit and sometimes taro, sweet potato, banana, beans, meat or fungus are inserted into the bamboo tube, the open end blocked with a bunch of leaves, and the bamboo tube laid on top of the hot coals of the fire. The bamboo tube is frequently turned to prevent its catching fire, and when cooking is complete, the contents are usually tipped onto banana leaves or a wooden dish and the food eaten with their fingers by all members of the family. Sweet potato and other tuberous vegetables are usually cooked in the ashes of the fire. Once a week, at least, food will be steam-cooked in a large hole in the ground over hot stones (North Fore: *taina;* South Fore: *taraina;* Pidgin English: mumu). Details of such cooking are described in the previous paper (20).

Usually, when a mumu is prepared, the family, together with friends and relatives will gather from the various hamlets of the village for the occasion, which tends to be a social one; occasionally, when a group of men and women are working in the garden together a mumu will be cooked there. Usually, all the food is not eaten immediately after such cooking; when everyone has had his fill the remainder is taken to the houses to be eaten later, or it is given to friends who will reciprocate another time.

Men, women and children usually eat together and of the same food, except for insects, spiders, small lizards and frogs which are eaten mainly by the women and children. If an older child is minding a younger child while the mother is in the garden, and the younger child becomes hungry, the older one may catch these arthropods and cold-blooded vertebrates and cook them for the younger child. Similarly, a mother will often catch insects in the garden and cook them and give them to her children there. Most insects are not eaten at regular meals; however, the witchetty grub (larvae of the Longicorn beetle, family: *Cerambycidae*) are a delicacy and are eaten by all at regular meals and at other times.

Usually only two meals a day are eaten: in the morning and in the evening. Frequent snacks of sugar cane, raw pitpit, raw heart of edible bamboo or palm, greens or insects, are eaten during the day; during the night sweet potato may be cooked over the home fires and eaten. Frequently, a mother will cook extra sweet potato at the evening meal, so that some will be left for the younger children if they should wake up hungry at night, but these same children will be left all day, from morning to evening meal, without food.

Methods

Daily Survey of Diet by Household

One of the authors (L. H. R.) had lived in the village in close association with the people for several months before the quantitative dietary survey was conducted, and therefore had their confidence and a good knowledge of their eating habits when weighing food intake was begun.

Three households were chosen for the survey. Those selected were close to the house occupied by the investigator in Wasinamunti, one of the several hamlets of Moke village, and each contained a number of members, including children who were likely to consume most of their meals at home. Unfortunately, most of the younger men in the hamlet had been recently jailed for fighting; consequently, no young married men were included in this survey. Because the husbands were away, the wives chose to live and eat together rather than separately, as would have been more likely if their husbands had been at home.

Household No. 1 was occupied by the village *tultul,* an official appointed by the Patrol Officer to represent him in each village, and his family. The second wife of the *tultul* was suffering from kuru at the time of the investigation, but she did not eat at this household; she usually occupied a house in another Moke hamlet and had recently been sent to live in another village. A third wife of the *tultul* died of kuru one year previously in the very house (Household No. 1) of this investigation. No recent cases of kuru had occurred in the other two houses of this study.

Kabiba, in Household No. 3, was the married sister of Yara, a teen-age girl victim of kuru, who lived in another Moke hamlet and was ill with kuru at the time of the survey. Kabiba and her child, Aki, often visited Yara and her parents and consumed meals with them. Kabiba herself came down with kuru a few months after this dietary survey was completed. She suffered a classical course of the disease, which lasted one year before her death in January 1959 [4].

Each day the women went to the gardens in the morning and returned at sundown with food for the household and for their pigs, enough for the evening meal and for the meal next morning. The women were met by the investigator at their houses as they returned from the gardens and after they had separated the food for the pigs, which consisted of the smaller sweet potatoes, the remainder of the food was sorted by the investigator, tabulated, and each kind was weighed. Food remaining in the house from the previous day was noted and weighed; this seldom included anything other than sweet potatoes. This procedure was carried out daily for the seven days of investigation.

From the second day until the end of the survey, each member of the household was questioned as to what snacks he had eaten during the day; these were noted and the approximate amounts estimated. There was considerable change in the individuals who ate at each household from day to day. In addition to the regular household members, the food was often consumed by visiting unmarried men, or men whose wives were away in other hamlets. Occasionally, household members would visit elsewhere for meals. Thus, the names of all members of the household and guests who partook of meals from the weighed supply were recorded.

Table 1 lists the members of each of the three households studied and the specific days each ate in the household during the week of the survey. Age and sex of each person are recorded with such additional information as the fact that a woman was lactating or was pregnant. In addition, the recommended dietary allowances for a New Guinea native of corresponding age, sex and state of health, as suggested by LANGLEY (14) is tabulated. Those transients who ate approximately half their full daily diet in the household are so indicated in the Remarks column. The use of these data in our analysis of Fore diet are discussed below in the section on Methods.

Individual Daily Food Consumption

The regular members of Household No. 3 were used for a more detailed individual quantitative dietary analysis which was conducted for one day, the day immediately following completion of the Dietary Surveys by Household.

The investigator stayed with the members of this household for the whole day and weighed all the food actually eaten by each person. Such investigations are most difficult to carry out, due to the crowded and smoky atmosphere of

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[4] Kabiba was autopsied and her brain has been studied neuropathologically.

TABLE 1

Subjects included in daily survey of diet by household and their recommended daily food allowances

Name	Age	Sex	Remarks	Days of study	Days eating in household	Recommended daily allowanees *				
						Calories	Protein g.	Calcium g.	Thiamine mg.	Ascorbi Acid mg.
Household No. 1				6						
1. Konkoni	50	M			1 2 3 4 5 6	2000	40	0.8	0.70	50
2. Onki	30	F	Lactating		1 2 3 4 5	2600	100	2.0	1.64	130
3.	1 mo.		Breast fed							
4. Orabe	18	F	Pregnant		1 2 3 4 5 6	2100	85	1.5	1.44	80
5. Aruia	5	M			1 2 3 4 5 6	1300	50	1.0	0.46	30
6. Ama	10	M			1	2000	70	1.2	0.70	30
7. Ontenti	2	F			1	1000	40	1.0	0.35	30
8. Oarika	16	M	1/2 day		1 2 3 4 5	2900	100	1.4	1.01	50
9. Kwata	17	M	1/2 day		1 6	2900	100	1.4	1.01	50
10. Akeku	30	M	1/2 day		4	2500	40	0.8	0.84	50
11. Merri	21	F			4	2100	40	0.8	0.77	50
12. Ogia	25	M	1/2 day		5	2500	40	0.8	0.84	50
13. Ariamu	23	M	1/2 day		5	2500	40	0.8	0.84	50
14. Pataro	17	M	1/2 day		5 6	2900	100	1.4	1.01	50
15. Agaka	18	M	1/2 day		6	2900	100	1.4	1.01	50
Household No. 2				7						
1. Mereveya	45	M			1 2 3 4	2500	40	0.8	0.84	50
2. Anto	30	F			1 2 3 4 5 6 7	2100	40	0.8	0.77	50
3. Kiliso	10	F			1 2 3 4 5 6 7	2000	70	1.2	0.70	30
4. Awato	17	F			1 2 3 4 5 6 7	2050	75	1.0	0.72	50
5. Mirii	21	F			1	2100	40	0.8	0.77	50
6. Schoolboy	9	M	1/2 day		3	1650	60	1.0	0.56	30
7. Oarika	16	M	1/2 day		3	2900	100	1.4	1.01	50
8. Katiba	25	M	1/2 day		4 6	2500	40	0.8	0.84	50
9. Ariamu	23	M	1/2 day		6	2500	40	0.8	0.84	50
10. Kangafe	28	M			7	2500	40	0.8	0.84	50
Household No. 3				5 **						
1. Yogia	35	F	Lactating		1 2 3 5 6	2600	100	2.0	1.64	130
2. Kou	6 mo.		Eating only an occasional piece pitpit							
3. Nemeta	8	F			1 2 3 5 6	1650	60	1.0	0.56	30
4. Nantu	4	F			1 2 3 5 6	1300	50	1.0	0.46	30
5. Akegu	3	F			1 2 3 5 6	1000	40	1.0	0.35	30
6. Kabiba	21	F			1 2 3 5	2100	40	0.8	0.77	50
7. Aki	3	F			1 2 3 5	1000	40	1.0	0.35	30
8. Mirri	21	F			2 3 5 6	2100	40	0.8	0.77	50
9. Kwata	17	M	1/2 day		2	2900	100	1.4	1.01	50
10. Yabi	25	M	1/2 day		2	2500	40	0.8	0.84	50
11. Kona	30	M	1/2 day		2	2500	40	0.8	0.84	50
12. Oarika	16	M	1/2 day		6	2900	100	1.4	1.01	50
13. Agaka	16	M	1/2 day		6	2900	100	1.4	1.01	50

* Taken from LANGLEY (14).

** On the fourth day all members of Household No. 3 stayed with friends in another hamlet of Moke. Thus, only five days of diet survey were made, namely days 1, 2, 3, 5 and 6 of the investigation.

the houses where most of the food is cooked and eaten and the fact that most meals are prolonged over several hours, during which time food is being continually cooked and eaten.

Food Weighing Procedure

The scales used were a "Weighmaster" spring scale marked in lbs. and ozs., and for weighing smaller quantities, an "Anax" Diabetic Scale marked in 1/4 ozs., weighing up to 4 ozs., manufactured by Elliotts and Australian Drug Pty., Ltd., Sydney. All food weighed in the Household Dietary Survey were raw foods, and those in the Individual Daily Consumption were cooked foods, with the exception of sugar cane.

The foods weighed were classified in the following categories: sweet potato, yam, pitpit, sugar cane, banana, and beans. No differentiation between varieties was made.

Only the mature non-dried bean seeds of *Phaseolus spp.* were eaten. In most cases these were weighed in the pod and it was estimated that the seeds comprised $^3/_5$ of the total weight.

Greens: where possible, the different types of greens were classified, but usually this was not possible since several varieties were generally picked and mixed together in a *kone* (string bag used for carrying food) and later cooked together. It was found that the loss of weight of the greens cooked in bamboo was negligible.

The edible proportion of pitpit was estimated as one half of that brought from the gardens.

The loss in weight of sweet potato and other root vegetables during cooking, and the discarding of the skin before eating, was not taken into account in the Household Survey, whereas in the Daily Individual Survey the prepared food was weighed.

Analysis of Data

Wherever possible, and unless otherwise stated, the tables used for the analysis of nutritive values of foods were taken from the New Guinea and Papuan Food Composition Tables by HODGES, FISH & RIENITS (13). In the case of beans, these tables gave only the analysis of green beans and, therefore, the nutritive values were taken from tables by PLATT (19) which gave values for dried *Phaseolus vulgaris*. As the beans eaten in the survey were mature non-dried seeds, half of the Platt evaluations were taken as a rough estimate. The weight of foods which was obtained in lbs. and ozs. was converted to grams for this analysis.

The greatest proportion of greens eaten consisted of *ebia (Ruellia sp.)* of which no nutritive analysis could be found. Therefore, the nutritive value of *ebia* and most other greens eaten was estimated from data for "high carotene dark green leaves", taken from the New Guinea and Papuan Food Composition Tables referred to above.

Kimoni (Cucurbita sp.) was calculated as pumpkin, wild birds (species unidentified) were calculated as squab (pigeon), using figures taken from data of WOOT-TSUEN WU LEUNG, PECOT & WATT (22), and lizard's eggs were calculated as a similar weight of hen's eggs, using figures taken from PLATT (19).

Daily Survey of Diet by Household. The total nutrient values of foods consumed each day by the group in each household was compared with the total

recommended dietary allowance for that group. This recommended total was calculated by adding together the recommended individual dietary allowances as given by LANGLEY (14) (and recorded in Table 1 for each member of the household) for each member of the household who ate there on a given day. These ideal values (i.e. recommended allowances) were calculated for each household for each day of the study. When an individual is recorded as consuming only approximately half his daily diet in the household, half the recommended daily dietary allowance for him has been used in the calculation.

A representative example of the calculations performed on the daily dietary intake is given in Table 2. The data are taken from the third and fourth day of study for Household No. 1.

The recommended daily allowance for the household on these two days was obtained by adding together the individual recommended values in Table 1 for each of the people who ate at the household on the respective days. It should

TABLE 2

Sample tabulation of daily dietary intake for Household No. 1

Food	Weight g.	Calories	Protein g.	Calcium mg.	Thiamine mg.	Ascorbic Acid mg.
Day 3						
Kaukau *	8,505	12,757	76.5	1,276	11.1	2,662
Pitpit **	1,474	168	60.4	147	?	310
Taro	113	23	1.6	121	0.1	7
Ebia ***	566	249	22.6	1,189	0.8	566
Corn	85	297	8.5	10	0.3	0
Sugar Cane	2,608	1,513	10.4	261	?	0
Day 3 total		15,007	180.0	3,004	12.3	3,545
Recommended daily allowance		9,450	325	6,000	4.7	315
Day 4						
Kaukau	6,350	9,526	57.2	953	8.3	2,558
Sugar Cane	5,443	3,157	21.8	544	?	0
Banana	57	14	0.7	5	0.03	18
Ne ****	57	623	56.7	2,978	2.1	1,418
Ebia	1,361					
Pitpit	255	98	10.5	26	?	31
Day 4 total		13,418	146.9	4,506	10.4	4,025
Recommended daily allowance		12,800	385	7,200	5.9	390

* Kaukau — sweet potato *(Ipomoea batatas)*.
** Pitpit — succulent core of a thick stemmed grass (*Saccharum* sp.).
*** Ebia — green leaf vegetable *(Ruellia* sp.: *Acanthaceae)*.
**** Ne — green leaf vegetable *(Rollia* sp.: *Commenlinaceae)*.

be noted that half daily requirements were allowed on day 3 for one male youth who ate only about half his diet at the household, and on day 4 for one male youth and one young male adult who were eating only approximately half their daily meals in the household.

These daily totals for food actually consumed and the recommended intake for each household were separately summed for all days of the study. Thus, total actual and recommended food consumption for the entire period of study for each household were obtained.

Individual Daily Food Consumption. The nutritive values of every food consumed by each of the two adults and four children in Household No. 3 on the day on which each individual's food was separately weighed was computed in the same manner as in the preceding Household Study. The same New Guinea and Papuan Food Composition Tables were used (13). The actual food consumption for each individual for the day was calculated by adding the nutritive values of all foods eaten and these were compared to recommended individual daily food allowances for New Guineans from LANGLEY (14).

Results

Dietary Study by Household

Table 3 lists the total nutritive value calculated for all foods consumed by each household for the entire period of the study. These values are compared with a total calculated from the daily recommended allowances in Table 1.

The percentage of the recommended allowances of calories and of dietary nutrients actually consumed run a similar pattern in each of the three house-

TABLE 3

Comparison of consumed and recommended intake by household over entire period of study

Household		Calories	Protein g.	Calcium g.	Thiamine mg.	Ascorbic Acid mg.
1	Consumed	78,663	935	22.7	65.25	21,459
	Recommended	68,750	2,260	41.0	31.85	2,045
	Per cent of recommended value	114	41	55	205	1,049
2	Consumed	110,920	1,352	28.5	91.90	26,602
	Recommended	63,675	1,675	28.2	22.34	1,325
	Per cent of recommended value	176	81	101	411	2,008
3	Consumed	82,126	1,185	20.4	64.17	21,454
	Recommended	60,400	1,920	38.3	24.97	1,745
	Per cent of recommended value	136	62	53	257	1,229

holds. In all three households the total caloric intake exceeds significantly the recommended value. Protein consumed in all three households was significantly below that recommended. The calcium in the diet was below the recommended value, except in Household 2, which obtained just the recommended requirement. On the other hand, thiamine and ascorbic acid in the diet exceeded the recommended amount by a factor of 2 to 4 and 10 to 20, respectively.

Comparisons were made between these Fore nutritive values and those of five other New Guinea areas (11, 14), where the same recommended dietary allowances of LANGLEY (14) have been used as a standard and very much the same techniques have been used to assess food intake. These data are presented in Table 4. In all cases allowances for nutritive losses in cooking have not been made. The Fore consumed significantly more calories and obtained more calcium than any of the other groups, and only in the Trobriand Islands, with a diet rich in fish, did the protein intake exceed that of the Fore. The high figures for ascorbic acid in the highland groups, compared to the lowland ones, may be accounted for by the larger quantities of sweet potato and other dark green leaves, rich in ascorbic acid which are eaten in the highlands.

TABLE 4

Comparison of the Moke (Fore) diet with that of five non-Fore New Guinea villages
(Expressed as percentage of recommended allowances)

Locality	Calories	Protein	Calcium	Thiamine	Ascorb Acid
Moke (Fore) [1]	148.6	62.0	70.6	296	1,454
Yobokogal (Chimbu) [2]	100.1	21.8	25.8	211	893
Busama [3]	67.2	33.7	50.0	100	309
Kaiapit [4]	87.8	47.0	60.0	143	446
Patep [5]	102.0	46.0	60.5	231	521
Kavataria [6]	81.7	81.7	21.5	172	300

[1] Average results from the three households studied.
[2] Yobokogal is a Chimbu village in the Central Highlands District of New Guinea.
[3] Busama is a coastal village in the Morobe District of New Guinea.
[4] Kaiapit is an inland lowland village in the Markham Valley of New Guinea.
[5] Patep is a village 25 miles inland at an elevation of 3500 ft in the Morobe District of New Guinea.
[6] Kavataria is a coastal village in the Trobriand Islands.

Individual Daily Food Consumption

Table 5 presents the actual weighed daily intake of two adult females (one lactating) and four children compared to the recommended total allowance for New Guinea natives, as taken from Table 1.

The protein intake, as shown in both the household and daily dietary surveys, is much below the recommended allowances. However, during the eight days of the survey, no pig was cooked in any of the households studied. As mentioned previously, pigs are plentiful and usually eaten for several meals, at least once a month, and often more frequently. Therefore, the overall protein intake of the people would be appreciably higher than that indicated by this survey. For

TABLE 5

Actual (A) and recommended (R) daily food consumption by individuals in Household No. 3

Name	Age	Sex		Calories	Protein g.	Calcium mg.	Thiamine mg.	Ascorb. Acid mg.
Yogia	35 (Lactating)	F	A	3,598	59.2	959.7	3.564	806.6
			R	2,600	100	2,000	1.64	130
Kabiba	21	F	A	3,387	37.5	1,155.6	3.816	792.4
			R	2,100	40	800	0.77	50
Nemeta	8	F	A	3,138	44.7	759.9	2.872	771.2
			R	1,650	60	1,000	0.56	30
Nantu	4	F	A	1,486	17.1	448.1	1.376	396.9
			R	1,300	50	1,000	0.46	30
Akegu	3	F	A	1,376	12.3	336.8	1.291	354.4
			R	1,000	40	1,000	0.35	30
Aki	3	F	A	1,869	18.6	290.4	2.175	287.2
			R	1,000	40	1,000	0.35	30

protein, at least, our results represent an overall minimum consumption by the Fore. In the household survey, totals of calories and nutriments, with the exception of protein, are probably maximal, since loss through waste such as the skin of sweet potatoes, which are discarded after cooking in the ashes, were not estimated. Furthermore, although sweet potato was set aside for the pigs at the time of daily weighing, it is possible that small portions of that amount included in the family's portion were later given to pigs. It was virtually impossible to control this matter completely.

Discussion

Food analyses given in tables by HODGES, FYSH & RIENITS (13) and elsewhere (19, 22) were not performed on specimens obtained from Highland areas. At the time of the survey no values were available for New Guinea Highland foods; values for other Highland areas have since been determined (for example, OOMEN [16] and PETERS [18]) and, while they often differ from those obtained from coastal varieties, it is not safe to assume that they are necessarily more applicable to the kuru region at the time of the survey than the values used. In either case, the assumption of approximately equivalent food composition between the varieties eaten and the varieties analyzed elsewhere has to be made. The cooking loss of nutriments, such as calcium, thiamine and ascorbic acid, has not been allowed for in this survey. It must be noted, however, that in the type of cooking practiced here, there would be little or no loss of soluble components in cooking water and very little heat inactivation of vitamins as compared to that in normal European methods of cooking.

Other nutriments besides those considered have not been estimated because of lack of appropriate food analyses and the absence of comparative data on other New Guinea groups.

Nutrition and the Virus Etiology of Kuru

Nutritional factors, a dietary deficiency, or a toxic item in the diet, were at first strongly suspected as the possible cause of kuru (2, 7–9). However, no soil or water contamination or use of a toxic plant as a food, a medicine, body paint, hallucinogenic smoke or snuff, or consumption of a poison through pica was found. There was no feature of the ecology or geology unique to the kuru region, nor was the use of any potentially toxic substance restricted to the populations of the kuru region and not shared by some kuru-free neighboring population. The occurrence of kuru in individuals who had been away from the region on the coast, or even on other islands for several years as laborers or students, made both toxin and deficiency unlikely factors in kuru pathogenesis. In these distant places it was no longer possible for these emigrants to consume the local Fore diet or to encounter the strange wild plants of the kuru area. The unlikelihood of toxic or deficiency factors accounting for the disease was further evident when no alteration of the clinical progression and duration of the disease was observed in such patients as they deteriorated rapidly to terminal illness without having yet returned to the kuru region. Similarly, patients removed completely from the kuru region at the time of onset of their disease, when first subjective awareness of their illness was reported, deteriorated as rapidly as did patients left in their native village, although the transported patients received food and water no longer originating in their kuru-affected homeland and were given enriched diets with ample vitamin, fat and protein supplements. Finally, patients treated with dimercaprol (British Anti-Lewsite, BAL) and calcium versenate showed no clinical improvement, and heavy metal determinations on all urine collected before, during, and after treatment showed no pathological increase in excretion of copper, manganese, or any other element. Spectrophotometric estimations of trace metal content of cerebrospinal fluid, serum, whole blood, urine, and tissues obtained at autopsy revealed no abnormal levels of any element.

We suggested at one time (2) that a silent genetic polymorphism without selective disadvantage may have developed in the kuru-afflicted population before the introduction of some environmental factor, presumably dietary which, although innocuous for normal subjects, was toxic to people of a different genetic endowment within the population. Such a dietary change as the introduction of corn into the diet, before European discovery of the region, might then have caused the change in nutrient load which resulted in kuru in individuals of the appropriately sensitive or idiosyncratic genetic constitution. MATHEWS has suggested protein, folic acid or pyrodoxine deficiency during periods of sweet potato shortage may act as a precipitating factor in kuru (15).

These theories have all been forced into the background by the successful transmission of kuru to chimpanzees (3, 4, 10) and spider monkeys (5), and the chimpanzee-to-chimpanzee passage of the disease using high dilutions of brain suspension (10^{-6}) as inoculum, and by gradacol membrane filtrates of such suspension through membranes of 220 mμ average pore diameter. Transmission is also possible using suspensions of lymph nodes, spleen, and kidney not containing brain tissue, and either intracerebral or peripheral (intraperitoneal, intramuscular, and subcutaneous) routes of inoculation are effective. A virus infection seems to underly the pathogenesis of kuru. However, nutrition

remains under question as a possibly important precipitating factor, although a virus is the primary agent of the disease: susceptibility might be increased through stress engendered by excess consumption of, or incomplete metabolic conversion of, a nutrient or through unusual fluctuations or deficiency of a specific nutrient (15), or, finally, through some unrecognized toxin in the diet.

Finally, earlier suspicion that cannibalism, which was practiced universally in the kuru region as an act of mourning and homage to the dead, might have played a role in dissemination and in the pathogenesis of kuru is reawakened by the transmission of kuru to chimpanzees (3, 4, 10). We had early suspected that a hypersensitivity to human brain protein might be provoked through this cannibalism, and the partial decomposition of the tissue which proceeded before cooking might serve to provide a bacterial adjuvant or so modify the human tissue as to make it antigenic for man. Otherwise, a heat resistant virus might have been quickly disseminated through the Fore population by cannibalism and, thereafter, perhaps at a critical stage of her infection, transmitted from mother to offspring in milk, or as a congenital infection (2).

Kuru virus produces a pathology thoroughly like that of scrapie virus infection in sheep, goats, mice and hamsters. Scrapie is remarkably resistant to inactivation by heat, ultraviolet irradiation, usual antiviral chemicals, enzymes, and gastric juice. Oral infection occurs with ease. If the heat resistance of the kuru agent resembles that of scrapie virus, Fore cooking practices would hardly have fully inactivated all virus in cooked flesh or brain tissue. Furthermore, contamination of hands with uncooked tissue would serve to contaminate all foods. Thus, a widespread oral dissemination of the agent through the population by cannibalism (and the associated possibilities of conjunctival, nasal, subcutaneous self-inoculation) with subsequent transmission possibly congenitally or neonatally from the mother (by prenatal infection in utero, venereal-vaginal contamination, neonatal contact with the mother, or, perhaps, even as a milk factor) would account for the dramatically high incidence of the disease.

The dietary survey reported here indicates that the Fore have an adequate diet, as compared to other New Guinea peoples; it lends no support to any of the many theories of the role of nutrition in determining or precipitating kuru – but, obviously cannot specifically investigate these hypotheses. It offers a baseline of traditional Fore diet with which all future studies of nutrition in the region will have to be compared. On the diet such as that described here, the kuru epidemic attained its peak incidence.

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Zusammenfassung

Um zu bestimmen, ob die Ernährung Mängel oder Überschüsse aufweist, die Kuru hervorbringen oder Empfänglichkeit dazu verursachen können, sowie um genaue Angaben zu bekommen über Diät und Essensgewohnheiten dieser Volksgruppe des Neuguinea-Hochlands, in welchem Kuru außerordentlich häufig vorkommt, wurde im Jahre 1957 eine ausführliche ernährungskundliche Untersuchung der Bewohner des Moke-Dorfes, welches der Fore-Sprachgruppe angehört, durchgeführt. Diese Untersuchung war beendet vor der Einführung europäischer Nahrungsmittel in die Diät der Eingeborenen, und bevor jegliche kommerzielle Nahrungsmittel dem Stamme zugänglich waren. Drei Familien wurden einer besonderen Beobachtung unterzogen. Die zugeführte Nahrung wurde gewogen, ihr Gehalt an Protein, Kalzium, Thiamin, Vitamin C und ihre Gesamtkalorien berechnet und mit für Neuguinea empfohlenen Rationen verglichen. In einem Haushalt wurde eine ausführlichere Untersuchung der Nahrungsaufnahme von Einzelpersonen durchgeführt. Die erhaltenen Ergebnisse wurden mit solchen aus anderen Gebieten von Neuguinea verglichen. Eine der Versuchspersonen, in einem Haushalt, in dem ein Jahr vor Studienbeginn Kuru vorgekommen ist, fiel zwei Jahre später derselben Krankheit zum Opfer. Die Ergebnisse dieser Untersuchungen liefern Angaben von minimaler Nahrungsaufnahme, da weder Festessen noch andere besondere Essen während der Zeitspanne der Beobachtungen stattfanden. Sie geben eine Idee von der ursprünglichen Nahrungszusammensetzung und den Ernährungsgewohnheiten der Fore des Kuru-Gebietes vor den vielfachen Veränderungen, die in den letzten zwölf Jahren stattfanden, und welche Lebensweise, Behandlung und Zubereitung der Nahrungsmittel sowie die Diät umgestaltet haben. Es zeigt sich, daß die Aufnahme von Kalorien, Protein und Kalzium zum mindesten ebenso hoch ist wie im übrigen Neuguinea, und daß die Aufnahme von Thiamin und Vitamin C sogar ungewöhnlich hoch ist. Es ist demnach anzunehmen, daß die Ernährung wahrscheinlich weniger für die Ausbreitung der Kuru-Krankheit verantwortlich ist als der Ritualkannibalismus bei Trauerveranstaltungen zu Ehren verstorbener Familienangehöriger, welcher die Ausbreitung der Krankheit auf die ganze Familie zur Folge hat.

Résumé

Une étude détaillée de la nutrition des habitants du village Moke, appartenant au groupe linguistique Fore, a été faite en 1957 dans un double but : le premier, de déterminer si des insuffisances ou des excès pouvaient influencer la réceptivité de la population pour le kuru ; le deuxième, d'apporter des informations sur une population habitant une région montagneuse de la Nouvelle Guinée où les cas de kuru sont particulièrement fréquents. Cette étude a été terminée avant l'introduction, dans l'alimentation indigène, de produits de consommation européens et avant toute possibilité de commerce entre indigènes et Européens. On a choisit trois ménages dont la nourriture fut régulièrement pesée et évaluée quant à sa teneur en protéines, calcium, thiamine et acide ascorbique, ainsi qu'à sa valeur calorique ; les résultats ont été comparés aux rations coutumières en Nouvelle Guinée. Dans l'un des ménages, une étude de la ration individuelle a été faite et les résultats comparés à ceux obtenus dans d'autres régions de la Nouvelle Guinée. Dans l'un des ménages aussi, où on avait dépisté un cas de kuru avant le début des observations, il y eut un décès deux ans après. Comme

aucun repas exceptionnel et aucune festivité n'eurent lieu durant la période d'observation, la présente étude reflète la ration alimentaire minimale. Elle apporte des informations sur les procédés nutritifs originels des habitants de la région où l'on trouve le kuru, avant les nombreuses transformations survenues au cours des douze dernières années et modifiant les habitudes de vie, les methodes de préparation des aliments et le régime alimentaire. Elle démontre que la valeur calorique et la teneur en protéines et en calcium sont au moins équivalentes à ce qu'elles sont ailleurs en Nouvelle Guinée, que le contenue en thiamine et an acide ascorbique est habituellement élevé et finalement que l'alimentation a moins d'influence sur l'incidence du kuru que le cannibalisme familial, rite mortuaire qui transmet la maladie à tous les membres de la famille.