

A FAMILY COEFFICIENT SCALE DEVELOPED FROM THE AUSTRALIAN NUTRITION SURVEY

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IN November 1937 the Technical Commission on Nutrition of the League of Nations Health Organization defined four types of nutrition survey. The third type was the family survey wherein an attempt is made to study the food consumed either by the family or by individual members of the family. One of the difficulties surrounding this type of survey is due to the differences of age and sex of the individuals of the household. To overcome this difficulty family consumption coefficient scales have been devised, to effect conversion of data to a common unit of consumption usually defined as that of the "adult male".

In 1932 a Conference of the Nutrition Experts of the League of Nations advanced a scale of family coefficients for International use and recommended that steps should be taken to provide the data necessary for the construction of an accurate scale of family coefficients for each country.

In 1936 the Government of the Commonwealth of Australia appointed an Advisory Council on Nutrition to enquire into and report upon the state of nutrition of the Australian people. The investigations, undertaken by this Council between 1936 and 1938, were made from two entirely different angles. A survey was made of the state of nutrition of groups of children and an analysis was undertaken of a large number of domestic food budgets. At the time it was realized that the latter type of survey would supply information upon the classes and quantity of foods purchased by households. In order to reduce these quantities from heterogeneous households to a common consumption unit it was necessary to use a family consumption coefficient scale. The one used was that advocated by the Health Organization of the League of Nations.

The Australian Survey measured the amount of food purchased by the household and this was assumed to be equal to the food consumed by the household. There is no reason why these two quantities should agree or why either should be equal to the physiological requirements of the individual members of the household.

The only way to obtain a measure of the food consumed would be actually to weigh each dish of food eaten and analyse the food constituents of a duplicate dish. Even this type of survey, which is long and laborious, would not necessarily measure the physiological food requirements of an individual.

Family food surveys can only measure the food purchased for the household, yet in the conversion of the results to a common basis—the adult male unit—family consumption coefficient scales are used which have been based on the actual food consumed or from the computed physiological requirements of individuals. As pointed out above, the quantities obtained by either of these methods need not correspond to the food purchased by a household.

The quantities of food purchased by the households that contributed to the Australian Domestic Food Budget Survey have been analysed in such a way as to prepare a scale of family coefficients based on the food purchased. The methods used in the statistical treatment of the figures and the scale evolved form the subject of this paper. Before presenting these, the scales previously advocated and their derivation will be discussed.

PREVIOUS SCALES ADVOCATED

Reference to literature reveals that although a number of family coefficients have been advanced by various workers the majority have had their origin in the coefficients prepared by Atwater (1895) and Lusk (1923).

Voit and the Munich school of physiologists estimated the requirements of different age groups for various food constituents. Their findings are shown in the following table.

Age group	Protein g.	Fat g.	Carbo- hydrate g.	Potential energy cal.
1. Children up to 1½ years	28	37	75	767
2. Children 6–15 years	75	43	325	2041
3. Women at ordinary work	92	44	400	2426
4. Labouring men at ordinary work	118	56	500	3055

Atwater made use of these figures and by interpolating an assumed value for children 2–6 years of age evolved the following table of coefficients:

Labouring man, moderate work	1.0 (3000 cal.)
Woman, ordinary work	0.8
Children: 6–15 years	0.7
2–6 years	0.5
Under 2	0.25

This scale of coefficients was derived from the food observed to be consumed by a number of individuals which was interpreted by Voit and his workers to correspond to the food required by these individuals.

Cathcart & Murray (1931) compiled a list of coefficients slightly fuller than that of Atwater:

Man	1.00
Woman	0.8
Boy 14–16	0.8
Girl 14–16	0.7
Child: 10–13	0.6
6–10	0.5
2–5	0.4
0–2	0.3

The source of this list could not be traced.

In 1917 and 1918 an Interallied Scientific Commission on food held a number of meetings in Paris and Rome, at which Graham Lusk was the representative of the United States of America. This Commission adopted a standard of 3000 cal. as the requirement for an average man doing an average day's work. Lusk (1923) advanced the following standard for women and children which he stated was "known in England as Lusk's Coefficients":

Persons	Cal.	Coeff.
Average man 14 years and older	3000	1.0
Average woman 14 years and older	2500	0.83
Boy or girl: 10-14 years	2500	0.83
6-10 years	2100	0.7
0-6 years	1500	0.5

In 1917 a committee of the Royal Society presented in a Parliamentary Command Document the following scale, the source of which was not given, but which agrees closely with Lusk's:

Males—adult	1.0
Females—adult	0.8
Males 14-15	0.8
Females 14-15	0.7
Children: 10-13	0.6
6-9	0.5
0-5	0.4

This scale was quoted again in a Medical Research Council's *Special Report* in 1918.

In 1931 Cathcart & Murray, after quoting the scales advanced by Atwater and Lusk, produced a scale which was really a compromise between them.

This scale was:

Adult male	3000 cal.	1.0
Adult female	2500 cal.	0.83
Boy over 14 years		1.0
Girl over 14 years		0.83
Child: 12-14		0.9
10-12		0.8
8-10		0.7
6-8		0.6
3-6		0.5
2-3		0.4
1-2		0.3
0-1		0.2

In 1932 this scale was quoted by the Advisory Committee on Nutrition held under the Ministry of Health.

In 1932 a Conference of Experts of the League of Nations for the standardization of certain methods used in making dietary studies advocated the following scale for international use:

Age	Coefficient		
	Male	Both	Female
14-	1.0	—	0.8
12-13		0.8	
10-11		0.7	
8-9		0.6	
6-7		0.5	
4-5		0.4	
2-3		0.3	
0-2		0.2	

Information upon the source of this scale was not supplied by the conference but it may be assumed that the list of coefficients was based either on those of Atwater or Lusk, or was computed by the conference.

In 1935 Burnet & Aykroyd reaffirmed the scale drawn up by the Expert Committee of the Health Organization of the League of Nations.

The scales adopted for southern parts of India and for Japan* follow closely that recommended by the League of Nations Technical Committee.

The last proposal of the *Report of the Technical Commission of the Health Organization of the League* published in 1938 was somewhat complicated and necessitated the addition of supplementary allowances for the type of activity of the individual to the basic energy requirements. To use this method in a food budget survey it would be necessary to obtain information upon the type of life followed by each member of the household, a complicated procedure, the accuracy of which might be questioned.

In America, Steibeling & Phipard (1939) used the Bureau of Home Economics scale in a survey during 1938 in preference to the international scale, since, in their opinion, it reflected more closely the requirements of the American people. This scale is set out in the following table:

	Men	Women
Moderately active work	1.0 (3000 cal.)	0.83
Very active work	1.5	1.00
Light work	0.9	0.77
Sedentary work	0.8	0.7
Boys: 16-19	1.20	
13-15	1.0	
11-12	0.83	
9-10	0.8	
7-8	0.7	
4-6	0.5	
Girls: 14-19		0.83
11-13		0.8
8-10		0.7
4-7		0.5
Children: 2-4	0.4	0.4
Under 2	0.3	0.3

Steibeling & Phipard were of the opinion that the calorie allowance in a food survey should be set fairly closely to the physiological requirements of the various age groups.

From this review of the scales previously advanced it is obvious that they were designed for the dual purpose of defining the food requirements of individuals, as in the Ministry of Health and Royal Society Reports, and for use in the statistical treatment of domestic food budgets; when used for the former purpose the scale should be based upon the physiological requirements of the different age and sex groups. In a family food survey in which food purchased for the household is statistically treated, a scale based upon food purchased would be more applicable.

* *Report of the Intergovernmental Conference of Far-Eastern Countries on Rural Hygiene*, pp. 81, 85.

SOURCE OF THE MATERIAL

In the survey of domestic food budgets conducted by the Advisory Council on Nutrition, Commonwealth of Australia, 2565 booklets from 1789 families listed the food purchased for one month by the households. In addition the composition of the family was shown, together with the additional or absent persons for each meal each day. From these data the statist computed the average daily quantities of protein, carbohydrate, fat and the caloric value per "adult male" for each family of the consumable food purchased. This figure was obtained by deducting from the food purchased the inedible portions and allowing a certain percentage for wastage. The statist in his report referred to these values as the average daily consumption per "adult male".

In reality at no stage in the survey was the actual food consumed by an individual recorded. In this paper these values for protein, carbohydrate, fat and calories will be referred to as the "purchase".

THE ANALYSIS

In the present analysis the mean daily "purchase" of protein, carbohydrate and fat per "adult male", which had been obtained by the statist for each family, was coded and transferred to cards which were then sorted into groups of similar family composition. Thus it was possible to obtain the mean daily "purchase" per "adult male" for all families with the same composition. Throughout this paper these figures will be referred to as the mean family daily "purchase" to distinguish them from the daily "purchase" for an individual family referred to as the family "purchase".

Up to this stage in the treatment the figures for the mean family daily "purchase" had been expressed as "per adult male". In the conversion of the "purchase" of a household to the "purchase" per "adult male" the statist used the international scale of family coefficients. The next step in this statistical treatment was the conversion of the mean family daily "purchase" per "adult male" back to the mean family daily "purchase" for the whole family. This was achieved by multiplying the "adult male" value by the conversion value corresponding to the composition of the family.

This introduced a slight error. The statist in the determination of the coefficient for any particular family allowed for extra meals taken with the family, and for absent members of the family. In the present analysis this correction could not be applied since the mean family "purchase" often represented the mean of a large number of families whose individual corrections could not be obtained.

The mean "adult male" value of the 1789 households calculated on the consumption of the families was 3.56 as shown in Appendix 1, Table XVIII of the *Final Report of the Advisory Council on Nutrition, Commonwealth of Australia*.

The mean "adult male" value of 1789 households allowing for absentees and visitors was 3·46, as shown in Appendix 1, Table III of the *Final Report*. This difference introduced a positive error of 3 per cent.

When the mean family daily "purchase" for each family composition had been obtained it was possible by a series of subtractions to obtain the "purchase" for individuals. It was argued that a family composed of a man, his wife, and a child aged two years, should "purchase" more than two adults. Of course this may not be so since the "adult male" purchase for the former may be low in the vicinity of 3000 cal. whilst the latter may be high, nearer 4500 cal.

The method adopted in this procedure might be more easily explained by using an example. There were thirty-seven families composed of one adult male, one adult female, and one child aged 3-4 years, who together purchased 300,902 cal. Thus the average purchase per family was 8132·5 cal. (a). There were forty-three families composed of one adult male, one adult female and two children, whose ages were under 2 years and 3-4 years respectively. The average purchase per family was 9487·5 cal. (b). By subtracting (a) from (b) it was shown that for these particular groupings an average of 1355 cal. was purchased by each of forty-three families because of the extra child. This was recorded as one observation involving forty-three individuals. For this particular age group forty-four similar subtractions were possible using all combinations of family means wherein a child under 2 years appeared.

This process was repeated for adult males and females and for children in each age group.

The number of observations made and the persons thus represented are shown in Table 1.

Table 1. *Number of observations and persons*

	No. of observations	No. of Persons
Men	93	1197
Women	44	1228
Children: 12-13	52	362
10-11	54	379
8-9	58	408
6-7	63	531
4-5	48	466
2-3	45	408
Under 2	44	417

Total protein, carbohydrate and fat were treated in a similar manner to calories.

RESULTS

The mean average daily "purchase" of protein, carbohydrates, fat and calories of each group is shown in Table 2. In this table these results are recorded as gross values.

Table 2. *Mean average daily "purchase"*

	Protein g.	Carbo- hydrate g.	Fat g.	Cal.
Male	96.4	429	128	3347
Female	62.5	415	104	2935
Children: 12-13	56.0	360	93	2573
10-11	61.6	329	89	2429
8-9	52.0	322	70	2191
6-7	47.5	302	69	2078
4-5	45.7	288	75	2060
2-3	30.7	237	67	1716
Under 2	40.5	204	57	1564

* Calories calculated from the "purchase" of protein, carbohydrates, and fat.

FAMILY COEFFICIENTS

A scale of family coefficients shown in Table 3 has been developed from the results obtained. In this table the results are expressed as "net" after deduction for wastage. The mean adult male calories as purchased were 3347 cal. gross. It was determined by a series of observations made during the Australian Nutrition Survey that the wastage of the edible portion of food in preparation and consumption amounted to 10% of the purchase. Thus the 3347 cal. gross are reduced to 3013 cal. net.

Table 3. *Scales of family coefficients*

Persons	Protein	Carbohydrates	Fat	Calories
Male	1.0 (86.8 g. net)	1.0 (386 g. net)	1.0 (115 g. net)	1.0 (3013 net)
Female	0.65	0.97	0.82	0.88
Children: 12-13	0.58	0.83	0.72	0.76
10-11	0.63	0.76	0.69	0.72
8-9	0.53	0.75	0.55	0.65
6-7	0.49	0.70	0.54	0.62
4-5	0.47	0.65	0.58	0.61
2-3	0.32	0.55	0.51	0.51
Under 2	0.42	0.43	0.44	0.47

(Statistical treatment has been applied to the values in Tables 2 and 3 and the differences between each adjacent set of values is significant.)

DISCUSSION

The scale of family coefficients given in Table 3 has been derived from the food purchased by the household. It is of interest to compare this scale with the determined or estimated physiological requirements of the various age and sex groups.

(i) *Energy requirements.* The calories purchased for a male adult were 3013 net which correspond closely to the figure suggested by the Technical Commission of the League of Nations for the adult man, average size and height (great majority of occupations).

The physiological calorie requirements of women and children, based on the recommendation of the Health Commission of the League of Nations, are shown in Table 4 together with the calories purchased determined in this analysis.

Table 4. *Comparisons between physiological calorie requirements and the values obtained in this analysis*

	League of Nations net	This analysis net
Child average weight:		
Under 2	840-1000	1408
2-3	1000-1200	1545
4-5	1200-1800	1854
6-7	1440-2040	1870
8-9	1680-2280	1972
10-11	1920-2520	2186
11-12	2160-3360	2316
12-15	2400-3600	—
Woman average weight, moderate work	3000-3600	2642

The calories purchased closely approximate to the physiological requirements except for the young children. Apparently in the younger age groups it was necessary to purchase more food than was required to satisfy the physiological requirements of these children. A satisfactory explanation cannot be made for this fact. More than 50% of the children under 2 and from 2-3 years were members of families of three and four children.

(ii) *Protein*. The protein purchased and the protein requirements based on the Health Council of the League of Nations and other sources of the various age groups are shown in Table 5.

Table 5. *Comparison between physiological protein requirements and this analysis*

	Other sources g. net	This analysis g. net
Man: Voit	118	—
Rubner	127	—
Atwater	125	84.4
Bigwood	110	—
League of Nations	70	—
Women: League of Nations	70	55.8
Children: 12-13 (League of Nations)	65-86	50.6
10-11	55-79	55.5
8-9	49-70	46.8
6-7	43-60	42.8
4-5	43-53	41.2
2-3	39-52	27.6
Under 2	33-48	36.4

(iii) *Carbohydrates*. The consumption of carbohydrates by women is both absolutely and relatively high, with a corresponding reduction in the consumption of protein. This confirms the belief held by many nutrition workers that women too often resort to a meal of "tea and toast".

SUMMARY

1. The existing scales of family consumption coefficients are reviewed and an attempt made to determine the sources from which they were developed. In the absence of definite information it was assumed that the majority of previous family coefficients were based upon the physiological requirements of the various age groups.

2. A family food budget survey recorded food purchased by the household. There was no guarantee that this food was eaten by the members of the household in proportions similar to a scale of coefficients based upon physiological requirements.

3. Using the statistical material collected by the Commonwealth Advisory Council on Nutrition a scale of family coefficients based on calories "purchased" has been evolved by a form of statistical treatment which measured the additional food purchased for an additional person. This scale was:

Adult man	(3013 cal. net) = 1.0
Woman	= 0.8
Children: 12-15	= 0.76
10-11	= 0.72
8-9	= 0.65
6-7	= 0.62
4-5	= 0.61
2-3	= 0.51
Under 2	= 0.47

This scale agrees more closely with that advanced by Lusk than any other.

4. Comparisons were drawn between the values obtained in this analysis and the physiological requirements of various age groups. It was found that for men and women and the older children the calories as purchased closely approximated to the physiological requirements, whilst for children of 2-3 years and under 2 years the former were considerably higher.

5. The protein purchased was within the range calculated to satisfy the physiological requirements.

REFERENCES

- ADVISORY COMMITTEE ON NUTRITION (1932). *The Criticism and Improvement of Diets*. Ministry of Health, H.M.S.O.
- ADVISORY COUNCIL ON NUTRITION (1938). *Final Report*. Commonwealth of Australia, Canberra.
- ATWATER, W. O. (1895). Methods and results of investigations on the chemistry and economy of food. *U.S. Dep. Agric., Office of Experimental Stations Bull.* No. 21.
- BURNET, E. & AYKROYD, W. R. (1935). *Nutrition and Public Health Bull.*, Health Organization, League of Nations, p. 323.
- CATHCART, E. P. & MURRAY, A. M. T. (1931). A study on nutrition. *Spec. Rep. Ser. med. Res. Coun., Lond.*, No. 151.
- FOOD COMMITTEE OF THE ROYAL SOCIETY (1917). *The Food Supply of the United Kingdom*. Parliamentary White Paper, C.D. 8241.
- FOOD SUPPLY OF THE UNITED KINGDOM (1918). An enquiry into special dietaries. *Spec. Rep. Ser. med. Res. Coun., Lond.*, No. 13.
- HEALTH ORGANIZATION OF THE LEAGUE OF NATIONS (1937). *Report of the Intergovernmental Conference of Far-Eastern Countries on Rural Hygiene*. Health Organization, League of Nations, p. 81.
- LUSK, GRAHAM (1923). *The Fundamental Basis of Nutrition*. Yale Univ. Press.
- Quart. Bull. Health Organization, League of Nations* (1932), 1, 477.
- REPORT OF THE TECHNICAL COMMISSION ON NUTRITION ON THE WORK OF ITS THIRD SESSION (1938). *Quart. Bull. Health Organization, League of Nations*, 7, 460.
- STEIBELING, H. K. & PHIPARD, E. F. (1939). Diets of families of employed wage earners and clerical workers in cities. *U.S. Dep. Agric. Circular*, No. 507.

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