Dental Caries in Maryland Children After Seven Years of Fluoridation

A. L. RUSSELL, D.D.S., M.P.H., and CARL L. WHITE, A.B.

A SUBSTANTIAL inhibition of dental caries after 5 years' use of fluoridated community water has been reported previously for children of Montgomery and Prince Georges Counties, Md., adjacent to the District of Columbia (*1*). At the end of the fifth year essentially all of the inhibitory effect was seen in teeth which had erupted after fluoridation was begun. The present report describes caries patterns in this same population 2 years later, after 7 years of fluoridation. Data presented here may be compared directly with the 5-year findings.

Design of the study and the methods employed have been described in detail (*2*). All the children in the study are white and were born in and have resided continuously in the area. None has received such caries-preventive treatments as the topical application of fluoride solutions. Examinations were made by a small and carefully calibrated group of examiners, using mirror and explorer. The survey described here was carried out in January and February 1959.

The area where these children live is supplied with water from a single filtration plant maintained by the Washington Suburban Sanitary Commission. The mean daily fluoride level in finished water at this plant was 1.005 ppm during 1957, the sixth year of the study, and 0.991 ppm during 1958. Most monthly averages were within the range of 0.99 to 1.02 ppm. Fluoride levels had been maintained at 0.9 to 1.0 ppm during the first 2 years of fluoridation and at 1.0 ppm during the third, fourth, and fifth years. The fluoridating vehicle used has been sodium fluosilicate (*1*).

Dr. Russell and Mr. White are with the National Institute of Dental Research, National Institutes of Health, Public Health Service, Bethesda, Md.

As in 1957 the mean numbers of permanent teeth in eruption were essentially those which would have been predicted from the 1952 data. In the 2,872 children observed there were 0.2 percent fewer permanent teeth than in 1952. Numbers of deciduous teeth present were virtually identical with the 1952 expectancies in the 2,103 children 9 years of age or older. In children 8 years of age or younger, however, there were substantially more deciduous teeth present than would have been expected from the 1952 data, an increase over this age range of about one-half tooth per child. This was due principally to greater numbers of retained first and second deciduous molars. In children aged 6 years in 1959 (the first large group born since fluoridation to enter this study) there was an average per child of 0.13 deciduous first molars missing or indicated for extraction because of dental caries; the average for deciduous second molars was 0.17 per child. Similar statistics for 6-year-old children in 1952 are 0.30 first and 0.51 second deciduous molars. Neither of these teeth is shed normally during this age span; virtually all this loss is premature and is due to dental caries. Mortality rates for deciduous first and second molars were 57 and 67 percent lower in 1959 than in 1952.

Total Caries Experience

Differences in total caries experience in the children between 1952 and 1959 are shown in tables 1, 2, and 3, and the chart.

Evidences of caries inhibition in deciduous

teeth were confined almost wholly to children 8 years of age or younger in 1959 (table 1). These children had not reached their second birthdays at the time of fluoridation, and many of their deciduous teeth were not yet in eruption at that point. Through the age of 8 years there were about 63 percent more children free of caries in the deciduous dentition (273 compared with an expected 168), and mean numbers of deciduous teeth which were decayed, indicated for extraction because of dental caries, or filled (def) were importantly lower than those seen in 1952 (table 2). In children aged 9–15 years there were about the same proportions free of caries in the deciduous dentition and about the same mean numbers of def teeth as in 1952.

Benefits to the permanent dentition were evident in all age groups. There were significantly fewer permanent teeth which were decayed, missing, indicated for extraction because of caries, or filled (DMF) at all ages except 5 years, at which point few permanent teeth were in eruption. Numbers of children free of evidence of caries in the permanent dentition were significantly higher through the age of 11 years. The difference was of borderline significance (P=.05) at the age of 12. At the time of fluoridation permanent teeth were beginning to erupt in children aged 12 years in 1959; few or none were in eruption in younger children.

Fewer DMF teeth than would have been expected on the basis of the 1952 observations have occurred in each of the study groups during this 7-year span. Eight-year-old children in 1952, for example, averaged 1.90 DMF teeth per child; 15-year-old children averaged 8.57 per child. The apparent increment of DMF teeth over the 7-year span from age 8 to age 15

Table 1. Proportions of caries-free children at the outset of fluoridation and 7 years later, Montgomery and Prince Georges Counties, Md.

Age at last birthday	Numbers examined		Percent caries-free in deciduous dentition		Percent caries-free in permanent dentition	
	1952 (N= 1,950)	1959 (N= 2,872)	1952	1959	1952	1959
5	60	31	36.7	[1] 67.8	98.3	100.0
6	171	244	26.9	[1] 43.4	81.3	[1] 94.7
7	211	257	22.3	31.5	50.7	[1] 85.6
8	181	237	14.9	[1] 27.4	32.6	[1] 61.2
9	223	223	18.4	19.3	19.7	[1] 43.5
10	199	226	33.7	31.4	16.6	[1] 29.2
11	191	218	52.4	50.5	12.6	[1] 24.3
12	228	451	77.2	76.5	8.3	13.5
13	233	382	91.0	89.5	6.9	7.9
14	188	451	94.1	94.0	3.7	4.7
15	65	152	100.0	95.4	7.7	3.3

[1] Significantly different from the 1952 finding at the P=.01 level.

Table 2. Mean numbers of def deciduous and DMF permanent teeth at the outset of fluoridation and 7 years later, Montgomery and Prince Georges Counties, Md.

Age at last birthday	Mean numbers of def deciduous teeth		Mean numbers of DMF permanent teeth	
	1952	1959	1952	1959
5	2.77	[1] 0.97	0.03	0.00
6	3.67	[1] 2.35	.41	[1] .09
7	4.04	[1] 2.85	1.09	[1] .25
8	3.78	3.36	1.90	[1] .77
9	3.43	3.49	2.42	[1] 1.34
10	2.30	2.39	3.09	[1] 2.02
11	1.29	1.34	4.39	[1] 2.40
12	.47	.46	4.96	[1] 3.65
13	.16	.18	6.15	[1] 4.74
14	.07	.09	7.66	[1] 5.80
15	.00	.05	8.57	[1] 6.66

[1] Significantly different from the 1952 findings at the P=.01 level.

Table 3. Expected and observed incidence of new DMF teeth in children using fluoridated water between 1952 and 1959, Montgomery and Prince Georges Counties, Md.

Age interval (years)	Age at time of fluoridation	Incidence of new DMF teeth per child per year	
		Expected [1]	Observed
8–15	8+	0.95	0.68
7–14	7+	.94	.67
6–13	6+	.82	.62
5–12	5+	.71	.52
5–11	4+	.73	.40
5–10	3+	.62	.40
5–9	2+	.61	.34
5–8	1+	.63	.26
5–7	<1	.55	.13
5–6	Unborn	.41	.09

[1] If attack rates observed in 1952 had remained unchanged.

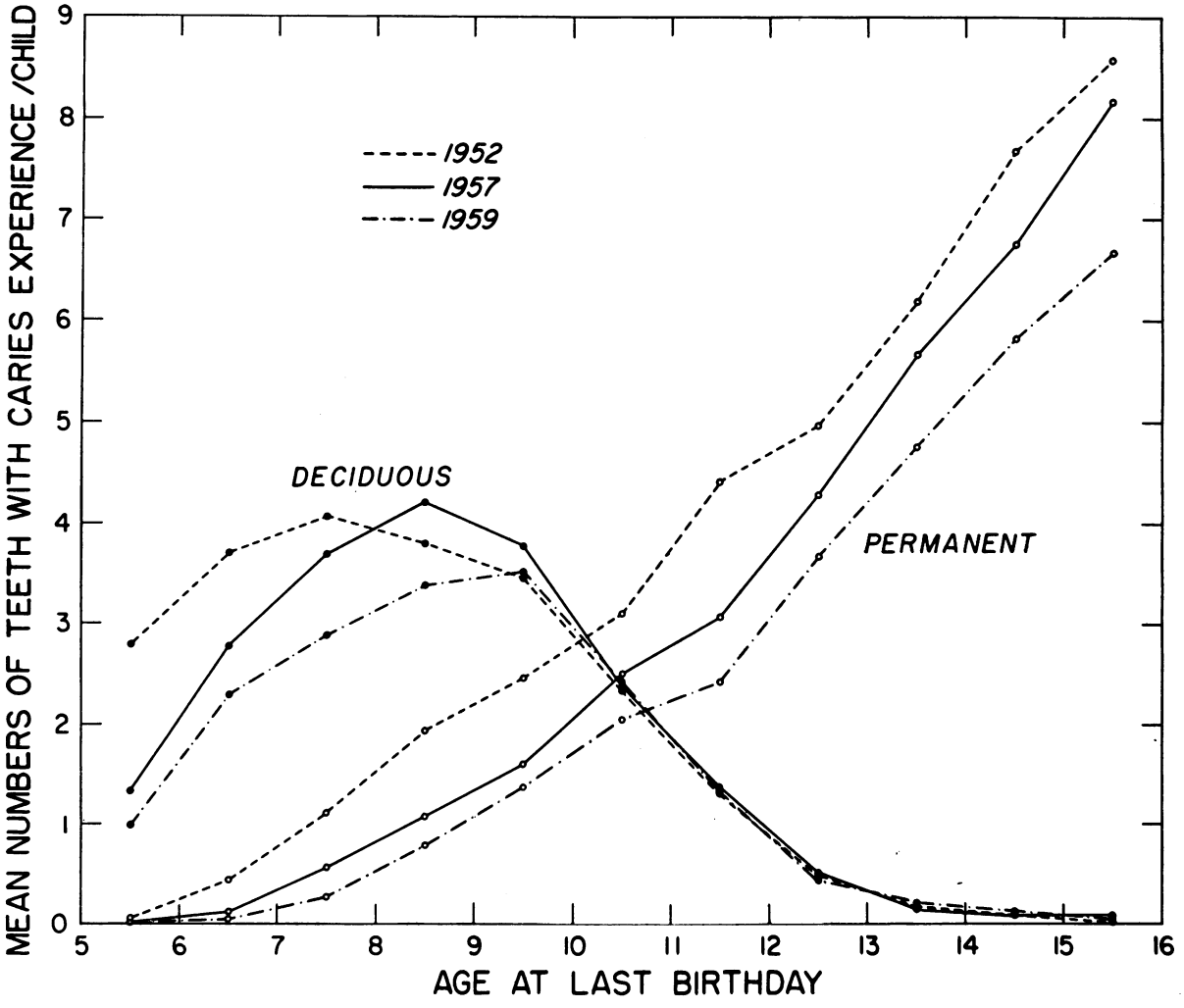
was 6.67 per child, a rate of 0.95 new DMF teeth per child per year. The actual increment from 1952 to 1959 in this age group was 4.76 new DMF teeth, an average of 0.68 new DMF teeth per child per year. Expected and observed increments for each of the age groups included in the 1959 survey are shown in table 3. In general, the younger the group at the time of fluoridation the greater the difference in incidence. The most striking differences are shown in children who were 2 years of age or younger at the time of fluoridation.

Permanent First Molars

Numbers of decayed, missing, and filled permanent first molars observed in children through 12 years of age in 1959 are shown in table 4. There were fewer DMF first molars in each age group than would have been predicted on the basis of the 1952 findings. Most of the benefit was seen in children aged 11 years or less; in this group of 1,436 children there were 1,060 fewer DMF first molars than would have been present in 1952. In general, the younger the age group at the time of fluoridation the greater the difference. Children aged 12 years in 1959, who received their first waterborne fluoride about the time these first molars were erupting, showed little reduction from the expected number.

Of these children—those aged 5–12 years in 1959—1,045 had also been examined in 1958. Their actual caries attack rates during the

Mean numbers of deciduous and permanent teeth with caries in native-born children of Montgomery and Prince Georges Counties, Md., 1952, 1957, and 1959



seventh year were likewise sharply lower than would have been predicted from 1952 data. In children aged 6 or 7 years, 5.0 percent of available first molars became carious for the first time during this period; in children aged 8 or 9 years, 11.4 percent; and in children aged 10 or 11 years, 13.8 percent. Attack rates for comparable age groups in 1952 were 17.0, 21.1, and 20.7 percent, respectively. Attack rates in children aged 12 years in 1959 were slightly higher than those computed for children of the same age in 1952.

Table 4. Expected and observed numbers of DMF first permanent molars in native-born children of Montgomery and Prince Georges Counties, Md., 1959

Age group (years)	Age at time of fluoridation	Number of children (N=1,887)	DMF first molars expected (Σ=3,808)	DMF first molars observed (Σ=2,692)	Difference (percent)
5	Unborn.	31	1	0	−100.0
6	Unborn.	244	98	23	[1]−76.5
7	<1	257	282	65	[1]−77.0
8	1+	237	446	181	[1]−59.4
9	2+	223	489	295	[1]−40.0
10	3+	226	576	416	[1]−27.8
11	4+	218	624	476	[1]−23.7
12	5+	451	1,292	1,236	−4.3

[1] Difference significant at the $P=.01$ level.

Older Children

In this study special attention has been given children aged 12–14 years because this group has, in the past, been slower than younger children to exhibit a caries-inhibitory effect following fluoridation. During the third year of fluoridation no decrease in the incidence of new carious teeth could be demonstrated in children aged 13 or 14 years at the end of that year (*3*). There was a decrease in incidence during the fifth year in children of these ages. The decrease was confined essentially to the six

Table 5. Mean numbers of DMF permanent teeth in 606 boys and girls 13 or 14 years of age at the end of the seventh year of fluoridation (1958–59), Montgomery and Prince Georges Counties, Md.

Tooth type	Mean numbers of DMF teeth			
	Start of year		End of year	
	Expected [1]	Observed	Expected [1]	Observed
Maxillary				
Central incisor	0.44	0.19 ±.021	0.50	0.28±.026
Lateral incisor	.45	.21 ±.022	.52	.28±.026
Cuspid	.04	.003±.002	.07	.02±.006
First bicuspid	.15	.11 ±.015	.27	.15±.019
Second bicuspid	.14	.11 ±.016	.25	.19±.021
First molar	1.37	1.44 ±.033	1.51	1.55±.030
Second molar	.42	.21 ±.022	.71	.38±.028
All maxillary teeth	3.00	2.26	3.83	2.85
Mandibular				
Central incisor	0.08	0.05 ±.012	0.08	0.08±.015
Lateral incisor	.07	.04 ±.013	.08	.06±.013
Cuspid	.02	.000±.000	.03	.01±.005
First bicuspid	.04	.04 ±.009	.09	.05±.011
Second bicuspid	.14	.09 ±.014	.24	.16±.018
First molar	1.63	1.59 ±.029	1.67	1.66±.027
Second molar	.76	.36 ±.028	1.09	.60±.034
All mandibular teeth	2.73	2.16	3.28	2.62
All teeth	5.72	4.42 ±.129	7.11	5.47±.162

[1] If rates observed in 1952 had remained unchanged.

tooth types which had erupted since fluoridation, amounting to a difference of about 12 percent in the total numbers of DMF teeth found at the end of that study year (*1*). At the end of the seventh year of fluoridation, this difference had increased to 23 percent, with a clear advantage accruing to each tooth type except the first molars and the mandibular incisors (table 5). Expectancies shown in this table differ somewhat from those computed for the fifth-year report, because the present study group differs from that seen 2 years ago in the ratio of boys to girls and in the distribution of ages.

Essentially the same numbers of teeth were in eruption in these older children as were seen in their counterparts in 1952. Had the 1952 rates persisted without change there would have been an average of 26.32 permanent teeth in eruption in these children at the beginning of the study year and 27.37 at the end. The actual means were 26.47 and 27.40 teeth, respectively.

Attack rates observed during the year in this group, together with rates which would have been observed had the 1952 patterns continued unchanged, are shown in table 6. As observed in the fifth year of fluoridation the degree of inhibition of caries is generally related to the developmental stage of the tooth at the onset of fluoridation. These children were 6 or 7 years of age when fluoridation was begun. Their first molars and their mandibular central incisors had been in eruption for an average of about 1 year at that time. Previous caries experience in these teeth and the numbers becoming carious during this seventh year were about what would have been predicted on the

Table 6. Expected and actual caries attack rates in 606 boys and girls 13 or 14 years of age during the seventh year of fluoridation, Prince Georges and Montgomery Counties, Md., 1958–59

Tooth type	Years at risk at start of fluoridation [1]	Mean DMF per child at start of year		Attack rate during year [3]		Total number of teeth becoming carious in year	
		Expected [2]	Observed	Expected [2]	Observed	Expected [2]	Observed
	Teeth in eruption and at risk of caries prior to fluoridation						
Mandibular central incisor	1. 10	0. 08	0. 05	0. 1	1. 4	0	16
Mandibular first molar	. 98	1. 63	1. 59	13. 1	17. 1	29	43
Maxillary first molar	. 88	1. 37	1. 44	22. 5	19. 6	85	67
Maxillary central incisor	. 05	. 44	. 19	3. 6	5. 3	32	58
Mandibular lateral incisor	. 03	. 07	. 04	. 5	1. 0	4	12
Total	. 61	3. 59	3. 31	4. 1	4. 8	150	196
	Teeth erupting after fluoridation						
Maxillary lateral incisor	−1. 03	0. 45	0. 21	5. 3	3. 9	46	42
Mandibular cuspid	−3. 04	. 02	. 00	. 6	0. 7	7	8
Maxillary first bicuspid	−3. 25	. 15	. 11	7. 0	2. 5	77	29
Mandibular first bicuspid	−3. 67	. 04	. 04	2. 5	0. 9	29	11
Maxillary cuspid	−4. 00	. 04	. 003	1. 7	0. 9	20	11
Maxillary second bicuspid	−4. 05	. 14	. 11	6. 3	4. 1	66	45
Mandibular second bicuspid	−4. 09	. 14	. 09	5. 7	4. 0	62	43
Mandibular second molar	−4. 55	. 76	. 36	28. 4	15. 7	201	148
Maxillary second molar	−5. 20	. 42	. 21	22. 0	10. 3	179	103
Total	−3. 61	2. 16	1. 13	7. 7	4. 5	687	440

[1] Measured from the median time of eruption to the mean age of the group at the time of fluoridation.
[2] If 1952 rates had remained unchanged.
[3] Percentage of teeth free of caries at the beginning of the year or erupting during the year which became carious during the year.

basis of the 1952 observations. The date of fluoridation coincided almost exactly with the median time of eruption of the maxillary central incisor and the mandibular lateral incisor. Only about half as many of these teeth as expected were carious at the beginning of the study year, but they were decaying at a somewhat faster rate than computed for children of the same ages in 1952, so that the margin of difference in these teeth can be expected to diminish with the passage of time.

Fluoridation preceded eruption by 1 to 5 years in all other tooth types. In these there were 48 percent fewer DMF teeth than expected at the beginning of the study year, and 36 percent fewer than expected became carious during this term of observation.

All of the teeth reported for children aged 13–14 years during the fifth year (*1*) had been completely calcified prior to fluoridation. In this seventh-year group a few cuspids and second bicuspids and most second molars would still have been in the process of calcification at the time fluoridation began (*4*).

Table 7. Dental caries patterns in permanent first and second molars before fluoridation and those observed during the third, fifth, and seventh years of fluoridation, in children aged 13 or 14 years at the end of the study year

Period	Mean number DMF at start of year	Mean number becoming DMF during year
	Permanent first molars	
Before fluoridation [1]	2.98	0.17
Third year	3.07	.23
Fifth year	3.14	.16
Seventh year	3.03	.18
	Permanent second molars	
Before fluoridation [1]	1.13	0.63
Third year	.72	.72
Fifth year	.65	.51
Seventh year	.57	.41

[1] Computed from 1952 baseline findings for an equal number of boys and girls at each age group, observed for exactly 1 year.

Discussion

In these findings, as in those of previous years, there is no indication of a caries inhibition large enough, and persistent enough, to affect the count of decayed, missing, or filled teeth in tooth types which were already in eruption at the time fluoridation began. Caries patterns in the deciduous teeth of children aged 9 years or older were essentially the same in 1959 as in 1952. The general pattern is illustrated in table 7, which shows expectancies and observed caries findings in children 12 or 13 years old at the outset who were examined again 1 year later. In the 1952 data there were 2.98 first molars per child and 1.13 second molars per child decayed, missing, or filled at the outset. These means increased by an average of 0.17 first molar per child, and by 0.63 second molar per child during 1 year. First molars have continued to decay at about the same rates during this study; the pattern after 7 years of fluoridation is almost identical with that seen in 1952. It is obvious that neither fluoride nor any other caries inhibitor has effected any essential change in the caries susceptibility of first molars in these children over the 7-year span.

Susceptibility of second molars in these children, on the contrary, has systematically been diminished according to the elapsed time since fluoridation of the community water. Second molars observed during the third study year had erupted about the time of fluoridation. While there were considerably fewer DMF second molars at the beginning of that year than had been seen in 1952, the attack rate observed during the year was somewhat higher than expected, so that the benefit gained may have been no more than a short delay in the time of onset of caries in these teeth. Children observed during the seventh year, by contrast, entered the year with only about half as many second molars decayed, and substantially fewer than expected became carious during the year. These teeth were in the final stages of calcification at the time of fluoridation. This pattern is consistent with the persistent and lasting inhibition of caries seen in adults who have lived in a

natural fluoride area essentially all their lives (*5*).

REFERENCES

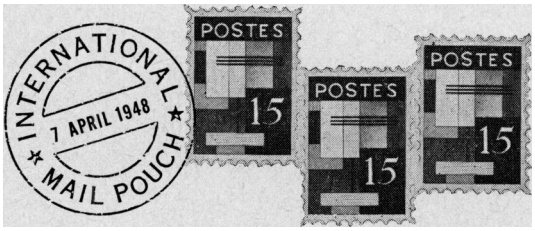
(*1*) Russell, A. L., and White, C. L.: Dental caries in Maryland children after 5 years of fluoridation. Pub. Health Rep. 74: 289–295, April 1959.

(*2*) Russell, A. L.: Oral health study in children of suburban Washington, D.C. Pub. Health Rep. 71: 626–632, June 1956.

(*3*) Russell, A. L.: Longitudinal technics in the study of oral disease. Am. J. Pub. Health 46: 728–735, June 1956.

(*4*) Chronology of the human dentition. *In* Kronfeld's histopathology of the teeth and their surrounding structures, edited by P. E. Boyle. Ed. 3. Lea & Febiger, Philadelphia, 1949, p. 41.

(*5*) Russell, A. L., and Elvove, E.: Domestic water and dental caries. VII. A study of the fluoride-dental caries relationship in an adult population. Pub. Health Rep. 66: 1389–1401, Oct. 26, 1951.



International Medical Research Center

Through a 5-year Federal grant, Louisiana State University will collaborate with the University of Costa Rica in establishing at San José an International Center for Medical Research and Training.

Although based in Costa Rica, the center's program will include cooperative scientific activities with other Central American countries in such fields as research in amebiasis; the control of intestinal parasites through evaluation of sanitation, therapy, and soil management; studies of viral and bacterial diarrhea common to Central America; fungal diseases; geographic studies of cardiovascular disease; and studies of unusual aspects of cancer in Central America.

The center will make available to the host country facilities for training physicians and scientific personnel and, at the same time, will enable U.S. physicians to study in an environment which is not available in this country.

Health Cooperation in the Middle East

Two regional conferences in the Middle East dealing with health matters are reported by the Public Health Division of the International Cooperation Administration.

The first conference, the CENTO Seminar on Teaching of Preventive Medicine in Medical Schools, was held in Shiraz, Iran, May 19–26, 1961. The meeting was attended by approximately 60 delegates from Turkey, Pakistan, Iran, the United Kingdom, and the United States.

The second conference was the ICA Near East-Southeast Asia Seminar on Water Supply Engineering and Management, held in Tehran, Iran, June 18–27, 1961. This was the first regional meeting of its kind, and was called to stimulate the concept that water is a community resource requiring judgment, organization, and authority for its best utilization.

This seminar was attended by engineering and waterworks experts from Jordan, Lebanon, Turkey, Iraq, Iran, Pakistan, India, and Nepal, and also by ICA and U.S. Operations Mission technicians.

From these meetings came a recommendation for formation of an association of sanitary engineers and waterworks men from the countries represented.

INCAP Director Decorated

Dr. Nevin S. Scrimshaw, former director of the Institute of Nutrition of Central America and Panama, has been awarded the Order of Rodolpho Robles by the government of Guatemala.

The decoration, one of the Guatemala's highest, was conferred upon Dr. Scrimshaw in recognition of the many achievements of the institute since its establishment in Guatemala City in 1949.

It was under Dr. Scrimshaw's directorship that a low-cost dietary supplement, INCAPARINA, was developed. This supplement increases the protein content of the diet and is especially efficient in combating malnutrition in children.