The development of primary teeth in children from a group of Gambian villages, and critical examination of its use for estimating age

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(*Received* 28 *November* 1967—*Accepted* 21 *December* 1967)

1. Numbers of erupted primary teeth were counted in young children in four rural villages in The Gambia. The ages of all children were precisely known, and their heights and weights were measured.

2. The majority of children were recorded as having an even number of teeth. The number of primary teeth present in children of given age varied widely. Up to 18 months of age, the Gambian children lagged behind American and European children in number of erupted teeth.

3. From the distributions, it appears that a child having no teeth is unlikely to be over 12 months of age, and one with all primary teeth is unlikely to be under 20 months. Between these dental limits, estimates of age from the number of primary teeth present are likely to be accurate to ± 3 or 4 months.

4. Children who were tall or heavy for age tended to have more teeth than those who were short or light. Thus, children with delayed dentition would be systematically assessed as younger than true chronological age.

5. There was, however, no evidence that slow growth was associated with prolongation of the total period of dental eruption, nor that seasonal variations in rate of growth were associated with similar variations in rate of tooth eruption.

Weights and heights of children at a given age are frequently used as an index of state of nutrition. In developing countries the precise ages of children can seldom be established and consequently nutrition surveys often include an assessment of age that is based partly on interrogation and partly on a medical and dental examination. Few detailed studies of the development of primary teeth in children reared in rural African communities have been made because of the paucity of reliable age records. Disparity between true and estimated age is therefore difficult to gauge. In a group of four adjacent rural Gambian villages, where birth records are maintained, height, weight and stage of primary dentition have been recorded periodically for several years. The results have been used to assess the adequacy of age assessment based on the development of primary teeth and the bias resulting from the use of ages so assessed in conjunction with values for height and weight.

EXPERIMENTAL

The information was obtained in 1962, 1963 and 1964 as part of a detailed study of health and growth (Thomson, Billewicz, Thompson, Illsley, Rahman & McGregor,

1968) and in 1966 and 1967 as part of a survey of the immunological status of the population (Rowe, McGregor, Smith, Hall & Williams, 1968). The children belonged to four neighbouring Mandinka villages situated nearly 100 miles from Bathurst, the capital of The Gambia. The villages are in a fairly isolated situation, being on a peninsula bounded by the Gambia river and one of its tributary creeks.

At each examination, almost all children in the villages within the relevant age range were seen. The ages of all were precisely known. The dental observations formed part of a more extensive medical examination and were all made under field conditions by one observer (I. A. M.). Teeth were inspected directly without the aid of a mirror and were recorded on a standard grid; any tooth which had at least partly broken through the gum was counted as present. A total of 3051 records were used in this analysis and the material has been treated cross-sectionally. Although many consecutive observations on the same children are available, the intervals are too long and too irregular to permit a useful longitudinal analysis. The results obtained during 1962–4 were first examined separately and then amalgamated with those of 1966–7 as no difference was found.

RESULTS

The order in which different teeth appeared was very variable, and the results below refer to the total number of teeth found at each examination. Excluding children with no teeth and those with a complete primary dentition, even numbers of teeth were recorded about five times as frequently as odd numbers. The age distributions of children with odd and even numbers of teeth were closely similar, so it was considered justifiable to group the numbers of teeth in the manner used in Table 1.

Sex. No differences were found between the sexes in the timing of dental eruption. In most of the tables the sexes are therefore combined.

Age. Table 1 shows the distribution of groups of teeth by age. It can be seen that the number of teeth that may be found at examination in children of a given age varies widely. The distributions of the numbers of teeth at 15, 16 and 17 months of age appeared to have a secondary mode at 11 or 12 teeth. No explanation can be given; most of these children were seen on later occasions and they did not differ from the remainder of children in these age-groups with respect to the total length of the dentition period.

At either extreme of the age range the distributions of the number of teeth erupted were highly skewed, so Table 2 gives, in addition to the mean and standard deviation, also the median and the minimum and maximum number of teeth recorded in each group. Table 3 compares the mean number of erupted teeth at given ages in the four Gambian villages with other published means.

The problem of estimating the age of a child having a given complement of primary teeth will now be considered. Percentages of children having a given number of teeth at a given age or earlier, graphed against log age (months) on probability paper, produce a series of points lying approximately along a straight line. When this property is used to smooth the observed percentages the results shown in Table 4 are obtained. There is a good agreement between the smoothed and the directly calculated percentiles of age. Ages can be estimated from the number of teeth present to within median age ± 3 or 4 months in 80 % of cases, and to within ± 2 months in half the cases. A child with no teeth is unlikely to be older than 12 months, and a child with a complete primary dentition is unlikely to be younger than 20 months (see Table 1).

Table 1. *Percentage distribution of the number of teeth present in Gambian children at a given age**

Age (months)	Number of teeth: 0	1 or 2	3 or 4	5 or 6	7 or 8	9 or 10	11 or 12	13 or 14	15 or 16	17 or 18 or 19	All milk	N
2–	100·0	—	—	—	—	—	—	—	—	—	—	136
3–	99·1	0·9	—	—	—	—	—	—	—	—	—	110
4–	98·4	1·6	—	—	—	—	—	—	—	—	—	123
5–	93·9	6·1	—	—	—	—	—	—	—	—	—	98
6–	87·6	11·5	—	0·9	—	—	—	—	—	—	—	113
7–	69·8	28·5	1·7	—	—	—	—	—	—	—	—	116
8–	63·7	30·4	3·9	2·0	—	—	—	—	—	—	—	102
9–	34·2	36·9	17·1	5·2	6·6	—	—	—	—	—	—	76
10–	25·0	26·9	27·8	13·9	6·5	—	—	—	—	—	—	108
11–	15·4	30·8	28·8	19·2	5·8	—	—	—	—	—	—	104
12–	7·0	17·4	33·7	19·8	20·9	—	1·2	—	—	—	—	86
13–	6·7	15·7	40·4	16·9	16·9	—	3·4	—	—	—	—	89
14–	1·2	8·5	25·6	20·7	23·2	9·8	9·8	—	1·2	—	—	82
15–	2·4	—	25·9	18·8	17·6	8·2	24·7	2·4	—	—	—	85
16–	—	1·2	17·3	22·2	13·6	9·9	28·4	3·7	3·7	—	—	81
17–	—	—	19·8	13·5	16·1	9·9	27·2	7·4	4·9	1·2	—	81
18–	—	—	9·2	14·9	9·2	5·7	27·6	17·2	11·5	—	4·6	87
19–	—	1·3	6·3	1·3	6·3	10·0	30·0	11·3	27·5	1·3	5·0	80
20–	—	—	2·2	5·6	7·9	10·1	25·8	14·6	20·2	5·6	7·9	89
21–	—	—	—	—	4·0	1·3	24·0	17·3	29·3	4·0	20·0	75
22–	—	—	1·2	—	—	3·6	19·3	15·7	22·9	7·2	30·1	83
23–	—	—	1·1	—	1·1	4·4	11·0	8·8	20·9	11·0	41·8	91
24–	—	—	—	1·1	—	1·1	6·9	9·2	24·1	10·3	47·1	87
25–	—	—	—	—	—	1·4	9·5	6·8	16·2	10·8	55·4	74
26–	—	—	—	—	—	—	2·9	1·5	8·8	7·4	79·4	68
27–	—	—	—	—	—	1·5	1·5	1·5	8·8	8·8	77·9	68
28–	—	—	—	—	—	—	1·3	—	6·5	11·7	80·5	77
29–	—	—	—	—	—	—	—	—	3·0	1·5	95·5	66
30–	—	—	—	—	—	—	—	—	2·6	2·6	94·7	75
31–	—	—	—	—	—	—	—	—	—	1·8	98·2	55
32–	—	—	—	—	—	—	—	—	—	—	100·0	67
33–	—	—	—	—	—	—	—	—	—	—	100·0	75
34–	—	—	—	—	—	—	1·4	—	—	1·4	97·1	70
35–	—	—	—	—	—	—	—	—	—	—	100·0	64
36–	—	—	—	—	—	—	—	—	—	1·8	98·2	56
37–	—	—	—	—	—	—	—	—	—	—	100·0	54

* All rows should add up to 100·0 %; small discrepancies are due to rounding off.

Health. If this method of assessing age is to be useful, it is necessary to ascertain whether the number of teeth erupted at a given age is affected by the state of health of the child or correlated with other criteria of the child's growth such as weight and height.

A scrutiny of medical examination notes of children developing a given complement of teeth early or late (below the 10th or above the 90th percentile of age) showed no

Table 2. *Mean, standard deviation and median number of teeth present in Gambian children at a given age. (Calculated from individual teeth and not groups shown in Table 1)*

Age (months)	No. of observations	Mean no. of teeth	SD	Median*
2–	136	0·0	0·0	0 (0–0)
3–	110	0·0	0·1	0 (0–1)
4–	123	0·0	0·3	0 (0–2)
5–	98	0·1	0·5	0 (0–2)
6–	113	0·3	0·8	0 (0–2)
7–	116	0·6	0·9	0 (0–3)
8–	102	0·8	1·2	0 (0–5)
9–	76	2·2	2·3	2 (0–8)
10–	108	2·9	2·3	2 (0–8)
11–	104	3·2	2·2	4 (0–8)
12–	86	4·5	2·5	4 (0–12)
13–	89	4·5	2·5	4 (0–12)
14–	82	6·4	3·1	6 (0–16)
15–	85	7·5	3·3	7 (0–14)
16–	81	8·4	3·6	8 (1–16)
17–	81	9·0	3·7	9 (4–17)
18–	87	10·9	4·3	12 (4–20)
19–	80	12·5	3·9	12 (2–20)
20–	89	12·9	3·9	12 (4–20)
21–	75	15·1	3·3	15 (8–20)
22–	83	15·8	3·5	16 (4–20)
23–	91	16·7	3·6	18 (4–20)
24–	87	17·4	3·1	18 (6–20)
25–	74	17·8	3·0	20 (9–20)
26–	68	19·1	1·9	20 (12–20)
27–	68	19·1	2·1	20 (9–20)
28–	77	19·4	1·5	20 (11–20)
29–	66	19·8	0·7	20 (16–20)
30–	75	19·8	0·8	20 (15–20)
31–	55	20·0	0·3	20 (18–20)
32–	67	20·0	0·0	20 (20–20)
33–	75	20·0	0·0	20 (20–20)
34–	70	19·9	1·0	20 (18–20)
35–	64	20·0	0·0	20 (20–20)
36–	56	20·0	0·1	20 (19–20)
37–	54	20·0	0·0	20 (20–20)

* Minimum and maximum number of teeth recorded in any age group is given in parentheses after the median.

Table 3. *Mean number of erupted teeth in children at given ages*

Age	USA*	London†	Paris†	Zurich†	Dakar†	Gambia‡
6 months	0·4	0·4	0·4	0·4	—	0·3
9 months	3·1	2·8	2·9	2·5	2·7	2·2
1 year	5·9	6·1	5·8	5·4	4·7	4·5
1 year 6 months	12·4	12·9	12·3	12·2	11·4	10·9
2 years	16·7	16·3	16·4	16·3	16·4	17·4
3 years	19·9	20·0	—	—	—	20·0

* Doering & Allen (1942). † Falkner (1957). ‡ This study.

differences. It would be, of course, more satisfactory to consider the health history of such children from birth to the date of the examination at which serious dental retardation or precociousness was found, but this was not possible as few children entered the study at birth and few were observed for a sufficiently long period.

Table 4. *Estimated percentiles of age (months) for a given number of teeth in Gambian children (observed percentiles in parentheses)*

No. of teeth	Percentile 10	25	50	75	90
1 or 2	6·7 (7·0)	7·9 (7·9)	9·6 (9·7)	11·6 (11·5)	13·7 (13·1)
3 or 4	10·1 (10·1)	11·5 (11·3)	13·3 (13·2)	15·3 (15·5)	17·4 (17·6)
5 or 6	10·7 (10·6)	12·1 (11·9)	14·0 (14·2)	16·1 (16·6)	18·4 (18·3)
7 or 8	11·5 (11·2)	12·9 (12·8)	14·8 (14·8)	17·0 (17·3)	19·2 (19·5)
9 or 10	14·8 (14·8)	16·4 (16·1)	18·3 (18·2)	20·5 (20·4)	22·6 (23·1)
11 or 12	15·5 (15·4)	17·1 (16·9)	19·1 (19·1)	21·3 (21·5)	23·6 (23·7)
13 or 14	17·8 (17·8)	19·2 (18·9)	20·9 (21·0)	22·7 (22·9)	24·5 (24·7)
15 or 16	18·8 (18·9)	20·4 (20·2)	22·3 (22·3)	24·4 (24·5)	26·5 (26·6)
17 or 18 or 19	21·1 (21·0)	22·9 (23·1)	25·1 (24·9)	27·4 (27·6)	29·7 (28·9)

Table 5. *Mean height (cm) of Gambian children having a given complement of teeth, by age and sex (numbers of observations in parentheses)*

Age (months)	Males		Females	
	No teeth	1 or more	No teeth	1 or more
5–	63·6 (45)	65·8 (3)	62·4 (47)	62·9 (3)
6–	65·2 (49)	66·8 (7)	63·6 (50)	64·0 (7)
7–	66·0 (39)	67·4 (17)	64·7 (42)	67·0 (17)
8–	67·1 (25)	67·9 (16)	65·3 (39)	66·5 (21)
	2 or less	More than 2	2 or less	More than 2
9–	67·9 (24)	69·3 (15)	67·3 (29)	66·7 (7)
10–	69·0 (27)	70·4 (22)	67·7 (27)	68·2 (30)
11–	67·9 (16)	70·6 (20)	67·2 (33)	69·1 (35)
	4 or less	More than 4	4 or less	More than 4
12–	70·5 (22)	70·8 (22)	69·1 (26)	71·4 (14)
13–	70·6 (26)	72·4 (17)	69·7 (29)	71·2 (16)
14–	70·0 (10)	72·1 (21)	69·3 (19)	71·9 (32)
	8 or less	More than 8	8 or less	More than 8
15–	73·1 (32)	73·6 (13)	71·7 (22)	73·2 (17)
16–	72·8 (22)	74·7 (20)	71·6 (22)	73·0 (17)
17–	73·2 (20)	74·3 (20)	72·7 (20)	74·7 (21)
	12 or less	More than 12	12 or less	More than 12
18–	74·2 (29)	75·1 (13)	73·9 (29)	75·1 (16)
19–	74·6 (22)	77·0 (16)	74·3 (21)	76·8 (20)
20–	74·6 (20)	76·4 (21)	74·3 (26)	76·5 (22)
	16 or less	More than 16	16 or less	More than 16
21–	76·2 (27)	80·1 (10)	75·8 (29)	78·0 (8)
22–	78·6 (23)	78·9 (13)	77·1 (28)	77·6 (18)
23–	77·4 (21)	78·4 (27)	76·7 (22)	78·7 (21)
	19 or less	All teeth	19 or less	All teeth
24–	78·4 (25)	79·9 (18)	78·0 (19)	79·6 (24)
25–	78·1 (18)	81·6 (23)	76·9 (14)	79·8 (17)
26–	79·9 (9)	80·0 (23)	77·7 (5)	80·7 (31)
27–	79·4 (10)	80·9 (27)	78·9 (5)	81·1 (26)
28–	82·2 (8)	83·2 (32)	79·9 (7)	81·6 (30)

McGregor, Rahman, Thompson, Billewicz & Thomson (1968) reported large seasonal variations in the increments of weight and height and in the incidence of communicable disease. There was no evidence of a similar variation in the eruption of teeth.

Height. To examine the association between the number of teeth at a given age and height, children were divided by age and sex, and each age × sex cell was divided into two groups: children having a given number of teeth or less and children having more than a given number of teeth. Table 5 shows that children who developed more teeth at a given age were taller than those with fewer teeth. The difference was observed in males and females and, in spite of small numbers in individual categories, was so consistent that no formal test is necessary to assert its significance.

Table 6. *Mean weight (kg) of Gambian children having a given number of teeth, by age and sex (number of observations in parentheses)*

Age (months)	Males		Females	
	No teeth	1 or more	No teeth	1 or more
5–6	6·6 (94)	7·0 (10)	6·3 (97)	6·3 (10)
7–8	6·8 (64)	7·4 (34)	6·5 (82)	7·2 (38)
	2 or less	More than 2	2 or less	More than 2
9–10	7·2 (52)	7·7 (37)	7·1 (57)	7·1 (37)
11–12	7·1 (28)	7·8 (54)	6·7 (42)	7·5 (67)
	4 or less	More than 4	4 or less	More than 4
13–14	7·4 (36)	8·1 (38)	7·1 (49)	7·8 (48)
15–16	7·7 (23)	8·2 (64)	7·3 (16)	7·9 (63)
	8 or less	More than 8	8 or less	More than 8
17–18	8·0 (37)	8·7 (45)	7·8 (32)	8·6 (54)
	12 or less	More than 12	12 or less	More than 12
19–20	8·4 (43)	9·1 (37)	8·2 (47)	8·9 (42)
	16 or less	More than 16	16 or less	More than 16
21–22	9·2 (51)	9·8 (23)	8·8 (58)	9·5 (26)
	19 or less	All teeth	19 or less	All teeth
23–24	9·2 (51)	9·9 (40)	8·8 (48)	9·7 (40)
25–26	9·0 (28)	10·3 (46)	8·5 (19)	10·0 (48)
27–28	10·0 (18)	10·7 (59)	9·2 (12)	10·2 (56)

Weight. For the examination of the association between the number of teeth at a given age and weight, it was necessary to take season at which observations were made into account, since weight varies with season in The Gambia (McGregor *et al.* 1968). To obtain adequate numbers within age-and-season groups, ages were amalgamated into 2-monthly periods. Within each season the tendency for children with more teeth at a given age to be heavier also was clearly apparent. Table 6 shows that, for all seasons together, children with a greater number of teeth were consistently heavier than those with a smaller number of teeth.

DISCUSSION

The evidence for a sex difference in the time or eruption of primary teeth is conflicting. Robinow, Richards & Anderson (1942) found that boys are in advance of girls. Similarly, Ferguson, Scott & Bakwin (1957) found that boys lead with respect to the eruption of the first tooth and have more teeth than girls at 1 year of age. Doering & Allen (1942), Sandler (1944), Falkner (1957), Nanda (1960), Lysell, Magnusson & Thilander (1962) and Kosiewski, Waliszko & Wich (1966) found no difference between sexes. In the present series no difference between boys and girls was found at any age.

Since the sequence of primary dentition is far from constant, the number of erupted teeth, irrespective of the order of appearance, was selected as the variable under study. At examination an even number of teeth was found much more frequently than an odd number. This, perhaps, is not surprising; the findings of Lysell *et al.* (1962) show that, in the average order of appearance, the interval between the eruption of the first and second tooth of a given pair is much smaller than the interval between pairs.

There was no evidence of seasonal variation in the eruption of teeth in spite of the large seasonal fluctuations in the increments of weight, height and the incidence of disease found by McGregor *et al.* (1968).

Opinion as to the effect of health on the timing of eruption appears to be divided. Boas (1927), comparing two series of Hebrew infants, suggested impaired health of children in one series as the explanation of delayed tooth development, but provided no positive evidence of ill health. Hamil, Reynolds, Poole & Macy (1938) found that children developing mild scurvy and rickets did not differ from a group of healthy infants. Stearns & Meredith (1945) found that male infants ingesting 300–400 USP units of vitamin D daily and having superior records for freedom from illness erupted their incisor teeth earlier than the remainder of children in the study. In the present series an analysis of medical examination records of children developing a given complement of teeth early or late (below the 10th and above the 90th percentile of age) showed no difference. Although complete health histories of such children were not available, this result, together with the lack of seasonal variation in the eruption of teeth, suggests that an association between the state of health and dental eruption times, if any exists, was too weak to be detected.

Comparison of various studies giving the mean number of teeth erupted at given ages shows that up to 18 months of age Gambian children are well behind American and European children. Since the ages of Gambian children were recorded in completed months, the difference is probably greater than that shown in Table 3 since the children were on the average about 2 weeks older than the indicated ages. There is no evidence, however, of a prolongation of the total period of dental eruption. The difference between the Gambian and the American or the European series is similar to that shown by Lysell *et al.* (1962) for premature by weight and non-premature infants. Since the average birth weight in the four Gambian villages is about 0·5 kg lower than in Western countries, part of the difference shown in Table 3 may be due to a greater preponderance of infants of low birth weight.

Provided that some but not all primary teeth are found at examination, the number of erupted teeth can be used to estimate the age of a child with an error rarely exceeding ± 3–4 months. Such estimated (median) ages cover the range 9–25 months; little can be said about the age of a child found at examination to have no, or a full complement of primary teeth. In terms of age-predictive value, our results appear to conform with those obtained by Voors & Metselaar (1958) in New Guinea.

Prediction of age from the primary dentition, within the limits indicated, may be useful under certain circumstances; but if 'dental age' is to be related to measurements of growth it is necessary to be sure that growth and state of dentition are not associated. Robinow *et al.* (1942) found no correlation between dentition and skeletal maturity or height. Lysell *et al.* (1962) found that the tooth development of fast-growing infants in Sweden was slightly ahead of that of slow-growing infants, but not to a statistically significant degree. In the present African series, children of either sex who developed more teeth at a given age were, on average, appreciably taller and heavier than those with fewer teeth. The differences are not likely to be due to an excess of children of low birth weight among those with fewer teeth; the differences of height and weight were observed over the whole age range instead of diminishing with rising age, when differences of tooth development between premature and non-premature infants tend to disappear.

It follows that children with delayed dentition may tend to be assessed as younger than their true chronological age, at least in conditions where impaired growth is present. Voors (1957) concluded from a review of the literature that: 'Under the age of two years, the use of dental age in nutritional studies where chronological ages are unknown, is statistically justified if due confidence intervals are taken into account.' This appears not to be universally true.

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Printed in Great Britain