Community Dent. Oral Epidemiol. 1977; *5*: 30–39
(Key words: *dental caries; dental plaque; Indians; periodontal disease*)

Plaque, caries, periodontal diseases, and acculturation among Yanomamö Indians, Venezuela

C. J. Donnelly*, L. A. Thomson, H. M. Stiles, C. Brewer**, J. V. Neel and J. A. Brunelle
National Caries Program, National Institute of Dental Research, National Institutes of Health, Bethesda, and Department of Human Genetics, University of Michigan Medical School, Ann Arbor, U.S.A.

ABSTRACT – The number of DM and d teeth and surfaces was recorded for 220 Yanomamö Indians from three groups of villages with different degrees of contact with Western culture. Specimens of plaque were taken from the teeth, transported in a holding solution, cultured and examined for specific oral streptococci. In addition, the periodontal health and oral hygiene of one group of villagers were assessed using the Russell PI and the Greene & Vermillion OHIS. Caries experience among the Yanomamö was shown to be positively associated with exposure to Western culture. *S. mutans* was recovered with about the same frequency from specimens taken from the teeth of Indians living at all three village locations. However, the presence of *S. mutans* alone did not account for the disparity in dental caries scores. The examinees had abundant and persistent accumulations of soft deposits on their teeth accompanied by markedly inflamed gingival tissues. However, periodontal pockets and loss of appreciable amounts of bone did not appear as early in life nor were they as severe as reported for some other populations which practice little oral hygiene. Those disparities in the distribution of plaque-induced oral diseases between Western populations and the Yanomamö warrant further study.

(Accepted for publication 2 September 1976)

The nature of the profound biomedical and cultural transition that has ensued when, during the past 500 years, primitive populations have come in contact with representatives of the Western world, is still poorly understood. Opportunities for significant studies are rapidly disappearing, as the number of relatively uncontacted populations steadily dwindles all over the world. With this in mind, a group of American, Venezuelan, and Brazilian scientists some 10 years ago initiated broad-gauge studies of the Yanomamö Indians, a tribe residing in a region drained by the Upper Orinoco River and its tributaries and some of the northern tributaries of the Amazon River, the precise area approximately bounded by latitudes 1° and 5° N and longitudes 62° and 65°30′ W (Fig. 1). There are estimated to be some 12,000 Yanomamö, dispersed among about 150 villages. Although the area in which they live was traversed by some of the early explorers of this region, sustained contacts with representatives of Western culture date from the early 1950's, when a few missionaries began to penetrate the region. Descriptions of the Yanomamö and of the program and the results to date have been published earlier[3,20–22]. Pererira & Evans[25] have described a Yanomamö population living in northern Brazil with detailed data on their occlusal relationships.

One focus of these studies has been the documentation, where possible under difficult field conditions, of the early stages of changes in disease patterns and immunologic status. Because the relative freedom of primitive humans from dental caries, and the rapid development of this condition upon contact with civilization, are well known[2,7,26,37] it seemed that observations on caries should be one aspect of the Yanomamö program. Preliminary ob-

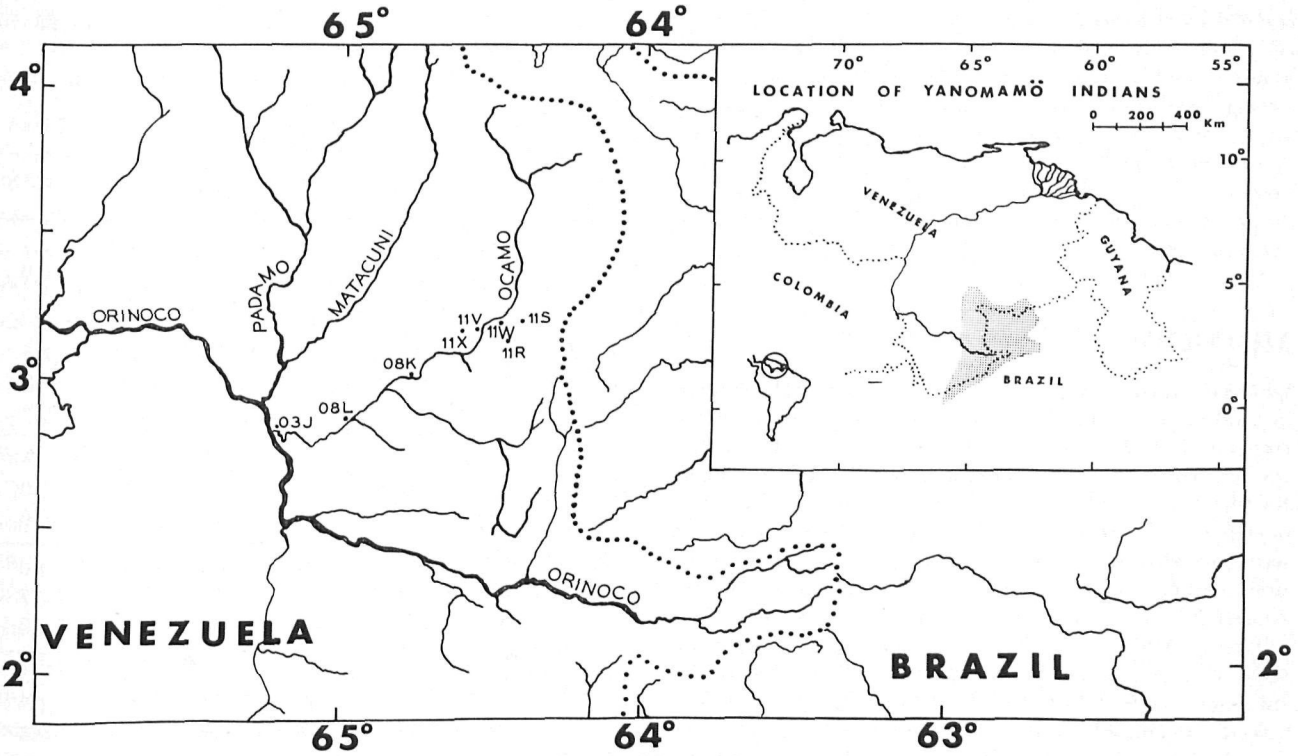

Fig. 1. Map showing location of Yanomamö Indian villages. (Ocamo Mission 03J, Wabatawatedi 08K, and Arata Falls villages 11R, 11S, 11V, 11W and 11X.)

servations made by one of us (C.B.) during the fieldwork of 1967 revealed an unusual epidemiologic situation: at the village of Iaweitedi, which is situated at the junction of the Ocamo with the Orinoco River, and which has a history of 11 years of close contact with an immediately adjacent Salesian Mission, the mean number of decayed and missing teeth (DMT) for 56 adolescent and adult Indians was 2.14 (village 03J in Fig. 1). At the village of Yabrobratedi (08L), approximately 58 km up the Ocamo River, the figure for 32 Indians was 1.53, and at Wabutawatedi (08K), some 42 km on up the Ocamo, the mean DMT for 40 Indians was 0.70. There was thus the clear implication of the existence of some cariogenic influence at the Mission. In this connection, it should be noted that the people in the Mission used refined foods (flour, sugar, salt), a small but indeterminate amount of which found its way to the Indians, and that visits of members of one village to another occurred, but with a frequency difficult to document.

The study reported here was undertaken in 1971 as a specific response to these preliminary findings, with the following objectives: 1) to confirm, under more favorable conditions, the earlier findings on caries prevalence. In this connection, it was decided to extend the observations to a cluster of seldom contacted villages still higher on the Ocamo, but, for practical reasons, to omit from reexamination the Yabrobratedi; 2) to determine whether relationships exist between the caries experience among Yanomamö villagers and data obtained from bacteriologic cultures of their dental plaque material; and 3) to record the presence or absence of disease of other oral structures in these Yanomamö villages.

MATERIAL

Two of the populations studied were the inhabitants of the previously mentioned villages of Iaweitedi (03J) and Wabutawatedi (08K). In each of these villages it was possible to examine approximately 70 % of inhabitants 6 years of age or older. The third population was drawn from a group of five villages located near the Ocamo River approximately 25 km above Wabutawatedi (11R, S, V, W, X). At this point there are extensive rapids, which made further ascent of the river with the heavy dug-out canoes used by the expedition impossible; a base camp was, therefore, established here. One of the five villages was then

reached by the team, but inhabitants of the other four villages were examined when they came to the camp in response to an invitation carried by a messenger. Under these circumstances it is impossible to determine how representative the 77 Indians examined were of their villages, but there is no reason to suspect a bias with reference to caries experience. These villages have experienced virtually no direct contacts with the Mission or other extensions of Western culture.

METHODS

Oral examinations were made using mirrors and explorers in good natural light. The time available did not allow the removal of hard or soft deposits from the teeth. Caries status was assessed on all examinations by a DMT count[15] for all 32 teeth. Only those teeth and surfaces for which objective signs of caries activity could be demonstrated were recorded as decayed. In addition at Wabutawatedi, time permitted recording of the periodontal health by the Russell PI[28] and oral hygiene status by the Greene & Vermillion OHIS[11]. Plaque material was obtained from the teeth of most examinees from all three village groups. The specimens were taken (1) from an interproximal area (usually the distal of a mandibular second premolar and mesial of the first molar) by placing a cleoid excavator just above the gingival tissue contacting both teeth and drawing the instrument upward toward the occlusal surface, (2) from the buccal surfaces of two or three mandibular teeth using a cleoid excavator, and (3) when possible from an occlusal fissure using a shepherd's hook explorer. Generally, occlusal specimens were obtained only from the younger Indians since by adulthood most occlusal fissures had been obliterated by wear. Instruments were flamed before taking the specimens. The plaque material collected from the teeth was placed in a screw-top vial containing VMG II transport media[18], and specimens were returned to the National Institute of Dental Research in two separate shipments. Those from teeth of isolated Indians living near Arata Falls were sent by boat to the Ocamo Mission, by bush pilot to Caracas, and then by air to NIDR laboratories at Bethesda, Maryland, for processing. Specimens were collected on the last day of examinations in Wabutawatedi and with those from the teeth of Ocamo Mission Indians were returned by bush pilot and commercial airline to the United States. The processing of all specimens was begun immediately upon arrival at NIDR and all were processed within 5 days after date of collection.

At the NIDR laboratory, each plaque-containing specimen was thoroughly mixed with a Vortex mixer; dilutions of 1.200, 1:2,000, and 1:20,000 were made using 0.05 % yeast extract and 0.1 ml of each dilution was placed on mitis salivarius agar and dispersed with the aid of a sterile rod. All samples were incubated 18–24 hours anaerobically, using Gas-Paks® (BBL) and then allowed to stand 18–24 hours at room temperature after which the total colony-forming units on the plates were determined. Speciation of the various streptococci on the agar plates was then determined and recorded using criteria based on work by JORDAN, KRASSE & MÖLLER[13], THOMSON[34] and THOMSON & FACKLAM[35].

Table 1. Distribution of decayed and missing permanent teeth and surfaces by village and age group

Age group, years	Village	No. of examinees	Percent caries free	Mean no. DMT	Mean no. DMS
6–11	Ocamo	13	54	1.2	2.5
	Wabutawatedi	6	100	0.0	0.0
	Arata Falls	6	100	0.0	0.0
12–19	Ocamo	11	45	2.4	5.1
	Wabutawatedi	20	85	0.4	0.8
	Arata Falls	24	88	0.3	0.9
20–39	Ocamo	25	64	0.8	2.6
	Wabutawatedi	32	72	0.9	1.9
	Arata Falls	29	85	0.2	0.6
40 and over	Ocamo	15	60	0.9	4.0
	Wabutawatedi	11	45	1.5	2.7
	Arata Falls	8	63	0.5	2.0
All	Ocamo	64	58	1.2	3.3
	Wabutawatedi	69	74	0.8	1.7
	Arata Falls	77	84	0.3	0.8

RESULTS

Since only one of the two dentists (C.J.D.) made observations at all three locations, the data reported here will be limited to his observations. The distribution by age group for examinees in the three village groups is given in Table 1. Since the Yanomamö do not record age, it was necessary to use estimates. The stage of eruption of the permanent teeth was a useful guide in estimating age for children and young adolescents. At Ocamo, recorded birth dates were available for those children born after the establishment of the Mission; for all others examined at Ocamo, age estimates made by the missionaries were used.

Caries experience in the permanent dentition among the Yanomamö Indians (Table 1) was appreciably less than that observed for groups examined in the United States and most other developed areas[6]. In contrast to the almost universal prevalence of caries among populations of Western countries, less than half of those examined at the Ocamo

Mission had one or more carious teeth. At Wabutawatedi and Arata Falls the percent of examinees with caries was 26 and 16, respectively. Mean numbers of DM teeth and DM surfaces per examinee were correspondingly low. Appreciably fewer teeth of the isolated Arata Falls Indians experienced decay than of their Ocamo counterparts who for 14 years had continuous exposure to the missionaries' Western way of life. The DM tooth and surfaces scores for examinees at Wabutawatedi were approximately midway between those recorded for mission and for isolated Indians. Differences in the caries experience among the three village groups were more striking for the younger subjects. Less than 10 % of the 6- to 20-year-old Indians of Wabutawatedi and Arata Falls villages were observed to have one or more decayed teeth, while at the Mission approximately 50 % of the same age group had one or more carious lesions.

Although DMT is a cumulative count of the number of permanent teeth affected and in theory cannot decrease as individuals age, some reduction with age in the number of carious lesions recorded can, in fact, occur among populations such as the Yanomamö when slowly developing incipient lesions are obliterated by relatively rapid wear of the occlusal surface. Any significant reduction in the D count attributable to attrition should be observable among adults of all villages. However, only among Ocamo Indians was a reversal of the usual increase in caries experience with age observed. The mean DMT count was less than 1 for Ocamo Indians over 20 years of age, 2.4 for those 12–19 years old, and 1.2 for 6- to 11-year-old examinees.

Caries prevalence was higher in the primary than in the permanent dentition of Indian children at the Ocamo Mission (Table 2). Of 21 children aged 4–11 years, only three were free of visually detectable carious lesions. The mean number of decayed primary teeth (dt) per person was slightly greater than four. Seven of the 12 6- to 11-year-old children examined at the other two villages were free of caries. Their mean dt was less than that of their Ocamo counterparts, but it should be noted further, that one of the two Arata children affected had three severely decayed maxillary incisors and contributed 17 surfaces to the mean DMS.

Carious areas were observed more frequently on fissured and pitted surfaces than on proximal surfaces. The occlusal surfaces of permanent teeth were affected two to three times more frequently than any other surface. Two- and three-surface lesions involving the occlusal and proximal surfaces are frequently observed in developed countries but were recorded relatively infrequently for the Yanomamö.

Evidence of caries was bilateral, i.e. affecting both right and left members of contralaterally matched surfaces, for only 30 % of 381 permanent surfaces recorded as decayed or missing. More striking is the relative infrequency with which proximal lesions were observed on both abutting surfaces. In only 11* of 101 instances (in one instance, one of the approximating surfaces was on a primary tooth) in which caries involved a permanent proximal sur-

Table 2. Distribution of decayed primary teeth and surfaces by village and age group

Age group, years	Village	No. of examinees	Percent caries free	Mean no. dt	Mean no. ds
4–5	Ocamo	8	25	4.4	8.0
6–8	Ocamo	8	0	4.2	7.5
	Wabutawatedi	3	67	1.7	2.0
	Arata Falls	4	50	1.5	5.0
9–11	Ocamo	5	20	4.2	12.6
	Wabutawatedi	3	33	1.0	2.7
	Arata Falls	2	100	0.0	0.0
All	Ocamo	21	14	4.3	9.0
	Wabutawatedi	6	50	1.3	2.3
	Arata Falls	6	67	1.0	3.3

Table 3. Presence of streptococci and caries experience by village

Village	No. of examinees cultured	Examinees with streptococci in culture		Mean no. DMT for examinees with streptococci
		n	%	
Ocamo	71	60	85	0.90
Wabutawatedi	68	58	85	0.51
Arata Falls	78	78	100	0.23
Village 1	18	18	100	0.22
Village 2	14	14	100	0.14
Village 3	26	26	100	0.35
Village 4	20	20	100	0.15

Table 4. Presence of *Streptococcus mutans* and caries experience for examinees with any streptococci in culture

Village	Examinees with any streptococci in culture		Examinees with *S. mutans* in culture			Examinees with no *S. mutans* in culture		
	n	Mean no. DMT	*n*	%	Mean no. DMT	*n*	%	Mean no. DMT
Ocamo	60	0.90	27	45	1.53	33	55	0.24
Wabutawatedí	58	0.51	22	38	0.71	36	62	0.39
Arata Falls	78	0.23	32	41	0.34	46	59	0.15
Village 1	18	0.22	10	56	0.40	8	44	0.00
Village 2	14	0.14	5	35	0.41	9	65	0.00
Village 3	26	0.35	6	23	0.50	20	77	0.30
Village 4	20	0.15	11	55	0.18	9	45	0.11

face, were both approximating surfaces affected. In the primary dentition of children living at the Ocamo Mission carious lesions occurred on both surfaces of a contralateral pair with about the same frequency as on a single surface. In addition, about half of all the proximal decayed surfaces were abutting pairs.

Table 3 shows the number of individuals from whom plaque material was cultured in each of the three areas and the number and percent of those whose plaque samples contained any streptococci at all. Only in the most remote area, Arata Falls, did 100 % of the plaque samples obtained produce detectable numbers of streptococci. Although there is decreasing caries experience from the Ocamo Mission upstream on the Ocamo River to Arata Falls, there is no parallel change for the proportion of plaque specimens producing streptococci. Qualitative data, such as these, do not reflect quantitative differences which may exist among individuals or village groups. Among those persons with streptococci, mean DMT was computed for those individuals with *S. mutans* and those without (Table 4). The general pattern of decreasing DMT with increasing distance from the Mission was apparent for those with any streptococci as well as those with *S. mutans* but was most striking for those with *S. mutans*. Mean DMT counts were higher for Indians with *S. mutans* from all three village areas than for those without *S. mutans*. The difference in DMT was greatest for the Indians at the Mission, where some sucrose was imported.

The association between presence of *S. mutans* and caries experience can be examined further and more directly by considering the frequency distribution of examinees with and without *S. mutans* by their caries status for all three village groups (Table 5). Although a positive correlation between presence of *S. mutans* and proportion of examinees with evidence of caries experience can be demonstrated with the data from Ocamo Indians, a similar association can not be demonstrated with the data from either Wabutawatedi or Arata Falls Indians. *S. mutans* were not recovered from relatively high

Table 5. Relationship between caries experience and presence of *Streptococcus mutans*

Village	Examinees			
	One or more DMT	Caries-free	Total	
Ocamo				
Mutans	21	6	27	
No mutans	17	27	44	$\chi^2=8.79$*
Both	38	33	71	
Wabutawatedi				
Mutans	9	13	22	
No mutans	12	34	46	$\chi^2=0.92$
Both	21	47	68	
Arata Falls				
Mutans	7	25	32	
No mutans	5	41	46	$\chi^2=1.01$
Both	12	66	78	

* $P < 0.01$.

Table 6. Distribution of PI and OHIS scores by sex for examinees at Wabutawatedi

Age group, years	Sex	No. of examinees	Mean debris score	Mean calculus score	Mean OHIS score	Mean PI score	Percent with pockets
12–19	Male	12	1.67	1.50	3.17	1.60	0
	Female	6	1.67	1.00	2.67	0.72	0
	Both	18	1.67	1.33	3.00	1.32	0
20–39	Male	17	1.83	1.67	3.50	2.37	30
	Female	15	1.67	1.67	3.33	1.58	0
	Both	32	1.67	1.67	3.33	2.00	15
40 and over	Male	8	2.00	2.33	4.33	2.52	62
	Female	3	2.00	2.00	4.00	2.95	33
	Both	11	2.00	2.16	4.16	2.64	55
All	Male	37	1.83	1.67	3.50	2.16	37
	Female	24	1.67	1.50	3.17	1.54	4
	Both	61	1.83	1.67	3.50	1.91	18

percents (82, 72 and 62) of examinees from the three villages who had no obvious carious lesions, but colonies of the organism were identified for only 55, 43, and 58 % of Indians with obvious carious lesions from whom specimens were taken at Ocamo, Wabutawatedi, and Arata Falls, respectively. For the same order of villages, 22, 59 and 78 % of Indians whose cultured plaque specimens produced colonies of *S. mutans* were classified as free of obvious carious lesions.

S. mutans were recovered with greater frequency from plaques sampled from the occlusal fissures than from the other two sites. Indeed, some specimens taken from occlusal fissures produced relatively pure cultures of *S. mutans*.

The periodontal tissues and hard and soft deposits on the teeth of subjects in Wabutawatedi were also examined. These findings are reported for all examinees over 12 years of age in Table 6. The mean PI score increased from 1.32 for 12- to 19-year-olds to 2.64 for those 40 years of age and over. No periodontal pockets were recorded for examinees estimated to be under 30 years of age and although an appreciable number of older individuals had visually detectable pockets, severe advanced destruction of the supporting tissues was not observed. Females had slightly lower PI scores, and pocket formation was confined almost exclusively to males. There were abundant amounts of deposits on the teeth of most male and female Indians examined. For the 12- to 19-year-old age group the mean debris score was 1.67 and the mean calculus score was 1.33. As expected, both mean scores increased with age, to 2.00 and 2.16, respectively, for the 40 years and over age group.

DISCUSSION

Numerous surveys of caries experience suggest that the development of carious lesions is a function of tooth morphology plus time at risk and that the pattern of caries development is quite similar in populations of Western culture[6]. Many pit and fissure sites decay shortly after the tooth erupts into the mouth[5,17]. Caries on smooth proximal surfaces develops more slowly[5] and often involves both of the abutting surfaces[16]. The free smooth surfaces offer the greatest resistance to demineralization[5,27]. The tendency for caries to develop at approximately the same time on the same surface of like teeth is so strong that it has been suggested that a count of the DMF teeth for half of the mouth is as accurate a measure of caries experience for a group as the count for all teeth[36]. In addition, in Western populations caries affects a large proportion of the permanent teeth and nearly 100 % of the population[6].

The deviations from this usual pattern noted from an examination of the data collected on the caries experience of the Yanomamö Indians are of interest. The percent of individuals affected and the total caries prevalence were low for all three Indian groups. The slightly higher experience observed

among the Mission Indians affected the young more strongly, giving an age-specific caries curve which increased to a peak at age 12–15 years and then decreased. A similar decrease in the total caries experience with age has been reported by RUSSELL[30] for Scouts in the Alaskan National Guard, by MOORREES[19] for Alaskan Aleuts and by PEDERSEN[24] for Greenland Eskimos; populations which also were examined several years after sustained contact with Western culture was established. This low caries experience of adults, even after exposure to Western ways, might be due to some previously acquired resistance of their teeth to cavitation or possibly to a reluctance, as a group, to adopt certain Western customs. If, indeed, the younger Yanomamö were more affected by cultural changes and if the factor(s) responsible for increased caries experience has (have) an influence after sustained contact with Western peoples then the effects should be apparent in the DM counts of those ≤ 20 years at the time of examination, since the recently erupted pit and fissured first molar surfaces of 20-year-olds were at risk when the Mission was established. Such an early effect, although not apparent in the data presented in Table 1 cannot be discounted because most 16- to 20-year-old Indians at Ocamo were hunting, fishing or working during the daylight hours and not available for examination.

The low prevalence of bilaterally symmetric carious lesions in the permanent dentition suggests an independent or haphazard pattern, in contrast to the high degree of symmetry reported for Western populations[1,31,36]. Of greater interest is the low frequency with which cavitation was recorded on both mesial and distal surfaces of an approximating pair. These abutting surfaces are subject to the same environmental influences and in Western populations behave like a single site for caries attack[16]. In addition, the relatively few two- and three-surface proximo-occlusal carious lesions recorded suggest that the usual pattern of early occlusal fissure caries followed by later independent attack on the proximal surfaces was not occurring. These observations lead to the speculation that, although the carious lesions observed among these Indians often involved more than one and often all surfaces, the initial attack may have been on a single pit or fissured surface which later with time extended to the others. The interaction of agent, host, and environmental factors which contribute to the cariogenic challenge of the Yanomamö living in relative isolation may limit cavitation mainly to sheltered protected areas of a developmental defect. A bitewing radiographic examination would establish whether or not the smooth proximal surfaces were sites of independent initial caries development, and could also verify changes in the level of cariogenic challenge if indeed that challenge is intensified by the introduction of foods rich in fermentable carbohydrate which induce cavitation also on surfaces free of developmental defects. The limited data on the primary dentition do not contradict that such a change in cariogenic potential may be occurring among children at the Ocamo Mission. Approximately 50 % of carious lesions among 6- to 11-year-old children were two- and three-surface lesions involving one or both proximal surfaces.

It is a generally accepted concept that some of the oral microflora contribute to the caries process in humans as well as rodents[8,23,30,39]. Of these microflora, *S. mutans* has been widely discussed with respect to its role in the odontolytic process[33]. While *S. mutans* was isolated from plaque for approximately the same proportion of examinees from all three village sites, the correlation between presence of the organism and presence of one or more carious lesions was significant only for Ocamo Indians, suggesting that some other factor may have been operative here. The availability of sucrose at the Mission and its absence in the villages supports the widely accepted premise that interaction of all three factors – host, agent, and environment – is required for the development of carious lesions[14,33]. Recent research[4,9,32] suggests that the number of surfaces colonized and the proportion of *S. mutans* in samples are useful indicators of cariogenic potential. This suggestion is supported by the finding that for plaque samples collected at the three village sites, those from the Mission Indians had both the greater quantitative prevalence of mutans in smooth surface specimens and the higher proportion of surfaces from which mutans were isolated.

These observations suggest, therefore, that the gradient in dental caries can not be explained solely by the presence or absence of *S. mutans* in cultures of plaque specimens collected during a single examination.

To assess the potential influence of waterborne fluoride on caries experience, samples of water from sources used for drinking and cooking were taken

at all three sites and analyzed for fluoride content. (The sample taken from the Ocamo River near Arata Falls represents the source for only one village, since the four located inland were not visited.) Fluoride concentration was uniformly low; of the six water samples analyzed, fluoride content ranged from 0.04 to 0.06 parts/10^6.

Of all the factors for which an association with periodontal disease has been reported, oral hygiene and age are said to account for most of the correlation[10]. Periodontal health has been shown to deteriorate both as the amounts of plaque and calculus increase and as the length of exposure to these deposits increases[28]. It is generally thought that constant, long, and undisturbed exposure to plaque and its products results in progressive destruction through a sequence of inflammation, pocket formation, loss of bone and eventual loss of teeth.

For the Yanomamö at Wabutawatedi, both the debris and calculus scores were high at the age of 12–19 years suggesting the absence of oral hygiene practices during the years of childhood. Since even heavier accumulations were observed in all adult age groups, it might be expected that the tissue response to a long continuous exposure to these local irritants would be both extremely severe and extremely destructive. Acute severe inflammation of the papillae, marginal, and attached gingival tissues circumscribing all teeth was observed in many adult examinees. For others, the acute response seemed limited to the papillae and the marginal tissue, while the attached gingival tissue appeared fibrous and quite normal in color. Visually detectable periodontal pockets were not recorded for any individual under 30 years of age. Although pockets were observed in about one third of those over age 30, it is significant that no teeth were scored 8, marked mobility with loss of masticatory function. Furthermore, gingival recession, while not specifically recorded, did not appear severe, nor were any exposed furcations noted. Thus the Yanomamö, who practices no form of oral hygiene, who receives no professional therapy, and whose periodontal tissues are challenged by the continual presence of hard and soft deposits and their by-products, retain most of their dentition through the mid and later years of life. It should be noted that lateral stress on the periodontium was minimal for most adults because severe occlusal attrition had eliminated cuspal interference. No reason was apparent for the greater prevalence of periodontal pockets in males.

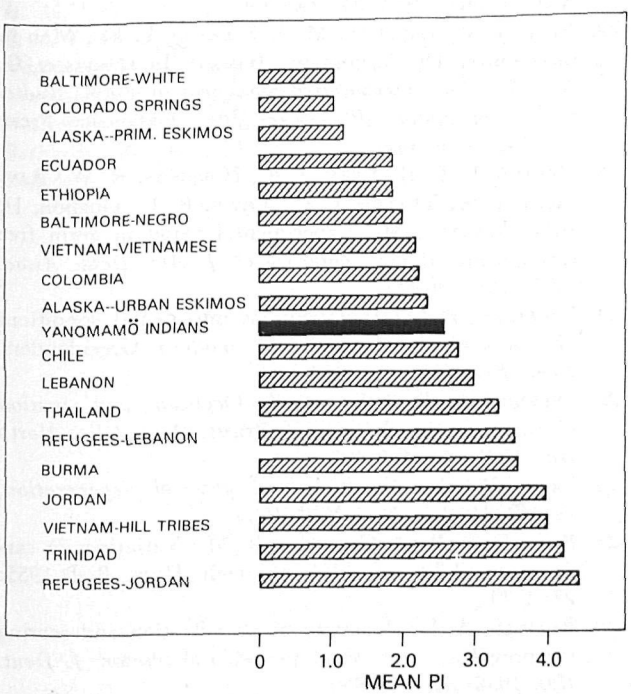

Fig. 2. Mean Periodontal Index (PI) scores in civilian groups, aged 40–49 years, from ICNND studies. Reproduced from the article by RUSSELL[29] in *Environmental variables in oral disease,* 1966, p. 28. Reprinted by permission of publisher and author.

The mean PI score for Wabutawa Indians aged 40–49 years has been incorporated in Fig. 2 into RUSSELL's graph for PI scores for civilian populations examined in ICNND studies[29] by investigators (C.J.D. was one of the ICNND investigators) whose comparability was enhanced by common training in criteria described by RUSSELL for the PI. Several of the populations included in these surveys had mean scores indicative of more severe and destructive periodontal disease than this group of Yanomamö Indians. Vietnamese villagers, for example, had OHI scores not unlike those of the Yanomamö (2.01 for 15- to 24-year-olds and 4.03 for those 45 years and over) but had PI scores of 0.96 and 4.64, respectively, for these two age groups[12]. Such PI scores are indicative of a disease process which with advancing age is more rapid and more destructive than that observed among the group examined at Wabutawatedi.

The Yanomamö are a unique population for the study of plaque-induced oral diseases. The present data which suggest that patterns of caries and periodontal diseases may differ from those observed in

other populations, should be documented by more thorough examinations, including radiographs, on larger samples of mission and isolated Indians. Opportunity still exists to collect baseline data on host, agent, and environmental factors among the isolated Yanomamö. Such data could be useful (1) for monitoring changes in disease levels and other variables following exposure to Western ways and (2) for comparison with data collected from Yanomamö populations which have already experienced sustained contact with Western peoples.

Acknowledgments – This work was supported in part by the U.S. Atomic Energy Commission (now Energy Research and Development Agency, ERDA) and the National Science Foundation.

REFERENCES

1. BARR, J. H.: Some characteristics of caries on the proximal surfaces of teeth. *J. Dent. Res.* 1949: *28:* 466–482.
2. CAMPBELL, T. D. & BARRETT, M. J.: Dental observations on Australian Aborigines: A changing environment and food patterns. *Aust. Dent. J.* 1953: *57:* 1–6.
3. CHAGNON, N. A.: *Yanomamö: the fierce people.* Holt, Rinehart & Winston, New York 1968.
4. DESTOPPELAAR, J. D.: The occurrence of *Streptococcus mutans* in dental plaque: an epidemiological survey with special reference to caries activity. In: FEARNHEAD, R. W. & STACK, M. V. (ed.): *International symposium on the composition, properties and fundamental structure of tooth enamel.* Wright, Bristol 1964.
5. DIRKS, O. B.: Longitudinal dental caries study in children 9–15 years of age. *Arch. Oral Biol.* 1961: *6:* 94–108.
6. DONNELLY, C. J.: The prevalence of dental-deposit induced diseases. In LASSLO, A. & QUINTANA, P. R. (ed.): *Surface chemistry and dental integuments.* Charles C Thomas, Springfield 1973.
7. FINN, S. B.: Prevalence of dental caries. In: *A survey of the literature on dental caries,* (NAS-NRC Publication No. 225), National Academy of Sciences – National Research Council, Washington, D.C. 1952.
8. FITZGERALD, R. J. & KEYES, P. H.: Demonstration of the etiologic role of streptococci in experimental caries in the hamster. *J. Am. Dent. Assoc.* 1960: *61:* 9–19.
9. GIBBONS, R. J., DEPAOLA, P. F., SPINELL, D. M. & SKOBE, Z.: Interdental localization of *Streptococcus mutans* as related to dental caries experience. *Infect. Immunol.* 1974: *9:* 481–488.
10. GREENE, J. C.: Oral hygiene and periodontal disease. *Am. J. Public Health* 1963: *53:* 913–922.
11. GREENE, J. C.: Simplified oral hygiene index. *J. Am. Dent. Assoc.* 1964: *68:* 7–13.
12. INTERDEPARTMENTAL COMMITTEE ON NUTRITI NATIONAL DEFENSE: *Vietnam nutrition survey, 1959: a report.* United States Government Print fice, Washington, D. C. 1960.
13. JORDAN, H. V., KRASSE, B. & MÖLLER, Å.: A m of sampling human dental plaque for certain "c inducing" streptococci. *Arch. Oral Biol.* 1968: *13:* 927.
14. KEYES, P. H.: Recent advances in dental caries search. Bacteriology. Bacteriologic findings and l logical implications. *Int. Dent. J.* 1962: *12:* 443–464
15. KLEIN, H. & PALMER, C. E.: *Dental caries in Americ Indian children.* United States Treasury Departme Public Health Bull. No. 239. United States Gover ment Printing Office, Washington, D.C. 1937.
16. LOSEE, F. L.: Dental caries in abutting or bilateral corresponding tooth surfaces. *J. Am. Dent. Assoc.* 1947 *35:* 323–326.
17. MILLER, J. & HOBSON, P.: Determination of the presence of caries in fissure. *Br. Dent. J.* 1956: *100:* 15–18.
18. MÖLLER, J. R. A.: *Microbiological examination of roo canals and periapical tissues of human teeth.* Thesi Akademiforlaget, Göteborg 1966.
19. MOORREES, C. F. A.: *The Aleut dentition.* Harvarc University Press, Cambridge, Mass. 1957.
20. NEEL, J. V.: Lessons from a "primitive" people. *Science* 1970: *170:* 815–822.
21. NEEL, J. V.: The genetic structure of a tribal population, The Yanomamö Indians. I. Introduction. *Ann. Hum. Genet.* 1972: *35:* 255–259.
22. NEEL, J. V., LAYRISSE, M. & SALZANO, F. M.: Man the tropics: The Yanomamö Indians. In HARRISON, G A. (ed.): *The international biological program: studie in human adaptability.* Cambridge University Pres Cambridge, in press.
23. ORLAND, F. J., BLAYNEY, J. R., HARRISON, R. W., RAYNIERS, J. A., TEXLER, P. C., ERVIN, R. F., GORDON, H A. & WAGNER, M.: Experimental caries in germ free rats inoculated with enterococci. *J. Am. Dent. Assoc.* 1955: *50:* 259–272.
24. PEDERSEN, P. O.: Investigations into dental conditions of about 3,000 ancient and modern Greenlanders. *Dent. Rec.* 1938: *58:* 191–198.
25. PERÉRIRA, C. B. & EVANS, H.: Occlusion and attrition of the primitive Indians of Brazil. *Dent. Clin. North Am.* 1975: *19:* 485–498.
26. PRICE, W. A.: *Nutrition and physical degeneration.* Paul B. Hoeber, New York 1939.
27. REID, D. B. W. & GRAINGER, R. M.: Variations in caries susceptibility of children's teeth. *Hum. Biol.* 1955: *27:* 1–11.
28. RUSSELL, A. L.: A system of classification and scoring for prevalence surveys of periodontal disease. *J. Dent Res.* 1956: *35:* 350–359.
29. RUSSELL, A. L.: World epidemiology and oral health. In KRESHOVER, S. J. & MCCLURE, J. F. (ed.): *Environmental variables in oral disease.* Publication No. 81. American Association for the Advancement of Science Washington, D. C. 1966.

RSSELL, A. L., CONSALAZIO, C. F. & WHITE, C. L.: ntal caries and nutrition in Eskimo scouts of the laskan national guard. *J. Dent. Res.* 1961: *40:* 594–03.

COTT, D. B.: A study of the bilateral incidence of carious lesions. *J. Dent. Res.* 1944: *23:* 105–110.

SHKLAIR, I. L., KEENE, H. J. & CULLEN, P.: The distribution of *Streptococcus mutans* on the teeth of two groups of naval recruits. *Arch. Oral Biol.* 1974: *19:* 199–202.

SHERP, H. W.: Dental caries: prospects for prevention. *Science* 1971: *173:* 1199–1205.

THOMSON, L. A.: *The development and testing of epidemiologic methods for sampling human dental plaque.* Typed Thesis, University of Michigan, School of Public Health, Ann Arbor 1970.

THOMSON, L. A. & FACKLAM, R. R.: Identification of *Streptococcus mutans* and other plaque streptococci and current taxonomic status. Ann. Meet. Int. Assoc. Dent. Res. 1972: Abstr. No. 64, p. 4.

TOVERUD, G.: The influence of war and postwar conditions on the teeth of Norwegian school children 7–8 and 12–13 years old. *Milbank Mem. Fund. Q.* 1957: *35:* 127–196.

TOVERUD, G.: Introductory review. In: *A survey of the literature on dental caries.* (NAS–NRC Publication No. 225), National Academy of Sciences – National Research Council, Washington, D. C. 1952.

ZINNER, D. D. & JABLON, J. M.: Human streptococcal strains in experimental caries. In HARRIS, R. S. (ed.): *Art and science of dental caries research.* Academic Press, New York 1968.

ZINNER, D. D., JABLON, J. M., ARAN, A. P. & SASLAW, M. S.: Experimental caries induced in animals by streptococci of human origin. *Proc. Soc. Exp. Biol. Med.* 1965: *118:* 766–770.

Addresses:

Charles J. Donnelly
Johns Hopkins University
School of Hygiene and Public Health
Department of Health Services Administration
615 N. Wolfe Street
Baltimore, Maryland 21205
U.S.A.

J. A. Brunelle
J. M. Stiles
H. A. Thomson
National Caries Program
National Institute of Dental Research
National Institutes of Health
Bethesda, Maryland 20014
U.S.A.

C. Brewer
Edificio Galipan
Averida Francisco Miranda
Caracas
Venezuela

J. V. Neel
Department of Human Genetics
University of Michigan Medical School
Ann Arbor, Michigan 48104
U.S.A.