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Dental caries prevalence in early Hawaiian children

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Abstract

The skeletal remains of 1338 dentate early Hawaiians (pre-Captain Cook — 1778) from the Bishop Museum collection in Honolulu were examined. The proportion of children with primary or mixed dentition in the overall sample was 18.3%. All major islands were represented. Minor geographic variations in caries prevalence were observed. For the entire sample of 245 children and 2854 teeth, caries was detected in 25 children (10.2%) and 63 teeth (2.2%). Carious lesions were restricted to the primary teeth, with the most frequent lesion occurring on the occlusal surface of the first and second molars. Proximal, facial, and lingual lesions were observed less frequently; but in several specimens, multiple proximal or facial lesions were noted on the maxillary central and lateral incisors. In comparison with contemporary school children residing in the Hawaiian Islands, the early Hawaiian children had a significantly lower prevalence of dental caries.

Late in the eighteenth century, when the first European sailing vessels arrived in eastern Polynesia, both French[1] and English[2] observers commented on the attractive, white, regular teeth of the island inhabitants. Approximately 100 years later, reports indicated that dental caries at the turn of the century was still practically unknown in that part of the world, thus apparently confirming the subjective impressions of the early voyagers.[3] The impact of these observations on the dental profession at that time was noted by Whitney:[4] "We have been taught that primitive peoples, living in simple conditions, were in great measure free from dental caries as we see it in the mouths of our patients, and that many of the forms of dental disease with which we have to contend were with them wholly unknown."

Whitney, a practicing Honolulu physician and dentist who had lived in the Hawaiian Islands for 24 years, made this remark in a paper presented in 1893 at the World's Columbian Dental Congress in Chicago. His examination of an unspecified number of ancient Hawaiian skulls presented a somewhat different picture of Polynesian dental health: "I think I have discovered every form of dental disease known to our practice; dental caries in all its many types, necrosis of the teeth, erosion, alveolar abscess, pyorrhea alveolaris, disease of the antrum of Highmore, necrosis of the maxillae, ankylosis of the jaw, salivary calculus, etc."

Although the romantic notion of primitive peoples living in pristine beauty and health still was being advanced at the time of Price's excursions into the South Pacific[5,6] and as recently as 1972,[7] scientific reports on the dental and skeletal pathology of precontact Hawaiians have tended to support Whitney's early observations.[8-11] The literature indicates that children and young adults in the ancient Hawaiian population were relatively free of dental caries compared to contemporary residents; but elderly individuals exhibited an extremely high caries attack rate of more than 40 carious teeth/100 teeth (primarily root surface caries) which approaches current rates based on age-specific DMFT scores.[12-14]

Knowledge of the caries experience of early Hawaiian children is based primarily on recent studies of a limited number of specimens from the well-known Mokapu Peninsula sand dunes site on windward Oahu.[10,11,14] Earlier, Chappel[8] had examined a small sample of skulls from each of the major islands in the Hawaiian group and although his age classification (young, middle aged, elderly) permits little comparative analysis, he did note that for 36 young individuals, only 18 carious teeth were observed in a total of 411 teeth.

In the present survey, which includes the entire Bernice P. Bishop Museum collection and represents

all of the major Hawaiian Islands, the focus is on 2 specific age groups of children: (1) those with only primary teeth present and having an estimated age at death of 6 months-5 years (N = 162); and (2) those in the mixed dentition stage having permanent as well as primary teeth present, with an estimated age of 6-11 years (N = 83). The inclusion of all islands in the study results in an approximate doubling of the number of individuals in the specified age groups available for examination compared to the Mokapu site alone and permits inter-island comparisons of dental caries rates.

Methods and Materials

The results of a 3-year study of the skeletal remains of more than 2000 individuals located in the Bishop Museum in Honolulu are presented. Although all the major islands in the Hawaiian group are represented in the collection, the largest number of specimens are from the island of Oahu with the Mokapu site being the largest single source (Table 1). The absence of artifacts such as rings, buttons, buckles, and other modern devices among the remains has been interpreted as evidence for a pre-European dating of the specimens and it has been estimated that their antiquity ranges from 200 to 500 years.[9,10] The possibility of some specimens falling within the European period cannot be excluded.[15]

Estimation of age at death was made by a combination of dental developmental staging[16] for younger individuals and occlusal attrition and/or alveolar bone loss in adults. Predentate infants and edentulous adults were excluded. In some instances where unerupted teeth could not be removed easily from their developmental crypts for inspection, radiographs were taken to assist in age determination. For convenience the children were placed into a primary dentition group (approximate age 6 months-5 years) and a mixed dentition group (approximate age 6-11 years). Baume[3] has noted that contemporary Polynesian children tend to erupt their permanent molars approximately[1-2] years earlier than their European counterparts. The actual number of individuals in the various groups (Table 1) probably is overstated to some degree because in some instances specimens are represented by single unmatched crania, mandibles, or isolated maxillary and mandibular fragments.

The number of teeth available for examination was recorded for each individual and included only those teeth that were judged subjectively to be in a state of clinical eruption. This procedure excluded many teeth that were obviously present in the jaws, but that probably had not been exposed yet to the oral environment during the life of the child. The anatomic location of carious lesions was recorded by visual inspection under good lighting conditions with the assistance of a sickle-shaped probe to remove superficial debris from tooth surfaces. Except for a few instances of enamel hypoplasia, only obvious defects in the surface continuity of the enamel were considered to be carious lesions. Chalky-appearing areas on the proximal and buccolingual surfaces were not considered carious unless there was an associated break in the enamel surface. Buccal, lingual, and occlusal pits on the molar teeth were not considered carious unless the probe easily entered into a "cavity." Relative softness or hardness at the bottom of the pit was not considered in the evaluation. Population estimates of caries prevalence were made by calculating the percentage of individuals affected (number of individuals with caries/100 individuals) and the percentage of teeth affected (number of teeth with caries/100 teeth).

Results

The island of Oahu and specifically the Mokapu site contributed the largest number of dentate spec-

Table 1. Geographic Distribution of Early Hawaiian Skeletal Material in the Bishop Museum Collection (includes dentate specimens only)

Geographic Site or Island	*Total Number of Individuals*	*Frequency of Children in Collection*					
		Primary dentition		*Mixed dentition*		*Total children*	
		N	%	*N*	%	*N*	%
Mokapu, Oahu	580	95	16.4	41	7.1	136	23.4
Oahu, excluding Mokapu	414	37	8.9	27	6.5	64	15.5
Kauai	85	11	12.9	10	11.8	21	24.7
Hawaii	105	9	8.6	1	1.0	10	9.5
Molokai	38	4	10.5	2	5.3	6	15.8
Kahoolawe	5	3	60.0	0	0	3	60.0
Maui	16	3	18.8	0	0	3	18.0
Lanai	95	0	0	2	2.1	2	2.1
Totals	1338	162	12.1	83	6.2	245	18.3

imens for examination (Table 1). The proportion of children 6 months-11 years of age in the collection varied from one island to another and ranged from 2.1% (Lanai) to 60% (Kahoolawe). The number of individuals in the primary dentition group was almost twice the number in the mixed dentition group and the proportion of these 2 groups of children in the overall sample of 1338 dentate individuals from all 7 islands was 18.3%.

Geographic variations in caries prevalence for children with primary and mixed dentitions are shown in Tables 2 and 3. Although the small number of specimens from most of the islands precludes definitive analysis, certain aspects of the data from Oahu are of interest. For the younger children with primary teeth only, 12.6% were affected in the Mokapu group compared to only 5.4% for the rest of Oahu. Despite this more than twofold difference, the proportion of carious teeth in the 2 groups was similar with the Mokapu group being slightly lower. This may have been a spurious finding since the data for children in the mixed dentition stage (Table 3) show nearly an identical caries prevalence for both Oahu groups. In Figure 1 the primary and mixed dentition groups have been pooled to illustrate caries prevalence in the 2 Oahu groups as compared to the other islands combined. For carious teeth, data for the 3 groups varied narrowly from 2.0% for Mokapu to 2.6% for the other islands. The increased proportion of affected children in the Mokapu group (12.5%) compared to the other 2 groups was not statistically significant (chi-square $= 1.76$; $p > 0.05$). For the entire Hawaiian sample of 245 children and 2854 teeth, caries was observed in 25 children (10.2%) and 63 teeth (2.2%).

The distribution of 25 children according to the number of carious teeth and total teeth present is shown in Table 4. Most of the affected children had only 1 or 2 carious teeth present; however, as many as 6-8 carious teeth were observed in 3 children. Although 8 of the children with caries were in the mixed dentition stage and a total of 24 first permanent molars had erupted into a clinically functional position, caries was observed only in primary teeth. The anatomic distribution of carious lesions is given in Table 5. The most common lesion occurred on the occlusal surfaces of the primary molars, appearing as a single lesion in 26 molars and as a discrete occlusal lesion on 2 other molars having other carious surfaces as well. Proximal lesions were found in 11 molars and 15 maxillary incisors. Facial or lingual lesions occurred in 15 anterior teeth and 1 molar. Examples of carious lesions observed in the deciduous teeth of the Hawaiian children are shown in Figure 2.

Discussion

Although many epidemiological investigations on the caries experience of living Polynesian children have been carried out during the past 100 years, surprisingly little information is available for the precontact period. The present report, which includes information on the skeletal remains of 245 children from all 7 major islands in the Hawaiian group, expands previously published data which are based on the Mokapu, Oahu, site alone. For children who were in the primary and mixed dentition stages of dental development at the time of death, the overall caries prevalence was 10.2% for individuals and 2.2% for teeth. Although classical DMF counts are not always appropriate for estimates of caries prevalence in skeletal populations, a conservative mean score of 0.44 DMF teeth can be calculated for the entire group of children, based on an average number of 20 erupted primary and permanent teeth. When the permanent teeth only were considered, the DMF score was 0. By contrast, Kau et al.[12] recorded an extremely high rate of caries for the permanent teeth of recent Hawaiian school children ranging from 7.6 teeth/100 teeth at age 5 years and increasing progressively up to 27.2 teeth/100 at age 11 years. Information on primary teeth

Table 2. Caries Prevalence in Early Hawaiian Children with Primary Teeth Only

Geographic Site or Island	*Number of Individuals*	*Caries Prevalence*		*Number of Teeth*	*Caries Prevalence*	
		N	*%*		*N*	*%*
Mokapu, Oahu	95	12	12.6	1314	31	2.4
Oahu, excluding Mokapu	37	2	5.4	252	8	3.2
Kauai	11	1	9.1	74	1	1.4
Hawaii	9	0	0	137	0	0
Molokai	4	1	25.0	43	8	18.6
Kahoolawe	3	0	0	17	0	0
Maui	3	1	33.3	18	2	11.1
Lanai	0	—	—	0	—	—
Totals	162	17	10.5	1855	50	2.7

TABLE 3. Caries Prevalence in Early Hawaiian Children with Mixed Dentition

Geographic Site or Island	Number of Individuals	Caries Prevalence		Number of Teeth	Caries Prevalence	
		N	%		N	%
Mokapu, Oahu	41	5	12.2	592	8	1.4
Oahu, excluding Mokapu	27	3	11.1	271	5	1.8
Kauai	10	0	0	86	0	0
Hawaii	1	0	0	4	0	0
Molokai	2	0	0	36	0	0
Kahoolawe	0	—	—	0	—	—
Maui	0	—	—	0	—	—
Lanai	2	0	0	10	0	0
Totals	83	8	9.6	999	13	1.3

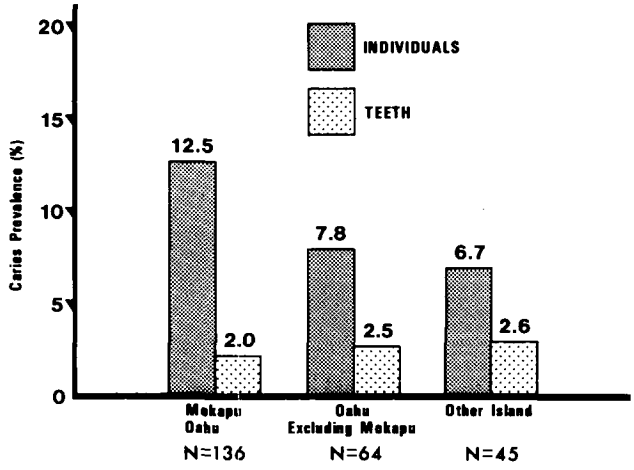

FIG 1. Comparison of caries prevalence in early Hawaiian children from different geographic areas. The primary and mixed dentition groups have been combined. N refers to the number of individuals in each group.

TABLE 4. Distribution of 25 Early Hawaiian Children by Number of Carious Teeth

Number of Carious Teeth*	Number of Children	Total Teeth Present	Carious Teeth	
			N	%
1	9	131	9	6.9
2	7	102	14	13.7
3	4	56	12	21.4
4	2	40	8	20.0
6	2	32	12	37.5
8	1	10	8	80.0
Total	25	371	63	17.0

* Carious lesions were observed only in primary teeth. In 8 children with mixed dentition, and carious lesions in primary teeth, no caries was observed in a total of 24 erupted first permanent molars.

TABLE 5. Anatomic Distribution of Carious Lesions in the Primary Teeth of 25 Early Hawaiian Children

Tooth and Lesion Type	Tooth Surface*	Number of Teeth	Number of Children
Single Surface			
Molars	O	26	15
Molars	M or D	9	3
Max. incisors	M or D	7	4
Max. incisors	F	5	3
Max. canines	F	1	1
Mand. canines	F	2	2
Multiple Surfaces			
Max. incisors	MD	4	3
Max. incisors	MF or DF	2	2
Max. incisors	FL	3	1
Max. incisors	DFL	1	1
Max. incisors	MDFL**	1	1
Molars	MO	1	1
Molars	DOF	1	1

* M = mesial; D = distal; O = occlusal; F = facial; L = lingual.

** Lesions in the multiple group were all discrete and nonconfluent except for 1 maxillary central incisor in which a circumferential ring-like lesion in the middle third of the crown involved the MDFL surfaces.

was not given. Similarly, Chung et al.[13] examined a large group of Hawaiian school children in the 12- to 18-year age group and recorded a mean DMF score of 10.43 teeth for the permanent dentition.

Pickerill[17] examined 260 Maori skulls from New Zealand and detected caries in only 2 specimens (0.76%). Although the number of children in the group was not specified, he also examined 50 Maori school children living under European conditions and found 95% of the individuals and 15.6% of the teeth with caries experience. For an unspecified number of Maori children who were living in more remote areas of New Zealand, Pickerill and Champtaloup[18] observed more caries than they had expected, but most of the children were caries free and carious lesions when detected were "found to be almost entirely confined to the younger ones, and in them to the deciduous teeth." This latter description of the dental caries experience of Maori children living in relatively primi-

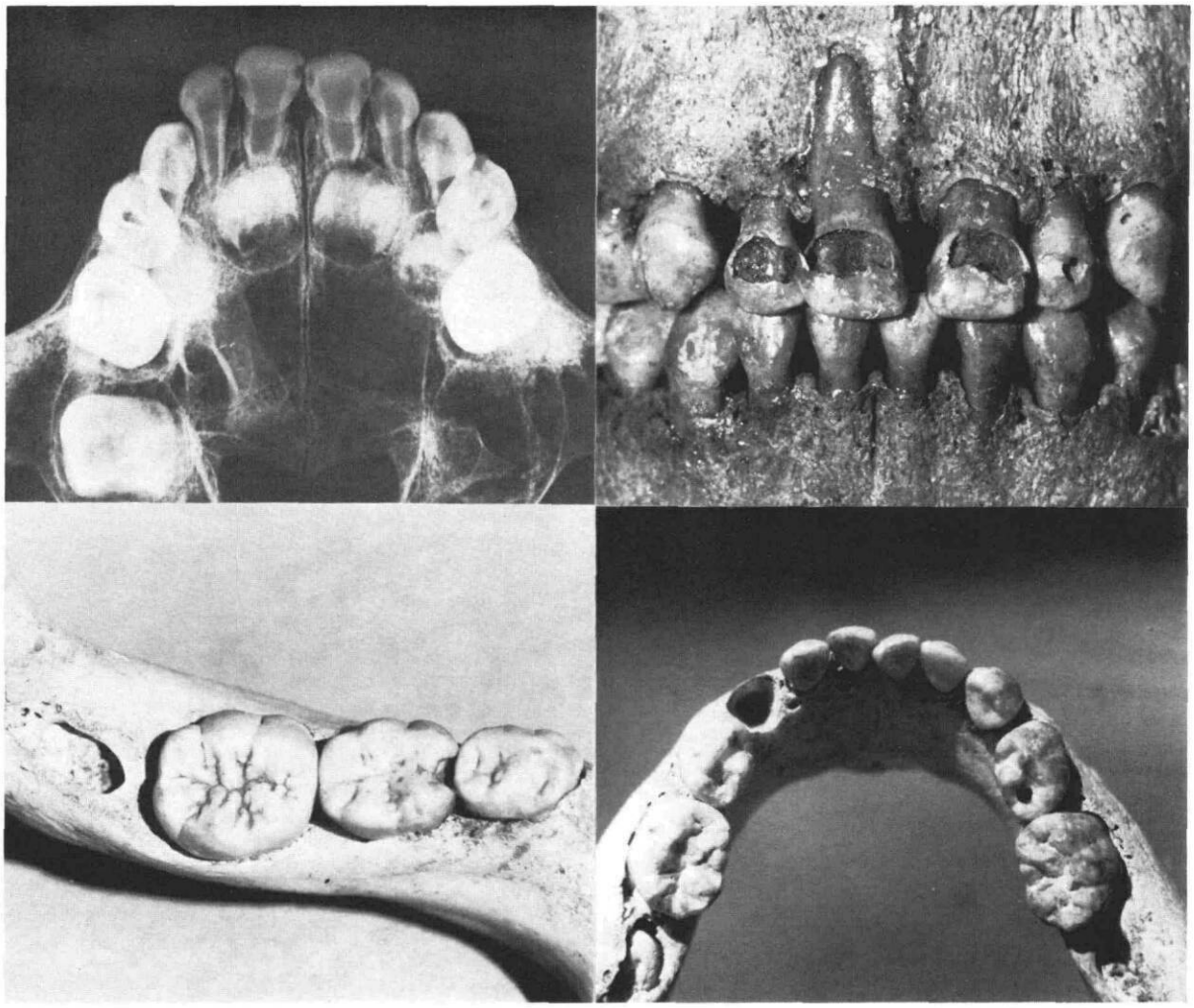

FIG 2. *Examples of carious lesions in the primary teeth of early Hawaiian children.* (A, *upper left*) Mokapu, Oahu No. 1841; radiograph showing multiple proximal lesions on maxillary incisors. (B, *upper right*) Mokapu, Oahu No. 2074; multiple facial surface lesions on the maxillary anterior teeth resembling the clinical appearance of "nursing bottle syndrome" seen in contemporary children. (C, *lower left*) Kawailoa, Oahu No. 1004; mandibular left first permanent molar and the primary first and second molars. Carious lesion involving the mesial and occlusal surfaces of the primary second molar is present. (D, *lower right*) Kauai No. 202; mandibular teeth of a young child showing a moderately large occlusal lesion in the distal pit region of the right first molar.

tive conditions is remarkably similar to the caries picture we have described in this report for early Hawaiian children.

Saunders and Taylor[19] examined a group of 36 Maori children living in Maungapohatu village, where European foods were readily accessible, and observed a high caries rate. For 3 children with primary teeth only present, 27 of 60 teeth were carious (45%); for 22 children in the mixed dentition stage, 165 of 529 teeth were carious (31.7%); for 11 children with permanent teeth only present, 31 carious teeth of 307 teeth were observed (10.1%). More recently, Hewat[20] and Ludwig et al.[21] also have noted higher caries rates among the Maori living under European conditions compared to those in more remote/rural areas.

Taylor[22] noted carious lesions in the skeletal remains of 10 of 45 pre-European adults from Tonga, but no data were given for 6 children who also were recovered from the same archaeological sites. Dental examinations of 4768 school children living in American Samoa were made by Neubarth.[23] Individuals ranged from 3 to 21 years of age and 54.5% had evidence of caries experience. For 3028 children with either primary or mixed dentitions, 46.3% were affected. Overall caries prevalence was found to be much higher in the Pago Pago Bay area, which is the commercial center of American Samoa (72.7%), compared to remote outlying villages (42.3%), and isolated islands in the Manua group (21.7%).

Twenty years earlier Ferguson[24] reported similar

geographic patterns of caries prevalence for 2257 children living in American Samoa, but the overall attack rate was considerably lower (10.1% of individuals, 0.84% of teeth). Camrass[25] noted a high proportion of caries-free individuals among the school-age population of Western Samoa. Two-thirds of children 14 years of age had no caries experience. In rural villages the mean DMFT score for 14 year olds was 0.41 and in the Apia urban area, 1.24. Earlier, Williams[26] had examined 1541 children from Western Samoa and found the lowest proportion of caries-free individuals (20%) among European and mixed descent children living in the Apia area and the highest proportion of caries-free children (62.5%) among 9 villages in the remote Savaii district.

In a survey of 12,344 children (4-19 years of age) which covered 83% of the total school population of French Polynesia, Baume[27] recorded an extraordinarily high caries prevalence which was considered comparable to that of Hawaiian school children. For young children with primary teeth only, 83.5% had experienced caries by the age of 4 years and by 6 years 96.1% were affected. By the age of 12 years, 84.1% of the children had one or more DMF permanent teeth. Geographic variations in caries prevalence were said to reflect "the rate at which ancestral food habits and indigenous foods were replaced by a modern unbalanced diet and refined imports."

While many observers of the rapid deterioration which has taken place in the dental health of previously isolated populations refer to "civilization", and changing food patterns (especially sucrose availability) as plausible explanations,[6,17,28] it must be remembered that the European oral microflora also accompanied the alterations in food habits. Cariogenic microorganisms such as *Streptococcus mutans* are infrequently detected in primitive societies,[29] and apparently require person-to-person contact for transmission.[30,31] Since *S. mutans* is the organism most frequently associated with caries in contemporary children,[32] it is likely that biological as well as cultural transmissions took place in the early European-Polynesian contacts and synergistically contributed to the spiraling pattern of increasing caries prevalence.

In a recent sampling of 55 Hawaiian children 3-13 years of age, living on the island of Oahu, *S. mutans* was detected in 90.9% of the subjects and the biotypes isolated could not be distinguished from those most commonly detected on the mainland.[33] The classic studies of Orland et al.[34] and Fitzgerald and Keyes[35] show that the nature of the diet should not be considered in isolation, and that caries, an infectious and transmissible disease, does not occur in the absence of a cariogenic microflora. While geographic variations in fluoride availability during dental development and differences in the fluoride content of native foods may help to explain some of the regional variations in caries prevalence observed,[36] the almost catastrophic increase in dental caries prevalence that has occurred in Polynesia during the past 200 years suggests that changing dieto-bacterial interactions probably played the major role.

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Quotable Quote: the child at play

Modern children spend an increasingly large part of their lives alone with their toys, a situation inconceivable several centuries ago. Childhood was once part of a collective village life. Children didn't play separately, but joined youths and adults in seasonal festivals that intruded upon the work world with considerable regularity and with great boisterousness.

The Industrial Revolution, by forcing fathers and mothers into distant employment during the late 18th and 19th centuries, slowly took the economic life away from home and village. Children often were left to run wild in the streets or hills and carry on the play that had been part of the earlier communal festivals. As early as the late 18th century, many clothes, books, and toys were beginning to be made specifically for children.

In the 19th century, the roaming urchins and vagabond children who were not employed in factories were brought under control by compulsory school attendance. In the 20th century, this control over play has been increased still further, first by playgrounds and gymnasiums, and more recently through organized activities (swimming, tennis, dancing, sports), consumer entertainments (movies and shows), and finally, through the most controlling of all instruments, television.

The shift in play has been steady: a taming of most violence; mechanization of toys, increasingly electronic in character; symbolization in games of language, information, and strategy, which have largely replaced rough physical play; decreasing differentiation between the play of boys and girls; increasing remoteness from direct experience through fantasy; and, most significantly, isolation.

The truth, I believe, is that play itself is neither good nor bad. Like language or music, it is a form of expression and communication. What makes it good or bad is what we do with it.

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