# Some Epidemiological Aspects of Tooth Decay*

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EXPERIENCE in the present war and in those of the past, together with related incidental data, offer opportunity to examine, on a geographic basis, certain epidemiological aspects of tooth decay. From an etiological standpoint, knowledge as to this disability is about on a par with speculations in the early part of the century as to the etiology of pellagra or knowledge as to the causation of malaria before Laveran's work in 1880.

Generally speaking, there are two schools of thought regarding the etiology of tooth decay. The first group considers the oral environment the sole determining factor, while the second group considers that the metabolic processes of the body influence the resistance of the teeth to the force or forces which cause decay. Whatever the merits of these or other hypotheses, they have no bearing on the present discussion.

The data herein presented for consideration consist of: (1) the rejection rates for "defective and deficient" teeth among the men in the draft for the United States Army in 1918; (2) exemption rates for "loss of teeth" among men drafted for the Federal Army in 1863–1864; (3) rates of past and present decay attacked teeth among U. S. Naval recruits in 1934, and surveys of tooth decay among United States school children.[4, 5, 6]

In this paper tooth decay includes past as well as present evidence of caries attack. It is realized that diseases other than tooth decay may contribute to the condition later referred to as "defective and deficient" teeth, or "missing" teeth, yet it is believed that among the age groups under consideration the effects of such diseases on the magnitude of the rates would be so relatively minor that they may be disregarded.

## DENTAL REJECTION RATES AMONG DRAFTEES OF 1918

During World War I, the physical condition described as "defective and deficient" teeth caused the rejection of significant numbers of men called up for military service from the various states. There were two drafts during that war. The first was in 1917, the second in 1918. Only the data of the 1918 draft are considered in this discussion. This draft has been referred to as that of the "second million." The 1918 mean rejection rate for the entire country for "defective and deficient" teeth was 24.2 per 1,000 men examined at the army camps.

The examinations were made subsequent to May, 1918. This indicates that most of the examiners at the army

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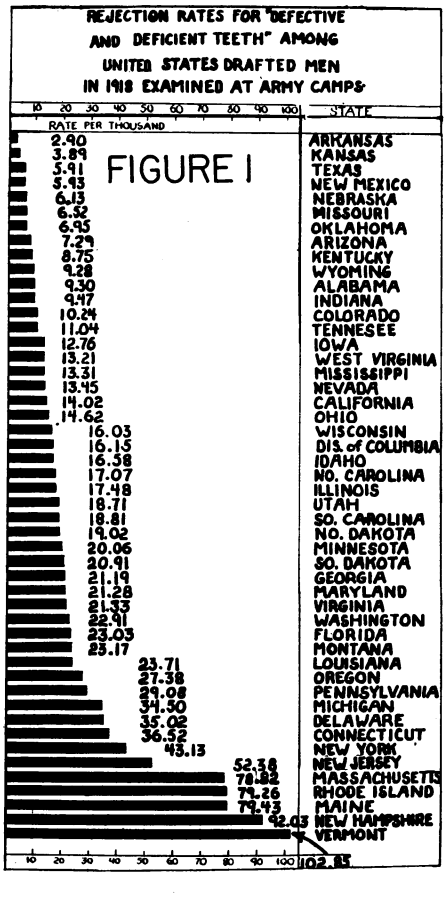
camps and the local boards probably had had a year or more to become familiar with the criteria and examining technics. Therefore, it does not seem unreasonable to assume that considerable uniformity would prevail, resulting in state rates, the magnitude of which may be properly compared one with another.

However, the states varied in the magnitude of their respective rejection rates. The Vermont rate was 102.85, while that of Arkansas was 2.90 per 1,000 men examined. The highest rates were among 5 New England states. The remaining state of that geographical group was 8th in rank among the 48 states and the District of Columbia. The mean rate for the New England states, as a group, was 76.15. The lowest rates were consistently among the southern and southwestern states. For example, the group composed of Arkansas, Texas, and New Mexico had a mean rate of 4.66 per 1,000 men examined.*

Unfortunately, the rejection rates for "defective and deficient" teeth at the local boards of 1918 are not available. However, when the rejection rates at the local boards for *all* types of physical defects are examined, it is found that the states with the high rates had, as a rule, high rejection rates for "defective and deficient" teeth at the army camps. This point seems important when comparing the magnitude of the several states' army camp rejection rates, because it helps to eliminate the possibility that the variations resulted entirely from careless screening at the source. The degree of correlation between high rejection rates for all types of physical defects at the local boards of the 48 states and the District of Columbia and high rejection rates for "defective and deficient" teeth at the army camps during the 1918 draft was determined by the correlation coefficient of Pearson. A value of $+.63 \pm .09$ was obtained. This is a further indication that on the average the higher the rejection rate at the local boards for all types of physical defects, the higher was the rejection rate for dental defects at the army camps. The rejection rates at the army camps and at the local boards among the various states and the District of Columbia are given in Table 1. The rates for the 48 states and the District of Columbia are shown graphically in Figures I and II.




* Several preliminary statistical reports of dental findings among draftees of the several states during 1940–1942 suggest that the New England states will again have the highest rejection rates at both the local boards and at the Army Induction Centers for dental defects, and that the southern and southwestern states will have the lowest rates; however, it is believed that the available data are too meager to permit a final conclusion to be drawn in this respect at the present time.

TABLE 1

*Rejection Rates for "Defective and Deficient" Teeth among Draftees of Various States at Army Camps and for All Types of Physical Defects at Local Boards During 1918* (A); *Rejection Rates for "Loss of Teeth" among Draftees of Northern States for Federal Army During 1863–1864* (B)

| | *Draftees of 1918* | | | | *Draftees of 1863–1864* | |
|---|---|---|---|---|---|---|
| | *Rejection Rate per 1,000 Men for "Defective and Deficient" Teeth at Camps* | | *Rejection Rate per 1,000 Men for All Types of Physical Defects at Local Boards* | | *Rejection Rate per 1,000 Men for "Loss of Teeth"* | |
| *State* | *Order of Magnitude* | *Rate* | *Order of Magnitude* | *Rate* | *Order of Magnitude* | *Rate* |
| Vermont | 1 | 102.85 | 2 | 286 | 8 | 20.57 |
| New Hampshire | 2 | 92.03 | 30 | 133 | 5 | 25.05 |
| Maine | 3 | 79.45 | 3 | 268 | 14 | 10.21 |
| Rhode Island | 4 | 79.26 | 1 | 369 | 6 | 22.46 |
| Massachusetts | 5 | 78.82 | 7 | 188 | 1 | 34.87 |
| New Jersey | 6 | 52.38 | 22 | 137 | 9 | 20.19 |
| New York | 7 | 43.13 | 12 | 168 | 2 | 27.56 |
| Connecticut | 8 | 36.52 | 10 | 169 | 3 | 26.53 |
| Delaware | 9 | 35.02 | 38 | 120 | 15 | 7.62 |
| Michigan | 10 | 34.50 | 15 | 157 | 12 | 13.11 |
| Pennsylvania | 11 | 29.08 | 27 | 135 | 4 | 25.70 |
| Oregon | 12 | 27.38 | 19 | 145 | .. | ..... |
| Louisiana | 13 | 23.71 | 18 | 150 | .. | ..... |
| Montana | 14 | 23.17 | 43 | 98 | .. | ..... |
| Florida | 15 | 23.03 | 34 | 126 | .. | ..... |
| Washington | 16 | 22.91 | 5 | 204 | .. | ..... |
| Virginia | 17 | 21.33 | 17 | 154 | .. | ..... |
| Maryland | 18 | 21.28 | 4 | 219 | 11 | 16.57 |
| Georgia | 19 | 21.19 | 35 | 126 | .. | ..... |
| South Dakota | 20 | 20.91 | 29 | 134 | .. | ..... |
| Minnesota | 21 | 20.06 | 26 | 135 | 7 | 22.08 |
| North Dakota | 22 | 19.02 | 40 | 108 | .. | ..... |
| South Carolina | 23 | 18.81 | 37 | 122 | .. | ..... |
| Utah | 24 | 18.71 | 14 | 157 | .. | ..... |
| Illinois | 25 | 17.48 | 20 | 143 | .. | ..... |
| North Carolina | 26 | 17.07 | 32 | 131 | .. | ..... |
| Idaho | 27 | 16.58 | 39 | 114 | .. | ..... |
| District of Columbia | 28 | 16.15 | 33 | 128 | .. | 13.75 |
| Wisconsin | 29 | 16.03 | 31 | 131 | 16 | 5.39 |
| Ohio | 30 | 14.62 | 21 | 141 | 10 | 18.87 |
| California | 31 | 14.02 | 6 | 203 | .. | ..... |
| Nevada | 32 | 13.45 | 36 | 123 | . | ..... |
| Mississippi | 33 | 13.31 | 42 | 104 | .. | ..... |
| West Virginia | 34 | 13.21 | 41 | 105 | .. | ..... |
| Iowa | 35 | 12.76 | 16 | 155 | .. | ..... |
| Tennessee | 36 | 11.04 | 9 | 174 | .. | ..... |
| Colorado | 37 | 10.24 | 8 | 179 | .. | ..... |
| Indiana | 38 | 9.47 | 25 | 135 | .. | ..... |
| Alabama | 39 | 9.30 | 45 | 91 | .. | ..... |
| Wyoming | 40 | 9.28 | 48 | 64 | .. | ..... |
| Kentucky | 41 | 8.75 | 13 | 165 | 13 | 10.98 |
| Arizona | 42 | 7.29 | 49 | 12 | .. | ..... |
| Oklahoma | 43 | 6.95 | 28 | 134 | .. | ..... |
| Missouri | 44 | 6.52 | 24 | 135 | .. | ..... |
| Nebraska | 45 | 6.13 | 47 | 78 | .. | ..... |
| New Mexico | 46 | 5.93 | 11 | 169 | .. | ..... |
| Texas | 47 | 5.91 | 23 | 135 | .. | ..... |
| Kansas | 48 | 3.89 | 46 | 89 | .. | ..... |
| Arkansas | 49 | 2.90 | 44 | 93 | .. | ..... |

(A) Britten, R. H., and Perrott, G. St. J. Summary of Physical Findings on Men Drafted in World War. *Pub. Health Rep.*, 56:41–62 (Jan. 10), 1941.

(B) Lewis, J. R. Exemptions from Military Service on Account of Loss of Teeth. *Dental Cosmos*, 7:240–242 (Dec.), 1865.

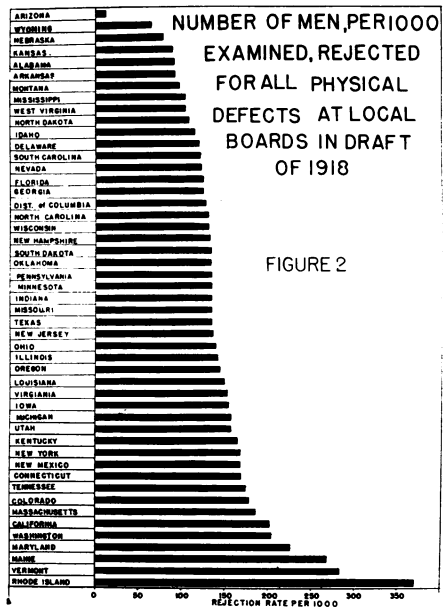



FIGURE 2

### DENTAL DEFECTS AMONG DRAFTEES OF THE FEDERAL ARMY IN 1863–1864

Dental defects also contributed to physical unfitness among the men of military age during the Civil War period. During that war there were two drafts for the Northern Army. In the draft of 1863 "loss of teeth" caused the rejection of 20.49 per 1,000 men examined. The 1864 rate was 25.37 per 1,000 men examined. As noted in the 1918 draft, the various states also differed in the magnitude of their rejection rates during 1863 and 1864. The New England mean rate for the 1863 and 1864 drafts was 23.07, while that of Delaware and Maryland was 12.09 per 1,000 examined men.

The mean rates for the Northern states contributing to the drafts of 1863 and 1864 are included in Table 1.

The states that contributed to both the 1863–1864 and 1918 drafts have been grouped into arbitrary but more or less natural geographical areas and their mean rejection rates for the two periods are shown in Figure III. It would be improper to use the magnitude of the rates of 1863–1864 and 1918 as a measure of the relative severity or extent of the dental disease or diseases which caused rejection during the two periods, because the criteria differed. But, it may be observed with interest and possible profit that the magnitude of the rates for the same areas assume nearly the same relative position in both series. This duplication of events after a period of half a century is striking indeed.

### TOOTH DECAY AMONG UNITED STATES NAVAL RECRUITS OF 1934

As previously pointed out, it is well known that the particular dental disease which contributed most to the dental condition in the draftees described as "defective and deficient" teeth in 1918 or "loss of teeth" in 1863–1864 was tooth decay. It is, therefore, pertinent to investigate the distribution of that disease throughout other groups of the population. Does the prevalence rate vary from state to state, from group to group living in different environments? Corroborative evidence which tends to substantiate this is found in a survey among a group of men who were enlisted in the United States Navy during the

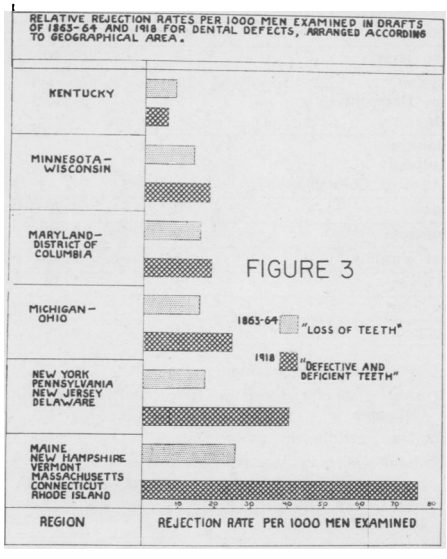



FIGURE 3

year 1934. While the men in that naval group and the condition of their teeth differed from the rejected draftees, inasmuch as they were found suitable for military service, yet the method used in determining their dental status allows an estimate of the relative prevalence of caries, past and present, among the teeth of men of the various states. In the naval survey under consideration there were 4,602 white men. After enlistment they were assembled at Norfolk, Va., where they were examined by the same dentist * and their present and past tooth decay experience was recorded according to the number of decayed, missing or filled (DMF) teeth. On subsequent study by the naval investigator it was found that, as a rule, the men of the northern states had more evidence of tooth decay, past and present, than did men from the southern states. The state with the highest rate, 12.54 decayed, missing, or filled (DMF) teeth per man was Connecticut—a New England state. Arkansas, the state with the lowest rejection rate for "defective and deficient" teeth at the army camps in the draft of 1918, likewise had the lowest decayed, missing, or filled (DMF) rate among these naval recruits of 1934. The New England states, as a group, had the highest rate in the entire series, 11.48; while Arkansas, Louisiana, and Mississippi, as a group, had a mean rate of 3.5 DMF teeth per man. The consistency with which these naval data tend to agree with the dental findings collected among men of the several states

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TABLE 2

*Mean Number of DMF (Decayed, Missing or Filled) Permanent Teeth among 4,602 White, United States Naval Recruits During 1934, Arranged According to the Magnitude of the Various State Rates* (A)

| State | Order of Magnitude | DMF Rate per Man |
|---|---|---|
| Connecticut | 1 | 12.54 |
| Massachusetts | 2 | 12.20 |
| Pennsylvania | 3 | 11.40 |
| Rhode Island | 4 | 11.00 |
| New York | 5 | 10.84 |
| Ohio | 6 | 10.53 |
| New Jersey | 7 | 10.30 |
| Vermont<br>New Hampshire<br>Maine | 8 * | 10.20 * |
| Delaware<br>Maryland<br>District of Columbia | 9 † | 9.70 † |
| Illinois | 10 | 9.25 |
| Minnesota | 11 | 9.10 |
| West Virginia | 12 | 7.90 |
| Michigan | 13 | 7.14 |
| Wisconsin | 14 | 7.00 |
| Nebraska | 15 | 6.80 |
| Oregon<br>Montana<br>Washington<br>North Dakota<br>Utah<br>Idaho<br>California<br>Nevada<br>Colorado<br>Wyoming<br>Arizona<br>New Mexico | 16 ‡ | 6.00 ‡ |
| South Dakota | 17 | 5.30 |
| Missouri | 18 | 4.40 |
| Indiana | 19 | 4.38 |
| Kentucky | 20 | 4.30 |
| Iowa | 21 | 4.10 |
| Louisiana<br>Virginia<br>South Carolina<br>Oklahoma<br>Texas<br>Kansas | 22 ‡ | 4.00 ‡ |
| Florida | 23 | 3.60 |
| North Carolina<br>Alabama | 24 ** | 3.50 |
| Georgia<br>Mississippi | 25 ** | 3.40 ** |
| Tennessee | 26 | 3.20 |
| Arkansas | 27 | 3.00 |

* Mean rate for the three states

† Mean rate for the two states and District of Columbia

‡ Mean rate for the twelve states

** Same value appears for indicated states

(A) Ferguson, R. A. Some Observations on Diet and Dental Disease. *J. Am. Dent. A.*, 22:392–401 (Mar.), 1935.

at different times over a period of some 70 years seems to allow greater weight to be given them as being representative of the universe from which they were drawn than would ordinarily be the case where the numbers in the samples are relatively small. The rates for the several states and the District of Columbia are shown in Table 2 and Figure IV.

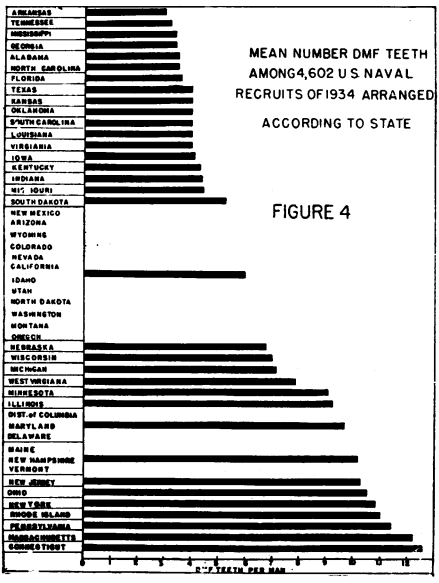


FIGURE 4

The Pearsonian correlation coefficient was used to determine the degree of relationship between high rejection rates at the army camps for "defective and deficient" teeth among the draftees of 1918 and high DMF rates among the naval recruits of 1934. The rates that were based on grouping the men of two or more states, as was done in the original report for 17 states, have been omitted from the calculations. The value of $r$ was found to be $+ .70 \pm .09$.

This value indicates a relatively high and statistically significant correlation between high rejection rates for dental defects among the men of military age of 31 states in 1918 and high DMF rates among the young men of the same age 16 years later; that the force or forces which tended to operate to produce dental diseases, particularly tooth decay, were not haphazard but more or less constant over a considerable period.

Most of the lesions of tooth decay which eventually caused the rejection of men in the several drafts or which caused the men in the naval group to have decayed, missing, or filled (DMF) teeth, had their inception when the individuals were relatively young, when their permanent teeth had been erupted a relatively short period. Therefore, as complementary to a study of the extent of dental defects among men of military age, it seems desirable to examine data as to permanent teeth of children in various parts of the United States.

Several dental surveys among children have demonstrated the geographical distribution of tooth decay. Mitchell [7] found that the white children of Puerto Rico had less tooth decay than did children of the same age and color in the United States. Moore [8] contrasted the dental condition of 393 preschool children in San Diego, Calif., with 550 children of the same age in Portland, Ore. He reported that 54.5 per cent of the San Diego children were without dental caries experience, while among the Portland children 22.5 per cent were without past or present tooth decay. In an extensive survey by private dentists coöperating with the U. S. Public Health Service during 1933–1934, the dental findings among some 1,500,000 school children are reported.[9] It was found that the dental caries prevalence rates of the permanent teeth of children residing in different states varied greatly in their magnitude. For example, it was found that the mean number of permanent teeth attacked by decay among boys aged 13 residing in cities having a population of 100,000 or over of the states of Florida, Virginia, and Massachusetts was 3.09, 4.17, and 5.69 respectively. In Table 3 the mean

number of decayed, missing, or filled permanent teeth among Florida, Virginia, and Massachusetts city boys aged 7, 10, and 13 respectively is given, together with the number of children composing each sample.

TABLE 3

*Mean Number Decay Attacked Permanent Teeth among Three Age Groups of Boys Residing in Florida, Virginia, and Massachusetts Cities Having Populations of at Least 100,000* (A)

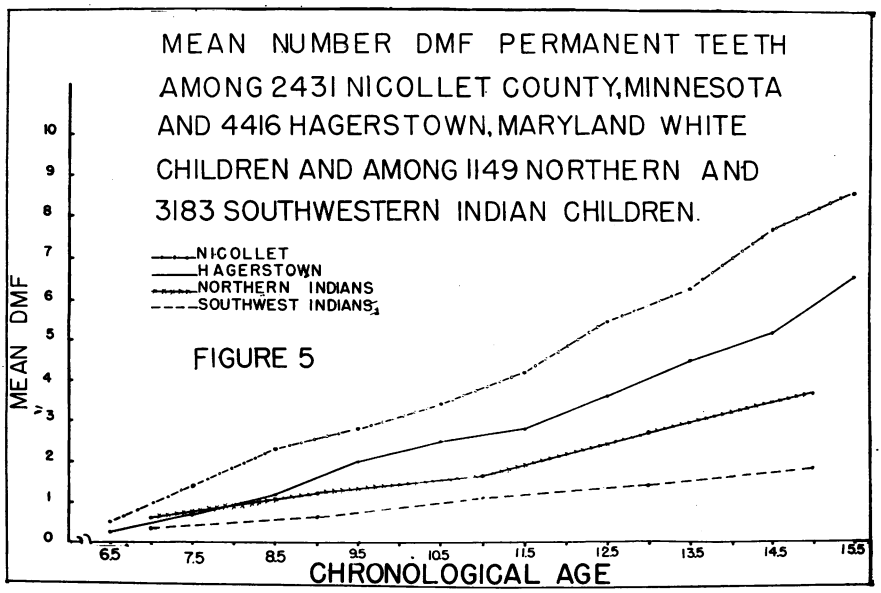
| Mean Age Last Birthday | 7 | 10 | 13 |
|---|---|---|---|
| *Florida* | | | |
| Number of Children Examined | 2,878 | 3,479 | 1,220 |
| Mean Number of Decayed, Missing, or Filled Permanent Teeth | 0.71 | 1.92 | 3.09 |
| *Virginia* | | | |
| Number of Children Examined | 1,350 | 1.492 | 951 |
| Mean Number of Decayed, Missing, or Filled Permanent Teeth | 0.93 | 2.60 | 4.17 |
| *Massachusetts* | | | |
| Number of Children Examined | 1,353 | 1,425 | 1,308 |
| Mean Number of Decayed, Missing, or Filled Permanent Teeth | 1.87 | 3.83 | 5.69 |

(A) Messner, C. T., *et al.* Dental Survey of School Children, Ages 6–14 Years Made in 1933–1934 in Twenty-six States. *Pub. Health Bull.*, 226, 1936.

Because the surveys among children which have just been referred to were made by groups of private practitioners, it has been suggested by some that differing criteria and methods of reporting might tend to vitiate them. Four other sets of data are presented which seem to be relatively free from such defects because the examinations were all made by members of the dental staff of the U. S. Public Health Service. This leads to the assumption that unusual uniformity would prevail in the data and that the relative magnitude of the different rates may be used as a reliable measure of the severity and extent of the disease among the different groups.

Two of these groups were whites who resided at Nicollet County, Minn., and Hagerstown, Md., respectively. The remaining two groups were Indian children who lived on reservations in northern and southwestern localities of the United States.

The decayed, missing, or filled rates among the permanent teeth for the various age groups of children are given in Table 4 and are shown, graphically, in Figure V. The values demonstrate



that, among these groups of children residing in different environments, the number of permanent teeth * attacked by caries at a given age differs, as do the rejection rates among the men of the Army drafts, and the DMF rates in the 1934 naval group. That is, the children who resided in the more northerly locations had greater evidence of past and present tooth decay than did those of more southerly areas.

Among these groups of children the relationship between the number of attacked teeth and time approaches linearity, the curves only differing in their slope. This relationship persists in spite of the fact that the number of permanent teeth erupted, and therefore eligible for caries attack, increased from approximately 6 to 28 during the age periods studied. The data suggest that the relative dental fitness of the men of military age of the various states probably could have been predicted with considerable reliability from the relative condition of their teeth when they were children. In suggesting the probability of such a relationship, it is assumed that the distribution of corrective dental service would be at least as great among the population of the states with the high attack rates as among those enjoying the lower rates.

While factors associated with latitude have been chosen to illustrate epidemiological aspects of dental disease, it should be emphasized that other conditions and circumstances could and probably do influence and contribute to tooth decay. Dean,[10, 11, 12] in his extensive investigations of the relationship between fluorine in communal water supplies and caries resistance, offers another illustration of the importance of introducing epidemiological methods when considering the phenomenon of tooth decay and its distribution among the population.

TABLE 4

*Mean Number Decayed, Missing, or Filled (DMF) Permanent Teeth among 2,431 Nicollet County, Minnesota* (A), *and 4,416 Hagerstown, Md.* (B), *White Children; and among 1,149 Northern and 3,183 Southwestern Indian Children* (C)

| *Age Last Birthday* → | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* |
|---|---|---|---|---|---|---|---|---|---|---|
| *Locality* | *Number DMF (Decayed, Missing or Filled) Permanent Teeth per Child* | | | | | | | | | |
| Nicollet Count, Minn. | 0.51 | 1.43 | 2.30 | 2.85 | 3.39 | 4.16 | 5.49 | 6.32 | 7.69 | 9.62 |
| Hagerstown, Md. | 0.29 | 0.72 | 1.19 | 2.01 | 2.51 | 2.84 | 3.65 | 4.54 | 5.21 | 6.47 |
| Northern Indians | ..... | 0.63 | .... | 1.27 | .... | 1.67 | .... | 2.75 | .... | 3.70 |
| Southwestern Indians | ..... | 0.37 | .... | 0.68 | .... | 1.47 | .... | 1.88 | .... | 2.70 |

(A) Knutson, J. W. Appraising the Dental Health Program. *J. Am. Dent. A.*, 29:543–556 (Apr.), 1942.
(B) Klein, Henry, Palmer, C. E., and Knutson, J. W. Studies on Dental Caries, I. Dental Status and Dental Needs of Elementary School Children.
(C) Klein, Henry, and Palmer, C. E. Dental Caries in American Indian Children. *Pub. Health Bull.*, 239 (Dec.), 1937.

## SUMMARY

Apparently there are marked differences in the distribution of dental diseases among groups of the population residing in various states of the United States. These differences are reflected in the magnitude of the rejection rates for dental defects among men who have been drafted for military service. When the rejection rates of the states contributing to more than one draft are listed according to magnitude, con-

* It has been assumed that the numbers of the various types of permanent teeth erupted at a given age would not differ among the children of the different localities. However, this is only a working hypothesis and has not been tested by extensive data. It has been found that no significant difference in this respect existed between the Hagerstown, Md., children and a similar age-sex group of Chicago, Ill., children. (Greenwald and East: Eruption Tables of Permanent Teeth of Chicago School Children. *Illinois Dent. J.*, Sept., 1941.)

siderable uniformity is observed in the resulting order of arrangement for each draft period. The possibility that these recurring phenomena can be explained entirely by chance and, or, by differing examining technics and criteria, is discussed and considered unlikely. Evidence tending to substantiate the probability that the observed differences are representative of the relative extent of the disease among the population of the respective states is offered by data resulting from the examination of naval recruits during 1934. The reasonableness of the hypothesis is further supported by data stemming from surveys of the extent of tooth decay among children residing in different geographical areas. The relationship between latitude and dental diseases, particularly tooth decay, has been used to illustrate some of the epidemiological aspects of the problem, but it is emphasized that many other known and unknown conditions and circumstances may, and undoubtedly do, influence the disease and its distribution. It is suggested that the study of dental diseases offers a particularly interesting and profitable field for the use of epidemiological methods.

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