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Dental Characteristics of a Large Military Population Useful for Identification

REFERENCE: Friedman, R. B., Cornwell, K. A., and Lorton, L., **"Dental Characteristics of a Large Military Population Useful for Identification,"** *Journal of Forensic Sciences*, JFSCA, Vol. 34, No. 6, Nov. 1989, pp. 1357–1364.

ABSTRACT: The number and complexity of dental restorations has decreased for younger Americans. Since the presence and extent of restorations are important data for forensic science identification purposes, the Computer-Assisted Postmortem Identification (CAPMI) system was used to assess the practical effect of the decreased selectivity expected as a result of improved dental health.

Dental examination data from 7030 soldiers were recorded on optical mark read forms and entered into a database. The data were reorganized and analyzed to generate summary statistics about the incidence of each type of restoration (divided into 16 categories) for both anterior, posterior, upper, lower, and combined segments. Patients' ages ranged from 17 to 49 with a mean of 24 years 5 months. Sixty percent were from 18 to 25 years old. A characteristic is defined as any situation other than a virgin tooth; for example, extracted, missing, unerupted, or restored. The average subject had 7 dental characteristics with approximately 75% having 4 or more. Within the entire population, 9% had 32 unrestored teeth. 3.6% had only one characteristic.

To test the selectivity and uniqueness of various combinations of dental characteristics, 363 simulations using the CAPMI system were made against the entire 7030 subject database. Sample records (33 per group) with 2, 3, 4, 5, 6, 7, 8, 9–11, 12–14, 15–18, and 19+ characteristics were chosen at random from the database and searches were made.

The variety of dental restorations was such that even the more common restorative situations yielded only two to four first-place ties. Eighty-five percent of all comparisons made with two or more characteristics gave a unique correct answer. Thirteen percent of the remainder were tied with three or fewer other records. It was concluded that *although dental restorations are diminishing in frequency in the younger population they still provide a high degree of selectivity for forensic science purposes.*

KEYWORDS: odontology, dental restorations, human identification, computers

The views of the author do not purport to reflect the position of the Department of the Army or the Department of Defense. (Para. 4-3, AR 360-5). Commercial materials and equipment are identified in this report to specify the investigative procedure. Such identification does not imply recommendation or endorsement, or that the materials and equipment are necessarily the best available for the purpose. Furthermore, the opinions expressed herein are those of the authors and are not to be construed as those of the U.S. Army Medical Department. Received for publication 16 Sept. 1988; revised manuscript received 17 Dec. 1988; accepted for publication 21 Dec. 1988.

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There has been a significant decrease in the incidence of dental caries in the United States over the past two to three decades. The presence and extent of dental restorations play an important role in forensic science identification. In military mass disasters where little soft tissue remains after crash and or explosion and fire scenarios, the presence of dental restorations, even in jaw fragments, often becomes the sole reliable means of identification. The use of the Computer-Assisted Postmortem Identification system (CAPMI) has increased efficiency of matching and comparing antemortem and postmortem records, potentially saving thousands of manhours [*1*]. Further research has given program authors new algorithms to enhance the investigator's ability to identify fragmented remains [*2*]. The entire CAPMI system is based on the presence of dental restorations in individuals giving many thousands of possible combinations of tooth-to-tooth comparisons. The system does not use decayed surfaces as sorting factors, as these are often subject to clinical and radiographic judgment calls, and have been shown in earlier studies to confound the matching process.

The purposes of the study were (1) to characterize (by dental findings) a large military population; (2) given the population, to run matching simulations to determine if the CAPMI system would work in a significant percentage of cases; and (3) to determine if the data gathering process would reduce the productivity of the dental clinics involved in the trial. This last purpose was an attempt to measure the cost in productivity of assembling this database so as to estimate some cost/benefit ratio.

Methods

An optical mark read (OMR) form was designed to gather data (Fig. 1). All personal data were to be completed by the individual soldier/patient while waiting for his/her appointment. Tooth-related data was entered by dental clinic personnel during the course of a dental visit. No visits were scheduled solely for the purpose of participation in this study since a prime concern of this study was the effect of this additional form on routine clinic productivity and effectiveness.

The CAPMI trials were run at a typical U.S. Army base with a high density of combat-related personnel in a multitude of diverse units. Dental, civilian, and administrative personnel in each of the four involved dental clinics were briefed on the scope and particulars of the project. Posters describing the process of data entry were given to each clinic director (commander) to use in the treatment and examination areas. Separate posters describing the recording of personal data were posted in waiting areas and each patient was provided with a clipboard, a No. 2 pencil, and blank form upon entry into the treatment facility. On-site meetings were held with dental officers and ancillary personnel to answer questions and to standardize responses to common situations. One of the investigators (R. F.) remained on the base during the first two weeks of trials to evaluate compliance of patients and clinic personnel and to resolve any problems with coding the forms. Each dental clinic director was asked to implement data collection so that his clinic routines were not interrupted. Each director was asked to insure that as many forms as possible be completed, to attempt to verify compliance by participants, and to call the USAIDR office with any questions or problems. Each clinic was provided with stamped addressed envelopes in which to return completed data forms.

The OMR forms were collected from patients, batched in a central location, and sent periodically to USAIDR for processing. An OMR form reader (OMR-25, Cognitronics Corp.) was used to input data (Fig. 2). Errors as a result of name or SSN fields being unreadable by the OMR were classified as "Fatal," and these forms were not entered into the database. These forms were preserved for inspection by the operator. Data were collected over a 10-month period from 7030 soldiers.

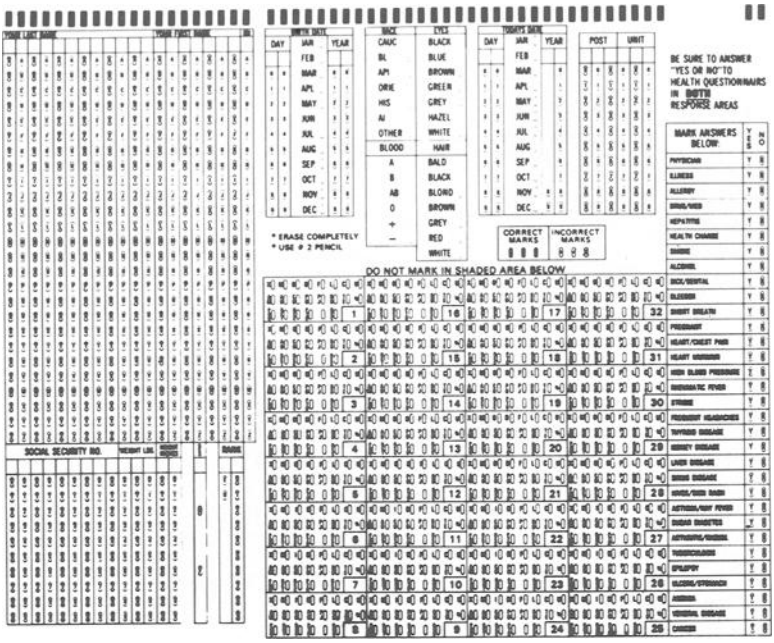

FIG. 1—*Optical mark read form.*

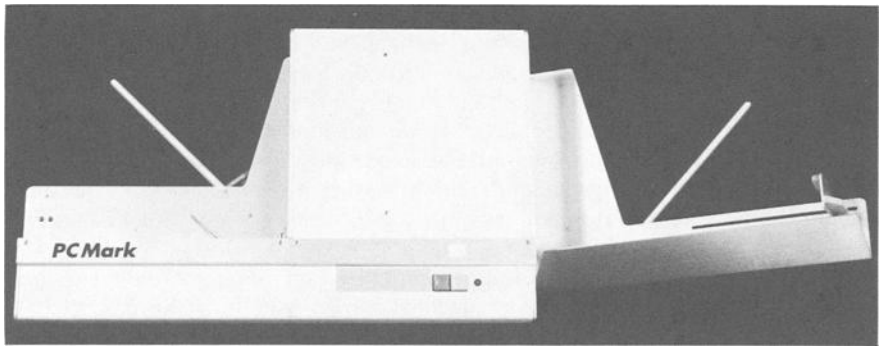

FIG. 2—*Optical mark reader (OMR-25, Cognitronics Corp.).*

The patient was requested to enter personal characteristics such as name, age, SSN, height, weight, and eye color. Dental data such as teeth present but unrestored, missing, restorative material, surfaces restored, and unique dental characteristics (that is, root canal fillings) were completed by the health care provider for each soldier. Since earlier studies have showed that the only dental characteristics that significantly affected computer sorted matches lists were restored surfaces, missing, or virgin teeth, only these characteristics were used in subsequent analyses and matching simulations. The entire population was described in terms of age, restorations present, missing teeth, and unrestored (virgin) teeth.

Demographic and raw (tooth-by-tooth) data were reorganized and analyzed to generate summary statistics for the incidence of each type of restoration. The database records were transformed electronically into a format acceptable to a microcomputer statistical package (Systat, Chicago, Illinois).

Using the 7030 records as the database and stratified random selection of records as the unknowns, 363 simulations were run on the CAPMI system. Sample records (33 per group) with 2, 3, 4, 5, 6, 7, 8, 9–11, 12–14, 15–18, and 19 or more characteristics were chosen from the database, and searches were made against 7030 "antemortem" records. These records assumed the role of postmortem records, and were compared to the entire 7030-person (antemortem) database to produce rank order lists of potential matches based on dental characteristics.

Results

Completion of the form took place at various times, at the dental officer's discretion, including while performing a routine examination, while waiting for local anesthesia to take effect, and while waiting for X-rays to be developed, to name a few. CAPMI exam and form completion did not add noticeable lengths of time to the dental visit. This observation was verified by workload reporting records which showed that the 7030 examinations did not cause any other category of treatment to decrease when compared with previous year's production.

All of the data, except for the age, sex, and dental information, was expunged from the records and summary statistics were calculated for each variable— means and standard deviations for age and frequency distributions for the tabular data. Soldiers' ages ranged from 17 to 49 years old, with the mean age of just over 24 years. Sixty percent of the population was between 18 and 25 years old (Table 1). These age distributions are consistent with the general military population.

The number of "characteristics" (that is, teeth affected by a dental restoration or missing teeth) were calculated for the population (Table 2). Any individual may have only a total of 32 characteristics—any tooth in a nonvirgin state. Each of 32 teeth may have 1 of 35 states; of these there are 35 different combinations of restored surfaces, missing, impacted, or crowned. This does not include unique identifiers like pontics or root canal fillings. The variety of different states available for each of 32 teeth makes a large number of unique combination of restorations possible and also makes possible a computer-guided search for a positive identification.

Since there are 12 anterior teeth, 12 is the maximum number of possible anterior characteristics in any one soldier. An individual may have up to 20 posterior characteristics, 1 for each posterior tooth. As mouths with a full complement of virgin teeth represent an identification problem, "virgin" characteristics were of interest to the researchers. Table 3 shows that 5% of the population had 32 erupted, virgin teeth. Most of the individuals with 28 or more virgin teeth had unrestored dentitions, varying only

TABLE 1— *Age distribution of military population. Numbers 17 through 49 denote age, numbers underneath represent percent distribution.*

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
0.3	3.4	9.3	13.1	12.0	9.9	8.4	6.9	5.8	4.5	4.0	3.1	2.9	2.3	1.9	1.8	1.5	1.2	1.3	1.1	1.2	0.9	0.9

40	41	42	43	44	45	46	47	48	49
0.5	0.5	0.3	0.2	0.2	0.1	0.1	0.1	.03	.03

BASED ON A TOTAL PDPULATION OF 7030. PERCENTAGES MAY NOT EQUAL 100 BECAUSE OF ROUNDING OFF.

TABLE 2— *Total number of characteristics (nonvirgin teeth).*

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ANTERIOR	66.0	12.1	8.6	4.4	3.9	1.7	1.5	.7	.3	.3	.2	.2	.03	-	-	-	-	-	-	-	-
POSTERIOR	9.3	3.6	4.1	4.3	5.4	6.4	6.9	8.4	10.7	8.8	7.5	6.5	5.1	4.7	3.7	2.4	1.3	.4	.2	.2	.01
TOTAL	8.4	3.6	4.1	3.9	5.3	5.6	6.0	7.2	9.0	8.0	6.8	6.5	5.3	4.5	4.0	3.2	2.4	1.9	1.4	.9	.7

	21	22	23	24	25	26	27	28	29	30	31	32
ANTERIOR	-	-	-	-	-	-	-	-	-	-	-	-
POSTERIOR	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	.5	.3	.3	.2	.04	.1	.1			.01		

BASED ON A TOTAL POPULATION OF 7030. PERCENTAGES MAY NOT EQUAL 100 BECAUSE OF ROUNDING OFF

	MEAN	STANDARD DEVIATION
ANTERIOR	901	1.698
POSTERIOR	7.369	4.333
TOTAL	8.270	5.176

TABLE 3— *Incidence of numbers of virgin teeth.*

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ANTERIOR	0.3	0.2	0.2	0.3	0.4	0.8	2.0	2.1	4.0	5.7	6.1	11.0	67.0					-	-	-	-
POSTERIOR	2.0	2.5	3.4	4.6	5.1	5.7	6.1	6.8	8.3	7.5	7.5	5.7	6.2	5.0	4.3	4.3	4.7	1.9	1.8	1.3	5.3
TOTAL	0.2	0.1	0.1	0.1	0.2	0.2	0.6	0.6	0.7	1.0	1.4	1.7	2.2	3.1	3.6	4.3	4.4	5.5	5.5	6.4	7.2

	21	22	23	24	25	26	27	28	29	30	31	32
ANTERIOR	-	-	-	-	-	-	-	-	-	-	-	-
POSTERIOR	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	6.6	6.6	5.2	5.6	4.9	4.1	4.0	4.3	1.8	1.8	1.2	5.0

BASED ON A TOTAL POPULATION OF 7030. PERCENTAGES MAY NOT EQUAL 100 BECAUSE OF ROUNDING OFF

	MEAN	STANDARD DEVIATION
ANTERIOR %	11.03	1.86
POSTERIOR %	9.61	5.12
TOTAL %	20.64	6.07

in the number of third molars removed. The total population had approximately 9% of its members with a complement of virgin teeth.

Missing teeth are often as valuable as restored teeth in providing information to forensic odontologists. In this population approximately 6% of the soldiers had at least one missing anterior tooth. Sixty-seven percent had at least one missing posterior tooth. Many of these were third molars (Table 4). Tables 5 and 6 show the relative percentages of each tooth with virgin (V), missing (X), or restored (R) status for the entire population.

While 7030 OMR forms were accepted into the study, an additional 109 forms were rejected as a result of unreadable identification numbers. Evaluation of this group showed that two thirds of these errors were easily recoverable. That is, the identifying number was written in the text blocks as required, but the corresponding bubbles were not shaded properly. Errors also included omission of shading, partial form mutilation, shading too

TABLE 4— *Incidence of numbers of missing teeth.*

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ANTERIOR %	93.9	3.1	1.1	0 5	0 6	0.2	0.4		0.1	.01	0 4	01	0 1	-	-	-	-	-	-	-	-
POSTERIOR %	32.7	10.0	11.7	7.6	21.7	5.6	3.5	1.9	2.4	1.0	0.5	0.5	0.3	0 2	0.1	0 1	0 1	0 1	01	01	0 1
TOTAL %	31.9	9.9	11 6	7 7	21.3	5.6	3.9	2 0	2.5	1.0	0 7	0 5	0 5	0 2	0 1	0 1	0 1	0 1	0 1	04	04

	21	22	23	24	25	26	27	28	29	30	31	32
ANTERIOR %	-	-	-	-	-	-	-	-	-	-	-	-
POSTERIOR %	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL %	.04	0.1	0.1	.03	.01	.03		.03				0 1

BASED ON A TOTAL POPULATION OF 7030. PERCENTAGES MAY NOT EQUAL 100 BECAUSE OF ROUNDING OFF

	MEAN	STANDARD DEVIATION
ANTERIOR %	0 15	0 78
POSTERIOR %	2 57	2 67
TOTAL %	2.72	3.04

TABLE 5—*Maxillary teeth.*

Tooth Number	Virgin, %	Missing, %	Restored, %
1	38.1	39.2	22.7
2	35.0	4.7	60.3
3	25.1	8.1	66.8
4	64.5	3.7	31.8
5	68.2	7.5	24.3
6	91.8	1.1	7.1
7	84.6	2.7	12.7
8	82.8	2.3	14.9
9	82.4	2.6	15.0
10	83.9	2.8	13.3
11	91.6	1.2	7.2
12	68.0	7.4	24.4
13	65.4	3.8	30.8
14	25.9	8.0	55.1
15	38.1	5.1	56.8
16	40.4	37.4	22.2

lightly, overlapped shading in the same column, or shading in pen instead of the pencil provided at the clinical site. These errors could be eliminated by a closer review of records at the time of completion or by rewriting them at the time of rejection from the OMR form reader. After recovery of salvageable forms only eight records were unusable.

The results of the sorting simulations bore out previous experience (Table 7). The variety and location of dental restorations was such that even the more common restorative situations, such as 2, 3, or 4 characteristics, yielded only 2 to 4 first-place "ties," that is, 2 or more records were identical. The group with 4 characteristics included 1 record with 4 third molars missing and no other restorative work—thus the tie with 62 other records—and 1 record with the 2 upper third molars missing and a single occlusal filling on tooth Number 30—the tie with 48 other records. If the results of the simulations are adjusted to take into account the actual percentage of cases with that number of

TABLE 6—*Mandibular teeth.*

Tooth Number	Virgin, %	Missing, %	Restored, %
17	35.3	38.6	26.1
18	30.3	7.2	62.5
19	22.7	15.0	62.3
20	68.1	3.0	28.9
21	82.5	4.5	13.0
22	97.2	0.2	2.6
23	97.7	0.5	1.8
24	97.3	0.7	2.0
25	97.7	0.7	2.0
26	95.5	0.5	4.0
27	97.2	0.3	2.5
28	82.5	4.6	12.9
29	67.9	3.4	28.7
30	22.9	14.1	63.0
31	31.0	6.6	62.4
32	36.9	37.3	25.8

TABLE 7—*Sorting selectivity.*

Number of Characters Per Record	Percent of Unique Records	Number of Similar Records in Group
2	73	2, 3
3	79	2, 4
4	67	2, 11, 48, 62
5	73	2, 3, 4
6	88	3, 4
7	91	2
8	91	2, 5, 7
9–11	90	2
12–14	100	...
15–18	100	...

characteristics, 80% of all comparisons made with 2 or more characteristics gave a unique correct match. Thirteen percent of the remaining records were tied with 3 or fewer other records. Ninety percent of all simulations made using records with 2 or more characteristics produced a single correct record at the head of the list and approximately 6% more will be tied with 2 to 4 similar records for most probable.

Discussion

The degree of selectivity offered by a program based on dental restorations is still valid for forensic science identification, in spite of the diminishing number of surfaces restored in younger individuals. It is feasible to collect this type and amount of information using OMR forms without imposing a great amount of additional work load on military health care providers. A database of this type can be held in readiness for forensic science use while providing health care management information in the form of caries prevalence and prosthodontic needs. The forensic science portion of this study demonstrated that,

in our current population, a computer system based on dental restorations is able to supply investigators with a list of potential matches for record-to-record comparison which will be very accurate. Even under extraordinary circumstances, comparison of records in the order suggested by this program will greatly decrease the number of manhours required for identification of large numbers of victims.

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