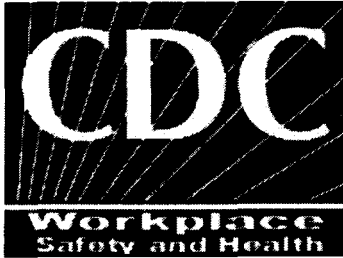


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**NIOSH HEALTH HAZARD EVALUATION REPORT:**

**HETA #99-0106-2838  
Indian Health Service**

**April 2001**

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DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health

***NIOSH***

## PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

## ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Dr. Robert Malkin of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Assistance was provided by Dr. James McGlothlin, Jenise Brassell and Marian Coleman. Statistical support was provided by Charles Mueller. Desktop publishing was performed by Pat McGraw. Review and preparation for printing were performed by Penny Arthur.

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# Highlights of the NIOSH Health Hazard Evaluation of the Indian Health Service, Dental Branch

The National Institute for Occupational Safety and Health (NIOSH) received a request from the management of the Indian Health Service (IHS) to evaluate musculoskeletal disorders of the hand/wrist, neck, shoulder, back, and elbow and possible causes of these disorders that might be related to the job at IHS dental clinics.

## What NIOSH Did

- We sent a questionnaire to all IHS dental clinic employees. We asked about musculoskeletal symptoms, work practices, and the work environment. 539 employees responded.

## What NIOSH Found

- Dental hygienists and dental assistants had a higher rate of work-related musculoskeletal disorders than dentists. The rates ranged from 4% (elbow) to 12 % (hand/wrist) in dentists and from 9% (elbow) to 34 % (hand/wrist) in other occupations.
- Among dental hygienists and dental assistants, risk factors for musculoskeletal disorders included: years at the present location, seeing less patients per day, comfort of one's chair, lack of fiber optics, and the location of the handpiece.
- Among dentists, risk factors included extracting more teeth in a week, fair or poor lighting, not having a direct view of the mouth, placing the patient in the 9 or 10 o'clock position, fair or poor chair comfort, and fair or poor lighting.

## What IHS Managers Can Do

- Replace older rear delivery equipment with more modern "continental-style" over-the-patient equipment.
- Provide patient chairs that are as thin as possible.
- Design operatories so that the assistant or dentist does not have to get up or twist to access equipment.
- Ensure that existing equipment is functioning properly.
- Evaluate ergonomically designed instruments.

## What the IHS Employees Can Do

- Take mini-breaks at work to decrease the time spent in one position.
- Maintain proper posture.



**What To Do For More Information:**  
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report # 99-0106-2838



**Health Hazard Evaluation Report 99-0106-2838**  
**Indian Health Service**  
**April 2001**

**Robert Malkin D.D.S., Dr. P.H.**

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## **SUMMARY**

On February 16, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the management of the Indian Health Service (IHS) to estimate the prevalence of and evaluate the risk factors for musculoskeletal disorders among IHS dental staff. The present evaluation is a questionnaire survey of all clinical dental employees of the IHS, based on a previous ergonomic study of six Phoenix area IHS dental clinics, as reported in a previous HHE.

A list of employees was given to NIOSH investigators by the IHS, and each employee was sent a questionnaire in the mail. Seven hundred and eighty five questionnaires were mailed to the IHS dental employees in the first mailing, and another (identical) questionnaire was sent to those employees who did not return it. A total of 539 employees (69%) returned the questionnaire. Participants were employed in all aspects of dentistry including dental assistants, expanded duty dental assistants, dental hygienists and dentists. Because of substantial differences in job duties between the dentists and the assistants/hygienists, separate analyses of risk factors were done for the two groups. There were 192 dentists and 338 dental assistants/hygienists (9 did not answer the question, and were excluded from the analysis that determined occupational risk factors); most of the dental assistants/hygienists were female (99%) and most of the dentists were male (79%).

We used a definition of a work-related musculoskeletal disorder (WRMD) for the five body areas studied (hand/wrist, neck, shoulder, back, elbow) that was previously used in other NIOSH HHEs. A WRMD was considered present if any discomfort (e.g. pain, numbness, tingling, aching, stiffness, or burning) in the affected body part occurred within the last 12 months and all of the following applied:

- (1) Discomfort began after starting work at the current location,
- (2) Discomfort lasted for more than one week or occurred at least once a month within the past year,
- (3) Discomfort was reported as "moderate" (the midpoint) or worse on a five-point intensity scale,
- (4) Discomfort in the past year was not related to an accident or sudden injury.

The prevalence of WRMDs was greater for each body part for dental assistants/hygienists (range, 9-34%) as compared to dentists (range 4-13%).

For the dental assistants/hygienists, multivariable statistical models were used to simultaneously assess the relationship between multiple occupational risk factors, confounders, and WRMDs. For dentists, only univariate models could be used, looking at one risk factor at a time. Occupational risk factors were different for each body area studied, and for whether the respondent was a dentist or dental assistant/hygienist.

For dentists, neck WRMD was statistically significantly related to not always having a direct view of the patient's mouth (Odds Ratio [OR] 2.1, 95% confidence interval [CI] 1.1, 4.1) and fair or poor dental chair comfort (OR 4.5; 95% CI 1.4, 14.2). Increased reporting of hand WRMD by dentists was based on extracting 10 more teeth per week (OR 1.4; 95% CI 1.1, 1.9) and rating the lighting as fair or poor (OR 6.3; 95% CI 1.0, 20.3). The risk of back WRMD for dentists was statistically related to fair or poor dental chair comfort (OR 3.8;

95% CI 1.0, 14.7) and sitting in the 9 or 10 o'clock position as opposed to the 11 or 12 o'clock position relative to the patient (OR 7.5; 95% CI 1.5, 11.4). Shoulder WRMD for dentists was related to not always having a direct view of the patient's mouth (OR 2.0; 95% CI 1.0, 4.0) and the time working at the same location, based on either spending 5-9 years at the same location (OR 4.4; 95% CI 1.3, 15.9) or spending more than 10 years at the same location (OR 7.3; 95% CI 1.6, 32.0).

For dental assistants/hygienists, neck WRMD was related to not having a fiber-optic handpiece (OR 2.4; 95% CI 1.0, 5.8), fair or poor dental chair comfort (OR 2.0; 95% CI 1.0, 3.9), and the years spent working at the same location (OR 1.3 [for a 5 year increase]; 95% CI 1.1, 1.7). The risk of neck WRMDs in dental assistants/hygienists decreased with an increase in the number of patients per day (OR 0.7 [for seeing 5 more patients a day]; 95% CI 0.4, 0.96). For dental assistants/hygienists, hand WRMD was related to spending more years working at the same location, (OR 1.3 [based on 5 year intervals]; 95% CI 1.1, 1.6). For dental assistants/hygienists, increased back WRMD was statistically significantly associated with locating the handpiece behind the patient rather than locating the handpiece in front of the patient (OR 3.7; 95% CI 1.2, 14.2) and spending more years working at the same location, (OR 1.5 [based on 5 year intervals]; 95% C 1.2, 1.9). Shoulder WRMD for dental assistants/hygienists was related to having an instrument tray on the left side of the patient versus in front of the patient (OR 8.3; 95% CI 1.3, 165.0).

NIOSH investigators concluded that some working conditions in IHS dental clinics posed a risk for WRMDs. Dental assistants/hygienists had a higher prevalence of symptom-defined WRMD than dentists. Risk factors for WRMDs included the comfort of the employee's chair, handpiece location, instrument tray location, lighting, the number of teeth extracted per week, not always having a direct view into the patient's mouth, fiber-optic use, the position of the patient relative to the dentist, and the number of years spent at the current location. Changes that the Indian Health Service should make to prevent these disorders are given in the Recommendations section.

**KEYWORDS:** SIC 8021 (offices and clinics of dentists) Dentists, ergonomics, dental equipment, neck injuries, work-related musculoskeletal disorder (WRMD), shoulder, back, hand, elbow

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## INTRODUCTION

On February 16, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the management of the Dental Branch of the Indian Health Service (IHS). Management was concerned about musculoskeletal disorders, particularly neck disorders, among the IHS dental clinic staff, and wanted to know the extent of the problem and what equipment and tasks were associated with these disorders.

A questionnaire, with questions based on observations made during previous NIOSH visits to Phoenix area IHS dental clinics,<sup>1</sup> was sent to all clinical dental staff of the IHS Dental Branch. The questionnaire was first sent in August 1999 and resent to non-respondents in November 1999.

## BACKGROUND

The IHS is a component of the Department of Health and Human Services, and the IHS Dental Branch is charged with dental health care delivery to Native Americans. It employs both civil servants and officers of the United States Public Health Service. The IHS operates over 300 dental clinics, staffed by approximately 800 employees, including dental assistants, dental hygienists, and dentists. Some dental clinics are administered by the local tribe, and not the IHS. They receive a grant from the federal government, and can either hire their own personnel or contract with the IHS. For this project, NIOSH investigators only surveyed IHS employees.

At the time of the evaluation, the IHS used predominantly rear delivery (behind-the-patient) equipment, which means that the dental hand pieces are usually located on a cart in back of the patient and behind the dentist. Because of these delivery systems, flexion of the neck, leaning, and rotation of the trunk may be necessary to select the proper handpiece. The assistant usually sits on the patient's left side and a right-handed dentist usually sits on the patient's right. The position is reversed if the dentist is left-handed.

The IHS employs expanded duty dental assistants who, besides traditional dental assisting, scale teeth and place amalgams, including cusp protective amalgams (CPAs). CPAs are amalgam fillings that

replace a cusp of the tooth and extend on to the biting surface. These are very large and are not frequently done in a private practice, where crowns are generally used instead. They are very time consuming in their placement and require substantial amounts of carving. This carving must be done quickly, before the amalgam gets hard.

## METHODS

In July 1999, a questionnaire survey was sent to all 785 IHS Dental Branch employees involved in patient care as identified by IHS management. The survey participants consisted of dentists, dental assistants, expanded function dental assistants, and dental hygienists. If an employee did not complete the questionnaire by the end of September 1999, and the questionnaire was not returned by the post office as "undeliverable," the employee was sent a post-card reminder to complete the questionnaire. If they still did not return the questionnaire, the employee was mailed another one. New questionnaires were sent to employees in November 1999.

We used a definition of work related musculoskeletal disorders (WRMD) that was previously used by NIOSH researchers.<sup>2</sup> For each body part (hand/wrist, neck, shoulder, back, elbow) a WRMD was considered present if any discomfort (pain, numbness, tingling, aching, stiffness, or burning) in the affected part occurred within the preceding 12 months and all of the following applied:

- (1) Discomfort began after starting work at the current location,
- (2) Discomfort lasted for more than one week or occurred at least once a month within the past year,
- (3) Discomfort was reported as "moderate" (the midpoint) or worse on a five-point intensity scale,
- (4) Discomfort in the past year was not related to an accident or sudden injury.<sup>2</sup>

For statistical analysis we divided the group of participants by occupation into dentists and dental assistants/hygienists (including dental assistants, expanded duty dental assistants, and dental hygienists), since the job duties varied by occupation. Among other things, dentists drilled cavity preparations, did endodontics (root canals), made dentures, and performed oral surgery (extracted teeth); most dental assistants/hygienists either filled cavities, did dental prophylaxis (teeth cleaning) or scaling, or readied the operatory for the

next patient. When a respondent listed their occupation as “other,” we reviewed the questionnaire and re-categorized the person as either a dentist or assistant on the basis of their job duties.

We examined the relationship between each of the five WRMDs and each of the 18 occupational risk factors listed in Table 1. Depending on the type of data, we used one of several statistical techniques to determine whether there was evidence of a relationship between the WRMD and the risk factors under consideration. The techniques used were: chi square tests for data in 2x2 tables, Fisher’s exact tests when the data in the 2x2 tables was sparse, and logistic regression for ‘continuous’ type risk factors or for analyses that considered multiple risk factors simultaneously. All of the analyses were done using SAS Version 8.1 statistical software.<sup>3</sup>

For each of the analyses, odds ratios (OR) were computed to measure the association between a WRMD and a risk factor. When the OR is 1 or less, we say that people with the risk factor are no more likely to have a WRMD than people without the risk factor. When the OR is greater than 1, we say that people with the risk factor may be more likely to have a WRMD than people without the risk factor. We also calculated the 95% confidence interval (CI) and “p” value for the OR. A CI that does not include the number 1 means that the evidence of an association between a WRMD and a risk factor is unlikely to have occurred by chance. A “p” value that is 0.05 or less is said to be statistically significant and indicates that an observed relationship is unlikely to be due to chance.

Possible confounders, i.e., non-work-related risk factors that might affect the relationship between WRMDs and work-related risk factors, were selected based on a review of previous studies. These possible confounders included body mass index (BMI), height, gender, and age. When appropriate, logistic regression models were used to control for the effects of these variables.

## EVALUATION CRITERIA

A number of studies have estimated the prevalence of WRMDs in dental work.<sup>4,5,6,7,8</sup> Most of the studies are cross-sectional, providing prevalence data; because these studies lack comparisons with control groups and do not account for the temporal pattern of

events, they are unable to demonstrate cause and effect.

## Neck and Shoulder Disorders

Neck and shoulder musculoskeletal disorders among dentists, dental hygienists, and dental assistants have been commonly reported by several researchers.<sup>9,10,11</sup> One case-control study found that a group of 99 dentists had a higher prevalence of neck symptoms than a group of 100 pharmacists (44% versus 26%; relative risk [RR] = 2.1; 95% CI 1.4, 3.1).<sup>12</sup> In that study, female dentists reported neck musculoskeletal disorders 1.4 times more often than male dentists (95% CI 1.0, 2.0) and the frequency of musculoskeletal disorders increased with age. This was not observed in male dentists or in either gender among pharmacists.

Published studies have found that repetitive neck movements and continuous arm and hand movements affecting the neck and shoulder demonstrate significant associations with neck musculoskeletal disorders.<sup>13</sup> Researchers have found a strong relationship between neck musculoskeletal disorders and high levels of static contraction, prolonged static loads, and extreme working postures involving neck and shoulder muscles.<sup>13</sup> There was, however, insufficient evidence of a positive association between force and shoulder musculoskeletal disorders.

Despite the variety of seating positions for dental personnel, dentists, and dental assistants are required to adopt non-neutral postures for much of the workday. The postures adopted usually require prolonged static contraction of the trunk and scapulothoracic (upper back) and scapulohumeral (shoulder) musculature, combined with repetitive contraction of muscles in the wrist, hand, and fingers during fine hand motor control work. We observed that dental workers usually assume these awkward postures for several reasons:<sup>1</sup>

- to coordinate their positions relative to assistants, with whom they often share limited space;
- to obtain optimal view of teeth within the patient’s mouth, often while maintaining a seated posture;
- to provide a comfortable position for the patient; and
- to maneuver complex equipment and reach for instruments.



Operating positions are usually identified in relation to where the dentist is sitting relative to the patient, using a 12 hour clock face. These positions include:

- (1) the 8 o'clock position, to the front of the patient's right side;
- (2) the 9 o'clock position, at the side of the patient;
- (3) the 10 o'clock position;
- (4) the 11 o'clock position;
- (5) the 12 o'clock position, in back of the patient;
- (6) the 1-4 o'clock position on the patient's left side (for left handed dentists)

The posture and biomechanics of dental workers have been analyzed by several authors. Dentists were found to most commonly use a combination of the flexed and right side-flexion position of the neck with a head-down position (45 to 90 degrees neck flexion) for 58% to 83% of the studied period.<sup>14,15</sup> Significant muscular fatigue can occur within 2 hours in this position.<sup>16</sup> Rundcrantz *et al.* found that dentists with cervico-brachial (neck and shoulder) disorders adopted a posture of neck flexion or rotation, or a combination of the two, more frequently than dentists without musculoskeletal disorders ( $p < .01$ ).<sup>9</sup> A study by Davies and Eccles showed that patients tend to prefer being in the 30-degree neck flexion position, while the operator prefers the patient to be in a nearly horizontal position of 15 degrees for clearer viewing without neck flexion.<sup>17</sup> They found that placing the chair in the horizontal position rather than at 30 degrees achieved a posture of less stress for the dentist. In general the patient's head should face forwards and not be rotated, except for certain tooth cavities (for example cavities facing the cheek). This study led to a list of recommendations for the design of dental chairs, including adjustability of the seat pan and backrest.

Because of the precision required by dental work, the muscles used in sustaining such activity are at risk of becoming fatigued and causing discomfort. Stability maintained through static muscle loading in the shoulder and elbow areas for prolonged periods can lead to fatigue and discomfort.<sup>13</sup> Grandjean suggested that with prolonged contraction of the upper trapezium (a neck muscle) during upper extremity stabilization, adjacent blood vessels and nerves may be compressed, making the upper extremity susceptible to temporary ischemia (loss of blood flow).<sup>18</sup>

In summary, several risk factors associated with neck and shoulder disorders are found in dental work. Prolonged static neck flexion and shoulder abduction or flexion, lack of upper-extremity support, and inadequate work breaks can be major risk factors for neck and shoulder musculoskeletal disorders.<sup>13</sup> Epidemiologic studies of other industries have shown an association between repetitive movements and shoulder and neck musculoskeletal disorders. To our knowledge, no specific studies in dentistry have examined the effects of repetitive movement on neck or shoulder problems.

## Wrist and Hand Disorders

Dental work has been associated with hand and wrist problems including carpal tunnel syndrome. Carpal tunnel syndrome is defined as symptomatic compression of the median nerve within the carpal tunnel, which is the space between the transverse carpal ligament on the palmar aspect of the wrist and the carpal bones on the dorsal aspect of the wrist.<sup>19</sup> Swelling of the tendon sheaths for example, can reduce the size of the tunnel, compressing its other contents. Symptoms of carpal tunnel compression can appear from any activity causing prolonged increased (passive or active) pressure in the carpal canal.

Liss *et al.*<sup>8</sup> used a standardized questionnaire to measure the prevalence of musculoskeletal complaints in 2,142 dental hygienists and 305 dental assistants. They found that after adjusting for age, dental hygienists were 5.2 times more likely than dental assistants to have been told that they had carpal tunnel syndrome and 3.7 times more likely to meet a questionnaire-based definition of carpal tunnel syndrome than were dental assistants. Osborn *et al.*<sup>20</sup> used a questionnaire to survey 444 Minnesota dental hygienists. They found that 7% had been previously diagnosed with carpal tunnel syndrome and that 63% of the sample reported one or more symptoms of carpal tunnel syndrome.

There is evidence of an association between carpal tunnel syndrome and highly repetitive work, alone or in combination with other factors.<sup>13</sup> Evidence also indicates an association between forceful work and carpal tunnel syndrome,<sup>13</sup> but the amount and type of repetitive movement performed during dental work has not been accurately quantified by most previous studies. Liss *et al.*<sup>8</sup> found that the predictors for carpal tunnel syndrome among dental hygienists

were where the hygienist sat in relation to the patient (10:00 or 12:00 o'clock positions having the highest risk of carpal tunnel syndrome), increased years of practice, and seeing more heavy calculus patients per day. He notes that seeing an increased number of heavy calculus patients in a day may more often require the use of increased force and may reflect an increased frequency of performing stressful maneuvers.

## Low Back Pain

Low-back discomfort has been associated with dental work in numerous studies.<sup>11,21,22,23,24,25,26</sup> Changes in operating methods in dentistry, which have occurred since the late 1950s, have altered the occupation from a standing to a sitting profession. Shugars *et al.* found that good (neutral) posture correlated negatively with back pain, and generally, dentists who sat 80% to 100% of the day reported more frequent lower-back pain, than those that do not sit as often.<sup>25</sup> Static work in the sitting posture requiring spinal flexion and rotation has been associated with increased risk of low back pain.<sup>27,28,29</sup> According to Visser and Straker, loads on soft-tissue structures of the lumbar spine and discs are increased by sitting. Additionally, extensor muscle activity in the lumbar spine area in the unsupported sitting posture is greater than in standing. Back discomfort experienced by dental workers was shown to increase over the working day.<sup>11</sup>

# RESULTS

## Characteristics of Dentists and Dental Assistants/Hygienists

### Personal Characteristics

Originally, 785 questionnaires were mailed to IHS clinical dental employees in August 1999. Sixty-two percent (496) were completed and returned. Forty-three additional employees responded to either the postcard reminder that we sent or the second questionnaire mailing for a total response of 539 participants in the study, and a participation rate of sixty-nine percent. Participants were employed in all aspects of dentistry including assistants, expanded

function dental assistants, dental hygienists, and dentists. Thirty-six percent (192) were dentists (36%) and sixty-four percent (338) were dental assistants/hygienists (64%), and 9 employees did not answer the question concerning occupation and were excluded from the analysis of WRMDs (Table 2). The dental assistants/hygienists were predominantly female (ninety-nine percent); and the dentists were predominantly male (seventy-nine percent). The dentists and dental assistants/hygienists were of similar age (Table 3).

Thirty-four percent (176 of the 524 employees answering the question) reported that they had discomfort that may be due to an accident or sudden injury in the preceding year. Dental assistants/hygienists (thirty-seven percent) reported a higher percent of accident/sudden injury than dentists (twenty-six percent). Fifty-eight percent (69 of 120 dental assistants/hygienists who reported an accident/sudden injury in the past year reported that it had occurred on the current job while only thirty-three percent (16 of 49 dentists) reported that their accident/sudden injury in the past year had occurred on their current job.

### Occupational Characteristics

Ninety-six percent (508 employees) reported that they usually worked sitting down and seventy-five percent (403) said that they usually placed the patient lying down. Of the 524 employees answering the question concerning getting a direct view into the patient's mouth, forty-one percent (213) reported that they always tried to get a direct view into the patient's mouth, forty-three percent (223) reported that they did so usually, fourteen percent (75) did so sometimes, and two percent (13) reported that they seldom or never got a direct view into the patient's mouth (Table 4).

We were told by IHS management that handpieces were predominantly located in the rear at the IHS, and this was corroborated by the study results. Seventy-one percent (380 of 534 employees) who answered the question had a rear delivery system, twelve percent (66 of 534) had an over the patient (front-delivery) system, fourteen percent (75 of 534) reported having a side delivery system, and two percent (13) either reported two locations or left the question blank.

There were differences between the dentists and the dental assistants/hygienists. The prevalence of all WRMDs was greater for dental assistants/hygienists than dentists when participants with accidents were excluded (Table 5). For each body part, dental assistants/hygienists had a higher prevalence of WRMDs than dentists. Dentist's chairs were also reported to be more comfortable than those of the dental assistants/hygienists. Seventy-three percent (137 dentists) reported that their chair comfort was good or excellent while fifty-three percent (176) dental assistants/hygienists reported that their chair comfort was good or excellent.

### **Operatory Comfort and Efficiency**

Employees were asked to list three suggestions for improving comfort and three suggestions for improving operatory efficiency at IHS dental clinics (Table 6). The comfort of the dental operatory was rated as excellent by seven percent (36 employees), good by thirty-nine percent (205 employees), fair by forty-one percent (215 employees), and poor by fourteen percent (73 employees); 10 employees did not answer the question. The operatory layout in terms of efficiency was rated as excellent by nine percent (49 employees), good by forty-five percent (236 employees), fair by thirty-five percent (185 employees), and poor by eleven percent (56 employees); 13 employees did not answer the question.

Suggestions for improving comfort from 273 employees were specific to that individual employee and included: having quieter hand pieces, better instrument tray position, increased privacy, being "nice," posters in the waiting room, prescription safety glasses, in-service courses, and increasing the length of tubing to the hand pieces. Suggestions to improve efficiency (341) were specific to that employee and included: new dental carts, keeping a dentist, having experienced dentists, getting cords off the floor, assigned units, longer hoses at the units, and having a janitor and receptionist.

### **Dentists**

Of the 192 dentists, 151 were males, and 40 were females (1 did not answer the question). The mean age of the dentists was 41 years (range 27-62). Of the 192, eight-five percent (161) were white, with the remainder including three percent (6) Native Americans, two percent (4) Asians or Pacific

Islanders, five percent (9) Blacks, and four percent (7) Hispanics. The dentists worked at the present location for a mean of 4 years (range 0-26 years) and had worked in their present occupation a mean of 12 years (range 1-38 years). The dentists extracted a mean of 17 teeth per week (range 0-greater than 99). Using a twelve-hour clock face as a way of describing location, 43 percent (81) dentists normally sat at the 11 o'clock position (for right-handed dentists). Of the 156 dentists (82 percent) worked with the patient lying down, and 137 dentists (72 percent) were usually or always able to get a direct view into the mouth. Additional information about study participants is given in Table 3 and Table 4.

### **Dentist Occupational Risk Factors for Musculoskeletal Symptoms**

Because of the small number of dentists with specific WRMDs, we were unable to assess risk factors using multivariate statistical models. Thus, the risks associated with each occupational characteristic are unadjusted for other occupational or non-occupational characteristics (Table 7).

### **Neck WRMD**

Neck WRMDs were statistically significantly related to the dentist not having a direct view of the patient's mouth and having an uncomfortable chair. Eight percent (9 of 119 dentists) who always or usually have a direct view of the mouth reported neck WRMD as opposed to twenty-three percent (10 of 43 dentists) who replied that they either sometimes or never had a direct view (OR 2.1; 95% CI 1.1, 4.0). Twenty-four percent (10 of 41 dentists) who thought their chair comfort was fair or poor reported neck WRMD while seven percent (8 of 120 dentists) who thought their comfort of the chair was good or excellent reported neck WRMD (OR 4.5; 95% CI 1.4, 14.2).

### **Shoulder WRMD**

Shoulder WRMDs were found to be statistically related to the dentist not having a direct view of the patient's mouth (OR 2.0; 95 percent CI 1.0, 4.0) and the number of years the doctor worked at the particular location. Dentists who worked 5-9 years at the same location had increased shoulder WRMD as compared to those in the 0-4 year group (OR 4.4;

95 percent CI 1.3, 15.9); those dentists who worked 10 years or more at the same location had an even greater risk of developing shoulder WRMD as compared to those in the 0-4 year group (OR 7.3; 95 percent CI 1.6, 32.0).

### **Back WRMD**

Where the dentist sat relative to the patient and the comfort of the doctor's chair were statistically significantly related to back WRMD. The position of the patient that resulted in the least back WRMD was the 11 o'clock position, and it was reported by 3 percent of dentists (two dentists) who placed their patient at the 11 o'clock position. This prevalence is lower than those dentists working with their patient in the 9 or 10 o'clock position, and 15 percent (eight dentists) who worked at the 10 o'clock position and 25 percent (three dentists) who worked at the 9 o'clock position reported back WRMD (OR 7.5; 95 percent CI 1.9, 71.4). Dentists who reported that their chair comfort was fair or poor (7 dentists, 18 percent) as opposed to good or excellent (5 percent, 6 dentists) were statistically significantly more likely to report WR back problems (OR 3.8; 95% CI 1.0, 14.7).

### **Hand WRMD**

Hand WRMD in dentists was statistically significantly related to extracting more teeth per week (OR 1.4 [for a 10 extraction increase]; 95 percent CI 1.1, 1.9) and reporting that the lighting was either fair or poor. Twenty-eight percent (12 of 43) dentists reporting that lighting was fair or poor had hand WRMD while only six percent (7 of 121) reporting that the lighting was good or excellent had hand WRMD (OR 6.3; 95% CI 2.1, 20.3).

### **Elbow WRMD**

Elbow WRMD was statistically significantly related to reporting that the comfort of the doctor's chair was fair or poor, that operatory lighting was fair or poor, and extracting more teeth per week. Dentists who reported that their chair comfort was fair or poor (nine percent, 4 of 44) were more likely to report elbow WRMD than those who reported their chair comfort as good or excellent (1 of 124, 1%) (OR 12.3; 95 percent CI 1.2, 610.5). Forty-seven dentists reported having an operatory light they considered fair or poor and five of those reported elbow WRMD

while one person of 123 who evaluated the light as good or excellent reported elbow WRMD (OR 14.5; 95 percent CI 1.5, 692.3). Dentists who extracted an additional 10 teeth per week had a greater risk of elbow WRMD than other dentists (OR 1.1; 95 percent CI 1.3, 3.1).

## **Dental Assistants/Hygienists**

There were 338 dental assistants/hygienists who participated in the survey and of those 334 were females and only 4 were males. Since the dental assistant/hygienist group was predominantly females, it was not possible to examine the effect of gender on WRMD. The mean age of the dental assistants/hygienists was 42 years (range 22-63). Eighty-seven percent (290) reported that they were Native Americans, seven percent (23) reported that they were white, and two percent (11) were Alaskan Natives, and two percent (8) were unknown. The dental assistants/hygienists worked at their present occupation a mean of 14 years (range 1-40 years) and had worked at their present location a mean of 11 years (range 0-40 years). Other characteristics of the dental assistant/hygienist population are given in Table 3 and Table 4.

### **Occupational Risk factors for Dental Assistants/Hygienists**

There were sufficient cases of WRMDs among the dental assistants/hygienists to allow a multivariate analysis, considering both occupational and non-occupational risk factors. The risk factors that were statistically significantly related to dental assistants/hygienists WRMDs are listed in Table 8.

### **Neck WRMD**

Seventy-three dental assistants/hygienists reported neck WRMD. The occupational risk factors for neck WRMD consisted of the years worked in a given location, the respondent's chair comfort, seeing fewer patients in a day, and not using fiberoptics. Working additional time at a given location increased the risk of having neck WRMD (OR 1.3 [for a 5 year increase]; 95 percent CI 1.1, 1.7). Seeing more patients a day lowered the risk of having neck WRMD (OR 0.7 [for a 5 patient increase]; 95 percent CI 0.4, 0.96). Forty percent (40 of 99) dental assistants/hygienists who felt that their chair comfort was "fair or poor" reported neck

WRMD while twenty-six percent (32 of 121) dental assistants/hygienists who thought that their chair comfort was "good or excellent" reported neck WRMD (OR 2.0; 95% CI 1.0, 3.9). Forty-seven percent (16 of 34) dental assistants/hygienists who had no fiber optics at their operatory had neck WRMD and thirty percent (55 out of 183) who had fiber optics had neck WRMD (OR 2.4; 95 percent CI 1.0, 5.8).

### **Shoulder WRMD**

Fifty-six dental assistants/hygienists reported shoulder WRMD. The location of the instrument tray on the left side of the patient (as opposed to "in front" of the patient) was statistically related to increased risk of shoulder WRMD for dental assistants/hygienists (OR 8.3; 95 percent CI 1.3, 185.0). The location of the instrument tray behind the patient was not related to increased risk of shoulder WRMD.

### **Back WRMD**

Back WRMD was reported by 67 dental assistants/hygienists. Thirty four percent (54 of 157) dental assistants/hygienists answering the question who had handpieces located behind the patient had back WRMD; fifteen percent (4 of 26) dental assistants/hygienists who had handpieces located in front of the patient had back WRMD. The position of the handpiece was statistically significantly related to back WRMD in the multivariate model (OR 3.7; 95 percent CI 1.2, 14.2). Working longer at the same location was also statistically significantly related to increased back WRMD (OR 1.5 [for a 5 year increase]; 95 percent CI 1.2, 1.9).

### **Hand WRMD**

Hand WRMD was reported by 78 persons and was statistically significantly related to working longer at the same location (OR 1.3 [for a 5 year increase]; 95 percent CI 1.1, 1.6).

### **Elbow WRMD**

Twenty three dental assistants/hygienists reported elbow WRMD. None of the occupational risk factors studied was statistically significantly related to elbow WRMD in a multivariate model.

## **DISCUSSION**

This study found that the prevalence of musculoskeletal disorders was greater for dental assistants/hygienists than dentists. For example, among dentists we found a prevalence of neck WRMD of 12% and a prevalence of shoulder WRMD of 10%; among dental assistants/hygienists we found a prevalence of neck WRMD of 33% and a prevalence of shoulder WRMD of 25%. Milerad and Ekenvall found that neck pain was reported by 54% of dentists and shoulder pain by 51%,<sup>12</sup> but we do not exactly know how this compares with our rates for WRMDs, as reported here. These rates for dentists in the Milerad and Ekenvall study were statistically significantly greater than those for pharmacists, and the authors attributed this increase to (1) cervical flexion and rotation, (2) abducted arms, and (3) repetitive precision-demanding handgrips.<sup>12</sup> Another study, by Stockstill *et al.*<sup>30</sup> found upper extremity neuropathy in 29% of dentists and cervical neuropathy in 46% of those. In that study, neuropathy was defined as "altered sensation" (which included pain, numbness, tingling, or loss of muscle function, with pain being the most commonly reported symptom). Even though the prevalence rates differed among the Stockstill study, the Milerad study, and this study, comparisons from one study to another are difficult because of different case definitions. In this study, we were only interested in WRMDs and had a very specific case definition, which may explain why the prevalence rates we found were lower than in the other studies.

Our case definition of WRMD required the symptoms to have begun after starting work at the present location, as opposed to the disorder starting while working at the current occupation. Many of the questions concerning potential risk factors dealt with what is presently occurring at a given location (i.e. the number of patients seen per week, the age of the dental unit, chair comfort, etc.). We wanted to be able to limit a "case" to symptoms that began during the current job and to relate these symptoms to current exposures.

Respondents reporting that their discomfort on a specific body part was related to a previous accident

or sudden injury were excluded from the WRMD analysis for that particular body part. This exclusion was done because we were most concerned with disorders occurring from chronic injury at the workplace and not from accidents or sudden injuries, even if the event had occurred at the workplace. We cannot determine whether a previous accident/sudden injury caused a current musculoskeletal disorder or whether that present musculoskeletal disorder is caused by certain, present-day, working conditions. Because of this uncertainty, we felt it best to eliminate those reporting an accident or sudden injury from the WRMD analysis, and follow the definition for WRMD of Bernard *et al.*<sup>2</sup>

The decision to stratify the study participants by occupation was based on the large difference in job duties between the two groups (dentists drill and extract teeth and the dental assistants/hygienists fill and clean them). Furthermore, the two groups were demographically dissimilar. The assistants/hygienists were mostly Native American females, and the dentists were predominantly white males. These demographic differences limited our ability to interpret the differences in WRMD prevalence between occupational categories.

Participation rate was 69 percent for the study, which we consider to be satisfactory for a mailed survey. It is possible that the non-respondents may have had more (or fewer) WRMDs than what was reported but we have no reason, however, to come to that conclusion. In addition, it is unlikely that the results for specific risk factors were biased by selective participation of respondents with WRMDs and certain risk factors. However, we identified and evaluated 18 potential occupational risk factors for each of the five WRMDs for both dentists and dental assistants/hygienists. Many statistical tests were done; the possibility exists that some of the statistically significant findings may have occurred by chance alone.

The dentist should find the proper position relative to the patient when working. The dentist must be able to move the patient chair up or down to get this position and must be able to properly adjust the chair

back to spread the work load to different muscles and not have to twist his or her back. We found that the dentist at the IHS was usually working 4-handed (with an assistant) and sitting with the patient in the 11 o'clock position; this position had a lower risk for back WRMD than sitting the patient in the 9 or 10 o'clock position. As for WRMDs on other body parts, the clock position of the dentist relative to the patient did not seem to be all that important. However, not always having a direct view into the patients mouth was related to neck WRMD among dentists. For a dentist, changing the position of the patient and changing one's position to allow for a direct view into the patient's mouth may be critical to achieving proper clinic ergonomics. One author has even suggested that working standing may be a useful way to vary one's position.<sup>31</sup>

We found that seeing more patients per day was associated with lower neck WRMD prevalence in dental assistants/hygienists. Seeing more patients in a day means that one is changing positions more frequently to seat the patient or clean up. Rundcrantz suggests that dentists interrupt their work with what she calls "mini pauses" to decrease the static periods in their work.<sup>32</sup> In another study Rundcrantz *et al.* found that significantly more dentists without pain and discomfort took advantage of the intermittent interruptions in their work (e.g., when the assistant was preparing the amalgam) and by using them for a rest or for raising and lowering their shoulders.<sup>33</sup> These pauses and interruptions may be helpful in preventing overloading and allowing proper physical and mental working capacity.

Additionally, the patient chair back must be thin enough to allow the operators' legs to fit under it. Our previous observations at IHS dental clinics were that older chair models tended to be thicker, and dental personnel could not easily get their legs under the patient's chair.<sup>1</sup> Newer delivery systems and chairs allowed more options for the dentist and dental assistant to sit in a comfortable position when working on a patient.

The IHS used rear delivery systems almost exclusively, due to concerns that children would kick the arm holding the hand pieces and interfere with

the dentists' work. Over-the-patient delivery systems, however, allow for bringing the handpieces into the dentist's or assistant's work area with less twisting, and also allow for proper transfer of hand pieces by the assistant. In "continental-style" delivery systems, the cords that supply the compressed air to the hand pieces retract and are kept away from the patient. These over-the-patient systems are easily adjusted for right or left-handed dentists and, since the cords are not dangling over the patient, might be less vulnerable to kicking by pediatric patients. Eccles and Davies<sup>34</sup> found that hand pieces positioned in the mid-line above the patients are most convenient for operators working at the 9 and 12 o'clock positions, thus decreasing postural problems. However, according to the authors, this mid-line position may not be accepted well by all patients. Side-delivery systems are also available. However, the assistant cannot easily reach the instruments with side-delivery equipment and the dentist must pick up and select instruments and hand pieces.

One of the clinics we had visited had newer, "continental-style" equipment, and the IHS was experimenting with "continental-style" over-the-patient delivery systems. Having the hand pieces, air/water syringe, and instruments in front of the patient should lessen the need for reaching, twisting and leaning by the assistant and dentist. Rear-delivery equipment was observed to require excessive stretching to access a handpiece; this might be related to the association between the this type of equipment and back WRMD among dental assistants/hygienists.

Being able to properly see the work area is important to dentistry and having enough light may be a critical part of dental clinic ergonomics. Much of dentistry uses reflected light, and it is necessary to adjust the patient or the light to achieve maximal illumination. Unfortunately, it may be easier for the dentist to adjust his/her position to increase visibility and illumination, at the expense of musculoskeletal comfort. The dentist should not have to look up from the oral cavity to a less illuminated area to select a handpiece, which is required when selecting a handpiece with the rear delivery equipment used by the IHS.<sup>35</sup>

Grace *et al.*<sup>36</sup> found that the position in which the patient is placed when first seated in the dental chair largely determines the patient's final chosen position for optimum comfort. Patients who are first placed in an upright position will choose a position that is closer to upright. Similarly, patients who are first placed in a supine position choose a final position that is close to supine. If the patient is initially seated in a dental chair that has been preset in the horizontal or supine position, the study suggests that the patient will not experience discomfort from the horizontal position and therefore will have no objections. However, the working positions of dental professionals vary depending on where in the mouth the dentist is working and on which surface of the tooth requires treatment. Even though the working position may vary, it is important for the dentist to maintain proper positioning of the patient, since ergonomic faults in positioning the patient can lead to unfavorable postures for dental professionals.<sup>37</sup>

## CONCLUSIONS

Because the dentists and the dental assistants/hygienists had different job tasks and were demographically different, we studied each group separately. Dentists had a lower prevalence of all WRMDs than dental assistants/hygienists. Prevalences of WRMDs in dentists ranged from a low of 4 percent (elbow) to 12 percent (neck and hand/wrist) and the prevalence of WRMDs for dental assistants/hygienists ranged from a low of 9 percent (elbow) to 34 percent (hand/wrist).

In this study, certain working conditions were found to be related to the development of WRMDs, and they varied with each WRMD studied. Occupational risk factors associated with WRMDs in dentists included not having a direct view into the patient's mouth, sitting in the 9 or 10 o'clock position (relative to the patient), extracting more teeth per week, uncomfortable chairs, and poor or fair lighting. Risk factors for dental assistants/hygienists included having an operatory that was not equipped with fiber optics, uncomfortable chairs, the number of years spent at the current location, having an instrument tray on the left side of the patient, and having a rear delivery unit.

## RECOMMENDATIONS

To achieve the goal of decreasing development of WRMDs at the IHS Dental Branch, NIOSH investigators recommend the following:

1. The IHS, Dental Branch, should develop a comprehensive ergonomics program with employee input that addresses equipment, work practices, training, and medical management.
2. Replace older, rear-delivery equipment with more modern "continental-style" over-the-patient equipment. Utilize patient chairs that are as thin as possible.
3. Ensure that existing equipment is functioning properly and that all chairs are able to be raised and lowered within the range for which they were designed.
4. Design operatories so that the assistant or dentist does not have to get up or twist to access a handpiece or suction device, or to use an amalgamator or curing light.
5. Evaluate ergonomically designed instruments, particularly dental instruments with larger handles. The IHS could start with employees who are having hand/wrist WRMDs and assess its comfort and performance before introducing it to all dentists at all clinics.
6. Encourage dental staff to take mini-breaks to decrease the amount of time they have to stay in one position.
7. Provide comfortable chairs to both dentists and dental assistants/hygienists.
8. Make sure that proper lighting is available in all operatories.
9. Remind staff of the importance of proper posture, and periodically evaluate postures. Training courses should be offered concerning proper ergonomic technique for dental workers.

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<b>Table 1</b> <b>Possible Risk Factors for Musculoskeletal Disorders for Dentists and Dental Assistants/Hygienists</b> <b>Indian Health Service</b> <b>August 2000</b>	
Years at the occupation	Number of extractions per week
Years at current location	How often hand scaling is done
Patients seen per day	Number of patients hand scaled per week
Where the dentist sits around the patient	Use of an ultrasonic scaler
Whether the respondent has a direct view into the patient's mouth	Rating of the operatory light
Where the handpiece is located	Use of fiberoptic handpiece
Where the instrument tray is located	Number of large amalgams per day
The comfort of the employees' chair	Ever doing cuspal protective amalgams
The comfort of the patient's chair related to the respondents' comfort	Age of the dental unit

<b>Table 2</b> <b>Job Title of Study Participants</b> <b>Indian Health Service</b> <b>August 2000</b> <b>n=530</b>		
Occupation	Number	Percent
dentist	192	36
dental assistant	173	33
expanded-function dental assistant	134	25
dental hygienist	31	6

**Table 3**  
**Personal Characteristics of Study Participants by Job Title**  
**Indian Health Service**  
**August 2000**

Personal characteristics	Dentist		Dental Assistant/Hygienist	
	number	percent	number	percent
number	192		338	
males	151	79	4	1
females	40	21	334	99
Native American	6	3	290	87
White	161	85	23	7
Other (black, Asian American, Hispanic, Alaskan Native)	22	12	19	6
mean age in years (range)	41 (27-62)		42 (22-63)	
had surgery for musculoskeletal problem ever	28	15	33	10

**Table 4**  
**Occupational Characteristics of Study Participants by Job Title**  
**Indian Health Service**  
**August 2000**

Occupational characteristic	Dentist		Dental Assistant/Hygienist	
	number mean	percent range	number mean	percent range
years worked at same location (mean (range))	4	(0-26)	11	(0-40)
years worked at same occupation	12	(1-38)	14	(1-40)
hand scaling-quadrants/week (mean (range))	4	(1-24)	8	(0-50)
hold dental instrument in right hand	152	80	150	45
hold dental instrument in left hand	13	7	25	7
use both hands equally	26	14	159	48
wore glasses at work	135	71	260	78
wore glasses for nearsightedness	70	37	94	30
wore bifocals	39	21	106	33
work with patient lying down	156	82	241	72
direct view into patients mouth-“always”	55	29	155	47
Chair comfort “good or excellent”	37	73	176	53

**Table 5**  
**Prevalence of Work-Related Musculoskeletal Disorders (WRMDs)**  
**Dentists and Dental Assistants/Hygienists**  
**Indian Health Service**  
**August 2000**

Dentists				Dental Assistants/Hygienists		
Body Part	denominator (after acute trauma exclusion)	# reporting a WRMD	percent	denominator (after acute trauma exclusion)	# reporting a WRMD	percent
hand/wrist	165	20	12	228	78	34
neck	164	19	12	223	73	33
shoulder	161	16	10	226	56	25
back	152	14	9	217	67	31
elbow	171	6	4	244	23	9

**Table 6**  
**Suggested Improvements To the Operatory Made by Dentists and Dental**  
**Assistants/Hygienists**  
**Indian Health Service**  
**August 2000**  
**N=539**

Suggested Improvement	To Improve Comfort		To Increase Efficiency	
	number	percent	number	percent
more comfortable chair	202	37	54	10
over-the-patient delivery	170	32	101	19
more operatory space	115	21	102	19
better lighting	93	17	61	11

**Table 7**  
**Occupational Risk Factors for Work-Related Musculoskeletal Disorders (WRMDs)**  
**Dentists <sup>1</sup>**  
**Indian Health Service**  
**August 2000**

WRMD	Risk Factor	Odds Ratio	95% Confidence Interval
Neck	Not having a direct view of the patient's mouth	2.1	1.1, 4.1
	Respondent's chair comfort (fair or poor vs. good or excellent)	4.5	1.4, 14.2
Shoulder	Years at the present location (10 yrs and up vs 0-4 yrs)	7.3	1.6, 32.0
	Not having a direct view of the patient's mouth	2.0	1.0, 4.0
Back	Respondent's chair comfort (fair or poor vs. good or excellent)	3.8	1.0, 14.7
	Sitting in the 9 o'clock or 10 o'clock position as opposed to the 11 o'clock or 12 o'clock position	7.5	1.5, 71.4
Hand/wrist	Number of extractions done per week (based on 10 additional extractions/week)	1.4	1.1, 1.9
	Operatory lighting (fair or poor vs. good or excellent)	6.3	2.1, 20.3
Elbow	Respondent's chair comfort (fair or poor vs. good or excellent)	12.3	1.2, 610.5
	Number of extractions done per week (based on 10 additional extractions/week)	1.1	1.3, 3.1
	Operatory lighting (fair or poor vs. good or excellent)	14.5	1.5, 692.3

<sup>1</sup>Unadjusted



**Table 8**  
**Occupational Risk Factors for Work-Related Musculoskeletal Disorders (WRMDs)**  
**Dental Assistants/Hygienists<sup>1</sup>**  
**Indian Health Service**  
**August 2000**

WRMD	Risk Factor	Odds Ratio	95% Confidence Interval
Neck	Years at the present location (for a 5 year increase)	1.3	1.1, 1.7
	Patients seen per day (an increase of 5 patients/day)	0.7	0.4, 0.96
	Chair comfort (fair or poor vs. good or excellent)	2.0	1.0, 3.9
	Lack of fiber optics	2.4	1.0, 5.8
Shoulder	Instrument tray (left side vs. front)	8.3	1.3, 165.0
Back	Location of the handpiece behind vs. in the front of the patient	3.7	1.2, 14.2
	Years at the present location (for a 5 year increase)	1.5	1.2, 1.9
Hand/wrist	Years at the present location (for a 5 year increase)	1.3	1.7, 1.4
Elbow	No statistically significant risk factors identified in a multi variate analysis		

<sup>1</sup>Adjusted for confounders

<sup>2</sup>Unadjusted

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