

INDIAN HEALTH SERVICE

ERGONOMICS RECOMMENDATIONS FOR DENTAL PROGRAMS

Executive Summary

The term work-related musculoskeletal disorders (MSDs) refers to musculoskeletal disorders to which the work environment contributes significantly or to musculoskeletal disorders that are made worse or longer lasting by work conditions or workplace risk factors. A review of the literature suggests that dental personnel, including dentists, dental hygienists, and dental assistants may be prone to work-related MSDs involving the neck, shoulder, wrist, elbow, hand, and lower back. Studies conducted on IHS dental personnel in 1998 and 1999 are consistent with the findings in the literature.

If dental program managers suspect that staff are suffering work related MSDs, their programs should be assessed for the following risk factors: awkward postures, forceful exertions, repetitive motions, contact stresses, vibration, and the duration of the exposures to these risk factors. Such risk assessments should be conducted by highly trained and experienced personnel who will perform walk-through observational surveys of the work facilities to detect risk factors, conduct interviews with workers and supervisors, and use checklists.

Training is recognized as an essential element for any effective safety and health program. For ergonomics, the overall goal of training is to enable managers, supervisors, and employees to identify aspects of job tasks that may increase a worker's risk of developing work-related MSDs, to recognize the signs and symptoms of the disorders, and to participate in the development of strategies to control or prevent them. Training employees ensures that they are well informed about the hazards so they can actively participate in identifying and controlling exposures.

What Direct Measures Can Managers Of Indian Health Dental Programs Take Now To Protect Personnel From Work-Related MSDs?

1. Whenever possible, dental programs should replace older, rear-delivery equipment with more modern over-the-patient equipment. Utilize patient chairs that are as thin as possible to allow personnel to sit as close to the patient as possible and minimize bending.
2. Ensure that existing equipment is functioning properly and that all chairs can be raised and lowered within the range for which they were designed.
3. 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.
4. Utilize ergonomically designed instruments, particularly dental instruments with larger handles.
5. Encourage dental staff to take mini-breaks to decrease the amount of time they have to stay in one position.
6. Provide chairs that provide adequate adjustability to allow proper positioning for all dental personnel.
7. Make sure that proper lighting is available in all operatories.
8. Train and remind staff of the importance of proper posture, and periodically evaluate postures.
9. Provide a slow-setting amalgam for use when doing amalgam build-ups or other large, multi-surface amalgams.
10. Increased use of ultrasonic and piezo-electric scalers, as opposed to the use of hand scalers, on patients with heavy calculus.

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PREFACE

Much of the information contained in this document has been excerpted directly from the public domain NIOSH publication ELEMENTS OF ERGONOMICS PROGRAMS: A Primer on Workplace Evaluations of Musculoskeletal Disorders. This publication can be downloaded from the NIOSH website in pdf format for more complete information. The two public domain NIOSH surveys of musculoskeletal disorders in IHS dental personnel, HETA 98-0032-2795 and HETA 99-0106-2838, were also excerpted in the preparation of this document. Copies can be obtained from NIOSH.

BACKGROUND AND DEFINITIONS

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population. The successful application of ergonomics assures high productivity, avoidance of illnesses and injuries, and increased satisfaction among workers. Unsuccessful application, on the other hand, can lead to work-related musculoskeletal disorders (MSDs). The term work-related MSDs refers to musculoskeletal disorders to which the work environment contributes significantly or to musculoskeletal disorders that are made worse or longer lasting by work conditions or workplace risk factors. Common examples of such workplace risk factors include jobs requiring repetitive, forceful or prolonged exertions of the hands; frequent or heavy lifting, pushing or pulling, or carrying of heavy objects; and prolonged awkward postures. The level of risk depends on the intensity, frequency and duration of the exposure to these conditions.

Ergonomics are a potentially regulated health and safety issue, and work-related MSDs are an important problem in the workplace for several reasons:

- According to the Bureau of Labor Statistics in 1995, work-related MSDs are among the most prevalent lost-time injuries and illnesses in almost every industry,
- Work-related MSDs involving the back are among the most costly occupational problems,
- Work-related MSDs may cause significant pain and suffering among afflicted workers,
- Work-related MSDs can decrease productivity and the quality of work.

SCIENTIFIC FINDINGS

Numerous studies have attempted to estimate the prevalence of work-related MSDs in dentistry. Most such studies have been cross-sectional in design, lacking control groups. Additionally, cross-sectional studies cannot account for the temporal pattern of events, and cannot therefore demonstrate true cause and effect. Given these potential shortcomings, and the fact that all of the findings have not been consistent, however, a review of the literature suggests that dental personnel, including dentists, dental hygienists, and dental assistants may be prone to work-related MSDs involving the neck, shoulder, wrist, elbow, hand, and lower back. A brief review of the literature concerning work-related MSDs in dentistry is included in Appendix I.

WORK-RELATED MSDs IN INDIAN HEALTH SERVICE DENTAL PERSONNEL

In 1998, the National Institute for Occupational Health and Safety (NIOSH) collaborated with the Phoenix Area to conduct a Health Hazard Evaluation (HHE) on several IHS Dental Clinics in Arizona. Their findings were reported in HETA Report #98-0032-2795, copies of which can be obtained by calling NIOSH at 513-841-4252. This study included interviews with dental employees and photographs and videotapes of workers doing their jobs.

NIOSH found that 48 percent of workers had work related (WR) neck disorders, 42 percent had WR back disorders and 37 percent had WR shoulder disorders. Dental assistants had a significantly greater prevalence of WR neck disorders than dentists. These percentages fall within the ranges reported among dentists in other studies (see Appendix).

The most significant risk factors for dentists were static loading of the neck and static loading and awkward positions of the hands. The greatest risk factors for dental assistants were twisting and turning of the back, extended reaches of the arms to access instruments, prolonged static postures, forceful exertions using dental instruments, and carving fillings.

Among other factors, the work-related MSDs were associated with working in older dental clinics (with rear delivery systems) and with malfunctioning dental equipment.

In 1999, NIOSH and the IHS collaborated to conduct another study of work-related MSDs in IHS dental personnel, this time sending a questionnaire to all dental employees working in IHS federally operated programs at the time of the survey. Sixty-nine percent of the employees completed and returned the survey. The full report of the survey can be obtained by calling NIOSH and requesting HETA report 99-0106-2838.

For dentists, there was a statically significant incidence of neck MSDs related to an increased frequency of indirect viewing of the patient's mouth and to poor to fair dental chair comfort. Increased reporting of hand work-related MSDs by dentists was related to extracting 10 or more teeth per week and to rating the lighting as fair or poor. The risk of back

work-related MSDs for dentists was statistically related to fair or poor dental chair comfort and to sitting in the 9 or 10 o'clock position as opposed to the 11 or 12 o'clock position relative to the patient. Shoulder work-related MSDs for dentists were related to not always having a direct view of the patient's mouth and to the time spent working at the same location, based on spending greater than 5 years at the same location.

For dental assistants/hygienists, neck work-related MSDs were related to not having a fiber-optic handpiece, to fair or poor dental chair comfort, and to the years spent working at the same clinic. The risk of neck work-related MSDs in dental assistants/hygienists decreased with an increase in the number of patients treated per day. For dental assistants/hygienists, hand work-related MSDs were related to spending more years working at the same location. For dental assistants/hygienists, increased back work-related MSDs were statistically significantly associated with locating the handpiece behind the patient rather than locating the handpiece in front of the patient and to spending more years working at the same location. Shoulder work-related MSDs for dental assistants/hygienists were related to having an instrument tray on the left side of the patient versus in front of the patient.

ERGONOMIC RISK FACTORS IN DENTISTRY

Neck and Shoulder

A comprehensive review of published studies, conducted by the Hazard Evaluations and Technical Assistance Branch NIOSH, found that repetitive neck movements and continuous arm and hand movements affecting the neck and shoulder demonstrate significant associations with neck musculoskeletal disorders. Researchers have also 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.

Dental personnel are required to adopt non-neutral postures for many of the clinical tasks they perform. These postures frequently require prolonged static contraction of the trunk and scapulothoracic and scapulohumeral musculature, combined with repetitive contraction of muscles in the wrist, hand, and fingers during fine motor control work. Dentists, for example, most commonly use a combination of a flexed and right-side-flexion position of the neck with a head-down position, often combined with shoulder abduction or flexion. Dental personnel assume these positions for the following reasons:

- To coordinate the relative positions between dentist and assistant,
- To obtain optimal view of teeth within the patient's mouth,
- To provide a comfortable position for the patient, and
- To maneuver complex equipment and reach for instruments.

Much dental work requires high precision, and 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 for prolonged periods could lead to fatigue and discomfort. Prolonged contraction of the upper trapezium during upper extremity stabilization (without armrests) can cause compression of adjacent blood vessels and nerves making the upper extremity susceptible to temporary ischemia.

Wrist and Hand

Dental work has also been associated with hand and wrist problems. Carpal Tunnel syndrome (CTS) has been associated with both repetitive work and forceful work. CTS 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. Symptoms of carpal tunnel compression can appear from any activity causing prolonged increased (passive or active) pressure in the carpal canal. There is evidence of an association between CTS and highly repetitive work, alone or in combination with other factors. Evidence also indicates an association between forceful work and CTS, but the amount and type of repetitive movement performed during dental work has not been accurately quantified by most studies.

Low Back Pain

Low-back discomfort has been associated with dental work in numerous studies. Shugars *et al.* found that good (neutral) posture correlated negatively with back pain; and generally, dentists who sat 80 percent to 100 percent of the day reported more frequent lower-back pain, than those that do not sit as often.¹ Static work in the sitting posture requiring spinal flexion and rotation has been associated with increased risk of low back pain. Sitting increases loads on soft-tissue structures of the lumbar spine and discs. 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.

Psychosocial Factors and Work-Related MSDs in Dentistry

Numerous studies have looked at stress levels in dentistry. Identified stressors include the psychological demands of doing meticulous surgery with little or no rest or diversion and time pressures. Dentists with work-related MSDs showed a significant tendency to be more dissatisfied at work and to be more burdened by anxiety, experiencing poorer psychosomatic health and feeling less confident with their futures.

Ergonomics requires understanding of both the physical and the psychological aspects of the workplace. From the review of literature, it is evident that ergonomics plays a significant role in the health of dental professionals. The musculoskeletal and stress-related disorders associated with dentistry seem to be interrelated. Literature about work-related MSDs and psychosocial disorders associated with dentistry is plentiful. However, ergonomic solutions for dental practitioners are under-reported in the literature. Furthermore, the few ergonomic solutions that have been provided have not been adequately evaluated or validated.

Ergonomic Interventions in Dentistry: Current State of the Art

Dentists usually work seated on a low stool, and the assistant, also seated, provides chairside assistance; this is commonly called four-handed dentistry. Instruments and equipment are placed within close reach of the dentist and the assistant. The patterns of floor area design have evolved on an empirical basis for each functional area and for flow in occupants' movements. The aim of ergonomic intervention should be to achieve

optimum access, visibility, comfort, and control at all times of treatment. Many ergonomists have urged an evaluation of the dental workspace and process to improve not only health, but also productivity.

WHAT SHOULD DENTAL PROGRAMS ASSESS TO HELP PREVENT WORK-RELATED MSDs IN THEIR EMPLOYEES?

A great deal of ergonomic research has been conducted to identify workplace factors that contribute to the development of musculoskeletal disorders. According to the scientific literature, the following are recognized as important risk factors for musculoskeletal disorders, especially when occurring at high levels and in combination. In general, knowledge of the relationships between risk factors and the level of risk is still incomplete. Also, individuals vary in their capacity to adjust to the same job demands. Some may be more affected than others.

Awkward postures

Body postures determine which joints and muscles are used in an activity and the amount of force or stresses that are generated or tolerated. For example, more stress is placed on the spinal discs when lifting, lowering, or handling objects with the back bent or twisted compared with when the back is straight. Manipulative or other tasks requiring repeated or sustained bending or twisting of the wrists, knees, hips, or shoulders also imposed increased stresses on these joints. Activities requiring frequent or prolonged work over shoulder height can be particularly stressful.

Forceful exertions

Tasks that require forceful exertions place higher loads on the muscles, tendons, ligaments, and joints. Increasing force means increasing body demands such as greater muscle exertion along with other physiological changes necessary to sustain an increased effort. Prolonged or recurrent experiences of this type can give rise to not only feelings of fatigue but may also lead to musculoskeletal problems when there is inadequate time for rest or recovery. Force requirements may increase with:

- use of an awkward posture,
- the speeding up of movements,
- increased slipperiness of the objects handled (requiring increased grip force)
- use of the index finger and thumb to forcefully grip an object (i.e., a pinch grip compared with gripping the object with your whole hand), and
- use of small or narrow tool handles that lessen grip capacity.

Many of these risk factors are present in the practice of dentistry.

Repetitive motions

If motions are repeated frequently (e.g., every few seconds) and for prolonged periods such as an 8-hour shift, fatigue and muscle-tendon strain can accumulate. Tendons and muscles can often recover from the effects of stretching or forceful exertions if sufficient time is allowed between exertions. Effects of repetitive motions from performing the

same work activities are increased when awkward postures and forceful exertions are involved. Repetitive actions as a risk factor can also depend on the body area and specific act being performed.

Duration

Duration refers to the amount of time a person is continually exposed to a risk factor. Job tasks that require use of the same muscles or motions for long durations increase the likelihood of both localized and general fatigue. In general, the longer the period of continuous work (e.g., tasks requiring sustained muscle contraction) the longer the recovery or rest time required.

Contact stresses

Repeated or continuous contact with hard or sharp objects such as non-rounded desk edges or unpadding, narrow tool handles may create pressure over one area of the body (e.g., the forearm or sides of the fingers) that can inhibit nerve function and blood flow.

Vibration

Exposure to local vibration occurs when a specific part of the body comes in contact with a vibrating object, such as a power handtool.

More detailed information concerning the above parameters can be found on the State of Washington's Department of Labor and Industries Ergonomics website at <http://www.lni.wa.gov/wisha/ergo/>

HOW SHOULD THESE ASSESSMENTS BE MADE?

Screening jobs for risk factors may involve the following:

- Walk-through observational surveys of the work facilities to detect risk factors.
- Interviews with workers and supervisors to obtain the above information and other data not apparent in walk-through observations such as time and work load pressures, length of rest breaks, etc.
- Use of checklists for scoring job features against a list of risk factors (an example of such a checklist, borrowed from the US Army booklet Ergonomics in Action, Booklet II, which is available for download from the US Army's ergonomics website listed below, is available in Appendix II).

Of the above three methods, the checklist procedure provides the most formal and orderly procedure for screening jobs. Numerous versions of checklists exist in ergonomics manuals. When persons familiar with the job task gather checklist data, the quality of the data is generally better. Checklist procedures are also typically used in more complete job analyses.

While screening tools such as checklists have been widely and successfully used in many ergonomics programs, most have not been scientifically validated. Combining checklist observations with symptoms data offers a means of overcoming uncertainty.

Integrating efforts to identify risk factors for musculoskeletal disorders with efforts to identify common safety hazards such as slips and trips should be considered. Jobs with risk factors for musculoskeletal disorders also may have safety hazards (such as the risk of sharp injuries from burrs in handpieces mounted in rear delivery systems).

The US Army's Ergonomics Program website contains information on and links to checklists and other tools. The site can be found at:
<http://chppm-www.apgea.army.mil/ergopgm/ergohome.htm>

Performing Job Analyses

Job analysis breaks a job into its various elements or actions, describes them, measures and quantifies risk factors inherent in the elements, and identifies conditions contributing to the risk factors. Persons with considerable experience and training in these areas usually conduct these job analyses. While most job analyses have common approaches, no standard protocol exists for conducting a job analysis to assess ergonomic hazards.

Most job analyses have several common steps. A complete description of the job is obtained. Employees are often interviewed in order to determine if the way the job is done changes over time. During the job analysis, the job is divided into a number of discrete tasks. Each task is then studied to determine the specific risk factors that occur during the task. Sometimes each risk factor is evaluated in terms of its magnitude, the number of times it occurs during the task, and how long the risk factor lasts each time it occurs.

The tasks of most jobs can be described in terms of (1) the tools, equipment, and materials used to perform the job, (2) the workstation layout and physical environment, and (3) the task demands and organizational climate in which the work is performed. Job screening as described above, provides some of these data. More definitive procedures for collecting information on these components can include the following:

- Observing the workers performing the tasks in order to furnish time-activity analysis and job or task cycle data; videotaping the workers is typically done for this purpose
- Still photos of work postures, workstation layouts, tools, etc., to illustrate the job
- Workstation measurements (e.g., work surface height, reach distances)
- Measuring tool handle sizes, weighing tools and parts, and measuring tool vibration and part dimensions
- Biomechanical calculations (e.g., muscle force required to accomplish a task or the pressure put on a spinal disc based on the weight of a load lifted, pulled, or pushed)
- Physiological measures (e.g., oxygen consumption, heart rate)
- Special questionnaires, interviews, and subjective rating procedures to determine the amount of perceived exertion and the psychological factors influencing work performance.

WHAT TRAINING CAN BE PROVIDED TO DENTAL PERSONNEL, AND WHAT SHOULD THE TRAINING INCLUDE?

Training is recognized as an essential element for any effective safety and health program. For ergonomics, the overall goal of training is to enable managers, supervisors, and employees to identify aspects of job tasks that may increase a worker's risk of developing work-related MSDs, recognize the signs and symptoms of the disorders, and participate in the development of strategies to control or prevent them. Training employees ensures that they are well informed about the hazards so they can actively participate in identifying and controlling exposures. Common forms of ergonomics training are noted below, along with their objectives. Employers may opt to have outside experts conduct these tasks. If so, the outside instructors should first become familiar with local operations and relevant policies and practices before starting to train. Tailoring the instruction to address specific concerns and interests of the worker groups can enhance learning.

ERGONOMICS AWARENESS TRAINING

The objectives for ergonomics awareness training are as follows:

- Recognize workplace risk factors for musculoskeletal disorders and understand general methods for controlling them.
- Identify the signs and symptoms of musculoskeletal disorders that may result from exposure to such risk factors, and be familiar with the organization's health care procedures.
- Know the process the employer is using to address and control risk factors, the employee's role in the process, and ways employees can actively participate.
- Know the procedures for reporting risk factor and musculoskeletal disorders, including the names of designated persons who should receive the reports

TRAINING IN JOB ANALYSES AND CONTROL MEASURES

The objectives for training in job analyses and control measures are as follows:

- Demonstrate the way to do a job analysis for identifying risk factors for musculoskeletal disorders.
- Select ways to implement and evaluate control measures.

TRAINING IN PROBLEM SOLVING

- The objectives for training in problem solving are as follows:
- Identify the departments, areas, and jobs with risk factors through a review of company reports, records, walk-through observations, and special surveys.
- Identify tools and techniques that can be used to conduct job analyses and serve as a basis for recommendations.
- Develop skills in team building, consensus development, and problem solving.
- Recommend ways to control ergonomic risks based on job analyses and pooling ideas from employees, management, and other affected and interested parties.

TRAINING RESOURCES

Materials for offering awareness training to the workforce are available, including videotapes and pamphlets from NIOSH and others. The American Dental Association offers one of their seminar courses on dental clinic ergonomics. Persons or groups assigned to or expected to play a key role in ergonomic hazard control work will require added instruction in problem identification, job analyses, and problem-solving techniques. Some fact sheets and other training tools are available on the previously mentioned Washington State and US Army websites. Additionally, the IHS has an Ergonomics workgroup that is currently developing training programs and policy documents. The current membership can be found by linking to the Institutional Environmental Health section (under “Nationwide Programs and Initiatives”) from the IHS Internet homepage (<http://www.ihs.gov/>), and clicking on “Workgroups” or “Site Map,” or by going directly to http://www2.ihs.gov/IEH/ergonomics_wg.asp. More information on IHS ergonomics activities, as well as links to other ergonomic-related websites, can be linked from the Institutional Environmental Health home page.

WHAT DIRECT MEASURES CAN MANAGERS OF INDIAN HEALTH DENTAL PROGRAMS TAKE NOW TO PROTECT PERSONNEL FROM WORK-RELATED MSDs?

1. When equipment needs to be replaced, when budget allows, or whenever clinic renovations are made, dental programs should replace older, rear-delivery equipment with more modern over-the-patient equipment. This delivery system allows access to the 12:00 position in relation to the patient, and greatly lessens the amount of twisting and turning that dental personnel must do to gain access to instruments and equipment. Utilize patient chairs that are as thin as possible to allow personnel to sit as close to the patient as possible and minimize bending. All new construction should be designed with these changes in mind. Additionally, elimination of the rear delivery systems will eliminate the risk of sharps injuries from burs on handpieces mounted behind the dentist.
2. Ensure that existing equipment is functioning properly and that all chairs can be raised and lowered within the range for which they were designed. Proper positioning should help to reduce the static physical stresses placed on dental personnel. Malfunctioning equipment was identified as a significant risk factor in one of the IHS NIOSH reports.
3. 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. There should be adequate space available at the head of the patient to allow access to the 12:00 position by the dentist, assistant, or hygienist, without bumping elbows on units, burs, etc.
4. Evaluate ergonomically designed instruments, particularly dental instruments with larger handles. Programs could start with employees who are having hand/wrist work-related MSDs and assess the comfort and performance of such instruments before introducing them to all dental personnel at all clinics.
5. Encourage dental staff to take mini-breaks to decrease the amount of time they have to stay in one position.

6. Provide comfortable chairs to both dentists and dental assistants/hygienists. These chairs should provide adequate adjustability to allow proper positioning for all dental personnel and adequate body and arm supports to eliminate or reduce the static loading of arm, shoulder, neck and back muscle groups.
7. Make sure that proper lighting is available in all operatories.
8. Train and remind staff of the importance of proper posture, and periodically evaluate postures.
9. Provide a slow-setting amalgam for use when doing amalgam build-ups or other large, multi-surface amalgams. Faster-setting amalgams such as Tytin may reach a hard set before carving is completed, leading to increased stress on the hands and wrists. Additionally, make sure that all amalgam carvers are kept sharp to facilitate the carving process.
10. Increased use of ultrasonic and piezo-electric scalers, as opposed to the use of hand scalers, on patients with heavy calculus may help to protect the hands and wrists of hygienists and perio-certified expanded functions assistants.

APPENDIX I, A REVIEW OF THE LITERATURE

In a cross-sectional study, 1,079 dentists were screened during the American Dental Association's Annual Health Screening Program in 1997 and 1998 by means of standard electrodiagnostic measures in the dominant hand and a self-reported symptom questionnaire. The prevalence of symptoms consistent with CTS in the dominant hand among dentists was higher than the prevalence in the general population. However, when electrodiagnostic confirmation was added, the prevalence of CTS was nearly the same as that among the general population.²

Bramson *et al.* undertook a study to determine the presence of certain ergonomic risk factors in typical tasks performed by dentists and dental hygienists. They further investigated, by means of electromyography and goniometry, the force, frequency and duration of the task. They concluded that when a task's duration, force and frequency are accounted for, scaling, polishing, flossing and probing activities do not represent exposure to high ergonomic risk.³

Rundcrantz and various associates have published numerous studies concerning dental ergonomics and work-related MSDs in the Swedish dental literature.^{4,5,6,7} One of these studies compared dentists with and without occupational cervico-brachial disorders with regard to the mobility of the neck and shoulders and the static endurance of the shoulder muscles. Differences in working position and the task performance on a stimulated case were also analyzed. Of 143 dentists surveyed, 96 had signs of cervico-brachial disorders and discomfort while 47 did not. The ergonomic examination showed that significantly more dentists without symptoms of pain applied a wedge cushion under the upper part of the back of the patient to get an optimum view. They also found that significantly more dentists without symptoms were aware of and utilized the naturally arising pauses in their work than dentists with pain and discomfort. Additionally, dentists with cervico-brachial disorders kept their head bent to the side and rotated to a greater extent than did dentists without symptoms. In another study, they found a high incidence of pain and discomfort in the locomotor system among dentists that could not be explained by ergonomic risk factors such as positioning of the patient, use of the mirror or alteration of the dentist's position. Regression analysis showed that personal harmony and age had the highest value for explaining the number of painful sites in the musculoskeletal system of those studied. In another study, they looked at patient positioning and use of the mouth mirror. They found that dentists who positioned the patient to achieve a direct view had a significantly lower frequency of headaches. They also concluded that those dentists who did not have discomfort in the upper locomotor system used the mirror more often than those who did suffer discomfort.

Finsen, Christensen, and Bakke looked at musculoskeletal disorders among dentists and variation in the tasks they performed.⁸ They looked at working postures and conducted electromyography of the shoulder/neck during the three most common work tasks. They found prolonged neck flexion and upper arm abduction, as well as high static muscle activity levels in the splenius and trapezius muscles. No differences between work tasks were found regarding postures, frequencies of movements or muscle activity. Alterations

between the three work tasks did not produce sufficient variation to reduce musculoskeletal load on the neck and shoulders.

Milerad and Ekenvall studied symptoms of the neck and upper extremities in dentists by means of telephone interviews.⁹ They compared the dentists to a reference group of pharmacists. They found 44 percent of the dentists and 26 percent of the pharmacists to have symptoms of the neck, 51 percent of the dentists and 23 percent of the pharmacists to have symptoms of the shoulder, and 12 percent of the dentists versus 1 percent of the pharmacists to have musculoskeletal symptoms in the forearm, mainly in the form of paresthesias and numbness. They concluded that the high frequency of symptoms from the neck, shoulders, and upper extremities of the dentists was probably related to difficult work positions with cervical flexion and rotation, abducted arms, and repetitive precision-demanding handgrips.

In 1995, Liss *et al.* surveyed musculoskeletal disorders among dental hygienists in Canada.¹⁰ Using logistic regression models, the number of heavy calculus patients per day, "clock" position around the dental chair, and years in practice were significant predictors of CTS among hygienists. Days worked, time with the trunk rotated, and years of practice were significant predictors of reported shoulder trouble in the past 12 months. The authors emphasized the need to inform hygienists during training and continuing education about musculoskeletal problems in general and CTS in particular. They stated that attention should be directed to areas such as workstation design, posture, treating patients with heavy calculus, and scheduling rest periods. A study by Osborn *et al.* among dental hygienists in Minnesota reported similar findings.¹¹

Lehto *et al.* surveyed musculoskeletal health in 131 professionally active dentists as part of a comprehensive health examination.¹² Forty two percent of dentists had experienced pain and interference with daily activities by neck-shoulder problems during the preceding year, with a tendency to greater prevalence in salaried dentists than in private practitioners. Thirty seven percent experienced lower back problems. Symptoms of stress, perceiving dentistry as physically or mentally too taxing and a poorer general health status rating were all associated with a greater 1-yr prevalence of neck-shoulder and lower back pain and disability and with poorer general physical fitness. Age, weekly work hours, working posture, use of an assistant, or radiographic degenerative changes in the dentist's skeleton were not associated with 1-yr prevalence of neck-shoulder or lower back pain and disability.

APPENDIX II

Ergonomic Analysis - General Risk Factor Checklist

This checklist covers most potential ergonomic issues. Use this checklist as general guidance when performing worksite surveillance. Check the box () if your answer is “yes” to the question. A “yes” response indicates that an ergonomic risk factor may be present, that requires further analysis.

MANUAL MATERIAL HANDLING

- Is there lifting of tools, loads, or parts?
- Is there lowering of tools, loads, or parts?
- Is there overhead reaching for tools, loads, or parts?
- Is there bending at the waist to handle tools, loads, or parts?
- Is there twisting at the waist to handle tools, loads, or parts?

PHYSICAL ENERGY DEMANDS

- Do tools and parts weigh more than 10 pounds?
- Are reach distances greater than 20 inches?
- Is bending, stooping, or squatting a primary task activity?
- Is lifting or lowering loads a primary task activity?
- Is walking or carrying loads a primary task activity?
- Is stair or ladder climbing with loads a primary task activity?
- Is pushing or pulling loads a primary task activity?
- Is reaching overhead a primary task activity?
- Do any of the above tasks require five or more complete work cycles to be done within one minute?
- Do workers complain that rest breaks and fatigue allowances are insufficient?

OTHER MUSCULOSKELETAL DEMANDS

- Do manual jobs require frequent, repetitive motions?
- Do work postures require frequent bending of the neck, shoulder, elbow, wrist, or finger joints?
- For seated work, are reach distances for tools and materials more than 15 inches from the worker's position?
- Is the worker unable to change his or her position often?
- Does the work involve forceful, quick, or sudden motions?
- Does the work involve shock or rapid buildup of forces?
- Is finger-pinch gripping used?
- Do job postures involve sustained muscle contraction of any limb?
- Is vibration present? Source:(include manufacturer, model, and serial #)

COMPUTER WORKSTATION

- Do operators use computer workstations for more than 4 hours a day?
- Are there complaints of discomfort from those working at these stations?
- Is the chair or desk nonadjustable?

- Is the display monitor, keyboard, or document holder nonadjustable?
- Does the lighting cause glare or make the monitor screen hard to read?
- Is the room temperature too hot or too cold?
- Is there irritating vibration or noise?

ENVIRONMENT

- Is the temperature too hot or too cold? Actual temperature (⁰F)_____
- Are the workers' hands exposed to temperatures less than 70⁰?
- Is the workplace poorly lit? Light meter measurement _____
- Is there glare?
- Is there excessive noise that is annoying, distracting, or producing hearing loss?
Sound level reading: _____
- Is there upper extremity or whole-body vibration?
- Is air circulation too high or too low?

GENERAL WORKPLACE

- Are walkways uneven, slippery, or obstructed?
- Is housekeeping poor?
- Is there inadequate clearance or accessibility for performing tasks?
- Are stairs cluttered or lacking railings?
- Is proper footwear worn?

TOOLS

- Is the handle too small or too large?
- Does the handle shape cause the operator to bend the wrist to use the tool?
- Is the tool hard to access?
- Does the tool weigh more than 10 pounds?
- Does the tool vibrate excessively?
- Does the tool cause excessive kickback to the operator?
- Does the tool become too hot or too cold?

GLOVES

- Do the gloves require the worker to use more force when performing job tasks?
- Do the gloves provide inadequate protection?
- Do the gloves present a hazard of catch points on the tool or in the workplace?

ADMINISTRATION

- Is there little worker control over the work process?
- Is the task highly repetitive and monotonous?
- Does the job involve critical tasks with high accountability and little or no tolerance for error?
- Are work hours and breaks poorly organized?

Ergonomic Analysis - Fatigue Assessment Checklist

Use this checklist as general guidance when performing worksite surveillance.

Yes No N/A

Are operators required to apply near-maximum force capacities over many cycles and for long periods of time?

Are there continuous, rapid, repetitive muscle contractions for long periods (e.g., pounding, tapping, cranking, or push-pull cycling)?

Do operators have to "hold" some device in a fixed position for long periods without intermittent rest periods?

Do operators have to maintain an upright posture for long periods without adequate body support (as in the case of a seat)?

Do operators have to make very long reaches, frequently, and for extended periods of time?

Do operators stand or sit in an awkward position and hold their arms above their heads for a long period of time?

Do operators work in a "bent-over" or squatting position or in a position on their stomachs or backs, with the accompanying stress of holding the head and arms in a strained position?

Are operators required to bend over and straighten up frequently and over a long period of time?

Does the workplace layout require many steps, repeated again and again over a long period of time?

Does the workplace layout require operators to sit "askew" (in a twisted position) in order to watch a display, and at the same time operate some control (especially a foot control)?

Are operators required to hold one foot above a foot control (between pedal depressions) for long periods of time?

Do the operators have to continuously move their heads from side to side, or up and down?

Do the operators have to step up and down frequently for long periods?

Are the job demands high, requiring increased rest to avoid excessive fatigue?

Does the job involve continuous monitoring or inspection?

Is the work performed in a hot environment?

REFERENCES

1. Shugars DA, Williams D, Cline SJ, Fishburne C. Musculoskeletal back pain among dentists. *Gen Dent*. 1984 Nov-Dec;32(6):481-5.
2. Hamann C, Werner RA, Franzblau A, Rodgers PA, Siew C, Gruninger S. Prevalence of carpal tunnel syndrome and median mononeuropathy among dentists. *J Am Dent Assoc*. 2001 Apr;132(4):434, 436
3. Bramson JB, Smith S, Romagnoli G. Evaluating dental office ergonomic risk factors and hazards. *J Am Dent Assoc* 1998 Feb;129(2):174-83
4. Rundcrantz BL, Johnsson B, Moritz U. Occupational cervico-brachial disorders among dentists. Analysis of ergonomics and locomotor functions. *Swed Dent J* 1991;15(3):105-15
5. Rundcrantz BL, Johnsson B, Moritz U. Pain and discomfort in the musculoskeletal system among dentists. A prospective study. *Swed Dent J* 1991;15(5):219-28
6. Rundcrantz BL. Pain and discomfort in the musculoskeletal system among dentists. *Swed Dent J Suppl* 1991;76:1-102
7. Rundcrantz BL, Johnsson B, Moritz U. Cervical pain and discomfort among dentists. Epidemiological, clinical and therapeutic aspects. Part 1. A survey of pain and discomfort. *Swed Dent J* 1990;14(2):71-80
8. Finsen L, Christensen H, Bakke M. Musculoskeletal disorders among dentists and variation in dental work. *Appl Ergon* 1998 Apr;29(2):119-25
9. Milerad E, Ekenvall L. Symptoms of the neck and upper extremities in dentists. *Scand J Work Environ Health* 1990 Apr;16(2):129-34
10. Liss GM, Jesin E, Kusiak RA, White P. Musculoskeletal problems among Ontario dental hygienists. *Am J Ind Med* 1995 Oct;28(4):521-40
11. Osborn JB, Newell KJ, Rudney JD, Stoltenberg JL. Carpal tunnel syndrome among Minnesota dental hygienists. *J Dent Hyg* 1990 Feb;64(2):79-85
12. Lehto TU, Helenius HY, Alaranta HT. Musculoskeletal symptoms of dentists assessed by a multidisciplinary approach. *Community Dent Oral Epidemiol* 1991 Feb;19(1):38-44