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A STUDY OF CUMULATIVE TRAUMA DISORDERS OF THE UPPER EXTREMITIES AND OCCUPATION IN WRIGHT-PATTERSON AIR FORCE BASE CIVILIAN PERSONNEL

THESIS

Scott T. Hillstead, B.S.
Captain, USAF

AFIT/GCA/LAS/95S-4

1995

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Wright-Patterson Air Force Base, Ohio

AFIT/GCA/LAS/95S-4

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A STUDY OF CUMULATIVE TRAUMA DISORDERS OF THE UPPER EXTREMITIES AND OCCUPATION IN WRIGHT-PATTERSON AIR FORCE BASE CIVILIAN PERSONNEL

THESIS

Presented to the Faculty of the Graduate School of Logistics and Acquisition Management of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Cost Analysis

Scott T. Hillstead, B.S.

Captain, USAF

September 1995

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Acknowledgments

I am indebted to the many people without whom this research would not have developed, progressed and been completed. First and foremost, the patient guidance, suggestions and inspiration provided by my thesis advisors, Major Kevin P. Grant and Major Wendell P. Simpson III, and my reader, Katharyn A. Grant, PhD, of the National Institute of Occupational Safety and Health, were invaluable.

I am especially grateful to Lieutenant Colonel David J. Louis, MC, FS, of Occupational Medicine Services for his epidemiologic direction and assistance. Thanks also to Lieutenant Colonel Phoebe Fisher, Base Chief of Public Health for her help in providing potential sources of occupational illness data. Additionally, thanks go to Captain Cindy Cogburn of Armstrong Laboratory at Brooks AFB for providing and explaining the AF Form 190 data, and to Julie Roe-Curran of the base civilian personnel office who, despite an already heavy workload, diligently provided information to supplement the AF Form 190 data.

Finally, I would be remiss and likely deceased if I did not thank my wife Karen, and children Geoffrey and Kaitlyn, for their understanding, sacrifice, encouragement, and support throughout this research effort.

Scott T. Hillstead

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Abstract

This study utilized a case-control methodology to describe and analyze the 115 cases of occupational illnesses reported by civilian employees of Wright-Patterson Air Force Base (AFB) between 1990 and 1995. Determining if a statistically significant association existed between age and duration of employment risk factors and cumulative trauma disorders (CTDs) was a primary objective. The frequency of CTDs among the various organizations at Wright-Patterson AFB are also described. The research could not prove the existence of a significant association for the 44 subjects and 176 controls matched on occupational group. However, the demographic and other descriptive results may form a foundation for subsequent ergonomically-based causal studies into those workcenters and occupational groups with a history of cumulative trauma disorders (CTDs). The results could further lead to the development of candidates for intervention and preventative measures by the base Occupational Medicine Service professionals to reduce the number of CTD incidents and subsequent workers' compensation claim costs among Wright-Patterson's civilian workforce.

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I. Introduction

General Issue

Organizations throughout the United States are becoming increasingly aware of the rising costs and lost productivity associated with occupational injuries and illnesses in the workplace. Workers' compensation insurance coverage is provided to civilian government employees under the Federal Employees Compensation Act (FECA). During 1991, the Federal government paid out over $1.5 billion in medical and compensation benefits, a 10% increase from 1990 (Nelson, 1993).

Notably, incidents of chronic musculoskeletal disorders of the upper extremities such as cumulative trauma disorders (CTDs) or repetitive strain injuries (RSIs) currently account for over 50% of all reported occupational illnesses in the United States (US Department of Labor, 1992:5). The National Council on Compensation Insurance (NCCI) reported that the average CTD claim cost for 1989 was $24,158 (Webster and Snook, 1994:713). Another study in 1991, using workers' compensation claims data from the Liberty Mutual

Insurance Company, estimated the average cost per case of carpal tunnel syndrome (CTS) at roughly $10,000, with CTDs accounting for about 2% of all compensation cases and 3.5% of all compensation costs (Brogmus and Marco, 1992:998).

This significant increase in CTD illnesses and associated workmen compensation costs has drawn the attention of the Occupational Safety and Health Administration (OSHA), and the Air Force Occupational Safety and Health (AFOSH) community. In 1987, the US National Institute for Occupational Safety and Health (NIOSH) included CTDs on its list of the Ten Leading Occupational Disorders (NIOSH, 1987). Reduction of CTD incidence has also been listed as one of the national health promotion and disease prevention objectives under the Healthy People 2000 initiative (Department of Health and Human Services, 1990:295).

In October, 1994, the U.S. Department of Labor (DOL) unveiled a first of its kind proposal for addressing CTDs (Litvan, 1994:44). The proposal would require employers to evaluate their company's histories of work-related CTD incidents, and if the review reveals CTD problem areas, the employer must initiate steps to protect the employee.

Accordingly, the Air Force leadership has tasked the service's occupational medicine and public health communities to identify, control and prevent the occurrence of ergonomic related injuries and illnesses. Furthermore, an AFOSH Standard 48-3, Ergonomics Program, prescribing the minimum requirements to anticipate, recognize, evaluate and control work-related musculoskeletal disorders in Air Force workplaces is nearing final approval.

The Department of the Air Force disburses millions of dollars each year under FECA for medical and compensation claims directly related to civilian occupational injuries and illnesses. More importantly, as current public and political pressure mounts to downsize the military sector and spend less on defense programs, as evidenced by numerous base closures, the Air Force must continually seek ways to employ limited tax dollars in the most cost efficient manner. A significant reduction in workmen's medical and compensation costs paid for preventable occupational injuries and illnesses is one step in the process of saving scarce Air Force funds.

Prevention is the primary mechanism for retarding the rapid growth of CTD illnesses. A detailed assessment methodology is necessary both to establish the cause of CTDs and formulate prevention strategies (Ranney, 1993:871). Successful prevention also requires identifying workcenters and specific tasks that place employees at high risk of exposure to CTDs, and supporting efforts to develop safer work environments (Rempel and others, 1992:838). The analysis of various employee demographic factors and associated incidence rates may identify organizations and specific jobs which pose the highest risk of CTD illnesses (Nelson and others, 1992:1550).

Armed with that information, occupational medicine and ergonomic specialists can conduct detailed CTD causal studies in those organizations with relatively high incidence rates of CTDs. The results of the studies will aid in the development of effective preventative measures for reducing CTD incidents.

Definition of Research

The primary objectives of this research effort are to:

1. Describe the number, type, and demographic characteristics of CTD illnesses reported by civilian workers at Wright-Patterson AFB from 1990 to 1994.
2. Determine if a statistically significant association between a risk factor and a cumulative trauma disorder can be identified, and if so,
3. Determine if one or more base-level organizations have experienced relatively more reported cases of CTD illnesses than others.

In addition to the primary objectives, existing base-level occupational illness reporting and compensation claim filing procedures and occupational injury and illness surveillance methods at Wright-Patterson AFB are described.

The results of this study will provide the base occupational medicine community with risk factors and odds ratios associated with CTDs among one or more selected occupational groups at Wright-Patterson AFB. The results will also form a foundation for subsequent ergonomically-based causal studies into those workcenters and job tasks with high risks for CTDs. The ergonomic-based causal study findings might then lead to the development of intervention and preventative measures for reducing the number of CTD incidents among Wright-Patterson's civilian workforce.

Research Questions

In order to satisfactorily accomplish the objectives described above, the following investigative questions need to be addressed:

1. What are the most frequently reported types of CTDs among Wright-Patterson civilian employees and the demographic characteristics of those employees reporting the CTD cases?
2. Does a significant association exist between age and duration of employment risk factors and cumulative trauma disorders among civilian personnel at Wright-Patterson AFB?
3. Which Wright-Patterson AFB organizations have experienced the highest frequency of CTD illnesses?

Scope & Limitations

This research was conducted through the case control study of CTD incidents involving civilian workers employed by: Headquarters Air Force Materiel Command (HQ AFMC), Aeronautical Systems Center (ASC), and all other 645th Air Base Wing organizations located at Wright-Patterson AFB. The data used in this descriptive study was obtained from several existing occupational illness and civilian personnel and medical data sources, spanning a period of five years from 1990 to 1994.

Since a portion of this research effort is descriptive and exploratory in nature, no attempt was made to resolve any problems identified or associated with the reporting, monitoring, and potential preventative measures for CTDs. Therefore, this report only describes the current state and demographic characteristics of those Wright-Patterson AFB civilian employees who reported a CTD illness. Only those full-time base civilian employees employed during the period of 1990-1994 with documented reports of a diagnosed cumulative trauma disorder were studied.

Although an analysis of lost work time and workers compensation costs due to CTDs in terms of actual hours was desirable, no current guidelines or reporting procedures exist to specifically categorize the purpose of sick leave hours. Additionally, requests for workers' compensation cost data tapes were denied. When access approval was eventually granted, attempts to retrieve the data were hampered by extensive software problems resulting in only fragmented data files which lacked cost data for any records. The time required to rebuild the files to examine compensation costs proved to be prohibitive for completion of this research study.

Thesis Organization

This research effort is organized and documented in the four subsequent chapters. Chapter II will provide a review of literature related to this research. Following the literature review, Chapter III will present the methodology used to perform this research and provide the procedures for gathering and analyzing the data. In Chapter IV, the data analysis and results obtained by accomplishing the various aspects of the methodology steps are presented. Finally, Chapter V will discuss and document conclusions and offer recommendations for future research endeavors.

II. Background

Chapter Overview

This literature review contains background information which defines cumulative trauma disorders, including a review of common risk factors for development of CTDs and a discussion of circumstances which may explain the recent increase in the reporting and costs of CTDs. A brief summary of the history, purpose and requirements of FECA is included as a prelude to the discussion of the workers' compensation claims filing and processing procedures. This literature review concludes with a survey of occupational injury and illness surveillance techniques used in various industries.

Background on Cumulative Trauma Disorders (CTDs)

Cumulative trauma disorders are more appropriately characterized as occupational illnesses, as opposed to occupational injuries. Initially, this nomenclature may appear confusing, therefore, a distinction between the terms is in order. An occupational injury is defined as a wound or other condition of the body caused by external force, including stress or strain, and must be caused by a specific event or incident or series of events or incidents within a single day or work shift (US Department of Labor, 1988:2).

A sprained finger, a laceration, or a broken bone are just a few examples of occupational injuries.

An occupational disease or illness is a nontraumatic injury, and is a condition produced in the work environment over a period longer than one workday or shift (US Department of Labor, 1988:2). An occupational illness may be caused by repeated stress or strain, a systematic infection, exposure to toxins, poisons, or other continuing conditions of the work environment. Furthermore, the disease could takes weeks or months, and in some instances, several years, before symptoms manifest themselves. Carpal tunnel syndrome is a common example of a CTD illness.

Cumulative trauma disorders (CTDs) are defined as "a class of soft tissue injuries and disorders that are caused, precipitated, or aggravated by numerous job-related activities, including repetitive motions, forceful exertions, and awkward postures" (Keyserling and others, 1993:807). Injury occurs when workers use the same muscles to perform tasks over and over, normally resulting in injuries to the hands, wrists, arms, shoulders or back. Repetitive tasks involving forces repeatedly applied to the same muscle group, joint, or tendon over prolonged periods of time can result in small, but additive tissue damage and trauma (Rempel and others, 1992:838).

CTDs may often be referred to as overuse syndromes, regional musculoskeletal disorders (MSDs) or repetitive motion disorders. Repetitive strain injuries (RSIs) is the term used in Australia and Canada to refer to work-induced overuse problems, whereas in Scandinavia the term occupational cervical-brachial disorder (OCD) is used (Ranney, 1993:871). The specific name of the CTD condition varies with the anatomical location of the tissues involved.

The effects of a CTD illness are painful and debilitating conditions that are so severe as to awaken workers at night and to impair the ability of workers to grip objects normally or perform normal muscle movements, making it difficult to perform even simple tasks (Kiesler and Finholt, 1988:1005). In response to a CTD condition, workers often try to compensate for the discomfort by adopting even more awkward postures, using a more forceful grip, or applying other compensating measures (Rempel and others, 1992). Unfortunately, by trying to compensate for the effects of CTDs, the workers may actually be adding to the injury by accelerating the onset of CTD illnesses (Lundstrom & Johansson, 1986:687).

The occurrence of CTDs in a number of industries and occupations is well documented in several research studies conducted both in the US and in other countries. In 1988, a computer-related RSI epidemic known as carpal tunnel syndrome (CTS) surfaced in Australia among computer keyboard operators (Kiesler and Finholt, 1988:1004). Carpal tunnel syndrome and other nerve entrapment disorders among Navy enlisted personnel have been studied as well (Garland and others, 1993:2). Extensive research studies involving CTD incidents in the meat-packing industry, US automotive operations, and among electricians further illustrate the prevalence of CTDs in today's work environment (Masear and others, 1986:228; Park and others, 1992:732; Silverstein and others, 1986:779). Ironically, similar studies for Air Force military or civilian occupations could not be found in the course of this literature review.

Common Risk Factors For Development of CTDs

Without some knowledge of the potential risk factors associated with a particular CTD illness, it is difficult to properly diagnose the CTD, and to design and implement appropriate intervention and preventative measures. Rempel, Harrison and Barnhardt list a number of key risk factors associated with a high incidence of CTDs (Rempel and others, 1992:838). The work-related risk factors identified by Rempel *et al* included awkward joint posture, repetitive movements, high force, vibration, direct pressure, and prolonged constrained posture (Rempel and others, 1992:838).

In addition to the factors just mentioned, Armstrong hypothesized exposure to low temperatures may be a risk factor for CTDs, although this has not been demonstrated empirically (Armstrong, 1986:553). It has also been shown that when two or more of these risk factors are present at the same time, the potential for development of specific musculoskeletal disorders tends to increase significantly and the onset of the damaging effects of the injury are accelerated (Silverstein and others, 1986:780; Armstrong and others, 1987:831).

Workcenter-related ergonomic factors are not the only factors associated with CTDs. A 1987 study of visual display terminal workers in Sweden identified several individual and organizational factors which were shown to influence the incidence of CTDs (Bergqvist and others, 1995:763). Individual factors found to increase the potential for CTDs included age, gender, smoking, stomach-related stress reactions and the wear of eyeglasses. Organizational influences included the opportunity for flexible rest breaks, frequency and nature of co-worker contacts, task flexibility and working overtime.

Factors Behind Increased CTD Reporting and Costs

In 1991, approximately $42.2 billion, or $450 for every worker protected by worker's compensation laws, was paid out for all injuries and illnesses in private, State and Federal workers' compensation benefits (Nelson, 1993:69). The $42.2 billion represents a $4 billion or a 10.3 percent increase over that paid in 1990 (Nelson, 1993:69). The recent increase in the number of reported cases of occupational CTDs, and the subsequent spiraling increases in the costs of workers' medical and compensation claims, are the products of several factors. The most significant influences are medical cost inflation, and the improved methods and accuracy of reporting.

The National Council on Compensation Insurance reported that medical costs exceeded premiums by 23% during 1991, and that 1991 was the eighth consecutive year in which costs outpaced premiums for workers' compensation insurers (Curtis, 1993:374). Indemnity costs per case increased rapidly also, averaging $12,833 in 1990, up $5060 from 1985 (Curtis, 1993:374). The number of lost workdays per lost-workday case rose as well, from 18.0 in 1986 to 22.2 in 1991(Nelson, 1993:69).

The factors noted by Curtis that contributed to the rapid rise in medical costs included: an aging workforce, lack of incentive for employees to choose a cost-effective provider, more expensive medical equipment and diagnostic procedures, expansion in the number of compensable injuries and illnesses, and cost-shifting resulting from the shrinking of provider reimbursement from insurance plans and Medicare. For indemnity costs in particular, litigation and attorney involvement have increased despite the best intentions of the original no-fault concept of the workers' compensation system (Glover, 1991:29). Finally, improved accuracy in reporting, better informed employees and employers, and the accelerating work-pace have been noted to increase claim costs (Rempel and others, 1992:838).

History of Federal Workers' Compensation

The Federal Employees Compensation Act (FECA), enacted in 1916, has roots extending back to the Industrial Revolution near the turn of the century, when the Federal Act of 1908 became the first workers' compensation law in the history of the United States. The purpose of the legislation was to provide protection to certain employees and their families working in hazardous occupations.

Prior to the 1908 legislation, the injured worker was burdened with proving that the injury or illness resulted from negligence on the part of the employer, before the employee could recover costs of medical care and lost wages. Today, proof of employer negligence is not required for an employee to lay claim to workers' compensation benefits. Nine states had established their own workers' compensation laws by 1911, and by 1949, the workers' compensation system was composed of separate state managed programs in all 50 states and the District of Columbia, and two Federal Programs administered by the Department of Labor (DOL). The Federal programs consist of the Federal Employees Compensation Act, covering civilian employees of the Federal Government, and the Longshoremen's and Harbor Workers Compensation Act covering longshore and harbor workers.

In 1969, a third Federal workers' compensation program, the Federal Black Lung Program, was established. The purpose of this latest program was to provide disability payments and medical benefits to coal miners diagnosed with pneumoconiosis ("black lung" disease) and to their dependents, or survivors.

Workers' compensation benefits provide medical care, hospitalization benefits, income maintenance protection to workers with temporary partial, temporary total, or permanent total disability, vocational rehabilitation expenses, and compensation to surviving dependents in the unfortunate event of death. Medical expenses are normally paid on a fee-for-service basis or fixed-fee schedule, depending on the jurisdiction. Disability payments are provided to compensate the injured worker for lost wages during the recovery period. Normally, medical benefits are paid immediately, but most programs have a short waiting period before disability benefits take effect.

Each state has modeled its own particular form of the Federal workers' compensation law; however, all programs are based on a no-fault premise wherein the employee is relieved from proving employer negligence. Although the original intent of workers' compensation was to relieve employers of liability from common-law negligence in return for assuming the costs of occupational injuries and illnesses, today the workers' compensation system is bogged down in liability suits (Curtis, 1993:373).

As of 1991, approximately 93.6 million workers were protected under workers' compensation programs (Nelson, 1993:69). The 93.6 million is an approximation because the actual number of workers covered is impacted by employment fluctuations in the economy and legislative activity which may add or subtract workers from coverage (Nelson, 1993:69). Additionally, employees of nonprofit, charitable, or religious institutions are exempt from most programs and only limited coverage is provided to workers in very hazardous occupations.

Purpose and Requirements of FECA

The Federal Employees Compensation Act, based on Public Law 93-416, Title 5 of the United States Code, is administered by the US Department of Labor, Employment Standards Administration, Office of Workers' Compensation Programs (OWCP), through District offices located in different regions throughout the United States.

The OWCP provides compensation benefits to Federal civilian employees for personal injury or employment related diseases sustained while in the performance of duty. FECA is a no cost Federal insurance program designed to cover lost wages and medical expenses, as well as survivor benefits. However, no benefits are paid if the injury is caused willfully or by the employee's misconduct.

The benefits available to civilian employees under FECA are the same as the medical, disability, income replacement, vocational rehabilitation and death benefits discussed previously in this paper. All claims for compensation are adjudicated by the DOL. Furthermore, all monetary benefits are paid by the DOL and are then charged back to each federal agency, including the Department of Defense, through a charge back system at the end of each year. Thus, each federal agency has the responsibility to reimburse the DOL for workers' compensation payments to its employees.

It is important to note that medical and compensation costs are not the only costs associated with occupational injuries and illnesses. Occupational illnesses such as CTDs significantly impact the health, welfare, and productivity of workers, and affect the productivity of the workcenter as a whole. Indirect costs such as administrative costs for claims processing, lost production time if disability occurs, and costs to train an unskilled worker to replace the disabled worker are examples of indirect costs that are more difficult to determine (Snook and Webster, 1994:717).

As with all Department of Defense employers, Wright-Patterson's injury compensation program is organized under FECA. Each year, the Department of Labor accumulates all of the OWCP medical and compensation cost data, segregates the data by agency, and then forwards the data to each Federal agency. For instance, the Department of Defense (DOD) receives a magnetic tape containing all of the chargeback data on costs paid to DOD employees by the OWCP during the DOL's fiscal year, which runs from 1 July through 30 June. This chargeback listing tape is then sent by the DOD to each branch of service, the Army, Navy and Air Force.

When the Air Force receives its portion, the total amount owed to the DOL is paid out at the headquarters level. Therefore, in actuality, the DOL has the responsibility to spend Air Force money. Additionally, each Air Force major command (MAJCOM) is provided a copy of the tape from which they extract their portion of the costs. For example, HQ AFMC/DPCC extracts their portion and forwards each AFMC base, including Wright-Patterson AFB, that portion of the chargeback listing pertaining to costs incurred at that particular installation. However, the compensation and medical costs are not assessed to the organizational level, and no requirement currently exists for charging each base its portion of AFMC's medical and compensation costs.

The chargeback data provided to Wright-Patterson AFB is used by several agencies, including base safety, OMS, Public Health professionals, and the base Ergonomics Working Group (EWG), for use in identifying high cost injuries and illnesses where efforts should be concentrated on reducing claim costs.

The injury compensation program is highly visible within the Air Force due to the ever increasing number of occupational injuries and illnesses reported each year and the costs associated with them. The Air Force is not unique with regard to increased injury and illness rates and cost containment efforts. During 1988, a comprehensive study of worker injuries and illnesses was performed to determine the most cost effective utilization of military medical resources in the FECA reduction goals at Fort Campbell, Kentucky (McCollum, 1988:3).

FECA Claims Filing and Processing Procedures

The general workers' compensation claim processing procedures for both occupational injuries and illnesses are described in detail in OWCP Pamphlet CA-550, Federal Injury Compensation. However, to provide the reader with a general understanding of the claims process, the procedure for filing, processing, adjudication and payment for occupational illness claims are summarized here.

At Wright-Patterson AFB, workers' compensation claims are managed through several agencies, beginning with the employee's immediate supervisor. Once the employee has notified the immediate supervisor of the illness or symptoms, other base agencies become involved, including the

Occupational Medicine Services (OMS), the individual physician, the base Civilian Personnel Office (CPO), and the district Office of Workers' Compensation.

Hoiberg's study, "A Cost Containment Case for Occupational Illness and Case Management," provides a comprehensive discussion of the importance of the roles carried out by claim participants in cost efficient case management (Hoiberg, 1988). In the study, Hoiberg emphasizes the importance of involvement by all participants in the development of a plan for returning the injured employee to work as soon as possible. This goal is important because it has been shown that the longer the temporary disability period the greater the risk that the individual will not return to work (Greenwood, 1984:596).

The employee must file a Form CA-2, "Federal Employee's Notice of Occupational Disease and Claim for Compensation," within 30 days from the date the employee realized the disease or illness was caused or aggravated by the employment (Department of Labor, 1988:2). Again, an occupational disease can be identified by the fact that the injury occurs over more than one eight-hour work shift.

It is the employee's responsibility to report the illness and provide medical and factual evidence to establish the essential elements of the claim. Therefore, two copies of the appropriate medical condition checklist, Forms CA-35a through h, "Checklist for Specific Medical

Conditions," are provided to the employee to be used for documenting various conditions or symptoms in order to facilitate submission of evidence (Department of Labor, 1988:25). The essential elements of the claim include: the claim was filed within FECA statutory requirements, the employee was employed within the meaning of FECA, the injury or illness was actually sustained and occurred during the performance of duties, and the condition found resulted from the injury or illness (Department of Labor, 1988:2).

Once the illness has been identified, the employee has the option to either seek treatment by a government physician in OMS, or by a physician of his or her own choosing. However, supervisors are encouraged to urge employees to make an initial visit to OMS before opting to go to a private physician. This allows OMS with the opportunity to document the occupational illness via an AF Form 190, "Report of Occupational Illness and Disease," that is forwarded to Brooks AFB, Texas, for tracking in the AF Form 190 data registry data base.

If the employee goes directly to an off-base physician, no requirements exist to have the employee report the incident to OMS. Thus, no AF Form 190 is completed and the CA-2 form obtained from the employee's physician is not routed through OMS, but flows from the supervisor to the CPO for further processing before it is forwarded to OWCP. Therefore, OMS personnel may not even be aware of the occurrence of the incident until some time well after the incident, if at all.

To claim compensation for loss of pay if the employee is disabled or loses time from work because of an occupational disease or illness, the employee must file a CA-7, "Claim for Compensation on Account of Traumatic Injury or Occupational Disease." The time limit for filing a claim for compensation is limited to three years from the date of the injury or illness. The CA-7 is processed through the base OCP to OWCP in Cleveland, OH for adjudication. The OWCP is the regional adjudication authority for compensation claims filed by federal employees in Ohio.

The disability compensation payments are computed at two-thirds of the employee's pay rate if the employee has no dependents, or up to three-fourths of the pay rate if the injured employee is married or has one or more dependents (Department of Labor, 1988:10). Also, an employee must be in a leave-without-pay (LWOP) status before compensation for wage loss is payable. However, because the processing of the compensation claim can take up to several weeks, the majority of employees cannot afford to enter a LWOP status while awaiting adjudication of their claim by OWCP. The employee normally resorts to using annual or sick leave to maintain an income until they return to work and then file a CA-7 claim with the OWCP.

If the OWCP approves the CA-7 claim and medical evidence shows the employee was unable to work because of the illness during the period claimed, any annual or sick leave taken as a result of the illness can be repurchased through a "leave buy back" (Department of Labor, 1988:10). An employee who chooses to use sick or annual leave may request "leave buy back" by submitting a Form CA-7 to OWCP through the base CPO. Any compensation payment from OWCP is used to partially reimburse the CPO for the leave pay. The employee must also arrange to pay the difference between the leave pay based on 100 percent of the employee's pay rate, and the compensation payment which is paid at two-thirds or three-fourths of the wage rate (Department of Labor, 1988:10). Once the leave pay has been reimbursed, the leave is restored to the employee's leave record.

There is no maximum period of time during which an employee can receive compensation payments for wage loss, as long as the medical evidence shows that the total or partial disability is related to the accepted injury or condition. However, most individuals receiving disability compensation are required by OWCP to submit to a medical examination at least once a year.

Review of CTD Surveillance Methods

The literature on surveillance techniques for detecting CTD incidents and conducting CTD risk assessments is voluminous. Therefore, a brief overview of the most common techniques used today, both in private industry and in the Air Force, is provided to describe the uses and limitations of certain surveillance data in the management of CTDs.

In the general private industrial sectors, surveillance is primarily dependent on two existing data systems: (1) the systematic sampling of OSHA-200 forms by the Bureau of Labor Statistics, and (2) the Supplementary Data System, an annual BLS analysis of workers' compensation claims data from participating states (Tanaka and others, 1988:491). However, individual high risk companies are not identified by these data systems, but associations with broad industrial and occupational categories are provided.

The most common source of surveillance data used is DOL's Labor and Industries' Industrial Insurance System, but no consensus has been reached on whether it is the most effective or accurate source. In Ohio, workers' compensation claims data covering a five-year period (1980-1984) were evaluated as a source of surveillance data for identifying those workplaces at high risk for CTDs and analyzed for employee demographic as well as industrial characteristics (Tanaka and others, 1988:488).

The researchers concluded that workers' compensation claims data were useful for identifying companies with high rates of CTDs by specific diagnosis and part of body, but suggested that the surveillance method remained to be validated. In a 1990 study, support for the usefulness of workers' compensation claims was successfully demonstrated in the surveillance of occupational skin diseases in the state of Ohio (Mathias and others, 1990:363).

Another study conducted in Athens County, Ohio, in 1987, produced by the Panel on Occupational Safety and Health under the National Research Council, concluded that the existing national surveillance system for occupational injuries might result in substantial underreporting of occupational injuries and illnesses (Fingar and others, 1992:779). The national surveillance system for injuries is managed by the DOL and is based on annual employer reporting of significant occupational injuries on the OSHA Form 200.

The sources of occupational injury data used in the Fingar *et al* study were the National Electronic Injury Surveillance System (NEISS) and lost-work time claims filed with the Ohio Bureau of Workers' Compensation (BWC). Fingar *et al* concluded that neither data set alone provided a complete nor an accurate description of occupational injuries in Athens County. When examined together, the NEISS and BWC data sets may provide a more accurate and complete representation of occupational injuries, and did result in a higher number of total injuries and illnesses than that predicted by national norms using the DOL's OSHA-200 data (Fingar and others, 1992:786). The conclusion reached by the Panel was that the national system might result in underreporting of occupational injuries, but that scarce data were available to accept or reject this claim (Fingar and others, 1992:779).

Most of the problems associated with the OSHA-200 system are that descriptions on the OSHA-200 logs varied considerably, and it was not always possible to code CTDs in particular because seldom was the condition described as acute or chronic (Nelson and others, 1992:1551). Some of the shortfalls in the OSHA-200 based system may be mitigated if the data is used in conjunction with medical insurance claims. The study by Nelson and others of CTDs among autoworkers from 1985 to 1986 suggested that health insurance records, although not perfect, identified considerably more potentially work-related CTD cases than the OSHA-200 data logs (Nelson and others, 1992:1551).

As discussed above in this paper, the chargeback listing is the primary tool currently used to provide a picture of occupational injuries and illnesses at Wright-Patterson AFB. However, this data source suffers from the same shortfalls as the OSHA-200 system it is based on. For example, the chargeback listing does not identify the base organization in which the injury or illness occurred, making it difficult to identify the high risk workcenters.

Furthermore, the chargeback listing uses nature of injury (Z16.2) codes, and a unique code for CTDs does not exist in the DOL's Z16.2 coding system. Instead, they are grouped under a generic code - "Diseases, unclassified", making it difficult to accurately pinpoint the exact CTD illness experienced by the employee.

The AF Form 190 data provides some data not found in the chargeback listing, but uses the International Classification of Diseases (ICD-9CM) coding system to identify the specific CTD diagnosis. However, the AF Form 190 does not contain any cost data. Thus, combining the two sources may be necessary to accurately describe the number of CTD-related cases, as well as the costs and amount of lost duty time resulting from CTD-related incidents at Wright-Patterson AFB.

Summary

This chapter provided background information needed to understand the importance and relevance of this research It is clear from the enormous amount of previous research into the causes, increased incidence rates, and compensation costs associated with CTDs, there is considerable need to discover and develop methods for reducing the risks of developing a CTD-related illness. Furthermore, appropriate surveillance methods are needed to provide occupational medicine and ergonomics professionals with the data needed to design intervention and prevention methods.

Although previous studies by McCollum, Hoiberg, and Garland *et al* have researched CTDs and occupational injuries and illnesses in the Department of the Navy, very little literature was available to describe Air Force efforts in these areas. Therefore, this research effort will attempt to provide a perspective on CTDs and CTD-related risk factors at Wright-Patterson AFB.

III. Methodology

Chapter Overview

This chapter describes the methodology used to analyze risk factors for reported cumulative trauma disorders (CTDs) among Wright-Patterson AFB civilian personnel. A discussion of the study design, population, data collection, risk factors, statistical methods employed, and the hypotheses tested are presented. A brief review of strengths, limitations and potential sources of bias associated with the case-control methodology is also provided.

Study Design

This study is based on a case-control, matched pairs design to identify the existence of an association between several hypothesized risk factors and reported CTD illnesses among civilian workers at Wright-Patterson AFB. The case-control method is appropriate because it is the most widely used technique for analyzing qualitative or categorical data, although it is subject to certain limitations. The risk factors chosen for analysis were age and duration of employment.

Given the fact that occupation is a known risk factor for CTDs, matching on occupation in terms of Air Force specialty codes (AFSC) was used to achieve higher precision in the analysis of the other risk factors. The reported cases of CTDs were examined to determine which workcenters, if any, experienced a higher number of CTD illnesses relative to other workcenters, and which AFSCs or occupations experienced the highest number of reported CTD illnesses.

Case-Control Study Considerations

In a case-control study, individuals enter the study classified as either diseased, in which case they are referred to as *cases*, or as nondiseased and classified as *controls*. Case-control studies are sometimes viewed as imperfect because approaches that relate exposure to disease rather than disease to exposure are viewed as unnatural (Monson, 1990:59). Theoretically however, case-control studies can provide valuable information if conducted correctly because an association between exposure and disease can be detected irrespective of the data collection method (Monson, 1990:59) These type of studies are more practical for studying rare diseases and can often be accomplished faster and more economically because they can be conducted with existing data. Additionally, a steady increase in the number of respectable case-control studies has been noted (Monson, 1990:59; Rothman, 1986:69).

Despite the advantages of the case-control study, the conduct of such studies is always subject to difficulties that could result from selection, observation and confounding biases (Knapp and Miller, 1992:115; Monson, 1990:34). Comparability of data is a paramount issue in any study and is especially important for case-control studies. Thus, because case-control studies are nonexperimental, efforts must be made to minimize the effects of bias and the results from such studies must be interpreted with caution (Monson, 1990:59).

Selection bias results from deficiencies in study design and data collection, and can occur if noncomparable criteria relating to exposure are used to select entrants into the two groups. Selection bias cannot be controlled but must be prevented. One method for limiting selection bias, as used in this analysis, is to include all individuals who were diagnosed with the disease or illness during the specified period, and to use population controls.

Observation or information bias, as with selection bias, results when information on exposure is obtained in a noncomparable manner for cases and controls, and therefore the data contain incorrect information as to exposure and disease (Monson, 1990:34). Like selection bias, observation bias is also a product of deficient study design and data collection; however, it can be prevented by maintaining an impartial view toward the nature and purpose of the study. The main concern must be that the data is collected to reflect nature rather than the bias of the investigator (Monson, 1990:36).

The third and final source of bias is confounding bias which is often present in all data and may occur if there are characteristics of individuals associated with exposure and disease or illness, such that data relating exposure to disease may convey an appearance of association (Monson, 1990:34). Three methods that can be used to control confounding bias are randomization, matching, and stratification. Matching is the usual method used in the design of case-control studies to prevent confounding, because it leads to an equal frequency of the potential confounding factor among the case and control groups. For purposes of this study, matching on job specialty code identifiers was used because occupation is a known risk factor for CTDs (Bergqvist and others, 1995:767, Kiesler and Finholt, 1988:1006).

Population

The analysis was limited to the Air Force civilian population at Wright-Patterson AFB. The study population included full-time employees who were actively employed at Wright-Patterson AFB during the 1990 through 1994 study period. During this period, the civilian population at Wright-Patterson averaged about 17,000. The base civilian population was selected because available information on employee age, duration of employment, gender, AFSC, and workcenter could be used in conjunction with AF Form 190 data to conduct the analysis.

Selection of Case Group

The case group consisted of prevalent cases, that is, individuals who have been diagnosed with the disease in the past. Reports of occupational illness among the entire civilian population at Wright-Patterson AFB, for the period of 1990 through 1994, were obtained from computerized Occupational Illness Data Registry (OIDR), records maintained by the Occupational Medicine Division of the Armstrong Laboratory (AL/OEMO) at Brooks AFB, TX.

An electronic search was conducted of the OIDR database for records of occupational illnesses reported via AF Form 190s between 1990 and 1994, by calendar year, at Wright-Patterson AFB. The results of the search were transmitted via fax to the researcher for further preparation, analysis, and matching with information obtained from the Base Civilian Personnel Office. All records of illness were then entered into a computer file, including data from each record describing an anatomical area corresponding to a specific cumulative trauma ICD-9-CM code. A case was then defined as the individual who filed an AF Form 190 report for any of the selected CTD conditions under study.

A total of 115 cases of CTD illness were reported by base civilians during 1990 to 1994. These 115 cases were narrowed down to those reported by persons in the 3A1x0 AFSC occupational group. Occupation was defined by the AFSC assigned to a particular job position and type of work performed. Secretaries, clerical assistants, librarians and administrative assistants are all assigned the identical AFSC (AFSC 3A1x0, with x denoting skill level) and perform similar duties. These job specialties were pooled together because the number of each was too small to provide stable estimates of disease occurrence. No other occupational group within the AF Form 190 data contained more than five reports of a CTD illness and were so dissimilar in the work performed that further pooling of AFSCs was not possible. The total number of cases in the secretary, clerical and administrative group was 44.

Selection of Control Group

The individuals comprising the control group were selected by a computerized random sample of the base civilian population from which the cases were derived. The DSCPD system has the capability to generate the required random sample. Generating the controls from the same population from which the cases were derived forms a basis for a comparison of the control occupational and demographic factors with those of the cases (Monson, 1990:137). A ratio of four controls per case was selected to increase the ability or power of a statistical test to correctly detect a difference of a specified magnitude, referred to as a clinically important difference or effect size, given that this difference exists in the populations being compared (Knapp and Miller, 1992:195).

A clinically important difference is defined as the difference between two population parameters that is meaningful from a clinical perspective (Knapp and Miller, 1992:195). Matching with multiple controls has also been demonstrated to be quite advantageous when the number of available control subjects is large relative to the number of cases and when the necessary information can be obtained relatively easily (Fleiss, 1981:123).

Selected Disorders

Based on the AF Form 190 data, a significant number of reported CTD illnesses in the secretary/clerical AFSC (3A0x0) over the period covered in this research warranted further study of risk factors for this major occupational group. In particular, nine categories of musculoskeletal disorders of the upper extremities that can be caused by workplace cumulative trauma were recorded for this occupational group, the most frequent being carpal tunnel syndrome (ICD-9 Code 354.0). These disorders were defined using the International Classification of Diseases, Clinical Modification, 9th version (ICD-9-CM) codes assigned to each incident on the AF Form 190 (Department of Health and Human Services, 1980:277-769).

Risk Factors

A risk factor is defined as a condition, physical characteristic, or behavior that increases the probability or risk that a currently healthy individual will develop a particular disease or illness. Risk factors may be causal factors of the disease in question or merely markers for the increased probability of developing a disease (Knapp and Miller, 1992:109).

Previous studies have found associations between several types of musculoskeletal disorders and gender, wherein females were found to experience higher rates of CTD illnesses, especially in secretarial, typing, and clerical tasks (Bergqvist and others, 1995:767, Kiesler and Finholt, 1988:1006). However, the 44 reports comprising the case group for this study were all female, therefore, gender was not examined as a risk factor.

Due to the limited information available from the AF Form 190 data, only two risk factors were available for analysis:

1. *Age*. Age of the employee is important in relation to musculoskeletal problems (Bergqvist and others, 1995:774), although it is unknown if this is a function of duration of employment. The ages for each case and control

subject were stratified into discrete categories for use in the significance testing. For odds ratio calculations, age at the time the illness was reported was expressed as a binary dummy variable, divided at the median value of the cases, 38.0 years. This procedure is similar to that used in other epidemiology studies (Daltroy and others, 1991:508).

2. *Duration of Employment.* This factor was studied for low back injuries, but little research as to the association between length of employment and CTDs exists (Daltroy and others, 1991:508). Duration of employment was also categorized into time intervals to facilitate significance test calculations. As with the age data, for OR calculations for duration of employment were calculated based on years from date of hire (Start Date in DCPDS) to date of reported illness, divided at the median value of the cases, 6.3 years.

Data Collection

Data used in this study was obtained from several sources as no single Air Force source maintains both AF Form 190 data and the necessary data describing occupational and employment information for both the cases and control group. The AF Form 190 CTD group data used in this study is provided in Appendix A.

An analysis of occupational illness/injury reporting systems at three selected Air Force bases with a high number of civilian employees indicated that the AF Form 190 reporting system does not capture the majority of illnesses (Fisher and Meyer, 1993). However, the data obtained from the OIDR data base was considered sufficient for the purposes of this particular study.

Data pertaining to an employee's AFSC, start-date of employment, age, and workcenter for both the case and the control groups were obtained from an electronic search of the Defense Civilian Personnel Data System (DCPDS) located in the on-base Civilian Personnel Office, and/or from employee medical records maintained by Occupational Medicine Services (OMS). The results of the DCPDS search were transferred into a text file format to a floppy disk for further preparation, analysis and merging with the OIDR AF Form 190 data for incorporation into the data set used in this study.

Information from both of these sources were matched using personal identifiers to produce the data base used in this study. In compliance with Privacy Act and Freedom of Information Act restrictions, confidentiality of AF Form 190 data and DCPDS data was maintained by deleting identifiers after matching occupational illness reports to personnel records in the DCPDS.

Data Preparation

Once the data from both the OIDR and DCPDS were merged to create the case and control groups, each case was randomly assigned four controls to form a quintuple. In all, there were 44 matched quintuples used in the analysis of each of the risk factors.

For purposes of the analysis, it was assumed that each subject was characterized by either the presence or absence of a particular risk factor or illness. The presence of the risk factor among the cases was indicated by a binary variable (1 or 0). A value of 1 indicated the case had the risk factor and a value of 0 indicated the case *did not* have the risk factor. The same procedure was applied to the control subjects. Data for both the case and control groups were then organized into the appropriate tabular formats, as described in the next three sections below, for use in performing the analysis.

Descriptive Data Analysis Methods

The CTD data for the 115 cases analyzed as part of this research was described demographically in terms of age, gender, and type of cumulative trauma disorder. The ages of the 115 cases were categorized in tabular format in ten year intervals for each of the five years covered in this study, with the totals summed for each year. The data were also tabulated by gender and summed by year of occurrence to obtain the percentage of male and female CTD illnesses for each year between 1990 and 1994. Finally, the 115 records were grouped and tabulated by CTD illness type, based on the ICD-9CM code assigned to each incident, to identify which CTDs occurred most often during 1990 to 1994.

Statistical Methods

The statistical methods applied in this case-control study are described by Knapp and Miller, Fleiss and numerous other biostatistics texts (Knapp and Miller, 1992:212-225; Fleiss, 1981:123-126). The methods consider the analysis of data resulting from the study of cases matched with multiple controls when the controls are selected from a single random sample. Thus, a two step approach for analyzing frequency or count data, based on a comparison of multiple matched controls was applied:

1. Determining if a statistically significant association between a risk factor and a cumulative trauma disorder can be identified, and
2. Determining a point estimate of the magnitude or strength of an association by quantifying the relative risk.

The generalized chi-square test was used to test for the existence of a statistically significant association between a risk factor and a cumulative trauma disorder. The odds ratio analysis is based on the described by Fleiss for multiple controls matched to each case (Fleiss, 1981:115).

To facilitate testing for a significant association, the data were arranged in an *ixj* contingency table, where *i* = number of rows and *j* = number of columns, for both the age and duration of employment risk factors. The specific *ixj* contingency table structures for the age and duration of emloyment risk factors are defined in the next section. Similarly, the specific table structure of the outcome data for matched quintuples used to compute the odds ratios is provided in the section describing the methodology for determining a point estimate of relative risk.

Test for Statistical Significance

In general terms, the test for statistical significance was conducted via hypothesis testing, wherein, the null and alternative hypotheses $\mathbf{H_O}$ and $\mathbf{H_A}$ are stated in terms of whether or not an association exists, or alternatively, in terms of a difference between proportions:

> $\mathbf{H_O}$: There is no association between the risk factor and the occupational illness ($p_1=p_2$);
>
> $\mathbf{H_A}$: An association between the risk factor and the occupational illness exists ($p_1 \neq p_2$).

Since the data is in the form of counts, the chi-square test is used to check for a statistically significant association between two variables. The chi-square test is also used for studies in which a question regarding the existence of an association between two variables is phrased in terms of a difference in proportions. An association or difference in proportions is said to exist if the proportion of cases having the risk factor is significantly different from the proportion of controls having it.

To test the significance of the difference between p_1 and p_2, the data for observed and expected values were each arranged in an *ixj* contingency table, as shown in Table 1.

Specifically, a 2x5 contingency table was used for the age risk factor data, with the ages stratified into one of five categories: 19-29, 30-39, 40-49, 50-59, and 60 years of age or older. A 2x4 contingency table was used for the duration of employment risk factor data, with years of employment data stratified into 4 four categories: less than or equal to five years, 6-10 years, 11-15 years, and greater than 15 years.

Table 1. General *ixj* Contingency Table

	Category 1	**Category 2**	**...**	**Category *j***	**Totals**
CTD Illness	O_{11}	O_{12}	...	O_{1j}	n_1
No CTD Illness	O_{21}	O_{22}	...	O_{2j}	n_2
Totals	C_1	C_2	...	C_j	N

The particular risk factor's "observed" table was then compared to its "expected" table . If H_0 were true, it would be expected that the two tables contain similar cell values. The more different the tables are, the more likely it is that $\mathbf{H_0}$ will be rejected. The general formula for computing the chi-square statistic was computed as:

$$\chi^2 = \sum_{all\,ij} \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} \qquad (1)$$

where,

O_{ij} is the number of observations in row i which fall into the category j

E_{ij} represents the expected number of observations in cell (ij) if $\mathbf{H_0}$ is true.

Each of the expected cell values, E_{ij} are calculated by the following equation:

$$E_{ij} = \frac{n_i C_j}{N} \qquad (2)$$

Once computed, χ^{2*} was compared to the critical value of chi square (χ_c^2) based on [(rows-1)x(columns-1)] degrees of freedom for significance at the .05 level of confidence. The decision criteria as to whether to accept or reject $\mathbf{H_0}$ is as follows:

(1) If $\chi^{2*} > \chi_c^2$: reject $\mathbf{H_0}$;

(2) If $\chi^{2*} \leq \chi_c^2$: *do not* reject $\mathbf{H_0}$.

In addition to the chi-square value, a *p*-value associated with χ^{2*} can be determined to obtain the actual probability of obtaining a test statistic equal to or greater than χ^{2*} by random chance when $\mathbf{H_0}$ is true, for a given level of significance α. For the purposes of this study, a significance level of .05 (α=.05) was used. Based on the p-value, the following alternative decision rule can be applied:

(1) Reject $\mathbf{H_0}$ if $p \leq \alpha = .05$

(2) Do not reject $\mathbf{H_0}$ if $p > .05$.

Simply stated, the larger the value of χ^{2*} or the smaller the p-value, the greater the evidence against $\mathbf{H_0}$ and the more probable it is that a significant association actually exists between a particular risk factor and the cumulative trauma disorder. In that case, the hypothesized association is likely due to random chance.

Validity of the Chi-square Test Statistic

Having described the chi-square test for significance to be used in this methodology, it is important to discuss the validity of this test. Generally, the chi-square test should not be used if the any of the expected values (E_{ij}) of the cells depicted in Table 1 fail to meet the criteria developed by Cochran (Cochran, 1954:418). Cochran studied the validity of the Chi-square test just described and recommends its use only under the following conditions:

1. No more than 1/5 of the cells have expected values (E_{ij}) less than 5.
2. No cells have E_{ij} with values less than 1.

The *ixj* contingency tables for both age and duration of employment were therfore designed with class intervals constructed to satisfy these conditions.

Point Estimate of the Relative Risk

Although a small *p*-value for the chi-square test indicates that the evidence in favor of an association between a particular risk factor and an occupational disease is strong, it does not correspond to the magnitude of the association. Therefore, a statistical measure that defines the strength of an association is required.

Relative risk (**RR**) provides a method for estimating the strength of an association, by estimating how much more likely a subject with a risk factor is to develop a particular disease than an individual without the risk factor. However, **RR** can only be directly calculated in a cohort or experimental study. Therefore, a comparative measure for **RR** must be used for case-control studies.

The odds ratio (**OR**) can be used to approximate the relative risk (**RR**) if the disease is relatively rare (prevalence of less than 10%) among the general population (Knapp and Miller, 1992:252). The odds ratio (**OR**) compares the odds that a disease will occur when a particular risk factor is present to the odds when the factor is absent (Fleiss, 1981:115). The occurrence of cumulative trauma disorders (CTDs) among the Wright-Patterson civilian population is considered to be relatively rare, therefore, an odds ratio can be used as a measure of **RR**.

To facilitate the computation of **OR** values, the outcome of the matched quintuples was organized into the tabular format, adapted from Fleiss, shown in Table 2.

Table 2. OUTCOME DATA FROM MATCHED QUINTUPLES.

Quintuple	Case Has Risk Factor	Number of Controls with Risk Factor (= x_i)	Total Having Factor (= n_i)
1	(1 or 0)	x_1	n_1
2	...	x_2	n_2
3		x_3	n_3
...		...	...
44		x_{44}	n_{44}
Total	**(B - A)**	**A**	**B**

For case-control studies with R controls matched to each case, the Mantel-Haenszel estimate of the assumed common odds ratio over the 44 quintuples (N=44) as illustrated in Table 3, is defined as:

$$\mathbf{OR} = \frac{(m-1)(B-A)-\sum_{i=1}^{N} x_i(n_i-x_i)}{A-\sum_{i=1}^{N} x_i(n_i-x_i)} \qquad (2)$$

where,

N is the number of matched m-tuples containing one case and m-1 controls

n_i is the total number of subjects (cases and controls) who had the risk factor

A is the total number of control subjects who had the risk factor, and

B is the total number of subjects for either group who had the risk factor.

From this equation, the results can be interpreted as the odds of having the cumulative trauma disease are **OR** times greater among individuals exposed to the suspected risk factor than among those who were not. Stated another way, it is **OR** times more likely that a diseased individual has been exposed to, or possesses, the risk factor than a healthy person, provided the disease is relatively rare in the study population.

Statement of Research Hypotheses

The need for hypothesis testing is based on the necessity of determining whether or not a statistically significant association exists between a particular risk factor and the development of cumulative trauma disorders. Statistical testing of a research hypothesis allows the researcher to approximate the risk in making inferences about a population based on information obtained from a sample. The hypotheses tested in this study, in terms of a null hypothesis, are:

1. No association exists between age and CTDs among secretary/clerical civilian employees. Stated differently, there is no difference between the ages in the proportion of

secretary/clerical workers diagnosed with a CTD illness (p_{1j}) and the ages in the proportion of secretary/clerical workers who have not (p_{2j}). Given a $2xj$ contingency table, the hypotheses are:

$$\mathbf{H_0}: \ \boldsymbol{p_{1j} = p_{2j}} \quad \text{for all } j$$

$$\mathbf{H_A}: \ \boldsymbol{p_{1j} \neq p_{2j}}, \quad \text{for at least one } j$$

2. No association exists between experience and CTDs among secretary/clerical and administrative civilian employees. Stated differently, there is no difference between the experience levels based on duration of employment for the proportion of those secretary/clerical or administrative workers diagnosed with a CTD illness (p_{1j}) and the years of experience for the proportion of those secretary/clerical workers who have not (p_{2j}). The null and alternative hypotheses are:

$$\mathbf{H_0}: \ \boldsymbol{p_{1j} = p_{2j}} \quad \text{for all } j$$

$$\mathbf{H_A}: \ \boldsymbol{p_{1j} \neq p_{2j}}, \quad \text{for at least one } j$$

The results of the above methodology for testing for a significant association between age and duration of employment or experience factors and the incidence of CTDs, as well as for estimating the relative risk or strength of the association are provided in Chapter IV.

CTD Frequency by Organization

The case-control methodology precludes the computation of disease prevalence because prevalence can only be determined when the number of diseased persons (cases) and persons without the disease (controls) are not fixed by the investigator (Knapp and Miller, 1992:37). Therefore, the frequency of CTDs in the various base workcenters was used to provide insight into which organizations might benefit most from concentrated intervention and prevention measures.

Personnel and medical records for the 115 reported cases were reviewed to determine the organization where the illness developed. Organizations were determined for 97 of the 115 cases where the organization was reported on the AF Form 190. Workcenter could not be determined for the remaining 18 records because they were signed out for administrative reasons and were not available in time to include them in this portion of the study.

For the 97 CTD cases, workcenter data was recorded for both the primary organization designation and the system program office or sub-organization designation levels. The number of CTD reported incidents per organization was determined by counting and grouping the reports by the primary workcenter designation. The results were then summarized in tabular format to show which organization(s) experienced the most CTD cases. The number of civilian employees assigned to each of the organizations during the 1995 fiscal year is provided to show the number of cases relative to the current civilian population in each of the particular workcenters.

IV. Analysis and Results

Chapter Overview

This chapter records the results of the analysis performed to accomplish the objectives of this study. The analysis was performed using an IBM-compatible desktop computer and Microsoft's Excel 5.0 spreadsheet application. The descriptive demographic analysis of CTDs reported at Wright-Patterson AFB from 1990 to 1994 is presented first. Second, the statistical analysis to determine if a significant association exists between age and length of employment (work experience) risk factors and CTDs is provided. Finally, the frequency of CTD illnesses among the major base organizations over the five year period covered in this study is examined.

Descriptive Analysis of Reported CTD Illnesses

All AF Form 190 records relating to CTD illnesses during 1990 to 1994 were examined to describe the number, type, and demographic characteristics in terms of age and gender of the reported CTD illnesses. There were a total of 115 reported cases of CTDs between January 1, 1990 and December 31, 1994. The tabulated results of the descriptive analysis based on age and gender for the 115 reported cases of CTD illnesses are summarized below, in Table 4 and Table 5, respectively.

Table 4. CTDs BY AGE, 1990-1994

Age	1990	1991	1992	1993	1994	Totals	%
Under 21	0	0	0	0	0	0	0
21-30	3	5	2	0	1	11	9.6
31-40	4	11	17	7	7	46	40.0
41-50	5	7	7	4	13	36	31.3
51-60	2	4	8	1	3	18	15.6
Over 60	1	0	1	1	1	4	3.5
Totals	15	27	35	13	25	115	-

Table 5. CTDs BY GENDER, 1990-1994

	1990	1991	1992	1993	1994	Totals	%
Male	2	4	10	6	5	27	23.5
Female	13	23	25	7	20	88	76.5
Totals	15	27	35	13	25	115	-

The data contained in Tables 4 and 5 indicate that nearly three-fourths of the CTD cases involved those individuals 30-50 years of age, and over 75 percent of the cases were reported by females. The ages for those employees diagnosed with a cumulative trauma illness ranged from 23-63 years of age, with a mean of 41.1 years and a standard deviation of 9.3 years. The mean age of female CTD patients was 40.1 years, and for male patients the mean age was somewhat higher at 44.2 years.

A summary of the number and type of CTD illnesses reported during 1990 to 1994 is listed by ICD-9CM code in Table 6. The data clearly show that carpal tunnel syndrome (ICD-9 code 354.0) was the leading CTD illness reported over the five year period, constituting over 74 percent of the reported CTD illnesses. Of the 86 reported cases of carpal tunnel syndrome, females accounted for 68 cases or 79 percent, and males comprised 18 cases or 21 percent. The next most frequently diagnosed CTD illness was "Other tenosynovitis of hand and wrist" (ICD-9 code 727.05), and comprised less than 5 percent of all CTD cases.

Table 6. SUMMARY OF REPORTED CTDs, 1990-1994

ICD-9 CODE	CLASSIFICATION TITLE	FREQUENCY	% OF TOTAL
354.0	Carpal Tunnel Syndrome	86	74.7
713.04	Arthropy associated with other disorders classified elsewhere	1	0.9
719.44	Pain in joint, hand	1	0.9
722.1	Displacement of lumbar intervertebral disk	2	1.7
723.1	Cervicalgia	1	0.9
726.0	Adhesive capsulitis of shoulder	3	2.6
726.10	Disorders of bursae and tendons in shoulder region, (rotator cuff syndrome)	1	0.9
726.31	Medial epiconylitis	1	0.9
726.32	Lateral epiconylitis (tennis elbow)	3	2.6
727.03	Trigger finger, acquired	1	0.9
727.04	Radial syloid tenosynovitis (de Quervain's disease)	1	0.9
727.05	Other tenosynovitis of hand/wrist	5	4.3
727.09	Synovitis & tenosynovitis other	2	1.7
727.41	Ganglion of joint	2	1.7
729.2	Neuralgia, neuritis, and radiculitis, unspecified	1	0.9
729.5	Pain in limb	2	1.7
733.1	Pathological fracture	1	0.9
840.8	Sprain/ strain of other specified sites of shoulder and upper arm	1	0.9

Characteristics of Cases and Controls

The cases and controls used for this analysis included 220 clerical assistants, secretaries and other related administrative assistants in the 3A0x1 occupational group performing similar duties. The characteristics of the cases and controls are provided in Table 7. The subjects ranged in age from 19 to 72, and duration of employment ranged from 0.1 to 43.5 years. Cases were, on average, 2.2 years older than controls, but the controls had approximately 2 more years job experience.

Table 7. CHARACTERISTICS OF CASES AND CONTROLS

Characteristic	Cases	Controls
AFSC 3A0x1	44	176
Males	0	29
Females	44	147
Mean age	39.2 years	37.0 years
Median age	38.0 years	33.0 years
Mean duration of employment	7.4 years	9.7 years
Median duration of employment	6.3 years	8.0 years

Hypotheses Test Analysis and Results

The chi-square test described in Chapter III was applied to the case-control data to test for a significant association between the age and duration of employment risk factors, and the incidence of a cumulative trauma illness. The decision criteria applied to deciding whether to accept or reject the null hypothesis (H_0) that an association does not exist, is to reject H_0 if p-value $\leq \alpha=.05$. The class intervals in the contingency tables satisfy the validity conditions discussed in Chapter III. The results of the analysis for the age and duration of employment risk factors are provided in Tables 8 and 9, respectively.

Table 8. χ^2 RESULTS FOR AGE AS RISK FACTOR

	AGE (years)					
Observed	***19-29***	***30-39***	***40-49***	***50-59***	***60>***	***Totals***
CTD Illness	8	19	7	7	3	44
No CTD Illness	57	63	23	18	15	176
Totals	65	82	30	25	18	220
Expected						
CTD Illness	13.0	16.4	6.0	5.0	3.6	44
No CTD Illness	52.0	65.6	24.0	20.0	14.4	176
Totals	65	82	30	25	18	220
Chi squares						
CTD Illness	1.9231	0.4122	0.1667	0.8000	0.1000	3.4019
No CTD Illness	0.4808	0.1030	0.0417	0.2000	0.0250	0.8505
Chi square						***4.2524***
p-value						***0.3729***

Table 9. χ^2 RESULTS FOR EMPLOYMENT DURATION RISK FACTOR

	YEARS EMPLOYED				
Observed	***<=5***	***6-10***	***11-15***	***15>***	***Totals***
CTD Illness	21	15	6	2	44
No CTD Illness	53	61	48	14	176
Totals	74	76	54	16	220
Expected					
CTD Illness	14.8	15.2	10.8	3.2	44
No CTD Illness	59.2	60.8	43.2	12.8	176
Totals	74	76	54	16	220
Chi squares					
CTD Illness	2.5973	0.0026	2.1333	0.4500	5.1833
No CTD Illness	0.6493	0.0007	0.5333	0.1125	1.2958
Chi-square					***6.4791***
p-value					***0.0905***

Summary χ^2 statistics are shown in Table 10 and describe the overall assessment of statistical associations between both the age and duration of employment risk factors and the incidence of cumulative trauma disorders.

Table 10. χ^2-TEST SUMMARY TABLE FOR α=.05

		Risk Factor	
		Age *(df=4)*	**Experience** *(df=3)*
p-value	Calculated	0.3729	0.0905
	Critical	0.05	0.05
Chi-square	Calculated	4.2524	6.4791
	Critical	9.488	7.815
Ho: $p_{1j}=p_{2j}$ for all j		***Cannot reject***	***Cannot reject***

Statistically significant associations between age and duration of employment risk factors and cumulative trauma disorders at the α=.05 level used for this test could not be detected. The p-values for both of the risk factors were greater than the chosen level of significance α=.05, and the critical chi-square values were also within the null hypothesis acceptance region. Thus, this study supports the conclusion that no statistically significant association exists between the age and duration of employment risk factors and the incidence of a CTD illness. However, it was noted that for the duration of employment risk factor, the p-value of 0.0905 indicates that a statistically significant difference does exist at the α=.10 level.

Relative Risk/Odds Ratio Analysis and Results

The *p*-values pertaining to the results of the χ^2 tests performed were greater than the .05 alpha level used in the study. Therefore, little if anything is gained from trying to estimate the relative risk (RR) or strength of an association where one does not statistically exist. However, because age and duration of employment are known risk factors, odds ratios were calculated for these factors despite the absence of a statistically significant association for the occupational group used in this study.

The OR calculations were facilitated by tabulating the outcome of the matched quintuples for each of the two risk factors into the tables provided in Appendix C. The odds ratios were determined for groups greater and less than the median age of the cases (38.0 years), and greater and less than the cases' median duration of employment, 6.3 years. Table 11 provides a summary of the OR estimates.

Table 11. ODDS RATIO SUMMARY

RISK FACTOR	MEDIAN VALUES	ODDS RATIO
Age	age $\leq$ 38.0 years	0.69
	age > 38.0 years	1.45
Duration of employment	exp. $\leq$ 6.3 years	1.66
	exp. > 6.3 years	0.60

The OR results suggest that for the occupational group studied, those workers with a duration of employment less than 6.3 years, and workers over the age of 38, are just slightly more susceptible to developing a CTD illnesses. Ironically, the risk factors appear to have a protective effect on workers with over 6.3 years of experience, and for those workers under the age of 38.

Analytical Summary

Neither of the hypotheses tested to determine the existence of an association between the risk factors and CTD illnesses could be rejected at the .05 alpha level of significance. However, a significant association did exist at the .10 alpha level for duration of employment. The odds ratios indicated that workers employed for less than 6.3 years and workers over the age of 38 were at just a slightly higher risk for developing a CTD illness.

Workcenter CTD Frequency History

A summary of CTDs by organization is shown in Table 12. The "Other/Unknown" row represents those records unavailable at the time organizations were determined.

The data in Table 12 shows that Aeronautical Systems Center (ASC) experienced the majority of CTD illnesses with 27 reported cases, amounting to 23.5 percent of the total number of cases. The 645 Civil Engineering Group and 645th Civil Engineering Squadron collectively accounted for 9.6 percent of the reported cases. Headquarters Air Force Materiel Command (HQ AFMC) experienced nearly 8 percent of the total cases, while the Foreign Aerospace Science and Technology Center reported 6.9 percent. Data for the remaining workcenters reported only 6 cases or less.

Table 12. CTD FREQUENCY HISTORY BY WORKCENTER, 1990-1994

ORGANIZATION	1990	1991	1992	1993	1994	TOTAL
4950 Test Wing	0	0	0	3	0	**3**
645 Air Base Wing Hq Squadron	1	1	0	0	0	**2**
645 Civil Engineering Group	0	0	3	0	0	**3**
645 Civil Engineering Squadron	2	1	4	1	0	**8**
645 Comm-Computer System Group	0	1	0	0	0	**1**
645 Mission Support Squadron	0	0	0	2	0	**2**
645 MWR/Services Squadron	1	0	0	0	0	**1**
645 Supply Squadron	0	0	0	0	1	**1**
645 Support Group	1	0	2	1	2	**6**
Aeronautical Systems Center	6	3	10	1	7	**27**
Air Force Audit Agency	0	0	0	0	1	**1**
Air Force Institute of Technology	0	0	0	0	1	**1**
CPTA/FM	1	0	1	0	0	**2**
Defense Inst/Security Assistance Management	0	0	1	0	0	**1**
Defense Reutilization/Marketing Office	0	0	0	1	0	**1**
Foreign Aerospace Science/Tech Center	0	5	2	0	1	**8**
HQ Air Force Materiel Command	1	3	1	1	3	**9**
International Logistics Center	0	1	0	0	0	**1**
Materiel Systems Center	0	1	0	0	2	**3**
NAIC/SC	0	0	1	0	1	**2**
USAF Medical Center	0	3	1	1	0	**5**
USAF Museum	0	1	0	0	0	**1**
Wright Avionics Laboratory	0	1	0	0	0	**1**
Wright Flight Dynamics Laboratory	0	2	2	0	1	**5**
Wright Materials Laboratory	0	0	1	0	0	**1**
Wright-Patterson Contract Center	0	1	0	0	0	**1**
Other/Unknown	2	3	6	2	5	**18**
TOTAL	**15**	**27**	**35**	**13**	**25**	**115**

Summary

In this chapter, the data were analyzed in terms of describing the type of CTD incidents in demographic terms, the chi-square test was applied to determine the existence or lack of a statistically significant relationship between age and duration of employment risk factors and CTD illnesses. Finally, CTD incidents by base organization over the five years were described to identify base organizations that are candidates for future ergonomic studies and CTD preventative and intervention measures. The next chapter discusses the results and limitations of this research effort, suggestions for the use of data unavailable for inclusion in this research that may provide valuable information in a follow-up study, and recommendations for future research efforts.

V. Conclusions

Discussion

The increasing number of cumulative trauma disorders (CTD) cases in the workplace, coupled with the steadily increasing costs in terms of workers' compensation benefits and lost productivity, have resulted in more pressure on the occupational medicine community to identify high risk occupations and workcenters and develop preventative methods for CTDs. This research effort was conducted to investigate CTDs among the civilian workforce at Wright-Patterson Air Force Base.

Determining if a statistically significant association existed between age and duration of employment risk factors and CTDs was a primary objective. Furthermore, an attempt was made to determine the relative risk, in terms of odds ratios, for the development of a CTD illness given the age and duration of employment risk factors. Finally, the frequency of CTDs among the various workcenters at Wright-Patterson AFB were described to identify organizations which have experienced the highest number of CTDs.

By far the most common CTD illness reported between 1990 and 1994 was carpal tunnel syndrome (CTS), accounting for nearly 75 percent of the cases. Furthermore, it was found that the secretarial and administrative assistant occupational group (AFSC 3A0x1) accounted for 51.2 percent of the CTS cases, and 38.2 percent of all reported CTD illnesses. The more frequent occurrence of CTS for this particular occupational group, and females in particular, is consistent with previous research by Kiesler and Finholt, and Garland *et al* (Kiesler and Finholt, 1988:1004; Garland and others, 1993:2). This would indicate that CTS cases are the leading candidates for ergonomic-based causal studies and intervention/prevention measures, and females in the 3A0x1 AFSC group may be at higher risk for CTS.

The results of the hypothesis tests were not consistent with previous research regarding age and duration of employment as risk factors for cumulative trauma illnesses. The failure of the chi-square statistical test used in this analysis to detect a significant association between the risk factors and the incidence of CTD illnesses, may indicate that such an association does not exist in the population from which the cases and controls were drawn.

The differences between the results found here and those of previous occupational illness studies by Bergqvist *et al*, Kiesler and Finholt, and Garland *et al*, are likely due to: differences in sample sizes, the power of the specific statistical tests employed, the confounding influence of other known risk factors, and perhaps even survivor bias. For example, the sample sizes used in the studies just mentioned were significantly greater than the

44 cases used in this analysis. Since power increases as sample size increases and as the number of controls per case increase, the small sample size (n=44 matched quintuples) may have contributed to the failure of the test to detect a statistically significant association. It is possible that a more powerful nonparametric test based on ranks could be used and provide more information than the methods used in this research study.

The results might also have been influenced by the effects of survivor bias that is difficult to control and to account for based on the available data. Survivor bias restricts the ability to generalize from the case-control study to the general population (Knapp and Miller, 1992:118). It is possible that a number of CTD cases were undetected because the patient elected to see a private physician and eventually dropped out of the workforce. Thus, only healthy people remained and subsequently no significant association was found between the risk factors and CTD illnesses. Therefore, the limited ability of the AF Form 190 data to capture the majority of CTD cases may have introduced survivor bias. It also points out the need for a better occupational illness surveillance system to identify the majority of, if not all, CTD illnesses that are diagnosed either on-base or off-base.

The precision of the odds ratio, as with the power of the chi-square test, decreases as sample size decreases and as the number of controls per case decreases (Fleiss, 1981:126). The odds ratio is also sensitive to the effects of overmatching and confounding bias. Since a statistically significant association could not be found between the risk factors and CTD illness in this study, the validity of the odds ratios may be suspect.

Furthermore, it seemed unusual to find that workers with duration of employment under 6.3 years had an odds ratio of 1.66, but at the same time, younger workers (with presumably lower duration of employment) were not at an estimated higher risk for CTDs with respect to the age risk factor. In fact, younger age appeared to have a protective effect (OR=.60).

The opposite could be said for workers older than the median age of 38 years and duration of employment greater than 6.3 years. With respect to the age factor, older workers were at slightly higher risk (OR=1.45), but with respect to the duration of employment factor, longer duration of employment (presumably correlated with age) appeared to have a protective effect (OR=.60).

The effects of survivor bias and confounding variables may have influenced the results to the point that a significant association was negated and protective effects emerged in the odds ratios where none were expected. For example, it may be that age and duration of employment are confounded. It is also possible that because the cases and controls were matched on a known risk factor, occupation, overmatching may have occurred. Overmatching usually results when subjects are matched on a variable that is related to exposure, artificially equalizing significant differences between the case and control groups (Knapp and Miller, 1992:119).

To a certain extent, matching on occupational group was intended to control confounding, however, because the administrative and secretarial occupation is correlated with exposure, a correlation between occupation and CTD illness was inevitably introduced. The effect of this correlation is that significant associations may have been masked and the odds ratios or association strengths were probably underestimated. If the potential effects of overmatching were considered when the matching variable was selected, the results may have been different and more consistent with previous studies. Therefore, matching on a different variable is recommended in any follow-on studies to this research effort.

Another possible explanation for the seemingly contradictory odds ratio results is the timeframe within which desktop computers became common in workcenters. It could be hypothesized that younger workers with less experience were exposed to computers earlier in their careers, while older workers were not exposed to desktop computers until later in their careers. However, this is only a hypothetical explanation and no empirical research exists to support it. Until it can be shown that a statistically significant association exists, no strict conclusions can be drawn regarding the odds ratios.

The results of this study, although not entirely consistent with previous research, still point to older 3A0x1 workers with duration of employment of under 7 years as being at potentially higher risk for developing carpal tunnel syndrome. Therefore, a study of the ergonomic factors associated with the workstations used by 3A0x1 personnel is still warranted.

An examination of the CTD incident history by organization indicated that Aeronautical Systems Center (ASC) experienced the highest number of CTD illnesses during the five year period studied. This is not surprising given that ASC employs nearly 27 percent of the Wright-Patterson AFB civilian workforce. The 645 Civil Engineering organizations also experienced a higher number of CTDs relative to other base workcenters, with 11 cases or 9.6 percent of the 115 total cases. Additionally, HQ AFMC, employing 10.8 percent of the base civilians, experienced nine cases or 7.9 percent of the cases, and eight cases or 6.9 percent occurred in the Foreign Aerospace Science and Technology (FASTC).

The remaining organizations, with the exception of the Wright Laboratories, are all significantly smaller than ASC, HQ AFMC, or FASTC, and experienced on average two cases over the five year period covered in this research. Therefore, intervention and prevention methods may provide the most benefit if initially applied in the larger organizations.

Limitation

The primary data source used for this study, the AF Form 190 data registry of reported occupational illnesses, has been shown to underreport the incidence of occupational illnesses at other Air Force installations with a high number of civilian employees (Fisher and Meyer, 1993:2). Therefore, more significant results may or may not be obtained by using the chargeback listing or some other Department of Labor data if it is available.

Another potential limitation is that since no males were members of the case group and testing the effect of gender (a possible risk factor) was therefore not possible, matching on gender should probably have been employed. It would have been more appropriate to ensure no males were included in the control group when the computerized random sample was run on the DCPDS database. This limitation was not identified at the time the control group was selected, and time constraints for completion of this study prohibited the running of another control group for analysis. It is recommended that this limitation be addressed in any follow-on studies to this effort.

Conclusions

Based on the descriptive characteristics of the 115 reported cases of CTD-related occupational illnesses during 1990 to 1994, the 3A0x1 occupational group is the leading candidate for further ergonomically-based causal studies by the occupational medicine and ergonomics communities. Other data-entry intensive occupations designated by an AFSC other than 3A0x1 are also likely candidates for study.

A significant association between the risk factors studied in this effort and CTD illness was not found. However, the results did indicate that perhaps older workers in the 3Ax01 career field and less experienced workers may be at higher risk for CTD illnesses, but this conclusion is tempered by the possibility of overmatching and survivor bias as discussed earlier. However, the overall findings should still be relevant for intervention activities.

Based upon the CTD incident history data by base organization shown in Table 12, intervention and prevention studies may be most appropriate for the ASC, HQ AFMC, FASTC and 645 Civil Engineering organizations. In particular, an ergonomically-based study of clerical and secretarial workstations in those workcenters could provide valuable information for use in the intervention and prevention of carpal tunnel syndrome, especially in those workcenters just mentioned as well as other base organizations.

Closing Remarks

Before submitting recommendations for further research, some discussion of the limitations and difficulties encountered in developing and conducting this research effort is in order to better prepare researchers for follow-on or related research efforts. In particular, data access clearance, historical data availability, and inadequate occupational illness surveillance techniques were the primary obstacles encountered which prevented accomplishment of a more comprehensive research study.

The Department of Labor (DOL) chargeback listing provides a more accurate record of the actual number of occupational illnesses as well as the workers' compensation costs associated with the illnesses. Determining the high cost illnesses experienced by employees at Wright-Patterson AFB was the original objective of this research, but was negated by the unavailability of historical chargeback data at the base level.

Several months were spent gaining access approval to the chargeback data due to Privacy and Freedom of Information Act concerns on the part of the data management agencies, only to experience data retrieval technical difficulties once approval was gained. As of this writing, DOL data was still unavailable and HQ AFMC and AFMPC were working together on troubleshooting the software to facilitate extraction of data from DOL historical data at

Randolph AFB. The need for access to the DOL data is understood by agencies responsible for managing the data, but it is important to take into consideration potential delays in actually acquiring the data in a useable format.

It was also determined that no single data source exists at the base level to adequately account for and describe all occupational injuries and illnesses. The DOL chargeback data contains important information such as workers' compensation claims data and number of payments, but lacks the diagnostic data contained in the AF Form 190. Alternatively, the AF Form 190 does not contain claim cost data and historically underreports the number of actual occupational illnesses significantly.

Efforts are currently underway to increase the accuracy and effectiveness of the AF Form 190 as a surveillance tool, by transferring the location of OWCP claim forms (CA-1 and CA-2) from the Civilian Personnel Benefits Office to the Occupational Medicine Services Office. This procedure will provide the Occupational Medicine Services physicians and staff the opportunity to document the occupational illness on an AF Form 190 without requiring the injured employee to seek on-base treatment if the employee elects to seek initial treatment from a private physician. It will likely require several years to accumulate enough data to reap the benefits of this effort. Therefore, it is recommended that data from the DOL chargeback listing, civilian personnel and medical records, and AF Form 190 data continue to be combined to facilitate research regarding civilian occupational injuries and illnesses.

Recommendations for Further Research

The following recommendations for further research efforts are made:

1. Given the small sample size and limited number of risk factors involved, it is recommended that a follow-up study be done in a few years when more data points can be included and additional risk factors examined. Additional risk factors such as amount of overtime worked, average workload, seasonality, job changes, medical history, and body mass index are candidates for study. With a longer time-span and more data points, a test for trends in the incidence of CTD illnesses would also be beneficial.

2. It is suspected that the number of actual cases of cumulative trauma illnesses within the civilian workforce is greater than reported by the OIDR data registry. Therefore, another study using Department of Labor chargeback data (if retrievable) may capture more of the CTD-related cases. The effort will benefit the OMS community by providing much needed information on the costs and lost time associated with occupational illnesses and could be used to formulate a model for predicting the costs of CTD illnesses.

3. A similar study, but on a larger scale, would be useful to determine the incidence of cumulative trauma disorders among the Air Force military population, and which military occupational groups would benefit most from CTD-related intervention and prevention methods. The results may provide the Air Force with target populations in which to focus efforts on reducing the lost duty time and medical costs for military personnel diagnosed with occupational related CTD illnesses.

Appendix A. AF FORM 190 CTD CASES, 1990-1994

REC	MIL/CIV	ORG	SEX	AGE	ICD9	SUBMIT	YRSEMP	AFSC	TITLE
1	CIV	645SPTG/MW	F	26	3540	3/16/94	9.0	3A051	CLERICAL ASSISTANT
2	CIV	645ABW/JA	F	38	3540	7/10/90	1.4	3A051	CLERICAL ASSISTANT
3	CIV	645MSSQ/MS	F	41	72705	3/23/93	9.6	3A051	CLERICAL ASSISTANT
4	CIV	ASC/EN	F	62	3540	9/5/90	7.6	3A051	SECRETARY
5	CIV	645CES/DE	M	41	3540	7/13/93	4.6	3E051	ELECTRICIAN
6	CIV	ASC/SM	F	34	3540	9/1/94	11.6	3A071	SECRETARY
7	CIV	645CCSG	F	49	3540	11/13/91	8.1	W3E671	COMPUTER OPERATION
8	CIV	-	F	49	72705	9/23/92	30.7	065F4	BUDGET ANALYST
9	CIV	645CEG/DE	M	33	3540	11/17/92	3.2	W3E671	COMPUTER SPECIALIST
10	CIV	-	M	37	3540	7/16/92	1.2	2A671	AIRCRAFT MECHANIC
11	CIV	-	F	42	7221	9/5/90	-	-	COMMISSARY STOCKER
12	CIV	MED/SG	F	34	72741	1/4/93	1.9	4D051	FOOD SERVICE
13	CIV	645MSSQ/MS	M	45	7331	7/13/93	19.2	3A031	POSTAL CLERK/DELIVERY
14	CIV	ASC/VF	F	26	3540	5/29/91	6.5	3A071	SECRETARY
15	CIV	645SUPS/LG	F	45	3540	8/22/94	5.0	2S051	SUPPLY TECHNICIAN
16	CIV	WL/FI	M	46	3540	3/11/92	6.4	45474	AIRCRAFT TEST MECHANIC
17	CIV	WL/FI	M	41	72705	2/19/92	6.6	062E3E	ELECTRONICS TECHNICIAN
18	CIV	-	F	34	7260	3/26/92	-	-	WAITER
19	CIV	WL/FI	F	32	72610	1/23/91	3.7	3A051	SECRETARY
20	CIV	AFMC/SF	F	36	72709	4/4/93	16.3	2F091	QUALITY ASSURANCE
21	CIV	MED/SG	F	38	7295	9/19/91	3.0	3A051	CLERICAL ASSISTANT
22	CIV	645CES/DE	M	36	3540	5/30/91	6.1	3E731	FIREFIGHTER
23	CIV	-	F	40	3540	10/20/92	-	-	CASH REGISTER CLERK
24	CIV	WL/FI	F	41	3540	1/16/91	1.3	3A051	SECRETARY
25	CIV	ASC/HO	F	62	3540	3/16/94	9.0	3A051	EDITORIAL ASSISTANT
26	CIV	DRMO/EF	M	38	7260	2/2/93	-	3E231	CRANE OPERATOR
27	CIV	CPTA/FM	F	41	3540	9/23/92	3.9	6F032	ACCOUNT CLERK
28	CIV	CPTA/FM	F	34	3540	9/5/90	1.8	6F032	ACCOUNT CLERK
29	CIV	4950TW	M	51	3540	5/10/93	21.5	2A773	SHEET METAL FORMER
30	CIV	ILC/GB	F	24	3540	8/13/91	6.7	2S071	SUPPLY CLERK
31	CIV	FASTC	M	57	3540	4/23/91	17.3	3V171	ENGINEERING TECHNICIAN
32	CIV	ASC/SM	F	47	3540	9/6/94	7.6	025L3	LOGISTICS MANAGEMENT
33	CIV	ASC/FM	F	53	71304	10/20/92	6.5	6F032	VOUCHER EXAMINER
34	CIV	4950TW	M	43	3540	7/29/93	7.6	2A172	INSTRUMENT WORKER
35	CIV	FASTC	F	26	3540	12/19/91	3.2	3A051	INTELLIGENCE AID/CLERK
36	CIV	ASC/DM	F	41	3540	4/6/94	19.7	2A771	SHEET METAL FORMER
37	CIV	ASC/DM	F	39	3540	10/24/91	17.3	2A771	SHEET METAL FORMER
38	CIV	-	F	41	3540	5/2/91	-	W3E671	COMPUTER SPECIALIST
39	CIV	ASC/AM	M	63	3540	12/11/92	9.8	2A771	SHEET METAL FORMER
40	CIV	NAIC/SC	F	35	3540	4/6/94	5.5	3A051	LIBRARY TECHNICIAN
41	CIV	-	F	49	3540	11/19/91	7.6	3A051	SECRETARY
42	CIV	FASTC	F	40	3540	12/7/91	8.1	3V071	VISUAL INFORMATION
43	CIV	-	F	39	3540	10/12/94	6.2	3A071	SECRETARY
44	CIV	MSC/SY	F	45	7231	8/22/94	9.6	W3E671	COMPUTER SPECIALIST
45	CIV	AFMC/JA	F	51	3540	9/1/94	8.5	3A071	SECRETARY
46	CIV	FASTC	F	28	3540	5/10/91	10.6	3A071	SECRETARY
47	CIV	-	M	44	3540	4/19/94	4.5	2A571	AIRCRAFT MECHANIC
48	CIV	MSC/SZ	F	39	7292	2/27/91	3.9	W3E671	COMPUTER SPECIALIST
49	CIV	ASC	F	49	3540	6/25/94	4.1	4T052	UNKNOWN
50	CIV	-	F	25	3540	3/9/90	4.1	065F3	FINANCE ADMINISTRATION
51	CIV	USAFM/MJ	F	42	3540	6/12/91	3.8	3N071	VISUAL INFO SPECIALIST
52	CIV	645SPTG/MS	F	51	3540	4/15/92	33.3	73250	PERSONNEL SECRETARY
53	CIV	ASC/FM	F	49	3540	9/5/90	6.9	67273	ACCOUNT CLERK
54	CIV	645CES/DE	F	39	3540	11/18/92	7.1	3A051	SECRETARY
55	CIV	MSC/SI	M	50	7260	8/8/94	2.1	033S3A	MISC ADMINISTRATION

56	CIV	ASC/AC	F	41	3540	3/9/90	-	6F032	ACCOUNT CLERK
57	MIL	-	F	32	3540	1/28/93	-	-	TECH/ADMIN SPECIALIST
58	CIV	-	F	53	3540	6/23/92	20.7	06746	MGT/PROGRAM ANALYST
59	CIV	645SPTG/MS	F	46	3540	1/4/92	6.8	3S071	EMPLOYEE RELATIONS
60	CIV	DISAM	M	56	3540	10/20/92	14.8	081T0	EDUCATION INSTRUCTOR
61	CIV	MED/SG	F	43	3540	7/15/91	4.9	2S051	MANAGEMENT ASSISTANT
62	CIV	WL/ML	F	23	3540	1/30/92	2.9	3A051	CLERICAL ASSISTANT
63	CIV	645CES/DE	M	40	3540	8/7/90	10.0	3E051	ELECTRIC EQUIP REPAIR
64	CIV	645CES/DE	M	41	72632	10/28/92	12.1	3E151	BOILER PLANT OPERATOR
65	CIV	MED/SG	F	31	72741	11/9/92	3.1	3A051	CLERICAL ASSISTANT
66	CIV	ABW/FM	F	36	3540	5/10/91	3.7	3A051	SECRETARY
67	CIV	645SPTG/MS	F	60	72703	3/9/90	2.7	72350	SECRETARY
68	CIV	ASC/DM	M	47	3540	9/28/94	7.9	2S071	SUPPLY TECHNICIAN
69	CIV	-	F	34	3540	1/28/93	15.9	3A051	SECRETARY
70	CIV	ASC/NAF	F	61	3540	7/12/93	-	-	HOTEL MAID
71	CIV	ASC/XR	F	26	3540	8/7/90	8.5	3A051	SECRETARY
72	CIV	AFMC/CE	M	51	72709	6/29/94	2.0	032E3G	ENVIRON PROTECTION
73	CIV	FASTC	F	25	3540	10/28/92	4.2	3A051	CLERK-TRANSLATOR
74	CIV	ASC/EN	F	40	3540	10/9/92	4.1	3A051	SECRETARY
75	CIV	WL/AA	F	36	71944	10/8/91	2.4	3A051	SECRETARY
76	CIV	ASC/PM	F	43	3540	3/9/90	5.4	6C051	PROCUREMENT CLERK
77	CIV	-	F	53	3540	10/28/92	-	-	DISHWASHER
78	CIV	ASC/DM	M	41	3540	10/20/94	11.4	2A771	SHEET METAL FORMER
79	CIV	ABW/SS	F	52	3540	6/4/90	-	-	COOK
80	CIV	ASC/PK	F	32	3540	10/20/92	3.0	6C051	PROCUREMENT CLERK
81	CIV	645SPTG/MS	F	32	3540	10/12/94	-	72350	PERSONNEL SPECIALIST
82	CIV	FASTC	M	54	3540	1/30/91	-	-	COMPUTER ANALYST
83	CIV	-	F	43	3540	9/6/94	12.8	037A3	MGT/PROGRAM ANALYST
84	CIV	WPCC/PM	F	32	72632	7/24/91	2.6	6C051	PROCUREMENT CLERK
85	CIV	AFMC/XR	F	48	8408	6/25/94	7.5	3A051	SECRETARY
86	CIV	645CEG/DE	F	34	72705	5/21/92	13.7	3E631	PRODUCTION CONTROL
87	CIV	ASC/YZ	F	30	3540	5/10/90	11.0	3A071	SECRETARY
88	CIV	AFMC/IM	F	36	7295	5/21/92	18.7	037A4	MGT/PROGRAM ANALYST
89	CIV	AFAA/WP	F	32	3540	9/9/94	20.8	3A051	SECRETARY
90	CIV	AFIT/CE	F	31	72631	9/1/94	1.1	081T0	EDUCATION TECHNICIAN
91	CIV	ASC/YG	F	34	3540	1/10/92	15.5	065F4	FINANCIAL SPECIALIST
92	CIV	ASC/YF	F	40	3540	9/25/91	2.5	3A071	SECRETARY
93	CIV	4950TW	M	38	3540	2/16/93	2.6	2A373J	AIRCRAFT MECHANIC
94	CIV	645CES/DE	M	34	72704	9/23/92	0.5	55130	LANDSCAPER
95	CIV	645CES/DE	M	41	72705	5/12/92	16.5	3E231	HEAVY EQUIP OPERATOR
96	CIV	ASC/NA	F	35	3540	3/27/92	5.2	3A071	SECRETARY
97	CIV	645CES/DE	M	42	7221	9/5/90	21.6	3E071	ENGINEERING TECHNICIAN
98	CIV	-	F	53	3540	2/13/91	8.4	3A071	CLERICAL ASSISTANT
99	CIV	FASTC	F	36	3540	6/29/94	4.6	014N3B	TECH INFO SPECIALIST
100	CIV	FASTC	F	33	3540	9/23/92	2.8	014N3B	TECH INFO SPECIALIST
101	CIV	-	F	53	3540	11/10/94	5.3	3A071	CLERICAL ASSISTANT
102	CIV	ASC/VJ	F	55	3540	11/20/92	11.1	3A071	SECRETARY
103	CIV	645CEG/DE	M	32	3540	9/23/92	2.9	3E151	REFRIGERATION MECHANIC
104	CIV	AFMC/CK	F	29	3540	5/28/91	0.7	3A051	SECRETARY
105	CIV	MED/SG	F	45	3540	5/22/91	-	W3E671	COMPUTER SPECIALIST
106	CIV	AFMCLC/JA	F	31	3540	5/10/90	1.4	3A071	LEGAL SECRETARY
107	CIV	ASC/DP	F	38	3540	4/29/92	4.6	3A071	SECRETARY
108	CIV	645SPTG/MS	F	32	72632	2/24/93	3.7	3A051	CLERICAL ASSISTANT
109	CIV	ASC/FM	F	59	3540	9/30/92	3.0	6F032	VOUCHER EXAMINER
110	CIV	WL/FI	F	40	3540	9/20/94	5.5	3A051	SECRETARY
111	CIV	NAIC/SC	F	56	3540	2/19/92	15.0	3A051	CLERICAL ASSISTANT
112	CIV	-	F	50	3540	9/28/94	15.5	3A051	SECRETARY
113	CIV	ASC/CS	F	38	3540	11/9/92	9.2	3A071	SECRETARY
114	CIV	AFMC/SC	M	51	3540	7/2/91	28.2	W3E671	COMPUTER SPECIALIST
115	CIV	AFMC/EN	F	36	3540	12/11/91	18.1	3A051	STAFF ASSISTANT

Appendix B. CTD Case Group Data

REC	SEX	AGE	ICD-9	SUBMIT	YRS EMP.	AFSC	TITLE
1	F	26	3540	3/16/94	9.0	3A051	CLERICAL ASSISTANT
2	F	38	3540	7/10/90	1.4	3A051	CLERICAL ASSISTANT
3	F	41	72705	3/23/93	9.6	3A051	CLERICAL ASSISTANT
4	F	62	3540	9/5/90	7.6	3A051	SECRETARY
5	F	34	3540	9/1/94	11.6	3A071	SECRETARY
6	F	26	3540	5/29/91	6.5	3A071	SECRETARY
7	F	32	72610	1/23/91	3.7	3A051	SECRETARY
8	F	38	7295	9/19/91	3.0	3A051	CLERICAL ASSISTANT
9	F	41	3540	1/16/91	1.3	3A051	SECRETARY
10	F	62	3540	3/16/94	9.0	3A051	EDITORIAL ASSISTANT
11	F	26	3540	12/19/91	3.2	3A051	INTEL AID/CLERK
12	F	35	3540	4/6/94	5.5	3A051	CLERICAL ASSISTANT
13	F	49	3540	11/19/91	7.6	3A051	SECRETARY
14	F	39	3540	10/12/94	6.2	3A071	SECRETARY
15	F	51	3540	9/1/94	8.5	3A071	SECRETARY
16	F	28	3540	5/10/91	10.6	3A071	SECRETARY
17	F	51	3540	4/15/92	33.3	3A051	PERSONNEL SECRETARY
18	F	39	3540	11/18/92	7.1	3A051	FIRE DEPT SECRETARY
19	F	23	3540	1/30/92	2.9	3A051	CLERICAL ASSISTANT
20	F	31	72741	11/9/92	3.1	3A051	CLERICAL ASSISTANT
21	F	36	3540	5/10/91	3.7	3A051	SECRETARY
22	F	60	72703	3/9/90	2.7	3A051	PERSONNEL SPECIALIST
23	F	34	3540	1/28/93	15.9	3A051	SECRETARY
24	F	26	3540	8/7/90	8.5	3A051	SECRETARY
25	F	25	3540	10/28/92	4.2	3A051	CLERICAL ASSISTANT
26	F	40	3540	10/9/92	4.1	3A051	SECRETARY
27	F	36	71944	10/8/91	2.4	3A051	SECRETARY
28	F	48	8408	6/25/94	7.5	3A051	SECRETARY
29	F	30	3540	5/10/90	11.0	3A071	SECRETARY
30	F	32	3540	9/9/94	9.3	3A051	SECRETARY
31	F	40	3540	9/25/91	2.5	3A071	SECRETARY
32	F	35	3540	3/27/92	5.2	3A071	SECRETARY
33	F	53	3540	2/13/91	8.4	3A071	CLERICAL ASSISTANT
34	F	53	3540	11/10/94	5.3	3A071	CLERICAL ASSISTANT
35	F	55	3540	11/20/92	11.1	3A071	SECRETARY
36	F	29	3540	5/28/91	0.7	3A051	SECRETARY
37	F	31	3540	5/10/90	1.4	5J071	LEGAL SECRETARY
38	F	38	3540	4/29/92	4.6	3A071	SECRETARY
39	F	32	72632	2/24/93	3.7	3A051	CLERICAL ASSISTANT
40	F	40	3540	9/20/94	5.5	3A051	SECRETARY
41	F	56	3540	2/19/92	15.0	3A051	CLERICAL ASSISTANT

42	F	50	3540	9/28/94	15.5	3A051	SECRETARY
43	F	38	3540	11/9/92	9.2	3A071	SECRETARY
44	F	36	3540	12/11/91	18.1	3A051	SECRETARY

Appendix C. Control Group Data

REC	CASE-MATCH	SEX	AGE	YRS EMPL	AFSC	TITLE
1	1	F	29	12.6	3A051	CLERICAL ASSISTANT
2	2	F	27	2.7	3A051	LIBRARY TECHNICIAN
3	3	F	36	12.6	3A051	CLERK-TYPIST
4	4	F	38	8.4	3A051	CLERICAL ASSISTANT
5	5	F	36	12.6	3A051	CLERK-TYPIST
6	6	F	37	18.4	3A051	CLERICAL ASSISTANT
7	7	F	37	5.3	3A051	SECRETARY
8	8	F	35	12.6	3A051	CLERICAL ASSISTANT
9	9	F	61	7.5	3A051	SECRETARY
10	10	F	64	28.6	3A071	SECRETARY
11	11	F	27	9.0	3A051	CLERK-TYPIST
12	12	F	43	10.1	3A051	SECRETARY
13	13	F	42	12.6	3A071	SECRETARY
14	14	F	40	12.6	3A091	CLERICAL ASSISTANT
15	15	M	44	8.4	3A031	CLERICAL ASSISTANT
16	16	F	22	3.2	3A051	CLERICAL ASSISTANT
17	17	F	27	8.0	3A051	ENGINEERING ASSISTANT
18	18	F	27	5.3	3A051	SECRETARY
19	19	F	61	4.5	3A051	CLERK-TYPIST
20	20	M	26	6.0	3A051	CLERICAL ASSISTANT
21	21	F	30	10.8	3A031	CLERK-TYPIST
22	22	F	36	9.7	3A051	SECRETARY
23	23	F	26	5.1	3A051	CLERICAL ASSISTANT
24	24	F	61	38.3	3A071	SECRETARY
25	25	F	36	12.6	3A051	DATA TRANSCRIBER
26	26	F	32	12.6	3A051	ENGINEERING ASSISTANT
27	27	F	30	7.8	3A051	LIBRARY TECHNICIAN
28	28	F	54	7.7	3A051	CLERICAL ASSISTANT
29	29	F	35	12.6	3A051	CLERICAL ASSISTANT
30	30	M	39	6.8	3A051	ENGINEERING ASSISTANT
31	31	F	62	43.5	3A051	SECRETARY
32	32	F	39	7.0	3A051	CLERK-TYPIST
33	33	F	27	6.0	3A031	CLERICAL ASSISTANT
34	34	M	33	12.6	3A051	CLERICAL ASSISTANT
35	35	F	61	41.1	3A071	LIBRARY TECHNICIAN
36	36	F	24	3.7	3A051	CLERICAL ASSISTANT
37	37	F	21	3.0	3A071	CLERK-TYPIST
38	38	F	51	8.0	3A051	CLERICAL ASSISTANT
39	39	M	43	8.9	3A051	ENGINEERING ASSISTANT
40	40	F	35	12.6	3A051	ENGINEERING ASSISTANT
41	41	F	32	10.5	3A051	SECRETARY

42	42	F	56	21.0	3A051	SECRETARY
43	43	F	19	2.0	3A051	CLERICAL ASSISTANT
44	44	F	23	4.9	3A051	CLERICAL ASSISTANT
45	1	F	60	4.2	3A051	SECRETARY
46	2	F	30	12.6	3A051	CLERICAL ASSISTANT
47	3	F	29	11.5	3A051	CLERICAL ASSISTANT
48	4	M	26	6.1	3A051	ENGINEERING ASSISTANT
49	5	F	32	12.6	3A051	CLERICAL ASSISTANT
50	6	F	32	12.6	3A051	CLERK-TYPIST
51	7	M	38	12.6	3A051	ACCOUNTING TECHNICIAN
52	8	F	26	6.1	3A051	CLERK-TYPIST
53	9	F	55	26.5	3A051	SECRETARY
54	10	F	26	4.6	3A051	ENGINEERING ASSISTANT
55	11	M	33	12.6	3A051	CLERICAL ASSISTANT
56	12	F	70	11.8	3A051	SECRETARY
57	13	M	36	4.9	3A051	CLERICAL ASSISTANT
58	14	F	48	7.6	3A071	SECRETARY
59	15	F	53	5.6	3A051	CLERK-TYPIST
60	16	F	37	12.6	3A051	CLERICAL ASSISTANT
61	17	F	55	13.2	3A051	SECRETARY
62	18	F	37	3.4	3A051	SECRETARY
63	19	F	43	12.6	3A051	CLERK-TYPIST
64	20	F	32	6.4	3A051	CLERICAL ASSISTANT
65	21	M	25	2.3	3A051	ENGINEERING ASSISTANT
66	22	F	28	8.8	3A051	SECRETARY
67	23	F	29	10.6	3A051	SECRETARY
68	24	F	72	12.6	3A051	CLERICAL ASSISTANT
69	25	F	40	2.8	3A051	SECRETARY
70	26	F	71	33.3	3A051	SECRETARY
71	27	F	23	5.0	3A051	ENGINEERING ASSISTANT
72	28	F	40	3.0	3A051	CLERICAL ASSISTANT
73	29	M	27	5.0	3A051	CLERICAL ASSISTANT
74	30	F	23	5.1	3A051	CLERK-TYPIST
75	31	F	31	8.1	3A051	CLERK-TYPIST
76	32	F	39	2.9	3A051	CLERICAL ASSISTANT
77	33	F	31	12.6	3A051	CLERICAL ASSISTANT
78	34	F	58	37.7	3A051	CLERICAL ASSISTANT
79	35	F	25	6.1	3A051	CLERK-TYPIST
80	36	M	32	12.6	3A051	CLERICAL ASSISTANT
81	37	F	30	12.6	3A051	CLERICAL ASSISTANT
82	38	F	61	41.8	3A071	LIBRARY TECHNICIAN
83	39	F	33	12.6	3A051	CLERICAL ASSISTANT
84	40	F	31	4.0	3A051	CLERICAL ASSISTANT
85	41	M	24	3.2	3A051	CLERICAL ASSISTANT
86	42	F	36	3.5	3A051	CLERK-TYPIST
87	43	F	27	2.7	3A031	CLERK-TYPIST
88	44	F	20	0.1	3A051	CLERICAL ASSISTANT

89	1	F	41	8.5	3A051	CLERICAL ASSISTANT
90	2	M	25	7.1	3A031	CLERICAL ASSISTANT
91	3	F	33	9.7	3A051	CLERICAL ASSISTANT
92	4	F	24	3.1	3A051	CLERK-TYPIST
93	5	F	38	9.7	3A051	CLERICAL ASSISTANT
94	6	F	26	5.0	3A051	CLERICAL ASSISTANT
95	7	F	52	12.6	3A071	SECRETARY
96	8	M	48	4.8	3A071	LIBRARIAN
97	9	F	19	1.1	3A051	CLERK-TYPIST
98	10	F	21	3.4	3A051	ACCOUNTING TECHNICIAN
99	11	F	61	7.1	3A071	LIBRARY TECHNICIAN
100	12	F	27	4.9	3A051	CLERICAL ASSISTANT
101	13	F	28	9.0	3A051	CLERK-TYPIST
102	14	M	46	5.1	3A051	CLERK-TYPIST
103	15	F	26	6.0	3A051	CLERK-TYPIST
104	16	F	58	31.6	3A031	CLERICAL ASSISTANT
105	17	F	23	3.3	3A051	CLERK-TYPIST
106	18	F	34	5.1	3A051	SECRETARY
107	19	F	52	2.9	3A031	CLERK-TYPIST
108	20	F	22	4.3	3A051	CLERICAL ASSISTANT
109	21	F	27	6.6	3A051	CLERICAL ASSISTANT
110	22	F	43	12.6	3A051	SECRETARY
111	23	F	31	12.6	3A051	CLERICAL ASSISTANT
112	24	F	22	3.2	3A051	CLERICAL ASSISTANT
113	25	F	56	7.7	3A071	SECRETARY
114	26	M	27	8.0	3A051	ENGINEERING ASSISTANT
115	27	F	29	8.0	3A051	CLERICAL ASSISTANT
116	28	M	29	9.0	3A051	CLERICAL ASSISTANT
117	29	F	31	2.7	3A051	CLERICAL ASSISTANT
118	30	F	29	8.1	3A051	CLERK-TYPIST
119	31	F	34	3.0	3A051	CLERK-TYPIST
120	32	F	35	6.8	3A051	CLERK-TYPIST
121	33	F	27	5.1	3A010	CLERICAL ASSISTANT
122	34	M	32	8.0	3A051	ENGINEERING ASSISTANT
123	35	F	25	3.0	3A051	CLERICAL ASSISTANT
124	36	F	39	12.6	3A051	CLERICAL ASSISTANT
125	37	F	37	0.6	3A051	SECRETARY
126	38	F	33	8.8	3A071	CLERICAL ASSISTANT
127	39	F	44	9.5	3A051	CLERK-TYPIST
128	40	F	64	12.8	3A051	CLERICAL ASSISTANT
129	41	F	53	12.6	3A051	CLERICAL ASSISTANT
130	42	F	49	8.4	3A051	SECRETARY
131	43	F	21	3.3	3A051	CLERICAL ASSISTANT
132	44	F	33	12.6	3A051	CLERK-TYPIST
133	1	F	36	12.6	3A051	DATA TRANSCRIBER
134	2	M	40	8.2	3A051	CLERICAL ASSISTANT
135	3	M	25	5.6	3A051	CLERICAL ASSISTANT

136	4	F	39	6.0	3A051	SECRETARY
137	5	M	28	5.1	3A051	ENGINEERING ASSISTANT
138	6	F	54	12.6	3A051	CLERICAL ASSISTANT
139	7	F	30	6.0	3A051	CLERK-TYPIST
140	8	M	41	6.1	3A051	ENGINEERING ASSISTANT
141	9	F	23	12.6	3A071	SECRETARY
142	10	F	45	7.0	3A051	CLERK-TYPIST
143	11	F	33	12.6	3A051	SECRETARY
144	12	M	33	12.6	3A051	CLERICAL ASSISTANT
145	13	F	29	9.0	3A051	CLERK-TYPIST
146	14	F	69	12.6	3A051	CLERICAL ASSISTANT
147	15	F	30	6.8	3A051	SECRETARY
148	16	F	33	7.1	3A051	SECRETARY
149	17	F	30	12.8	3A051	SECRETARY
150	18	F	55	21.6	3A071	CLERICAL ASSISTANT
151	19	F	36	1.0	3A051	CLERICAL ASSISTANT
152	20	F	54	25.6	3A071	CLERICAL ASSISTANT
153	21	F	28	7.3	3A051	CLERICAL ASSISTANT
154	22	F	54	8.9	3A091	SECRETARY
155	23	M	25	3.5	3A051	ENGINEERING ASSISTANT
156	24	F	40	12.6	3A051	CLERICAL ASSISTANT
157	25	F	45	12.6	3A051	CLERICAL ASSISTANT
158	26	F	55	5.4	3A051	CLERK-TYPIST
159	27	F	30	12.6	3A051	CLERICAL ASSISTANT
160	28	F	29	6.0	3A051	CLERK-TYPIST
161	29	M	32	12.6	3A051	CLERK-TYPIST
162	30	F	34	12.6	3A051	ENGINEERING ASSISTANT
163	31	M	39	4.8	3A051	ACCOUNTING TECHNICIAN
164	32	M	25	3.0	3A051	MATHEMATICS TECHNICIAN
165	33	F	26	6.2	3A031	CLERICAL ASSISTANT
166	34	F	32	7.7	3A031	CLERICAL ASSISTANT
167	35	F	56	5.5	3A051	SECRETARY
168	36	M	28	7.0	3A051	CLERK-TYPIST
169	37	F	33	7.0	3A051	CLERK-TYPIST
170	38	F	42	9.0	3A051	SECRETARY
171	39	F	21	12.6	3A051	ENGINEERING ASSISTANT
172	40	F	33	12.6	3A051	CLERICAL ASSISTANT
173	41	F	60	21.6	3A051	SECRETARY
174	42	F	41	6.5	3A051	CLERICAL ASSISTANT
175	43	F	30	8.0	3A031	CLERICAL ASSISTANT
176	44	F	46	12.6	3A051	CLERK-TYPIST

Appendix D. MATCHED QUINTUPLES OUTCOME DATA

Matched Quintuples Outcome Data: Age ≤ 38 Years

Age ≤ 38 5-TUPLE	CASE w/FACTOR	CONTROLS w/FACTOR (x)	TOTAL w/FACTOR (n)	x(n-x)
1	1	2	3	2
2	1	3	4	3
3	0	4	4	0
4	0	3	3	0
5	1	4	5	4
6	1	3	4	3
7	1	3	4	3
8	1	2	3	2
9	0	2	2	0
10	0	2	2	0
11	1	3	4	3
12	1	2	3	2
13	0	3	3	0
14	0	0	0	0
15	0	2	2	0
16	1	3	4	3
17	0	3	3	0
18	0	3	3	0
19	1	2	3	2
20	1	3	4	3
21	1	4	5	4
22	0	2	2	0
23	1	4	5	4
24	1	1	2	1
25	1	1	2	1
26	0	2	2	0
27	1	4	5	4
28	0	2	2	0
29	1	4	5	4
30	1	3	4	3
31	0	2	2	0
32	1	2	3	2
33	0	4	4	0
34	0	3	3	0
35	0	2	2	0
36	1	3	4	3
37	1	3	4	3
38	1	1	2	1
39	1	2	3	2
40	0	3	3	0
41	0	2	2	0
42	0	1	1	0
43	1	4	5	4
44	1	3	4	3
TOTAL	**25** (=B-A)	**114** (=A)	**139** (=B)	**69** $\Sigma[x(n-x)]$

Matched Quintuples Outcome Data: Age > 38 Yrs

Age > 38 5-TUPLE	CASE w/FACTOR	CONTROLS w/FACTOR (x)	TOTAL w/FACTOR (n)	x(n-x)
1	0	2	2	0
2	0	1	1	0
3	1	0	1	0
4	1	1	2	1
5	0	0	0	0
6	0	1	1	0
7	0	1	1	0
8	0	2	2	0
9	1	2	3	2
10	1	2	3	2
11	0	1	1	0
12	0	2	2	0
13	1	1	2	1
14	1	4	5	4
15	1	2	3	2
16	0	1	1	0
17	1	1	2	1
18	1	1	2	1
19	0	2	2	0
20	0	1	1	0
21	0	0	0	0
22	1	2	3	2
23	0	0	0	0
24	0	3	3	0
25	0	3	3	0
26	1	2	3	2
27	0	0	0	0
28	1	2	3	2
29	0	0	0	0
30	0	1	1	0
31	1	2	3	2
32	0	2	2	0
33	1	0	1	0
34	1	1	2	1
35	1	2	3	2
36	0	1	1	0
37	0	1	1	0
38	0	3	3	0
39	0	2	2	0
40	1	1	2	1
41	1	2	3	2
42	1	3	4	3
43	0	0	0	0
44	0	1	1	0
TOTAL	**19** *(=B-A)*	**62** *(=A)*	**81** *(=B)*	**31** $\Sigma[x(n-x)]$

Matched Quintuples Outcome Data: Duration of employment ≤ 6.3 yrs

≤6.3 yrs **5-TUPLE**	**CASE w/FACTOR**	**CONTROLS w/FACTOR (x)**	**TOTAL w/FACTOR (n)**	**x(n-x)**
1	0	1	1	0
2	1	1	2	1
3	0	1	1	0
4	0	3	3	0
5	0	1	1	0
6	0	1	1	0
7	1	2	3	2
8	1	2	3	2
9	1	1	2	1
10	0	2	2	0
11	1	0	1	0
12	1	1	2	1
13	0	1	1	0
14	1	1	2	1
15	0	2	2	0
16	0	1	1	0
17	0	1	1	0
18	0	3	3	0
19	1	3	4	3
20	1	2	3	2
21	1	1	2	1
22	1	0	1	0
23	0	2	2	0
24	0	1	1	0
25	1	1	2	1
26	1	1	2	1
27	1	1	2	1
28	0	2	2	0
29	0	2	2	0
30	0	1	1	0
31	1	2	3	2
32	1	2	3	2
33	0	3	3	0
34	1	0	1	0
35	0	3	3	0
36	1	1	2	1
37	1	2	3	2
38	1	0	1	0
39	1	0	1	0
40	1	1	2	1
41	0	1	1	0
42	0	1	1	0
43	0	3	3	0
44	0	2	2	0
TOTAL	**22** (=B−A)	**63** (=A)	**85** (=B)	**25** $\Sigma[x(n-x)]$

Matched Quintuples Outcome Data: Duration of employment > 6.3 yrs

Exp > 6.3 5-TUPLE	CASE w/FACTOR	CONTROLS w/FACTOR (x)	TOTAL w/FACTOR (n)	x(n-x)
1	1	3	4	3
2	0	3	3	0
3	1	3	4	3
4	1	1	2	1
5	1	3	4	3
6	1	3	4	3
7	0	2	2	0
8	0	2	2	0
9	0	3	3	0
10	1	2	3	2
11	0	4	4	0
12	0	3	3	0
13	1	3	4	3
14	0	3	3	0
15	1	2	3	2
16	1	3	4	3
17	1	3	4	3
18	1	1	2	1
19	0	1	1	0
20	0	2	2	0
21	0	3	3	0
22	0	4	4	0
23	1	2	3	2
24	1	3	4	3
25	0	3	3	0
26	0	3	3	0
27	0	3	3	0
28	1	2	3	2
29	1	2	3	2
30	1	3	4	3
31	0	2	2	0
32	0	2	2	0
33	1	1	2	1
34	0	4	4	0
35	1	1	2	1
36	0	3	3	0
37	0	2	2	0
38	0	4	4	0
39	0	4	4	0
40	0	3	3	0
41	1	3	4	3
42	1	3	4	3
43	1	1	2	1
44	1	2	3	2
TOTAL	**22** *(=B-A)*	**113** *(=A)*	**135** *(=B)*	**50** $\Sigma[x(n-x)]$

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Vita

Capt Scott T. Hillstead began his Air Force career in 1982 as an enlisted member assigned to the Training Systems Program Office, Aeronautical Systems Center (ASC), Wright-Patterson Air Force Base,. In 1987, he was selected for the Airman Scholarship and Commissioning Program. He received his commission in December 1989 after graduating Summa Cum Laude from Wright State University, with a Bachelor of Science degree in Business Administration.

Capt Hillstead completed aircraft maintenance officer training in 1991, and was assigned to the now deactivated 72 Fighter Squadron (72 FS), 56 Fighter Wing, MacDill Air Force Base (AFB), Florida. While assigned to the 72 FS, he served as the Assistant OIC for 26 assigned F-16 aircraft. The 72 FS deactivated in 1992, and he was assigned as the Squadron Section Commander for the 410 Maintenance Squadron, 410 Bomb Wing, K.I. Sawyer AFB, Michigan.

Capt Hillstead entered the School of Logistics and Acquisition Management, Air Force Institute of Technology in 1994. After receiving his Master of Science in Cost Analysis degree in September 1995, he will be assigned to the Electronic Systems Center, Hanscom AFB, Massachusetts.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
September 1995

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
A STUDY OF CUMULATIVE TRAUMA DISORDERS OF THE UPPER EXTREMITIES AND OCCUPATION IN WRIGHT-PATTERSON AIR FORCE BASE CIVILIAN PERSONNEL

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GCA/LAS/95S-4

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
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USAF MED CTR/SGPO
Wright-Patterson AFB, OH 45433

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study used a case-control methodology to describe and analyze the 115 cases of occupational illnesses reported by civilian employees of Wright-Patterson Air Force Base (AFB) between 1990 and 1995. Determining if a statistically significant association existed between age and duration of employment risk factors and cumulative trauma disorders (CTDs) was a primary objective. The frequency of CTDs among the various organizations at Wright-Patterson AFB are also described. The research could not prove the existence of a significant association for the 44 subjects and 176 controls matched on occupational group. However, the demographic and other descriptive results may form a foundation for subsequent ergonomically-based causal studies into those workcenters and occupational groups with a history of (CTDs). The results could further lead to the development of candidates for intervention and preventive measures by the base Occupational Medicine Service professionals to reduce the number of CTD incidents and subsequent workers' compensation claim costs among Wright-Patterson's civilian workforce.

14. SUBJECT TERMS
Research, Repetitive Motion Disorders, Carpal Tunnel Syndrome, Occupational Safety, Public Sector, Statistical Data, Occupational Injury

15. NUMBER OF PAGES
97

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL