CUMULATIVE TRAUMA DISORDERS IN THE WORKPLACE

BIBLIOGRAPHY

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

HOW TO USE THIS PUBLICATION

This publication is divided into two parts. Part I includes complete or partial copies of NIOSH and non-NIOSH references on cumulative trauma disorders (CTDs). These references were selected to provide a summary of NIOSH research and policy, and to provide CTD information of general interest to the reader. The titles of the references in Part I are listed in the Contents (page iii).

Part II contains a comprehensive bibliography of NIOSH documents on cumulative trauma disorders (Part II.A), as well as a brief listing of selected non-NIOSH references (Part II.B). Part II.A is arranged in six sections by type of NIOSH document. A brief description of each document type precedes the listing of documents in that section. Each document citation includes the title and year of publication, the number of pages, and where applicable, identifying number(s) and ordering information (see below). In addition, a brief abstract of each NIOSH document is provided. These abstracts were taken from NIOSHTIC®, a bibliographic database of worldwide occupational safety and health references maintained by NIOSH. (More information about NIOSHTIC® is available by calling the NIOSH 800-number information service at 1-800-356-4674; press 1, and follow the prompts for databases.)

Documents listed in Part II are **NOT** available from NIOSH. However, they may be obtained as follows:

1. Copies of any document cited with an "NTIS NO" may be ordered from the National Technical Information Service (NTIS) using the NTIS order form on page 209. Both paper and microfiche copies are available. NTIS has recently changed its pricing schedule; current prices should be confirmed with NTIS before ordering (telephone 703-487-4650). ***Do NOT send NTIS orders to NIOSH.***

2. Copies of journal articles and book chapters listed in Part II.A (Sections 3, 4, and 5) and Part II.B may be obtained from a university or public library using the bibliographic information provided in the citation.

NOTE: This publication replaces the NIOSH bibliography *Carpal Tunnel Syndrome Selected References,* March 1989.

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INTRODUCTION

The primary purpose of this publication is to provide a compilation of materials describing research conducted by the National Institute for Occupational Safety and Health (NIOSH) on cumulative trauma disorders (CTDs) in the workplace. Research on CTDs is conducted as part of the Institute's program on work-related musculoskeletal disorders. A description of this program, and a summary of its findings and recommendations, are included in Part I.

NIOSH defines work-related musculoskeletal disorders as those diseases and injuries that affect the musculoskeletal, peripheral nervous, and neurovascular systems that are caused or aggravated by occupational exposure to ergonomic hazards (see Part I, reference C). A definition of CTDs can be constructed by combining the separate meanings of each word. **Cumulative** indicates that these injuries developed gradually over periods of weeks, months, or even years as a result of repeated stresses on a particular body part. The cumulative concept is based on the theory that each repetition of an activity produces some trauma or wear and tear on the tissues and joints of the body. The word **trauma** signifies bodily injury from mechanical stresses. **Disorders** refers to physical ailments or abnormal conditions. The term **CTD** is generally used to describe disorders of the upper extremities (e.g., hands, shoulder, neck). Therefore, references on disorders or injuries of the back or legs have been intentionally omitted from the bibliography in Part II of this publication.

Perhaps the best known occupational cumulative trauma disorder is carpal tunnel syndrome, which is caused by compression of the median nerve within the carpal tunnel of the wrist. A diagram of the wrist showing its internal components appears in Figure 1 (page vi). For additional information specifically on carpal tunnel syndrome, see Part I (reference H) as well as references listed in Part II.

In addition to the references listed in this publication, there are numerous occupational, medical, surgical, and ergonomics journals in which related articles on cumulative trauma disorders are likely to appear on a regular basis. Listed below are some of these journals; however, keep in mind that this list is not exhaustive.

- American Journal of Industrial Medicine
- Applied Ergonomics
- British Journal of Industrial Medicine
- Ergonomics
- International Journal of Industrial Ergonomics
- Journal of Bone and Joint Surgery
- Journal of Hand Surgery
- Journal of Occupational Medicine
- Muscle and Nerve
- Neurology
- Orthopedics
- Rheumatology and Rehabilitation
- Scandinavian Journal of Work, Environment and Health

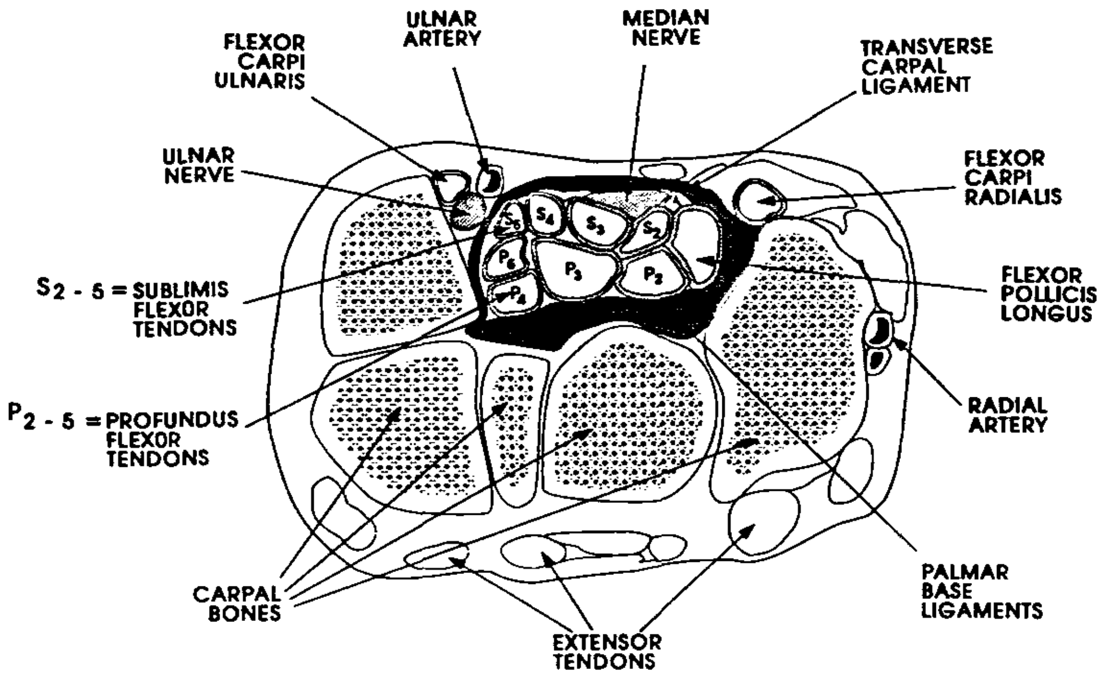

Figure 1. Transverse section of right wrist looking distally (with the palm side up), showing relative positions of the median nerve, flexor tendons, transverse carpal ligament and carpal bones. Note that the shape of the median nerve is conforming to the space available to it inside the tunnel. (From Tanaka S and McGlothlin J [1993]. A conceptual quantitative model for prevention of work-related carpal tunnel syndrome (CTS). International Journal of Industrial Ergonomics *11*(3):181-193.)

PART I

SELECTED NIOSH AND NON-NIOSH REFERENCES ON CUMULATIVE TRAUMA DISORDERS

A. NIOSH ACTIVITIES IN PREVENTING WORK-RELATED MUSCULOSKELETAL DISORDERS

There is widespread recognition that work-related musculoskeletal disorders (WMSDs) are common and increasing in the United States. Between 1982 and 1994, the reported number of musculoskeletal disorders of the upper extremity has steadily increased, accounting in 1990 for more than 60% of all occupational illnesses, the most recent year for which statistics are available (BLS 1994). Studies conducted by NIOSH staff have documented work-related musculoskeletal disorders in a wide range of industries including newspapers, health care, telecommunications, manufacturing of transportation equipment, construction, and food processing. Depending on the job, these disorders may cause pain, restricted motion, and weakness in the hands, arms, shoulders, neck, back, and lower limbs.

In a recent national health interview survey, 1.62 million workers (1.47%) reported symptoms of hand discomfort consistent with carpal tunnel syndrome, one of the most serious disabling conditions that is associated with performing repetitive and forceful manual work (Tanaka et al. 1995). In 1989, meat packing, poultry processing, and motor vehicle manufacturers had the highest reported rates of repeated trauma disorders in the manufacturing sector, based on data from the OSHA 200 logs. Coupled with the human costs in suffering and lost wages, work-related musculoskeletal disorders are responsible for growing economic costs to the nation as evidenced by increases in worker's compensation costs, as well as escalating costs of diagnosis and treatment. Total compensable costs to the nation for these disorders is estimated to exceed $20 billion annually (BLS 1993).

To address this growing problem, NIOSH and the Association of Schools of Public Health convened a Conference more than ten years ago involving 50 expert panelists and 450 other occupational safety and health professionals. The resulting document, released in 1986, summarizes 12 broad tactical approaches, and 23 immediate and future actions needed to understand and prevent a variety of occupational musculoskeletal injuries. This document, entitled Proposed National Strategy for the Prevention of Musculoskeletal Injuries, served as the NIOSH blueprint or strategy for setting research priorities through the end of the decade (NIOSH 1986).

A second Conference was held in early 1991 to examine the progress towards implementation of the recommendations in the 1986 plan. To perform this examination, a one and one-half day Conference and Workshop was held in Ann Arbor, Michigan. The proceedings from the Conference were published in a document entitled A National Strategy for Occupational Musculoskeletal Injury Prevention: Implementation Issues and Research Needs (NIOSH 1992). These two NIOSH Prevention Strategies provide a comprehensive view of the primary components of an effective research program for reducing the frequency and severity of work-related musculoskeletal problems.

Subsequently, employers, employees (with support from organized labor), loss control insurers, academia, states, and the federal sector have joined hands in seeking new ways of preventing and controlling work-related musculoskeletal disorders. In this context, the following general research recommendations were developed by the conference participants (NIOSH 1992).

1. An improved capability to identify hazardous job stressors is needed that recognizes how subtle physical exertions on jobs combine with other risk factors (such as awkward postures, high repetition, long work cycles, cold temperatures, vibrations, or high amounts of psychosocial stress) to create musculoskeletal tissue trauma, pain, and disability.

2. An improved ability to objectively measure and quantify job stresses believed to cause WMSDs is needed. In particular, we must develop more sensitive measurement systems, capable of accurately describing small body motions, and static and dynamic forces now required in many jobs that are known to cause localized tissue trauma and disability.

3. Most participants believed that there is a rapidly growing need to develop objective medical tests to identify people who may be at special risk of WMSDs when exposed to certain job conditions. Such tests need to be carefully constructed to be safe, reliable, accurate, and efficient (low operational time cost); to be directly related to the job requirements; and to be highly predictive of an individual's risk level when required to perform a specific manual task in a job. Other participants were concerned about the feasibility for this type of testing in a prevention program from a policy or scientific perspective.

4. Much more fundamental biomechanical and other types of research is needed to understand why for the majority of the WMSDs the specific nature of the damage to the body cannot be conclusively established during routine clinical evaluations. Worker population biomechanical tolerance data are needed to specific tissue and musculoskeletal structures. In addition, biomechanical models that more accurately predict tissue stress levels during work are needed, as well as empirical studies to validate the output from these models.

5. Job hazard surveillance and health-related reporting systems for WMSDs need to be improved. These should be easily implemented (user-friendly) systems that link job hazard data (from job evaluations, checklists, psychophysical effort reports, and worker questionnaires) to medical injury and illness reports in a timely fashion.

6. A variety of WMSDs control procedures and equipment are available today. These controls need to be carefully evaluated to determine their effectiveness in preventing future WMSDs, and the operational conditions under which they are effective. Additional research is recommended to refine the effectiveness of early comprehensive medical interventions and rehabilitation strategies.

7. The design of various industrial planning and social-organizational issues need to be studied to understand how these impact the implementation of various control strategies.

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Work-related musculoskeletal disorders: prevention and intervention research at NIOSH

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Introduction

Work-related musculoskeletal disorders (WMD) have been a recognized problem since the 17th century when Bernardo Ramazzini first described the illnesses caused by "violent and irregular motions and unnatural postures of the body" (1), and cited the strains on the hands and arms of scribes and notaries which led to a "failure of power to the right hand." By the end of the 19th century, the same conditions and symptoms were noted not only in scribes but also in other occupations such as shoemakers, milkmaids and seamstresses (2). In the 20th century, the incidence of cumulative trauma disorders (CTDs) and other WMD began to escalate dramatically – in the United States and in other industrialized countries as well. The costs, both economic and human, are immense. As an example, the rates of reported upper extremity disorders in the United States (US) tripled between 1986 and 1992 (3). This increase is accompanied by lost work days and reduced productivity: Workers suffering from carpal tunnel syndrome were away from work for 32 days (median value). Low back pain is a greater problem: A study of 1989 workers' compensation costs (4) reported that low back disorders represented 16 % of all claims and 33 % of all claims costs with a mean cost of USD 8,300/case.

Clearly, the development and implementation of appropriate preventive strategies for WMDs is of urgent importance. The classic approaches to the resolution of a public health problem start with surveillance; proceed through the conduct and completion of relevant (both laboratory and field) research studies to elucidate the etiology and develop the methods needed to fully characterize the problem; and, finally, design and implement appropriate interventions. Current public health research practice too often emphasizes only the first two steps of this process. Although these steps are necessary to identifying and evaluating the problems, they are not sufficient to ensure effective prevention. A greater research emphasis on the prevention/intervention efforts themselves is needed. However, the development and delivery of prevention technologies are only the first steps in implementing effective prevention programs. Of equal importance is the need to evaluate and demonstrate the effectiveness of these prevention strategies and then to effectively communicate this knowledge to others.

NIOSH is refocussing our research efforts, placing a greater emphasis on prevention/intervention efforts. This report provides examples of current NIOSH research activities directed at the prevention of WMDs. These research studies are collaborative efforts which utilize skills and expertise found in five NIOSH Divisions[1].

Development of prevention strategies: from laboratory to field research

Exposure assessment tools

Traditional ergonomic job analysis techniques have relied on experts to conduct time-consuming task analyses through direct observations or evaluation of photographic/videotaped records. An easy to use "Ergonomic Hazard Identification Checklist" has been developed which can be used by industrial hygienists and other safety personnel for initial ergonomic evaluations of jobs/tasks. The checklist covers 14 different task factors which the investigator observes and rates as "never," "some ($\leq$ 3 times daily)" or "usually (>3 times daily)." Use of this tool can quickly identify potentially hazardous tasks and trigger follow-up ergonomic assessment by an expert.

The usefulness and validity of the checklist is being assessed by comparing the checklist ratings of 50 representative tasks with ergonomists' expert assessment of the same tasks.

In 1981, NIOSH developed and published an equation for calculating a recommended weight limit for specified two-handed, symmetrical lifting tasks. In 1991, the equation was revised using more recently published biomechanical, physiological, psychophysical and epidemiological data to address a more diverse range of lifting tasks (5). The equation allows computation of a recommended weight limit for a lifting task (the ratio of the weight lifted by the worker to the recommended weight limit); and a lifting index. The equation can also be used for job redesign by identifying the most hazardous features of the lifting task. A current study is directed at validation of the equation for predicting risk of a back injury. The initial phase of the validation will include a comparison of exposure data, workers' compensation records and other records of injuries for exposed workers with similar data for unexposed workers. The goal of this study is to provide data defining the relationship between the lifting index and the incidence and severity of work-related low back pain or injury.

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[1]. Division of Safety and Research, Division of Surveillance, Hazard Evaluations and Field Studies, Division of Physical Sciences and Engineering, Division of Biomedical and Behavioral Science, and Educational and Information Division.

In 1994, NIOSH published a manual (6) which explained the procedures and provided examples for accurately applying the lifting equation to a variety of lifting tasks. Efforts are underway to develop an interactive computer-based training module for applications of the lifting equation.

Evaluation of the efficacy of back belts for prevention of low back injury

Efforts to control or prevent back injuries have included a variety of approaches. Recently, "back belts" have been promoted as a control solution. A variety of employers, from retail store chains to hospitals, have introduced back belts or back supports to the workers; some have instituted mandatory use policies. Numerous inquiries to NIOSH both from management and labor about the effectiveness of back belts in preventing low back injury led to a comprehensive review and evaluation of the published, scientific literature on back belt use (7). From this review, NIOSH concluded that the laboratory and epidemiologic data were insufficient to support the assertion that back belts reduce or prevent low back injury. More research was clearly needed to augment the available scientific data on use of back belts.

Based on these findings, NIOSH is undertaking both laboratory and field studies. In a laboratory study of approximately 100 different industrial-type back belts, investigators are examining physiologic, psychophysical and biomechanical aspects related to the use of the belts. Factors included in the evaluation are spinal load reduction, heat retention and fatigue, changes in range of motion and resonance frequency alterations after exposure to whole body vibration. To examine the efficacy of back belts in the reduction of the workplace incidence of low back injury, NIOSH also will conduct a 24-month prospective study of approximately 8,000 employees of a large retail company which 2 years ago instituted a company-wide mandatory back belt program. workers will be divided into three groups: back belts worn for only 12 months of the study period, and worn (or not worn) throughout the study period. Self-administered medical histories will document low back symptoms and compensation data from company files will document injuries which lead to lost work days. Exposure to lifting tasks will be characterized andrecorded periodically by NIOSH investigators. The goals for these two studies are to provide data not only on the effects of back belt use but also of their effectiveness in preventing low back injury.

Delivery of prevention technologies: evaluating intervention efforts

HETA follow-ups

NIOSH provides technical assistance to employers, workers, and regulatory agencies through a Hazard Evaluation and Technical Assistance (HETA) program. An increasing number of requests for assistance in recent years have been related to ergonomics and work-related musculoskeletal disorders. To evaluate the efficacy of NIOSH assistance related to ergonomics, follow-up contacts were made with companies where NIOSH had provided significant ergonomic recommendations during the previous 10 years. The effects of changes made by 7 companies (a large metropolitan newspaper publisher, a supermarket chain, two printing companies, a plastics manufacturing facility, an appliance glass manufacturing facility, and a motorcycle manufacturing facility) were evaluated. In all of the facilities, some attempts had been made to address ergonomic problems.

Although it is difficult to separate out the contributions of the many different concurrent changes such as downsizing, product changes and safety and health policy changes, attempts to redesign the workplaces contributed to some successes in reducing the number and severity of musculoskeletal problems. Also, some important lessons about what facilitated or impeded the success of an intervention program were learned. The most successful programs were those that included a comprehensive approach to the problem and utilized active input from front-line workers in the planning and implementation of changes.

Efforts at a major motorcycle manufacturing company exemplified a successful approach towards developing an ergonomic intervention program(8). In 1990, NIOSH received a joint labor/management request for assistance in evaluating musculoskeletal problems. Of particular concern was the flywheel milling department in which there had been a dramatic increase in the number of injuries and lost work days. One of the key tasks in this department was the process used to straighten or "true" the flywheel. This job, in which a brass-head hammer is used to deliver a forceful blow, required tremendous skill. However, between 1982 and 1990, ten workers had been injured doing this job and there were few skilled workers left who could perform this task. In 1989, 27 % of the workers in the department had developed a musculoskeletal disorder requiring either work restriction or time off the job. NIOSH conducted an in-depth ergonomic evaluation and worked with this company to develop and evaluate changes in the truing task as well as in several other work processes in the factory. The change in the truing process was probably the most dramatic. A new press was acquired which completely eliminated the use of brass hammers and thus of manual force. While the new press cost USD 51,000, the cost of the brass hammers had been USD 40,000 per year. Thus, even if the cost of the injuries are not included, this intervention completely paid for itself in less than 2 years. More importantly, the postintervention incidence rate for recorded musculoskeletal disorders in this department showed a 29 % decrease while the severity rate, as measured by restricted or lost workdays, decreased by 82 %. Other changes were also implemented in the factory. Some of the changes, such as raising the drill press to avoid stooped working postures, cost little. Additionally, some of the changes not only reduced exposure, but increased production quantity and quality. It is estimated that these changes saved the company over USD 50,000/year in costs related to musculoskeletal problems.

The approach this company took exemplifies some of the principles which we found were most likely to lead to a successful intervention program: 1) The company involved the workers in every step. An intervention team was formed that consisted of production workers, supervisors and engineers. 2) The management gave full support to this team, allowing them to make decisions and facilitated a quick turn around time for purchasing new equipment. 3) The team developed the concept for the new equipment and worked with the equipment manufacturers to assure that it was designed correctly. 4) After the new equipment was installed , there was a transition period during which workers could evaluate and make final adjustments to the new equipment.

Meatpacking industry

Ergonomic hazards in the US meatpacking (slaughtering, processing and packaging) industry are legendary in the US. In the late 1980s, the meatpacking industry's incidence of disorders due to "repeated trauma" was approximately 75 times that of industry as a whole. Demonstration studies at three different places were undertaken to examine the utility of participatory approaches in addressing ergonomic problem areas (9). The efforts were aided by university investigators with expertise in ergonomics (and, in one case, organizational behavior) who collaborated with and provided guidance to the teams. The teams included production workers, supervisors, as well as staff from other departments; the goals were to identify and solve ergonomic problems and reduce musculoskeletal injuries.

In each of the case studies, benefits from this type of participatory intervention approach were recorded. While each of the intervention approaches measured benefits somewhat differently, there were successes in reducing incidence rates of cumulative trauma disorders, lost work days and compensation costs. In addition, these intervention efforts were instrumental in fostering an increased knowledge about the use of participation of workers and others in developing work site improvements and problem-solving efforts.

Office environment: work organization issues

The increased prevalence of WMDs associated with video display terminal (VDT) work has been well documented. Characteristics of data entry tasks frequently include constrained postures, highly repetitive movements of the fingers, hands, and wrists and static muscle loading. These working conditions can produce musculoskeletal strain and discomfort as well as other deleterious effects. Intervention efforts have usually focussed solely on ergonomically optimizing the work environment. However, these efforts have been less than fully effective in eliminating operator discomfort and performance decrements.

Therefore, NIOSH initiated a series of laboratory studies to examine the effects of changes in work organization factors such as rest break regimens. These studies have evaluated a variety of changes such as number and length of breaks, as well as active (i.e., involving physical exercise) vs. passive rest breaks. The results showed that conventional rest break schedules (mid-morning and mid-afternoon breaks of 10–15 minutes) may not be optimal for highly repetitive VDT work. There were significant performance (up to 15 %) and comfort gains with more frequent, shorter rest breaks; in contrast, the benefits were modest, if any, from including exercises in the rest break regimen. The results also showed that for work periods with infrequent breaks, there was a higher prevalence of poor, potentially hazardous work postures (10,11,12). However, the alternate rest break regimens did not completely eliminate the decrements in overall productivity and operator comfort over the workday which have been observed in all of the laboratory studies of VDT work conventional rest breaks regimens. Additional intervention strategies such as job redesign/task rotation may be needed for these aspects.

A field replication and validation of these laboratory studies is currently underway. The effects of an alternate rest break schedule on comfort and performance have been evaluated in a pilot study of 100 data entry operators at a large service center; a second, similar pilot study is underway. The results obtained to date confirm the findings of the laboratory studies. A large scale prospective validation study of rest break regimens and tests of various job redesign strategies such as job enlargement, task rotation, etc. for workers engaged in intensive data processing tasks will be initiated late in 1995. Data on worker performance, objective performance measures and measures of musculoskeletal strain will be collected and related to the development of musculoskeletal problems in this workforce.

Summary

Documentation of these and other success stories are essential to the continued development and implementation of effective intervention strategies. While we have made a start in these efforts, we still have a long road ahead of us in the prevention of the tens of thousands of cases of musculoskeletal disorders and injuries which occur each year. Implementation of interdisciplinary approaches – which incorporate knowledge about the causes of musculoskeletal disorders, engineering changes in the work environment and the insights of social science about organizational and individual behavior – is an essential basis for these efforts. But to effectively move from research to the practice of prevention, we need to move beyond the traditional uni-directional approaches (surveillance followed by etiological research and experimental intervention efforts) by implementing approaches which are interdisciplinary, dynamic and interactive. Implementation of specific prevention strategies needs to be undertaken even when we still lack definitive knowledge about some aspects of the strategy and cannot assure in advance that a given strategy is the best and final approach to effective prevention. This interactive approach, with on-going evaluation and adjustment of the prevention efforts, will enable us to more quickly eliminate, or at the least minimize, the tremendous toll of work-related musculoskeletal injuries and disorders.

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