NIOSH RESEARCH REPORT

Problems in Occupational Safety and Health:

A Critical Review of Select Worker Physical and Psychological Factors

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE / CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the National Institute for Occupational Safety and Health.

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PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT PHYSICAL AND PSYCHOLOGICAL FACTORS

INTRODUCTION

Historical Trends

In recent years, several trends have joined to focus interest on the fact that individual workers may have characteristics that will affect their safety and health while performing their jobs. Historically, the first trend was the concern of psychologists with individual differences in all aspects of human behavior. The fact that people differ in how well they do a task, how long they take to do it, and in the methods they choose, is a fundamental psychological concept. From this building block developed the practice of using tests for selection and placement of employees on the job. Correlations could be established between test performance and certain aspects of job performance, thus assisting in the prediction of work capability. Industry saw this as a means of reducing turnover, training costs, production error, and so forth. Consequently, personnel testing in industrial settings has grown tremendously over the years.

Accompanying the growing awareness by business and industry of how measures of individual differences could be used profitably, was an increasing concern about worker safety. Although great strides in reducing hazards had been made by engineering and technology, many accidents still occurred. Some workers consistently had more accidents than their fellow workers. It seemed reasonable to assume that if there were individual differences between workers on other physiological and behavioral measures, it might be entirely possible that there existed individual differences in the propensity to have accidents. Research had been conducted since the 1920's and earlier to determine whether there were such individual differences and what they might be. Many hypotheses had been tested, but the trend had proceeded generally from trying to profile a permanently accident-prone type, to noting specific conditions of the workplace and the worker which might interact to increase the probability of an accident at a given time. Such conditions might be temporary or permanent.

After World War II, there developed the study of human factors engineering, a science which integrates knowledge of individual differences and engineering design to produce equipment and systems which can be operated safely and efficiently by the people assigned to them. Such effort requires a knowledge of the limits within which people's sensory and motor capabilities operate.

In still more recent years, there has been a growing awareness that the work environment has adverse health effects on individuals. These effects can be considerably delayed in their appearance, such as the development of asbestosis in insulation workers years after their initial exposure to asbestos. Some harmful elements are not directly perceivable by the normal human senses (such as low levels of carbon monoxide), or they may produce effects short of tissue damage (such as irritability or raised auditory thresholds when working in noisy environments). Although difficult to ascertain, it is likely that there are also individual differences in tolerance to these conditions. In such situations, it becomes necessary to monitor conditions by some device which supplements the human sensory system.

Need for a Literature Review

As a result of various pressures, many standards, regulations and laws have been developed over the years to protect workers possessing specific personal characteristics from working in conditions that would endanger their health and safety. Some of these have been used in a discriminatory fashion. Most particularly, the rules and laws concerning hours of work and kinds of work which can be performed by women are challenged now as having contributed to discrimination against female employees.

Simultaneous with the lifting of many bans, has come the promulgation of Federal legislation tightening health and safety standards in a wide range of jobs. There are, then, questions of how stringent such rules should be and whether there should be exceptions or built-in safeguards for workers who, by virtue of some personal characteristic, may be subjected to a greater risk than other workers on a particular job.

In an article in the American Psychologist, Cohen and Margolis state that study of the relation of individual differences to worker safety and health is one of the general areas of research under investigation by the National Institute for Occupational Safety and Health. They suggest that a review of past research in this area is needed and that such a review ". . . will hopefully reveal the nature of conclusions that can now be drawn in this subject area and the needs and priorities for future work."[1] It was to provide such an assessment of past research that this review was initiated.

Purpose of Review

Relevant scientific literature was examined to determine the amount and quality of existing research on personal characteristics of the individual worker, as related to his safety and health on the job. Individual differences of primary concern were physical attributes, such as age, sex, and physical work capacity; and psychological attributes, such as personality characteristics, and stress resistance.

The review was also intended to assess the shortcomings in existing methodology, and identify areas where there was little relevant research or knowledge. To the extent permitted by the literature, areas have been identified where

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1 A. Cohen and B. Margolis, Initial psychological research related to the Occupational Safety and Health Act of 1970. American Psychologist, 1973, 28, 604.

differential selection and placement of workers is indicated to protect some from environmental stresses to which they may be particularly susceptible. Environmental limits and methods by which tolerance to stress can be increased have been considered.

In achieving the above purposes, an extensive literature search was undertaken with relevant studies compiled, abstracted, and suitably classified by subject area. Also identified were research persons and centers with interests and competence in researching occupational health and safety problems involving individual physical and psychological factors.

METHOD

Search for Information

In the search for information on personal factors related to occupational health and safety, emphasis was placed on contacting as many sources as possible to ensure including reports of limited distribution, as well as reports in the published literature. In addition to searching the numerous general and special purpose libraries in the Washington, DC area, personal visits were made to or telephone and written correspondence was initiated with persons, organizations, and associations knowledgeable in the subjects of interest. Computer search services were also assessed for their possible contribution to identifying either appropriate literature or researchers and research centers where pertinent work had been completed.

Library search. The following libraries were visited and used with varying degrees of success:

1. The Dahlgren Memorial Library (Georgetown University Medical Library).
2. The National Library of Medicine.
3. The National Institute of Health Library.
4. The Veterans Administration Library.
5. The National Agricultural Library
6. The U. S. Department of Health Education and Welfare Library
7. The Civil Service Commission Library.
8. The U. S. Office of Education Departmental Library.
9. The U. S. Department of Labor Library.
10. The American Red Cross Library.
11. The U. S. Department of Transportation Library.
12. The A.F.L. - C.I.O. Library.
13. The Federal Aviation Administration.
14. The Atomic Energy Commission.

Many of the explored libraries proved to be important resources because they provided long-term periodical holdings, a comprehensive cataloging system, a reference area containing good abstract and bibliographical sources, and a source for referrals to other libraries or institutions containing pertinent information. The National Library of Medicine and the National Institute of Health Library were particularly useful.

Libraries outside of the Washington, DC area were also searched when possible. Such libraries included the John Crerar Library in Chicago, the Battelle Memorial Institute and special collections at the New York State University at Geneseo. Subject and author indexes were reviewed for the entire human engineering-human factors collection at the Aeromedical Library of Wright Patterson Air Force Base in Dayton, Ohio.

Data base searches. Various computer data base facilities were assessed for their possible usefulness in the information search. To identify specific references of possible interest, only two of the many possibilities were actually used. These were:

1. National Technical Information Service, U. S. Department of Commerce (NTIS).
2. MEDLINE (the off-line bibliographic citation list of the National Library of Medicine's remote-access retrieval service).

Other possible sources were not used for a variety of reasons. The Educational Resources Information Center (ERIC) Index and Abstracts were searched manually for the relevant subjects, but it was found that most entries dealt specifically with educational interests and not with individual differences as related to occupational safety or health. Therefore, no further search was conducted.

The American Psychological Association computer search of Psychological Abstracts was not used because the search covered only the years since 1967, and a manual search of much of this material had already been accomplished. That search had uncovered only limited numbers of references of interest to the project.

Defense Documentation Services were not used because, except for documents with a government security classification, the materials are duplicated in the NTIS search.

Any computer search must be supplemented by manual search of the years prior to their coverage. This was done in the case of the NTIS computer search which covered only the years from 1964, and for Index Medicus, which, in the MEDLINE search, is limited to the more recent years.

Abstract sources. A number of sources of abstracts were searched with varying success. Among those examined were:

Occupational Safety and Health Abstracts

Employment Relations Abstracts

Biological Abstracts

Excerpta Medica

Psychological Abstracts

Dissertation Abstracts

Index Medicus

Bibliography on Smoking and Health (published by the National Clearinghouse for smoking and Health, U. S. Public Health Service)

U. S. Civil Service Commission Personnel Bibliography series

Industrial Hygiene Digest

International Aerospace Abstracts

Nuclear Science Abstracts

Identifying research centers. Several lines of inquiry were used to identify places and people who have performed work of interest to the project. A search of the Smithsonian Science Information Exchange files of ongoing research was requested and approximately 80 projects were identified.

The _Research Centers Directory_, published by Gale Research Company, lists and describes research institutes, centers, foundations, laboratories, bureaus, experiment stations, and similar non-profit research facilities, activities and organizations in the United States. This directory was reviewed and approximately 90 organizations were identified as working in the field. _Industrial Research Laboratories of the United States_ published by the Jacques Cattell Press was another useful directory from which 65 laboratories were identified as possibly conducting relevant research. Other sources of information on persons, laboratories, or institutions performing work on personal factors in occupational health and safety included:

- Office of Naval Research
- U. S. Navy Bureau of Medicine and Surgery
- U. S. Navy Safety Center
- U. S. Army Environmental Hygiene Agency
- U. S. Army Medical Research and Development Command
- U. S. Army Office of Surgeon General
- U. S. Army Health and Environment Directorate
- U. S. Army Behavior and Systems Research Laboratory

U. S. Army Aeromedical Research Laboratory

Frankfort Arsenal Laser Safety Team

Institute for Defense Analysis

Office of Alcohol Countermeasures, National Highway Traffic Safety Administration

American Psychological Association

National Referral Center for Science and Technology of the Library of Congress

Representatives of the International Union of Psychological Science in 36 countries were contacted and asked for referrals to institutions or persons performing research on individual factors in occupational safety and health.

Authors of papers on this general problem area were also queried for information on related work, as were directors of relevant currently active contracts of the National Institute for Occupational Safety and Health.

Abstracting References

The various search procedures used to identify appropriate literature may be generally characterized as resulting in three types of materials. These were:

1. titles, usually obtained from computer searches or referrals from various other sources;

2. abstracts (which of course included titles) usually resulting from the search of periodical abstract listings; and

3. documents and reprints of actual articles, books, reviews and the like, obtained either by library search or by referral.

There were several procedures for processing these materials, and Figure A-1 illustrates the general methods used

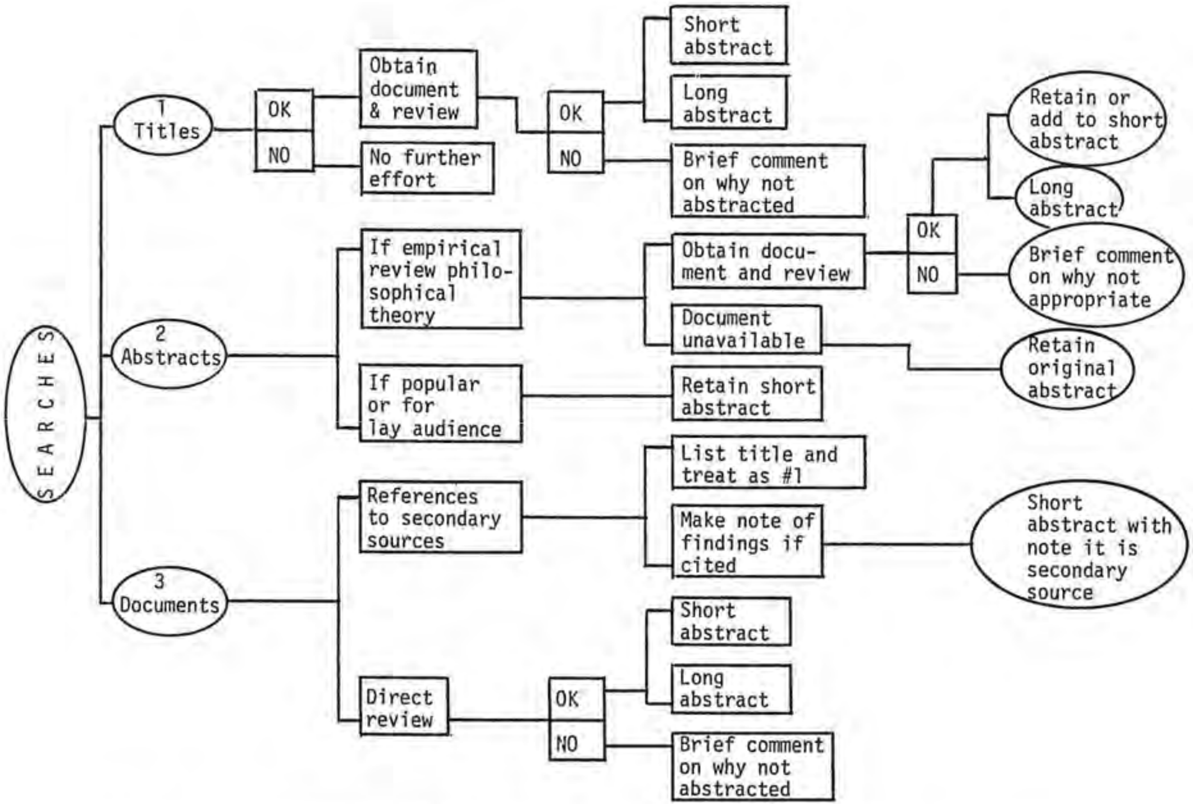

Figure A-1 Treatment of the three major types of materials resulting from the literature search.

and the resulting types of abstracts. The following discussion may be better understood by reference to Figure A-1.

When only titles were available, as from a computer search or referral from another source, the title itself sometimes clearly indicated that the reference was inappropriate. For example, in searching the literature for the effects of training on job safety, there were many references of a popular nature (safety brochures, articles for the layman and so forth); other titles indicated that the references discussed methods of training people in a job but did not touch on the effects of training. By title, then, these references were eliminated from further consideration. Some totally inappropriate items did filter through because the titles did not clearly indicate their subject matter, and the fact that they appeared in a subject listing search indicated they should be checked further. When titles appeared promising, the document was obtained and reviewed. At this point, a decision was made by the reviewer to do one of several things. The reading might indicate the article was inappropriate or of little use to the project, in which case the reviewer so noted. Relevant articles were abstracted either in a short form or a long form. Long abstracts were prepared when the reviewer felt the article was particularly worthwhile, and he wanted to communicate details of the method and results. Short abstracts were usually prepared when it was found that the article, while relevant, did not present details that made a long abstract necessary.

A second possible course of action followed when the search resulted in an already published abstract or summary of the item. References obtained from any of the published abstracting services (such as Psychological Abstracts) usually had this form. If the item was a popular or lay article, usually the published abstract was copied or summarized and no further search was made for the original document. If the abstract revealed that the article contained empirical data, a review of the literature, or a philosophical or theoretical position on personal factors, then, if possible, the original document was obtained and reviewed. The reviewer added to the short abstract, retained it as it was, or prepared a long abstract, if the article was appropriate. If the article was inappropriate, the reviewer added a note to that effect. When original documents were unavailable, the original abstract was retained.

Frequently, references were mentioned within an article. These were obtained for review, or a note of the reported findings was made and the secondary source nature of the note recorded.

Classification System

All references which were obtained and which went through at least one of the steps cited above were assigned accession numbers. Retrieval was by means of either an author index or a subject index.

The author index consisted of an alphabetical listing of all authors and coauthors of articles with the accession numbers of the references they authored.

The subject index was developed by adopting subject headings from various sources, including: the Occupational Health and Industrial Medicine section of Excerpta Medica; a classification of human factors engineering literature used by Tufts University and by the U. S. Army Engineering Laboratory; several classification schemes used by textbooks; and other classifications of individual factors in the literature. Subjects included occupational diseases, personal characteristics of individuals, disease or injury agents, occupational titles, accident types, and related topics. Each accessioned reference was assigned as many topics as appropriate, and the accession number recorded with the associated subject. Retrieval in this index was accomplished by searching for the desired subject and retrieving all associated references. The indexes, referenced titles, and abstracted articles are presented in Volume II.

Developing the Reviews

Deciding how the available literature should be grouped to produce a useful document was partly a function (a) the relative importance of factors considered, (b) the level of explanation sought, and (c) whether there was sufficient literature on a topic to demand its review as a separate entity. Listed below are the topics which have been reviewed, with a brief statement of why they were considered important.

Physical factors. Age, sex, physical work capacity, and temporary states of the individual caused by alcohol consumption, drug use, or fatigue have been reviewed.

Age is a relatively easily determined trait of all workers and there are many known correlates of age suspected of being associated with occupational safety and health.

Sex has been a commonly used selection factor in employment practices, and there are correlates of sex and various functional characteristics and absenteeism.

Physical work capacity encompasses a number of conditions of the individual, from his general health and bodily condition, to size and weight, all of which are related to dependent variables ranging from frequency and severity of illness, to ability to perform physical motor tasks.

Temporary or altered states of the individual include those conditions resulting from things one consumes or does, which may dissipate over time. Reviewed were studies on the use of alcohol or drugs as they are known to degrade performance, and the effects of fatigue, a controversial issue in the literature for many years.

Psychological factors. There is a wide variety of characteristics of individuals which may be considered within the realm of psychological factors. These may range from characteristics with a physiological basis, such as individual sensory capacities, to characteristics which are purely conceptual in basis, such as personality and attitudes. In actual fact, the literature search did not produce very much quantity in some of the areas which might be considered relevant. Those which have been reviewed include the following:

Personality and emotional factors have been the variables of most concern to behavioral scientists seeking (a) to understand the reasons why some workers apparently have a disproportionate share of accidents, or (b) to ascertain whether some conditions of personal adjustment or emotional state will increase the likelihood of unsafe acts.

Life stress includes a variety of changes in a worker's psychosocial environment which can affect his health and job performance. Examples are the death of a family member, divorce, or other drastic changes in one's life style or living situation.

Smoking is a common habit among workers and is known to have adverse health effects. The literature reviewed is not concerned with smoking as a reaction to stress, but as a cause of illness and accidents. Particular emphasis is placed on the detrimental health effects produced by the interaction of smoking and already existing occupational hazards.

Coronary heart disease is a leading cause of death in the United States. This review treated it as a dependent variable and examined the influence of life stress, occupation, personality, socio-economic status, and physical and heredity traits upon such a disease.

Cross tabulations. For each factor that was reviewed, a summary chart was prepared relating the character of available literature to relevant occupational safety and health indicators. Categories used to define the nature of the literature were:

1. Empirical data

   a. Observations or statistical accumulations. Articles in this class report data on the numbers or percentage of cases observed, with little or no information which permits interpretation as to causes or correlation. Government statistical reports presenting the prevalence of a given illness were classified in this category.

   b. Controlled field studies or laboratory studies. This category includes all those studies introducing procedural or statistical controls that permit some estimate of possible causal or correlational relations. A very broad definition of "control" was used so that even a statistical accumulation might be so classified it it presented the data in a manner that gave any indication of association. For example, in the review of sex as a personal factor, statistical accumulations which presented separate figures for males and females were classified as "controlled" studies.

2. Opinion, theory, or "experience"

In this category are classified those articles which present some theoretical position, state opinions, or report or imply experience showing the interrelation of the given personal factor and the given dependent variable. A paper stating a theoretical position may also report data, in which case it was classified in more than one cell of the table. Reports of "experience" include items which describe some incident or company program which implies an association of the personal factor and the dependent variable. Rules and laws are also included in this category.

3. Reviews

   a. Critical or integrative. Literature reviews in which the reviewer attempts to assess the quality of the work, the methodological problems, or the problems of interpretation, are considered critical reviews. Integrative reviews are those which attempt to bring together a great deal of literature and derive general implications. Again, a very broad definition was used in classifying specific articles, so that reviews which brought together a great deal of information were classified as critical or integrative, even when the author made only a small attempt to make a coherent statement from the material.

   b. Bibliography or sketchy reviews. When the item merely presented listings of titles, either with or without annotation, it was considered a bibliography. When the review covered the subject matter in a very superficial or a very selective manner, it was also classified in this category.

There were cases in which the nature of the item was unknown, usually because the information on it was obtained from a secondary source which did not state the kind of article referenced.

Dependent variables acknowledging safety and health measures are briefly defined below:

1. Frequency and severity of job accidents includes items specifying that the given factor was related to accidents on the job. Some items reporting highway accidents are classified here if they might have application to driving as an occupation.

2. Agent-specific diseases include reports of situations in which an illness can be directly associated with some identifiable health hazard. Much of the smoking habit literature is of this type, reporting either lung problems or chronic bronchitis associated with smoking.

3. Non-specific disorders includes reports on a variety of adverse bodily conditions arising as secondary or indirect consequences of a hazardous condition or agent. Much of the life-stress literature is so classified, because stress produces a number of general bodily reactions which are not specific to the nature of the stress.

4. Critical incidents includes items which report a relation of the personal factor to some important event that could have resulted in an accident. Critical errors and near-miss situations would be examples. These incidents might permit the inference of a factor/accident relation.

5. Rate or amount of sick absence includes reports on absence due to both illness and injury.

6. Performance indices includes all items which show an association of a factor in question with certain measures of performance, such as speed and accuracy of response.

7. Strain indices includes measures of worker behavior which show evidence of increased cost to the body even though overt performance may remain normal.

8. Morale includes any items showing a relationship between personal factors and satisfaction or dissatisfaction with the job.

9. Compliance with rules includes items showing measures of obedience to laws and regulations.

10. Off-job problems includes studies in which such indicators as marital discord, arrests, off-job accidents and the like, were the dependent variables.

11. Miscellaneous was used to classify those items not elsewhere classifiable and includes studies of highway accidents (where the sample is from the general population) home accidents, and so forth.

Studies are not evenly distributed among these categories. The literature search stressed locating items relating personal factors to sickness or accidents. While there is much literature on job satisfaction, unless it could be related to health impact, it was not included. Similarly, data from the general psychological literature on performance indices was limited to those materials related to personal factors, and to situations in which the performance index might imply an increased or decreased probability of accident.

Preparing the summary chart for Coronary Heart Disease (CHD), presented a problem because the disease itself is a dependent variable. The bulk of the references fell within the Empirical Study of Non-Specific Disorders category. This indicated that the articles so classified reported statistical or experimental data on CHD as a non-specific response to factors in the physical or psychosocial environment.

Summary

Among the general impressions obtained from this effort is the reinforcement of the already known fact that conducting controlled research in actual field settings is difficult to do. There is little opportunity to incorporate the controls necessary for ensuring that the independent variables are indeed responsible for the effects obtained. As a result, there is considerable appeal to inferences from disparate research sources to bolster confidence in results. Alternatively, there are researchers who totally ignore the need for control measures or conditions and make conclusions based on inadequate findings or evaluations.

Another feature resulting, one might believe, from the difficulty of doing applied research, is that there is a considerable amount of literature which reviews other research and offers little that is new. Such literature could make a significant contribution through providing a synthesis of evidence on a given problem or new insights. Too often this is not the case.

After doing a literature study such as this, one can get some solace from a quote from Lord Rayleigh in 1884:

> "In science, by a fiction as remarkable as any in law, what has once been published is spoken of as known, and it is often forgotten that the rediscovery in the library may be a more difficult and uncertain process than the first discovery in the laboratory."

But difficult as it is, building today's research program on yesterday's knowledge is an essential procedure.

AGE

A portion of a report--

PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT WORKER PHYSICAL AND PSYCHOLOGICAL FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

AGE

Introduction

Aging is something everyone does. Age is also fairly easily obtainable datum on an employee. Furthermore, everyone knows that we change as we grow older - that we are not the person today that we were five, ten, or twenty years ago. Generally it is the popular image that we are worse off as we grow older; that our functioning is degraded below what it was in earlier years.

Since it is a universal characteristic, easily obtainable, and popularly thought of as being associated with some level of performance, it is tempting to use age as a selection device for new employees, a cut-off device to retire current employees, and a cautionary measure in reassigning an employee to new duties or returning him to duty after an illness or injury. Indeed, age has been a ubiquitous item in nearly every personnel department's armamentarium of selection requirements.

Granted that there are numerous known changes in health, sensory capacity, and psychomotor performance as a function of age, the question becomes one of identifying whether those changes are correlated with accidents or with other occupational health problems. There appear to have been several research approaches taken in attempting to determine how age affects occupational safety and health:

1. Relating chronological age to accident records.
2. Studying the decrements in various psychological

and physiological functions with increasing age and inferring that these increase the possibility of accidents.

3. Relating chronological age to illnesses and severity of injury.

Among studies relating age to accidents, there are two kinds. Some studies merely examine the gross figures showing the frequency of accidents in each of several age groups; other studies report the rates of accidents in given age groups. Normally an accident rate implies that the figure represents some frequency per unit of numbers of employees (such as 100,000) or per unit exposure time (such as one million hours). However, in some studies it is not at all clear whether a gross frequency is being reported or a rate is being reported. This is sometimes caused by the researcher using the word "rate" apparently to mean "frequency" or at least not specifying the denominator of the rate fraction. As in other accident research, there are also differences in defining reportable accidents; that is, an accident may refer to those injuries requiring medical treatment, or only those involving lost time as well.

This and many other problems plague the review of research relating accidents to age. These will be discussed in appropriate sections below.

Age and Accidents

Accidents and the younger worker. Although there is much conflicting data and considerable latitude for interpreting results, there are many studies which indicate that younger people have more accidents than older people. Tiffin (1952) cites several studies which support the hypothesis that accidents decrease as age increases. He offers the data shown in Figure B-1 as an example of the relationship between frequency of accidents and age of the worker. Tiffin himself specifies cautions that one must take in interpreting such graphs relating age to accidents. For example, he indicates that the following explanations may account at least in part for the noted relationship:

1. It has been suggested that the younger employees are placed on the more hazardous jobs and that, as they become older and more "plant wise" they tend to be transferred to jobs of greater relative safety.
2. Younger employees generally have fewer family responsibilities and are less cautious than the older employees.
3. Lack of experience results in a lessened knowledge of potential dangers among younger employees.

Tiffin suggests that in industries where such a relationship is found, training should be focused on the less experienced and/or the younger employees.

In a study of miners, Davies (1963) found the highest number of accidents was for those 21 to 30 years old followed by a gradual reduction until retirement. Those 15 to 21 had higher rates than those over 40, but lower than those between 21 and 40. Another study of miners (Wohlberedt, 1965) verified that the young miner is a greater risk than older workers. The 18 - 24 year olds had 18% of the accidents but they comprised only 13% of those employed. The

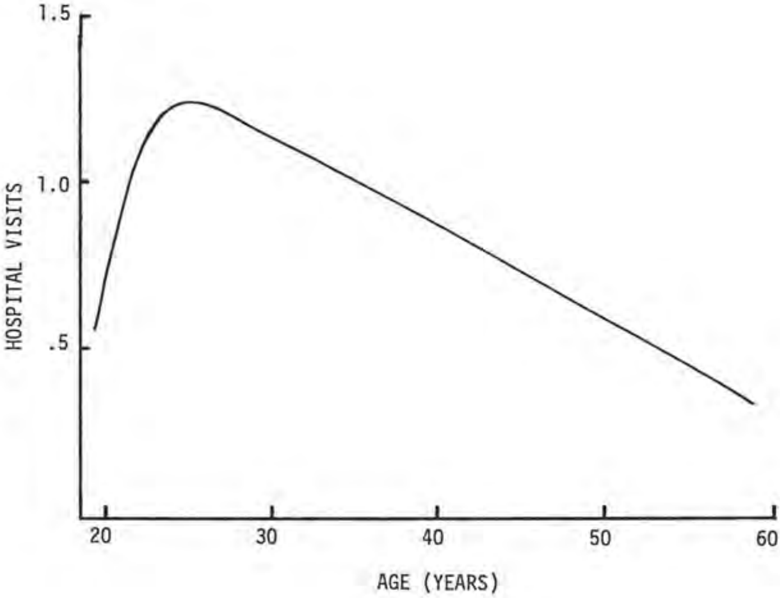

Figure B-1. Relation between age and hospital visits per man per year among 9,000 steel workers. (Adapted from Tiffin, 1952.)

lower rate shown in Figure B-2 for those under 17 is attributed by Wohlberedt to the protection of this age group by legal regulation. Wohlberedt believes the high rate group (18-24 years) is employed doing piecework, and the decline in accident rate from 30 years onward reflects a growing sense of responsibility and prudence. Older employees are assigned to lighter and less hazardous work and therefore have the lowest accident rate in Wohlberedt's analysis.

Similar reasons for decreasing accident rates with increasing age have been specified by Adum (1964). He interprets the high accident rate in the 16-29 age group as the result of a large number of apprentices among the employees. In Adum's analysis, the accident hazard decreases after 30 and the 50-55 year range is often the safest group.

In her review of the literature, Surry (1968), cites studies showing a higher injury rate for younger individuals but approximately equal fatality rates from industrial accidents at all ages. Although the injury rate is higher for the younger worker, the death rate as a result is ascribed to the decreased ability to recover due to physiological degeneration in the older person. Surry concludes that there is insufficient data to support the hypothesis that decreasing ability of the worker approaching retirement creates more of a hazard.

Similarly, Hale and Hale (1971) in their review of accident research state that the studies generally agree

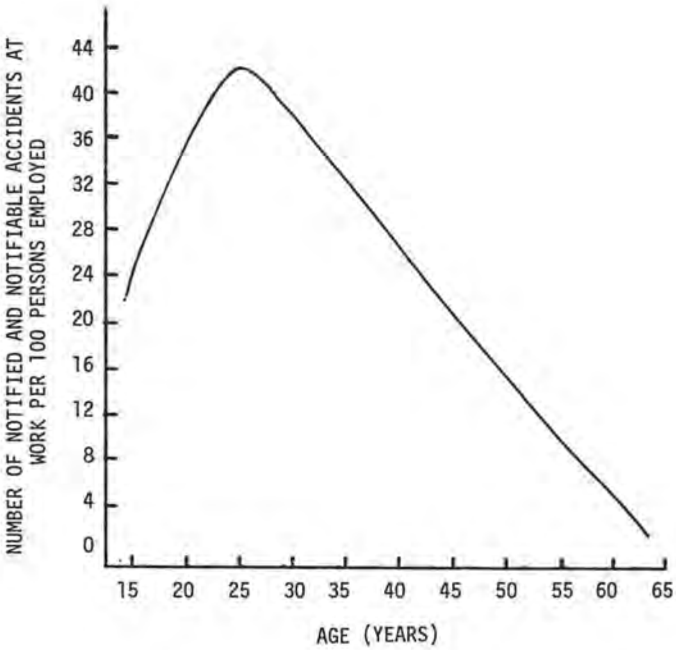

Figure B-2. Accident rate (notified notifiable accidents at work per 100 persons employed) for accidents at work in bituminous coal mines as a function of age in the years 1960 to 1963. (Adapted from Fried et al. 1972 based on Wohlberedt, 1965.)

that accidents are high in the teens and twenties with a slight decline until the middle or late 40's. However, they indicate that there is then a gradual rise until the end of the working life.

There has been considerable amount of work in relating age to traffic accidents. This material is considered relevant to the current review because (a) driving skill involves sensori-motor capability and experience factors from which at least limited generalization to industrial tasks is possible, and, (b) industry employs people as drivers which then makes the driving task an occupational one. Generally this work corroborates the finding that younger persons have a number of accidents that is disproportionately high compared to the numbers of youthful drivers, their miles driven, and so forth. For example, DeSilva (1938) reported that the number of driving accidents in the 16-30 year old group was higher than would be expected based on the numbers of licenced drivers in this age group as shown in Figure B-3.

Such increased risks of youthful drivers are not limited to the general population of drivers but also apply to persons whose occupation is driving. McFarland, Mosely, and Fisher (1954) cite data to support the notion that older truck drivers are less likely to have accidents than younger truck drivers when all the conditions of operation are equal.

A summary of the problem of youth and traffic safety by the National Transportation Safety Board (1971) offers data which show that the accident rate for youth is not only higher than for older groups, but is increasing. As shown in Figure B-4, since 1961 there has been a steady increase in accident rate among youths which is greater than

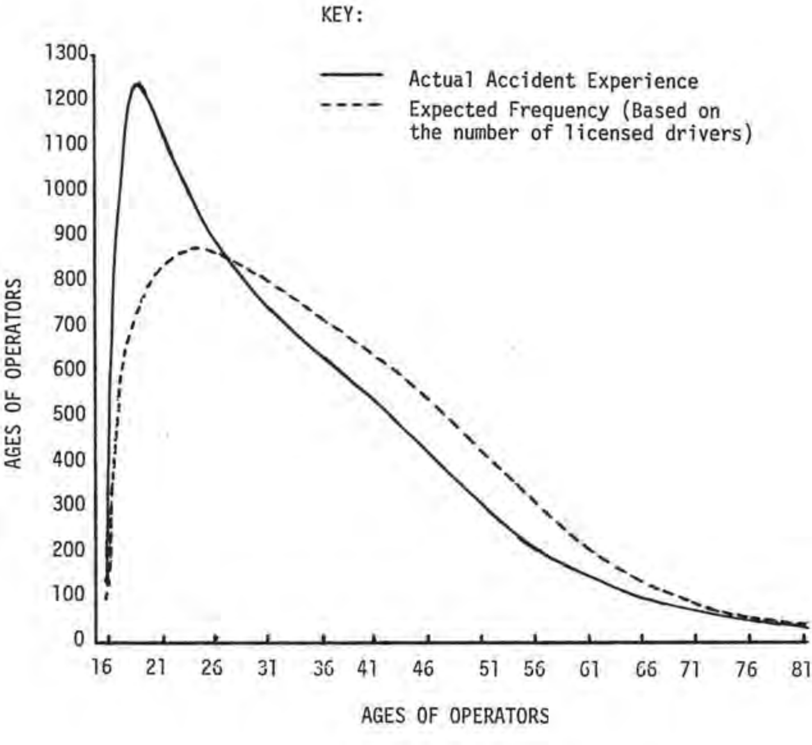

Figure B-3. Comparison of actual traffic accident experiences, with expected accident frequency. (Adapted from De Silva 1938.)

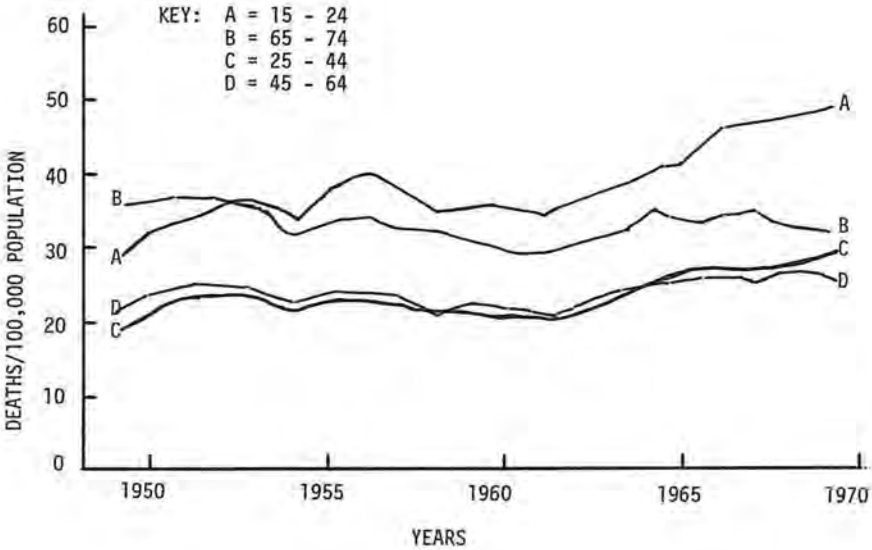

Figure B-4. Motor vehicle death rates for different age groups for period 1949-1969. (From National Safety Council, Accident Facts, 1970 Edition, as produced in National Transportation Safety Board, 1971.)

increases in other age groups. This is attributed to (a) the increasing affluence of the populace, with earlier ownership, licensing, and driving among youth; (b) changes in usage of alcohol and drugs; and (c) perhaps changes in attitudes toward our system of jurisprudence.

As with studies of the relation of age to accidents in industrial settings, there is the question of the role of experience in the relationship.

In a review of research focusing specifically on the problem of the youthful driver, Goldstein (1971) referred to data (Brezina, 1969) which compare the first year driving records of beginning drivers with one year averages of experienced drivers of the same ages. The accident rate for beginning drivers in their first year exceeded the average yearly rate for the experienced drivers in each of three age groups (16-19, 20-24, and 25-54) and for both sexes with the exception of males aged 16-19. So there does appear to be some effect of experience which can account in part for the observed decreases in accident rate with age. But it was still found that the beginners who were 16-24 had a higher accident rate than the beginners in the 25-54 age range. Goldstein (1971) also cites statistics (District of Columbia Traffic Safety Reporter, 1971) demonstrating that the younger drivers violate the traffic laws at a greater rate than older drivers. As shown in Table B-I, the rate of traffic violations is highest for registered drivers who are 18 or 19 years old.

Table B-I

Violation Rates by Age Groups for District of Columbia (D.C.) Drivers [a]

Age	Violations per 1000 D.C. Drivers Registered	Accident-associated Violators per 1000 D.C. Drivers Registered
16-17	26.0	6.4
18-19	305.1	52.3
20-24	272.3	44.5
25-65+	Not greater than 171 for any age group	Not greater than 28.8 for any age group

[a]From the District of Columbia Traffic Safety Reporter, 1971, as cited in Goldstein, 1971.

Table B-II presents data from Campbell (1966) as reported by Goldstein (1971) showing that, compared to drivers older than 25 years old, the percentage of accidents on weekends and during nighttime hours is greater for young drivers. The percentage of single vehicle accidents is also greater for younger compared to older drivers.

In his review, Goldstein stated several conclusions and offered a number of suggestions for approaching solutions to the youthful driving problem. Included were the following:

1. "...Personal characteristics, background characteristics, and the stress of life characteristic of this age group play an active role in the highway accidents of youth [p. 72]."
2. In light of the fact that the 15-24 year old group has a disproportionate share of accidents, solutions must be found to prevent fatalities while youths work out those broader problems inherently adolescent.
3. The driver's licensing examination needs to be reformed so as to serve a "diagnostic-remedial" purpose in which the applicant's weaknesses are identified so counselors can provide instruction in those areas.
4. Characteristics of individuals such as the habit of driving after drinking alcohol, high blood pressure, and color blindness, which together can have a considerable impact in terms of accidents must be

Table B-II

Percentage of Accidents by Age for Day of the Week, Time of the Day, and Type of Accident[a]

Age	Saturdays & Sundays	Nighttime 6 PM - 5:59 AM	Single Vehicle
25 and under	46.4	58.7	58.7
26 - 59	41.7	46.6	42.9
60 and older	34.4	24.4	28.2

[a] Data from Campbell, 1966 as presented in Goldstein, 1971.

identified. This would involve comparing the accident rate for the group with the characteristics and the group without them, when other relevant factors are controlled.

To an experienced researcher this last point is very basic to study design if appropriate conclusions are to be drawn. But identifying groups of people with and without given characteristics and comparing their accident rates with other factors controlled is an extremely difficult condition to achieve. Many accident research studies only seem to achieve the goal because factors which may affect the results are ignored or it is not realized that they exist. In reporting their study of over 2,000 accidents in four different industrial workshops, Powell, Hale, Martin, and Simon (1971) continually emphasize the importance of considering accident statistics within the framework of the specific job to which they apply. One may not generalize the data from one company to another or from even one department to another. For example, their analysis of age as a factor in accidents was arrived at by dividing each shop group into low and high accident units and matching each individual in a high group to an individual in a low group with regard to the experience variable. Varying results were found from shop to shop. In the machine shop, people in the higher accident group were younger than in the low accident group ($p < .05$). The reverse was found in the assembly shop with the older group having the most accidents

($p < .03$). No differences were found in the mill or the dispatch department. The authors hypothesize that the results reflect task and experience effects although they state that they did not have sufficient data to prove it.

Usually company records on accidents are kept by some convenient grouping by occupation or department. But Powell et al. (1971) indicate that such groupings ignore technical causes contributing to the accident including such things as:

1. Nominally identical machines are not identical because of wear and maintenance.
2. Machines have things added to them which limit the jobs done on them so that on a row of seemingly similar machines only a selection of the available work may be done on each.
3. Each job done on a machine carries its own risks. Brass may be turned on the lathe dry while other cuttings will be wet with oil. The former carries the risk of eye injury while the latter carries less risk of such injury.
4. There is self-selection by the operators so that certain operators will be favored to do certain tasks because they do them well or they may prefer to do the task because it carries a bonus.

Thus, although the accident statistics in a study may group all "lathe operators" together in an effort to control risk as a factor influencing results, it is the contention of Powell et al. (1971) that even within the group of lathe operators there are great differences in machines, operators, tasks, and the interaction of all of these, that may affect the variable under consideration (such as age or vision).

Hale and Hale (1971) cite various sociological and psychological studies which attempt to explain the causes of differences in accident rates with age and conclude that each job must be treated separately in accident analysis.

Accidents and the older worker. Some data exist which indicate that older workers do have higher accident rates than younger or that conditions exist in which the older worker cannot function as efficiently as the younger workers and is therefore at some risk of accident. As an example of the latter point, Bedford (1964) concludes as a result of reviewing the literature that older workers are more susceptible to accidents as a result of higher ambient temperatures than are younger workers. There are indications that the frequency of various types of accidents change with age. Some types of agricultural accidents, for example, falls and being hit by falling or moving objects increase with age while others, such as getting caught in a machine or starting a machine, decrease with age (King 1955). Government statistics (Public Health Service, 1963) show that injuries from falls also rise with age in the general population. Birren (1964) says the data suggest that accidents preventable by judgment based on experience decrease while there is an increase in those which could be prevented by rapid evasive response to sudden events.

Welford (1958) suggests that if an accident is the failure to make an adequate response to a hazardous situation, it could arise either because of a failure to appreciate the demands of the situation or a failure to adequately produce the appropriate response. He suggests that young persons experiencing repeated accidents tend to fail in appreciating the demands of the situation whereas the older subjects fail in adequate response. Welford proposes that traffic accidents, for example, could arise from older people deciding upon a course of action and then carrying it through despite a subsequent change in traffic conditions.

There are a number of studies in the literature which purport to show that older workers have more accidents but the data are such as to make it unclear whether the author is reporting rates for each age or frequencies within an age group. Tumyan and Oganesyan (1970), for example, examined the causes of accidents through 16 years of records. They provided data showing a very high percentage of accidents for the 26-35 age group as seen in Table B-III and a sharply decreasing rate thereafter. Also provided are data showing a decrease in accidents as experience increases with a marked decrease in accidents between the third and fifth year of employment. However, the authors are apparently reporting simply the numbers of accidents in the given categories rather than the rate of accidents in the category.

Table B-III

Percentage of Worker Injuries by Age and Experience[a]

AGE	% of INJURIES	EXPERIENCE	% of INJURIES
18-25	22.3	Up to 3 yrs.	70.1
26-35	61.5	3-5 years	16.9
36-45	10.1	6 yrs. +	13.0
46 +	6.1		

[a] From Tumyan and Oganesyan, 1970 as presented in Fried et al. 1972.

Tyminski (1969) reports both the percentage of accidents in a group and the relative number of workers in that group. For example, in his study, miners who were 50 years old or older had only 11% of the total number of accidents but then comprised 20% of the total employment. Thus, without a clear statement of the manner of reporting, the data can be misleading as a result of the confusion over whether numbers or rates are being reported.

A study by Mueller (1965) purports to show that old workers (51-60 years old) have the most accidents and those 41-50 years old have the fewest. But the data actually show that the total number of accidents, most involved people who were 51-60 years old. Perhaps this is because there were more people who were 51-60 years old in the population, in which case the rate of accidents might be low.

A study of injuries to hospital workers (Mann, Abramson, Cambrass, and Alon, 1967) noted a higher injury rate for workers more than 55 years old. However, the study included injuries sustained to and from work and may therefore reflect some of the rise noted in traffic accidents in older drivers.

Severity of injury. Although older workers may suffer fewer injuries the severity of injury seems to increase with age as various physiological processes suffer from decreasing recuperative capacity. Baker and Spitz (1970) investigated 328 drivers who had died as the result of highway crashes. Autopsy records and police reports indicated that a decreased ability to survive the accidents caused older people to be greatly overrepresented among the fatally injured drivers. The proportion of drivers who were 60 years of age and over was five times as high among those killed as among drivers who survived multivehicle crashes. Delayed death was more common among older drivers and was associated with less-serious injuries than in younger drivers.

Another indication of the increasing severity of injuries with age is the number of days lost per man per injury. A study of injuries in a hospital (Mann, Abramson, Cambrass and Alon, 1967), found that the mean annual injury rate from 1955 to 1965 was 7.9/100 workers. Forty-seven percent of the 1,201 injuries resulted in a loss of less than six days. Thirty-seven percent of the injuries resulted in losses of from 6 to 20 days and sixteen percent of the injuries resulted in 21 or more days lost. Injuries to both male and female workers over 55 years old were more frequently followed by the loss of 21 or more workdays than were injuries to younger workers.

Supervision. In the industrial management literature much emphasis has been placed on the identification and rehabilitation of the problem employee. Management is concerned about young, inexperienced employees because they offer industry youthful vigor and capability of change, although they present problems. The younger worker is generally attributed with an inordinate amount of recklessness which results in danger to himself and other workers. Automobile insurance rates are current testament to the conviction among insurance companies that young people are a high risk group. An article by Liberty Mutual (1970) offers an example of industry's approach. In this article supervisors are provided with suggestions for dealing with the accident potential of these young employees. They include the following:

1. Place the new employee under an experienced worker's wing, as an employee with a flawless safety record will set a good example for new employees.

2. Explaining the job within the context of the entire industry will make the new employee safer.

3. Do not assign workers to jobs beyond their physical capabilities.

4. Do not expose young workers to certain industrial toxic substances as they are especially susceptible; older workers are apparently more immune.

5. Discuss in-plant accidents with the employee accompanied by suggestions for prevention.

6. Cite difficulties that young workers have in setting a work pace.

7. Teach boys how to lift and girls not to wear high heels.

8. Urge employees to think of their co-workers.

Although no data are provided to support these solutions to the work-accident problems of youthful employees, they do provide a sampling of some solutions offered to supervisors and they have some semblance of sound psychological and human factors bases. Providing new employees with models of good safety behavior in the form of experienced employees with safe work practices is in line with theories of social learning proposed by Bandura & Walters (1963). Instructing employees in proper task duties (lifting) and attire (shoes) is sound from a human factors standpoint as is the admonition to restrain from assigning workers to jobs beyond their physical capabilities. However, as with any set of principles, their success or failure will ultimately rest on the quality of the actions taken to apply them in actual operations.

Interdependence of age and experience. Almost every comprehensive study cited in this review gives at least some consideration to experience as a variable in the age/accident relationship, and most studies either control for experience or attempt to discuss the experience factor in addition to others. It is difficult to completely separate the two effects since the longer a person works on a job the older he becomes. However, there have been attempts to isolate the two effects.

In Zeller and Moseley's (1956) study of Air Force pilots, the age and experience relation was scrutinized. Although there was an unexpected increase in accident experience in the 45 and over age group, the number of major accidents was so small as to be considered insignificant. There was reason to believe that limited experience with recently introduced jet fighter aircraft accounted for the rise in accidents among the older pilots. When experience in flying was considered, there was a decrease in accident rate with increasing experience as can be seen in Table B-IV. Based upon the results of the study the authors felt that the experience factor was most important and they attributed a decrease in accidents to an increase in experience. They recommended greater emphasis on training to provide the younger pilots the necessary experience. Another study (Lentz and Zeller, 1962) offered support to the importance of experience. Younger pilots experienced a higher accident rate during their early hours of rated flying than did the pilots who received their wings when 25

Table B-IV

U. S. Air Force Accident Rates by Age and Experience of Pilots[a]

Age of Pilot	Experience[b]					Rates for Each Age Group[c]
	0-499	500-999	1000-1999	2000-2999	3000+	
24 & under	76	28	35	---	---	70
24 - 29	58	32	26	26	28	37
30 - 34	16	22	19	18	10	17
35 - 39	8	19	25	15	16	19
40+	0	0	24	15	7	10
Rate for Each Experience Group[c]	61	27	22	18	12	29

a From Zeller and Moseley, 1956, p. 21.

b Total hours of flying as either a first pilot or instructor.

c "Rate" is not specifically defined for this table in the original report, but is presumably the number of accidents per 100,000 hours of flying as a first pilot or instructor.

or older. The older pilots apparently had previous experience that, at least in part, contributed to their lower accident rate.

Continuing the argument for experience as the more important factor in the age-experience-accident relationship is a study of copper workers by Van Zelst (1954) who found that, even when experience on the present job was less, older employees maintained better safety records during an 18 month experimental period. Van Zelst also notes the importance of training in the reduction of accidents. The possibility exists that employees hired at a later age by the company but who had previous experience in another job, similar or dissimilar, might transfer skills from one job to the next which would account for the consistently lower rate among older yet less experienced employees.

Kunce (1967) studied 62 subjects from a full range of occupations with a mean tenure of nine years. He administered the Strong Vocational Interest Blank and obtained an "accident proneness score" by subtracting the standard score for the Banker scale from that for the Aviator scale. He found that longer than average tenure was significantly related to a low accident rate (phi coefficient = -.38) and to lower accident proneness scores (phi coefficient = -.27).

In their extensive study of shop accidents, Powell et al. (1971) found several variables at work in accident reduction and among them was experience. Accidents decreased as work experience increased. The authors conclude that the experience effects may depend on specific tasks under observation.

Thorndike (1951), commenting on studies showing conflicting evidence emphasizing either age or experience, noted that the accident rate/age/experience relationship was not a universal constant.

The relationship shows variation dependent upon individual plant factors. Thorndike hypothesizes that the most important variable may be the nature of work performed by groups of differing ages and levels of experience.

Burov and Bizyayev (1967) compared accident rates for miners of different ages and experience levels. Their results are shown in Figure B-5. By age 34 there was a decline in injuries followed by a steady increase. The lowest accident group was the 26 year old workers with one to two years of experience. It was noted that workers who constantly changed places of work and occupation were more likely to have accidents. It should be noted in light of the comments of Thorndike (1951) and Powell et al. (1971) on the variability of accident rate from task to task, that Burov and Bizyayev do not report what the tasks of the miners were or whether "experience" was experience in general mine work or on a specific task. Past studies have failed to make this type of distinction and certainly experience on one type of job may differ from experience on another type even when the degree of hazard is apparently controlled.

Dobrowolski (1959) underlined the importance of accounting for the difference in tasks when considering age, experience, and accidents. He studied 860 accidents in a coal mine during one year and found, as shown in Figure B-6, that the majority who had accidents were 21 to 25 years old. There was a decline in the percentage of workers having accidents to age 40 with an increase to the age range of 51-55 followed by a sharp decline. Dobrowolski, in measuring experience, recorded both the time the subject was employed in the mining industry and the time since his last

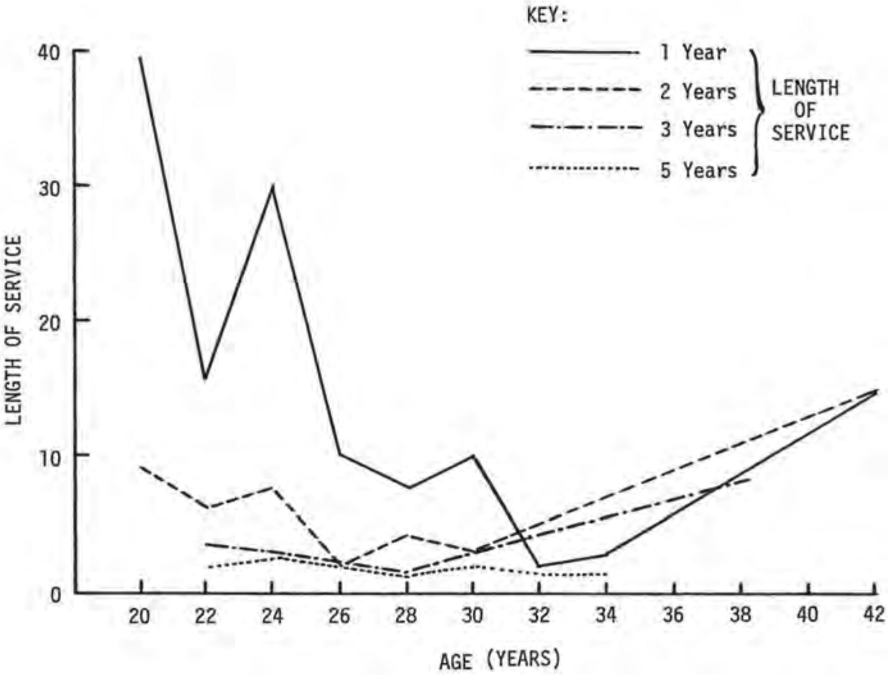

Figure B-5. Accident rates of underground miners as a function of age and length of service. (Adapted from Burov & Bizyayev, 1967 as cited by Fried et al, 1972.)

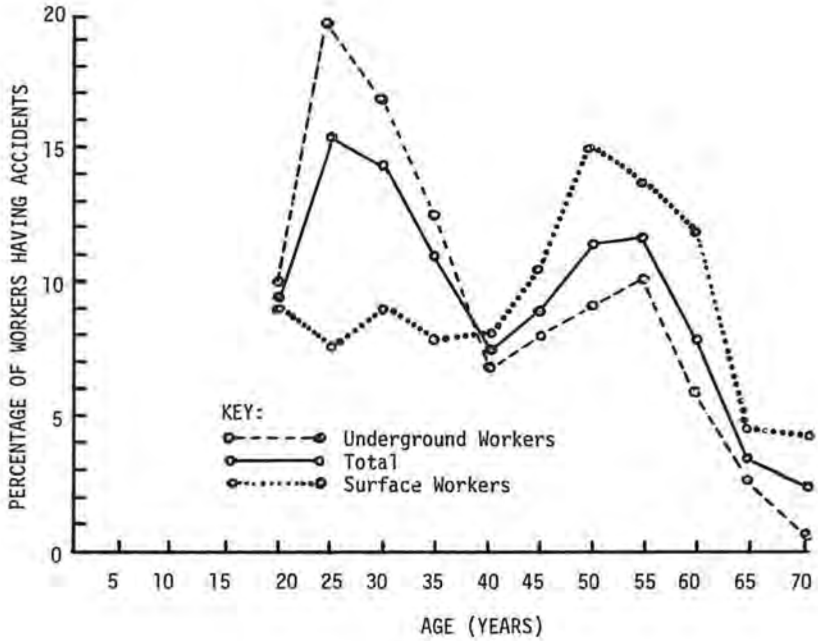

Figure B-6. Percentages of workers having accidents according to age groups. (From Dobrowolski 1959, as cited by Fried et al, 1972.)

occupation change. The highest number of accidents was in the second and third months of work in new working conditions. Workers who had many years of experience in mining, but whose work assignments had changed, showed a rise in accident rates during their first month in a new job as shown in Figure B-7. Martin & Prather (1973) report similar findings, namely that inexperience with the specific task rather than general experience or inexperience was the major factor in mining accidents. Although eliminating job postings or seniority bidding on jobs might decrease job mobility in underground mines which, in turn, might decrease the number of accidents, they suggest that such a procedure leaves the fundamental problem unsolved. Training, certification, and supervision are suggested as most important in reducing the number of accidents by ensuring that workers are aware of possible hazards and have some experience in dealing with them.

Data reported in National Safety News (1969) draws attention to the much neglected middle age group, between 25 and 44 years old and notes their low accidental death rate. As in studies noted above, the article cites evidence that accident rates are high in the first year of a new job assignment irrespective of age or length of company experience. This phenomenon, it is suggested, results from advancing technology which places older experienced workers in new jobs.

Cautions in interpreting age-experience-accident research. Many of the studies cited account for some of those variables which may affect the age/accident relationship. If a true picture is to be had of the influences of age on accidents, then we must consider some of the following.

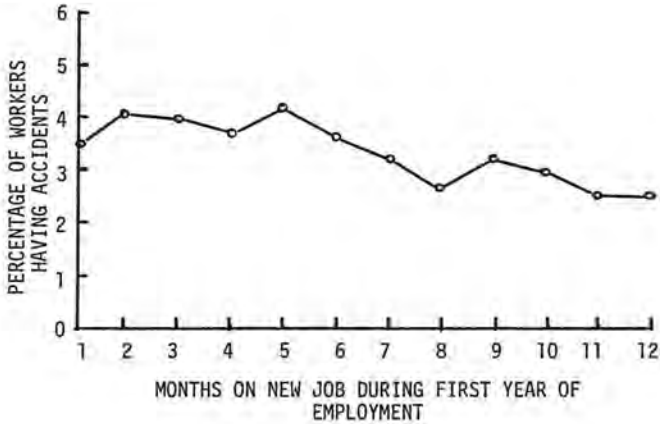

Figure B-7. Accidents during first year of work in new job situation. (From Dobrowolski, 1959 as cited in Fried et al, 1972.)

1. The types of hazards to which the worker is exposed must be noted. A study citing industry-wide statistics showing an especially low accident rate for older workers may result from the fact that all the older employees are in the least hazardous jobs while the younger persons are in the most hazardous jobs.

2. Those who have repeated accidents or who are unable to cope with the demands of the job may quit, die, or be severely injured, thus removing themselves from the population under study. Data showing that older employees are safer may do so because many persons have been eliminated by natural or self-selection. Also, there is a tendency for persons to gravitate toward jobs for which they feel qualified and in which they feel safe.

3. Those who are new on the job, regardless of age, may affect the data of the age group of which they are a part. Also, an old worker on a new job may or may not transfer old skills to a new job.

4. The way in which injuries are reported may affect the study's outcome.

5. The different jobs studied may have different age groups represented in them.

6. In some studies there is a tendency to fail to differentiate between numbers and rates. If more of the employees are under forty than over, then the number of accidents might be reported as extraordinarily high for the under forty group, although the rate might reflect no significant difference between the two groups.

Assessing all of the variables contained in the referenced literature gives us the picture of the older worker as one who is more careful and who has greater experience, but who is increasingly impaired physiologically. In summarizing their review of the literature, King and Speakman (1953) state, "...the picture which presents itself is that of two opposing tendencies:

on the one hand, the effect of experience, greater carefulness, and so on, becoming more pronounced with age and so tending towards a lower accident rate among the older workers; on the other hand, the biological decline of the organism as age advances. The resulting interplay issues as the observed accident rates for different ages [p. 57-58]."

Age and Performance

Over the past several years there had been increasing interest in the aging process and in behavioral changes as one grows older. As a result, there is a considerable amount of literature on the changes in sensory and motor capacity. Information on these changes is of interest in occupational safety and health because it has frequently been used to exclude older persons from specific jobs. Although there may be little information relating some specific sensory decrement to the incidence of accidents, the fact that there is a decrement is presumed to indicate the possibility of increased susceptibility to accidents. This is a presumption which ignores the fact that people compensate for their deficiencies by such things as wearing eye glasses, working more slowly, or self-selecting themselves out of dangerous situations. For this reason the review below is merely cursory to give a flavor of the performance decrements that if they occur in workers, may indicate a need for attention. Much material of this nature will be found in the Handbook of Aging and the Individual edited by J. E. Birren (1959) and to a lesser extent in Birren's (1964) textbook on The Psychology of Aging.

Work capacity. Snook (1971) studied the effects of age on continuous work capacity. Twenty-eight males were divided into two groups by age, 14 between 25 and 35 years and 14 between 45 and 60 years, and were instructed to perform 54 manual handling tasks for a duration of 40 minutes. The subjects were to adjust their workload to the maximum amount they could do without strain or discomfort. There were no differences between the two groups on measures of force exerted, in work rate, or in heart rate. Snook concludes that continuous work capacity does not decrease with age in moderate environments but that the older men were apparently working at a higher percentage of their maximum oxygen uptakes and maximum heart rates.

A review of the literature by Henschel (1970) supported the conclusions that (a) the capacity to perform light to moderate physical work is not grossly age-dependent, at least up to 65 years of age; and (b) the capacity to perform hard, exhausting work is strongly age-dependent with maximum aerobic capacity occurring between 20 and 25 years of age. The problem as outlined in the review is to develop simple tests for predicting the maximum aerobic capacity if an acceptable level of submaximal work is to be based on such a test. Shepard (1969) noted a decline in aerobic capacity and strength and an increase in obesity with age. By the age of 60 it is suggested that many men and almost all women seem unlikely to be able to sustain an eight-hour work load at three times the resting level of energy expenditure without fatigue.

Vision. Various visual functions have been cited as age-dependent. These include visual acuity, dark adaptation, critical flicker frequency, color differentiation, and perception of pattern and form.

Corso (1968) reviewed the literature on the effects of age on sensory processes and indicates that visual acuity is relatively poor in young children and improves to young adulthood; from the mid-twenties to the fifties there is a steady decline. Acuity, however, is affected to some degree by the level of illumination. In a summary of his chapter on perceptual processes in the Handbook of Aging and the Individual, Braun (1959) says, "In the case of vision, we know that acuity declines with age, but that acuity may be improved by increased illumination. Although the older eye benefits more than the younger eye from such heightened illumination, it never equals the latter in acuity [p. 558]." Braun further notes that untimed tests of acuity do not seem to find differences due to age.

The rate and final level of dark adaptation have been found to be related to age. McFarland and Fisher (1955) found a consistent decline in an ability to see at low levels of illumination with increasing age, and that the final level of dark adaptation was clearly a function of age as shown in Figure B-8. The linear correlation between age and final threshold level was .89. Each increase of 13 years in age requires a doubling of the intensity of the light. The rate of adaptation had a curvilinear relationship to age as evidenced by a slower rate for both older (50-59 years) and younger (20-29) age groups than for the intermediate group (30-49). Birren (1964) notes in his book on aging that the minimum light threshold of the dark adapted eye rises from about 2.60 Log $\mu\mu$L to about 3.00 at age 65 and to 3.85 at 70 to 80 years.

McFarland and Fisher (1955) warn that their findings

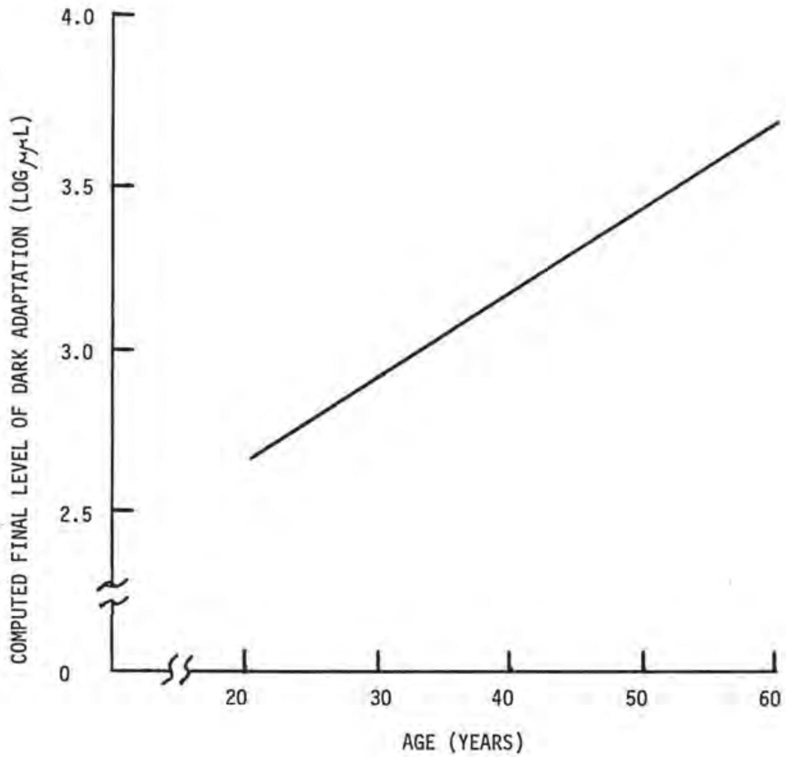

Figure B-8. Approximation of the relationship between age and final level of dark adaptation. (Adapted from data in McFarland & Fisher, 1955.)

imply serious questions of safety for persons over 55 to 60 years old in flying or driving at night. Corso's review (1968) reiterates the point of safety and stresses the slower rate of dark adaptation: "The older person has a lengthened period during which he cannot see in the dark, and this lengthened period could lead to a delay in driving response which might be fatal [p. 9]."

The ability to focus on objects at varying distances, which is called accomodation, is affected by age as noted by Birren (1964). The older person has a more fixed focus and is less able to adjust to objects close to the eye. At age 10 the capability is about 12 to 22 diopters and falls until at age 55 the capability is about 1 to 3 diopters. Capability is approximately constant thereafter.

Table B-V presents the nearest distance at which the eyes can focus on a point, and demonstrates the manner in which the point recedes with age. Corso cites Weale (1960) as indicating a part of this decrease in ability to accomodate is a continuous accumulation of insoluble proteins causing hardening of the lens.

There is also a concentration of yellow pigment which decreases the amount of light which falls on the retina. In certain situations, depending upon the color of light being used as a stimulus, this can affect performance. Gilbert (1957) as cited by Braun (1959) notes that an ability to match blue and green declined rapidly with age. This phenomenon is ascribed to the yellowing of the lens with age. This

Table B-V

Near Point of Vision at Various Ages [a]

Age	Near point distance (Inches)
10	3
20	4
30	5.5
40	8.5
50	15
60	39

[a] From Morgan & King, 1966 as cited in Corso, 1968.

yellowing acts as a filter, and if the stimulus light is predominately in the blue part of the spectrum, then the amount of light reaching the retina is reduced and thresholds are raised. Corso cites Weale (1961) discussing the use of white light as a stimulus in establishing threshold. If the absolute threshold is measured with short wavelength blue or violet, there is a significant increase in threshold with age.

There are also decreases in critical flicker frequency with age and these decrements are ascribed to a reduction in the efficiency of the central nervous system (Corso, 1968). Poorer performance of older persons on many perceptual problems is interpreted as reflecting a change in the speed with which older people can perceive and respond (Braun, 1959).

Audition. Corso (1968) has reviewed the literature on age related hearing loss (presbycusis). Combining data of eight publications has produced a general function from which the hearing loss due to age can be determined. These are summarized by Corso as follows:

1. For frequencies up to 1000 Hz, the hearing loss is less than 5 db up to 50 years of age and is almost independent of frequency.
2. Above 1000 Hz, hearing loss increases with frequency for ages 55 and over.
3. Persons under 55 years old have their greatest hearing loss at 4000 to 6000 Hz rather than at 8000 Hz.

The formula used to produce these conclusions considered only those frequencies of 8000 Hz or less. Northern, et al

(1972) indicate that instrumentation problems plagued researchers who wished to study auditory sensitivity of 8,000 to 18,000 Hz. They performed a field survey of high frequency hearing and, as shown in Figure B-9, they found decreasing sensitivity with advancing age. The decrement is greater at higher test frequencies.

According to Corso's (1968) review, intelligibility of speech is seriously affected by presbycusis. There is difficulty in discriminating between consonants which have high-frequency components in their acoustic patterns as for s, z, t, f, and g since presbycusis involves high-tone hearing loss. Corso says the older person finds it difficult to discriminate between phonetically similar words which also affects his ability to follow the sense of a particular conversation. The problem is worse in noisy environments since the noise tends to mask the weaker high frequency components of speech sounds. However, McFarland and O'Doherty (1959) maintain that people even with moderate decreases in sensitivity above 2000 Hz still have fairly normal hearing for speech in the presence of background noise.

Motor skills. The question of the impairment of motor skills as a function of increasing age has been the subject of several studies.

Planek and Fowler (1971) reviewed accident data and administered a questionnaire to determine the nature of the traffic accident problems of the aging driver. They note that aging drivers may face problems in driving when their adaptive reactions must match the rate of other drivers.

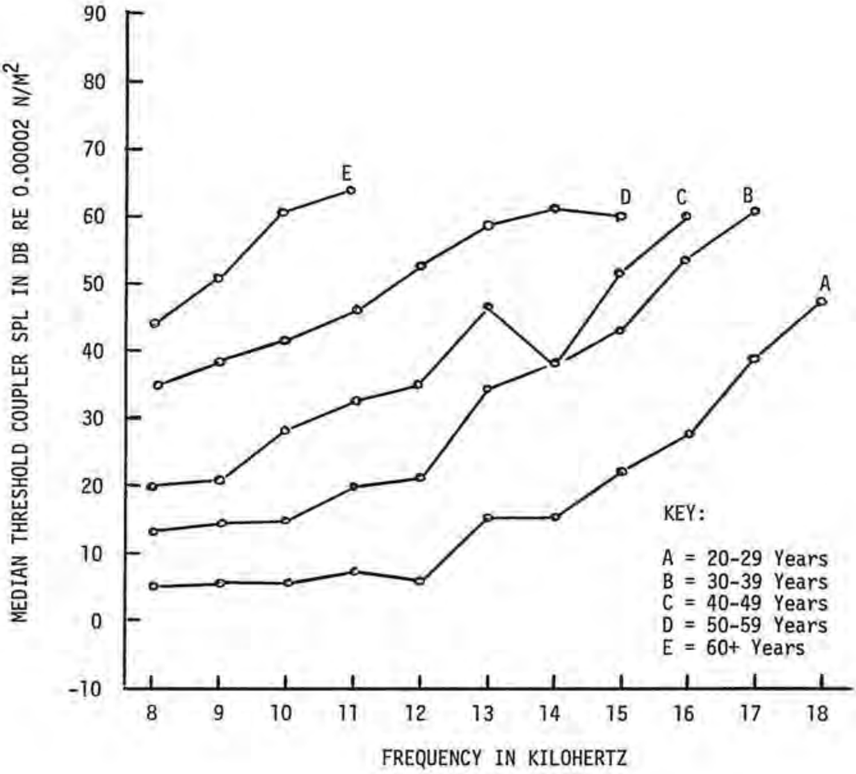

Figure B-9. Median thresholds in a field survey of high-frequency hearing loss. (Adapted from Northern et al, 1972.)

They feel that an education program for aging drivers should concentrate on reducing the need for rapid adaptive reactions in the driving process.

Cation, Mount, and Brenner (1951) in a study of the variability of reaction time found a statistically significant correlation between mean reaction time and age.

Whitfield (1954) in a study of accidents among miners found that the older subjects who had accident histories greater than would be expected by chance were markedly deficient on tests of motor control.

In a review of the research, Welford (1962) cited a slowing of sensorimotor activities with age.

Figure B-10 presents information from De Silva (1938) showing a decrease in ability on tests of steering coordination, and breaking reaction with age.

Birren's (1964) summary of the literature on psychomotor skills indicates that changes in basic motor skills in persons over 65 contribute to their high accident rate as in injuries from falls. There is a slowing of all the psychomotor skills which the older person adapts to by avoiding situations with unusual time pressures (Birren, 1964).

Welford's (1959) review of psychomotor performance in the Handbook of Aging and the Individual maintains that there is relatively little change of speed or accuracy among older people with very simple tasks such as classical reaction-time measures, but changes do appear with age when movements have

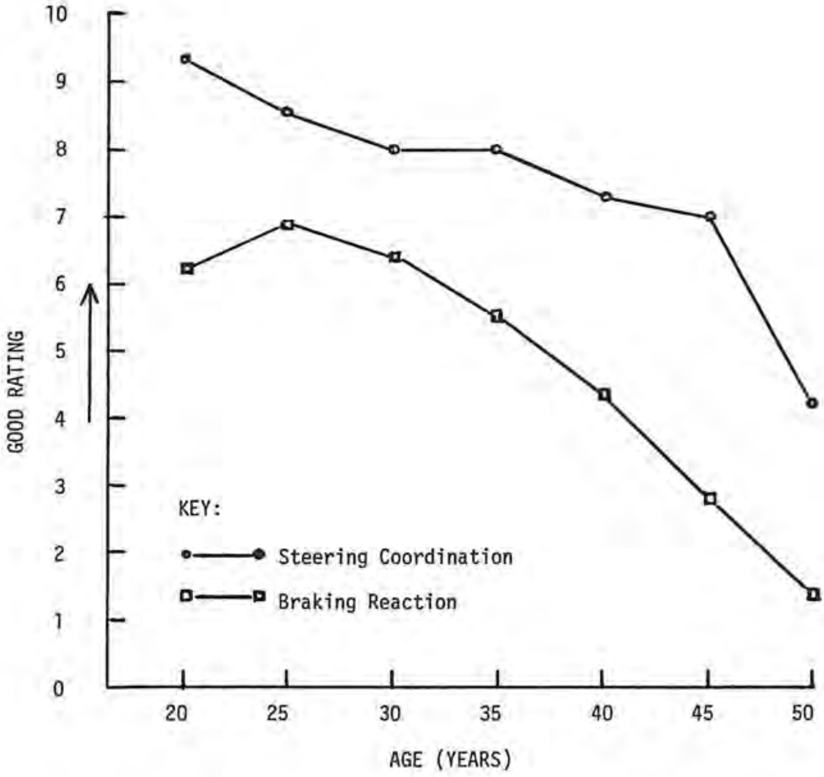

Figure B-10. General decrease of ability with age in steering or eye-hand coordination and braking reaction time. (Adapted from De Silva, 1938.)

to be carried out in a continuous coordinated series. Changes are much greater when complications are introduced into the rules by which the subject must relate what he perceives to what he does. There is also a tendency for older people to shift from speed to accuracy when the situation permits.

Ventilatory function. Ashford, Brown, Morgan, and Rae (1968) report an effort to evaluate the significance of various factors such as anthropometric measurements, smoking habits, respiratory symptoms, and age on ventilatory functions of coal miners. Thirty thousand miners were subjected to medical examination and the data were fitted to a multiple regression equation which assumed ventilatory functions might be expressed as a linear function of age, height, sitting height, and weight as follows:

$$\text{Ventilatory function} = b_o + (b_1 \times \text{age}) + (b_2 \times \text{height}) + (b_3 \times \text{sitting height}) + (b_4 \times \text{weight}) + e$$

in which b_o is a constant, b_1 through b_4 are the regression coefficients, and e is the residual error term.

Table B-VI presents the predicted values of forced expiratory volume 1 second (FEV_1), vital capacity (VC), and the ratio of the mean FEV, to the mean VC (FEV_1/VC%) for a given set of conditions. The most significant variable was age and the second most significant was height. There was a negative correlation between ventilatory function and age. Smokers developed symptoms at an earlier age than non-smokers and the overall prevalence of respiratory problems was higher for the

Table B-VI

Predicted Values of FEV_1, VC and FEV_1/VC Percent for Men of Height, 170 Cm, Sitting Height, 90 Cm, and Weight, 71 Kg at Ages 40, 50, and 60 Years Analysis for All Collieries, Men Aged 25 to 61 Years[a]

Smoking Habits	Pneumoconiosis Category	Respiratory Symptoms	No. of Men	FEV_1 40 Years	FEV_1 50 Years	FEV_1 60 Years
Smokers	0	Without	12,559	3.21	2.84	2.44
		With	3,771	2.86	2.42	1.98
	1 or more	Without	1,801	3.17	2.76	2.34
		With	1,625	2.84	2.45	2.05
Nonsmokers	0	Without	2,437	3.31	2.95	2.60
		With	299	2.70	2.29	1.89
	1 or more	Without	382	3.23	2.83	2.44
		With	169	3.41	3.04	2.66
Ex-smokers	0	Without	1,102	3.33	2.93	2.54
		With	299	3.19	2.73	2.27
	1 or more	Without	171	3.19	2.86	2.52
		With	136	2.92	2.44	1.97

Continued

[a] From Ashford, Brown, Morgan, and Rae, 1968.

Continuation of Table B-VI

No. of Men	VC 40 Years	VC 50 Years	VC 60 Years	No. of Men	$FEV_1/VC\%$ 40 Years	$FEV_1/VC\%$ 50 Years	$FEV_1/VC\%$ 60 Years
10,705	4.37	3.98	3.60	10,705	73.6	70.7	67.8
3,245	4.06	3.59	3.11	3,245	69.9	66.4	62.8
1,660	4.28	3.86	3.43	1,660	74.3	71.2	68.0
1,436	3.95	3.51	3.11	1,436	72.3	68.7	65.1
2,098	4.35	4.01	3.66	2,098	75.4	72.9	70.4
266	3.93	3.47	3.02	266	67.8	61.7	61.5
350	4.26	3.88	3.51	350	75.9	72.5	69.2
148	4.03	3.63	3.24	148	74.8	70.2	65.5
907	4.40	4.01	3.63	907	75.1	72.3	69.5
258	3.94	3.44	2.93	258	68.4	64.3	60.1
148	4.17	3.84	3.52	148	74.4	71.7	69.1
120	4.11	3.53	2.95	120	72.4	69.3	66.2

smokers.

Holland and Stone (1965) also found a significant negative correlation (-.40) between age and FEV_1 in 625 telephone company employees working in various places on the east coast. Figure B-11 shows the distribution of FEV_1 in two age groups.

Densen et al. (1969) also found a decrease in FEV_1 with increasing age of postal and transit workers.

Ferris (1971) performed simple tests of pulmonary functions and collected anthropometric measurement on the same group of subjects. The results showed that age and standing height correlated most closely with the tests of pulmonary functions in a white population. Because of differences among people in the proportions of trunk length to overall height, the same results cannot be obtained with interethnic comparisons.

Leblanc & Ruff (1970) found that in seated subjects older than 65 years and in supine individuals older than 44 years there was significant impairment of ventilation distribution to the dependent lung zones. This impairment causes restricted gas exchange within the lungs.

A questionnaire administered to asbestos miners by McDonald et al (1972) found that breathlessness on exercise was related to age and dust exposure but not to smoking while the prevalence of persistent cough and phlegm was related to age and smoking habits.

Learning and training. Birren (1964) cites evidence suggesting that changes with age in the primary ability to learn are small under most circumstances. When differences do

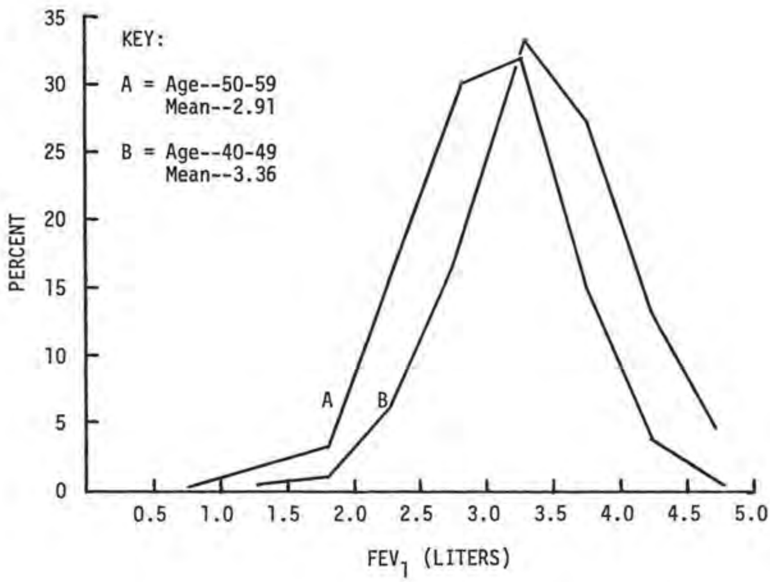

Figure B-11. Distribution and mean values of forced expiratory volume (1 second) by age, in American telephone men. (From Holland & Stone, 1965.)

appear, they seem to be more readily attributable to processes of perception, set, attention, motivation, and physiological state than to a change in the primary capacity to learn.

McFarland and O'Doherty (1959) note that there is no reliable procedure to estimate mental abilities such as insight, judgment, and reasoning, which seem to increase in efficiency with age.

In a study of air traffic controllers, Trites and Cobb (1962) found that the chances for an individual to be considered a satisfactory controller if he is 33 or older at the time when he enters training are approximately 1 in 4; if he is under 33 years of age at entry into training, the chances are 1 in 2. This is indicative of a considerable higher success rate for the younger candidates. A subsequent study, (Trites, 1964) explored the relationship between training entry age and intellectual and personality characteristics in a population of more than 900 air traffic control specialists with the following results:

1. Older trainees had lower test scores than younger trainees on tests of immediate memory and non-verbal abstract reasoning,
2. Older trainees had higher test scores than younger trainees on tests of arithmetic and verbal ability,
3. In highly speeded aptitude tests, the type of test (such as arithmetic, spatial, vocabulary,) seems to determine whether the older or younger trainees have higher scores, and
4. Older trainees were found to be more intellectually

efficient, responsible, and tolerant, than their younger classmates.

Trites (1964) concludes that the higher training failure rate of the older individuals can be partially accounted for by inferior aptitudes for non-verbal abstract reasoning, memory for new material and ability to work as rapidly and accurately as required in training on the job.

Job requirements. Any research on the relation of age (or many other personal factors) to occupational safety and health must take into account the effects of job requirements on the sample of persons studied. McFarland and O'Doherty (1959) quote data (from Le Gros Clark and Dunne, 1956) showing "survival rates" in various occupations. By this they mean the number of workers who are physically able to continue in various occupations beyond the mid sixties. Table B-VII shows samples.

Job requirements may place demands upon the older worker that he cannot handle even though he may have been quite capable when younger. Griew (1958) concluded that older workers in jobs normally occupied by younger workers (electrician, miller, and grinder) tend to have more accidents than expected. He interprets this as reflecting the difficulties of older workers in meeting the demands of certain types of work.

There have been many attempts to match job demands with worker abilities. McFarland and Philbrook (1958) discuss some of these methods relating to placing the older worker on jobs.

Table B-VII

Percentage of Workers Who Are Physically Able to Continue In Various Occupations After Age 65[a]

Occupation	Percentage Survival Rates
Watch and clock makers	75 - 85
Carpenters/bricklayers	65 - 75
Mine surface workers Plumbers/plasterers	55 - 65
Underground mine workers not at the coal face Riveters Cabinet makers	45 - 55
Foundrymen/Paper makers	35 - 45
Construction engineers	25 - 35
Coal-face workers	5 - 15

[a]Adapted from LeGros Clark & Dunne, 1956 as cited in McFarland & O'Doherty, 1959.

1. The intuitive method where the "boss" peruses the "stock" and picks those who look most suitable for the task at hand.
2. The disability method based on the notion that people with specific disabilities cannot perform certain tasks but ignores the fact that the remaining abilities differ from person to person.
3. The rating method in which subjective estimates of the surviving abilities are made and matched to the results of a job analysis.
4. The "specific method" in which the physical and environmental demands of the job are measured and the abilities of the individual to meet these demands are determined.

In performing research in industry on the relation of aging to worker health and safety it may be that the results are partially influenced by whether such a program of matching is or is not present in the plant. There are changes with age, and the plant may or may not be taking cognizance of such changes.

Birren (1964) notes that one's physical capacities develop and decline earlier than one's mental capacities. The later development and continuance of one's psychological capacities permits high-level achievement over most of one's life time. However, older persons and those with low educational attainment tend to be dropped from employment in periods of high technological change. This phenomenon may be the result of technological change and subsequent outdated skills rather than a lack of physical and/or mental capacity.

Illness

Backaches. Tauber (1970) discovered that seasons of the year, height of the individual, and age seem to have an effect on backaches. Young persons were involved at a higher rate than older persons as shown in Table B-VIII.

Simons and Mirabile (1972) in a literature search and survey of over twenty thousand workers found that the younger age groups had the greatest number of back injuries. Several reasons for this phenomenon are offered by Simons and Mirabile including: (a) the younger workers are more careless and less fit, (b) they are less reticent to visit the physician, and (c) they are employed in more dangerous jobs. Self selection may also be operating so that younger persons experiencing back problems in a given job may change to a job where they do not suffer back problems.

Dermatitis. Barnes (1970) in a study of 300 cases of dermatitis revealed that the highest incidence occurred among the 40 to 50 age group, but this quite likely reflects job assignment rather than real age differences in susceptibility. Burrows (1972) found that the incidence of dermatitis diminished with age, although risk was reduced by only 50% in the older age group as compared with the younger age group.

Respiratory system. There is an increasing incidence of many types of respiratory disorders with increasing age. Of most concern is the risk of lung cancer and the development of chronic bronchitis. Identifying specific sources of the risk is difficult although there have been attempts to show that exposures to specific agents results in greater incidence of the disease than does lack of exposure and that the greater the length of time exposed, the greater the risk. Since the

Table B-VIII

Frequency of Backache in Each of Several Age Groups of Workers in a Large Plant [a]

Age (years)	Backache Frequency (%)
18-24	3.25
25-34	2.34
35-44	1.68
45-54	1.74
55-64	1.68
65 and over	0.00 (of 326 employees, none had backaches.)

[a]From data reported in Tauber, 1970.

longer the person is exposed to an agent, the older he is, there appears in many cases to be an age/disease relationship with exposure. For example, Boucot et al (1972), in studying 6,136 males 45 years old and over, report that the risk of developing lung cancer increased with age. Saccomanno et al (1971) found that the incidence of epidermoid carcinoma increased with age in a study of lung cancer among uranium miners. Naeye (1971) found an increase in the volume of macular dust lesions with age among 322 Appalachian miners. Armasu et al (1971) studying workers facing various occupational hazards found the incidence of chronic bronchitis greater among older employees who had more years of service. Doll, Morgan and Speizer (1970) concluded that susceptibility to cancer induction associated with the refining of nickel is determined by the amount of previous exposure to other agents. Susceptibility to nasal cancer increased with the age of the worker at his first exposure, but susceptibility to lung cancer varied irregularly.

In other cases, where no specific agent can be identified, there is still an increase in certain respiratory problems with age. Holland and Stone (1965) studied 625 telephone company employees working in various places on the east coast. They found an increase in sputum production with age (Table B-IX) and an increase in dyspnea and other respiratory problems with age (Table B-X).

<u>Notions of Performance Capacity and Age</u>

There appears little doubt that, as a person ages, his performance changes. The available data support the notion

Table B-IX

Sputum Volume by Age (saliva counted as nil volume) in East Coast Telephone Plant Men, Percentages [a]

Sputum Volume (cc)	Age-group (years)		
	40-49	50-59	40-59
Nil	70.2	65.5	68.5
<2	19.2	22.7	20.5
2-6	6.8	8.7	7.5
6+	0.3	1.3	0.6
Not returned	3.5	1.7	2.9
Number of men examined	396	229	625

[a] From Holland & Stone, 1965.

Table B-X

Prevalence of Respiratory Symptoms by Age in East Coast Telephone Plant Men[a]

	Age group (years)					
	40 - 49		50 - 59		40 - 59	
	No.	Per-cent	No.	Per-cent	No.	Per-cent
Q1 Morning cough, winter	112	28.3	80	34.9	192	30.7
Q2 Morning cough, summer	82	20.7	57	24.9	139	22.2
Q3 Day cough, winter	89	22.5	56	24.5	145	23.2
Q4 Day cough, summer	65	16.4	47	20.5	112	17.9
Q5 Persistent cough	113	28.5	80	34.9	193	30.9
Q6 Morning phlegm, winter	126	31.8	76	33.2	202	32.3
Q7 Morning phlegm, summer	88	22.2	65	28.4	153	24.5
Q8 Day phlegm, winter	88	22.2	55	24.0	143	22.9
Q9 Day phlegm, summer	67	16.9	39	17.0	106	17.0
Q10 Persistent phlegm	126	31.8	73	31.9	199	31.8
Q12 Chest illness	61	15.4	32	14.0	93	14.9
Q14 Dyspnea grade 1	261	65.9*	110	48.0*	371	59.4
grade 2 +	135	34.1*	119	52.0*	254	40.6
Q15c Wheeze most days/nights	36	9.1	21	9.2	57	9.1
Q17f Weather + dyspnea	18	4.5	13	5.7	31	5.0
Q20 Persistent stuffy nose	94	23.7	57	24.9	151	24.2
Q21 Chest illness	85	21.5	50	21.8	135	21.6
Q22 Asthma	18	4.5	7	3.1	25	4.0
Q23 Hay fever	28	7.1	20	8.7	48	7.7
Cough grade 2 (Q1 + 3 + 5)	54	13.6	39	17.0	93	14.9
Phlegm grade 2 (Q6 + 8 + 10	60	15.2	36	15.7	96	15.4
Persistent cough + phlegm (Q1/3 + 5 + 6/8 + 10)	88	22.2	59	25.8	147	23.5
Persistent cough + phlegm + chest illness (Q1/3 + 5 + 6/8 + 10 + 12b/c)	27	6.8	16	7.0	43	6.9
No. of men examined	396	100.0	229	100.0	625	100.0

* $p < 0.01$.

[a] From Holland and Stone, 1965.

that performance decrement is one result of aging, yet as age increases the individual compensates for decreasing ability. The older worker may in fact outperform the younger in specific instances. Age is only one factor in judging the performance of an individual. Birren (1964), indicates that anatomical changes in the sensory receptors associated with aging reduce the amount of information that can be imparted per unit of time. While there are wide variations so that it is difficult to tell exactly when this reduction becomes important in the limits it places on behavior, he proposes age 70 as being the point at which the sensory processes themselves have changed so much as to be limiting. Until age 70, disease and other unique circumstances would appear to be more relevant than age related changes.

Welford (1959) discusses the concept of "capacity" in connection with aging. He proposes that peripheral and central mechanisims have a capacity which is limited both in the amount of data that can be handled at any one time and the amount that can be dealt with in a given period of time. Also, signals must be dealt with against a background of random neural activity or "noise." Loss of signal or lowering of signal to noise ratio can in part be compensated for by integrating data over a longer period of time. Hence, the older person, through a lessening of the number of receptor cells receives fewer signals in a given period of time and must take more time to process them. This is the explanation for the slowing of virtually all processes in the older person.

Welford (1959) maintains that, where conditions permit the person to compensate for deficiencies, he does so and the effects of aging on total performance are minimized. However, when the form or pace of performance is rigidly determined, then the effects of aging on performance are severe. Modifying "the design of jobs to lessen requirements for rapid action or the risks of sudden hazards . . . could bring many jobs at present confined to younger people into line with the capacities of those much older (p. 610)."

McFarland and O'Doherty (1959) stress the individual differences in the aging process. They maintain that "age" is determined by things other than chronological age. There are physiological and functional differences among individuals such that a given 60 year old may be faster reacting than a given 20 year old. They also maintain that age is only one factor in judging the probable behavior of an individual and a very poor one at that, principally because of the wide physiological and functional differences among individuals.

In any event, there seems little doubt that the inevitable intermixing of age and experience effects, the self-selection and other kinds of selective factors, and the compensatory behavior of individuals to reduce risk all serve to make difficult the isolation of purely age effects as a variable in health and safety research.

SUMMARY OBSERVATIONS

Problems of Research Methodology

In discussing age as an individual factor in worker safety and health, it is almost universally accepted that one is discussing chronological age. Research has demonstrated numerous changes in health, sensory capacity, and psychomotor capabilities with increasing chronological age. However, the literature on the effects of age in worker safety and health presents major problems when one attempts to translate the research findings into action. For example:

1. While clearly demonstrating that various capabilities decline with age, research efforts have generally failed to correlate these decrements with accidents.
2. There has not been proper consideration of the tremendous individual differences in measured capability at any given chronological age.
3. The effects of compensations which the worker might make to maintain his performance have been largely neglected.

Some researchers have been particularly sensitive to these points and have attempted to call attention to them. McFarland and O'Doherty (1959) discuss these problems and indicate the need for a concept of "functional age" to replace the concept of chronological age in age-related effects. This suggestion is offered to make explicit the facts that aging persons do compensate so their performance may remain at a given level even though specific capabilities decline, and also that there are great individual differences at a given age. Welford (1959) indicates that there is a slowing of all sensori-motor activities with age, but that when conditions permit the person to compensate for difficulties and deficiencies he does so. In such cases, the effects of age on his performance are minimized. However, most research studies on the effects of age on accidents do not incorporate such refinement in their designs. That is, older workers are nearly always compared to younger workers with little regard for whether the tasks involved permit compensation. It is likely that some of the discrepant research findings owe their inconsistency to such problems.

A seemingly insoluble problem of doing research on age and accidents is the difficulty of eliminating the effects of experience. As the worker grows older he also becomes more experienced. It is not easy, therefore, to determine how much of a given effect found in a research study is due to age and how much to experience. One procedural solution to this dilemma is to constitute subgroups of subjects so that pairs of subgroups have approximately equal experience but differ in ages. This is only a partial solution because persons of equal tenure on a specific job may differ radically in their experience in the industry or in work shop experience in a different job.

A related problem in the age and accident research is the selection process that results in the "survivors" constituting the older group. Those workers involved in fatal accidents at young ages are, of course, not in the older sample. Also, if a person experiences several accidents early in his career he may decide to move to a less hazardous job. Older workers because of seniority privileges usually can select the jobs in which they would like to work and may select less hazardous jobs. All of these selection factors can function so as to leave as the older workers in a given job those who have been able to survive. Hence the accident rate for these workers may appear lower compared to young workers when, indeed, the selection factors may have produced the effect.

Hypersusceptibility

Given the considerable caution with which one should interpret the work on aging, it still appears that there is indeed some association between age and hypersusceptibility to accidents. Whether this is due to differences in experience, or changes in sensori-motor capability is unknown, but the effects appear to be age-related. It would appear, furthermore, that there is an interaction effect among age, experience, sensori-motor capability, and task requirements so that no single factor can be considered independently. The evidence may be summarized as follows:

1. Workers in the age range from about 25 or 30 years to about 55 years generally appear to have fewer accidents than might be expected by chance.
2. Tasks requiring a considerable amount of judgment and anticipation of unexpected conditions may result in the younger worker being at a disadvantage.
3. If the task is so structured or the pace of performance is rigidly determined so that it does not permit the older worker to compensate, then the effects of aging can be severe.
4. Older workers will, in general, do less well on complex tasks requiring fast response.

Accidents to older workers are apt to produce more severe and long-lasting effects than those to younger workers. It has been suggested that this is a possible result of lessened physiological recuperative capability. Also, older workers appear more vulnerable to unhealthy work environments such as high temperatures or inhalatory irritants due either to the effects of long exposure or to lessened resistance.

Selection and Placement

As a general rule, older workers should not be placed on paced work especially when speedy and complex responses are required. Just when a person becomes "an older worker" is indefinite. However, when measures of an individual's complex sensori-motor capability are below the average for younger workers on the job, it would not seem advisable to place him in a possibly hazardous category. Alternatively, the job could be redesigned to accommodate these lessened capabilities.

Older workers should not be considered incapable on the basis of chronological age, but rather should be judged on their mental and physical capabilities. Chronological age may be used as an indicator that certain capabilities should be checked. Even then, there should be some direct or clearly inferred evidence of an unsafe condition resulting from reduced capabilities. For example, ventilatory capacity decreases with age, but performance measures on tasks where ventilatory capacity might play a role may not necessarily deteriorate. That is, the older person may work at a greater percentage of his capacity or compensate in other ways.

There is some evidence that older workers should not be chosen for work requiring the ability to memorize quantities of material. Memory and non-verbal abstract reasoning abilities tend to deteriorate with age.

Ameliorating Age-Related Hazards

Experimental evidence suggests some methods for reducing the effects of age on accidents. These include:

1. Providing young employees with sufficient training time to permit acquiring experience as well as job skill.

2. Introducing employees of any age slowly into a new job situation by such means as classes and working in simulated conditions prior to actual on-the-job experience.

3. Assisting older workers by providing periodic vision and audition examinations and recommendations of corrective devices which may help them. Compensation for reduced sensorimotor capability may be facilitated by retraining older workers in new work techniques to alleviate the need for fast responses to paced work.

4. Redesigning job tasks to eliminate the need for older workers to make fast responses to paced work.

Research Needs

1. Although studies in the past have inferred that the reduced performance capability of the older worker means increased risk of accidents, there is little experimental evidence linking accidents to specific age-related sensory and motor decrement. This is true for measures of both behavioral and physiological performance.

2. Physiological and behavioral performance standards defining functional age need to be developed. These standards would be more useful to industry than is chronological age in determining worker placement.

3. There appears to be an interacting effect of age, experience, sensori-motor capability and task requirements in age-related accidents. There is a need to identify types of industrial tasks or job situations in which these effects operate.

4. Study should be made of the compensatory behavior of successful older workers, comparing the manner in which they accomplish specific tasks to the methods of trained younger workers. Such study could lead to task reorganization or retraining techniques for the less productive older worker and possibly reduce accident risk. It also could suggest ideas for training new workers for prolonged careers in any given job.

5. There is considerable work needed in assessing the impact of adult training and education in reducing rates of workers illness and injury and of motivational programs aimed at getting those workers who will be exposed to hazardous situations for many years of their working life to use appropriate protective gear.

6. More work should be done relating age to worker attitude toward the job. Attitude should be thoroughly studied as a factor in accidents. This factor may prove comparable to inexperience in determining the higher accident rate for young workers in many occupations.

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AGE

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	 Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	 Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents	93 859 480 1036 481 487 490 494	85 754 341 901 482 935 491 1001 492 1113 496 1196	88 94	1 914 2 931 6 1026 478 1214 493 901		
Agent - Specific Diseases		55 790 97 829 647 830 740 834		914		
Non-Specific Disorders	517	11 242 26 1083 77		914		
Critical Incidents						
Rate/ Amount of Sick-Absence			94	493 901 914		
Perform-ance Indices	56	11 855 27 1025 77 1083 140 186 242 434	312	714 1214 719 1215 810 1216 901 1275 914 1276 972 1280 1025 1282		1217
Strain Indices						
Morale						
Compliance with Rules						
Off Job Problems						
Miscel-laneous	1208 1211 1279	56 96 1210 1212 1218	315	914 1026 1209 1277 1281		

SEX

A portion of a report--

PROBLEMS IN
OCCUPATIONAL
SAFETY AND HEALTH:
A
CRITICAL REVIEW
OF SELECT WORKER
PHYSICAL
AND
PSYCHOLOGICAL
FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

SEX

Historical Background

Between March 1940 and April 1945, the number of women in the labor force in the United States rose from 13,783,000 to 19,290,000. This increase in the employment of women during the years of World War II was unparalleled in industrial history. Not only were more women working as wage earners, but many were doing jobs previously filled only by men. Songs told of Rosie the Riveter and attention of those concerned with such matters focused on the various social, psychological, and economic effects of this movement. Because they were filling jobs previously filled by men, attention was also directed to their safety and health on the job.

Although there was a post-war decrease, the number never dropped to pre-war statistics and the percentage of women joining the female labor force population was also higher after than before the war. The increasing numbers of women in the labor force is attributed to a number of factors.

1. Women outnumbered men in the 1970 Census of the United States by about four million, which is double the 1960 figure. Even though there are more male than female births, males have a higher mortality rate. There is also a larger total of female immigration.
2. There is an increasing demand for labor as the industrial structure of employment has shifted progressively from agriculture to goods-producing

activities and more recently to service-type activities. In 1970 there were about 35% fewer farm workers compared to 1960 while factory workers and machine operators were up 21% and service workers had increased 14% compared to 1960 figures.

3. Partly as a result of this progressive shift in occupations, there has been a trend toward urban living. Three times as many people in the United States lived in urban areas as lived in rural areas in the 1970 Census.
4. Aspirations for a higher standard of living and a higher level of education have created a desire for employment outside of the home. Widespread use of laborsaving equipment in the home has given women the time to seek such employment.
5. Rapidly expanding clerical, service, and sales occupations have provided increased job opportunities for women.
6. Over the years there has been an evolution in social attitudes and values have changed so as to encourage women to develop their abilities and talents to the fullest in paid work.

In recent years there have been efforts to remove all references to sex in advertising employment opportunities.

One result is that, as in World War II, women are again filling jobs that almost exclusively employed males in previous years. As in the previous war years, there is at least scientific concern about the safety and health of women on the job. Are there data to show that there are differences in accident rates between male and female workers? Are there special precautions that should be taken to guard against occupational stresses to which women may be more susceptible than men? Accordingly, the available literature on this topic was searched.

Although the ultimate goal of the review is to contrast male and female occupational health and safety matters, attention in this chapter is devoted to literature which pertains to the safety and health of women. In outlining the response of women to a given industrial environment one compares them to men, so the approach provides data on both men and women.

Furthermore, a discussion of the sex factor in industrial safety and health includes all literature dealing with the individual response of males and females. Since workers can be categorized as male or female, a great deal of the literature on occupational safety either directly or indirectly contains relevant information. It appears to be generally assumed in the literature that the data are for an exclusively male population. In many cases this is true, for those industries which receive the greater attention are often the more hazardous and consequently, in the past, have employed fewer women. In some cases, the researcher does not even specify sex, and therefore the reader has no way of knowing the response of the female population, if one exists. The literature in this review, then, has been selected to demonstrate the collective and individual responses of women to the industrial environment. This approach is used to set some limit on the scope of the literature to be covered and will highlight, citing representative literature, where women vary in their response to occupations when compared with men.

Data Limitations

Historically, women have been considered inferior to men in their abilities to perform certain tasks. The generally smaller size of women and their lesser strength when compared to the average adult male have been cited as the basis of this stereotype. Sherman (1971) in a survey of studies on the psychology of women notes that physiological data indicate that the old stereotype of the female being the "weaker sex" is clearly correct because women are not as strong muscularly as men.

Another factor which is mentioned to show that women are inferior to men in certain tasks is their greater susceptibility to fatigue. Surry (1968) makes the point that working women were also working several hours at home after a normal workday. As a result they were constantly active 16 to 18 hours of a day. She postulates chronic fatigue as a result which could account for a dramatic decrease in accidents for women working 10-hour days compared to those working 12-hour days in Vernon's (1945) study.

As a result of these stereotypes and data, laws and restrictions exist or have existed regulating the following aspects of women's employment:

- hours of work
- days of work
- meal periods
- rest periods
- nightwork
- industrial homework
- place of work
- work before and after childbirth
- seating and weight lifting[1]

These laws have been developed as protective legislation to prevent the excesses of exploitation indulged in by many industrial organizations who took advantage of the inferior bargaining power of the female worker. However, in recent years these restrictive laws have come to be viewed by some people as obstacles to equal employment opportunity. As a result, many such laws have been repealed and women are moving into occupations previously considered unfit for them.

Table C-I presents data on the distribution of women in various manufacturing industries in 1968 compared to 1960. In almost every case there has been an increase in the number of women employed and small increases in the percentage of the total labor market that they represent.

Many restrictions applicable to women workers were in part founded on social custom. The restriction on night work,

1 Baetjer (1946) and Ill. Dept. of Public Health (1961).

TABLE C-I

Women in Manufacturing Industries, 1960 and 1968[a]

Industry	As Percent of Total Employed		Percent Increase
	1968	1960	1960-68
Total	28	26	24
Nondurable Goods			
Subtotal	38	37	16
Apparel and related products	80	79	17
Textile Mill products	45	43	8
Food and kindred products	26	23	5
Printing, publishing, allied industries	31	28	29
Chemicals, allied products	20	18	34
Leather, leather products	56	52	7
Rubber, Misc. plastic products	31	28	58
Paper, allied products	21	22	13
Tobacco manufactures	43	50	26
Petroleum refining and related products	9	8	5
Durable Goods			
Subtotal	20	18	35
Electrical equipment, supplies	39	36	42
Machinery (except electrical)	14	13	43
Fabricated metal products	18	17	28
Transportation equipment	11	11	26
Instruments, related products	35	34	32
Furniture, fixtures	22	17	57
Stone, clay, glass products	16	15	9
Primary metal industries	7	6	15
Ordnance, accessories	26	19	111
Lumber, wood products (except furniture	10	7	32
Misc. manufacturing industries	44	39	20

[a] Extracted from U. S. Department of Labor Women's Bureau, 1969.

for example, was probably not a function of empirical data on the inability of women to adapt to a shift in time of work, but on consideration of women's traditional "household duties: and concern for their safety in transit late at night. Over 25 years ago, Baetjer (1946) recommended that "women who have heavy household duties or who have not made adequate provision for the care of their children or aged relative should not be employed, since experience has indicated that the high labor turnover and absenteeism among women is largely due to home responsibilities" (p. 30). Yet in the face of her admonition, "the number of working mothers (women with children under 18) has increased more than eightfold since 1940. They now number 12.7 million, an increase of 3.9 million in the last decade" (U. S. Department of Labor Women's Bureau, 1973).

What is the implication of such factors for interpreting any data on the occupational health and safety of women? Clearly women have been placed in a protected situation. Even when working on a job that is ostensibly the same as one filled by male employees, it is quite likely that there are subtle differences. Some of these are imposed by law, such as the number of hours the woman can work at the job. Other differences are introduced by the manner in which women are treated on the job. If there is overtime to be worked, those who "need the extra money" (usually considered to be males with families to support) will be asked to work the extra time. Difficult jobs or jobs requiring activities which do not fit the stereotype of the female will be assigned to male workers. Of course, the laws and other work restrictions frequently operate to prevent any females from filling certain jobs (underground mining is an example) in an industry. Hence, industry figures are virtually meaningless when they attempt to compare the sickness or accident rates of male and female workers in the industry as a whole.

Restrictions and laws have also operated to prevent females from accumulating a background of industrial experience. Thus, for male and female workers in the same job, the male workers probably have had greater experience in the plant or the industry. Women working on stamping presses had eight times as many accidents as men on their first day on the job, but after a month the sexes had the same rates (Vernon, 1945).

In interpreting any past studies of the relation of sex to accidents and illnesses on the job, one should remember the data are affected by the formal set of laws and regulations which restricted the exposure of females to hazards and to practices which might indirectly affect accident rates. In planning future studies, one should keep in mind the changing situation of the female employee who will be getting into possibly hazardous jobs with greater frequency and about whom attitudes are changing which could affect the manner in which job assignments are made within a plant or department.

The Task Force on Labor Standards report to the Citizens Advisory Council on the Status of Women (1968) made several recommendations pertinent to laws restricting women in employment. They recommended:

a. That the laws regarding lunch periods, rest periods and physical facilities be reviewed by the states, and that assuming that they are still useful, they be incorporated in to a safety and health program applicable to both sexes;

b. That weight lifting laws be repealed, and that relative safety and health regulations be inacted applicable to men and women;

c. That night work restrictions be removed for adult workers, and that police protection, transportation, and meal facilities for workers be supplied for those men and women employed at night.

If and when such changes occur, they will affect any retrospective comparisons of future research results with those obtained in past years.

Accidents and Injuries

Baetjer (1946) outlines methods for determining the differential accident rates of men and women:

1. Comparing the accident rate of women with that of men in an industry.
2. Calculating what percentage of all industrial accidents occurred among women and comparing this with the percentage of women among all industrial workers.

She also supplies methods for determining if women are more susceptible to certain types of accidents than men by:

1. Comparing the rate of types of accidents for men and for women and
2. Determining the number of female accidents of each type, comparing this to the total female accident rate, repeating the procedure for men, and then comparing the male and female rates.

Baetjer is careful to state that these methods are good only if the subjects are doing comparable work for the same number of hours under similar conditions. One must also control age and experience as well. Studies in the literature are generally remiss in one or more of these controls. In addition, the National Safety Council (1970) cautions that accident rate statistics for female employees are not as definitive as those for men because there are more male workers. The following discussion of the literature illustrates the various measures outlined by Baetjer and the care which must be taken in interpreting any studies which claim to show different accident rates for men and for women.

Hazardous industries. When overall industrial figures are used, they generally indicate that female employees have fewer accidents and injuries in proportion to their numbers than do male employees. For example, Mohr (1947) in her report on women's industrial injuries cites data on 836,753 women among 2,843,588 workers in 9,000 manufacturing firms. Of the 27,063 injuries, 4,072 were received by women. Thus, the overall rates were one injury for each 205 female employees compared to one injury for each 85 male employees. Figures from the California Bureau of Occupational Health and Environmental Epidemiology (1969) confirm that women covered by the California Workmen's compensation law have disproportionately fewer work injuries compared to men in the labor force. Women constituted 39% of the employees covered by the law but only 23% of the reports. Table C-II summarizes industries that employ large numbers of women and have either high or low injury rates. One may question whether the kinds of jobs women fill in these various industries are comparable.

From the California data it is clear that females do not invariably have fewer accidents and injuries. Figure C-1 compares the rates of work injury reports for men and women employees in several industries. For ordnance and food industries the women's rates are higher than the men; they are about equal in apparel industries, and the men's rates

Table C-II

Manufacturing and Nonmanufacturing Industries
Which Employ Large Numbers of
Women and have Either High or Low Injury Rates[a]

Injury Rate	Type of Industry	
	Manufacturing	Nonmanufacturing
High	Food processing Furniture manufacturing Textiles Dairy products Leather products	Restaurant and hotel Laundries Retail food establishments Hospitals
Low	Radio tubes Electric lamps Synthetic fibers Synthetic rubber Explosives	Apparel Telephone communication Radio broadcasting Banks and insurance companies

[a] From Spiro, 1960.

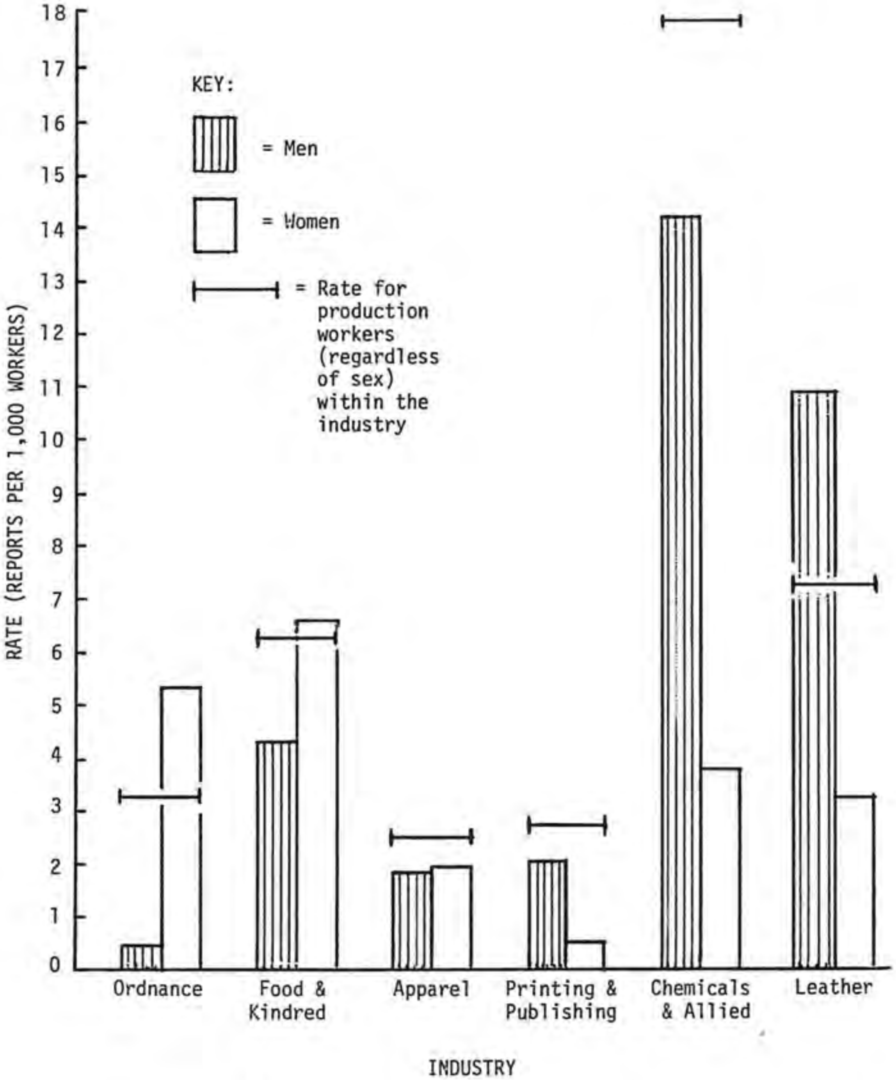

Figure C-1. Rates of Doctor's First Report of Work Injury under California Workmen's Compensation Law. (From California Bureau of Occupational Health and Environmental Epidemiology, 1969) are clearly above the women's rates in chemical and leather industries.

Mohr (1947) cites statistics for industries that have high accident rates for women and shows that one injury occurs for each of the following numbers of employed women:

Industry	Rate
Chain groceries	22
Drug stores	26
Slaughtering & meat packing	67
Stamped & pressed metal products	76
Fabricated metal products	155
Textiles & cotton yarns	186

As indicated previously, Mohr reported the overall injury rate for females to be one in 205 and that for males to be one in 85. Thus, all of the above listed rates are greater than the average for female workers and the first four listed are greater than the average male rate. Mohr concludes by noting that when rates are found to be comparable for men and women, the hazard exposure is also similar in the industrial environment.

Traffic accidents. Finding situations in industrial settings where men and women are working on the same job is rare. Hale and Hale (1971) in their review of industrial accident literature state that because men and women are rarely working on the same job it is difficult to make comparisons of accident rates and sex and, as a result, few studies of this type have been carried out in industry.

A study in the 1920's found that women taxi drivers had three times as many accidents as men drivers for the same number of miles driven and over three times as many accidents for the same number of fares taken (Viteles and Gardner, 1929). However, the women's accidents were less serious.

A more recent study using different methodology (McCarroll and Haddon, 1962) analyzed 43 fatal automobile accidents. The victims consisted entirely of men whereas 11% of the 258 cases taken as controls were women. This supports the Viteles and Gardner conclusion that women are involved in less serious accidents. The authors suggest that the male/female differences might be related to the percentage of intoxicated drivers in each group as there is a strong relationship between the use of alcohol and the incidence of accidents.

Data from the National Safety Council, shown in Table C-III do not seem to support the Viteles and Gardner results showing females have a higher accident rate than males. On the contrary, the female rate has been lower than the male rate for both fatal accidents and all accidents for several years.

Social and psychological factors. Brinton and Frasier (1940) compared the incidence of nonindustrial injuries causing disabilities of eight days or longer in single and married women employees of a mail order store and reported that single women under 35 had a slightly higher rate than the married women, the rates being 417 and 313 cases per 1,000 respectively.

Table C-III

Accident Rates for Male and Female Automobile Drivers[a]

Year	Drivers in Fatal Accidents				Drivers in All Accidents			
	Male		Female		Male		Female	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[c]	No.	Rate[c]
1958	38,800	80	5,200	29	14,400,000	297	3,200,000	178
1959	40,400	79	5,600	29	14,400,000	282	3,600,000	189
1960	41,000	78	6,000	31	15,000,000	286	3,500,000	180
1961	40,000	75	6,000	30	14,900,000	278	3,600,000	180
1962	43,000	77	7,000	34	15,000,000	268	4,000,000	193
1963	46,200	79	7,800	36	15,700,000	267	4,300,000	198
1964	48,900	79	8,600	38	16,700,000	270	4,800,000	210
1965	50,300	78	8,900	37	18,300,000	282	5,300,000	221
1966	54,600	81	9,700	37	18,600,000	276	5,700,000	218
1967	54,600	80	9,900	35	18,500,000	272	5,800,000	205
1968	59,500	84	10,500	35	19,600,000	275	6,400,000	211
1969	59,800	80	10,900	33	20,000,000	268	6,800,000	209
1970	57,800	75	10,700	31	20,500,000	265	7,200,000	209
1971	56,700	71	11,100	30	20,900,000	270	7,400,000	214

[a] From National Safety Council, 1972

[b] Number of drivers in fatal accidents per 1,000,000,000 miles driven.

[c] Number of drivers in all accidents per 10,000,000 miles driven.

Suchman (1970) in a study of the relation between social deviance and accidents found that among his group of college students the percentage reporting two or more accidents in the preceding year was 11.2% for males and 5.1% for females.

Hours of work and shifts. Baetjer reports a study by Vernon (1937) of minor accidents in a fuse factory during World War I. He found that the hourly rate for cuts was 2.7 times greater during a 12 hour day than during a ten hour day. The accident rates of women increased more than those of men, a phenomena attributed to a difference in fatigability of women as has been discussed in a previous section. A study of the effect of long working hours revealed no clear relationship between hours worked and female accidents (Kossoris, 1944). Baetjer notes that "where plants had good active accident prevention programs, the lengthening of hours did not bring about a disproportionate increase in work injuries" (p. 120).

A study by the U. S. Department of Labor, Bureau of Labor Statistics (1945) found that the rate of accidents on the second shift was lower than on the first and third, but the differences were not significant to support the contention that there were different accident rates by shift.

General accidents. Freeman, Goshen and King (1960) report that "irrespective of the exposure rate or different social role, women have fewer accidents than men in every year of life after the first. This varies from 1:2 to a 1:3 ratio (up to 1:9 in farm accidents), depending upon the age, and should be weighted in any mixed sex sample. The situation is reversed with some types of accidents in the aged (p. 28)."

National Safety Council statistics for several types of accidents are shown in Figure C-2. The sexes are just about split 50-50 in the population of the United States. If types of accidental deaths by sex were distributed by chance in the population then the bars in Figure C-2 would all be approximately equal. This occurs only in the case of deaths by falling. It would appear that men in the population are exposed much more than women to conditions in which accidental deaths can occur.

Illness and Absenteeism

Days lost. There appear to be many conflicting reports concerning women's sickness and absenteeism. These differences appear to be due partly to such factors as:

1. When (year) the report was written.
2. Industry(ies) reviewed.
3. Purpose of the report.
4. Definition of injury and illness, and types of absences.
5. Inclusion of absences due to specific female conditions.

Much of women's illness and absenteeism is attributed to complaints inherently female and these problems are discussed in a later section.

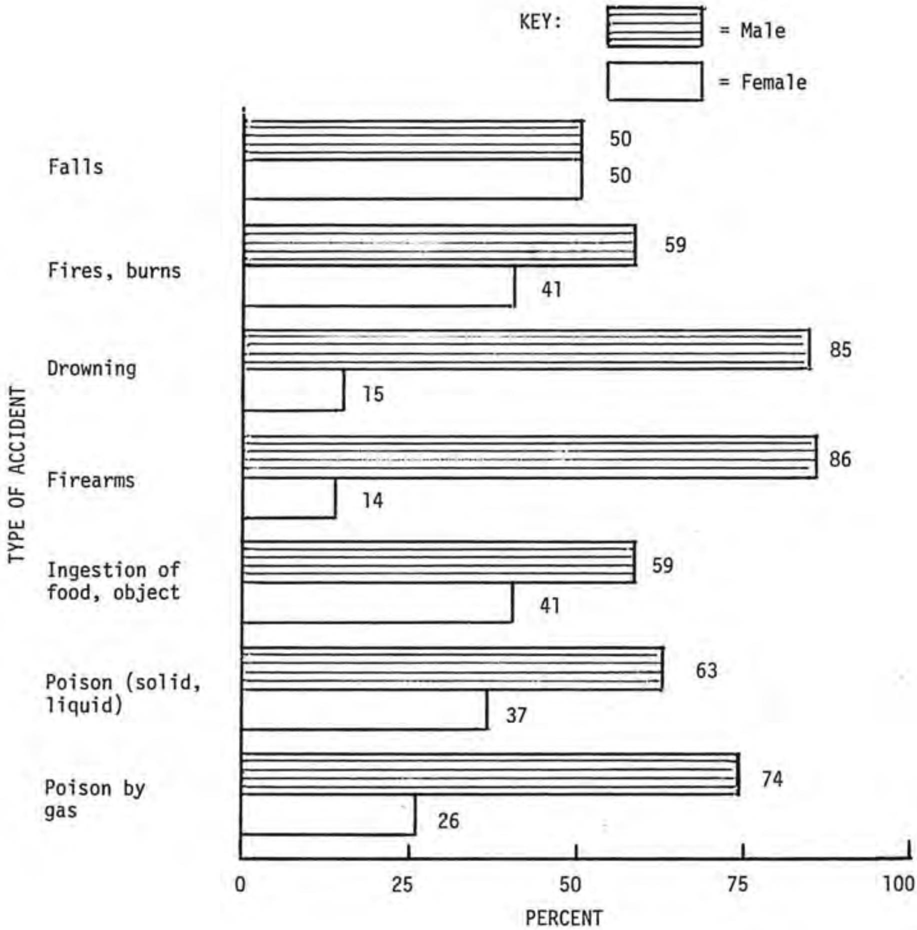

Figure C-2. Percentage of accidental deaths of males and females. (Data from National Safety Council, 1972)

The Women's Bureau Handbook on Women Workers (U. S. Department of Labor Women's Bureau, 1969) devotes two paragraphs to absenteeism (p. 80):

> "Like labor turnover, absenteeism is an important factor in determining labor costs. On the average women lose more workdays because of acute conditions than men do, but the reverse is true for chronic conditions such as heart trouble, arthritis, rheumatism, and orthopedic impairment. According to a recent study, employed persons 17 years of age and over lost an average of 3.1 days during the period July 1966 to June 1967 because of acute conditions (3.3 for women and 3 for men).
>
> "When both types of conditions were counted, the worktime lost by persons 17 years of age and over because of illness or injury averaged 5.3 days for women and 5.4 days for men over the same period."

Baetjer (1946), quoting a report of the U. S. Public Health Service, reports that the annual number of absences per 1,000 employees because of sickness and non-industrial injuries disabling for eight consecutive calendar days or longer averaged 142.4 for women and 85.1 for men in the period of 1934 through 1943. She reports that there is less data available on short-term illnesses.

Baetjer (1946) draws the same conclusion from the data prior to 1945. This conclusion, (supported by more contemporary statistics), might be termed the "more-than-but-not-as-serious-as" conclusion. Although women are more frequently ill and more frequently absent from work because of sickness than are men, the average duration per case is, in general, higher for men than for women. More recent data support this notion. A study reported by Sherman (1971), (a study by Scheinfeld, 1944), indicates that "even excluding indispositions related to menstruation and childbirth, women are sick about 20% more often than men, (p. 5)." But another (Petersen, 1964) reports that, when relevant variables are controlled, women actually lose fewer work days because of illness than men, possibly because their illnesses tend to be less severe.

On the other hand, Spiro quotes statistics from the U. S. Public Health Service National Health Survey (1959), which demonstrate that the number of days lost from work per year was about the same for men and women. For females, it averaged 7½ days per year. This is not contradictory to the "more-than-but-not-as-serious" conclusion. A study of 28,000 employees (Wade, 1955) showed that women's absences from work were only one-half as long as absences of men. However, because women had twice as many absences as men the average number of days lost during the year was about the same (9.9 days for women and 9.3 days per year for men).

From the National Center for Health Statistics, McKiever (1965) compiled data for a review of the health of working women. During the years 1957-60, male workers averaged 5.5 days and females 5.7 days of work loss per person per year. Men averaged 1.5 and women 1.9 acute conditions per person annually due to illness, causing slightly more work loss among women than men.

A study of 3,673 workers in a textile plant in Lodz, Poland showed women lost slightly more days than men

(Indulski, 1967). Men lost about 4.15% of the working days and women lost 4.5% of the days. Converted to a five-day work week, this amounts to about 10.7 days per year for men compared to 11.7 days per year for women.

Hinkle, Redmont, Plummer, and Wolff (1960) reviewed the 20 year retrospective medical histories of a random sample of male and female employees of the New York City Telephone Company and then followed their medical status on a prospective basis for five years. The two random samples (96 female telephone operators and 116 male craftsmen) represented one-third of all females and one-sixth of the males employed by the company continuously for 20 years. The subjects had in common:

1. A medical exam and history at the time of employment.
2. Employment in an occupation with no significant intrinsic hazards.
3. Situated in the same geographical living area, exposed to the same pathogens, and sanitation.
4. Similar social and economic backgrounds.

Some of their results are summarized in Table C-IV. As in previously cited studies, females in this study were sick more frequently than the males. However, unlike the previously cited studies, they had a much greater number of days of sickness each year.

Among their conclusions, the researchers postulate that the higher incidence of illness reported, the greater amount

Table C-IV

Means of Various Measures of Illness and Absenteeism in a 20-Year Retrospective Study and a 5-Year Prospective Study of Telephone Company Employees[a, b]

Measure	20-Year Retrospective (age 17-37)		5-Year Prospective (age 37-42)	
	Male	Female	Male	Female
Mean number of Illness Episodes Each Year	1.401	2.434	1.85	3.14
Mean Number of Days of Sickness Absence Each Year	4.3	10.5	7.6	20.5

[a] Data from Hinkle, Redmont, Plummer, and Wolff, 1960.

[b] Females were 96 telephone operators; males were 116 craftsmen.

of disability, and the greater number of visits to the doctor among women results from culturally determined differences in the attitudes toward what constitutes illness and what creates an acceptable reason for disability in men and in women. Perhaps this together with many other factors accounts for the differences found in studies.

Diseases. Respiratory diseases apparently account for the great mass of sick absenteeism. Gafafer (1944) notes that 50% of the cases reported by the Public Health Service were due to respiratory diseases with colds accounting for about one-half of them or 26% of all cases. Data from a study of Polish textile workers indicate that respiratory diseases (excluding tuberculosis) accounted for about one-fifth to a quarter of the sick absenteeism (Indulski, 1967). Hinkle, et al. (1960), in their study of telephone company employees health records over a 25 year period, report that the episodes of illness most frequently recorded were those whose major manifestations occurred in the respiratory and gastrointestinal tracts, the muscular system, the skin, the eyes, and the teeth. However, there are some differences between men and women in rates of disease incidence and these are summarized in Table C-V. McKiever (1965), in reviewing data from the National Center for Health Statistics for 1957-1960, concludes that women had a greater resistance than men to heart attacks, a longer life expectancy and slightly superior disease resistance. At least one study in Berlin, Germany, indicates women live "healthier" lives (Huettner and Huettner, 1972). Hinkle,

Table C-V

Summary of Differences Between Men and Women in Frequency of Causes of Sick Absenteeism

More Frequent for Women	More Frequent for Men
Headache (Hinkle, et al., 1960)	Heart and circulatory (Baetjer, 1946) (McKiever, 1965) (Gafafer, 1953)
Genital tract syndrome (Hinkle, et al., 1960)	Pneumonia (Baetjer, 1946)
Disturbances of mood, thought, behavior (Hinkle, et al., 1960)	Diseases of stomach (not including cancer) (Baetjer, 1946) (Gafafer, 1953)
Respiratory disease (McKiever, 1965)	Hernia (Baetjer, 1946) (Gafafer, 1953)
Disabling mental illness (Bond, 1969)	Tuberculosis (Gafafer, 1953)
	Serious life endangering illnesses (Hinkle, et al., 1960)

et al. (1960) also indicate the female worker appears to be at less risk of death from illness. Based upon expected case fatality rates of illnesses experienced, they estimated that, over a 20 year period, the men experienced a risk of death from illness greater than that of the women in a ratio of about 4 to 3.

Age and sick absenteeism rates. Baetjer (1946) cites a U. S. Public Health Report by Gafafer (1940) which presents the data in Table C-VI showing absences and number of days absent of men and women workers in various age groups. There are several items of interest in this table:

1. Women had more absences than men at every age.
2. Women were sick a greater number of days of the year than were men and this was true in every age group.
3. Older employees were absent longer than younger ones on each absence.
4. The differences between men and women on these measures were generally reduced as age increased.

Such findings led Baetjer (1946) to caution that one must consider the age distribution in comparing the sickness rates of women with men. She reasoned that, "since younger men and women have higher frequency rates than older persons, and since there are more older men employed in industry today, this would naturally tend to distort any comparison of the

Table C-VI

Sickness Causing One Day or Longer Absence According to Age of Employee on the Payroll of a Public Utility Company, 1922-1924[a]

Age Group	Annual No. of Absences Per 1000 Persons			Annual No. of Days of Disability Per Person			No. of Days Per Absence	
	Male	Female	% Female Excess	Male	Female	% Female Excess	Male	Female
15-24	1120	2499	123	5.35	12.77	139	4.78	5.11
25-34	1085	2461	127	5.58	14.06	152	5.14	5.71
35-44	1015	1730	70	7.04	11.51	63	6.94	6.65
45-54	963	1247	29	7.06	13.22	87	7.33	10.60
55+	852	1273	49	11.39	16.32	43	13.37	12.82

a Data from Gafafer, 1940, as presented in Baetjer, 1946.

sickness rate between the two sexes in favor of men" (Baetjer, 1946, p. 61).

Kossoris (1948) in a study of 17,800 employees in 109 manufacturing plants surveyed by the Bureau of Labor Statistics found, as did Gafafer, that (a) older workers recover more slowly than younger workers, (b) the rate of absenteeism decreases with age, and (c) women had higher absenteeism than men.

However, other studies give results that make such a conclusion less clearcut today than it may have been when Baetjer was writing. McKiever's (1965) data show that days lost increased with age for both sexes. Up to age 45, women had a higher work loss rate; after age 45 to about 55 the rates for men and women are comparable.

A study by Wells (1962) indicates that the reports of absence per 100 male employees of the Chesapeake & Potomac Telephone Company steadily increases from ages 25 to 45. The increase is pronounced at ages over 45 years. Absence trends are higher among the females to age 55 after which the male and female rates approximate each other.

Other studies claim the rates for men and women do not differ with changes in age. Indulski (1967) supplies data indicating that sick absenteeism in a textile factory was partly a function of the conditions of the environment regardless of age. This was indicated by the increasing absenteeism in those employees with more years of service when an adjustment was made to rule out the correlation of age and length of service.

It would appear that, in spite of some inconsistent findings, the pattern of sickness absenteeism of women workers differs from that of men. Women take off more frequently than men but probably do not stay off as long on each incident. Frequency decreases and length of time off increases with age. The differences between men and women employees on these two points become less pronounced as age increases.

Hours and days of work. Wyatt (1945) in a study reported by Baetjer (1946), reviewed certified absence among women in industry and found that sick-absenteeism among women on a permanent day shift was less than among women on a shift system. However, the figures were too few to offer any definite conclusion regarding the findings. Considerable study of circadian rhythm has been undertaken by researchers since 1945 finding that some workers adapt more readily to the shift system than others (Östberg, 1972 reviews such work).

The distribution of sickness-disability by the day of the week has been reviewed by Lynch (1943) and reported in Baetjer's review, and demonstrates that although the rates differ for the several days of the week, men and women do not differ in this regard.

Gynecological and Obstetrical Problems

The whole question of the role of gynecological and obstetrical problems in sick absenteeism and accidents of female workers is characterized by much disagreement in the literature and is affected by much subjective evaluation.

Illustrative of the debate is a letter appearing in the New England Journal of Medicine concerning sexual prejudices (Lennane, 1973). The author's thesis is that dysmenorrhea, nausea of pregnancy, pain in labor, and infantile behavioral disturbances are conditions commonly considered to be caused by or aggravated by psychogenic factors. He feels that, although scientific evidence exists which implicates organic causes, acceptance of a psychogenic origin has led to an irrational and ineffective approach to the management of such problems. Furthermore, because the condition affects only women, he feels that cloudy thinking characterizes the relevant literature and may be due to a form of sexual prejudice.

With this caution stated, the relevant literature is reviewed in two sections, one on menstrual problems and one on the literature on pregnancy in the industrial setting.

Menstruation and dysmenorrhea. Prompted by the lack of agreement in the literature as to the role of dysmenorrhea in sick absenteeism, Svennerud (1959) conducted an extensive investigation among women in three occupational groups. Most were working in various branches of industry, while the rest belonged to a theatre group or were gymnasts by profession. Questionnaires were submitted to and personal examinations and interviews conducted with 890 women ages 14-44. Dysmenorrhea was noted in 31% of the group; for 17% it was not disabling, for 8% it was sometimes disabling, and for 6% it was regularly disabling. It was most common in the 20-24 years old group (46.3%). In this age group, dysmenorrhea was sometimes disabling for 15% and regularly disabling for 9%. After age 25, the frequency of dysmenorrhea decreased rapidly, especially for married women, and after age 35 it was less than 2% of all absences. Frequency was not found to be influenced by environmental or emotional factors, but was the same in the widely different occupations studied (factory workers, actors, and gymnasts). Factory workers were away from work on an average of 28.8 days per year and office workers averaged 10.6 days per year, but absence because of dysmenorrhea represented only 1.1 and 0.3 days respectively which was no greater than absence without permission. No difference was found between dysmenorrheic women, nondysmenorrheic women and previously dysmenorrheic women regarding absence for reasons other than dysmenorrhea. Neither was there any difference found between the dysmenorrheic and nondysmenorrheic group regarding duration of employment in the same company, working capacity, or average wages.

In spite of the low frequency of absences because of dysmenorrhea, Behrend (1961), speaking about special planning for women at an occupational health conference, claimed that reproductive function and gynecological problems were, after respiratory problems, the most frequent health problem of women in industry. Similarly, Wells (1962), in a general discussion of the women worker, noted that menstruation needed close medical supervision and that gynecological problems caused a loss of efficiency and time, although he found no difference between these functions in working and non-working women.

Although there is some loss of work time for these problems as noted in the previous discussions, the loss is not significant, representing only 3.7% of the total absences for factory workers and 2.5% for office workers (Svennerud, 1959). That there may indeed be some loss of efficiency is indicated by studies showing there are some relationships between menstruation and performance.

Dalton (1960) found that of 84 accidents to regularly menstruating females, over half occurred just before menstruation and during the first four days of the cycle (See Figure C-3). This finding was confirmed by Lees (1966) and was particularly marked in older women.

Lees (1966) further found that although there appeared to be no relation between blood estrogen level and accident rate that women taking oral contraceptives had a lower and non-fluctuating accident rate.

A study by Wickham (1958) tested two groups twice on various performance measures. Results of the second tests were compared to the first to determine to what extent they varied beyond expectations when the subjects were passing through some disturbed phase of the menstrual cycle. He concluded that during the period phase there appeared to be a slight depression of scores, other than in practical

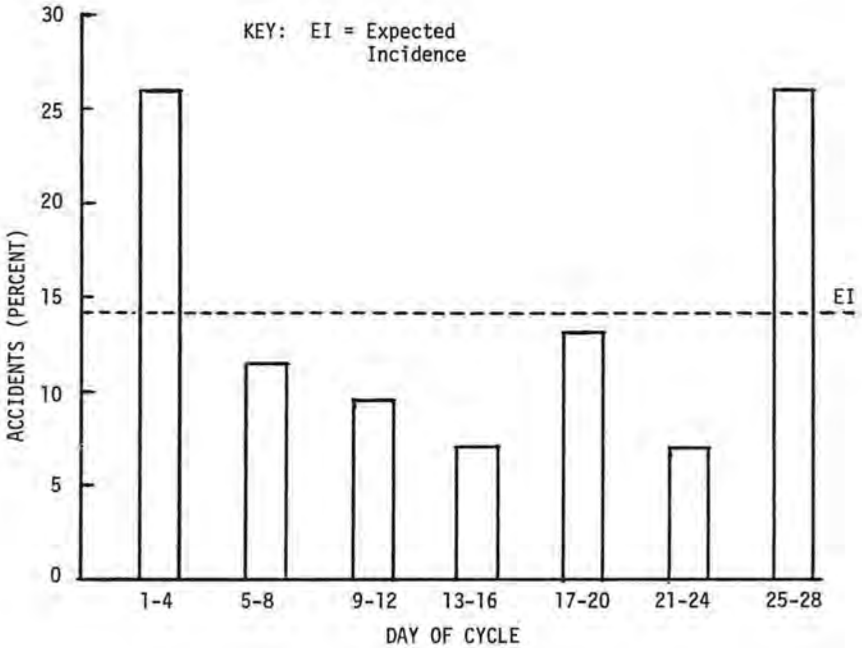

Figure C-3. Percentage of 84 accidents to females as related to the day in the menstrual cycle when the accident occurred. (Data from Dalton, 1960. Adapted from Conger & Gaskill, 1967.)

mechanical performance, but concluded that the data were inconsistent and insignificant, being no greater than the effects of the more common minor ailments such as bad colds. The National Safety Council (1970), in a brief review of the literature on the relation of menstruation to accidents concludes that there may be an association, but the studies are conflicting.

Pregnancy. Baetjer (1946) considers the subject of pregnancy from two points of view: (a) the effect of work on pregnancy and (b) the effect of pregnancy on the ability to work. She reports several studies on the topic.

Using data from the Children's Bureau of the U.S. Department of Labor, a comparison of infant death rate among mothers employed or not employed during pregnancy revealed a higher infant death rate when mothers were employed during pregnancy. The work by women during the latter part of pregnancy was deemed especially harmful to the health of the infant. Rochester (1923) reported a higher incidence of stillbirths among those women employed away from home, which was evident even when allowance was made for variations in economic and racial factors. The stillbirth rate was also higher among those women who did not stop work until within two weeks of confinement than among those who ceased their employment at an earlier date.

Teleky (1943) reported that the death rate of infants, in the first week after birth among 100 firstborns was between 3.2 and 3.5 for a group of women who worked up to delivery, as compared with 0.7 for those who rested for the last weeks preceeding delivery.

Another study reported by Baetjer (Balfour, 1938) found no significant difference in the premature birth rate between the gainfully employed women and the non-occupied women when the working groups ceased work before the end of the sixth month of pregnancy. There was a significantly greater premature rate among the women who worked longer than the first six months of pregnancy.

McCall and Trace (1960) have noted various types of industries and subsequent noxious environments to be avoided. They commented that some of the physiological changes associated with normal pregnancy may affect, to a mild degree, the employed women's ability to work but that with individualized prenatal care the problems could be circumvented. The pregnant woman's ability to perform industrial work is also commented on by Diddle (1970) who concludes that a pregnant woman's working capacity is affected by her increased weight, changes in posture, and physiologic changes in the urinary tract and cardiovascular system. He states that a pregnant woman may be threatened by anemia, dusts, chemicals, laboratory viruses, and doses of radiation. Also, pregnancy decreases efficiency of concentration and alertness.

The danger of various fumes and gases to the pregnant women is also commented on by other writers.

Wells (1962) states that there is no proof that temperature, humidity, toxic dusts, gases, and fumes or the over-all sanitary conditions of a plant affect women and men differently except in cases of pregnancy. He further notes that pregnant women should be able to work during the first 28 weeks of pregnancy at least, and that they should not be exposed to chlorinated hydrocarbons, benzol, lead, carbon monoxide, and ionizing radiation. They should not return to work until six weeks after delivery. He suggests close supervision of the pregnant employee.

A review of the literature on carbon monoxide poisoning during pregnancy (Kells, 1968) states that carbon monoxide passes from the maternal to the fetal blood and that carbon monoxide poisoning during pregnancy can cause fetal death, due primarily to a toxic anoxia in its own circulatory system.

Out of such dire findings and pronouncements have come a large number of recommendations, rules, restrictions and the like on the employment of pregnant women. Based on the data she had available to her in 1946, Baetjer made the following suggestions concerning the matter:

1. Pregnant women should work regular shifts and should not be employed on the night shift since the latter interferes with their rest and normal

eating habits. Furthermore, night work may alter the diurnal physiological changes which normally occur in the body. Luce (1971, p. 280) indicates that there are more recent studies indicating there may be marked effects of various rhythms on pregnancy, birth, and menstruation. There have been some indications (anecdotal in nature) that mere exposure to light at critical periods in the menstrual cycle may affect the time of ovulation.

2. Pregnant women should not be employed more than eight hours per day or 48 hours per week, and in many cases shorter hours or half-time work is desirable.
3. Provisions should be made for rest periods in each shift and adequate facilities for rest should be provided.
4. Provisions should be made for change of posture during the work period, neither continual sitting nor continual standing being considered desirable.
5. Pregnant women should not be required to do any heavy work, heavy lifting, constant bending or stretching, constant carrying of any appreciable load, work involving a strained position or marked vibration or any work requiring a good sense of balance. After the twentieth to the twenty-fourth

week of gestation, women become progressively more awkward and therefore must avoid climbing and walking where delicate balance is involved.

6. Such women should not be exposed to conditions involving hazards which predispose to accidents.
7. Pregnant women should not be employed in occupations involving significant exposure to any toxic substance which affects the internal organs of the body, especially the liver, kidneys, blood or circulation.
8. Adequate nutritional facilities should be available and sufficient time for lunch should be allowed.

Baetjer further recommends a minimum of six weeks of leave prior to and after delivery. Also, breast feeding should be discouraged as full breasts while working are uncomfortable.

Standards, whether supported by hard data or not, have been recommended by many sources. The Federal Aviation Administration, for example, in a proposed rule published in the Federal Register (1973) notes that airlines will not accept persons ill with a communicable disease, intoxicated passengers, or women in their 9th month of pregnancy who cannot present an obstetrician's certificate dated within 72 hours of the time of flight departure. This standard seems to arise out of concern over emergency evacuation procedures.

Forssman (1964) notes that women should not be exposed to certain chemicals during pregnancy such as chlorinated hydrocarbons, benzene, and carbon monoxide. He also states that women who begin manual work at an early age may develop pelvic malformation and subsequent delivery complications.

Another example of standard setting, the Illinois Department of Public Health (1961) defined several limitations for pregnant women without citing sources of supporting data. These were:

1. Pregnant women should not be employed from 12 midnight to 6 a.m. or work longer than eight hours per day and 40 hours per week.
2. Two ten-minute rest periods are needed per day.
3. Women should not be employed in occupations which require strain of the joints or muscles; require a sense of balance; entail vibration; or expose women to lead, mercury, aniline, benzol, toluol, nitrobenzol, carbon tetrachloride, or ionizing radiation.

The Illinois Department of Public Health noted that pregnant women were often placed in danger by not reporting pregnancies in order to protect their jobs.

Other Sex-related Differences

In the mass of traditional behavioral and biological literature the researchers frequently attempt to take measurements separately on their male and female subjects. On many measurements of performance and on physical and physiological factors, the sexes do indeed differ. The Tuft's Handbook of Human Engineering Data (1952) summarized the differences in motor responses as follows:

> "Men differ markedly from women in muscular strength, speed, and coordination of gross bodily movements....Men...show shorter and more consistent reaction times. In aiming and tracking tasks, men also excel. In tasks calling for manual dexterity of finger and wrist movements, women excel. Learning and practice are important here; while women may at first be inferior in some operations requiring coordination, with practice they are often able to equal the performance of men." (Part VI, Chapter II, Section V, Paragraph 5-9, p. 1.)

Baetjer (1946) noted that various psychologists and others had attempted to determine the differences between men and women in reaction time, discrimination time, speed of voluntary movements, coordination, and so forth. Yet she felt that generalizations and inferences drawn from the data were limited by a number of problems, including:

1. Lack of control of the effects of prior training and effects of the types of measurements made,
2. The difficulty in applying such laboratory material to industrial work, and
3. The lack of conclusive evidence.

Nevertheless, as the number of women in industry increases and as they begin to function in jobs they have not handled heretofore, interest mounts in identifying special problems in insuring their safety and health.

In establishing criteria for a recommended standard for occupational exposure to hot environments, for example, several studies were cited demonstrating the differential response of men and women (see references 80 through 97, p. VI-7 of National Institute of Occupational Safety and Health, 1972). These studies resulted in establishing wet bulb globe temperature cut off points at 79°F for men and 76°F for women, at which point various procedures would be instituted to insure that the employee's body temperature would not exceed 100.4°F. Other differences in male and female physiological responses are reported in Sherman's (1971) review. These include works by Garai and Scheinfeld (1968), Anastasi & Foley (1949), and Tanner (1962) on differences between males and females in vision, olfaction and auditory response. Males purportedly have better vision and prefer visual stimuli, while females prefer auditory stimuli. It is reported that females can hear higher tones better and, at times, they have a better sense of smell. The researchers suggest that the sense of smell depends on estrogen and hence the superior olfaction in the female. Women are apparently slightly less susceptible to a temporary threshold shift after being exposed to a 2000-hertz pure tone at 105 decibels sound pressure level for 10 minutes Women also show a slower rate of hearing deterioration with age than men (Smith, 1969).

The National Safety Council concludes that physical characteristics of women (such as smaller hands, and lesser lifting ability) account for workplace requirements that are different from men.

Sex differences have also been found in risk-taking behavior. Cohen, Dearnaley, and Hansel (1955) found that, as pedestrians, men take more risks than women.

Given that men and women employees do differ, for whatever reasons, on a number of dimensions that can affect their health and safety on the job, what safeguards are there in an era of equal employment opportunity which is moving more women into jobs not previously filled by them? Lockheed Missiles and Space Company (Rosenthal & Muller, 1972) has attempted to develop a routine testing system for matching personnel to the physical demands of required tasks. The personnel of various departments were given tests which duplicated the abilities required by a specific job. In matching employees to the demands of the job, a reduction in injury and accident rate was sought as well as a fair, nondiscriminatory selection process that places in a job only those employees that are physically capable of handling the job.

The tests were a hand grip test, an overhead push test, and a two-finger, two-hand pull test. These tests were selected to measure physical abilities which task analyses had indicated were necessary to perform given tasks. They were measured, respectively, by crimping ability, attaching an air hose to an overhead connector, and installing cable sleeving. The results are summarized in Figure C-4. In each test the male employees generally exceeded the female employees in the force exerted. None of the female employees tested could apply the force required (48 pounds) on the overhead push test, and only one female tested could exert the 30 pounds required on the two-finger, two-hand pull test. On the hand grip test, it was concluded that the male population could be expected to perform the job easily and that females would be less likely to perform the task satisfactorily. Among the recommendations in the report is one specifying that jobs which are too demanding for the personnel assigned to perform the tasks should be redesigned.

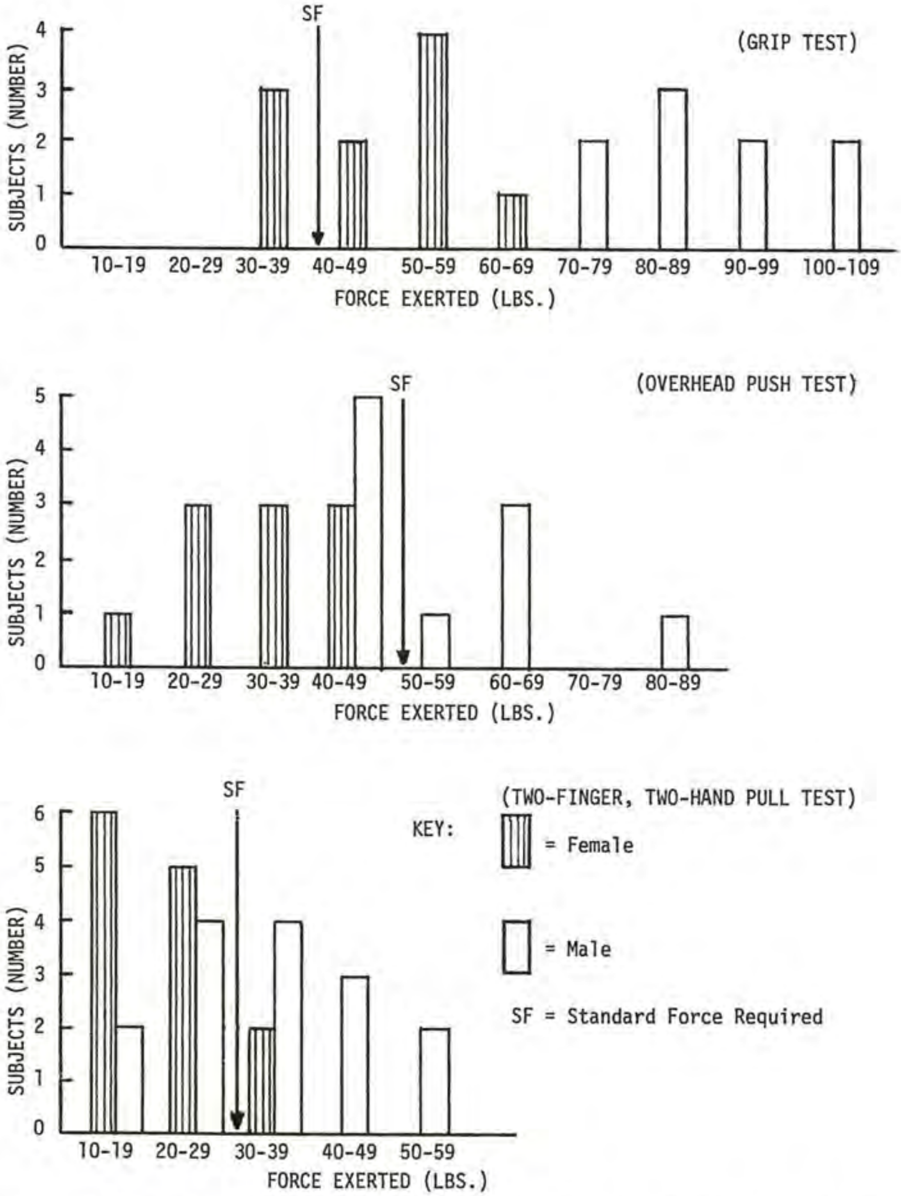

Figure C-4. Force exerted by men and by women employees on a hand grip test (top), overhead push test (middle), and two-finger, two-hand pull test (bottom). (Adapted from Rosenthal & Muller, 1972.)

SUMMARY OBSERVATIONS

Problems of Research Methodology

In considering the literature on sex as a factor in occupational safety and health, two extreme points of view may be discerned:

1. Sex is only a descriptive category for reporting accidents or illness and is not a causative factor.
2. The sexes differ in physical strength, body build, biological rhythms and so forth, thus women can indeed have sickness and accident records that are different from men and these differences are in a sense caused by the sex differences.

Actually neither position is totally correct. If the literature is reporting statistics for gross categories such as plant, industry or the like; then sex serves only as a descriptive category. This is because jobs of men and women often differ on a plant-wide or industry-wide basis and hence any differences in accident or sickness records may simply reflect the differences in exposure to hazards. But, when one is considering a specific job, it is well to remember that there appear to be differences in average performance, in risk taking, in training, and in past experience that are a function of sex and/or of sex roles as traditionally defined. In a sense, then, findings showing different sickness or accident records may be considered as sex-related if not sex caused. To the extent that they are due to experience, training and traditional sex role definitions, they may, of course, be changed and modified over time.

It is well to emphasize the point that sex-related differences in accident and illness records may be determined by socially prescribed roles and expectations as opposed to biologically determined differences. For example, the finding that females have more sick absenteeism may be ascribed to biologically determined causes. However, it is possible that females report ill more readily than males because society (in the United States) defines the man as one who is "big and strong" and reporting sick is a sign of weakness not befitting this role.

Related to this possible underlying explanation of sex-related differences found in the literature is the fact that nearly all the literature in this review antedates the major change in laws, employment practices, and attitudes regarding working women. In other words, the literature from past years may be inappropriate when one wishes to apply them to current or future situations. Writing in 1946, Baetjer concluded that:

> 1. Women may take their aches and pains more seriously than men and seek medical attention earlier and more frequently than men thus avoiding more serious illness, and
>
> 2. Women may view their occupations with less responsibility than men -- as an interlude between school and marriage -- and hence there may be a lack of mental adjustment to work.

Now, over 25 years later, these conclusions may not apply. With changed laws and attitudes working women may, as a group, view their occupations with responsibility equal to that usually ascribed to men. Thus, not only the conclusions may change in future research, but the data on which Baetjer based her conclusions may change.

Access to the literature on the health and safety problems of women in industry was not easily achieved. The most appropriate description when using the MEDLINE computer service at the National Library of Medicine was the term "women." There was no way to access information on sex factors under the terms "industrial accidents" and "industrial medicine." The terms "male" and "female" produced nothing of use to this review. While not a major methodological problem in future work, those searching for literature in this area should be cautioned on this point.

Hypersusceptibility

There appear to be some possible differences in male and female accident rates and sick absenteeism. Methodological problems preclude assigning sex as a cause of such differences. However, whatever the underlying causes, they appear to be related to sex. Even then, the data on which such differences are based are, for the most part, old. They predate changed laws and attitudes which may result in former inequalities of accident and sickness data being eliminated. The following areas in which sex related differences have been found should be accepted as being areas where caution may be needed rather than any firm indication of sex-caused differences.

1. Females have lower fatal traffic accident rates, fewer general accidents, and fewer accidental deaths in a number of categories of high hazard. The latter are probably related to the degree of exposure to hazards which as a general rule is less for females. Less frequent use of alcohol by women drivers has been offered as an explanation of their better traffic records.

2. Women may suffer more accidents when faced with increased work hours as their social roles usually require them to perform household tasks regardless of their hours of gainful employment.

With regard to sick absenteeism, the data are somewhat conflicting but it appears that men and women differ on this point. Women take off more frequently than men but probably for lesser periods of time in each instance. Frequency of sick absenteeism decreases and the length of time off increases with age with the difference between men and women being less pronounced as age increases. Although women do lose more time from work because of the inherently female problems of menstruation, the loss is apparently relatively insignificant.

There appears little doubt that pregnant women should avoid exposure to various noxious fumes and radiation. Also, while there are data indicating dangers to the fetus and infant when women continue to work late in pregnancy, such findings need updating. It is possible that improved health care and medical treatment during pregnancy and for the infant immediately after birth may have improved the situation.

Selection and Placement

There appears to be little support for establishing selection and placement standards on the basis of sex alone. Because men and women differ in specific abilities, there may be a need to exercise caution in assuming that they are interchangeable in filling specific jobs. However, any selection should be based on performance requirements rather than sex.

The move to nondiscriminatory employment practices and the consequent move of women into jobs formerly held only by men may have implications for selection and placement of women on such jobs. It may be necessary for organizations to reexamine physical requirements of tasks and establish the minimum force, reaction time and so forth. Although men and women differ on many such measures, there is nothing that precludes a women performing the tasks safely so long as she meets the minimum physical requirements. In jobs traditionally held by men, such minimum requirements may not have been established and there may be some danger in placing women in such jobs without first establishing physical requirements. In the interim, it would seem possible to assess women's capability for filling the job by comparing satisfactory male employees performance with female performance. Any female who meets or exceeds male performance on relevant measures would certainly be at no more risk than the male employees. However, this is only an interim measure because minimum performance requirements may be considerably lower than the average performance of males on the job. Therefore, many females would be excluded from the job who could perform it safely. This discussion assumes that male performance is, on the average, higher than female performance. In some areas, female performance will, on the average, be better than male performance. For example, older women have better hearing than older men on the average.

Where physical requirements of the job would exclude women, it is possible to overcome some of the gap by redesign of the job, providing accessory aids, and increasing training.

With regard to pregnant women, there seems little doubt that they should avoid exposure to certain chemicals, fumes, and radiation. There have also been established rules and regulations which are designed to keep pregnant women from heavy work, lifting, bending, stretching, vibration, and work requiring a sense of balance. Unfortunately these rules have become controversial because they are applied indiscriminately as excuses to remove pregnant women from jobs that do not require these activities as well as those that do.

Research Needs

Much of the research cited in this review is based on the situation that existed prior to the changes of recent years in laws and attitudes toward women workers. Hence, much of the work may have to be redone in coming years. Listed below are some of the topics that may be pertinent in such a reworking and updating of data.

1. Determination of sex differences in adaptability to shift work and to newer concepts of work hour arrangements (such as four-day weeks and flexible starting times).
2. Further examination of the effects of the menstrual cycle on accident frequency to clarify conflicting data.
3. Effects of use of birth control pills on sickness and accident records.
4. Differentiation of socially determined and biologically determined sickness and accident records.

5. Analysis of generally performed industrial tasks and specifications of minimum force requirements and other physical requirements. Also specification of male and female capability to perform these activities.

6. Reexamination of sick absenteeism and accident rates for females who may be in roles comparable to those usually conceived of as male roles including:

   a. women in jobs which have heretofore generally been held by men.

   b. women providing sole support for a family vs. those providing supplemental income.

   Further analyses of single vs. married women may provide data indicating underlying dynamics of marital status which may be related to sickness and accidents.

7. How long can pregnant women remain gainfully employed without endangering their own health and safety or that of the fetus? This is a controversial issue for which the data appearing in this review are dated.

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SEX

Worker Safety & Health Measures	EMPIRICAL		Theory or Opinion or "Experience"	REVIEWS		Unknown
	Obs. or Statis-tical	Contr. Field or Lab		Critical or Inte-grative	Bibliog. or Sketchy	
Frequency & Sever-ity Job Accidents	947 958 1052 1177 1182	1176		1 2 530 602 1082	46 1168 1294	971 1173 1184 1185
Agent - Specific Diseases	1165		78	92 529 826 1068		
Non-Specific Disorders	105 866 1167	209	162 <u>Fed.</u> <u>Reg.</u> '73	602		
Critical Incidents						
Rate/ Amount of Sick-Absence	679 1169 1081 1170 1157 1171 1159 1183	209 846 1053		526 530 602 1163	528	1175 1178 1179 1186
Perform-ance Indices		134 973 1156 1265	78 1164	1 1163 62 1180 92 1181 602 1315 628		1172
Strain Indices			162			
Morale						
Compliance with Rules						
Off Job Problems	1157	138	162			
Miscel-laneous	1160 1291 1293 1296	1292	1042	1163	1174	

PHYSICAL WORK CAPACITY

A portion of a report--

PROBLEMS IN

OCCUPATIONAL

SAFETY AND HEALTH:

A

CRITICAL REVIEW

OF SELECT WORKER

PHYSICAL

AND

PSYCHOLOGICAL

FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

PHYSICAL WORK CAPACITY

Introduction

There is a large body of literature on the subject of anthropometry and physical fitness which indicates a relation between the capacity to do work of various types and an individual's size and physical condition.

Much of the research literature located by the key words "physical fitness" deals with the subject of performance in relation to measures of physical condition. Many studies investigate the relation between illness and physical fitness measures. Few studies are concerned with physical size or fitness and worker accidents.

By indicating that a person is physically fit, we usually refer to homeostasis, the condition of delicate balance among the various physiological systems. This state is usually assessed by measuring the functioning of the body during states of stress such as exercise, or exposure to hostile environmental conditions such as heat, cold, or toxic chemicals. For example, a determination was made for volunteers entering a NASA physical fitness program (Durbeck et al. 1971) which included a medical and dietary history, chest X-ray, CBC with differential, urinalysis, two-hour postprandial blood glucose, fasting cholesterol, fasting triglycerides, uric acid, creatinine, anthropometric measurements and a physical examination. An assessment was made of the volunteer's health attitude, habits, resting ECG, and treadmill performance.

A program of physical training resulting from such assessment generally brings an improvement in objectively and subjectively evaluated health. For industry, physical training may mean less absenteeism and perhaps even fewer on-the-job accidents.

The physical fitness literature will be reviewed by first considering two physical measurements, weight and height, and their relation to safety and health. Secondly, the literature on low back pain will be examined as physical fitness is often cited as an important variable in lifting and handling tasks. Next, environmental conditions of heat and cold will be considered in relation to measures of physical fitness, and finally, attempts to match the man and the task with regard to physical abilities will be reviewed.

Weight

Obesity has often been equated with affluence and the United States appears to be especially endowed with both. An increasingly popular pastime, therefore, is weight reduction in an attempt to avoid a coronary and even a possible accident.

Henschel (1967) reviewed the literature on obesity as an occupational hazard and found some evidence to support the illness, accident/obesity relationship. He found that "the higher morbidity and mortality experience of obese people points to it as a major health problem." Situations in which "obesity may alter the intensity of the response to an occupational hazard include:

1. heat exhaustion and heat stroke in hot working and living conditions;

2. physiological strain in performance of hard physical work;

3. respiratory strain and disorders associated with hard physical work;

4. accidents associated with equipment operations and other duties;

5. decompression sickness;

6. high altitude tolerance, and

7. pesticide toxicity (p. 491)."

Henshel's observations were as follows:

Heat. A relationship between obesity and increased chance of heat stroke and heat exhaustion was observed among those doing strenuous work in hot environments.

Physical work. Heat has an effect on the work of the obese worker in that the energy cost is higher and endurance lower on a job than those of normal weight.

Respiratory strain. There is data to show increased respiratory distress among the obese.

Accidents. Machinery and equipment are engineered to be used by the man of average size and pose special problems for the corpulent. Henschel stated that the obese person's decreased agility makes him more susceptible to an on-the-job accident.

Decompression. As a result of increased nitrogen loads among the obese in hyperbaric environments, there is a special risk of nitrogen narcosis.

Altitude tolerance. Decreased tolerance to altitude among the obese is a question still under debate.

Pesticide Toxicity. The question is being studied as to whether or not the obese are more sensitive to pesticides, many of which are fat soluble.

Henschel concluded by noting that obesity is a significant occupational hazard.

Although Bar-Or et al. (1969) found that motivation and will power played a role in the heat tolerance of lean and obese women, an increased heat strain was generally observed among both. His subjects included nine female university students. Obesity was said to exist if body fat comprised more than 23% of total body weight. One measure of increased stress in heat, namely heart rate, is shown in Figure D-1 to steadily increase with environmental temperature for all the exercising subjects, although the rate is consistently higher for the obese individuals.

A study of 823,199 Navy recruits by Edwards et al. (1971) found that morbidity associated with tuberculosis was higher among underweight subjects than overweight subjects.

The review by Hale and Hale (1971) referred to several studies of obesity which included:

1. Cresswell and Froggatt (1963) who found that obese bus drivers tended to have repeated accidents, and
2. Powell et al. (1971) who found no accident/weight relationship in the dispatch department, machine and assembly shops or mills.

<u>Height</u>

Many occupations have not only weight but also height restrictions. Professions such as military service, police work, flight stewardship, and athletics have height requirements. Although no data seem readily available, some of

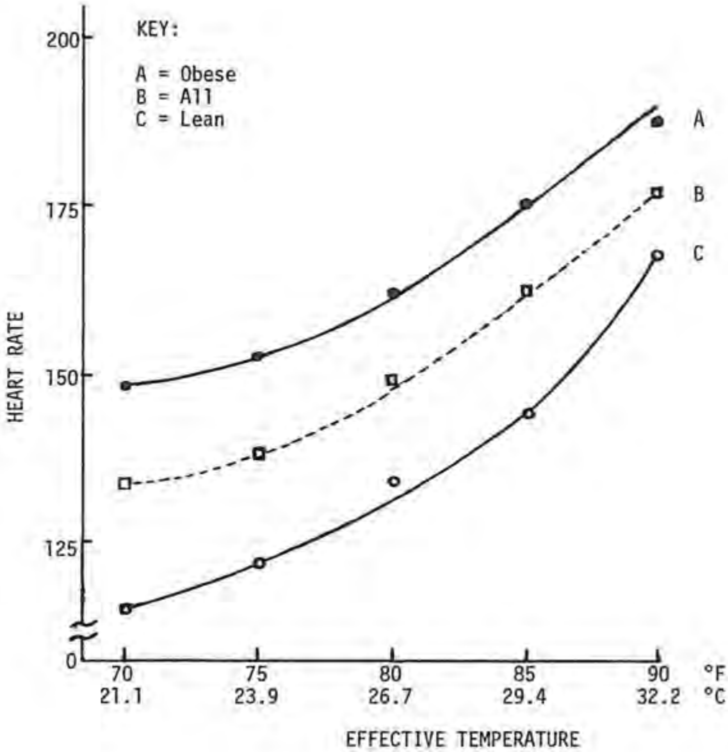

Figure D-1. Final heart rate at different effective temperatures in obese and lean women. (Adapted from Bar-Or et al, 1969.)

the occupations have little, if any, justification for their restrictions.

Powell et al. (1971) found that in the dispatch department, those who were 5'9" or less had significantly higher accident rates than those who were taller. In the mill, although the results were insignificant, a slight trend was found for shorter people to have fewer accidents. The higher rate for the shorter employees of the dispatch department was attributed to difficulty in handling equipment. This general reasoning, perhaps, applies to all of anthropometry, for if work spaces and tools are designed for the norm, then those who vary from it are more likely to suffer a decrease in efficiency in their jobs and possibly injury.

Hale and Hale (1971) conclude that ". . . physical dimensions are likely to play a part in some accidents because tools and machinery place definite limits on the sort of person who can operate them successfully and safely (p. 65)."

Edwards et al. (1971) found that susceptibility to tuberculosis increased with height.

Ferris (1971) found that age and standing height correlated most closely with tests of pulmonary function in a white population.

Low Back Pain

Related to physical fitness is the literature dealing with low back pain in industry. A significant relationship seems to exist between low back pain, physical fitness, and other individual physiological and psychological factors.

Low back pain and injury is responsible for a great deal of lost work time each year in the industrial community. A National Safety Council Survey (1967) reported by Snook and Cirrello (1972) stated that there were 400,000 disabling back injuries each year. Because of the cost to industry and the employee, criteria have been developed to eliminate those employees who may be especially susceptible to back injury from the work force or to control their work assignment in such a way as to prevent injury. Also, management has employed training in safe lifting and handling to help reduce back trauma.

Age. Age is apparently a factor in back injuries. The middle-age group in the 30's and 40's appear to be the most susceptible to back injury. Snook and Cirrello (1972) found the maximum frequency to be in the late 30's and 40's. Brown (1972) found that low back injuries were highest in the 31-40 age bracket, (as demonstrated in Figure D-2). Figure D-3 shows that the severity of the injury, which was possibly reflected by the number of days lost, was highest for the 51-60 age group. He stated that, "our observations would indicate that most of the problems arise during the period of years 31-40 and it is, of course, during this period that the intervertebral disc is undergoing a considerable change in structure and in consistency and mechanical strength. Under these conditions it is not surprising, therefore, that most accidents occur in this age group (p. 16)."

Physical fitness. Brown (1972) considers the most

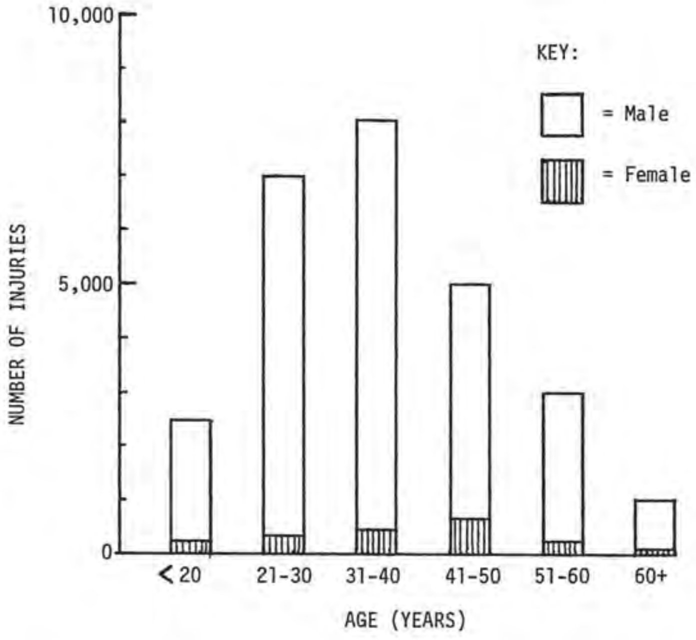

Figure D-2. Age and sex distribution of low back injuries. (Adapted from Brown, 1972.)

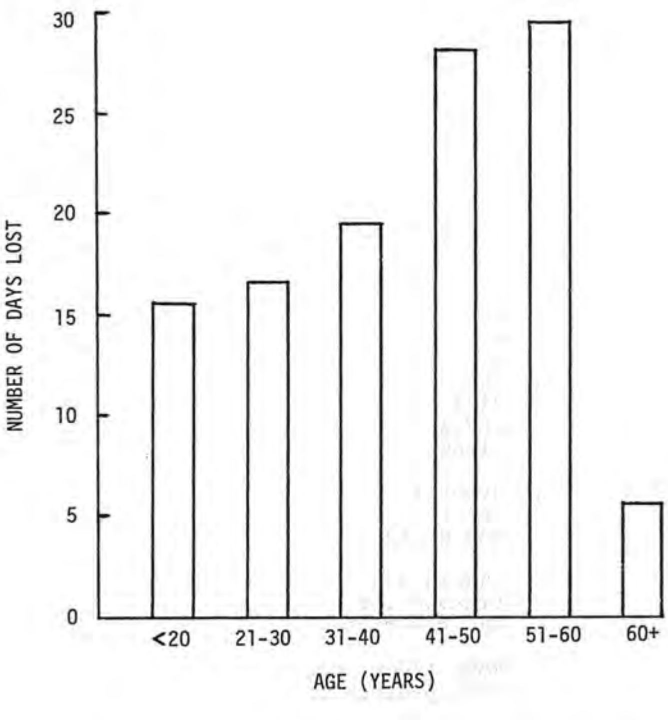

Figure D-3. Average number of days lost due to low back injuries in a food chain distribution operation. (Adapted from Brown, 1972.)

important factor in low back pain to be the physical condition of those bending. In the review by Snook and Cirrello (1972) several studies of the low back pain/physical fitness relationship are cited.

1. Magora (1970) found low back pain in younger persons related to jobs which required either prolonged sitting or hard physical work. This is cited to support the hypothesis that one may suffer from too much or too little physical activity.

2. Feffer (1971) attributed increases in low back pain to one's lack of exercise.

3. Kraus (1965) supported Feffer in the relationship between lack of physical activity and low back pain.

4. Magora (1970) found the lowest incidence of low back pain in a highly physical fitness-oriented occupational group.

5. Guthrie (1963) also found a negative relationship between low back pain and a highly active life style.

6. Magora and Taustein (1969) found increased low back pain among those who had restricted spinal movements.

7. Rowe (1969) also suggested an exercise program to combat low back pain.

Regarding results in terms of reduction of low back pain in industry, Snook and Cirrello concluded from the literature that apparently physical fitness offers the greatest return, followed by job design, selection, and instruction in decreasing order.

Other causes of weight lifting accidents noted by Brown include:

"General causes:

> reduction of the working space,
>
> inadequate dietary intake,
>
> inadequate or incorrect lighting,
>
> inadequate ventilation.

Personal causes:

> the accident proneness of the individual,
>
> numerous psychological disturbances which may arise out of situations in the home and in the workshop (p. 123)."

Heat

A host of scientists have explored the effects of heat on man, concluding that intense heat has a deleterious effect on man's performance and may be injurious both physically and mentally. Some persons may become acclimatized to heat or cold, although many physical conditions may affect the outcome of the process.

Table D-I offers subjective features of tropical fatigue identified by servicemen in the tropics (Ellis, 1953 in Floyd and Welford, 1953).

Gafafer (1964) also noted an increase in lassitude, irritability, and anxiety with hot environments as well as a decrease in morale and ability to concentrate.

Henschel et al. (1969) analyzed all deaths in St. Louis during a summer heat wave to determine the effects of heat on mortality and morbidity. For the period June 22 until July 20, except for July 7, the temperatures exceeded the normal rate

Table D-I

Features of Tropical Fatigue which impair Mental Efficiency identified by Naval Officers and Men serving in the Tropics[a]

	SUBJECTS DESCRIPTION
Lethargy	Lassitude. Lack of energy. Listlessness. Fatigue easily. Less staying power. Tire quickly. Less stamina. Easily exhausted. Lack of vitality. Lack of alertness. Physical and mental fatigue. Capacity for long hours less. Hard to stay awake, especially in afternoons.
Reduced concentration	Cannot concentrate. Hard to concentrate on intricate jobs. Hard to think profoundly. "Grasshopper mind." Reduced concentration in the afternoons.
Retardation	More effort is required. Think more slowly. Manual work is more difficult. Reactions are slower. Work takes longer. Output of work is less. Inclination to go slower. More difficult to learn new subjects. New problems must be tackled more slowly. Slowing of mental and physical activities. Capacity for work is less.
Lowered responsibility	Tendency to leave or rush work in hot spaces. Neglect to detail. Less incentive to explore responsibilities in hot situations. Procrastination. "Couldn't care less" attitude. Less drive. Accept reports without scrutinizing them. Too hot to "jump to it" and "dash around". Tendency to avoid physical effort. Tendency to avoid office work. Make hasty decisions. Lack of interest. Lazy mentally. Harder to maintain discipline. Less keen to get out of the office and see for oneself. Inclined to take the path of least resistance. "Slap-dash" methods.
Personality changes	Short-tempered. Irritable. Impatient. Depressed. Neurotic. Anxious. Apathetic. Inclined to worry more. Minor troubles are magnified out of all proportion to their real importance.
Memory defects	Forgetfullness. Forget simple things. Absent-minded. More effort is required to remember.

[a]From Floyd & Welford, 1953.

by 2 to 17 degrees. During this period it was found that there was an increase in susceptibility to heat-related deaths with advancing age as shown in Table D-II. As demonstrated in Table D-III, the distribution of deaths by age and race showed equal numbers of females and males. Also the ratio of Negro to Caucasian in both male and female groups was approximately the same.

Lind et al. (1955) concluded that there was no significant difference in tolerance to heat due to age or occupation.

Heat acclimatization. Surry (1968) noted an increase in accidents with variations in temperature. Acclimatization occurs in four to seven days in actively working individuals, although the acclimatization is quite slow among the inactive.

Wyndham (1969) described experiments in acclimatization at South African gold mining operations. The author found that the level of production depends on the quality of supervision at low temperatures (below 30° C wet bulb).

At higher temperatures (above 33.3° C wet bulb,) productivity was governed by the heat load, with quality of supervision a less important factor. "Good" and "inefficient" managers were measured in terms of production record and reputation, although no mention was made in the abstract of how the supervisors achieved their production quotas or reputations.

The literature points to the need for the acclimatization process to take place within the hot environment.

Table D-II

Total Daily Deaths by Age Group, St. Louis, July, 1966[a]

July	Under 1 yr	1-19	20-39	40-49	50-59	60-69	Over 69
Preheat wave							
1	1	0	3	6	7	8	18
2	4	0	1	1	4	14	11
3	4	1	0	1	2	10	29
4	2	3	1	3	2	2	25
5	1	1	0	2	8	14	26
6	1	1	0	3	3	10	21
7	0	0	3	3	5	8	19
8	1	1	1	0	6	10	11
Heat wave							
9	1	0	2	4	4	6	27
10	1	2	2	1	6	10	27
11	2	0	0	3	10	19	43
12	4	1	2	5	12	18	53
13	6	3	4	7	17	31	84
14	0	0	2	9	14	23	78
Post-heat wave							
15	3	1	3	5	14	22	49
16	3	0	1	1	4	11	29
17	1	2	4	3	10	9	24
18	2	0	1	0	4	7	25
19	1	1	0	1	4	10	19
20	0	0	2	1	3	5	16
21	1	0	3	2	5	6	12
22	1	0	3	2	6	7	22
23	0	0	4	3	0	7	13
24	2	3	1	3	4	3	26
25	0	1	2	3	9	5	22
26	0	0	2	4	3	6	8
27	2	0	1	1	2	8	12
28	2	0	1	0	4	4	11
29	0	0	0	1	1	3	5
Totals	46	21	49	78	173	296	765

[a] From Henschel et al, 1969.

Table D-III

St. Louis Deaths for
July 1966[a]
by Sex and Ethnic Group

	All causes			Due to heat		
	Male	Female	Total	Male	Female	Total
Caucasian	525	514	1,039	69	87	156
Negro	186	201	387	32	56	88
Indian		1	1		1	1
Unknown		1	1		1	1
Totals	711	717	1,428	101	145	246

[a] From Henschel et al, 1969.

Strydom and Williams (1969) found that physical training in cool environments is not an adequate substitution for heat acclimatization.

Pternitis (1970) in evaluating the burdens of mining operations on workers in normal and hot environments found that the average energy expenditure is related to the intensity of muscular effort, but not to the temperature at the job site.

The author recognized a hyperreactive segment of the population exposed to heat stress. Air conditioning, which lowered the temperature 2° C, had an interesting effect on absenteeism. Absenteeism due to sickness in the hot group exceeded that of the normal group before air conditioning, although absenteeism due to injuries was lower than the normal group. After air conditioning, the absenteeism among the hot group due to sickness decreased, whereas absenteeism due to injuries increased.

Gisolfi and Robinson (1969) studied the effects of strenuous physical training on man's tolerance for work in heat. The subjects performed a pre-training walk in heat (27° C wet bulb) during which measurements of skin temperature, sweat rate, pulse, rectal temperature, weight loss, respiratory change, and energy metabolism were taken. The tests were followed by six weeks of training and a post-training test. Syncopal symptoms occurred in most men during the first walk, yet were absent after training. Measurements of rectal temperature, mean skin temperature and heart rates prior to training were 39.6° C, 37.8° C and 168/minute respectively. After training, the corresponding measurements were 38.7° C, 36.8° C, and 144/minute. Although the indoor training significantly improved the men's heat tolerance, total acclimatization was not achieved.

As noted by Wyndham (1969), motivation plays a part in the heat acclimatization process. Also, Wyndham et al. (1965) found that the ability of miners to endure the middle range of heat stress appears to depend on the individual's desire.

In Bar-Or's study (1969) of the acclimatization process of lean and obese women, he indicated that motivation and will-power play a role in heat tolerance. Most studies reviewed do not discuss the effect of motivation in the acclimatization procedure, although the effect is not unknown. Attention by the experimenter, for example, was shown by the well-known Hawthorne study to have a positive effect on worker productivity even when environmental conditions were adverse.

Baker (1968) referred to individual characterists which may predispose one to heat affliction. Heat cramps, for example, seem to affect only those in good physical condition. Also, those with pre-existing disease states are said to be more liable to suffer heat stroke. Another interesting point is the accident/illness distinction in sunstroke. In 1934 the U. S. Supreme Court in Landress v. Phoenix Mutual Life Insurance Co. ruled "sunstroke" an accident, resulting in the award of double indemnity on a life insurance policy.

Gafafer (1964) stated that "acclimatization is essential if man is to withstand prolonged increased heat loads. This process of adaptation is characterized by the worker's ability to perform with less increase in core temperature and by the secretion of decreased amounts of perspiration. This perspiration is more dilute, that is, it contains a lower concentration of sodium chloride than the perspiration of a nonacclimatized individual....Acclimatization to heat occurs in from 1 to 2 weeks (p.279)."

The National Institute for Occupational Safety and Health (1972) released a criteria document on occupational exposure to hot environments which provided an extensive review of the literature. This document offered guidelines in giving a pre-placement examination for those employees who will be working in heat, identifying factors in one's medical history that could be indicative of intolerance to heat stress. Regarding new employees, the document stated that, ". . . without previous occupational exposure to heat, they should not be assigned to hot jobs where the environmental conditions exceed 79° F WBGT for men and 76° F WBGT for women until they are acclimatized. It has been established that both heat tolerance and also physical work capacity decline with age (p. V-20)." Significant pre-existing impairments of the heart, kidneys, lungs, liver, endocrines, and skin should disqualify applicants for exposure to hot environments. Use or abuse of drugs by employees should also be scrutinized to offset possible harmful drug-heat interactions.

Close medical surveillance is recommended. The authors noted that, "exposure to hot environmental conditions can lead to primary heat illnesses, to unsafe acts, or to increased susceptibility to toxic chemicals and physical substances (p. V-25)."

Cold

Surry (1968) found a dearth of studies on the effect of cold on accident rates. "The 'cause' of accidents in cold might be due to sluggish movement, reduced feeling in fingers or toes, slow visual response, or interference from bulky clothing. Impairment of judgment or decision-making ability might be a result of personal worry or annoyance at the cold, but it is not directly a function of the cold (p. 97)."

She feels that a careful study of the cold/accident relationship is needed.

Cold injury. Hansen and Goldman (1969) in a review of the etiology of cold injury were specifically interested in cold injuries among military personnel. They found the following:

1. The front line infantry was most affected.
2. A major factor in susceptibility was inactivity.
3. The most affected parts of the body were the feet.

4. Of 705 cases reviewed, 59% of injuries to the hands or feet involved Negros, while 41% involved whites. This apparent increase in susceptibility was explained by:

   a. personal hygiene,

   b. physiological factors,

   c. previous history, and

   d. level of training.

5. Negroes also showed less susceptibility to spontaneous rewarming than whites.

The author noted that a prediction of cold injury might be based on the chill factor and amount and quality of protective clothing.

Gafafer (1964) pointed to various physiological conditions which may be caused or aggravated by exposure to cold. The conditions include chilblain, Raynaud's disease, acrocyanosis, and thromboangiitis obliterans.

Matching the Man and the Task

The assessment of physical fitness and general ability is important to industry if a match between man and the task is desired. Rosenthal and Muller (1972) sought to demonstrate the possibility of establishing a testing routine with physical standards for matching personnel to the physical demands of the task. The goals of the study were to optimize the man/task compatibility, reduce injuries and accidents, and eliminate discriminatory hiring practices (one would be hired on the basis of ability rather than age, sex, etc.). A task analysis was made of various jobs to determine the necessary force required to perform them. Hand grip, overhead push, and two-finger, two-hand pull tests were given to 10 males and 10 females to determine their abilities on comparable tasks on the job. Figures D-4, 5, and 6 give the distribution of the abilities of the subjects on the various tasks.

It may be seen that the figures represent the combination of both the male and the female subjects. On the two-finger, two-hand pull test, Figure D-4, only one female subject was able to exert a force above 29 pounds, whereas six male subjects exerted forces over 29 pounds.

The bimodality of the grip test, Figure D-5, also reflects a sex differential, for no female subject was able to exert a force in excess of 69 pounds.

The overhead push test, Figure D-6, demonstrated that only 30% of the female subjects were able to exert a force greater than 39 pounds.

Based upon such tests, the distribution of test scores is used to determine the percentage of the population capable of meeting the requirements. If 90% of the population can perform the task, then the demands of the job are reasonable. If 90% of the population is unable to meet the requirements, then only 10% of the population should be allowed to perform the task in question, or the task should be changed to accommodate more people.

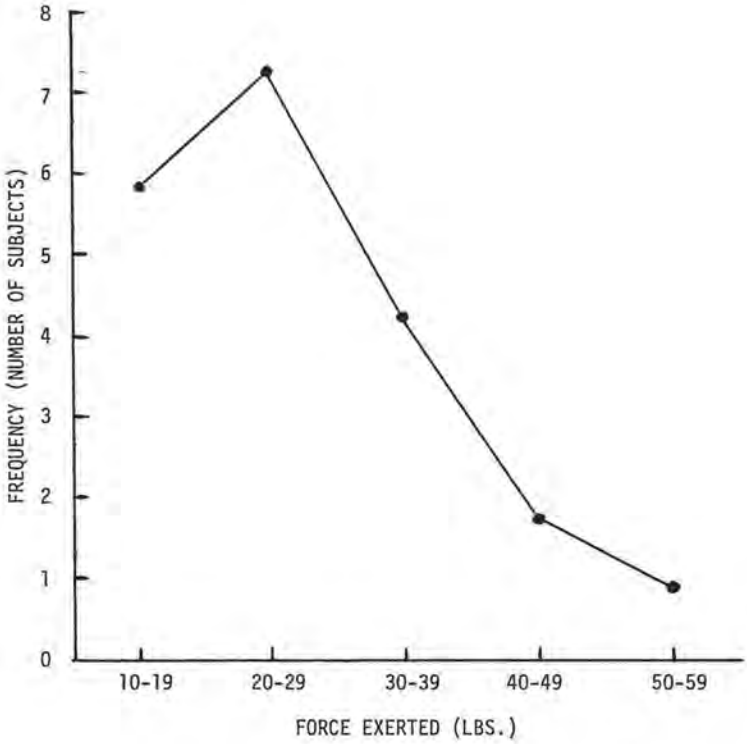

Figure D-4. Two-finger, two-hand pull test. (Adapted from Rosenthal and Muller, 1972.)

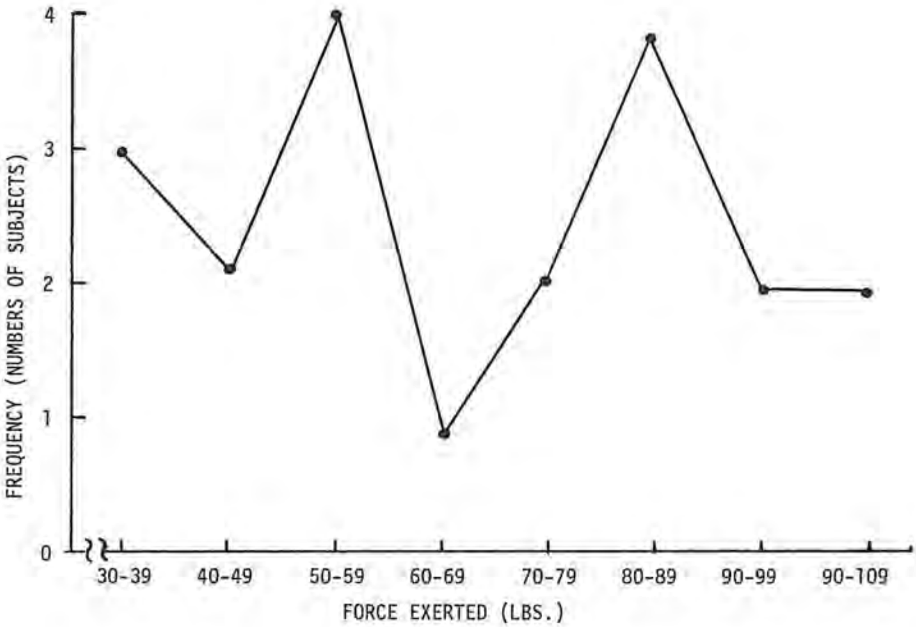

Figure D-5. Grip test. (Adapted from Rosenthal and Muller, 1972.)

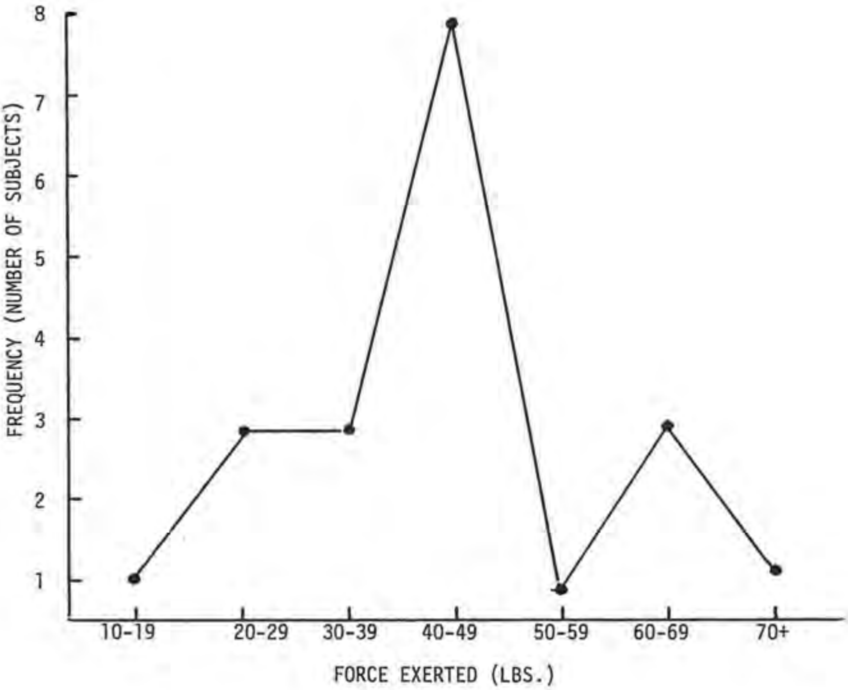

Figure D-6. Overhead push test. (Adapted from Rosenthal and Muller, 1972.)

SUMMARY OBSERVATIONS

Summation

An analysis of the literature relating various measures of physical work capacity to safety and health revealed generally that the overall physical state, height, weight, physical fitness, and acclimatization to the work environment affected one's ability to perform safely and with little illness.

Hypersusceptibility

Increased tendencies to industrial accidents and illness result in part from an individual's inability to perform expected work tasks or withstand the challenge of a potentially stressful or hazardous environment. Within this group of persons who cannot perform a specified task and/or withstand a hazardous environment there are those who (a) are capable of altering their physical condition to meet the demands of their work and (b) those who, by virtue of unalterable states such as age or sex, cannot change their strength, size, or co-ordination to meet job demands.

The published literature points especially to obese individuals as having heightened sensitivity to heat exhaustion, heat stroke, physiological strain, respiratory strain, decompression sickness, pesticide toxicity and accidents (Henschel, 1967).

Those who are physically out of condition or who have debilitating diseases are susceptible to injury and illness at work. The unacclimatized individual, unable to withstand environmental demands also may suffer illness and accidents.

Selection and Placement

A match of man and machine is necessary in the reduction of accidents. Rosenthal and Muller (1972) indicate the importance of assessing an individual's physical capacity to perform his job assignment in industry.

Jobs requiring certain physical abilities to perform tasks or to withstand stressful environments should consider the physical abilities of the employees. Selection based upon these measurements eliminates generalized assumptions concerning the inability of women or certain age groups. The industry involved in hiring might determine the quantifiable skills necessary to perform the job tasks then test employees experimentally on their abilities to perform these tasks. An industry requiring the continual lifting of 40 pound boxes should not hire someone capable of lifting only 20 pounds unless the task itself is altered. Rosenthal and Muller (1972) note that if 90% of the population can perform the task then the demands of the job are generally considered to be reasonable.

Acclimatization to adverse environments should be a consideration in hiring, for some individuals are unable to adapt readily to hot, cold, dusty, or noisy conditions.

Amelioration

As accident rates are said to be high among those physically unfit, it seems reasonable to suggest that industry provide for the physical conditioning of their employees. Two aspects of such conditioning may be important: (a) conditioning prior to assuming full job responsibilities (such as in acclimatizing the worker to heat prior to assignment in a hot working environment) and (b) conditioning while employed to maintain adequate levels of physical capacity to perform the assigned tasks. The latter seems especially necessary in jobs with sporadic heavy physical requirements such as may be encountered by firemen, for example.

As physical fitness is also a contributing factor in the reduction of illnesses, it should be encouraged by providing exercise areas for employees and/or suggested physical training programs. This type of program is currently advocated for some U. S. Government employees.

As an adjunct to a general physical training program industries might attempt to facilitate such means of going to and from work as walking and bicycling. This might be accomplished by providing easy routes of access to industrial facilities, lockers and changing rooms, and areas for bicycle storage.

Other amelioration techniques would be those designed to change the designs of work environments and machines to accommodate a wider range of individual differences.

Research Needs

An assessment seems to be in order of the current state of industrial procedures regarding physical standard setting and programs designed to alter the physical work capacity of the individual, or the requirements of the job. This program might include:

1. A collection of appropriate data on the accidents and illnesses resulting in whole or in part from poor physical conditioning or from physical conditioning less than the physical requirements of the job.

2. A judgment as to the levels of physical work capacity needed to perform certain industrial tasks.

3. An assessment of how individual differences may best be dealt with by redesign of the work environment, selective placement based on uniform and valid criteria, programs for physical training, or a combination of the above.

4. An evaluation of how industrial programs are succeeding in ameliorating individual differences in work capacity.

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PHYSICAL WORK CAPACITY

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents	1316	1196		1 2 720 1204		697
Agent - Specific Diseases	721 827	3 12 67 330 486	476 488	720 748 1068 1203		1205 1206
Non-Specific Disorders		109 301 517		2 320 1200 1201 1204		1207
Critical Incidents						
Rate/ Amount of Sick-Absence						565
Perform-ance Indices		3 67 186 330 474 1156	488 1202	2 720 1200 1201 1203 1204		1205
Strain Indices		3 67 474 486	476 488	748 1068 1203 1204		1205
Morale		474				
Compliance with Rules						
Off Job Problems						
Miscel-laneous						

ALCOHOL AND DRUGS

A portion of a report--

PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT WORKER PHYSICAL AND PSYCHOLOGICAL FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

ALCOHOL AND DRUGS

> "If the law (prohibition) were changed, we'd have to shut down our plants. Everything in the United States is keyed up to a new pace... . The speed at which we run our motor cars, operate our intricate machinery, and generally live would be impossible with liquor."
> Henry Ford, 1929
> (Fox & Fox, 1963)

Most of the literature dealing with the use of alcohol by industrial workers focuses on methods of rehabilitating the alcoholic employee. Despite its possible significance, little research has developed linking industrial accidents to alcohol intake before or during the work day.

This review covers those studies which investigated the role of alcohol use in accidents. The fact that much of this research deals with drunk-driver traffic accidents reflects the nature of the majority of studies in this area.

A number of researchers considered biographical and social variables as important factors in the alcohol problem. Their work is included in this review, as is research on alcohol as a cause of illness.

Finally, studies of drug use and its relation to safety and health are cited.

Accidents

A review of the indistrial accident literature (Hale & Hale, 1971) determined that alcohol has a deleterious effect on performance because it affects vision, psychomotor function, judgment, reasoning, and memory (Cohen, Dearnaley & Hansel, 1958; Drew, Colquhoun & Lang, 1959). The results of other studies cited in this review indicated:

1. Adult pedestrians fatally injured by motor vehicles were identified as middle-age and heavy drinkers. They were involved in more than their fair share of accidents (Haddon et al., 1961).

2. 17% of persons involved in road accidents had consumed alcohol and their accidents tended to be more serious (MacKay et al., 1969).

3. Alcohol consumption was found more often in an accident group (McCarroll & Haddon, 1962).

4. An investigation was made of 97 cases of workers dying before the age of 65. It was found that 16 of the workers were killed in accidents, and, in 7 of the 16 cases, the workers were under the influence of alcohol (Godard, 1955).

5. An alcohol concentration of over 0.05 gm/L was associated with a 10% increase in accidents (Metz & Ledermann, 1960).

6. Drinking accounted for 7.4% of all accidents and the subjects with one serious accident drank more heavily than those with only minor accidents (Metz & Marcoux, 1960).

7. People who had sustained two or more accidents before the survey were more likely to have a blood alcohol level of 1.01 gm/L or more at the time of the survey. The authors cautiously pointed out that the results could be coincidentally or causally connected with accidents (Marcoux, Siebert & Metz, 1960).

8. No significant relation was found between high-accident groups and those who drank more than two pints of beer at lunch time (Powell et al, 1971).

Hale & Hale (1971) concluded that alcohol is related to road accidents, but that this relationship has not been established in industry.

Tabachnick, et al. (1966) studied 15 matched sets of male suicide and one-car fatalities. It was found that half of the fatalities in each group had been drinking.

A three-year study by Eilkema (1970) of the accident and violation rates of those discharged from state mental hospitals indicated that alcoholics showed some decrease in accidents and violations after discharge, compared to a matched general population group. He found, however, that punitive measures did little to affect the accident rates for alcoholics.

Waller (1970) found, in an investigation of blood alcohol concentrations among drivers and pedestrians fatally injured in collisions involving trucks, that:

1. drivers of large trucks probably had not been drinking before their crashes; they were usually not at fault and almost always survived;

2. the fatally injured drivers or pedestrians who initiated the crashes commonly had high blood alcohol concentrations;

3. drivers of pickup trucks usually had high blood alcohol concentrations; they often were responsible for their crashes and were frequently fatally injured.

Waller & Turkel (1966) reported the results of autopsy on 208 traffic deaths. An examination of the liver and blood alcohol level demonstrated a relationship between alcohol and accidents. This relationship is shown in Table E-I.

A review of the literature by Waller (1971) also demonstrated support of the alcohol/accident relationship.

Selzer (1969) found that alcoholics were significantly overrepresented in an accident group of 96 deceased and surviving drivers when that group was compared to 96 controls. The accident group also had more previous accidents and moving violations, more psychopathology and social stress, and were part of a lower social class. The author suggested that an alcohol-related conviction is a strong indication of alcoholism, and that drinking drivers are often known by family and police before an accident.

Demone and Kasey (1966) stated that, based on their review, the frequency and seriousness of industrial accidents and the mean number of days lost per accident are greater among alcoholic than non-alcoholic persons.

Surry (1968), in a section of her review entitled "Alcohol", cited a "classic Canadian work" which showed that as blood alcohol level increases, accident liability increases. Table E-II demonstrates this relationship by comparing the alcohol levels of victims of accidents with controls. As the percent of alcohol in the blood increases the accident hazard increases. Table E-III shows the effects of various quantities of alcohol.

Surry also recognized the dearth of information on the relationship of alcohol to industrial accidents. She stated that "...no North American studies have investigated the

Table E-I

Cumulative Blood Alcohol Levels According to Age Among Drivers and Pedestrians Who Had Been Drinking Before Death and Who Died Within Six Hours After an Accident[a]

Age	Blood Alcohol Level 49 mg./100 ml. or Less	99 mg./100 ml. or Less	149 mg./100 ml. or Less	199 mg./100 ml. or Less	All Levels
Year	No. of Cases	No. of Cases	No. of Cases	No. of Cases	No. of Cases
15 - 24	0	4	5	12	14
25 - 64	0	2	6	12	28
65 & older	1	2	3	6	7
Totals	1 (2%)	8 (16%)	14 (29%)	30 (61%)	49 (100%)

[a] From Waller and Turkel, 1966.

Table E-II

The Effect of Alcohol on Accident Liability (Hazard) on the Road[a]

% Alcohol in Blood	Hazard
0.05	1.0
0.05 - 0.10	1.5
0.10 - 0.15	2.5
More than 0.15	9.7

[a]From Surry, 1968

Table E-III

The General Effects of Alcohol on Man[a]

Quantity of Whiskey	Blood Alcohol Level (Average Man)	Effects
2 oz.	.04%	Depresses higher order intellectual functions. Judgment, memory, reasoning, etc. are decreased. Sense of euphoria.
6 oz.	.12%	Affects motor control centres. Lack of fine control; increasing need to lie down.
10 oz.	.20%	Affects emotional centre. Increasingly stuperous.
16 oz.	.32%	Affects sensory area, e.g., reduced vision and sense of pain.
24 oz.	.48%	Affects perception, increasing to coma.
32 oz.	.64%	Destroys control of breathing and heart, inducing death.

[a]From Surry, 1968.

involvement of alcohol in work accidents. This is presumably due to the belief that drinking is well controlled in industry. However, given the damning evidence of alcohol involvement in traffic accidents, it would be worthwhile to take blood samples of industrial accident victims and compare with fellow workers. Until it is proven that very little drinking occurs at or before work, the possibility of effects on accident liability must be borne in mind (p. 81)."

Surry noted two French studies indicating involvement of alcohol in 10% of all industrial accidents and in 29% of those requiring hospitalization. She concluded that accident liability while driving increases with even small qualtities of alcohol consumption, and that the role of alcohol in industrial accidents should be investigated.

A study by Tichauer and Wolkenberg (1972) investigated the side effects of alcoholic intoxication on occupational safety and health. Various instruments were used to measure these effects, for example, the lordosimeter, the triaxial kinesiometer with task board, an eye/hand coordination device, and a breathalyzer. The subjects ingested various amounts of alcohol producing blood alcohol levels ranging from 65 mg. % - 175 mg. %.

The delayed effects of alcohol were observed as much as 18 hours after ingestion. Observed changes were found in eye/hand coordination not involving tracking, precision in manipulation and object positioning tasks, and a general posture in materials handling. It was noted that these changes could create safety and health hazards.

Thorndike (1951), in his review of the literature, stated that common sense tells us that a drunk man's performance is not as good as a sober man's. He reported that no studies had been found indicating the proportion of cases in which alcohol was a factor in industrial accidents. He found no evidence as to the amount of alcohol necessary for an increased possibility of accident. It was concluded by Thorndike that information is needed on:

a. the proportion of accidents in which alcohol is a factor;

b. the effect of less extreme indulgence in alcohol on accident liability; and

c. the role of the delayed effects of alcohol, as represented by "hangover" or accumulated fatigue, on accident potential.

Illness

Pell and D'Alonzo (1968) found that hypertension and cirrhosis of the liver were the only conditions which were both unequivocally and strongly related to alcoholism. The authors, after a review of the prevalence of chronic disease among problem drinkers, found that it doesn't necessarily follow that alcohol plays a direct role in their pathogenesis. Other variables noted as associated with chronic disease include:

1. Nutritional deficiencies;

2. Excessive use of drugs in addition to alcohol;

3. Psychiatric problems frequently seen in alcoholics, such as anxiety states; and,

4. A disorderly way of life and poor health habits.

Absenteeism

Thurber (1971) estimates that 4% to 5% of employees will be involved in problem drinking, and that resultant absenteeism, decreased work performance, and loss of skills will cost industry four billion dollars annually. He suggested good rehabilitative programs and noted that success may depend on early detection and the motivation of potential job loss.

Indulski (1967) reported that smoking and drinking increase absenteeism.

Social-biographical Variables

In considering the type of social environment at work purportedly conducive to the development of drinking problems, Roman and Trice (1970) listed the following factors:

a. The occupancy of jobs in which production goals are nebulous;
b. Flexible work hours and schedule of output;
c. Low supervision;
d. Work addiction;
e. Work role removal;
f. Novel job role;
g. Drinking as part of the job role; and
h. A change from a tension-filled supervised job to a tension-filled unsupervised job.

Perrine (1970) presented data on the psychological and biographical variables associated with drinking drivers. Of the driving-while-intoxicated group, 97% were males, 75% were over 24 years of age, 18% were without spouses, and 50% were laborers.

One facet of industry's program to combat the deleterious effects of alcohol and drug abuse is the screening program. An article by Selzer (1971) outlined the Michigan Alcoholism Screening Test (MAST). The test consisted of 25 questions and was given to various alcohol-involved groups and subsequently validated by review of their records.

Drugs

Most of the literature on drugs in industry deals with the problem of the drug abuser. Less information exists on drug use or misuse as a factor in sickness or accidents. Animal studies, such as those by Falk (1972), demonstrate that drugs such as salicylates, quinine, diuretics, and antibiotics may increase susceptibility to noise-induced hearing loss. A letter from Dr. Falk (1973) stated that: "To my knowledge, the noise-drug interactions...have not been documented in humans as yet, although their chance of occurring seems probable."[1]

The Harris and Mackie survey (1972) of bus and truck drivers asked the drivers, "Among other drivers whom you know, what percent would you say occasionally use some sort of pill, like Benzedrine, to pep them up when they get tired on long hauls (p. 68)?" The question was also asked again, substituting the word "frequently" for occasionally. The results are shown in Table E-IV.

The authors note that drivers who drove 2,000 + miles per week and who were under 30 years of age were more inclined to

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[1] S.A. Falk, personal communication, April 19, 1973.

Table E-IV

Knowledge of Drivers Who Use Pep Pills (By Type of Carrier)

Amount of Use	Owner Operators (N=202)	Common Carriers (N=100)	Private Carriers (N=98)	Bus Drivers N=148)	All Drivers (N=548)
Yes, know drivers who use pills occasionally	45	42	47	16	37
No, do not know of drivers who use pills occasionally	32	38	38	74	46
Don't know whether they do or not	23	20	15	11	18
Yes, know drivers who use pills regularly	31	24	34	3	23
No, do not know drivers who use pills regularly	46	54	50	86	59
Don't know whether they do or not	23	22	16	11	18

[a] From Harris and Mackie, 1972.

"know" drivers who used pep pills as a means of combating fatigue. It was also noted that, with respect to alcohol use, similar frequencies of response were obtained. It was concluded that the similar patterns may "lend some credence to the assertion that there is significant use of both drugs and alcohol by some truck drivers engaged in long haul operations and, to a much lesser extent, by bus drivers (p. 68)."

Another study of drivers, Woody (1970), reported on three episodes of visual disturbance as a result of hallucinogenic drug usage. The author concluded that drug usage may create driving hazards as a result of visual disturbances.

O'Connor (1968) characterized the "typical" drug user as living alone, influenced by friends and manifesting a deep-seated depression and search for euphoria. He suggested urine screening for detection in the pre-employment physical.

A guide for managers (Chambers & Heckman, 1972) presents a table, Table E-V, summarizing drug use in an industrial survey. The table categorizes the employee population by type of positions held and type of drug abused. The authors discussed the great cost of drug abusers to industry, and estimated that a practicing drug abuser is only 50% efficient. The abuser is also responsible for an inordinate amount of absenteeism.

Bitter (1971) also pointed to the problem of drug users in industry. He felt that the drug user lacks initiative, exhibits poor attention to detail, is accident prone and his

Table E-V

Numerical Distribution of Regular Drug Users (at Least 6 Times Per Month) of All Workers in New York State [a,b]

Worker Classification	Marihuana	LSD	Methedrine	Heroin	Barbiturate	Other Sedative
Professionals, technical workers, managers & owners	48,000	2,000	2,000	4,000	44,000	21,000
Clerical & other white collar workers	57,000	--	3,000	9,000	23,000	12,000
Skilled & semiskilled workers	86,000	4,000	--	8,000	27,000	21,000
Unskilled workers	17,000	1,000	1,000	1,000	7,000	6,000
Service & Protective workers	35,000	3,000	--	--	33,000	10,000
Sales workers	50,000	15,000	4,000	12,000	71,000	1,000
Farmers	--	--	--	--	--	1,000
Totals	293,000	25,000	10,000	34,000	205,000	72,000

Continued

Table E-V (Continued)

Worker Classification	Minor Tranquillizer	Major Tranquillizer	Anti Depressants	Pep Pills	Diet Pills	Narcotics Non-Heroin
Professionals, technical workers, managers & owners	50,000	3,000	--	14,000	34,000	4,000
Clerical & other white collar workers	81,000	20,000	4,000	12,000	35,000	1,000
Skilled & semiskilled workers	36,000	15,000	8,000	9,000	21,000	5,000
Unskilled workers	10,000	1,000	1,000	1,000	2,000	1,000
Service & protective workers	38,000	4,000	--	7,000	4,000	3,000
Sales workers	25,000	12,000	--	8,000	21,000	5,000
Farmers	--	--	--	--	--	--
Totals	240,000	55,000	13,000	51,000	117,000	19,000

[a] Adapted from Chambers and Heckman, 1972 based on a study by the Division of Research, New York State Narcotic Addiction Control Commission.

[b] Numbers are estimates projected from survey results to the population of approximately 7.3 million workers in New York state.

job interest and productivity tend to decline. The author recommended training for the supervisors on the drug problem among workers.

A study of drug-related deaths among military personnel by Froede & Stahl (1971) concluded that:

a. 2/3 of the drug-related deaths are in the 18-25 age bracket and that the highest incidence is in the 20-25 year age bracket;

b. narcotic usage is greatest in the lower economic or social groups;

c. the current movement of the abuse is from the lower to the higher socio-economic groups;

d. the boredom factor is thought to account for an increase in drug usage during holding actions;

e. the majority of deaths result from an overdose or hypersensitivity.

Some evidence exists that coffee may affect one's health. The Boston Collaborative Drug Surveillance Program (1972) noted the daily hot beverage intake of 276 patients before their admission to a hospital with acute myocardial infarction, and compared it to that of 1104 matched control patients with other diseases.

The quantity of tea taken by each of the two groups was approximately the same, yet more coffee was consumed by the patients with acute myocardial infarction. The difference could not be explained by cigarette smoking. The consumption of coffee and cigarettes were strongly correlated, however, the relation between coffee consumption and acute myocardial infarction could not be explained by cigarette smoking.

The author suggested the re-evaluation of the role of coffee drinking in the etiology of acute myocardial infarction.

Another study on the effects of caffeine (Goldstein et al., 1965) found large individual differences in the degree of wakefulness produced by caffeine in a group of 20 subjects. Some indication of chronic sleep disturbance was noted among those drinking the most coffee. It was concluded that individual differences in sensitivity may arise from basic differences in responsiveness to caffeine at the action sites in the brain, rather than from differences in absorption, distribution, or metabolism of the drug.

SUMMARY OBSERVATIONS

Summation

Sufficient anecdotal and empirical data exist to support the positive relationship between the use and abuse of drugs or alcohol and accidents and illness.

Use of alcohol and drugs may cause illnesses ranging from temporary malaise to degenerative diseases such as cirrhosis of the liver or hypertension. The performance decrement resulting from the use of alcohol and drugs may lead to increased on-the-job and off-the-job accidents.

Hypersusceptibility

The off-the-job use of alcohol in small quantities does not seem to be a problem for industry, although evidence does exist showing rather lengthy delayed effects which drinking may have on performance. What seems to be the greatest problem for industry is the abuse of alcohol and drugs leading to degeneration of skills and loss of efficiency. This abuse may be viewed as a manifestation of severe employee problems. That is, a worker may resort to frequent or excessive use of alcohol or drugs as an escape with there being, as a consequence, increased risk of accidents and illness.

In particular, it seems that men over 24 years of age have an increased probability of drinking while driving. Also, those in especially flexible and unstructured work roles appear more prone to the development of drinking problems.

Selection and Placement

Campaigns waged against the abuse of alcohol and drugs may be aimed at particular target audiences. The group of persons using illicit drugs or abusing licit alcohol or drugs appears to be different from those who are termed "social drinkers" or who use aspirin or other common drugs rationally. A program suggesting wise use seems logical for the latter group, while close medical supervision seems in order for the first group.

Amelioration

If a relationship exists between job stress and the increased use of alcohol or drugs, then it seems that industry should be concerned with either reducing job stress or selecting those able to handle it appropriately.

Workers identified as alcoholics should be encouraged to participate in programs which have as their goal resolution of the individual's problems. Those who appear to have had a problem with alcohol or drug use in the past, or who manifest psychological characteristics deemed especially conducive to the development of a drinking problem, should be carefully supervised.

As job hazards increase (for example, where a worker is required to make precise psychomotor responses) the potentially injurious effects of alcohol abuse increase.

Those who are or were considered drug addicts should be required to present data demonstrating their control of the problem prior to employment as they might endanger themselves and others if on complex multi-man jobs.

Those who are currently undergoing medicinal drug therapy should be identified, as such drugs may have an adverse effect on their job performance.

Research Needs

A great deal of research has been done demonstrating the effects of alcohol and drug use on driving performance. These results apply to those industries employing drivers, but generalization to other industries should be done with caution. There is a need for controlled studies of the effects of alcohol and drugs in specific industries or work tasks other than those involved in transportation.

Another area in which little data exists is the effect of licit, prescription and non-prescription drugs on employee safety and health. It seems logical to assume, for example, that the use of sedatives and the simultaneous operation of a drill press or other complex machinery would be contra-indicated.

Regarding drugs, research is indicated on the possible interactions between an individual's use of licit drugs and a potential chemical challenge. No specific data were found in this regard.

Since a great deal of U. S. alcohol consumption is accounted for by so-called "social drinking," not alcoholism, research is needed in this area. Tichauer & Wolkenberg (1972) have explored these long-term effects and find them an important factor in performance decrement. Possibly this work should be expanded.

One study (Powell et al., 1971) investigated the effects on accidents of alcohol consumption during work. The lunch period finds many employees drinking various amounts of alcohol and perhaps this would have some effect on accidents. The practical solutions to such problems will come about only with scientific study approaches aimed at realistic goals.

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ALCOHOL AND DRUGS

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	 Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	 Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents		146 752 1196 1199		1 2 6 25		1193 1194
Agent - Specific Diseases		126 867 951		736		1192
Non-Specific Disorders		752 1199	101 276 718 1197 1198			
Critical Incidents						
Rate/ Amount of Sick-Absence		846		736		
Perform-ance Indices		735 1199 1297	298	2		
Strain Indices						
Morale						
Compliance with Rules						
Off Job Problems				736		
Miscel-laneous		139 946 146 1111 183 1176 734 1189 871 1190	1197	1 2 145 736 1191		524 1195

FATIGUE

A portion of a report--

PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT WORKER PHYSICAL AND PSYCHOLOGICAL FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

FATIGUE

Introduction

A voluminous body of literature has been devoted to the definition and study of fatigue. Tiffin's Industrial Psychology (1952) lists three types of fatigue:

1. physiological=chemical change in muscle tissue;
2. psychological=a condition of boredom which may have no relation to physiological state;
3. industrial=reduction of efficiency on the job.

Many definitions of fatigue have been formulated by researchers, dictated by their particular area of study. These include the following:

1. a decrease in the capacity to do work;
2. a decrease in interest or willingness to do work;
3. a failure to maintain physiological or organic equilibrium;
4. a lessening of irritability and responsiveness of the tissue,
5. a convenient word to describe a variety of phenomena.

Bartley and Chute (1947) note that the subject of fatigue is approached in different ways by scientists in different disciplines. Biochemists study fatigue in terms of body chemistry, physiologists study muscle and nerve activity, and psychologists study performance.

Cameron (1973) characterizes fatigue as a generalized response to stress extending over a period of time. He suggests that the severity of fatigue may be most effectively measured by examining the time required to recover from it.

Hartman (1970) distinguishes three general categories of fatigue:

1. Acute fatigue occurs in a single work cycle between sleep periods. Recovery to a normal condition is accomplished by normal sleep and rest. Its primary effect is a reduction in efficiency and/or productivity, in almost any kind of work. Effects are limited mostly to increased feelings of tiredness. Motivation and morale in the long-range sense are unaffected.

2. Chronic fatigue is a clinical condition unrelated to work cycles, or to conventional kinds of rest and recovery. Recovery usually does not occur without clinical intervention. Efficiency and productivity are depressed, but this is really not very relevant since this effect is the result of an unwillingness to work. Specifically, the affective states are paramount, and morale and motivation are severely degraded.

3. Cumulative fatigue occurs across an extended series of work cycles, frequently against a background of marginal schedules or situations for rest and recovery. Efficiency and/or productivity usually are not reduced much more than the changes seen in the one day, single-cycle effect obtained in acute-fatigue conditions, but the men report that it "costs" them a great deal more to keep going and express concern about being able to continue under existing conditions.

Grandjean (1970) considers fatigue, whether related to workload or monotony, as a state of the central nervous system controlled by the antagonistic activity of the activating and inhibitory system of the brain stem. He notes that the symptoms of fatigue are:

1. decrease of attention,
2. slowed and impaired perception,
3. impairment of thinking,
4. decrease of motivation, and
5. decrease of performance for physical and mental activities.

Studies of fatigue are important to industry in that they may help determine working conditions which will encourage maximum production over extended periods. The concern in this review, however, is focused on what effects fatigue may have on health and safety of workers and whether there may be a differential effect related to some personal characteristic.

Industrial Accidents and Fatigue

Most of the literature dealing with the relationship of fatigue to safety and health is concerned with accidents. Research reports relating fatigue to motor vehicle accidents are especially plentiful, for example, Baker (1967) and Case and Hulbert (1970).

It is usually assumed that the normal individual has more accidents when fatigued. However, Bartley and Chute (1947) point out that research has not found a close positive or negative relation between fatigue and accidents. The relation may be complex, and unless actually confirmed, they believe accidents should not be used as an index of fatigue.

In the review of the literature by Hale and Hale (1971), several studies are cited on the relation between fatigue and accidents.

1. Vernon (1945) appeared to find evidence for greater fatiguability in women, reporting an increased accident rate for women over men when the working day was increased from 10 to 12 hours in a factory. He qualified this finding by noting that women usually are responsible for considerable work outside the factory.

2. Age was a fatigue factor in a study by Vernon and Bedford (1928). They found that the increase in

accident rate for older miners was disportionately greater than the rate increase for younger miners when the shift length was increased by 30 minutes.

3. King and Speakman (1953) noted that physical defects affect susceptibility to fatigue.

4. Murray (1968) argued that fatigue reduces the individual's spare capacity or margin of safety, thus reducing his ability to avoid danger.

5. Some relationship has been established between the time of day and accidents. Studies generally have found that the accident rate is low in the first hour of the morning and then rises to a peak sometime between 10:30 a.m. and the lunch break. The rate is low again after lunch, climbs to a mid-afternoon high and then levels or declines to the end of the shift (Surry, 1968). This relationship is described in Figure F-1. These results do not seem to verify a rise in accidents as fatigue cumulates during the course of the workday.

6. Some evidence shows that accident rates tend to be higher just before breaks than they are after break periods (Horney, 1953; Graf and Paul, 1956; Powell et al, 1971). The rate of work (work pace) tends to increase just before breaks, and this rate change is suggested as a more important factor than fatigue in explaining the accident rates.

7. Work on the night shift seems to produce fewer accidents than work on the day shift in a three-shift system (Kubler, 1956; Andlauer and Metz, 1955; Neuloh, et al 1957). Other studies reported in Wyatt and Marriott (1953) and Matthews (1965) show higher accident rates for workers on the night shift. It should be noted that direct comparisons between day and night shift workers on accident rate or other response measures are confounded by self-selection factors for night workers, less supervisory influence (or interference), smaller and apparently closer-knit working groups on the night shift. Accident rates seem to rise after work breaks in contrast to the day shift pattern. See Figure F-2.

8. A cumulative fatigue effect is not evident in studies of the distribution of accidents over the days of the week. Monday nearly always has the highest accident rate.

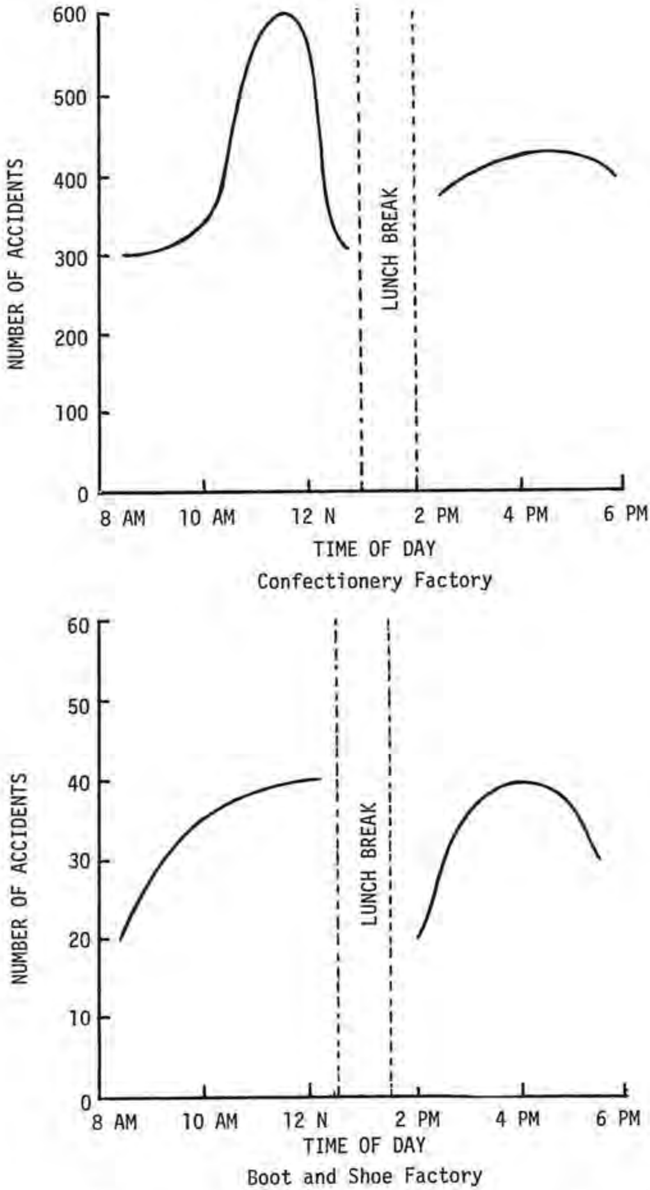

Figure F-1. Accidents in the day shift. (Adapted from Farmer, et al, 1933, as cited in Surry, 1968)

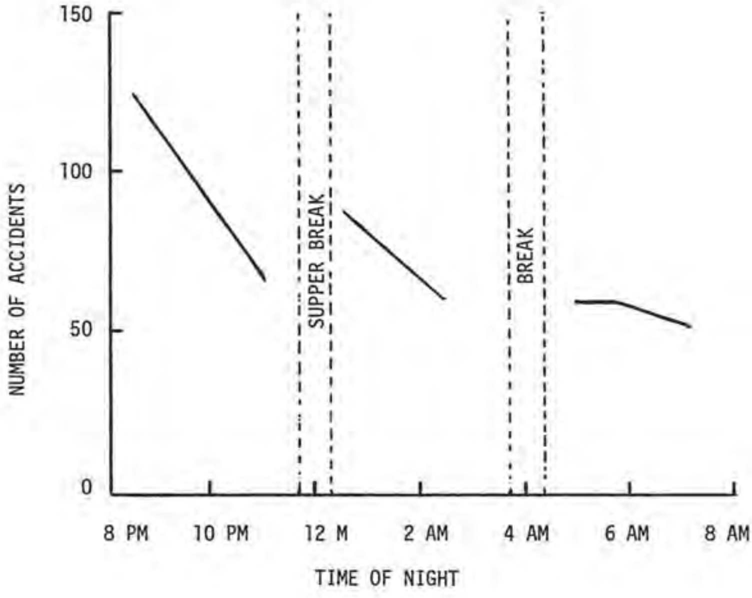

Figure F-2. Accidents in the night shift. (Adapted from Osborne, et al., 1922, as cited in Surry, 1968)

9. Several studies have investigated accident rate as a function of the rate of productivity:

   a. Horney (1953) found that accident peaks coincided with productivity peaks.

   b. Graf and Paul (1956) found accident peak and output peak were related in coal mines.

   c. Powell (1968) reported that the number of accidents was related to the volume of goods handled.

   d. Hale (1969) found a relationship between the amount of work done and errors, except when he considered the two extremes of very light or very heavy work loads.

Hale and Hale (1971) noted that the data "suggest that more work brings with it more presentation of the hazards inherent in it, and hence a greater liability to accidents per unit of time (p. 80)."

Several studies support the contention that more work increases the accident rate per unit of work done (Vernon, 1918; Powell, et al, 1971; Hale, 1969). These studies found that overtime increased the accident rate substantially, which would seem to implicate fatigue as a factor.

Little work has been done relating accidents to work pace. Hale and Hale admitted that one study (Keenan, Kerr and Sherman, 1951) showed no relationship between accident frequency and production tempo, but they contended that factors such as work pace and work flow might prove more important than fatigue in explaining the differences in accident distribution over time.

Studies of Fatigue in Special Work Situations

Piloting airplanes. Thorndike (1951) reviewed several studies relating flying accidents to such possible fatigue factors as:

1. number of hours in the air
2. formation flying
3. flying two consective nights
4. flying in bad weather
5. strong enemy opposition

He cited Drew's evidence that flying performance does show decrements over a period of time which would increase the probability of flying errors.

Thorndike (1951) noted other studies dealing with fatigue, but stated that they were based on opinions rather than data (Kalez and Hovde, undated; Williams, 1942; McFarland, 1941; Lepley, 1947; O'Gorman et al, 1946). He indicated that studies were needed on the effects of different work and life conditions on performance decrement in a flying or simulated flying task. At the time of his review, he felt that there was little experimental evidence to support the commonsense notion that fatigue affects performance and leads to accidents.

Baruch (1970) examined the relation of working conditions to fatigue and flight accidents among agricultural pilots. The study was designed to determine the effects of:

1. exposures to poisonous materials
2. hours of sleep

3. weather
4. workload
5. combinations of factors

The author concluded that changes in these conditions especially combined changes, could be significant in affecting flying safety.

Sixty airline pilots and their wives were interviewed in the first stage of a study reported by Cameron (1971). On-board flight data were collected and then, during the second stage of the study, questionnaires were completed by 480 air crewmen. The purpose of the study was to assess the role of working conditions in pilot fatigue and trace how this fatigue was reflected in performance and personal behavior. The study indicated that the pilots did exhibit signs of stress and fatigue. The author concluded that the high order of accuracy and consistency demanded in occupations of this nature may require special shift systems to prevent fatigue.

Operating motor vehicles. Harris and Mackie (1972) described several studies of the effect of fatigue on motor vehicle operation in a review of the literature prefacing their study of bus and truck drivers.

1. The Bureau of Motor Carrier Safety (1970) investigated 286 commercial vehicle accidents, 142 fatalities, 281 injuries and $4,785,000.00 in property damages were categorized as attributable to the drivers being either asleep at the wheel or inattentive.

2. Baker (1967) in an investigation of 850 single vehicle accidents found that "driver asleep" was a factor in 24.4% of the cases.

3. Case & Hulbert (1970) stated that 22% of the accidents occurring between 1953 and 1964 were the result of the driver being asleep at the wheel. These accidents accounted for 48% of the traffic fatalities.

Studies using simulators to create the automobile environment were also reviewed:

1. McFarland & Moseley (1954) tested subjects who had not slept for 24 hours. There was an improvement in performance from the first to the twentieth trial and then a decrement in performance from the 20th to the 90th simulated driving trial.

2. Duggar, Epstein, Kanter, Weene, and Fox (1965) studied the influence of the diurnal cycle on driving performance. After an initial driver categorization, three "good" and three "poor" drivers were tested for 4 hours on a simulated driving task. The "good" performers maintained a low and relatively constant steering wheel reversal rate (SWRR) and were able to keep within the "traffic lane"; poor performers, on the other hand, had a high SWRR and went "off the road" at least two times each. No physiological measures differentiated between the two groups although a slight degree of association was found between good performance and high heart rate.

3. Sussman & Morris (1970) investigated the effects of acoustic noise levels and task complexity upon prolonged driving. It was found that road position error increased linearly over time and that SWRR decreased in a similar manner over time. Performance during an emergency "blowout" situation was substantially poorer during the last hour of the test period, and there was a significant increase in the frequency of occurrence of alpha bursts (EEG) from the first to the last hour of the drive.

Other simulator studies reviewed include: Mast, Jones, and Heimstra (1966); Heimstra (1970); Heimstra, Bancroft, and DeKock (1967); and Ellingstad and Heimstra (1970).

A second group of fatigue studies as outlined by Harris and Mackie include those on a closed circuit track which combined laboratory control with real driving experience.

1. Michaut and Pottier (1964) recorded heart rate of subjects on a test track. They found that the heart rate decreased throughout the drive but remained above base line levels and that the respiration rate decreased gradually during the first $1\frac{1}{2}$ hours and then stabilized. It was also noted that SWRR and velocity and use of directional signals decreased over time.

2. Pin, Lecret, and Pottier (1969) found in another study that various driving conditions affect physiological processes.

Harris and Mackie point to the failure of these studies to simultaneously record behavioral measures of driving performance and physiological measures.

A third type of study reported in the Harris and Mackie review is the open road studies; which includes their own truck and bus driver study (1972). This study investigated the fatigue-accident relationship among bus and truck drivers over 1,550 hours of continuous data recording and observation. The results showed that operating within the present Department of Transportation 10-hour limit on driving time, driver performance deteriorates, driver alertness diminishes, rest breaks become less effective and accident probability increases. More specifically, the following items were noted:

1. Significant increases in driver performance errors and a significant decrease in the level of psychophysiological arousal of the drivers was found. The frequency of accidents increased disproportionately after about 7 hours of driving.

2. The effectiveness of rest needs on driver performance and level of psychophysiological arousal varied with the amount of total trip time.

3. Sleeper drivers (those who sleep on board while a partner continues the trip) appeared to recover less completely from rest breaks than did the relay drivers (those who drive to a point and are relieved by a driver who boards at that point).

4. There appeared to be a cumulative effect on the drivers' level of psychophysiological arousal due to several successive days on duty.

5. The adverse effects of prolonged driving were evidently more pronounced for older drivers (aged 45 or more) than for younger drivers.

6. There are marked diurnal variations in level of psychophysiological arousal with the lowest levels occurring, for most individuals, between about 2:00 A.M. and 7:00 A.M.

Deep-sea fishing. Schilling (1971) studied the health and safety problems of deep-sea fishing. He concluded that the dangers of that occupation are underestimated and are actually higher than those of coal mining. Long working hours and resulting fatigue contributed most to the hazards of the job. Schilling found that fishing crews were fatalistic about accidents, taking for granted the likelihood of their occurence.

Performance Studies

Researchers at Century Research Corporation (1959; 1960; Peterson, Wright, and Sleight, 1959) studied efficiency as a function of time for primary duty, secondary duty, and sleep, and other performance studies. Included in their research findings were the following:

1. Speed and accuracy decrements over time varied considerably with the nature of the task being performed.

2. Reaction time remained constant even after extended sleep loss.

3. The longer a task continued, the more chance there was for error because of the greater frequency of lapses.

4. If a task was nonautomatic, occasional changes helped keep performance high.

5. All individuals have diurnal curves of performance, and in groups of individuals, the peaks and troughs of these curves often coincide.

At the time of their report, they found no experimental studies testing performance on continuous or frequent tasks over an extended period of time. However, subsequent to the report, Alluisi (1969) conducted a series of studies of sustained performance. He designed synthetic work situations, containing measurable elements of real work situations, and tested his subjects' performance of multiple tasks. His research established the following:

1. A 4/4 work-rest schedule (4 hours on duty and 4 hours off) could be followed for long periods without performance decrements.

2. More demanding schedules used up a greater proportion of man's capability to perform, and in such cases, ability to respond to demands of emergency conditions suffers. However, some men could follow a more demanding schedule without loss of efficiency.

3. Evidence of diurnal rhythm could be observed in performance. However, this effect depended on work load, information given to the subject, and motivation.

4. Even in the presence of high motivation, performance was affected by the diurnal cycle if an operator was overloaded or subjected to other stress.

According to Bartley (1965), fatigue-inducing situations include: (a) tasks requiring extreme energy expenditure,

(b) prolonged work activity without adequate rest breaks, (c) tasks that are machine-paced rather than worker-paced, (d) task goals which are vague or remote, (e) task situations involving conflicting performance requirements, roles, demands, or responsibilities, and (f) extreme environmental conditions, as, for example, heat, noise, and vibration. Other situations which may precipitate fatigue at the workplace include sleep loss, frequent shift rotation, time of day (circadian rhythms), emotional upset, alcohol or drug hangovers, and so forth. Wherever possible, such situations should be eliminated or optimized. It is necessary to insure that the worker is fully able to recover from task and environmental demands. Consequently, Roth (1968) recommends that four hours be considered the maximum allowable duration of physical and mental work without a rest period. However, Edholm (1967) suggests that short, frequent rest pauses are more effective in preventing fatigue than longer rests at longer intervals, since recovery from low levels of fatigue have been demonstrated to take proportionately less time than recovery from excessive fatigue. Furthermore, such rest pauses should probably be distributed evenly across the total work period. Based on the average energy cost the total amount of rest required for any given physical work activity has been developed (McCormick, 1970; Murrell, 1965), as follows:

$$R = \frac{T\ (K-S)}{K - 1.5}$$

where R is the rest required in minutes; T is the total working time; K is the average energy expenditure per minute of work; S is the energy expenditure value adopted as a standard; and 1.5 is an approximation of the basal metabolism rate. Although a comparable formula for mental tasks does not exist, a logarithmic relationship between mental work and fatigue has been found, that is, the required rest increases with the speed and duration of the work (Kerhoven, 1966).

Though quite prevalent in highly repetitive massed-production or assembly-line operations, machine-pacing reduces the extent to which a worker can efficiently use his skills to compensate for slowness in one instance and excessive speed in another. Worker-paced operations, on the other hand, are more fatigue-resistant by optimizing the interval between successive task activities according to the worker's own capabilities and needs (Welford, 1968).

SUMMARY OBSERVATIONS

Problems of Research Methodology

Physiological measures of fatigue are easily recorded by the scientist. Problems arise when he attempts to relate physiological data to performance decrements, particularly to decrements which precipitate accidents. Bena, et al (1962) pointed out that it is important to distinguish accident behavior (operational errors) from the cause of accident behavior. However, accident statistics usually describe these in combination and they are equally difficult to isolate in a research situation.

Designing research environments and task requirements for fatigue studies is a frustrating process. If a simulated or synthetic work situation is used, there is still a problem of validity of the data when applied to real-life work situations. As Harris and Mackie concluded in their study of bus and truck drivers, on-the-job studies may yield the only valid data on performance decrements as a function of fatigue.

Contributing to the problems of research is the evidence of sizeable individual differences in base-line performance and in resistance to fatigue. Motivation may cause subjects to work harder to counter fatigue effects.

Performance changes also may result from psychological fatigue or boredom. Unless this state has a demonstrable physiological correlate, its presence and its effect would be difficult to establish objectively.

Hypersusceptibility

There is evidence that increased work time does endanger the older worker in some industries. Women may have more accidents than men on extended shifts. Those with physical handicaps may tire more quickly than normal individuals and thus be vulnerable to accidents. However, the research support for these positions is far from conclusive.

Selection and Placement

Until there is more data on the physiological and psychological bases for fatigue resistance in various occupations, there is little experimental support for selective placement, except in those industries requiring physical strength and endurance. There, it would be logical to choose strong, healthy employees.

Amelioration of Fatigue

McFarland (1971) recommended that fatigue be combated by adequate sleep, an established rest-work pattern, the elimination of stressful, anxiety-producing or boring conditions, a physical exercise program and the wise use of medication.

Industries could influence workers to follow a proper health program by enlisting their medical and administrative departments in educational campaigns. Stress could be lessened during periods of peak production by shortening work periods as work pace increases. Task variation might prove helpful in counteracting boredom on repetitive jobs. Care could be taken to avoid stress or overload on night shifts when diurnal rythmn effects might be expected.

Shift length is a controversial issue at this time. There is some pressure for the option of working longer hours for fewer days. Research does point to the danger of increasing accident rates by lengthening shifts, at least for some elements of the working population. It might be wiser to allow management selective judgment in determining those eligible to work longer shifts.

Research Needs

If we are to define the role of fatigue in the accidents and absenteeism in a given industry, we must develop operational definitions for fatigue associated with the tasks in that industry. Fatigue for a coal miner is not necessarily comparable to fatigue for an auto assembly worker or for a radar operator. Basic work needs to be done measuring performance decrements over extended time in major work tasks specific to different industries.

Once a performance picture of fatigue is established, more work can be done isolating the environmental and behavioral factors which contribute to fatigue. Shift length, particularly, needs multi-industry study in light of the move toward a work week of four ten-hour days.

There is a need for study relating illness to worker fatigue. After obtaining a knowledge of the factors contributing to fatigue in an industry, researchers should check the relation between absent-for-illness rates and exposure to fatigue factors.

Boredom is usually considered a form of fatigue, however, little work has been done treating boredom as anything but a subjective state. What happens to an individual performing the same mechanical task over and over again? Are there any physiological manifestations of boredom -- changes in brain-wave pattern or threshold changes for visual or tactile stimuli? One may suspect that boredom and inattention can cause accidents, but the time required to become bored undoubtably differs considerably for different tasks and for different individuals. Until there is some independent measure of boredom, there is no way to check its impact on performance or on industrial accident rates.

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FATIGUE

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	Contr. Field or Lab	Theory or opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents		1196 1199 1307 Farmer et al '33	305	1 2 6 884 901 1245		401 1250 931 1251 971 1252 1246 1253 1247 1254 1248 1259 1249 1262
Agent - Specific Diseases						
Non-Specific Disorders			1308	901		
Critical Incidents						
Rate/ Amount of Sick-Absence						1244
Perform-ance Indices	1261	48 1270 1266 1271 1267 1272 1268 1273 1269 1305	1304 1308 1309 1312 1313	376 1242 595 1243 819 1260 884 1274 966 1298		1256 1257 1258 1264 1310
Strain Indices			1312			
Morale						
Compliance with Rules						
Off Job Problems						
Miscel-laneous			1308 1309 1311 1312	1301 1302		1255 1263

PERSONALITY AND EMOTIONAL FACTORS

A portion of a report--

PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT WORKER PHYSICAL AND PSYCHOLOGICAL FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

PERSONALITY AND EMOTIONAL FACTORS

Introduction

The vital role of personality and emotional factors in industrial safety and health research may be indicated by the rather large volume and sophistication of pertinent literature in the field. This attention is not surprising since over 80 percent of all industrial accidents are said to be attributable to human failures (Heinrich, 1951) and a significant portion of industrial illnesses may be due, at least in part, to emotional disorders (Aldridge, 1970).

Numerous man-at-work studies have contributed additional data in this field. Herzberg (1968), with his studies of worker dissatisfaction and job enrichment, touched upon emotional factors in accidents and psychosomatic factors in industrial health. Suchman (1970), related deviant behavior and impaired self-image to greater vulnerability to accidents. Studies on cigarette smoking and correlated behavior, such as those by Adams and Williams (1966) and Lebovits, Ostfeld, Moses and Paul (1972) touched upon a newly opened area of man's involvement with accidents and disease.

The above references are examples of studies coupling personality and emotional factors to safety and health.

Two Approaches to Studying Personality Factors

In a review of pertinent literature, a problem of definition always exists. For this review, personality and emotional factors have been limited to those overt manifestations -- observable and measurable -- which seem to have a direct relationship to an individual's behavior and which may have implications for industrial accidents and occupational disease. Although definitions, by nature, are limiting, this collection does show the flexibility permitted in the above meaning. While personality and emotionality seem to imply a specific individualism, many of the cited studies tend to hide human uniqueness behind the term "worker" or "group member" and move on from this view of social dependence. Some researchers, however, have given attention to individual differences.

Group membership. Klein (1971) considers many of the personality traits which are observed in accident repeaters as group-accepted and taught. Society wants children to be aggressive, competitive, self-reliant and innovative. The group not only endorses risk-taking but abets thrill-seeking endeavors. The work world is in direct conflict with group values. Mulder (1971) in reviewing violators of formal company rules, agreed completely with Klein on group and societal influences.

Viteles (1953) in his textbook on motivation and morale in industry concluded that personality modifications may be best accomplished through team relationships. To belong to a group, the industrial worker must accept many of the attitudes of that group, even when consensus is sometimes contrary to his own safety and wellbeing.

An article in Occupational Hazards magazine (1972) discussed the concept advanced by Herzberg that accidents result from worker dissatisfaction. The article reported a dialog among Herzberg, (who promoted the solution of job enrichment), David Klein (who saw the work environment as a frontal assault on the cultural or group concept of manhood) and Albert Porter, an economist (who believed that job dissatisfaction leads to destructive self-hate).

The word "worker" in many reports of studies tends to imply a being who has little or no existence apart from his job and co-workers -- thus making emotion and personality subordinated concerns.

Individual differences. While groups of similarly influenced and reacting persons can be identified, each person is a unique entity. Each has been exposed to slightly different kinds and amounts of possibly influential variables. As a result, one must consider individual experiences and personality as they may relate to accidents. Selzer, Rogers, and Kern (1968) found that an excessive number of accidents by an individual may well indicate a previously undetected emotional abnormality. Since an investigator can not always be aware of individual emotional problems, his predictability of the accident-prone (also called hypersusceptible) being is limited.

Ansbacher (1967), in reviewing the Adlerian concept of life style, thought greater attention should be given to individual uniqueness, creativity, and ego-goal oriented behavior, as well as the worker's relationship to his group and culture, in interpreting worker involvement in production, safety and health programs and complex systems.

After reviewing 27,000 accident cases over a period of twenty years, Schulzinger (1954) was forced to conclude that while some people may have more accidents than others, anyone under stress or with emotional problems may become more likely to have an accident. It seems, though, that a group, designated as "most accident prone" would be a changing one, always adding and losing members. Not only is one individual different from another, the same individual is a different "personality" under everchanging situations and conditions.

Hirschfeld and Behan (1963), in studying 300 industrial accident reports, frequently observed a psychiatric change in the worker preceding the accident. The personality of the worker may well indicate some near-psychotic evidences of lower self-esteem, decreasing sociability, and anxiety as well as other indicators of emotional disorder. In brief, the individual changed his behavior as though he were actively seeking an accident. It might be said that accident predictability becomes effective only in exaggerated individual change to unpredictability.

Contrary Research Factors

As some of the foregoing references may indicate, research in the field of personality and emotional factors has severe limitations. Many of the studies herein reviewed have relied heavily on two devices, namely, statistical analysis and stereotype.

Statistical analysis. Once given the concept that the individual is unique, the use of mathematical systems becomes somewhat complex since statistics can neither measure nor compare the unique.

Not found in the available literature is an adequate basic statistical platform. It could be assumed that each and every individual in a given work group would have an accident or an illness in some pattern or order before there was a repetition. On the other hand, mathematical probabilities would indicate the likelihood of some random repeaters.

From a review of over 1,000 sources of personality and emotional factors as related to industrial safety, only one predictive study was found. Fitzpatrick (1953) studied a group of fighter pilots who had been involved in accidents and attempted to apply his conclusions about pertinent personality factors to prediction about a second group of pilots. He found that the relationships considered as pertinent could not be transferred to other groups. He concluded that generalization could not be made from one group to another.

Some of the reported studies of accident proneness have application to this problem of statistical analysis and predictability. Stewart (1958) offered mixed results in giving psychological tests to auto drivers. Personality factors such as aggressiveness, antisocial attitudes and disregard for traffic laws and rules, as exhibited by repeating violators were marginally significant. Stewart concluded that a number of other variables must be considered in such studies.

Stereotype. Recently Crawford (1971) launched an all-out attack on the concept of the poor worker as a self-dangerous worker. He tried to show that the pressures and perils of the work environment have a greater relationship to industrial accidents and disease than any composite of traits which is present to varying degrees in every individual. He denied the validity of a statistical analysis or a stereotyping of an individual when the following factors are considered:

> sex, age, experience, intelligence, emotional stability, fatigue, perceptual skills and dexterity, reaction time, alcoholism, and general condition of physical and mental health.

This Australian psychologist further contended that behavior moves in cycles, and any individual has a period of time when he is more likely to have an accident than other times. He felt that a "stable and enduring" personality characteristic of accident proneness does not exist in any worker.

Hall, Jerrold, Fox and Wright (1969) reported a more direct approach to accident-prone stereotypes by demonstrating that workers of low intelligence are not necessarily accident prone. Educationally subnormal subjects were enrolled in a British school prior to entering industry. Despite low IQs, the subjects actually posted below average accident records, possibly due to the training and attention received.

A shop safety training manual, compiled by the University of the State of New York (1950), listed the stereotypes most susceptible to accidents regardless of length of employment. The list included:

> the day-dreamer, the social misfit, the uninterested student, the emotionally unstable, the slow learner, and the physically handicapped.

The publication warned that these six worker sterotypes are the ones least susceptible to safety training.

Henderson (1971) agreed with Crawford as to the inadvisability of stereotyping but used traffic accidents as his study element. He maintained that previous research on accident proneness had obvious flaws. The statisticians capitalized on the elements of chance. Personality traits were used when the total life style should have been evaluated.

Personality and Emotional Factors and the Accident-Prone Worker

Several analyses of research on the possibility of accident proneness have been completed over the years. Rawson (1944) cited some of the early studies, dating from the 1920's, which supported the concept of the accident-prone worker.

Leon Brody (1963) acknowledged that the research to date determined that there are accident repeaters, but that they are a relatively small segment of the population experiencing accidents. He felt the majority of accidents are the result of temporary stress response, inadequate sense of responsibility regarding safety, and chance. From the point of view of accident prevention, Brody thought it more profitable to examine the total work situation rather than concentrating on identifying accident repeaters.

Levinson (1969) pointed at what he termed the "emotional toxicity of the work environment". In his words, problems of the work place can "poison" the worker and his emotional state so that he may become ill or prone to accidents.

Using a series of psychological tests, Harris (1950) sought to identify industrial workers with significant industrial accident histories by personality traits. Tested in the study were two groups: (1) a group considered accident prone based on work histories, and (2) those workers with good safety and health records. Harris could find no significant difference in the personalities of the two study groups. He concluded that the accident-prone workers can not be identified by personality traits or overt patterns of behavior.

From a study using interviews, Davids and Mahoney (1957) concluded that problem workers do have identifiable personality traits. The dominant overt personality trait of such subjects was aggressiveness. Less significant was the evaluation of the subjects as emotionally and socially immature and "loners". They believed the accident-prone worker is not readily amenable to general safety and health training efforts. Fairly broad conclusions were made by these investigators on the basis of a limited sample.

In a specialized report for supervisors, de Reamer (1958) advised industrial managers to be alert to disruptive members of the work group. He identified such workers as being physically inept or poorly coordinated, inattentive, and/or emotionally distraught. He believed an angry or frustrated worker deserves special attention. Not explicit in the educational report were the concepts of short and long-range personality and emotional conflicts which may be related to safety and health problems.

For the industrial personnel administrator, Jenkins (1956) offered some clues for identifying the potentially unsafe worker. He felt such a worker would have a limited attention span, could be easily distracted, and would be relatively resistant to group pressures. The accident-prone workers in his study tended to give an appearance of greater self-confidence, being not only independent in attitude but less sensitive. He found the unsafe worker may be physically weak and chronically tired as well as somewhat less self-controlled. Psychological tests may show tendencies toward egocentricities, anxiety, and social resentment.

Writing for safety engineers, Altman (1970) pinpointed several problem areas for the individual worker, which may lead to abnormal pressure and emotional disturbance:

> conflict between safety requirements and speed of production, lowered performance standards, faulty communications from one organizational level to another, and the human drive to create tension for the enjoyment of its release.

Selling (1945) listed certain attitudes and physical deficiencies in his identification of potentially self-destructive workers. He saw the dangerous worker as one possessing some mental deficiencies and neuroses, pre-occupied with other problems, dissatisfied with his job, reckless, indifferent, and antagonistic to all symbols of authority. The worker may be overtly against safety devices, machine guards, and accident-prevention programs.

In a literature review prepared for the medical profession in Australia, Sampson (1971) made the distinction between long and short-term accident tendencies. He said that a lifetime tendency to become involved in personal accidents could be traced to certain mental attitudes of the worker. The accidents are expressions of self and societal-contempt. The short-term repeaters may be under temporary mental stress, on work unsuited to their temperament, or be bothered with some physical abnormality.

Using data collected in a Budapest hospital and compiled from a series of articles in a British medical publication, Csillag and Hedri (1949) resorted to Freudian concepts to explain the problems of accident-prone workers. They said that the unhappy childhood of the unsafe worker establishes a reserve of unexpressed aggression which can find release through self-destructiveness. Kunce and Brewer (1966) refuted the Csillag and Hedri study with an investigation of 116 mental patients in the United States. They found a variety of personality traits, many considered psychologically normal, which have a greater significance in accidents than chronic emotional disturbance.

General Research

A number of research studies have been included in this review which were not made in an industrial setting. It is presumed that the personality and emotional factors involved in other life situations may be applicable to the industrial scene.

Research on automobile operation has yielded much data which could be significant in understanding the role of personality in accidents. For example, Goldstein and Mosel (1956) performed a factor analysis in their study of driver attitudes and narrowed the area of concern to one personality characteristic, namely, aggressiveness.

Andersson, Nilsson and Henriksson (1970) through psychological testing of young auto drivers found that the drivers observed as "accident-loaded" were characterized by an extreme dependence on external factors in the social and physical environment. However, their study indicated that the results may be due to group characteristics rather than individual traits.

Harrington (1971) studied young drivers, reviewing 104 references, and analyzing the accident history of 13,915 male and female drivers from 16 to 19 years of age. He found personality and emotional differences between the young driver with accident experience (and a history of police problems) and the safer drivers, demonstrated by tobacco addiction and social deviancy. McFarland (1968) doing studies similar to those of Harrington had less significant results with only one factor seeming to separate the "good" and "bad" young driver -- the number of accidents recorded.

Tabachnick (1970) offered a theory on the etiology of traffic accidents which could be extended to the industrial environment. He reported skilled observers believe many traffic fatalities are actually suicides. He presented three possible causes of self-destructive behavior:

1. the presence in every individual of a death instinct;
2. self-destructiveness arising from a temporary or permanent mental illness;
3 an adaptational mishap or a suitable situation at an opportune time.

He believes the destructive traffic "accident" requires two of these causes in concert. The finding that accident and suicide victims have some similar characteristics was first made by Tabachnik, Litman, Asman, Jones, Cohn, Kasper and Moffat (1966). Some of their results are shown in Table G-I. A follow-up study with similar results was done by Litman and Tabachnik (1967).

Viney (1971) reviewed literature which referred to human accidents in general and concluded that both short and long-term accident repeaters have personality faults and emotional problems. The long-term accident repeaters tend to have short-range goals and are resentful of authority. The short-term repeater often is in a stressful situation

Table G-I

Compared Life Style of Suicide and Accident Victims [a]

	Accident	Suicide
Similar		
Conscientious	12	10
Unconscientious	3	5
Concerned with performance	15	12
Not concerned with performance	0	3
Impulsive behavior	6	9
Nonimpulsive behavior	9	6
Different		
Self-critical	4	13
Self-satisfied	11	2
Concerned with appearance (N = 14)[b]	11	5
Not concerned with appearance	3	10

[a] Adapted from Tabachnick et al. (1966).

[b] In each of the accident and the suicide groups the total number is 15 except in the "Concerned with appearance" group where the total number in each group is 14.

and the accident sometimes serves to discharge emotions. While not listed in the Viney references, quite similar conclusions about worker personality and emotions were drawn by Strong (1957) who noted that some workers may enjoy pain and the attention minor injuries may bring.

Using 50,000 student records as a data source, Paffenbarger et al., (1969) examined several personality and emotional characteristics for their individual and collective effects on risk of self-destruction. Antecedent patterns led to the speculation that anxiety and despair characterize the future accident victim.

Krall (1953) attempted to distinguish character trait differences between accident-free children and accident repeaters in the 5 to 8 years of age bracket. She anticipated that such traits would carry over into adult life. She found the accident repeaters were somewhat more aggressive, active, and unrealistic in play. Unfortunately, the study was inconclusive statistically. A later study on the same topic by Mannheimer and Mellinger (1967) yielded similar inconclusive results.

Various occupations have been selected for in-depth safety and health studies, with emphasis on personality and emotional factors.

Reinhardt (1967) examined the emotional stress that may be present in pre-accident conditions for aircraft pilots. While psychological tests and biographical information may be of assistance in pilot selection, he found individual differences are so great that predictions about potential accident-prone pilots remains a problem. Yanowitch, Mohler, and Nichols (1972) disagreed with Reinhardt and contended that predisposing conditions may be discerned, and that pilots may be given insight in the roles of emotions and situational stress. However, they noted another difficulty of prediction: all individuals go through behavioral cycles so that any given pilot is in a better emotional condition to fly at one time than another. However, there are times when the best of pilots should not fly.

Worry and fear play significant roles in air accidents, according to a study by Aitken (1969). According to this investigator each individual views the hazards of work differently, although the occurrence of an accident makes fellow pilots more safety conscious for a time.

Industrial Research

A study of Polish coal miners by Tyminski (1969), found significant correlation only between accident repeaters and absenteeism. His profile of repeaters listed no other major personality or emotional factor.

Gass (1970), using a limited number of hardcore unemployables, revealed several personal and work attitudes which may have significant impact on accidents and health once one of these individuals is on the job. Pressures on this type of worker arise from his retreat or desire to escape the conforming life, and he lives in a constant state of fear and anxiety in the alien world of work. Such workers have learned to cope with failure so they fear success.

Whyte (1961) described the usual work situation as one in which personality and job description are not static. The industrial psychologist noted that not only do individual differences exist in people, but the job performance and requirements are varied by the performer so that all the variables in safety and health are inconsistent and variable in themselves. Riemer (1967) also believed that the countless variables imply that modifications in both job and worker are necessary to prevent injury. Hepner (1962) gave an example of inconsistent work and worker by observing the differences in performance by workers when they are given the variable of different hours of work. Workers on the night shift have less pressure from management, less intense noise and lower production standards, and they perform more safely.

Sales (1969) investigated personality and attitude changes in various workload situations. While the worker reactions did exhibit some changes as the amount of the workload was increased, Sales believed that these changes were not sufficient to significantly influence job performance or safety.

Hill and Trist (1953) hypothesized that some accidents may be motivated perhaps unconsciously, by the person suffering the accident. They believed that accidents are a form of escape from the work environment, and that incidence of accidents would show a positive relation to other forms of absence. Table G-II shows that individuals in their study sample who had accidents also had significantly more absences than those who did not have accidents. However, Hill and

Table G-II

Number of Other Absences Per Man
Among Those Who Did Not Have Accidents
and Those Who Did [a]

Absences	No Accidents	Accidents	Absences	No Accidents	Accidents
0- 4	38	6	50-54	3	3
5- 9	52	11	55-59	1	2
10-14	36	15	60-64	2	-
15-19	23	14	65-69	-	-
20-24	16	7	70-74	-	1
25-29	12	10	75-79	-	-
30-34	3	5	80-84	1	-
35-39	6	6	85-89	-	-
40-44	4	2	90-94	-	1
45-49	3	5	95-99	-	1

[a] Adapted from Hill & Trist (1953).

Trist, on the basis of their data, concluded that workers did not deliberately choose to have accidents.

Studies Including Variables Other Than Personality Factors

Block and Campbell (1963) discussed the low accident-rate they observed for a group of workers who had physical handicaps. They felt that this low rate resulted from the workers' less-than-average impulsiveness and high motivation to perform. Leon Brody, however, as quoted in Occupational Hazards (1973), said that the chronically accident-prone group is composed of those with neurological disorders and/or those with anatomical deformities and handicaps. The much larger group of the temporarily accident-prone is generally suffering from temporary emotional stress.

In a British study of accident susceptibility among coal miners, Whitfield (1954) investigated a wide range of factors -- age, family background, physical characteristics, scores on psychological and special ability tests -- in an attempt to profile the accident-prone worker. He found that there were more multi-accident workers than would be expected by an assumption of equal liability. His findings included the fact that younger accident-prone individuals reported greater adversity in their backgrounds and present life.

Meltzer and Ludwig (1971) related age differences to mental health in the work situation. Figure G-1 shows a sharp drop in their measure of mental health for individuals over 40. Those in the 20 to 29 years group also showed a decrease and this was ascribed to a period of adjustment to

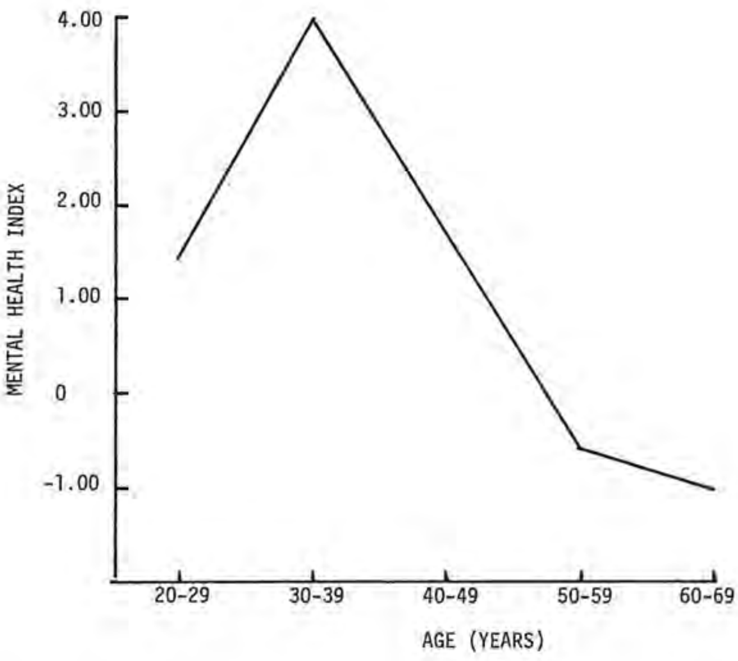

Figure G-1. Age difference in positive mental health. (Adapted from Meltzer & Ludwig, 1971.)

marriage, family responsibilities and vocation.

Trites (1964) related age, intelligence and personality to work training and proficiency. He tested over 900 future air traffic controllers and found that older students tended to have lower scores on intelligence tests but gave indications of more stable personalities and job interests. The older trainees had a higher failure rate due to lower scores on non-verbal abstract reasoning and memory practices. These factors are considered not only pertinent to job performance but to work attitudes which could be indirectly related to safety and health.

Birren (1964) noted some aspects of aging which are related to industrial safety and health, including:

> social and cultural determinents; weakened special senses and perception; failed timing and speed: deteriorated psychomotor skills, and decreased learning abilities.

Engel (1968) observed that some life settings are conducive to illness. Under conditions of great personal pressure, stress or frustration, the individual goes through a process of giving up: first, emotionally and mentally, and finally, physically. In the industrial situation, this sometimes means the worker escapes failure by becoming too ill to compete. Thurlow (1971) has added to the Engel concept by observing that some people use illness as a defense mechanism and have a sick-role tendency as a part of their life style.

Pell and D'Alonzo (1968) see alcoholism as often a psychiatric problem growing out of tension, anxiety and frustration. Their attempt to relate alcoholism to a susceptibility to other diseases offered only mixed results except with regards to hypertension and cirrhosis of the liver. Their data did suggest a positive relation to those diseases based on nutritional deficiencies, the use of drugs in addition to alcohol and poor health habits.

Drug abuse is an employment problem, according to Bitter (1971) in that drug use not only alters personality, but makes the worker less attentive, and there is usually some loss of psychomotor skills. The individual becomes unstable. The drug addict is essentially self-destructive.

Occupational asthma is yet another emotion-based disease according to Markham (1967) who found that over 61 percent of 233 affected patients who were studied exhibited some form of reaction to psychological stress.

Another occupational disease which is often psychosomatic is dermatitis. Goldman (1961) reported that many people with dermatitis are emotionally prone to the disease and that the disease is a reaction to stress.

The coronary-prone personality has been the subject of many studies since the concept was introduced by Dunbar (1948). She described this special heart disease victim as one who has a high rate of illness, high marriage rate, large family, inadequate sexual adjustment and who uses tobacco and coffee excessively. Such an individual often presents a surface calm which conceals underlying aggression and resentment. He is, however, typically a hard-working, ambitious creature. However, studies by Storment (1951) disagreed with every personality concept offered by Dunbar. Mordkoff and Parsons (1967) reviewed the literature and concluded that if the coronary personality exists, it should be considered in conjunction with hereditary and sociocultural factors.

SUMMARY OBSERVATIONS

Problems of the Research Methodology

Any study of a personality or emotional basis for illness and accidents encounters the basic problem of defining and isolating variables.

The identification of emotional state is usually dependent on subjective judgments such as, "I was very depressed last week" or "I believe he was angry yesterday." Personality characteristics vary with the definition of the researcher. One may define aggression in terms of behavior, for example, while another uses a score on a psychological test.

The relation of traits or emotional states to industrial accidents cannot be calculated until there are dependable measures for these variables. Elaborate statistical models will not compensate for imprecision in experimental design.

Health and Safety Measures

The attempt to modify the human element in industrial accidents is not new. The use of wage and non-wage incentives to involve the worker in his own welfare was only partially successful when attempted more than twenty years ago, according to a study by Pajowski (1950). Blake (1953), however, stated that effective safety campaigns must involve the individual worker. In a textbook on industrial safety, he recommended trying several avenues of approach concurrently.

Two personnel administrators proposed industry efforts for meeting the industrial health and safety problems. Crawford (1965) thought that accident prevention begins with proper selection of workers. He endorsed a move to more sophisticated testing and interviewing techniques. Okrangley (1966) added that accident prevention includes changing worker and management attitudes through broader-based educational and informational systems presented on site.

Directions for Industry Based on Present Evidence

Despite the doubtful validity of much of the reviewed research as applied to industry a few conclusions can be made:

1. there will be a small group of individuals in any population who are accident repeaters.

2. the accident-prone individuals may show greater-than-average absence rate.

3. the accident and absence rates for this group demonstrate a history of maladaptive response to stressors in the environment. Such maladaptive response may be dependent to some degree on personality characteristics.

4. the great majority of accidents result from physical factors in the work environment and temporary reactions to stressors. Again, such temporary reactions may differ as a function of personality variables.

Until there are reliable measures of personality characteristics, there seems little possibility of matching the job and the man in this respect. However, proper personnel screening techniques and periodic review of the records should show a pattern of possible poor stress reaction (job-hopping, high absenteeism, conflicts with others) before this is reflected in accident figures. Supervisors can be alerted to be aware of these patterns.

One personality characteristic that does have a fairly clear behavioral correlate is aggression. Since there seems to be a relation between this trait and accidents, ways must be found to channel direct aggression so that the aggressive individual is not destructive to himself or others. It would be unwise to place several aggressive individuals on the same work team, as team pressure may be the best form of behavior modification in this regard.

If, as Klein (1971) reports, society influences the individual to take risks and disregard safety measures, management must find ways to organize group acceptance of safety rules so that workers will develop more favorable attitudes toward their safety and health.

Research Needs

Much more research is needed to isolate and describe operationally different aspects of personality and emotional states. Then these factors should be examined in industrial settings to determine their relation to performance decrements which could produce accidents. Their relation to absence-for-illness should be tested.

Job studies could be made using the performance-decrement data in an attempt to work toward a better worker-job fit. Finally, studies might be done testing whether alteration of the behavior of other members of the work team can affect the performance of the identified problem worker.

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PERSONALITY AND EMOTIONAL FACTORS

Worker Safety & Health Measures	EMPIRICAL		Theory or Opinion or "Experience"	REVIEWS		Unknown
	Obs. or Statistical	Contr. Field or Lab		Critical or Integrative	Bibliog. or Sketchy	
Frequency & Severity Job Accidents	13 61 68 89 124 129 210	30 491 37 492 64 656 149 722	9 137 24 290 35 307 36 313 50 331 60 1317 130	5 8 102 128 493	143	29 202 985
Agent - Specific Diseases		126				
Non-Specific Disorders	1008	126 865 1011	23 244 101 264 182 294	994		525
Critical Incidents						
Rate/ Amount of Sick-Absence	13					
Performance Indices		434	101	914		
Strain Indices	1008	997				
Morale			206 343 349			
Compliance with Rules		272				
Off Job Problems			231			
Miscellaneous	110	14 139 38 507 84 843 86 847 133 878 138	410	15 207 757 809		

LIFE STRESS

A portion of a report--

PROBLEMS IN
OCCUPATIONAL
SAFETY AND HEALTH:
A
CRITICAL REVIEW
OF SELECT WORKER
PHYSICAL
AND
PSYCHOLOGICAL
FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

LIFE STRESS

Introduction

For the layman, there is little confusion as to what is meant by "stress" or a "stressful situation". For the scientist, the terms become ambiguous. There is one basic disagreement in definition: to some researchers, stress is a stimulus or combination of stimuli which produces physiological, psychological or behavioral change; to others, stress is a non-specific response of the body to demands made upon it.

Study of the research literature on stress, therefore, is hampered by the problem of semantics. When a researcher is discussing the effects of stress in a situation, does he mean the effects of a stimulus outside the body or the effects of a response to a stimulus?

Conceptual definitions. Selye (1964), a prominent endocrinologist, distinguishes between stress, as a reaction causing increased rate of wear and tear of an organism, and stressors, the physical, chemical, biological and interhuman causative agents. Morgan (1956) says that stress may be considered as any situation that makes the body mobilize its resources and burn more energy than it normally does. Margolis and Kroes (1972) define job stress as "the condition in which some factors, or combination of factors, at work interacts with the worker to disrupt his psychological or physiological homeostasis" (p. 4). McLean (1972) however, believes that stress is a general term for a large collection of related problems. It is an area of study rather than a stimulus or response.

Operational definitions. Often the researcher does not attempt to provide a conceptual definition of stress, preferring to define the phenomenon operationally. He investigates the effects of "stressful" situations, as in the following studies:

1. Noise during attempts to hold a stylus in a hole without touching the sides (Parsons, et al., 1954)
2. Same tasks as 1. above but subjects were told they performed below normal (Parsons, et al., 1954)
3. Paratrooper training (Korchin & Basowitz, 1954)
4. Undefined conditions causing people to be psychotic (Board, et al., 1956)
5. Military combat conditions (Berkun, Bialek, Kern, & Yagi, 1962)
6. Simulated emergency crash landing of aircraft (Berkun, 1964)
7. Subjects were led to believe they were in an artillery impact area (Berkun, 1964)
8. Subjects led to believe they had seriously injured a friend by a mistake in wiring an explosive charge (Berkun, 1964)
9. Loss of job (Kasl & Cobb, 1970)
10. Adapting to life situations (Hinkle & Wolff, 1957)
11. Disruption in life situation, together with changes in personal, family, social, religious or economic experience (Rahe, McKean, & Arthur, 1967; Rahe, 1968)
12. Repeated frustrations, deprivations, unrewarded responsibility, and inter-personal conflict (Hinkle & Plummer, 1952)

13. Divorce (Goode, 1956; McMurray, 1970)

Types of Stress

For the purposes of this review, stress has been categorized as either physical or psychological. Physical stress is that occurring when the body is exposed to environmental conditions such as noise, noxious fumes or extremes in temperature. Psychological stress is that resulting from change in the psychosocial environment.

Schaffer (1954) says that psychological stress occurs when a highly motivated organism is unable to find an appropriate adjustive response to a problem confronting it. This seems to imply that stress is present only in the instance of unpleasant psychosocial stimuli. Other researchers, however, maintain that pleasant life changes (marriage, birth of a child) also may produce stress. Psychological stress can be considered as that stress resulting from an individual's maladjustment to his life situation -- his "life stress".

Both physiological and psychological stress may produce behavioral effects. This review concentrates on studies relating physiological disorders and behavioral effects such as accidents and performance decrements to stress factors on and off the job.

The General Effects of Stress

From a review of the available research literature, it appears that there are two principal chains of reaction studied by researchers. These are diagrammed in Figure H-1. The upper chain in the diagram follows the physiological reactions

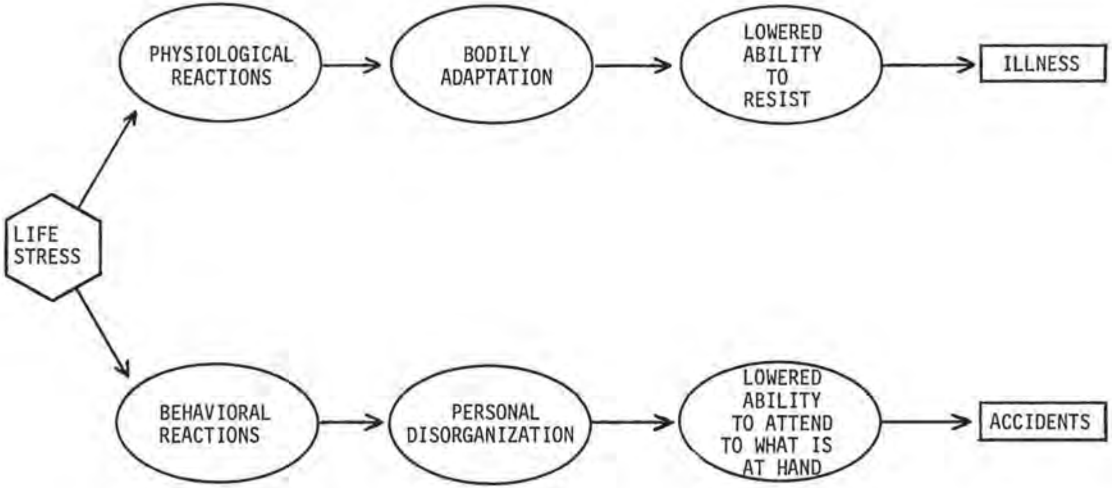


Figure H-1. A conceptual framework for categorizing the literature on life stress effects on occupational health and safety.

in a stress situation to their effects on the body and eventual illness. The lower chain emphasizes behavioral reactions and inability to maintain performance within the limits necessary to avoid accident and injury. Not all of the literature is concerned with every link in these chains. For example, considering the physiological chain, some investigators attempt to relate life stress to physiological reactions; others, relate physiological reactions to illnesses; and, finally, some work is directed at the relation of life stress to illness without postulating or examining the intervening links.

Selye's (1964) work on stress lead him to conclude that agents which demand increased vital activity in an individual automatically elicit non-specific defense mechanisms, raising the resistance to the agents. This process evolves in three stages, which Selye calls the General Adaptation Syndrome:

1. The "alarm reaction" consists of a number of physiological changes during which defensive forces of the organism are mobilized.

2. The "stage of resistance" during which the organism seems to develop a resistance to the stressor or an adaptation to it and the symptoms which appeared in the first stage of stress disappear.

3. The "stage of exhaustion" in which the organism can no longer adapt to a continuing stress, the symptoms of the alarm reaction stage may reappear and death may occur if the stress is not relieved.

Selye states that an important part of the stress defense mechanism is an increased release of hormones. This reaction, if prolonged or repeated often, leads to increased morbidity and mortality. Thus, an individual often pays a heavy price for adaptation to a stressful situation.

Morgan (1956) cites the reaction of the adrenal glands when a person is under stress as an example of possible bodily harm from adaptation. One of the hormones produced by the adrenals, adrenaline, increases heart rate and blood pressure and makes extra sugar available to the body. In the second stage of adaptation -- the resistance stage -- the body is overproducing adrenalin. When stress is continued, elevated heart rate and hypertension may result in heart disease.

Because of the physiological reactions associated with stress, the presence of such reactions has been used as a sign that a person is experiencing stress. Pulse rate has been found to be a good indicator of acute emotional stress, and a rise in body temperature (psychogenic fever) is indicative of emotional stress of prolonged nature (Renbourn, 1961).

Stress and Illness

As a starting point in examining the literature on life stress, work demonstrating physiological reactions will be reviewed. This essentially constitutes an examination of the first link of the conceptual framework presented previously in Figure H-1. The other links in the chain leading to illness will then be examined.

Blood pressure changes. Kasl and Cobb (1970) conducted a study of the changes in blood pressure in a group of men who were going through the stress of job loss due to a permanent plant shutdown. The purpose of the study was to measure the health effects of job loss and the ensuing unemployment. Subjects of the study were 162 married, blue collar workers in two plants who had been employed at least three years in the plant prior to the shutdown. A control group consisted of similar persons, except that they remained continuously employed. Blood and urine samples, blood pressure, pulse rate, height, and weight, were measured by public health nurses who visited the home of each worker at approximately three to four-month intervals. A structured interview was also used to collect social, psychological, and health data, including information about their current employment situation and economic circumstances. After the visit, the nurse also rated the mental health and well-being of the respondent on a number of dimensions.

A significant relation was found between job loss and increases in blood pressure. Workers in the control group showed no significant long-term trends, but the blood pressure levels of the unemployed subjects were clearly higher during anticipation of job loss and unemployment, or probationary reemployment, than during later periods of stabilization on new jobs. Men whose blood pressure levels remained high longer (a) had a more severe unemployment experience, (b) reported a longer lasting subjective stress, (c) were lower on "Ego Resilience," and, (d) failed to show much improvement in Self-Esteem or much reduction in irritation. These findings held much more strongly for diastolic than for systolic blood pressure. The authors pointed out that if we accept the assumption that prolonged blood pressure elevation due to stress increases the chances of hypertension, then the states of unemployment and anticipation of unemployment might be seen as influencing the development of hypertension. While this study appears thorough and provides us with evidence of the physiological reaction to a life stress, similar prospective longitudinal studies are needed so that the role of stressful life events in the development of hypertension can be substantiated.

Serum uric acid and cholesterol levels. From the same study described above of men undergoing job loss and unemployment, Kasl, Cobb, and Brooks (1968) also analyzed the stability and variability of serum uric acid and serum cholesterol levels. Both increased uric acid and cholesterol in the blood are morbidity indicators. Serum uric acid appeared to rise before job loss and return to normal rather quickly after finding reemployment. This anticipation rise is noticeable in Figures H-2 and H-3, which show the serum uric acid levels in the men anticipating job loss was above that of the control group, and drops to about the levels of the control group during unemployment. Cholesterol levels did not increase during job loss anticipation (Figures H-2 and H-3), but appeared largely sensitive to the transition from unemployment to employment, as indicated by the decreases in the lines connecting unemployment and employment points in Figure H-4.

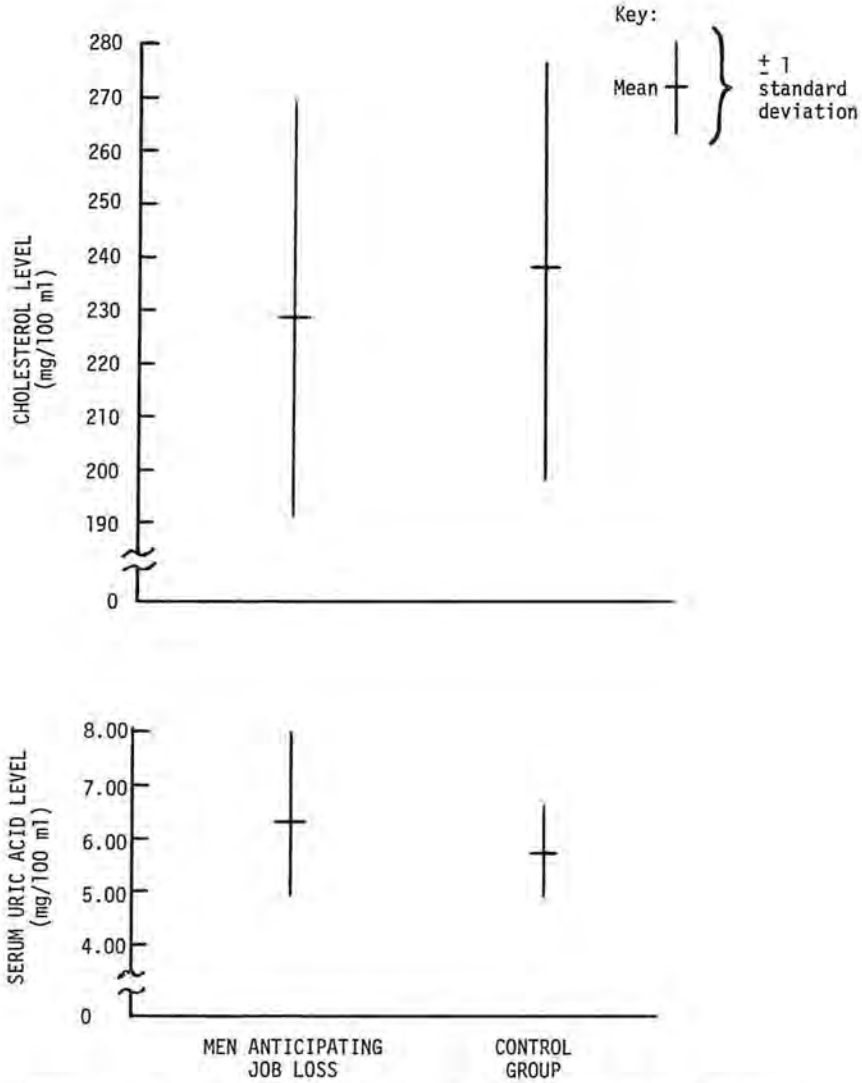


Figure H-2. Mean and variation of serum uric acid (bottom) and cholesterol levels (top) of men anticipating job loss and men in a control group not so anticipating. (Drawn from data in Kasl, Cobb, and Brooks, 1968.)

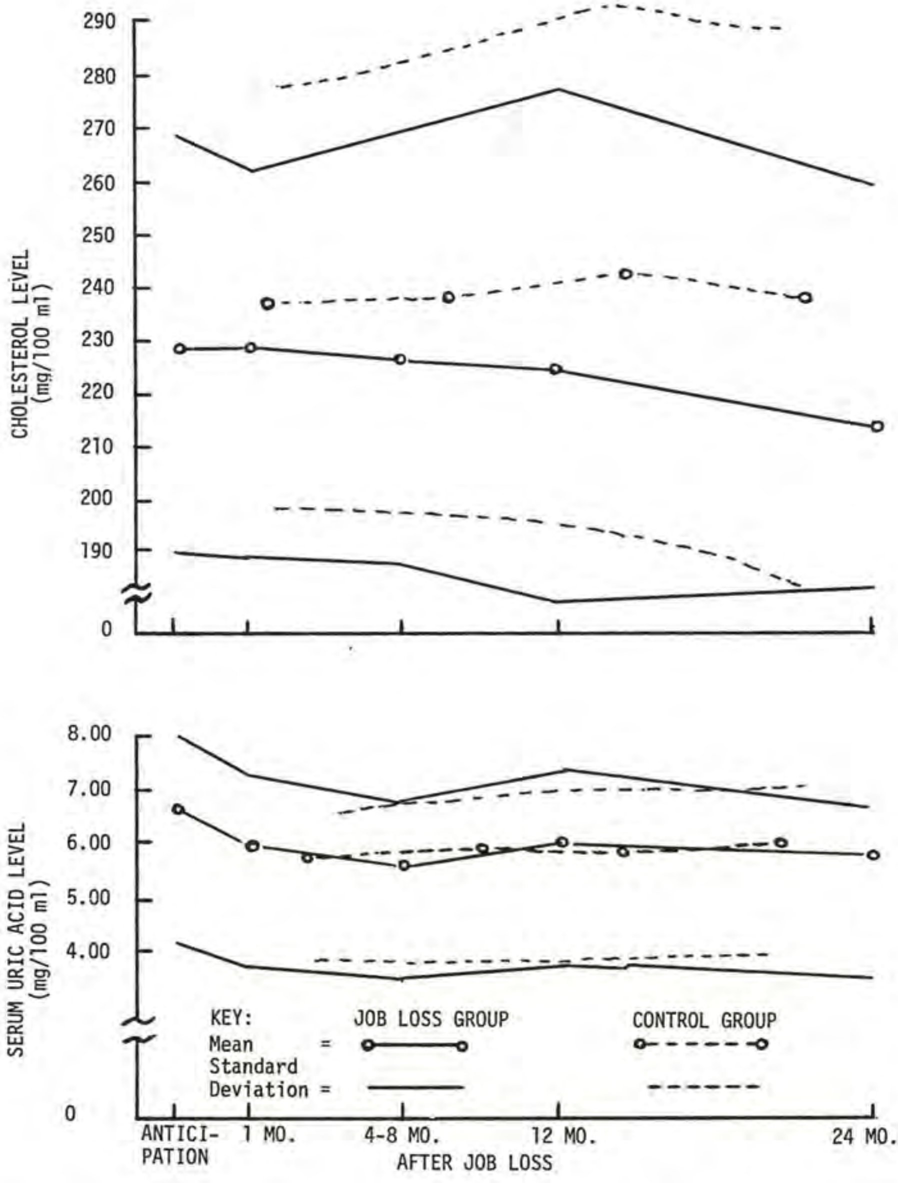


Figure H-3. Changes in serum uric acid (bottom) and cholesterol levels (top) in men facing job loss and a control group of continuously employed men. (Drawn from data in Kasl, Cobb, & Brooks, 1968.)

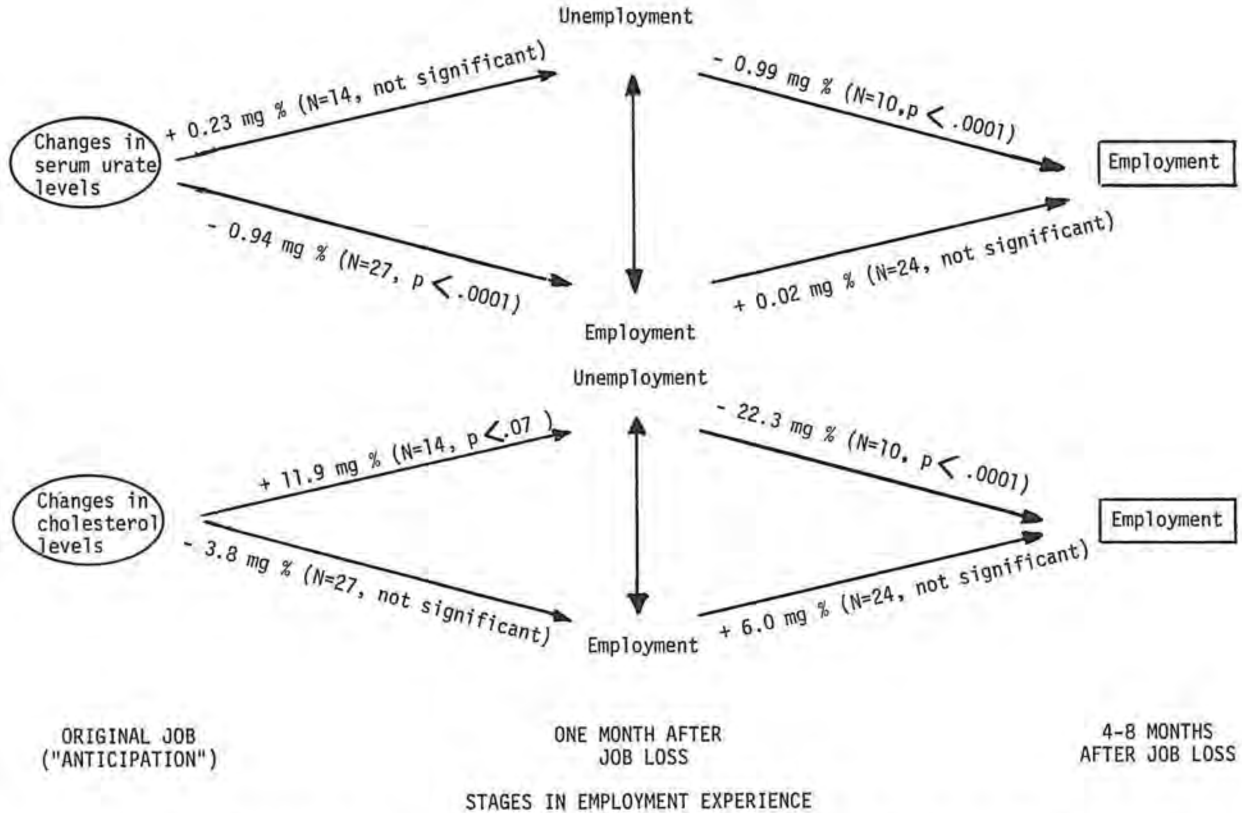


Figure H-4. Changes in serum urate and serum cholesterol levels in men facing job loss. (From Kasl, Cobb, & Brooks, 1968)

Psychiatric hospitalization. Brenner (1969) examined records for 42 years to determine the numbers of first admissions to New York State Mental Hospitals. He was interested in the importance of changes in economic status as a precipitating factor in mental hospitalization.

He found that short-term changes in the aggregate level of industrial activity appeared to have a marked effect upon the level of mental hospital admissions. This aggregate relationship was not confined to relatively low or to high socioeconomic groups (as defined by educational attainment). Members of the most economically insecure groups, however, appeared to show the greatest risk of mental hospitalization during periods of economic adversity for the general population. The stresses of financial insecurity may be an additional burden on a person's mental health and adversely affect his ability to continue to function adequately.

On a less serious level, Neel (1955) classified blue collar workers in a heavy equipment manufacturing company into "worriers," "sometimes worriers," and "never worriers" on the basis of questionnaire responses and a correlation of their feelings of nervous tension and worry with factors in the work situation. Foreman behavior correlated .23 with feelings of nervous tension; worry about getting work done correlated .30 with the time-study system. Neel concluded that:

1. an unsatisfactory work situation may induce or increase nervous tension in an employee;

2. such an employee may be sensitized to unsatisfactory job conditions which, in turn, heightens his nervous tension;

3. it is probably a combination of both individual and situational factors which contributes to poor mental health in the industrial situation.

There would seem little doubt, that, constituting as it does a major part of a person's waking hours, the work situation with potentialities for inter-personal and situational stresses could be a major source of stress for the individual.

Adaptative dysfunctions. In discussing the general adaptation syndrome, Selye has emphasized how his initial thinking stemmed from his observations that regardless of the disease agent, there were a great many nonspecific manifestations that seemed to go with being sick (for examples, see Selye, 1964). Sometimes long before the specific diagnostic signs were evident, the patient complained of being sick. If, as Selye contends, it is true that there is a general, non-specific reaction of the body to any form of stress, whether physical or psychological, and if these reactions fail in assisting the body to adapt to the stressor, then persons under various forms of stress should be ill more frequently than others. Although not designed to test such a hypothesis, there are some studies in the literature which indicate that persons living in stressful conditions are ill more frequently than those who are not in stressful environments. For example, Hinkle and Wolff (1957) reviewed the medical records and examinations of 2,924 subjects in industry over a period of five years. They noted that members of otherwise homogeneous adult populations exhibited differences in their general susceptibility to illness. Some of the subjects experienced many more illnesses per unit of time than did the others. They found that those having the greater number of bodily illnesses had more accidents and more disturbances of mood, thought, and behavior. Clusters of illnesses more often appeared when a person was having difficulty adapting to his environment as perceived by him. Those persons who exhibited a higher susceptibility to illness were those who exhibited the greatest difficulty in adapting to their life situations (again, as was perceived by them). Hinkle and Wolff assessed the differences in the amount of illness exhibited by different subjects as appearing to be partly the result of differences in the environmental situations which they encountered. Finally, they noted that man's relation to his social environment appears to have small influence upon the form which illnesses will take, but a major influence upon the time and the situation in which illnesses will occur and the course they will pursue.

Such findings fit well with Selye's postulations about bodily reactions to stress and the morbidity that can occur if the adaptation fails or the stress is not relieved for a long period. Stress can also be defined as occurring whenever there is a major change in the environment. In such cases, the adaptation previously achieved is disrupted and the phases in the adaptation syndrome are reinitiated. Major disruptions in a person's life situation or environment may occur when there are many changes in the areas of personal, family, social religious, economic, and residential experience. Presumably such disruptions act as stressors on an individual and persons experiencing such changes could be ill more frequently than others.

Indeed, such findings have been obtained. In a longitudinal analysis of illness and life-change patterns it was found that a high number of life changes experienced fairly close together was often followed by illness (Rahe, McKean, and Arthur, 1967). Subjects of the study were men who had retired from the Navy with a temporary disability allowance because of psychiatric illness manifested while on active duty. Questionaires collected data on changes in a person's life situation, and medical records were examined for evidence of illness. Disruptions in the person's life were measured in "life change units", which is a system devised for weighting various incidents that a person may experience, and which reflect some change from his previous condition. Table H-I shows the scale of points assigned to these changes.

Both life changes and illnesses were seen to cluster during certain years. In general, a cluster of life changes was seen to occur immediately prior to an illness or to a cluster of illnesses. The more severe illnesses were preceded by cluster years of higher life-change magnitude than years prior to minor illnesses. Two instances of death and one instance of near death were preceded by clustering of high life-change magnitude. These results are summarized in Table H-II, which shows that there were more life changes prior to minor illnesses and still more prior to major illnesses than were found in the mean for the total sample.

Table H-I

Life-Change Units Scale[a]

Events		LCU
1.	Loss of wife through death	100
2.	Divorce	73
3.	A lot more or a lot less than usual association with wife, due to marriage trouble	65
4.	Held in a civilian jail or a brig	63
5.	Loss of close family member by death	63
6.	Marriage	50
7.	Court-martial	47
8.	A lot more or a lot less than usual association with wife, due to orders	45
9.	Change in health or behavior of a family member	44
10.	Major change in dating habits (engagement, etc.)	40
11.	Major change in the situation of parents (divorce,etc.)	40
12.	Gain of a new family member	39
13.	A lot more or a lot less financial problems	38
14.	Loss of close friend by death	37
15.	Change to a new line of work, or a new type of work than done previously in the rating	36
16.	A lot more or a lot less arguments with wife	35
17.	Took on mortgage or loan greater than $10,000	31
18.	Experienced a foreclosure on a mortgage or loan or received a letter of indebtedness	30
19.	To a Captain's Mast for disciplinary reasons	30
20.	Major change in responsibilities at work	29
21.	A son or daughter married or moved out of the home	29
22.	A lot more or a lot less in-law troubles	29
23.	Personal successes	28
24.	Either begun or ceased attending high school or college	26
25.	Wife started or stopped working outside the home	26
26.	Substantial change in living conditions	25
27.	Substantial change in personal habits	24
28.	A lot more or a lot less trouble with superiors	23
29.	Eligible for promotion but 'cut by quota' (enlisted) or 'passed over' (officer)	20
30.	Changed high schools or colleges	20
31.	Change of residence	20
32.	Substantial change in working hours or conditions	20
33.	Substantial change in church activity	19
34.	Substantial change in usual amount and/or type of recreation	19

Continued

Events		LCU
35.	Substantial change in social activities	18
36.	Took on mortgage or loan less than $10,000	17
37.	Marked change in sleeping pattern	16
38.	Substantial changes in family get-togethers	15
39.	Marked change in eating habits	15
40.	Taking a leave or a vacation	13
41.	Guilty of minor infractions of the civilian law	11

[a] From Rahe, McKean, & Arthur, 1967

Table H-II

Mean LCU Per Year for Total Sample Compared To The Mean LCU One Year Prior to Minor Health Changes and the Mean LCU One Year Prior to Major Health Changes[a]

	Mean	Code	Compared Pair	t-test	Significance
LCU per year for sample	72	A	A & B	5.01	($p < 0.001$)
LCU 1 year prior to minor health change	130	B	B & C	2.40	($p < 0.05$)
LCU 1 year prior to major health change	164	C	C & A	8.41	($p < 0.001$)

[a] From Rahe, McKean, & Arthur, 1967

Rahe (1968) has expanded this work to attempt to predict future illness based on examination of a person's life-change record at a given point of time. Prior to deployment on six to eight month cruises, groups of Navy men from three vessels filled out a questionnaire which was an inventory of life changes in the areas of personal, family, social, religious, economic, community, occupational, residential, and health experiences over the prior six months. The men were divided into three groups, based on the ranking of their total life-change units. The upper 30% were designated the high-risk group, the lower 30% were the low-risk group. On returning from deployment, sick call visits to the ship's dispensary (considering only new illnesses) were recorded. For the first month of the cruise, the high-risk group had nearly 90% more first illnesses than did the low-risk group. In the second month the high-risk group had 30% more. After that, both groups essentially encountered equal numbers of first illnesses. Over the entire six months period, the high-risk group had significantly more men who developed at least one illness. They also had uniformly more illness severity each month over the six month cruise than did the low-risk group. Rahe stated that even though the differences in reported illness experience between the high and low-risk groups were highly significant, life-change data only accounted for a small portion of the total variance. Other factors found significantly influencing illness reporting were Negro race, young age (17-18), anxiety over health prior to the start of the cruise, and working in certain of the varied environmental conditions on board. These other conditions mentioned should be studied further before accurate analysis of their significance can be made. However, the original question of whether analysis of life changes could be useful in predicting the near-future illness distribution in a population was answered affirmatively.

Rahe, Mahan, and Arthur (1970) conducted a similar study on 2,684 Navy men on three cruises, this time measuring the life changes that the men had experienced over the prior two years, rather than limiting the investigation to six months. Illness experiences of the men in this study were restricted in severity and number, with most having only one or two minor illnesses during the cruise.

Plotting the men's life-change unit rating against their cruise period illness rates produced a linear relationship as shown in Figure H-5. The positive relationship of life changes to illness was most impressive for the ships with the less arduous cruises in terms of work and combat stress, and was least impressive for the ship with the most arduous cruise experience. Rahe, Mahan, and Arthur suggested that the stressful environment itself may have raised base illness rates for the entire crew, and thereby decreased any differential illness experience based on a man's life-change experiences prior to the cruise.

Although somewhat tenuous in nature and possibly obscurred by other effects, the research evidence tends to show an association apparently exists between a person's life stress, as

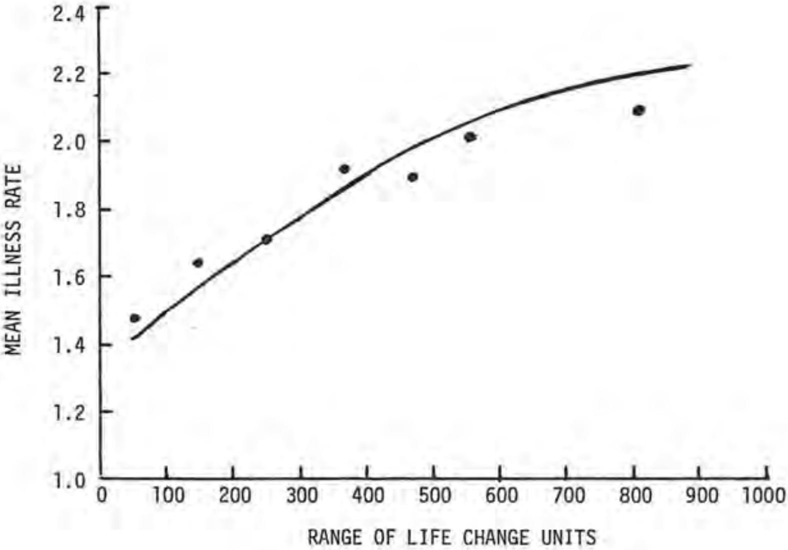


Figure H-5. Mean illness rates for equal divisions of the total range of life change units. (Adapted from Rahe, Mahan & Arthur, 1970.)

defined by life change, and the subsequent incidence of illness in that individual. These studies suggest that the psychological stress imposed on an individual due to his life situation, sufficiently weakens his body to a state of heightened susceptibility to illness.

Furthermore, although the instances may be rare, there is the possibility of psychological stress being imposed by inter-personal conflicts in the work situation. Markham (1967) reported a case of a patient with asthma who was forced to leave his job as a result of attacks precipitated by emotional reactions to conflict in the work environment.

Absenteeism. Life stress in relation to illness, industrial absenteeism, and accidents was reported in a study of 1,297 female telephone operators and clerks (Hinkle & Plummer, 1952). It was found that in 1950, 1/3 of the women were responsible for 4/5 of the total days lost by absenteeism, as demonstrated in Figure H-6. Furthermore, the same employees fell into the high-absence or into the low-absence groups throughout their entire period of employment. Absence records in the first year of service and absence records throughout subsequent years of service showed a high positive correlation.

In a medical study of 40 women from this population (20 low-absence employees and 20 high-absence employees), the same pattern was apparent regarding illnesses and accidents. Hinkle and Plummer reported that critical review of the medical reports of these two groups indicated that the 20 women with high absences had:

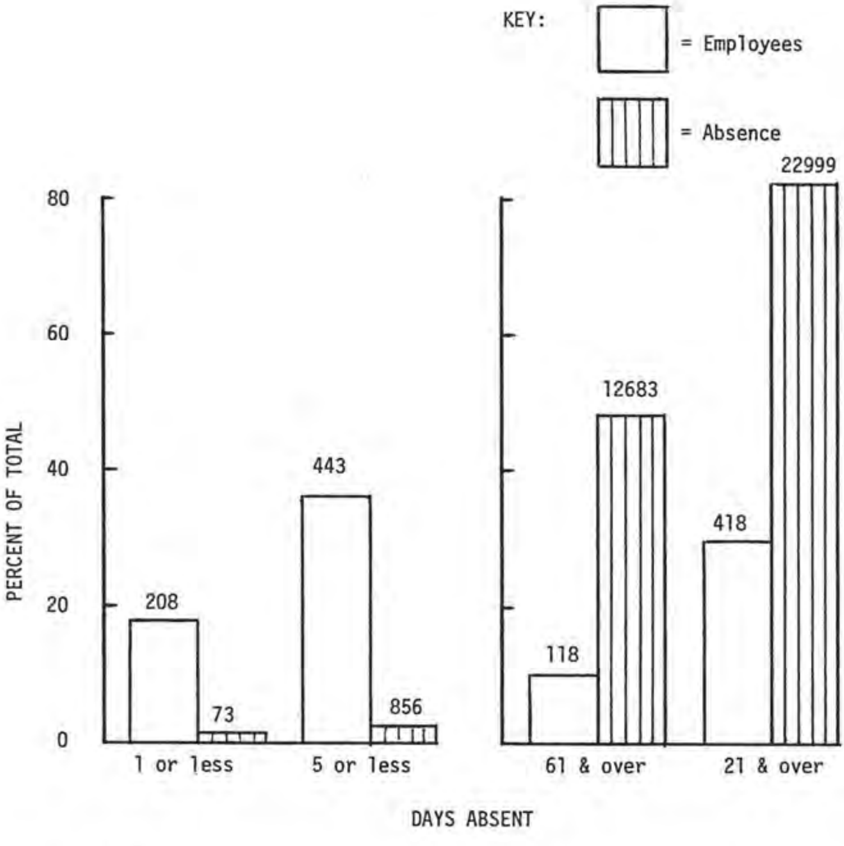


Figure H-6. Female employees absent during 1950 and number of days absent for given groups.
(Note: Total number of employees having absences of given number of days or less is shown over the unshaded bars; the total number of days accounted for by those employees is shown over the shaded bars. The height of the bars represents the percentage of the total.)
(From Hinkle & Plummer, 1952.)

a. Frequent minor illnesses (see Table H-III for examples of respiratory ailments);

b. A large number of major illnesses;

c. Frequent and prolonged minor disturbances and a large number of major disturbances of feeling-state, thought, and behavior (see Table H-IV);

d. Frequent minor injuries;

e. A large number of major injuries causing time loss from work;

f. A large number of surgical operations, both major and minor (see table H-V).

The women in the low absence group on the other hand, had:

a. Relatively few and scattered illnesses (see Table H-III);

b. Few and minor disturbances of feeling-state, thought, and behavior (Table H-IV);

c. Relatively few injuries;

d. Relatively few surgical operations (Table H-V).

Hinkle and Plummer tried to analyze what variables in the lives and background of these women were affecting their health and susceptibility to accidents (which was also higher for the high-absence group). Regarding working conditions, travel to work, income and domicile they were relatively homogeneous. It was also found that the cultural, economic and family background of the two groups were quite similar. Hinkle and Plummer stated that the one outstanding difference in the histories of the two groups lay in the degree to which they had been exposed to what is broadly termed "life stress" throughout their period of employment. The women in the low-absence group had been content, comfortable, and secure in their life situations with relatively few experiences which

Table H-III

Respiratory Disorders of Female Telephone Operators and Clerks[a]

Low-Absence Group			High-Absence Group		
Diagnoses	Instances	Persons	Diagnoses	Instances	Persons
Influenza	2	2	Lobar pneumonia	1	1
Pertussis	1	1	Bronchopheumonia	2	1
Chronic bronchitis	1	1	Asthma	1	1
Chronic tonsillitis	4	4	Bronchiectasis	1	1
Acute tonsillitis-pharyngitis	7	6	Pleurisy with effusion	1	1
"Colds"-grippe	15	11	Hemoptysis	2	1
Acute sinusitis	2	1	Pertussis	2	2
Chronic sinusitis-P.N.D.	2	2	Influenza	10	9
Allergic rhinitis	1	1	Virus pneumonia	3	3
			Pleuritic pain ("dry" pleurisy)	13	7
			Chronic bronchitis	7	6
			Acute tracheobronchitis	74	16
			Laryngitis	30	16
			Chronic tonsillitis	5	5
			Acute tonsillitis-pharyngitis	62	13
			"Colds"-grippe	158	17
			Acute sinusitis	39	11
			Chronic sinusitis-P.N.D.	8	8
			Allergic rhinitis	1	1
			Epistaxis	1	1
			Deviated septum	2	2

[a] Adapted from Hinkle & Plummer, 1952.

Table H-IV

Disorders of Feeling-State, Thought, and Behavior Among Female Telephone Operators and Clerks[a]

Low-Absence Group			High-Absence Group		
Diagnoses	Inst-ances	Per-sons	Diagnoses	Inst-ances	Per-sons
Tension	8	5	Tension	126	18
Anxiety	5	3	Anxiety	94	18
Asthenia	3	3	Asthenia	118	19
Mild depression	3	3	Mild depression	63	16
Insomnia	1	1	Major depression	1	1
Brief situational upsets	3	3	Nervous breakdown	2	2
			Panic	1	1
			Schizophrenia (paranoic)	1	1
			Alcoholism	1	1
			"Psychoneurosis"	9	5
			Hypochondriasis	1	1
			Obsessions-compulsions	1	1
			Phobic symptoms	1	1
			Post-concussion syndrome	1	1
			Insomnia	17	10
			Anorexia	4	4
			Hysterical Symptoms:	26	9
			Pains	10	3
			Globus	2	2
			Aphonia	2	2
			Coccydynia	1	1
			Anesthesia	3	2
			Syncope	4	4
			Spasm of eyelids	1	1
			Fits	1	1
			Vomiting	1	1

[a] Adapted from Hinkle & Plummer, 1952.

Table H-V

Surgical Operations Among Female Telephone Operators and Clerks[a]

Low-Absence Group			High-Absence Group		
Diagnosis	Inst-ances	Per-sons	Diagnoses	Inst-ances	Per-sons
Appendectomy	1	1	Cholecystectomy	2	2
Tonsillectomy-adenoidectomy	3	3	Appendectomy	8	8
Excision of sebaceous cyst	1	1	Hysterectomy-oophorectomy	2	2
			Oophorectomy	4	4
			Tonsillectomy adenoidectomy	8	8
			Dilation and curettage, diagnostic	4	4
			Completion of spontaneous abortion	2	1
			Hemorrhoidectomy	5	3
			Excision of fistula in ano	1	1
			Exploration of spine	2	1
			Spinal fusion	1	1
			Excision of sarcoma of arm	1	1
			Excision of sebaceous cyst	1	1
			Excision of meibomian cyst	1	1
			Excision of chalazion	1	1
			Submucous resection	2	2
			Irrigation of calcified bursa	1	1
			Incision and drainage, abscess	4	3

[a] Adapted from Hinkle & Plummer, 1952.

they had interpreted as stressful. These women in the high-absence group, however, had been made unhappy, insecure, and discontented by repeated frustrations, deprivations, unrewarded responsibility, and inter-personal conflict throughout their adult lives. They felt they had been exposed to life situations and experiences which were stressful. Their moods were constantly those of frustration, resentment, depression and anxiety which, characterized the observed "nervous and emotional illnesses" among them.

Hinkle and Plummer thus assessed that, in this group of women, absenteeism, bodily illness, psychological disturbances, and accidents were concentrated in those members who were having difficulty in adapting to the situations and experiences to which they were chronically exposed. They further felt that such individuals could be recognized soon after employment, and suggested that early in the employee's career, a suitable assessment be made of his physical condition, and of the possible stress factors in his life. Indiviudals predicted to have a high probability of absence could be avoided, or accommodations could be made in the work situation to reduce stress, so that the highest level of productivity could be attained.

Stress and Accidents

Preoccupation and distraction. Henderson (1971) has noted that, in the highway safety accident-proneness literature, one characteristic possibly related to the propensity to have accidents is personal stress, which can cause distraction from the driving task. Similarly, Sachs, (1962) in discussing the psychosomatic aspects of accidents, maintained that many employees apparently handle the stresses of everyday life inadequately. They become preoccupied while driving or while working with complex and dangerous machinery and have accidents they normally would have avoided. He indicated that problems involving health, home, work, and money may absorb an employee's concentration. Frustration, failure, illness, catastrophe, marriage, sterility, fear of death and other life stresses may disturb an individual to such a degree that he is more susceptible to accidents. Such preoccupation makes one less alert to environmental hazards and less able to use effectively the knowledge, judgment, and skills that a person may have previously used for his safety (Sachs, 1962). Wells (1966) also maintained that boredom, discontent, domestic strife, frustrations, inferiority feelings, hostility, and resentment may contribute to irresponsibility, maladjustment, and accidents.

Poor social and personal adaptation. Tillman and Hobbs (1949) studied accident repeaters in the general population and found them (compared to a sample of accident-free automobile drivers) more frequently known to social service agencies, the public health venereal disease clinic, credit bureau, adult court on other than traffic charges, and juvenile court. This type of evidence suggests rather poor social and personal adjustment to life situations on the part of many accident repeaters. Similar findings were reported for an industrial setting, where high-accident groups compared to low-accident groups reported more broken homes, juvenile court record, truancy, irregular work, marital discord and firings from a job (Wong & Hobbs, 1949). Neves (1969) found a greater incidence of conflict and poor adaptation in the home life of industrial accident repeaters.

Rogg (1961) suggested the importance of subjective emotional factors in producing accidents. He believed that it would advance the cause of accident prevention for more to recognize that, as human beings subject to frustrations and conflicts, there are times when all of us demonstrate an increased susceptibility to accidents that is not necessarily part of a lifelong pattern of behavior. This would mean that no one personality type is specific for accident repeaters. Rogg saw accidents as possibly being an unconscious physical solution of an emotional problem. The reverse of the statement about taking your work home with you might be true; that is people could take home-related stresses to work with them and their domestic frustrations and problems would become part of their work environment. Rogg studied 35 blue-collar workers recently involved in an accident in an attempt to delineate their emotional and mental state prior to the accident. Of the 35 men interviewed (within three days of the accident), 44% had some psychological problem just before the accident.

Viney (1971) also saw short-term accident proneness as an individual's way of discharging emotions when he is involved in a stressful situation. Similarly, Felton (1969) maintained that accidental injury is one manifestation of an intolerable work situation which defies resolution.

Hinkle and Plummer (1952), in their study of absenteeism among telephone operators and clerks, found the group with more absenteeism also had greater numbers of accidents. There were 133 accidents recorded in the poor attendance group and only 38 in the good attendance group. As shown in Table H-VI, nearly all of the accidents in the good attendance group were of a minor nature and led to no disability or lost time, whereas the major accidents such as factured skulls, concussions, and major burns, were all localized in the group with poor attendance. The group with poor attendance is the one which Hinkle and Plummer described as constantly frustrated, deprived, and undergoing great inter-personal conflict.

Divorce. Representing as it does a rather substantial disruption of one's life, divorce can many times be a major life stress. With the increasing divorce rate that confronts our country, it is of considerable importance to determine what, if any, effects divorce might have on an individual's ability to function safely. Goode (1956) studied the experience of 425 divorced, urban mothers and concluded that 3/5 of the respondents appeared to show various kinds of personal disorganization at times associated with marital dissolution. These personal disorganizations included difficulty in sleeping, poor health, loneliness, low work efficiency, memory difficulties, increased smoking and increased drinking. The main time of

Table H-VI

Accidents in Groups of Female Telephone Operators and Clerks[a]

Low-Absence Group			High-Absence Group		
Diagnoses	Inst-ances	Per-sons	Diagnoses	Inst-ances	Per-sons
Fractures	3	3	Fractured skull-brain injury	2	2
Sprains, severe	3	3	Concussion	2	1
Sprains, strains, minor	4	4	Fractures	6	4
Contusions, abrasions, minor	16	12	Herniation-nucleus pulposus	1	1
Lacerations, minor	3	2	Burns, major	2	2
Burns, minor	3	2	Contusions, abrasions, severe	23	9
Foreign body in eye	1	1	Contusions, abrasions, minor	43	14
Broken tooth	1	1	Sprains, severe	9	5
"No injury"	4	4	Sprains, strains, minor	17	11
			Lacerations, major	2	2
			Lacerations, minor	15	8
			Burns, minor	3	3
			Foreign body in eye	3	3
			Electric shocks	1	1
			Insect bites	1	1
			"No injury"	8	6

[a] Adapted from Hinkle & Plummer, 1952.

emotional impact was at the time of separation. These stress effects decreased at the time of the filing of the decree and measured still less at the time of the final decree.

McMurray (1970) analyzed the driving performance and traffic accident records of persons under the emotional stress of divorce. Her findings confirmed those of Goode's. Individuals undergoing divorce are in a period of high emotional stress, reflected in McMurray's study by poorer-than-average driving records and increased accidents. Table H-VII shows the percentage increases in accidents and violations during a year of stress (consisting of the six months before and after the filing for divorce) for the study groups.

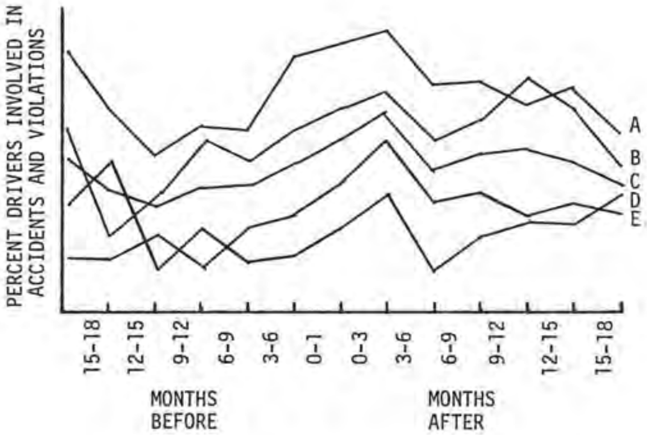
However, unlike Goode, who found the main emotional impact had fallen off by the time of filing the decree, McMurray found that the greatest number of violations and accidents occurred during the three months after the filing of the petition for divorce. This can be seen in Figure H-7. Male defendents were the greatest percentage of drivers involved in accidents and violations during this period, with male plaintiffs second. McMurray noted that within the year in which the subjects were involved in divorce proceedings, the accident problem rather than the violation problem was accentuated. Drivers with poorer-than-average violation records had 40% of the accidents during the period of stress. The group also had more speeding violations, more "failure to stop" violations and more defective equipment citations than average.

Table H-VII

Percentage Increase in Traffic Accident and Violation Rates During a Year of Divorce Proceedings Compared to Other Periods[a]

Group	Accidents	Violations	Accident & Violations Combined
Female Plaintiffs	140	167	159
Female Defendents	141	60	86
Male Plaintiffs	6	97	77
Male Defendents	137	103	110

[a] From data in McMurray; 1970



KEY:

A = Male defendents
B = Male plaintiffs
C = Total
D = Female defendents
E = Female plaintiffs

Figure H-7. Percentage of drivers involved in accidents and violations. (Based on McMurray, 1970.)

Acute disturbances. In an effort to analyze the existing state of mind of drivers involved in fatal traffic accidents, Selzer, Rogers, and Kern (1968) conducted a study by interviewing the drivers (if surviving) their "significant others" (those close to them), and their employers some months after the accident. They found that significantly more psychopathology and social stress was present in the 96 drivers causing fatal accidents than in a matched control group. The fatality group had more personal conflict (32% vs. 8%) and vocational-financial stress (36% vs. 8%) than the control group. Another relevant point was that 20% of the fatality drivers had acutely disturbing experiences, usually quarrels, within six hours of causing a fatal accident.

In general, those in the fatality group who displayed forms of psychopathology found in this study had significantly more previous accidents than the nonsymptomatic fatality drivers. Conversely, the fatality drivers with a history of recent personal conflict or vocational-financial stress did not have significantly more prior accidents.

Knorr and Edgerton (1971) studied the emotional distress observed in patients who had suffered a hand injury and noted that six out of the 22 subjects admitted to definite emotional stress immediately prior to the accident. The stresses of marital life, their job, and feeling like they wanted to quit were all mentioned.

Aitken (1969) studied 90 fighter pilots and found that more pilots from high-accident squadrons were worried about flying, bereavement, wives, and love life than were pilots from low-accident squadrons.

Studies of psychological stress produced by threat of failure or fear frequently show impaired performance. Deese and Lazarus (1952) tested 280 Air Force enlistees on a variety of psychomotor tests and subjected them to the threat that implied they would be eliminated from a career in Air Force technical service if they failed. Mean performance, for the experimental group was poorer than for unthreatened subjects. Making the threat early in the subjects' learning of the task produced small decrements of performance while introducing the threat late in the learning produced a small facilitation. Although this study did not examine the relation of stress to accidents, there is a demonstrated relationship of stress to poorer performance. Several other studies have shown similar findings. In one, (Lazarus & Eriksen, 1952) the effects of failure threat on college students performing an extended version of the Wechsler-Bellevue digit-symbol subtest was evaluated. There was a significant increase in inter-individual variability in test performance in the stress group; an increase in speed was accompanied by an increase in the number of errors. Students with poor academic records did more poorly under stress while students with high college grades showed a tendency to improve their performance.

Beier (1951) gave subjects of an experiment "stressful" Rorschach results and then tested them on an abstract reasoning test, a sorting test, and a mirror tracing test. The results indicated that persons faced with threat and in a state of anxiety show a lessening of abstract abilities and a disorientation of visual-motor coordination.

Lybrand (1953) tested 48 college students on four tests of reasoning and problem solving while manipulating the stress conditions and amount of ego-involvement of the testees in the task. He concluded that motivation, induced by increasing ego-involvement, acts to increase efficiency in certain kinds of problem solving. However, high ego-involvement may induce the feelings of operating under stress and may sensitize the individual to other stressful features in the reasoning tasks.

In a review of the literature on the effects of stress on performance, Lazarus, Deese, and Osler (1952) concluded that, "failure stress" produces poorer performance on problem solving, perceptual-motor or verbal tasks. Behavior changes in such such cases is variable, and may be manifested in increased time to perform or decreased accuracy. Other changes in behavior which can be induced by threat of failure include stereotyping of response, inattention, disorganized activity and increased overt activity.

Using fear as a motivation force may improve performance but occasionally depresses it. When the fear is too great, certain kinds of nonadaptive behavior can appear, such as an increase in speed accompanied by increased errors, changes in technique from good to poor, and concentration on a frustrated need or on ego defense (Lazarus, Deese, & Osler, 1952). Perhaps such findings have their counterpart in the industrial setting where one article (Making Night Work Pay, 1948) points out that although night shift work has fewer managers and supervisors accident rates are lower. While this is an oversimplification, it is true that demands of foremen, supervisors, and management can induce fear or threat of failure, and hence may lead to degraded performance, rather than the desired improved performance.

McGuire (1970) posed a theory as to why individuals who have been subjected to emotional stress are more susceptible to accidents. In his typology of accident-proneness, he stated that the principal characteristic of short-term accident-proneness is the fact that the individual is reacting to disruptive influences, which originate primarily from external pressures. Once the pressures are relieved, the individual begins to return to his former state of more favorable adjustment. The accident-prone person, involved in a stressful situation such as divorce, family illness, financial trouble, or unwanted pregnancy, McGuire termed the "Crisis Reaction" type. At such stressful times the person tends to show other symptoms. When driving, the person might show forgetfulness, inattention to traffic signals, unusual irritability, unwillingness to give up the right of way, a tendency to speed, or the use of alcohol. It is when he is in this state that increased accidents occur. McGuire proposed that when the personal crisis is over, good adjustment returns, and the individual is out of his short-term accident-prone period.

SUMMARY OBSERVATIONS

Problems of the Research Methodology

One serious problem facing researchers in the stress field is that of reaching an agreement as to whether they are studying a type of stimulus or a response. Many follow Selye (1964) and consider stress the non-specific response of the body to physical or psychosocial demands. However, some scientists discuss stress as an element or a combination of elements in an individual's environment which elicits a maladaptive response. Viewed from one perspective, stress conceivably can have beneficial effects. The other definition makes it an evil to be avoided. A meaningful body of research on the relation of stress to accidents or illness cannot be developed as long as stress retains this dual identity.

Additional pitfalls for the researcher have been noted by Margolis and Kroes (1972). In attempting to correlate a stress effect with a particular stressor, one may discount other stressors in the environment. For instance, a factory worker who suffers from asthma may do so because he has a poor relationship with his supervisor. On the other hand, an allergy to a material he is handling may be the cause. But the allergy would not surface if the supervisor conflict did not exist. Margolis and Kroes warn there is doubtful validity in treating separate job stressors as additive when they may be synergistic or ameliorative in combination.

They also caution that stress may exist in a work environment even if stress effects are not found. Those workers most vulnerable to the stressors in the environment may have left the job, and therefore, the reactions of a study sample could yield an inaccurate picture of the job situation.

Hypersusceptibility

There are vast differences in individual reactions to stressors. McLean (1972) says that this differential response is a result of:

1. biochemical individuality
2. early life experiences
3. psychological set
4. cultural factors
5. conscious and unconscious mechanisms of defense (habitual methods of coping)

There is little evidence to suggest that there is a particular age, sex, or race more vulnerable to stress than others. However, evidence does indicate that those individuals operating under conditions containing one or more stressors have increased vulnerability to additional strain.

Selection and Placement

Until industry is able to rate its jobs in terms of the number of possible stressors in each job situation, it can find little scientific basis for selective employment and placement of "vulnerable" individuals. One could assume that it would not be wise to place an individual subject to severe domestic stressors (those associated with divorce or the death or serious illness of a mate, for example) in a high-stress job. The problem arises in identifying the degree of stress in the job.

Amelioration of Stress

Basic psychology would suggest that one common reaction to stressors in the work situation is flight. This does not mean necessarily that the stressed worker leaves his job completely, although job-hopping is one form of flight. He may exhibit a recognizable pattern of tardiness, absence, and avoidance of deadlines. He may seek partial self-destruction, taking on much more work than he can possibly handle, quarreling with supervisors and co-workers or experiencing accidents. Increased number of dispensary visits is another stress indicator. The extreme form of flight is complete self-destruction or suicide.

Management should be aware of these flight symptoms and should educate supervisors to recognize them in their employees.

Once evidence of a problem has been found, there should be remedial efforts, perhaps a team approach (involving supervisors, a mental health expert, doctor or nurse, and environmentalist) for identifying the stressors in the situation and alleviating them.

It would be useful if employee records contained more information other than age, marital status and job history. However, there is often resistance to demanding more personal information from employees and thus these data which could be predictive of accidents or illness are rarely available.

Management can predict in one area, however. Major department overhauls, or plant moves are bound to cause stress effects for many employees. Management should be aware that it is in its best interest, from a health and safety viewpoint, to do all they can to ease such transitions.

Research Needs

Much of the literature in the stress field reflects the opinions of the investigators and offers little empirical evidence. This is the inevitable result of confusion as to what was being measured and (quite often) the use of subjective tools with which to do the measuring.

Apparently, there is clear evidence of a number of physiological stress effects. However, the following research gaps remain:

1. The relationship of physiological stress effects to particular stressors in the environment (physical or psychosocial);

2. The measurement of individual differences in reaction to such stressors;

3. The relationship between observed variations in stress reactions with individual factors such as physical condition, sex, age, race, and cultural background, social supports on and off-the-job.

4. The rating of jobs in industry on the basis of identifiable stressors in the job situation, i.e., defining stress profiles for specific job types.

5. The determination of the direction of causality of stress and health and safety problems by longitudinal studies in high stress jobs.

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LIFE STRESS

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents		235 656 891 910 1116	15 235 256 923 1091 1113 1115	15		
Agent-Specific Diseases		264				
Non-Specific Disorders		1086 1087 1124	1114			
Critical Incidents						
Rate/ Amount of Sick-Absence	1085	917 918 990 1118 1119				
Perform-ance Indices		1122 1129 1123 1130 1125 1131 1126 1188	1120	1187		
Strain Indices	1088			1128		
Morale		1103				
Compliance with Rules		1089				
Off Job Problems						
Miscel-laneous		735 902 1089	1299 1300	1280	143	

SMOKING HABIT

A portion of a report--

PROBLEMS IN

OCCUPATIONAL

SAFETY AND HEALTH:

A

CRITICAL REVIEW

OF SELECT WORKER

PHYSICAL

AND

PSYCHOLOGICAL

FACTORS

By: Century Research Corporation

For: National Institute for Occupational
Safety and Health

November 1974

SMOKING HABIT

Health Effects

In 1962, ten physicians and scientists were selected to serve as the Surgeon General's Advisory Committee on Smoking and Health. This committee was to review and evaluate data which had been presented in a Public Health Service report in 1959 and much additional data which had accumulated on the subject of the relation of smoking and health. These studies had shown, in general, that the use of tobacco (especially in cigarette smoking) was causally linked to lung cancer, coronary artery disease, chronic bronchitis, emphysema, and other diseases. Table I-I shows how the number of deaths of cigarette smokers from various causes exceeds the expected number of deaths. These data represent the deaths of men in a sample of 1,123,000 who provided histories of smoking habits and other background data. Studies of females indicate that cigarette smoking is associated with increased death rates, but to a lesser extent than in males.

In general, death rates are positively related to the number of cigarettes smoked daily as is shown in Figure I-1. Data on deaths from lung cancer in Japan have also shown a positive relationship to the number of cigarettes smoked each day as shown in Figure I-2. These data are of interest because they represent a population with genetic, dietary, and other cultural differences from previously examined Western populations. Although the mortality rates reported in this study are lower

Table I-I

Expected and Observed Numbers of Deaths of Various Causes for Cigarette Smokers[a]

Cause of Death	Expected Deaths	Observed Deaths	Mortality Ratio
Cancer of lung	170.3	1,833	10.8
Bronchitis and emphysema	89.5	546	6.1
Cancer of larynx	14.0	75	5.4
Oral cancer	37.0	152	4.1
Cancer of esophagus	33.7	113	3.4
Stomach and duodenal ulcers	105.1	294	2.8
Other circulatory diseases	254.0	649	2.6
Cirrhosis of liver	169.2	379	2.2
Cancer of bladder	111.6	216	1.9
Coronary artery disease	6,430.7	11,177	1.7
Other heart diseases	526.0	868	1.7
Hypertensive heart	409.2	631	1.5
General arteriosclerosis	210.7	310	1.5
Cancer of kidney	79.0	120	1.5
All causes[b]	15,653.9	23,223	1.6

a Table extracted from Smoking and health - Report of the Advisory Committee to the Surgeon General of the Public Health Service, 1964.

b Includes all listed causes as well as all other causes of death.

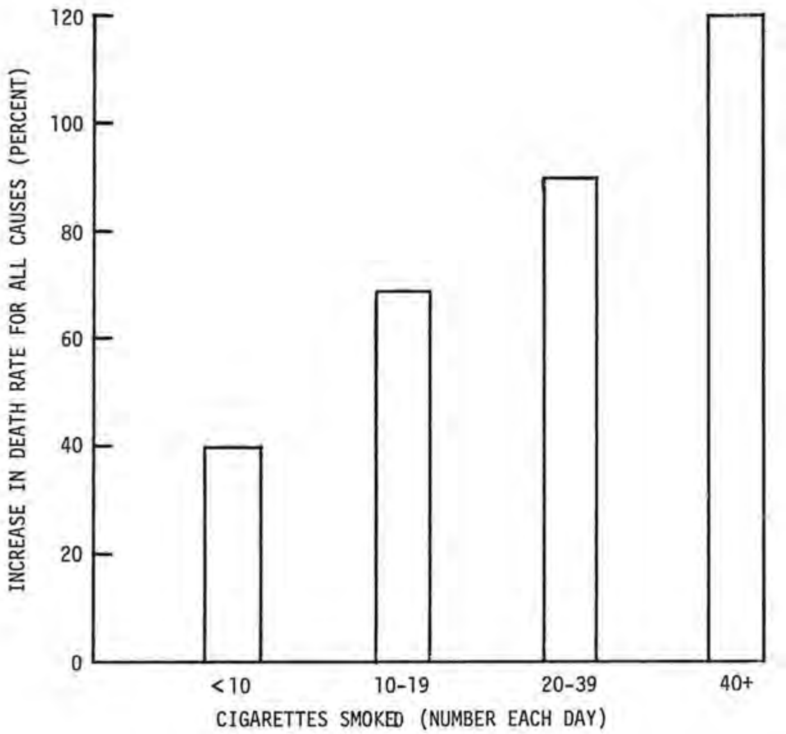

Figure I-1. Increase in death rates for all causes for male cigarette smokers as a function of the number of cigarettes smoked daily. (From data supplied in Public Health Service, 1964.)

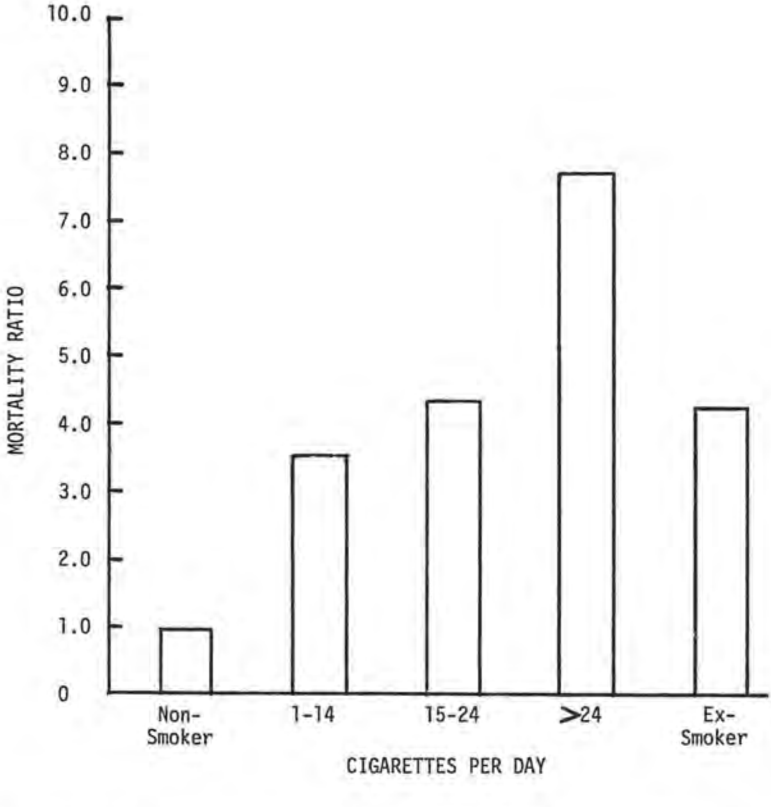

Figure I-2. Standardized lung cancer mortality ratios (1966-1970) of Japanese by number of cigarettes smoked. (From Public Health Service, 1973 based on Hirayama, 1972.)

than those reported for the United States, the overall results are similar to the results of all other major epidemiological studies.

Evidence of the health hazards of smoking has been reviewed in several Public Health Service publications of which the most valuable are the Report of the Advisory Committee to the Surgeon General of the Public Health Service (Public Health Service, 1964) and reports which update the literature reviewed in this report (Public Health Service, 1967; 1968; 1973).

However severe the health hazards of smoking may be, they would not be of interest in this review unless there were data to show that smokers are differentially affected by occupational health hazards or have different accident rates than workers who do not smoke. Hedrick (1969) reports U. S. Bureau of the Census figures showing the days of work loss, days of bed disability, and days of restricted activity. These data are presented in Figure I-3 which illustrates that persons who smoke cigarettes generally have more days lost on the measures than do nonsmokers. Although mortality rates for women smokers are lower than those for men, their statistics on these measures of days lost exceed that of men. Similar results have been reported for workers in a Polish textile factory (Indulski, 1967). These data are presented in Figure I-4. Hedrick (1969) goes on to quote Public Health Service figures to show that in a single year (probably 1964-65) there were 399 million workdays lost because of illness and that 77 million of those days (19%) were excess workdays lost because of the higher

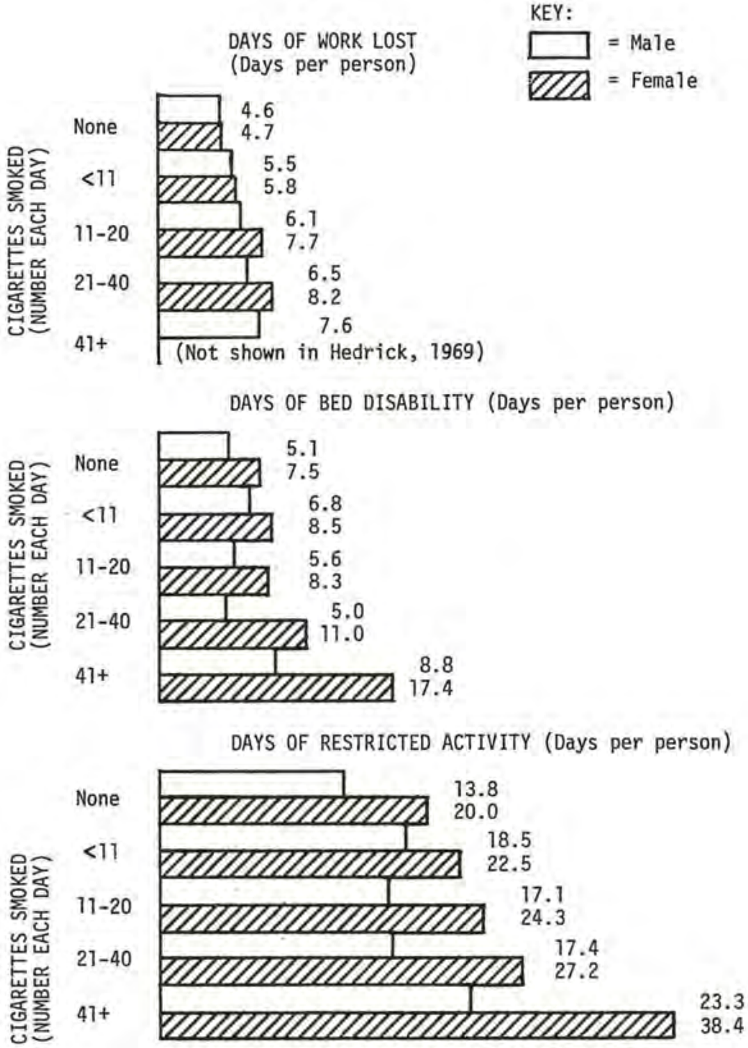

Figure I-3. Days lost from work, bed-disability days, and restricted activity days (all per person) for present smokers and nonsmokers. (Adapted from Hedrick, 1969.)

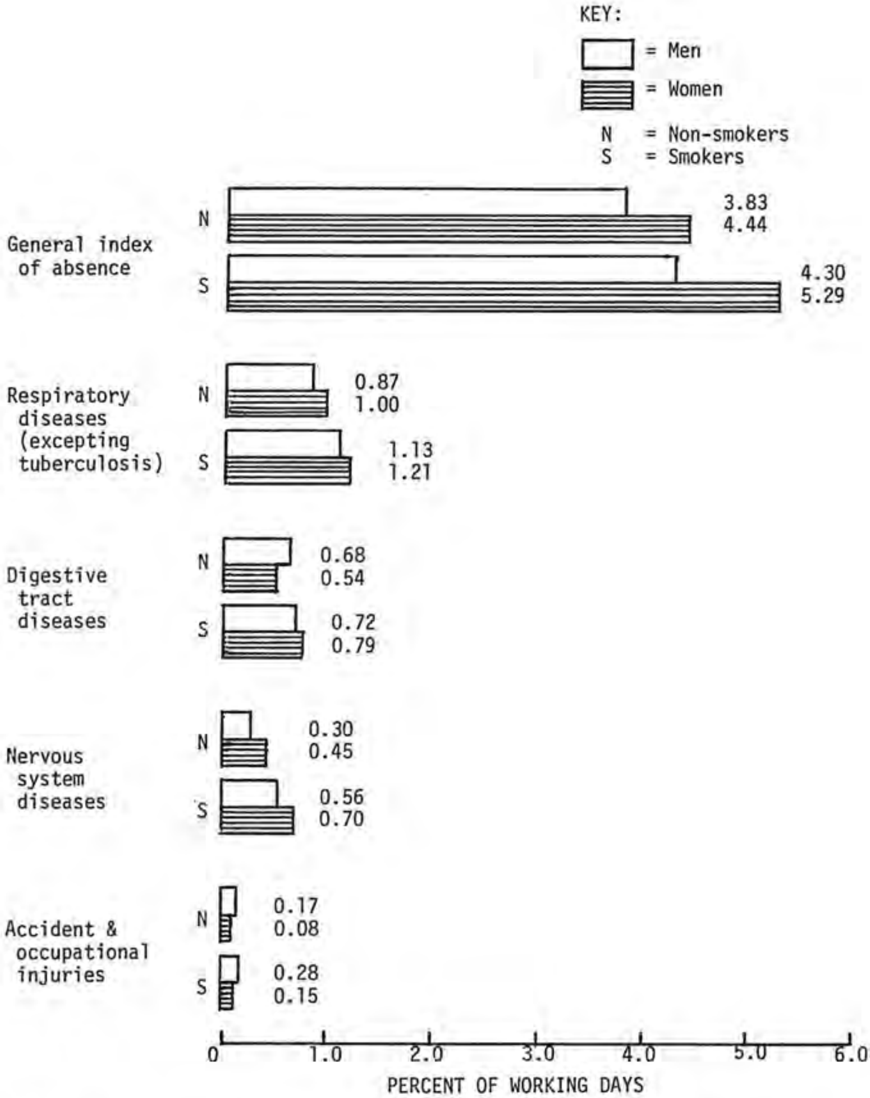

Figure I-4. Sick-absenteeism of men and women in a Polish textile factory in 1961-62. (Drawn from data in Indulski, 1967.)

rates of smokers compared to nonsmokers.

But there is even a more direct relationship between smoking and the health of workers. Several studies have shown that when there is exposure to an element in the work environment such as cement dust, coal dust, or asbestos, that in itself can cause respiratory problems, then the rates for respiratory disease are higher in groups of smokers than in nonsmokers in the working population. Table I-II summarizes the results of some of these studies and shows that pulmonary or respiratory diseases associated with specific occupational hazards are exacerbated by smoking. Because the habit of smoking is a detriment to the health of the individual and therefore to workers and furthermore because of the evidence that smoking can increase the severity of some illnesses, a brief review of pertinent literature is reported below.

Lung cancer and respiratory impairment. The publicity attending the issuance of the Report of the Advisory Committee to the Surgeon General (Public Health Service, 1964) and the legislation which followed to require notices of the hazards of smoking on cigarette packages and the banning of cigarette advertising on television has made the threat of increased susceptibility to lung cancer from cigarette smoking widely known. While this review will not duplicate the extensive reviews of the research literature on this topic that will be found in other sources, a few studies of industrial workers will be cited. Brett (1968) reports a three-year study on 54,460 workers, 40 years and over in age, of which 68% were

Table I-II

Studies Indicating Increased Risk of Smoking in the Presence of Some Other Occupational Hazard

Occupation	References	Hazard or Risk	Increased Risk as Result of Smoking
Port & shipyard workers in Coal loading; Apatites, phosphorites, sulphur, cement; Corn; Welders; Timber loading (control group) (Poland)	Dobrzynski, Kisielewicz & Kociecka, 1970a	Dusts	Cigarette smoking was the main factor in chronic bronchitis. However, the incidence of bronchitis ranged from 48% in coal loaders to 74% in those working with apatites, phosphorites, etc.
Millers; Textile workers; Foundry men; Pall-bearers; Others exposed to dusts (France)	Golli, 1970	Occupational Dusts	Chronic bronchial irritation 5.6 times higher in smokers and only 2.5 times higher in dust exposure. Over 32% of dust exposed smokers had chronic bronchitis compared to 4% of nonsmokers not exposed to dust inhalation
Harbor grain elevator	Dobrzynski, Kisielewicz, & Kociecka, 1970b	Dust	Although chronic bronchitis was found in 35% of those employed up to 6 years and in 74% of those up to 16 years, only 18% of nonsmokers were afflicted compared to 57% of smokers

Continued

Occupation	References	Hazard or Risk	Increased Risk as Result of Smoking
Cement plant workers Coal miners Tramway personnel (Czechoslovakia)	Vyskocil, 1972	Bronchitis	Smoking worsens bronchitis in all occupational groups
Foundry workers (Great Britain)	McCallum, 1972	Foundry & other dust	Smokers of 25 cigarettes per day but not exposed to dust have as much "sputum-chest-illness syndrome" as those who have never smoked but worked in the foundry for 45 years. Smoking and foundry dust have additive effect
Coal miners	Lapp, Hankinson, Burgess & O'Brien, 1972	Dust	Miners who smoked showed larger decreases in forced vital capacity and forced expiratory volume in one second after a work shift than did nonsmoking miners. Changes were not statistically significant but authors propose that had current smokers been separated from exsmokers the differences would have been significant

Continued

Occupation	Reference	Hazard or Risk	Increased Risk as Result of Smoking
Coal workers	Naeye, Mahon & Dellinger, 1971	Coal dust	Bituminous workers who smoked had 9 to 25% more emphysema and 56 to 68% more chronic bronchitis than nonsmokers. Evidence of chronic pulmonary heart disease in a group of miners was more severe for smokers than for nonsmokers
Magnetite miners Sinterers	Kleinfeld & Messite, 1968	Dusts of iron oxide, silicates & free silica	Lower vital capacity in sinterers who smoked than those who did not smoke. No difference in miners who smoked compared to those who did not smoke
Gold miners	Osburn, 1969	Arsen-ical dust	Exposure to arsenical dust or cigarette smoking can each by itself produce lung cancer, but the factors acting together accounted for the high incidence of the disease in this study
Insulation workers (Ireland)	Langlands, Wallace, & Simpson, 1971	Asbestos	Considerable impairment of lung function in smokers compared with nonsmokers. Nonsmokers with lung field abnormality in chest x-ray show less impairment of lung function than smokers with normal x-rays

Continued

Occupation	Reference	Hazard or Risk	Increased Risk as Result of Smoking
Textile factory (Brazil)	Luz, DeBustamante, Szklo, & Strozenberg, 1972	Respiratory symptoms	Smoking associated with increased frequency of respiratory symptoms
Wool industry workers (Poland)	Brysiewicz, Buluk, Cesarz-Fronczyk, Kordecka, Leszczynski, Lukjan, & Sadokierska, 1970	Dust	Dust concentrations over 10 mg/m^3 resulted in 17% to 30% of the workers having chronic bronchitis. Only 5 to 7% of workers had bronchitis when concentration was less. Ratio of smokers to nonsmokers with chronic bronchitis was 3 to 2.
Hemp workers (Spain)	Lopez Merino, Flores Marco, Barbero Carnicero, & Llopis Llombart, 1971	Hemp dust	49% of nonsmokers had hemp dust pneumoconiosis and less than 5% developed most severe stage; 88% of smokers were affected and over 36% developed most severe third stage.
Bakers (Yugoslavia)	Valic & Stahuljak, 1971	Dust	Incidence of Chronic Bronchitis Bakers / Control Nonsmokers: 24% / 6% Smokers: 46% / 23%

Continued

Occupation	Reference	Hazard or Risk	Increased Risk as Result of Smoking
Chlorine gas workers	Chester, Gillespie, & Krause, 1969	Chlorine gas	Smokers exposed to chlorine had decreased maximal mid-expiratory flow
Sulphuric acid plant	Thiess, Oettel, & Uhl, 1969	Sulphuric acid fumes	Incidence of lung cancer greater in smokers than in nonsmokers
Chemical plant workers	Oettel, Thiess, & Uhl, 1970	Borane, nitrous & other irritant gases	Evidence from analysis of lung cancers indicates a definite potentiating action between cigarette smoke and lung-irritating gases, vapors, or dusts
Laboratory workers	Welti & Hipp, 1968	Polymer fume exposure	Flu-like chills and other vague complaints occurred in smokers exposed to polytetrafluorethylene fumes; nonsmokers experienced no symptoms. Contamination of the cigarettes was ruled out as a cause. Habitual smoking predisposes to polymer fume fever and smoking after significant exposure can precipitate an attack.

smokers. He found that the annual rate of mortality from lung cancer in nonsmokers and ex-smokers was 0.33/1000 and for cigarette smokers 1.2/1000. The rate was higher in heavy smokers than in light smokers. Heavy smokers who tended to retain the cigarette in their mouth between puffs had an annual death rate of 4.1/1000.

Langlands, Wallace, and Simpson (1971) studied 252 (93%) of the insulation workers in Belfast by chest x-ray, questionnaire, clinical examination and tests of respiratory function. In this case the dangerous element was asbestos. They found that there was considerable impairment of lung function in smokers compared with nonsmokers. Smokers with normal chest x-rays had a lower mean forced vital capacity and single breath carbon monoxide transfer factor than nonsmokers with lung field abnormality in their chest x-ray. They concluded that smoking and exposure to asbestos have an additive effect in causing impairment of lung function in respect to vital capacity and gas transfer, as well as in causing lung cancer.

Weiss (1971) examined 100 asbestos textile workers by means of chest x-rays and a questionnaire concerning age, sex, smoking habits, and duration of occupational exposure to asbestos. Prevalence of pulmonary fibrosis increased with increasing amounts and duration of cigarette smoking as well as with increasing duration of exposure to asbestos.

Another study (alluded to in Fahy, 1969) found that cancer of the lung could not be detected in insulation workers who did not smoke cigarettes, even when their exposure to asbestos was equal to that of smokers who developed cancer. Such evidence leads some researchers to believe that asbestos fibers will not cause lung cancer without the presence of some co-factor and the most serious co-factor is cigarette smoking (see Fahy, 1969).

McCallum (1972) in studies of the health status of British foundry workers, found that they had more chronic bronchitis than other comparable workers in industrial areas. The prevalence of bronchitis increased with the years of employment in foundry work and with smoking characteristics. They found that men not exposed to foundry dust or any other dust, who smoke 25 cigarettes a day, have as much bronchitis as those who have never smoked but worked in the foundry for 45 years. The rates of bronchitis in different smoking groups in this study suggest an additive rather than a synergistic effect of smoking on bronchitis.

Various measures of respiratory function have been found to be affected by smoking. Already noted in the Langlands, Wallace, and Simpson (1971) study cited above have been lower mean forced vital capacity and single breath carbon monoxide transfer factors found in smokers compared to nonsmokers.

Ventilatory function before and after a work shift in a coal mine has been measured (Lapp, Hankinson, Burgess, O'Brien, 1972). The forced expiratory flow, the forced vital capacity, and the forced expiratory volume in one second was measured in 93 coal miners and 42 nonminers. There were small but significant decreases in ventilatory capacity among the miners and significant increases in the ventilatory capacity of the nonminers. The researchers assign as the most likely explanation of these and other findings the degree and extent of exposure to coal mine dust. When they compared miners who smoked with those who did not smoke they found that the smokers showed larger decreases after a work shift. While these findings were not significantly different, the researchers postulate that it is possible they would have been significant had current smokers been separated from ex-smokers. On the other hand, the smokers who were not miners showed greater increases in some measures after a work shift than the nonminers who were also not smokers. The situation is summarized in Table I-III.

Another study of ventilatory function in miners using very large numbers of medical examinations and questionnaires has shown similar small differences when comparing smokers with nonsmokers (Ashford, Brown, Morgan, Rae, 1968). The researchers derived a multiple regression formula to predict ventilatory function which had the following form:

$$\text{Ventilatory function} = b_o + (b_1 \times \text{age}) + (b_2 \times \text{height}) + (b_3 \times \text{sitting-height}) + (b_4 \times \text{weight}) + e$$

In the formula, b_o is a constant and b_1 through b_4 are the regression coefficients by which each variable in the formula is weighted. These were calculated separately for smokers and nonsmokers and other subgroups. Figure I-5 shows a

Table I-III

Summary of Measures of Ventilatory Capacity of Workers Before and After Work Shift[a]

	Miners	Nonminers
Nonsmokers	Decreased capacity	Increased capacity
Smokers	Extra decreased capacity	Extra increased capacity on some measures

[a] Table summarizes results of several measures of ventilating capacity made by Lapp, Hankinson, Burgess, and O'Brien, 1972.

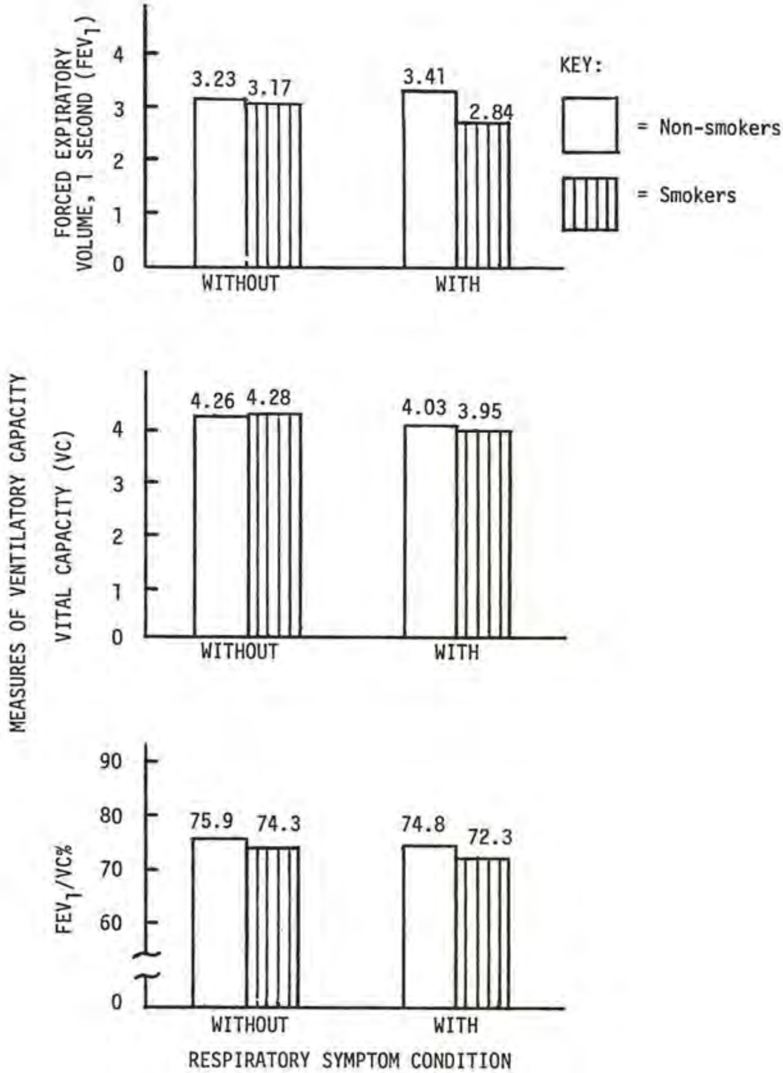

Figure I-5. Predicted values of three measures of ventilatory capacity of 40 year old miners with evidence of pneumoconiosis (with and without respiratory symptoms) who are 170 cm in height, 90 cm sitting height, and 71 kg weight. (Drawn from tabular data in Ashford, et al., 1968.)

comparison of the values of three measures of ventilatory function which result when the formula is used. The differences between smokers and nonsmokers are small. For both smokers and nonsmokers there is a definite decrease in the measures as age increases.

Lest it be assumed that smoking invariably compounds any lung impairment caused by dusts or gases, it should be noted that several studies of lung problems among cement workers have failed to find clearcut additional effects as a result of smoking (El-Sewefy, Awad & Metwally, 1970; El-Sewefy & Awad, 1971; Kalacic, 1973a; 1973b). Other researchers warn that "whenever the relations between cigarette smoking habits and ventilatory capacity in a population study do not follow those expected from the effects of smoking, exposures to other agents should be suspected" (p. 797) (Bouhuys, Schilling & van de Woestijne, 1969). They found heavy smokers among hemp workers who exhibited better lung function than light smokers and reason that those hemp workers most affected by dust stop smoking. Since they have the poor measures of lung function because of dust, it appears the smokers are better off than nonsmokers. No direct proof of this explanation is presented because such proof is difficult to obtain (Bouhuys, et al., 1969). Perhaps a similar explanation can be given for a study of wool workers (Mathur & Misra, 1972) which found that 17.6% of wool workers who smoked had chronic bronchitis while 25% of smokers in a control group had the disease.

Heart and circulatory system. The Report of the Surgeon General's Advisory Committee on Smoking and Health (Public Health Service, 1964) indicated that smoking and nicotine administration cause acute cardiovascular effects, but that the effects produced do not account well for the observed association between smoking and coronary disease. However, the Public Health Service updating of the earlier report (Public Health Service, 1967) says the data suggest that death from coronary heart disease may be caused by cigarette smoking. The 1968 and 1973 updatings (Public Health Service 1968; 1973) emphasize the relationship between smoking and other risk factors in the development of coronary heart disease.

None of the studies identified in this review specifically related the heart and cardiovascular problems of smoking with occupational health and safety problems.

Carbon monoxide. Exposures to carbon monoxide (CO) are widespread in our present environment. In the United States, cigarette smoking is probably the most important source of CO followed in importance by motor vehicle exhaust, occupational sources, and home heating and cooking devices (Goldsmith and Landow, 1968). Exposure to CO is of concern because in the body it combines with hemoglobin (Hb) to form carboxyhemoglobin (COHb) and makes the hemoglobin molecule less able to bind with oxygen (see the National Institute of Occupational Safety and Health, 1972). The median COHb concentrates for one pack per day cigarette smokers who inhale is 5.9%, which is a concentration sufficient to imply a serious threat to health in persons with underlying vascular insufficiency (Goldsmith and Landaw, 1968). Aside from the direct health effects on the individual, the exposure to CO through smoking is thought to be dangerous for the following reasons:

1. Complex psychomotor tasks are impaired (Goldsmith and Landaw, 1968).

2. Time perception is impaired (Goldsmith and Landaw, 1968).

3. Tolerance to additional other exposures of CO is lowered (Prerovska and Drdkova, 1971; Magdaleno, 1968).

4. Sensory thresholds are adversely affected (Gibson and Moroney, 1972).

5. The suspicion that higher COHb levels may be associated with increased risk of accidents (Goldsmith and Landaw, 1968; Szollosi, Medve, and Jeney, 1970; Surry, 1968).

6. The COHb levels in the body from smoking are added to by exposure to other sources (motor vehicle exhaust, gas ranges) of CO in the course of daily life (Emara, Waguih, El-Gendi, and El-Samara, 1971; Surry, 1968, p 98; Hale and Hale, 1971).

Details on some of these effects are discussed in other sections of this report.

Performance Degradation

Evidence in the previous sections that smoking produces a variety of health problems, impairs lung function, and affects sensory thresholds raises the question of whether there are real performance decrements in motor, psychomotor, and perceptual skills either as a direct result of smoking or from secondary effects as the result of the lowered state of health, or CO toxicity. In its latest review of literature on the health consequences of smoking, the Public Health Service reports on a number of such measures (Public Health Service, 1973). Studies using only smokers as subjects have found no difference in measures of grip strength for smoking and nonsmoking trials. Similarly, no differences were found for a tapping test, strength test, and a jumping test. No differences in swimming times were found for increasing lengths of periods of abstinence. Only three of eight subjects showed statistically significant better average riding times in nonsmoking compared with smoking trials in a bicycle ergometer test.

However, when studies compare smokers to nonsmokers on various tests, it is clear that nonsmokers perform better, especially on tests or activities involving maximal work capacity.

The mean distance covered in a 12-minute maximum running test was greater for nonsmokers than smokers. Smokers did more poorly than nonsmokers in a one-mile run. Many studies indicate that the physiological cost of motor activity is much greater for smokers than for nonsmokers. The Public Health Service (1973) report concludes that some of the decrements in performance for smokers "are mediated by reduced oxygen transport and reduced cardiac and pulmonary function."

With regard to the studies showing lesser performance levels for smokers compared to nonsmokers, in many cases the magnitudes are not of practical significance. This was one of the conclusions of Gibson and Moroney (1972) who reviewed the literature on the relationship of smoking and any adverse effects it might have on air crew performance. Their results indicated that although cigarettes do significantly affect various sensory thresholds, the changes appear to be of little practical importance. However, they note that withdrawal from smoking produces significant performance decrements. They recommended that research on CO and nicotine effects in an aviation environment and at altitude is needed. In particular, they specified that reduction induced by smoking in the visual field at altitude especially needs attention. Magdaleno (1968) points out that inhaling the smoke of three cigarettes, smoked consecutively without a pause, has the same effect as a 2,300 meter (over 7,500 feet) increase in altitude. Among the effects is a reduction in the efficiency of nocturnal vision.

Behavioral and physiological responses of cigarette smokers and nonsmokers exposed to varying degrees of stress have been studied using a driving simulator (Ashton, Savage, Telford, Thompson and Watson, 1972). While the smokers were smoking a cigarette, some of their reaction times to light signals differed significantly from those of nonsmokers, some being longer and some shorter. These differences were not present when they were not smoking. Among the physiological measurements, only the heart rates differed significantly, being higher among smokers at all levels of stress.

Surry's (1968, p. 82) review of industrial accident research mentions a study by Tarriere and Hartemann (1965) which compared smokers and nonsmokers on a visual vigilance task. They found smokers, while smoking, were significantly better performers than nonsmokers and especially better than smokers who were not smoking during this task which was characterized as unstimulating. It is suggested that the nicotine served as a stimulant, thus improving the vigilance of those smoking.

In summary, it would seem that smoking most affects performance on those tasks requiring a near maximum physical output, it raises sensory thresholds in amounts that are statistically significant but possibly unimportant practically, and may actually serve as a stimulant in some tasks.

Accidents

There apparently has been relatively little research done on the association of smoking and occupational accidents. Hale and Hale (1971) in their review of the industrial accident literature mention only two studies, one by Lowe (1960) and one by Molitor and Mosinger (1967), both of which found a correlation of smoking with accidents. Surry's (1968) review of industrial accident research quotes neither of the studies found by Hale and Hale (1971) but does mention a study by Adams (1965) which found that 46% of male drivers with numerous accidents and violations smoked while only 17% of those with no accidents or violations smoked. This relationship is reported in another source (Adams and Williams, 1966) as having a chi-square significance at the .025 level. Adams and Williams attempt to explain the association between smoking and accidents as evidence of overdependency in the personality of the accident repeater. The overdependent person wants to be taken care of and not to be responsible for his behavior; the responsible person relies on himself to take action to avoid or prevent accidents. Overdependency is also a characteristic of the oral personality and it has been suggested that smoking is regressive oral behavior. Therefore, it appears, according to Adams and Williams, that smoking does not cause accidents but rather both smoking and accidents are manifestations of overdependency in the personality of the individual who repeatedly has accidents. It should be noted that their study does not test this hypothesis, but rather they offer the hypothesis as a possible explanation for the association which they found.

A study by Naus, Engler, Hetychova, and Vavreckova (1966) shows a prevalence of smokers in a group of injured workers. They recorded all the injuries in a machine works with 1,500 employees during a ten month period. The injured persons were asked to fill out a short questionnaire which included inquiries about their smoking habits, the source and cause of the accident, and other details necessary for classification of the injuries. They report only descriptive statistics and there seem to be internal inconsistencies in the data reported. Some of their results are summarized in Figure I-6. Although they show 31% male smokers and 19% of female smokers as having been injured in the ten months of their study, they report only 18% of the total sample of smokers as having been injured. From other data in the report it appears that the figures presented for male and female workers are not the percentage of those injured, but rather the number of injuries as a percentage of the number in the group, some workers having several accidents in the period of study. Regardless of what appears to be an inconsistency, there seems little doubt (and the authors so report) that accidents in the smoking group exceeded those in the nonsmoking group. Unlike Adams and Williams (1966) these authors offer no Freudian based hypotheses to explain their results. Rather they indicate "...that the habit of smoking causes injuries due to the loss of attention and to the occupation of hands or to the irritation of eyes, to the cough, etc., or, ... because the prohibition of smoking...is not strictly obeyed (p. 585)." There is nothing in their article to either suggest or support such a position.

There are other suggestions that smoking and accidents may be related. Goldsmith and Landaw (1968) note a possible role of CO in motor vehicle accidents is suggested by data which show higher levels of COHb in drivers involved in accidents

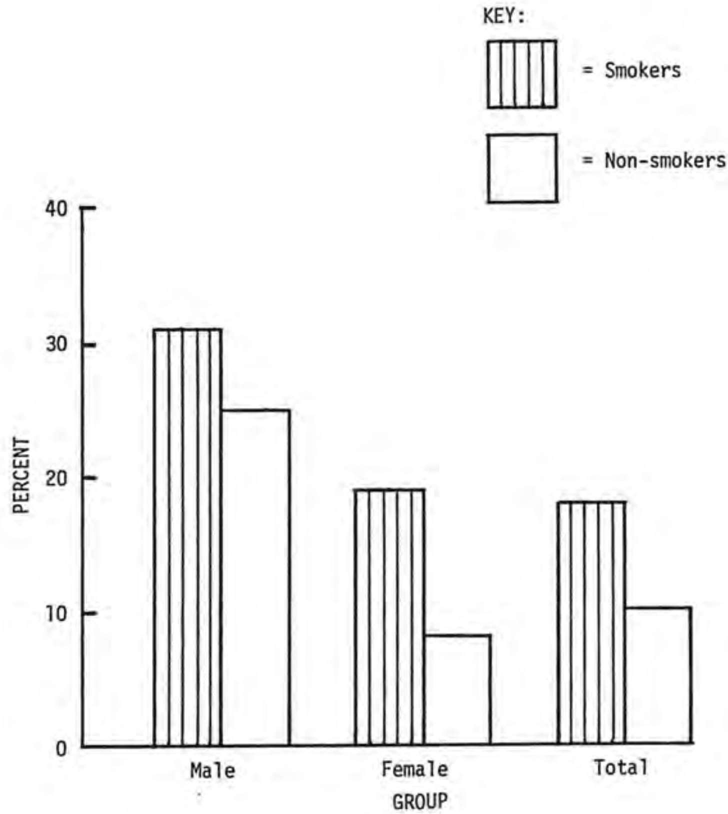

Figure I-6. Percentage of injuries registered in a machine works by sex and smoking habit. (From data presented in Naus, et al., 1966. See text for discussion of inconsistency in the figures.)

than in policemen and in other occupationally exposed populations. As discussed earlier, the COHb level of the blood is affected by smoking. Two studies already discussed in the section on CO (Emara et al., 1971; Szollosi, et al., 1970) report that drivers who smoke had higher COHb levels than nonsmoking drivers. One study (Szollosi, et al., 1970) maintains that the added CO concentrations in vehicles where the operators smoke can cause accidents because of the lowered hemoglobin content. If this is true, it could presumably be caused by the impairment of complex psychomotor capability and/or time perception which can result from carbon monoxide inhalation as noted by Goldsmith and Landaw (1968).

This review of the rather sparse literature on smoking as a factor or co-factor in accidents reveals a less concise and determinable relationship than that revealed by the literature showing associations of smoking and respiratory problems.

SUMMARY OBSERVATIONS

Problems of Research Methodology

One of the major problems facing the researcher who would study the effects of smoking on respiratory illness and ventilatory function of workers is the inability to determine accurately the exposure either to cigarette smoke or to industrial dusts and fumes which might be co-factors in any debilitation observed. Dunn and Weir (1968) cited a number of problems in their study which can be applied to any study of worker's smoking habits:

1. Workers have multiple occupational experiences.
2. A work environment may supply several inhalation irritants and there usually is little information on the type and quantity experienced by individual workers.
3. The relationship in time of a particular occupational exposure and the onset of disease may raise questions regarding the relevance of the exposure.
4. When considering many variables in contrasting populations, it can become difficult to distinguish real from chance associations.

The relation of smoking to performance and accidents is equally difficult to research. First, there is the problem of explicitly isolating smoking as a determinant in producing differential performance effects. Then, if such effects are found, there is the difficulty of showing any causal relationship between them and accidents. With regard to possibly implicating the behavioral manifestations of smoking (such as lighting, holding, puffing, flicking ashes) in accidents, it seems unlikely that the injured party would indicate that his attention was diverted from his assigned task by such a mundane activity.

Hypersusceptibility

Based on currently available evidence, there appears little doubt that individuals who smoke:

1. Have a higher mortality rate than non-smokers;
2. Have increased susceptibility to lung cancer;
3. Experience greater incidence of respiratory disease; and
4. Exhibit decreases in ventilatory function over time in excess of those who do not smoke.

Whether these or other effects of smoking affect a worker's performance has not been demonstrated conclusively. It is apparent that smoking most affects performance requiring maximum physical output.

Persons exposed to concentrations of carbon monoxide can manifest impaired psychomotor capability, time perception, or other behavioral degradation. Cigarette smoking is a source of carbon monoxide and may be a proportionately significant source to workers otherwise exposed to low concentrations of CO. In either case, the concentrations of CO in the blood of exposed persons are additive from various sources. Other things being equal, the smoker will have higher blood concentrations of CO than nonsmokers and consequently run the risk of greater impairment of performance and increased risk of accidents.

In occupations in which workers are exposed to lung health hazards in the form of dusts or fumes, more smokers than nonsmokers will be affected. Such effects appear to be additive rather than synergistic, but there is still some debate on this point for specific lung irritants.

Selection and Placement

There does not appear to be enough evidence to support administrative actions which might bar smokers from jobs that may produce increased susceptibility to respiratory problems. For most occupations where lung problems may be associated with irritants from some industrial process, then the incidence of such lung problems in smokers is higher than for non-smokers. But, the environmental conditions causing such increased incidence may be alleviated by such procedures as increased ventilation or by respirators. Such procedures should reduce the incidence of lung problems in smokers to that which can be expected only from smoking.

Ameliorating Health Hazards Associated with Smoking

Assuming that ventilation will not be completely effective and that workers may resist wearing respirators, it appears that smokers employed in jobs which can cause lung problems should be educated about the possibility of increased danger they face.

Workers who smoke should be encouraged to decrease their potential susceptibility by many of the methods proposed to smokers generally. They could be advised to:

1. Stop smoking, if possible.
2. Reduce smoking.
3. Switch from cigarette smoking to another form of tobacco use.

4. Reduce the amount of smoke inhaled.

5. Avoid stressful or social situations which may increase their smoking.

Periodic physical examinations, particularly for lung function, would assist in early detection of lung problems.

Research Needs

Because of the known health hazards of smoking, and the possibility of interactive effects between cigarette smoking and occupational respiratory hazards, there is research that is needed. The difficulties of conducting such research have been indicated earlier. In spite of these difficulties, attempts should be made to assess a number of possible effects. Most of the research cited in this review indicated that the effects of cigarette smoking on lung function are additive to effects which might be produced in respirable dusts and fumes. However, there still exists the possibility that specific dusts may produce synergistic effects. This has been suspected particularly regarding various forms of asbestos dusts.

Also, despite the known health effects of cigarette smoking, no study appears to determine the importance of the degraded health on worker performance. For example, the data indicate that smokers lose more days from work than non-smokers, but it is not known how many accidents might be ascribed to degraded health or how much productivity suffers through degraded performance related to poor health at least partially caused by smoking.

Work on the relation of smoking to accidents is sparse. at least the following kinds of information are lacking:

1. Measures of degraded sensory and psychomotor performance as a result of smoking.

2. Measures of degraded performance resulting from the accessory behaviors involved in smoking such as holding the cigarette, laying it on the machine, flicking ashes, and so forth.

3. Data on the relationship of accidents to CO concentrations in the blood when such concentrations have been caused by or increased beyond safe levels by smoking.

4. Measures of the common antecedent causes of smoking as related to accident and health problems.

Regarding the first point, some research on vigilance has found performance improved when the subjects (who were smokers) smoked. Thus it is not necessarily the case that performance will be degraded by smoking. However, it is probable that variations in performance while smoking would bear some relation to the type of task.

Furthermore, study of the effects of smoking on sensory thresholds has suggested that such effects are real ones, but unimportant in normal activities. While this is probably true as a generalization, the effects may become important for performing specific tasks or for people having certain personal characteristics. Night driving is the most readily understood example, where a rise in brightness-contrast threshold by smoking may be critical. Similarly, threshold shifts or psychomotor effects in older workers may be more critical than in younger workers.

Examining any performance degradation effects caused by the buildup of CO in the blood may be difficult to do in any but laboratory settings. More to the point, but even more difficult to perform in a controlled manner, would be studies of accidents which relate the accident to performance degradation induced by CO concentrations in the blood which have been caused by smoking. However, there is reason to suspect CO concentrations as a possible factor in accident causation and hence reason to research the possible contribution of cigarette smoking to such a situation.

In all future studies of performance, care must be taken to isolate the effects of smoking, or the products of smoking, from those of personality difference or stress. There may indeed be a smoker personality, and some workers may increase their smoking under stress. Such factors should be controlled when the study is to examine only the effects on performance which may be produced by smoking.

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SMOKING HABIT

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	 Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	 Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents		118 1151 788 1152 846 1154 847			1 2	
Agent - Specific Diseases	431	52 833 116 841 414 848 416 851 420 853 424 854 427 857 429 868 430 870 431 1028 648 1029 741 1030 744 1031 831	849	191	844	
Non-Specific Disorders		846				
Critical Incidents						
Rate/ Amount of Sick-Absence	1149	846				
Perform-ance Indices		52 855 424 969 648 1028 650	849	191 1145	2 1027	
Strain Indices						
Morale						
Compliance with Rules						
Off Job Problems				191		
Miscel-laneous	107 1148 1150	651 848 1154		1 1147 1145 1148 1146 1153	2	

CORONARY HEART DISEASE

A portion of a report--

PROBLEMS IN OCCUPATIONAL SAFETY AND HEALTH: A CRITICAL REVIEW OF SELECT WORKER PHYSICAL AND PSYCHOLOGICAL FACTORS

By: Century Research Corporation

For: National Institute for Occupational Safety and Health

November 1974

CORONARY HEART DISEASE

Introduction

Coronary heart disease (CHD) continues to be the leading cause of death in the United States. In 1967 it was responsible for 567,710 deaths or 31.0% of the total 1,833,900 deaths. Its high incidence has led to great concern for prevention, detection and treatment of the disease in an effort to curb its destructiveness. In the past two decades, cardiovascular diseases have been of primary concern as both national and occupational health hazards.

French and Caplan (1969) conducted research designed to identify risk factors in coronary heart disease to be used in a preventive medicine program. They have summarized the significance of CHD as a factor vitally influencing our occupational efficiency in the following manner:

> "Despite the seeming complexity and size of modern organizations, we still find that single individuals often exercise critical influence in terms of the unique expertise and understanding they develop in their particular roles. It takes months, even years before a top administrator or a scientist fully begins to understand all of the subtle, yet important nuances which surround his work. When such a valuable person, a human asset, dies before retirement, the organization suffers a valuable loss (one which to this day we are unable to measure in dollars or in accomplishment of the mission.) No amount of financial insurance can reimburse an organization against such loss, particularly under conditions where there are deadlines to be met and little time to train replacements. Under such conditions, and they appear to be more frequent in the fast-moving modern world, the best form of insurance is to prevent premature death among the members of the organization (P. 37)."

During the past twenty years much research has been done which indicates that the incidence of CHD varies from one broadly-defined social or physical condition to another such as foreign born vs. native born, ethnic groups, socio-economic status, blue collar vs. white (Wardwell, Hyman, & Bahnson, 1964; Cassel et al, 1971a; 1971b; Paffenbarger & Wing, 1969; Kaplan, et al 1971; Stamler, Lindberg, Berkson, Miller & Poindexter, 1960; Shekelle, Ostfeld, & Oglesby, 1969; and Keith, Lown, & Stare, 1965). Obviously, it would be impossible to eliminate those broad groups which have a higher risk in an effort to prevent heart disease.

French and Caplan (1969) believe that the hope in being able to prevent or reduce the incidence of CHD within an organization lies in dealing with the attributes of the environment which are more specific than social class or occupation. They feel that by identifying particular job stresses which produce the risks, it might be possible to reduce those stresses and thus control the disease.

In addition to the environmental and stress factors, individual risk factors such as personality, smoking, blood pressure, family history, and social status have been examined by researchers in an effort to specify what effect they have on the incidence of CHD (Wardwell, Hyman & Bahnson, 1964; Williams, 1970; Meigs, et al 1965, 1966; Stamler, et al 1960; Shekelle, Ostfeld & Oglesby, 1969; Cassel, et al 1971a, 1971b; Friedman & Rosenman, 1960; Jenkins, Rosenman & Friedman, 1967; Barron & Rosenman, 1968; and

Mordkoff & Parsons, 1967).

There is considerable disagreement in the literature over the significance of the various environmental and personal coronary risk factors. It would be impossible at this point to establish any one factor as the primary one in increasing one's susceptibility to coronary heart disease. House (1974 in press) has provided a paradigm for integrating existing evidence from many different sources on the relationship of occupational stress to heart disease.

Stress of Job

It is rather well known from a wealth of medical research that there are certain physiological risk factors which increase a person's chances of having heart disease. French and Caplan (1969) indicate that smoking, blood pressure, cholesterol level, serum uric acid, and glucose have all been suggested as such risk factors in heart disease.

The question of whether certain types of job stresses cause certain changes in these physiological risk factors has been dealt with in the literature. Friedman, Rosenman, & Carroll (1958) conducted a significant study of this question. They examined what effects the stress of a high pressure job with deadlines would have upon the serum cholesterol level and blood coagulation time of a group of intelligent, conscientious males. The occupational group involved was made up of certified public tax accountants divided into group A, tax accountants, and group B, corporate accountants. The occupational stress involved was the large amount of work required by the high pressure deadlines of tax work. The study was conducted during the first six months of the year. The participants' serum cholesterol levels were obtained bi-weekly, the blood coagulation time measured at monthly intervals, and records were kept on weight, exercise, diet and relative work load. Diet and exercise were to be kept normal during the time observed. When the data were analyzed individually, each subject's highest serum cholesterol level consistently occurred during severe occupational or other stress (one man was divorced, others had additional stresses at home) and the lowest at times of minimal stress. (See Figure J-1). The results could not be ascribed to any changes of weight, exercise, or diet. In similar fashion, marked acceleration of blood clotting time consistently occurred at the time of maximum occupational stress, in contrast to normal blood clotting during periods of respite as shown in Figure J-2. The profile of one accountant's work stress in relation to his cholesterol level is shown and described in Figure J-3. This was typical of the reaction of all the subjects.

The results indicate that severe occupational stress is indeed associated with a sudden and profound increase of serum cholesterol and a marked acceleration of blood coagulation time. Friedman, Rosenman and Carroll (1958) suggest that a causal relationship between occupational stress and coronary atherosclerosis and thrombosis is possible due to the increase in physiological risk factors as a reaction to stress.

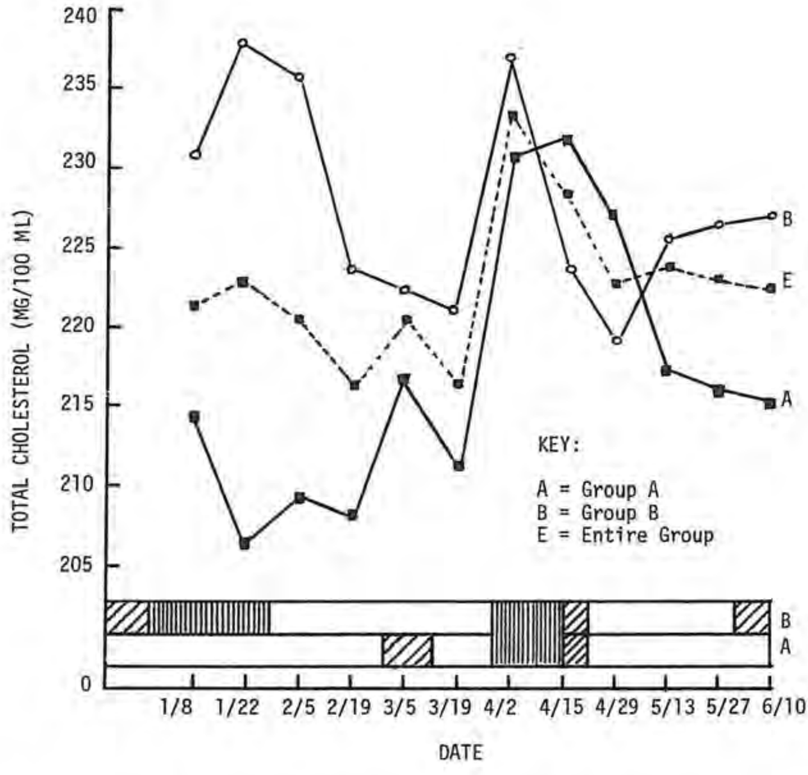


Figure J-1. Serum cholesterol changes observed in tax accountants (Group A) and corporate accountants (Group B). Periods of unusually severe work stress are indicated by vertically-lined blocks and periods of severe emotional stress due to other causes by diagonal-lined blocks. (From Friedman, Rosenman, and Carroll, 1958.)

AVERAGE COAGULATION TIME (MIN.)

Date	Group A	Group B
2/19	8.1± 0.27* (5.5 - 10.7)+	7.0± 0.80 (3.0 - 9.0)
3/19	7.2± 0.26 (4.0 - 10.0)	6.1± 0.60 (4.2 - 8.0)
4/15	5.0± 0.38 (3.0 - 7.0)	5.5± 0.47 (4.0 - 6.5)
5/13	6.2± 0.33 (4.0 - 8.5)	7.8± 0.96 (5.5 - 10.5)
6/10	8.8± 0.63 (5.5 - 12.5)	9.7± 0.58 (8.0 - 11.5)

* = Standard error of mean; + = Range of values

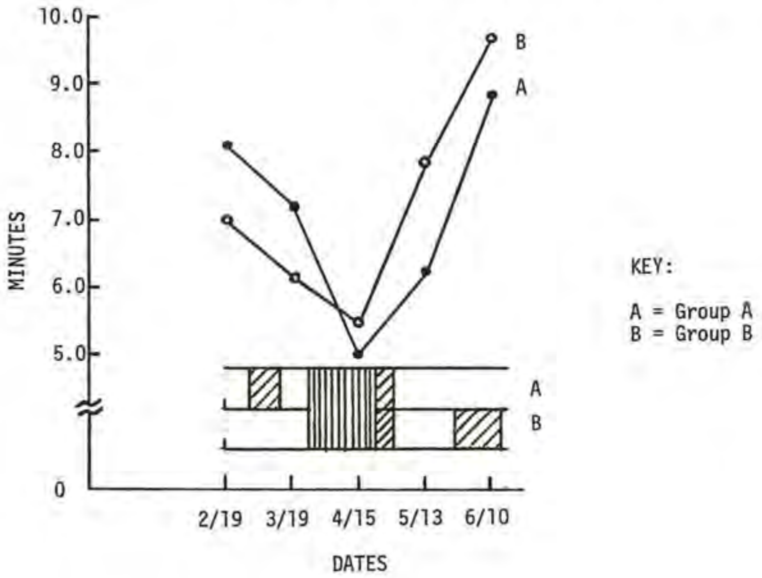


Figure J-2. Average blood coagulation times in a group of tax accountants (Group A) and corporate accountants (Group B). Periods of unusually severe work stress are indicated by vertically-lined blocks, and periods of severe emotional stress due to other causes by diagonal-lined blocks. (From Friedman, Rosenman, and Carroll, 1958.)

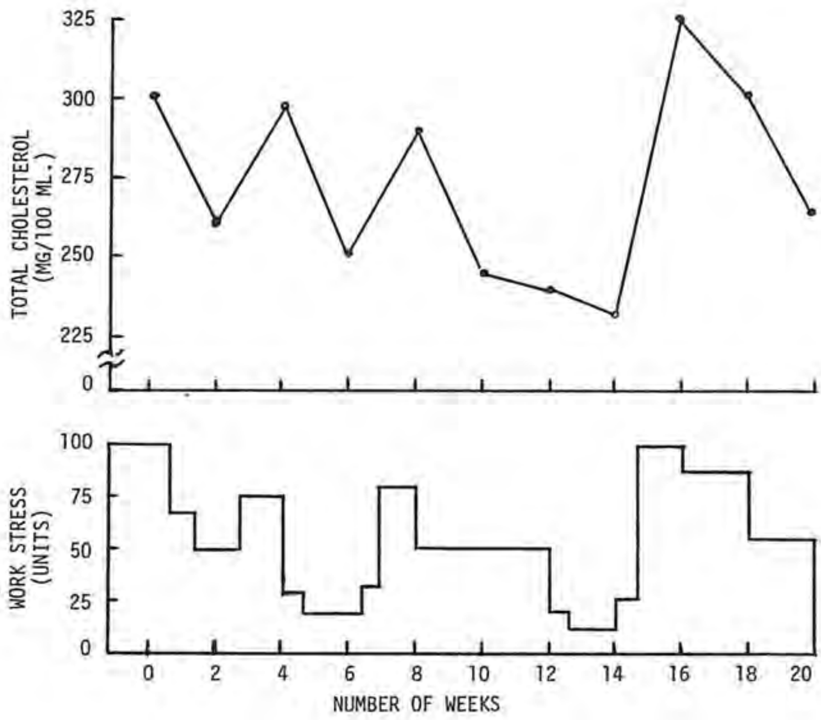


Figure J-3. Correlation of serum cholesterol with reports from an accountant's diary of work stress. High points correlated with stress of year-end statements and assuming presidency of a corporation, quarterly and April 15 tax returns deadlines, several complicated tax problems, and bidding on a large Federal project. Low levels corresponded with reduced work, winning an award on a government project and taking a vacation. (Adapted from Friedman, Rosenman, and Carroll, 1958.)

Load of Responsibility

Much attention has been drawn to the topic of executive stress and its causative role in physical disorders such as peptic ulcers, hypertension, arthritis, and coronary heart disease. Eaton (1963) listed some of the causes of executive stress to be:

1. overwork or fatigue;
2. threat to security, self-esteem, or basic goals in living; and
3. adjustment to new experiences or rapidly changing environmental factors.

Another type of stress which is related most frequently to executive or management positions is responsibility. Whether there is a differential rate of coronary heart disease among personnel with the highest loads of responsibility has been the topic of several studies.

Russek (1965) surveyed by questionnaire 12,000 professional men in 14 occupational categories to determine the interrelationship among smoking habits, occupation-related emotional stress and coronary heart disease prevalence. He asked persons in professional occupations to order general practice and various specialties in their fields on the amount of occupational stress found in each. He then randomly chose a sample of persons in these occupations. The questionnaire was designed to determine the hereditary background and prevalence of coronary or hypertensive heart disease, or both, and the time of onset of these disorders in relation to the selected class of work. Of the total 12,000 who were mailed a questionnaire, 64% replied. The most striking finding in the study was the tendency of coronary heart disease prevalence rates to increase with advance in stress rank. The observed gradient was found to be remarkably consistent within the age groups as shown in Figure J-4. There were no apparent differences in heredity or diet among the three stress groups that would account for the unequal distribution of the disease across the groups. Russek considers diets in all of the stress groups to be relatively high in animal fats, in which case the results support the theory that occupational stress is an important accelerating factor in atherogenesis.

Mortensen, Stevenson, and Whitney (1959) analyzed the mortality due to CHD by broad occupational groups. Using the annual Bell Telephone Company employee censuses, detailed death reports, and occupational codes, they compiled data on 1,082 deaths due to CHD. The employees were classified and divided into groups according to the work they did and the responsibility involved. These groups were then combined into management and nonmanagement. The ratio of actual to expected deaths for the management group is 106%, with a probable deviation of $\pm$ 3. A similar range for nonmanagement is 93% to 99%. The fact that the two ranges do not overlap indicates that there is a good chance that the level of mortality from coronary causes is greater in the management group. Subdivisions were made in the management

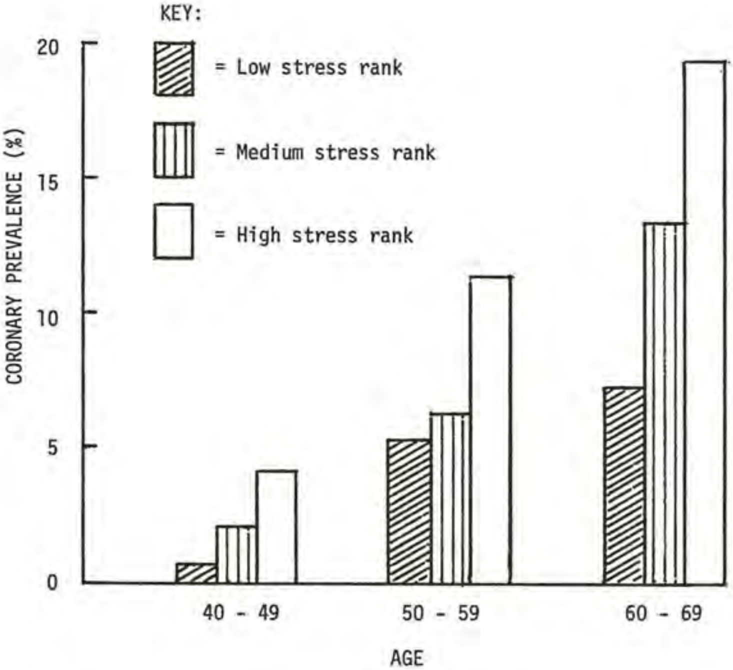


Figure J-4. Coronary heart disease in groups of high, medium, and low-stress professional occupation groups. (From Russek, 1965.)

group and were labeled officials, supervisors and staff, and foremen. Those categories were roughly considered as top, middle, and low management, respectively. The top management group not only showed the lowest level of mortality for the management group but for the entire group of employees as well. Middle management had the highest level with low management falling somewhere between the high and middle. (See Table J-I).

There seems to be no appreciable difference in coronary mortality between the top management group and the craftsmen and laborers group. Only the difference between middle and top management seems to be important. Mortensen, Stevenson, and Whitney (1959) suggest that the popular notion that high executive positions are associated with high coronary mortality is probably due to the greater publicity connected with such deaths rather than to statistical facts.

Other research studies were conducted which arrived at different results and conclusions concerning the effect of position and responsibility on CHD rates. Lee and Schneider (1958) gathered preliminary information as to whether there is any outstanding increase in the incidence of hypertensive and arteriosclerotic disease in executives as compared to non-executive personnel. They observed 2,374 employees of one large company over periods averaging 5 years. All subjects underwent complete medical examinations including medical history, urinalysis, blood cell count, chest x-ray and electrocardiogram. Persons involved in policy formation and implementation were placed in the executive group. They further

Table J-I

Mortality Due to Heart Disease Among Bell System Active Male Employees Aged 40-64, Census Years Ending Oct. 31, 1951-1955 a

Group	Average Annual Exposure	Number of Deaths: Actual	Number of Deaths: Expected *	Ratio Actual to Expected, %	Probable Deviation of A/E Ratio †	Deaths per 100,000 ‡
			Management			
Officials	3,145	37	44	84	±9	231
Supervisors and staff	20,800	340	298	114	±4	321
Foremen	13,486	184	185	99	±5	286
Total	37,431	561	527	106	±3	300
			Nonmanagement			
Craftsmen and laborers	33,910	435	479	91	±3	259
Clerks	4,424	86	66	130	±9	384
Total	38,334	521	545	96	±3	274
			Management and Nonmanagement			
All	75,765	1,082	1,072	101	±2	286

* Based on average Bell System experience 1951-1955 for all occupations
† Chances are 50-50 that actual to expected ratio plus or minus this quantity will be within such range.
‡ Based on age and number distribution for all occupations, active employees only.
a From Mortensen, Stevenson, & Whitney, 1959.

divided the executives into top executives (members of the board, corporate officers, and general managers), middle management executives (department heads, assistants to corporate officers) and minor executives (division heads and auditors). Employees with fewer responsibilities such as stenographers, secretaries, clerks, assistant supervisors and supervisors were designated non-executives. The results showed that hypertensive cardiovascular disease in non-executive males had an incidence of 3.7% to 2.5% in the group of executives. A chi-square test revealed a p value of between 0.05 and 0.1 indicating a lack of association between the executive state and hypertensive disease. In actuality, hypertension was almost significantly more frequent in nonexecutives. Analysis of the differences in the incidence of arteriosclerotic disease (all types) between the executive and nonexecutive males of comparable age by the chi-square test reveals a p value of less than 0.01. Its infrequency in executives is therefore considered to be significant. The evaluation of the incidence of "heart attacks" in both groups by the same method reveals no relationship with the level of responsibility (p value > 0.1).

Master (1960), in a study of 2600 cases of coronary occlusion, obtained data supporting his contention that coronary occlusion is not caused by modern stress and strain. He believes that the incidence has increased because of the increased age of the population, improved diagnostic skill of the physicians and changes in the classification of heart diseases.

Pell and D'Alonzo (1963) also provided data inconsistent with the idea that a heavy load of responsibility makes executives more prone to coronary disease. They studied 1,356 employees who had had heart attacks compared to matched controls. The subjects were divided by 5 levels of responsibility and it was found among these groups that the salaried employees' risk of infarction appears to be inversely related to job level. (See Figure J-5). The chances of developing an attack were increased during the working hours and among persons with hypertension, diabetes, and certain electrocardiographic abnormalities. Overweight increased the risk of infarction among men under 45 years, but not in older persons. One might assume that greater risk of attack would go hand-in-hand with greater responsibility. However, Pell and D'Alonzo concluded from the data that one man's stress may not be stressful to another individual. Top management responsibility may be no more stressful to managers than situations encountered by persons in lower job levels. The authors suggest that supervisors may knowingly or unknowingly select persons for advancement who are well-adjusted and who are, therefore, better able to cope with life's stresses.

In a similar study, Hinkle, Whitney, Lehman, et al (1968) found that, among telephone company employees, men in high management positions as a group do not have a higher risk of CHD than do men at lower job levels (see Figure J-6). A relationship between high educational attainment and low attack rate was also found, although the phenomenon was attributed to socio-economic factors (see Figure J-7). The authors

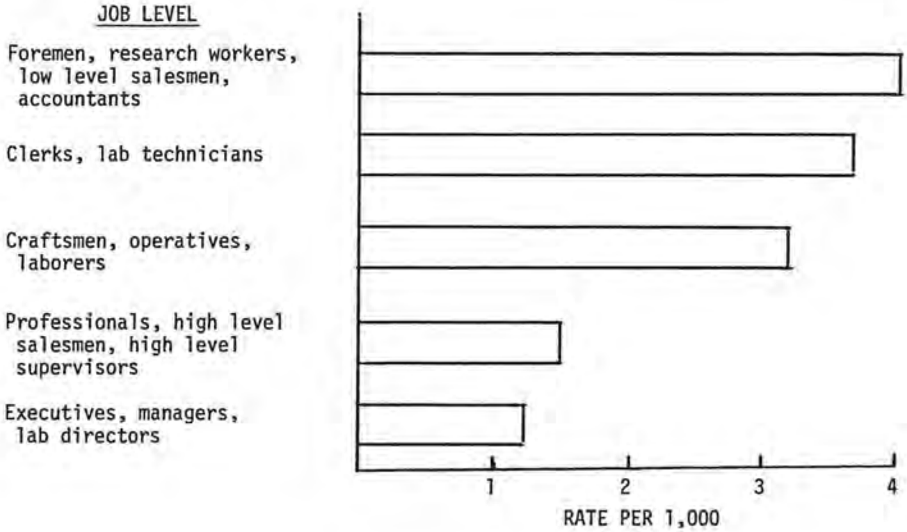


Figure J-5. Average annual age-adjusted incidence rates of myocardial infarction among male employees in five occupational categories, 1956 through 1961. (Adapted from Pell & D'Alonzo, 1963.)

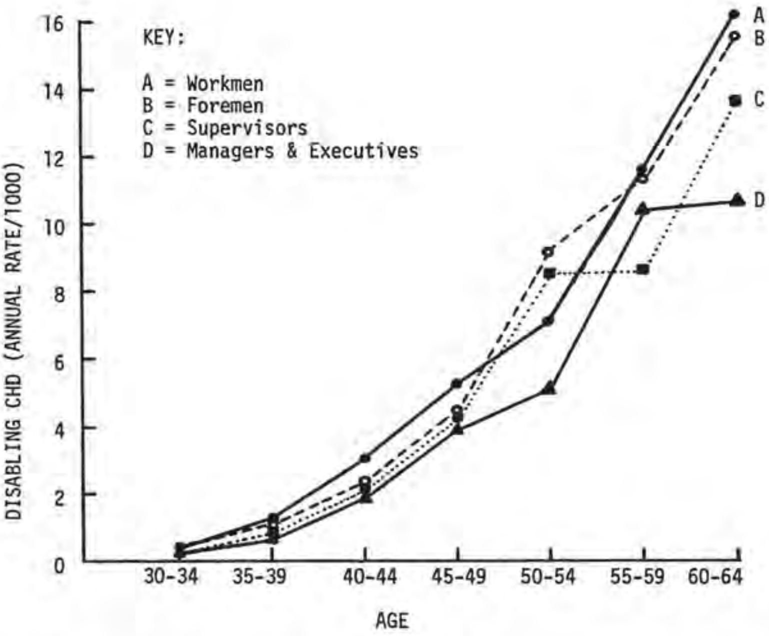


Figure J-6. Incidence ("first events") of disabling coronary heart disease in Bell system men during the period 1963-1965, by age and job level. Rates for managers and executives are consistently lower than those for workmen and foremen. This is true even among the most rapidly promoted men who have attained managerial levels before the age of 40. (From Hinkle, Whitney, Lehman, et al, 1968.)

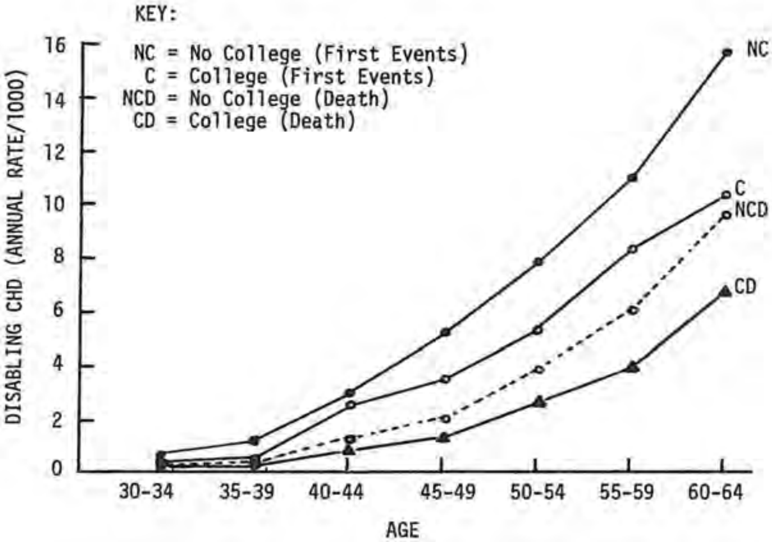


Figure J-7. Incidence of disabling coronary heart disease ("first events") and deaths among men in the Bell System, 1963-1965, by age and education. At every age the rates are lower in the men who had college degrees when they were hired. (From Hinkle, Whitney, Lehman, et al, 1968.)

suggest that the determinants of CHD risk predate adult life and are unaffected by experience or behavior.

Occupational Mobility

Occupational mobility has been investigated to determine what its behavioral determinants are and what effects it has on subsequent physiological and psychological behavior. A longitudinal study by Elder (1969) assessed the life experiences, role attitudes, and personality characteristics associated with occupational mobility. Upward mobility was found to be associated with adolescent ego-function. The upwardly mobile tended to enter family roles at a later age and had a more orderly worklife. A sense of well-being, autonomy, and effectiveness characterized the upwardly mobile in adulthood. That there are behavioral consequences associated with occupational mobility is not surprising since the mobility itself implies different behavior than that characteristic of a non-mobile person. But does such differential behavior affect the incidence of CHD?

Friedman and Rosenman (1960) characterized high pressure competitive persons who are involved in many activities with deadlines as having seven times as much CHD as do people in the general population. Such persons are designated as behavior type A personalities; persons who lack competitive drive, needs for recognition and advancement, are not subject to deadlines, and do not have a fast pace of living and working are type B personalities. In a five year study consisting of questionnaires and physical exams, Williams (1969) found that behavior type A was more associated with subsequent occupational change than was type B. Furthermore, on intake to the study there was no difference in blood pressures and cholesterol between those who later experienced occupational change and those who did not. Although blood pressure and cholesterol increases were not found to be positively associated with occupational change, the data did show that men experiencing locale or employer changes tended to have more absolute increasing or decreasing mean change in blood pressure and cholesterol than those who experienced either (a) other forms of job change or (b) no change in the job situation.

Two types of social class mobility as risk factors in CHD have been studied by Kaplan et al (1971). It was found that people in the two lower social classes were more at risk from CHD if they were mobile from one social class to another in their own lifetime (intragenerational mobility) than if they were in the stable population (Table J-II). However, change in social class relative to the father's social class (intergenerational mobility) was a more sensitive indicator of increased risk and Table J-III shows the much higher rates for upwardly mobile men of the lower classes. The data indicate that those in the lower social classes are the least adaptable to the strains of upward social mobility.

The authors conclude that their data were consistent with the assumption that psychosocial processes are important in the genesis of CHD, although they did not conclusively confirm such an assumption.

Table J-II

Coronary Heart Disease Prevalence in White Men by Intragenerational Occupation Mobility and Social Class[a]

Mobility Status	Par[b]	Cases	Crude Rate/ 1,000	Age Adjusted Rate/ 1,000
SOCIAL CLASS I, II, III (higher)				
Upward	229	18	78.6	83.1
Downward	13	1	76.9	113.4
Stable	61	8	131.1	155.9
SOCIAL CLASS IV, V (lower)				
Upward	172	19	110.5	104.3
Downward	40	6	150.0	147.3
Stable	117	11	94.0	83.0

[a] From Kaplan et al., 1971.

[b] Persons at risk.

Table J-III

Coronary Heart Disease Prevalence
by Upward Intergenerational
Occupational Mobility of White Men
and Social Class Groups[a]

Social Class		Par[b]	Cases	Crude Rate	Age Adjusted Rate
I, II	Higher	47	3	63.8	63.9
III		109	10	91.7	117.3
IV	Lower	95	11	115.8	139.0
V[c]		20	3	150.0	158.6

[a]From Kaplan et al., 1971

[b]Persons at risk.

[c]It is possible to be mobile yet still in social class V since current social class is defined by summing the index based on source of income, education, and occupation, while mobility is the difference between the respondent's occupational level and the occupational level of the respondent's father.

Overt Behavior Patterns and CHD

Although behavior patterns have been identified as an adjunct to various job stress studied, several reports deal specifically with CHD related behavior.

French and Caplan (1969), previously cited, initiated a study of the identification of CHD risk factors. A population of aerospace administrators, scientists and engineers participated in a program of examinations and questionnaires. Figure J-8 presents the interrelation of various occupations, job stresses, risk factors and personality types in the incidence of CHD. Table J-IV presents occupational differences in certain, background, health and job-stress variables. Differences among the occupational groups included:

1. Person-oriented responsibilities among administrators. Object-oriented responsibilities among scientists and engineers.
2. Greater role conflict among individuals involved in person-oriented responsibilities.
3. More subjective and objective workload among administrators.
4. More quantitative overloads among administrators and qualitative overloads among scientists.
5. More cigarette smoking among administrators than engineers or scientists.
6. A tendency among administrators to have less college than engineers and scientists.

Cigarette smoking has been implicated as a risk factor in CHD and French and Caplan discovered that heavy smoking was moderately but statistically significantly correlated with a number of other physiological and behavioral variables as shown in Figure J-9.

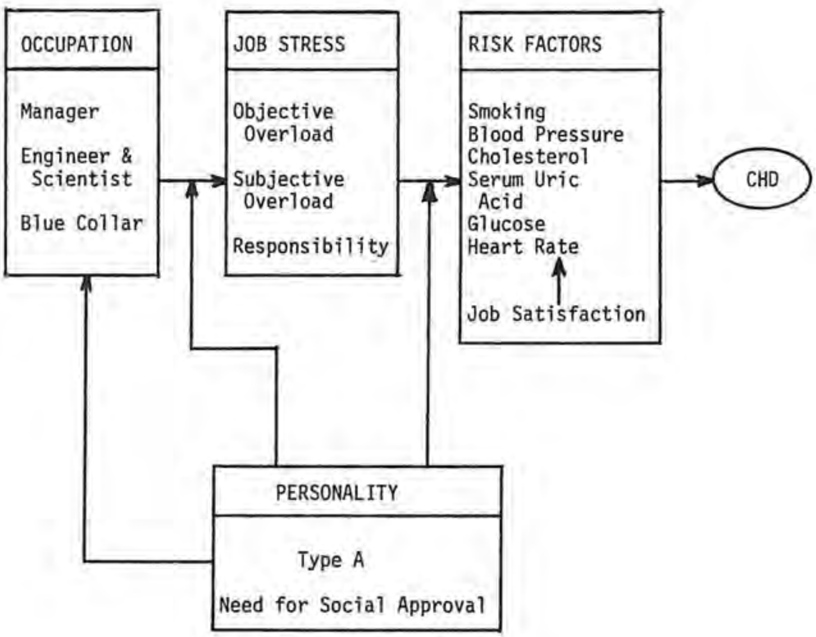


Figure J-8. Suggested interrelations of various occupations, job stresses, risk factors, and personality type in the incidence of CHD. Horizontal arrows suggest causal relationships; vertical arrows indicate possible mediating influences. (From French & Caplan, 1969.)

Table J-IV

Occupational Differences in Certain Background, Health, and Job Stress Variables [a]

Measures	Occupation			
	Administrator	Engineer	Scientist	p
Age	44.4	39.0	35.6	.001
Average schooling	completed college	some grad. school	masters	.001
% participate in annual NASA health exams	71.0	59.0	26.0	.001
# cigarettes smoked [b]	31.6	18.8	19.9	.05
% smokers	33.0	22.0	21.0	n.s.
Systolic blood pressure	134.8	128.6	131.3	.05 [c]
Subjective quantitative overload cluster	3.7 [d]	3.4	3.1	.001
Days elapsed until questionnaire returned	19.9	13.1	14.5	.05
Subjective qualitative overload factor	1.8	2.0	2.1	.05
Opportunity to use administrative skills	3.6	3.0	2.6	.001
Opportunity to use one's education, talents, and abilities	3.3	3.2	3.8	.001
Role conflict	2.2	2.1	1.9	.05

[a] From French and Caplan, 1969.
[b] For persons smoking one or more cigarettes per day.
[c] Significant when corrected for age differences.
[d] These values are based on a five-point rating scale where 1 = "very little" and 5 = "very great."

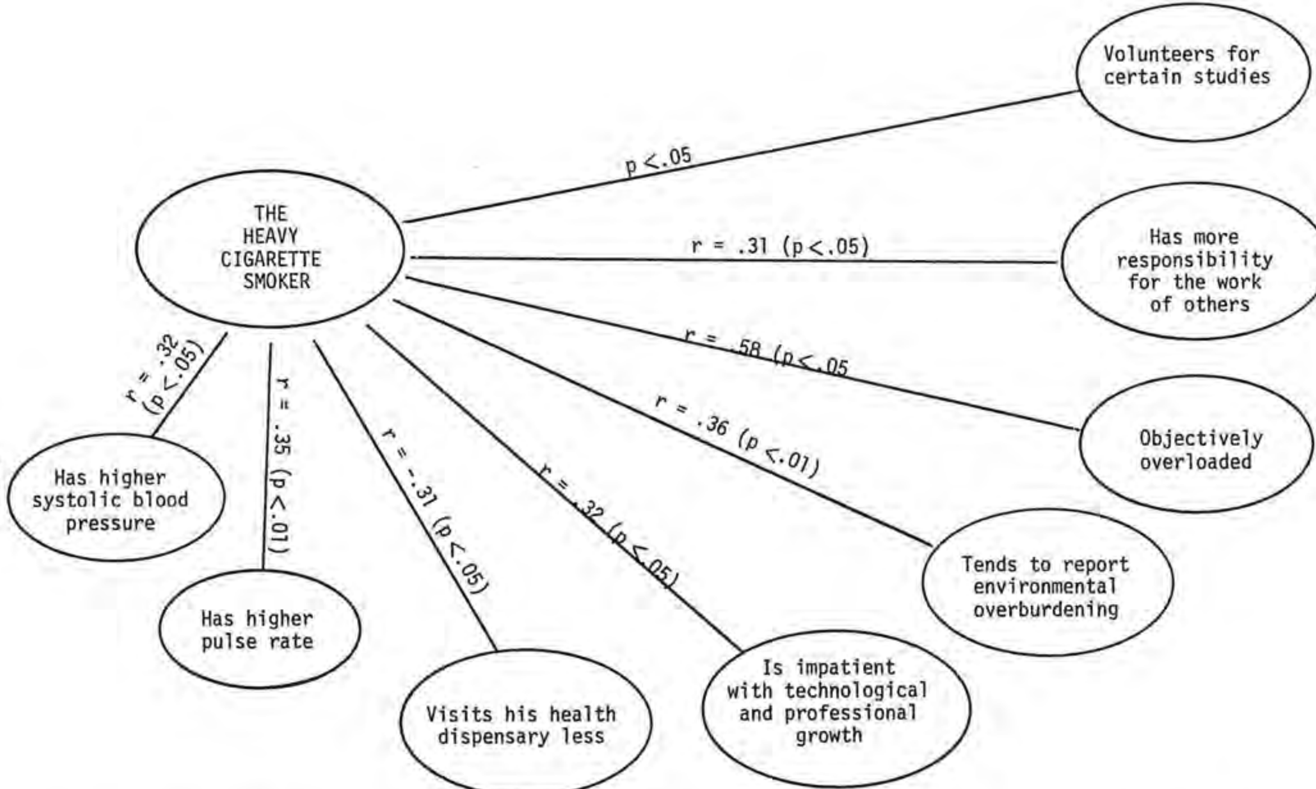


Figure J-9. Correlations of heavy cigarette smoking with other behavioral, physiological and job situation variables in NASA administrators, scientists, and engineers. (From French & Caplan, 1969.)

Minc, Sinclair, & Taft (1963) postulated that male subjects with CHD would differ from subjects free of CHD by displaying less impulsivity and a lower level of emotional reactivity. It was also hypothesized that CHD subjects would demonstrate slower cerebral cortical processes. Thirty CHD subjects were matched with an equal number of CHD-free controls all of whom were hospitalized. Assessed were the subjects alpha index, impulsivity, primary difference (a measure of satisfaction with one's own life), reaction time, serum cholesterol, speed, critical frequency of flicker, and height-weight ratio. Significant differences between the two groups are displayed in Table J-V. Analysis of the data reveals that coronary heart disease is caused by socially imposed pressures which lead to a controlled mode of activity and to insufficient integration of emotional and rational activity. Inhibition was demonstrated in the CHD patients in their cerebral cortical functioning and general behavior.

Beneficial to employers and employees would be a test which could determine susceptibility to CHD based on behavioral variables exclusively. The type A personality previously referred to is often cited as a model of the CHD prone individual. Friedman & Rosenman (1960) stated that the type "A" personality was characterized by:

1. excessive competitive drive;
2. persistent drive for recognition and advancement;
3. persistent involvement in multiple functions subject to deadlines;

Table J-V

Significant Differences Between Groups of Coronary and Noncoronary Patients[a]

	Coronary Patients			Noncoronary patients			
	No. of cases	Mean	Standard Deviation	No. of cases	Mean	Standard Deviation	Significance
Alpha index	22	16.8	13.4	17	7.1	6.4	.01
Impulsivity	30	16.4	6.1	30	20.3	7.4	.05
Primary difference	30	1.7	1.8	30	2.6	2.0	.05
Serum cholesterol	30	318.4	67.5	30	259.3	40.7	.01
Family history	30	10		30	0		.01

[a] From Minc, Sinclair, & Taft, 1963.

4. fast pace of living and working;
5. high serum cholesterol levels;
6. faster blood clotting time;
7. 3 to 5 times as much arcus senilis; and
8. 7 times as much CHD.

The "B" type is the inverse of personality type "A". The authors describe a test for detection of the "A" behavior pattern. Subjects exhibiting the disease were exposed to irritating stimuli of simultaneous and competing recorded monologues. It was found that the CHD subjects exhibited greater reaction to the stimuli than the control subjects as measured by hand clenching, respiration, and body movements. The reactions were not the result of CHD but rather to their psychological responses. The authors suggest that a test of this type might be used to detect type "A" personality and hence predict CHD in one ostensibly free of the malady.

A similar study by Jenkins, Rosenman and Friedman (1967) altered somewhat the "A" type personality by modifying the characteristics to include: pressure for vocational productivity, and enhanced sense of time urgency, restless motor mannerisms, staccato style of verbal response as shown in Table J-VI which lists the traits of the "A" and "B" personality types from the study. A test developed by Jenkins, Rosenman, and Friedman demonstrates a statistically significant difference between groups of men clinically judged to manifest the coronary-prone behavior pattern and those groups judged not to manifest the pattern.

Table J-VI

Behavior Patterns in Type A (CHD Prone) and Type B (Not CHD Prone) Persons[a]

The CHD Behavior Pattern	
TYPE A	TYPE B
EXCESSIVE DRIVE	RELAXED
AGGRESSION	EASY GOING
AMBITION	SELDOM BECOMES IMPATIENT
INVOLVEMENT IN COMPETITIVE ACTIVITIES	TAKES MORE TIME TO PURSUE AND ENJOY AVOCATIONAL INTERESTS
FREQUENT VOCATIONAL DEADLINES	NOT EASILY IRRITATED
PRESSURE FOR VOCATIONAL PRODUCTIVITY	WORKS STEADILY, WITHOUT A FEELING OF BEING DRIVEN BY TIME
AN ENHANCED SENSE OF TIME URGENCY	NOT PREOCCUPIED WITH SOCIAL ACHIEVEMENT
RESTLESS MOTOR MANNERISMS	LESS COMPETITIVE
STACCATO STYLE OF VERBAL RESPONSE	HAS A MORE SMOOTHLY MODULATED STYLE

[a] As postulated by Jenkins, Rosenman, & Friedman, 1967.

The "A" personality type was also noted to be significantly related to CHD in another study (Barron & Rosenman, 1968). Although the article implicates such well known factors in CHD as lack of exercise, a history of parental smoking, and hypertension, it emphasizes the importance of behavioral considerations as well. The authors state that "the presence or absence of a specific behavior pattern carries an important prognostic relevance and these factors must be included in the assessment of other prognostic indices to avoid errors in interpretation (P. 1114)." Table J-VII presents some of the factors involved in CHD including behavioral considerations. Table J-VIII lists CHD incidence ratios for both A and B behavior types. In summary, the study found no evidence that CHD incidence was influenced by the work assignments or responsibilities peculiar to industry (aerospace) in which the subjects worked.

> "All the evidence indicates that coronary heart disease is a product of our way of life and that measures designed to reduce the morbidity of this disease must relate to the total environment of the individual. It would appear insufficient to simply control one's diet, increase exercise, and reduce one's use of cigarettes without simultaneously attempting to alter the behavioral or personality factors which characterize the type A individual (P. 1115)." (Barron & Rosenman, 1968).

Cautions in Research Relating Personality and CHD

Although considerable data exist in supporting a relationship of personality to CHD, as is often the case, past methodology frequently leaves the results far from being definitive. In a review of the literature on personality as

Table J-VII

Coronary Heart Disease in Employees of a Plant in the Aerospace Industry[a]

	Mean Values	No. of CHD Cases	% of CHD Cases
Total		43	
Exercise Habits			
None - occasional		39	90.6
Regular		4	9.4
Smoking Habits			
Never smoked		8	18.6
Formerly smoked		7	16.3
Current cigarette (i.e. at intake)		28	65.1
Number 1-7/day*		2	7.1
8-17/day*		2	7.1
18-35/day*		18	64.3
35+/day*		6	21.4
Serum Cholesterol			
Mean	249.5		
Number under 225		14	32.6
225 - 274		18	41.9
275+		11	25.6
Beta Lipoprotein	53.7		
Beta/alpha Lipoprotein	2.25		
Number over 2.35		18	41.9
Blood Pressure			
Systolic	137.0		
Diastolic	86.6		
Number under 95		34	79.1
95+		9	20.9
Triglycerides			
Mean	176.9		
Under 100		4	10.8
100 - 176		17	46.0
177+		16	43.2
Behavior Pattern			
Type A		28	65.1
Type B		15	34.9

* % are for those currently smoking cigarettes

a From Barron & Rosenman, 1968.

Table J-VIII

Incidence Rates of CHD by Behavior Pattern[a]

	Total Cases	Behavior Patterns Type A	Type B	Ratio A/B
Number of Subjects	3182	1584	1598	0.99
Cases of CHD	133	94	39	2.41
Incidence of CHD	9.3	13.2	5.4	2.40
Schooling				
High School	11.1	17.1	5.5	3.1
College Graduate	5.3	6.1	4.4	1.4
History of Hypertension	25.1	32.8	14.4	2.3
Income				
Under $10,000	7.8	11.2	5.2	2.2
Over $10,000	10.5	14.5	5.6	2.6
Work				
Sedentary - Light	9.4	13.2	5.7	2.3
Moderate - Heavy	8.8	13.2	4.3	3.3
Exercise				
None - Occasional	10.1	15.0	5.3	2.8
Regular	7.4	9.1	5.7	1.6
Smoking				
Never	4.9	7.1	3.3	2.2
Current Cigarettes	12.4	16.7	7.5	2.2
Over 15/Day	13.7	18.8	7.7	2.4
Systolic Blood Pressure				
Under 160	8.2	11.5	4.9	2.4
Over 159	35.9	46.8	20.6	2.3
Diastolic Blood Pressure				
Under 95	7.9	11.0	4.8	2.3
Over 94	23.0	31.2	12.1	2.6
Serum Cholesterol				
Under 220	4.4	5.7	3.2	1.8
220-259	11.1	17.0	5.1	3.3
Over 259	17.5	21.5	12.4	1.7
Serum Triglyceride				
Under 100	5.2	7.7	2.9	2.7
100 - 176	8.2	11.5	4.9	2.3
Over 176	14.9	21.1	8.7	2.4
Beta/Alpha Lippoprotein Ratio				
Under 2.01	6.3	10.7	2.2	4.9
2.01 - 2.35	9.9	11.1	8.8	1.3
Over 2.35	14.5	18.2	10.3	1.8

[a] Extracted from Barron & Rosenman, 1968.

related to CHD, Keith (1966) refers to sources of problems in the data and offers recommendations for future work. His critical review includes the following studies:

1. Dunbar (1948), who is credited with influencing the perpetuation of the idea of the coronary personality, is criticized for the homogeneity of her sample as well as its small size. Characterization of the CHD personality type was based on 22 patients and the sample was 50% Jewish. Dunbar proposed that her sample could represent a cultural group rather than a disease category.

2. Based on only nine cases of CHD, Arlow (1945), based on clinical impressions, suggested that CHD candidates are individuals who compulsively and unceasingly strive for success but are never really satisfied. Also, an emotional upset was found to precede a coronary attack in all of the cases reported by Arlow.

3. The personality questionnaires developed by Guilford were used by Storment (1951) in a comparison of several groups of individuals with cardiac disorders. Of 65 patients, only 5 scores deviated from Guilford's norms. The data did not verify Dunbar's conclusions. However, Keith suggests that the respondent sample was so selective (through excluding patients who refused to complete the 511 item questionnaire) and the usefulness of the Guilford norms was so questionable for this study that it did not allow a real test of the Dunbar hypotheses.

4. The findings of a study of coronary patients compared to controls (Gertler & White, 1954) failed to support the notion of the stereotype CHD personality. The heart patients were found to be less aggressive, enterprising and self-assertive. They were more interested in domestic affairs, art and literature than controls. The authors point out that a sedentary life style might be the result of CHD disease.

5. Keith states that Miles et al. (1954) failed to test the Dunbar hypothesis adequately in a study of CHD patients. The study found no convincing evidence of the relationship between CHD and personality and Keith attributes this finding in part to methodological problems.

6. Another study, Weiss et al. (1957) found no evidence to support the Dunbar-Arlow hypothesis.

7. Keith states that more recent research work has tended to avoid specific testing of Dunbar's description because of the difficulties involved. A more recent series of studies, by Friedman and Rosenman between 1958 and 1966, several of which have been reviewed previously in this report, have found associations between Behavior Pattern A and:

   a. an increase in clinical CHD;

   b. elevated total serum cholesterol, triglycerides and B-lipoproteins.

   c. decreases in blood clotting time;

   d. an increased incidence of arcus senilis;

   e. elevated daytime excretion of norepinephrine; and

   f. capillary ischemia in conjunctival tissue.

8. Another study (Keith, Lown, & Stare, 1965), failed to support the Friedman and Rosenman data. Of 76 CHD patients only 36 were found to be type A personalities. It was found that better correlations were obtained at younger ages.

Keith reports other studies of the CHD personality relationship and arrives at the following conclusion and recommendations regarding methodologies involved:

Retrospective investigations

1. Most studies have compared CHD patients with other groups, and the approach has suffered from the difficulty of separating lasting personality characteristics from those which are the result of CHD. Other problems have been access to subjects, the mortality of CHD victims, and the lack of identification of those who manifest the disease but are not aware of its existence.

2. It would be better to collect observations on a sizeable population, even though heterogeneous on many variables, rather than draw conclusions from several small, highly biased samples which has been the case in much past research relating CHD to personality variables.

3. Many studies that could have done so did not introduce "blind diagnosis" controls. The individual who assesses the personality of the patient must not be aware of the patient's medical status nor should the physician diagnosing CHD be aware of personality judgments as subjective evaluation is part of the process and each diagnosis can be influenced by knowledge of the other condition.

Prospective studies

4. Prospective studies (which examine a sample before the presence of a disease is established) eliminate many of the problems of retrospective studies (which reconstruct the past history of the sample already manifesting the disease).

5. One type of prospective study is the observation of a large group of individuals over time while attempting to predict which will incur the disease. Because it requires large samples and years of study it has been used infrequently.

6. A second type of prospective study is the observation of high risk individuals, as, for example, relating behavior to

high cholesterol level. Such methods, while less decisive than longitudinal prospective studies, are still valuable.

Other research problems

7. There are very considerable obstacles in relating personality factors to CHD. The disease is the result of a series of processes, any one of which could be affected by emotion, and determining where the impact of personality is important is not easy to identify.

8. One problem in attempts to relate CHD and personality is the high incidence of the disease, therefore, to have a significant role, particular personality factors must be present in large numbers of Americans. Keith finds it difficult to accept the notion that either a single personality type or a limited class of situations could account for the great percentage of persons afflicted.

Mordkoff and Parsons (1967) subsequently reviewed the theories of CHD as related to personality variables. They found little evidence in the literature to support the concept of a "coronary personality." The authors indicted many studies for failing to take into account such psychologically relevant parameters as age, I.Q., and socioeconomic status which may interact with characteristics psychologically pre-disposing one to coronary artery disease.

Personal Factors and CHD

Socioeconomic factors. An admittedly limited study by Wardwell, Hyman & Bahnson (1964) related social background variables and CHD in three different groups of subjects. Their results are summarized in Table J-IX which shows the

Table J-IX

Summary of Ratios of Observed to Expected Cases of Myocardial Infarction or Arteriosclerotic Coronary Heart Disease in the Middlesex County, Connecticut, Midtown Manhattan, and North Dakota[a]

	North Dakota	Middlesex County		Midtown Manhattan	
Type of comparison group	'Well'	Other Sick	'Well'	'Well'	Normal
Number of experimental cases	203	32	87	16	16
Number of comparison cases	406	32	435	128	176
Immigrant generation					
1st: Respondent and parents European-born	0.72	0.50	0.77	0.72	0.69
2nd: Both parents European-born	0.70	0.92	0.81	1.48	1.34
2nd: One parent European-born	0.93	1.67*	1.32	2.29*	2.75*
3rd or later: Both parents born in U.S.	1.54	1.29	1.16	0.88*	1.10*
Religion of parents					
Both Catholic	--	0.47	0.51	0.80*	0.73*
Both Protestant	--	3.00	1.27	1.70	1.55
Both Jewish	--	0.33	1.32	0.00*	0.00*
Mixed (1 Protestant, 1 Catholic)	--	1.00*	2.38	0.73*	0.52*
Religion of respondent					
Catholic	--	0.58	0.66	0.68*	0.72*
Protestant	--	2.00	1.34	1.57	1.41
Jewish	--	0.33*	1.11	0.00*	0.00*
Ethnic group (nationality or stock)					
Southern European, Eastern European, and French-Canadian	--	0.47	0.64	0.57*	0.57*
Old Yankee and Northwestern European	--	1.54	1.24	1.40	1.35

(continued)

Type of comparison group	North Dakota 'Well'	Middlesex County Other Sick		Midtown Manhattan 'Well'	
	'Well'	Other Sick	'Well'	'Well'	Normal
Childhood environment					
Rural	0.88	0.67	0.69	--	--
Urban	1.33	1.13	1.13	--	--
Farm	--	--	--	2.28*	2.59*
Village, town, city	--	--	--	0.54*	0.61*
City over 500,000 (other than N.Y.C.)	--	--	--	0.00*	0.00*
New York City	--	--	--	2.13	1.87
Occupational level of father					
Lower	0.95	0.73	0.76	1.04	0.98
Higher	1.33	1.31	1.40	0.95	1.05
Occupational level of respondent					
Lower	0.87	0.60	0.94	0.62	0.58
Higher	1.82	1.67	1.66	1.44	1.51

* Because of the small number of cases on which certain of the ratios are based, they may be excessively influenced by chance factors.

a From Wardwell, Hyman, & Bahnson, 1964.

ratios of observed to expected cases. Those ratios over 1.00 are indicative of a possible association. Wardwell, Hyman and Bahnson characterize the more vulnerable persons as those who are closest to the American urban middle class Protestant ethos. Some subgroup analyses are of interest. In Middlesex County, Connecticut, where coronary mortality rates are high in general, Catholics whose fathers were in low status occupations had exceptionally low rates. In rural North Dakota, where rates are low in general, exceptionally high rates were found in sons of American-born fathers in urban occupations.

Shekelle, Ostfeld, & Oglesby (1969) tested the hypothesis that the incidence of CHD is positively associated with five types of incongruity in social status:

1. Range of status.
2. Class of origin different from present social class.
3. Wife's class of origin different from present social class.
4. Husband's educational status less than his wife's educational status.
5. Husband's class of origin less than his wife's class of origin.

An analysis of social status was based on occupation, education, income, neighborhood, dwelling, religion, and membership in voluntary associations.

As can be seen in Table J-X, only educational status of the subject was significantly associated (by Chi-square statistical tests) to the frequency of angina pectoris or

Table J-X

Relationship Between Status on Seven Variables of Social Status and Incidence of Angina Pectoris and of Myocardial Infarction or Death From CHD[a]

Variables	Strata	Frequency			Incidence/1000		Stat. test
		No CHD	Angina pectoris	MI or death	Angina pectoris	MI or death	
Occupation	1-2	90	9	2	18	4	
	3	318	20	6	12	3	$x^2=7.55$
	4	314	11	9	6	5	d.f.=6
	5-7	647	29	17	8	5	$P<0.50$
Education	1-2	140	13	1	17	1	
	3	121	5	1	8	2	$x^2=16.24$
	4	450	15	9	6	4	d.f.=8
	5	429	25	18	10	8	$P<0.05$
	6-7	229	11	5	9	4	
Income	1-3	209	15	4	13	4	$x^2=2.66$
	4	391	18	9	9	4	d.f.=4
	5-7	769	36	21	9	5	$P<0.75$
Neighborhood	1-3	200	10	3	9	3	
	4	458	19	9	8	4	$x^2=5.26$
	5	477	26	12	10	5	d.f.=6
	6-7	234	14	10	11	8	$P<0.75$
Dwelling	1-2	51	2	4	7	14	
	3	168	10	2	11	2	$x^2=7.95$
	4	775	39	18	9	4	d.f.=8
	5	283	15	8	10	5	$P<0.50$
	6-7	92	3	2	6	4	

(continued)

Variables	Strata	Frequency			Incidence/1000		Stat. test
		No CHD	Angina pectoris	MI or death	Angina pectoris	MI or death	
Associations	1-3	151	8	2	10	2	
	4	452	26	15	10	6	x^2=5.93
	5	720	35	15	9	4	d.f.=6
	6-7	46	0	2	0	8	P < 0.50
Religion	1-2	43	2	1	8	4	
	3	99	8	1	15	2	x^2=3.93
	4	398	23	11	11	5	d.f.=6
	5-7	829	36	21	8	5	P < 0.75

Diagnostic category is determined by the first manifestation of CHD. Ratings of social status have been combined where necessary to avoid very small total frequencies. Incidence is the mean annual incidence occurring over the 5-yr period of study. For each variable chi-square has been used to test the hypothesis that classification into 3 diagnostic categories (no CHD, angina only, and myocardial infarction or CHD death) is independent of classification into the strata shown in the table.

[a] From Shekelle, Ostfeld, & Oglesby, 1969.

with myocardial infarction or death from CHD. However, when the subjects were classified on incongruities in social status as listed above, the incidence of CHD was, in every case, higher in the group predicted by the hypothesis and was statistically significantly higher in four of the five tests as shown in Table J-XI. Furthermore, incidence of CHD increased as the number of incongruities per subject increased so that men with four of five incongruities had about six times the risk of CHD as compared to men with no incongruities. This association could not be explained by the correlation between number of incongruities and other variables related to risk of CHD as shown by the lack of significant relationships in Table J-XII. In spite of the statistically significant findings in the predicted directions, the authors warn that generalization of the results beyond the observed subjects should be done with caution.

A black-white epidemiological study which was initiated in 1960 (Cassel, 1971), traced the incidence of heart disease in subjects in Evans County, Georgia. The subjects included 100% of all residents over age 40 and a 50% sample of those between 15 and 39 years of age. The study determined that:

1. CHD occurred rarely in black men (Figure J-10).
2. Whites demonstrated a sharp difference in CHD by social class (Figure J-11).
3. None of the risk factors measured such as blood pressure, cholesterol level, smoking, weight, and diet could account for either the ethnic or social class difference in prevalence rates. See, for example, Figures J-12, J-13, and J-14.

Table J-XI
Relationship Between Incongruities in Social Status and Incidence of Coronary Heart Disease [a]

Type of incongruity	Categories	Subjects not showing CHD	Cases of CHD	Mean Annual Incidence per 1000	Relative risk	Statistical significance (df=1)
Range of status 3	Absent	1246	83	12		x^2=10.73
	Present	123	20	28	2.3	P <0.005
Subject's class of origin ≠ present class	Absent	757	46	11		x^2=3.95
	Present	612	57	17	1.5	P <0.05
Wife's class of origin ≠ present class	Absent	733	43	11		x^2=4.88
	Present	636	60	17	1.5	P <0.05
Subject's educational status wife's	Absent	1028	67	12		x^2=4.56
	Present	341	36	19	1.6	P <0.05
Subject's class of origin wife's	Absent	1131	80	13		x^2=1.28
	Present	238	23	18	1.4	P <0.50

Upward social mobility accounts for almost all cases in which the class of origin is different from present social class. The frequency of downward social mobility in this cohort is too small to permit separate analysis.

[a] From Shekelle, Ostfeld, & Oglesby, 1969.

Table J-XII

Relationship Between Number of Incongruities Per Subject and Other Variables Related to Risk of CHD[a]

Variable		Number of incongruities per subject: 0	1	2	3	4-5	F ratio
Serum cholesterol (mg%)	Mean	229	234	230	229	238	<1.00
	S.D.	41	47	42	39	48	
	N	368	381	448	231	43	
Systolic pressure (mm Hg)	Mean	132	129	131	130	130	1.20
	S.D.	19	18	18	16	17	
	N	367	378	447	232	43	
Diastolic pressure (mm Hg)	Mean	83	83	83	83	82	<1.00
	S.D.	11	10	11	10	12	
	N	367	378	447	232	43	
Blood Sugar (mg%)	Mean	101	101	106	102	99	1.04
	S.D.	37	39	41	37	28	
	N	367	381	446	226	42	
Age at first examination (yr)	Mean	47	47	48	48	48	2.94
	S.D.	4	4	4	4	5	
	N	368	381	448	232	43	
Relative weight (%)	Mean	105	104	106	104	107	1.46
	S.D.	13	13	13	13	12	
	N	364	371	441	227	42	
Cigarette smoking	Number no	172	172	237	114	25	
	Number yes	196	209	211	118	18	
	Percentage yes	53	55	47	51	42	

[a] From Shekelle, Ostfeld, & Oglesby, 1969.

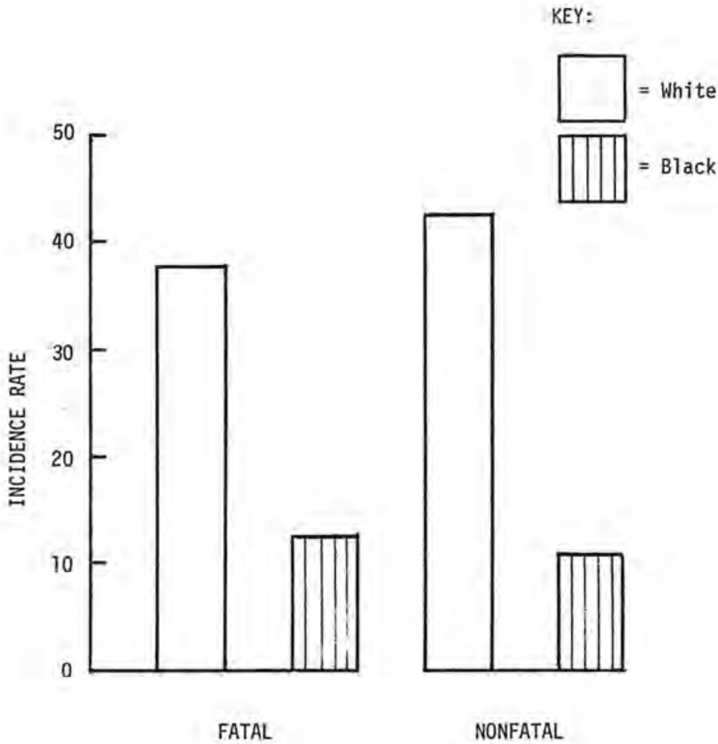


Figure J-10. Age-adjusted incidence rates for fatal and nonfatal events by ethnic group, 1960 through 1962 to 1967 through 1969 (men only). (Fatal events included all deaths ascribed to myocardial infarction and all sudden deaths.) (From Cassel, et al., 1971a.)

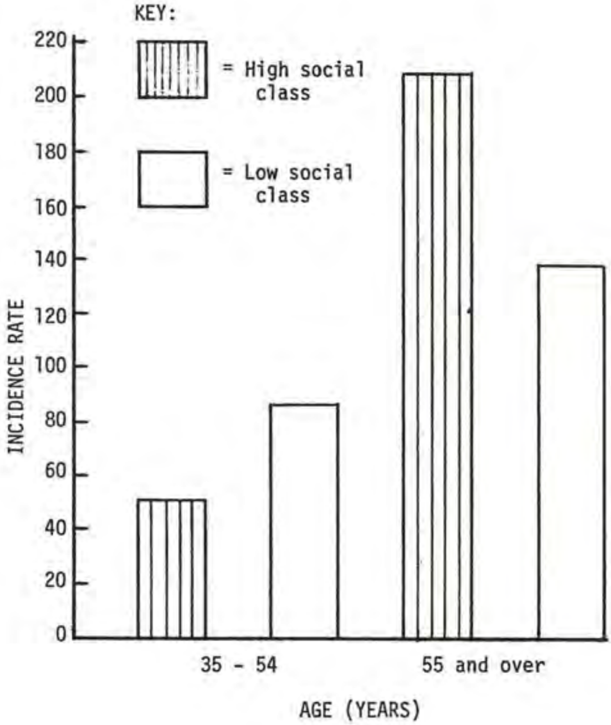


Figure J-11. Incidence of coronary heart disease per 1,000 by age group and social class, 1960 through 1962 and 1967 through 1969 (white men). (From Cassel, et al., 1971a.)

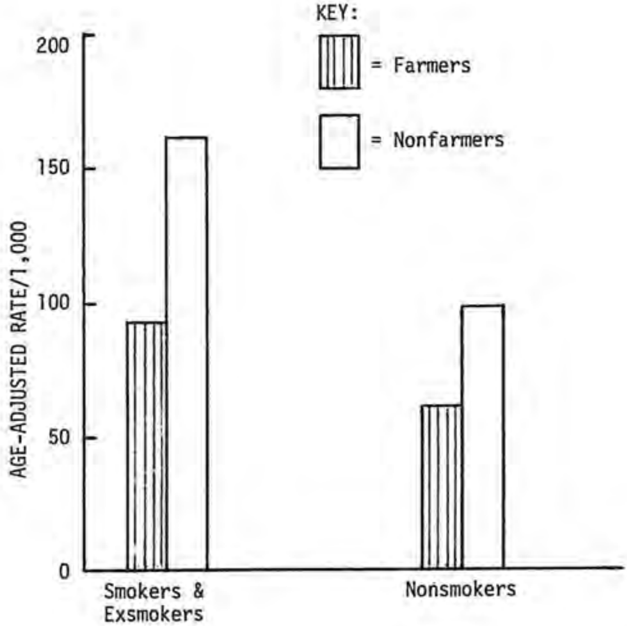


Figure J-12. Age-adjusted incidence rates per 1,000 (1960-1962 to 1967-1969): coronary heart disease in white men, farmers and non-farmers (40-47 years), by cigarette smoking status. (From Cassel, et al., 1971b.)

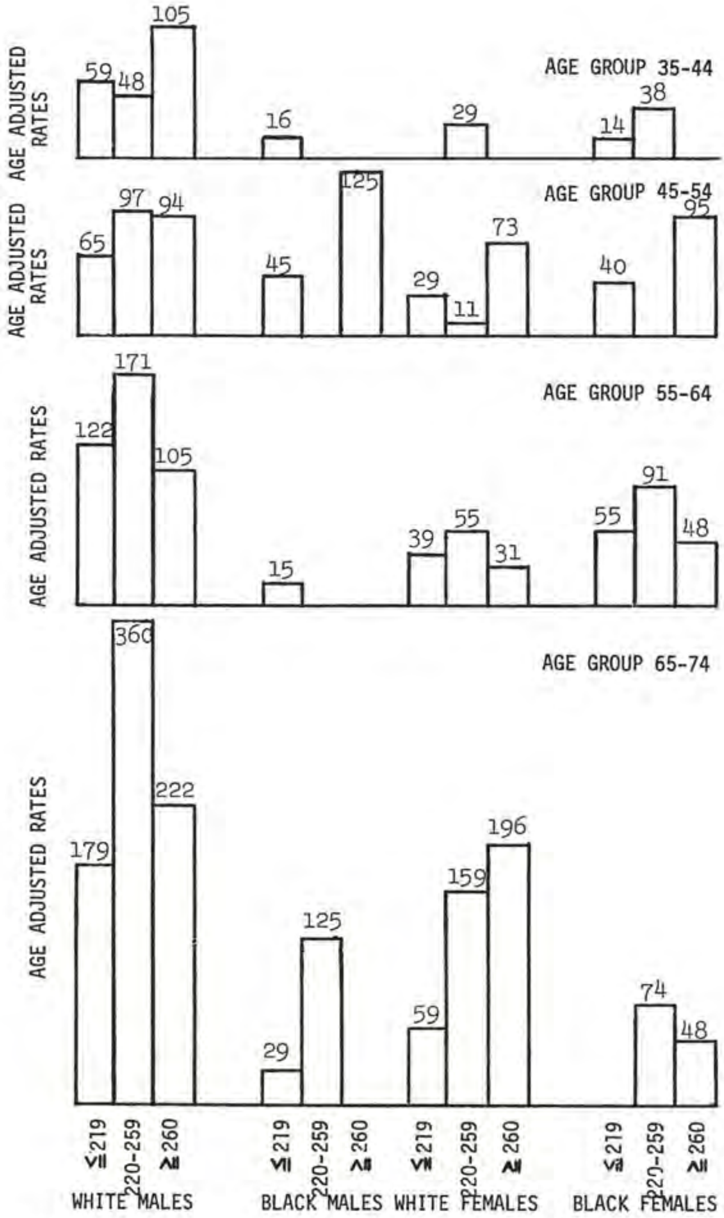


Figure J-13. CHD incidence rates by serum cholesterol levels-race-sex groups by age (rate/1,000). (From Tyroler, Heyden, Bartel, et al., 1971.)

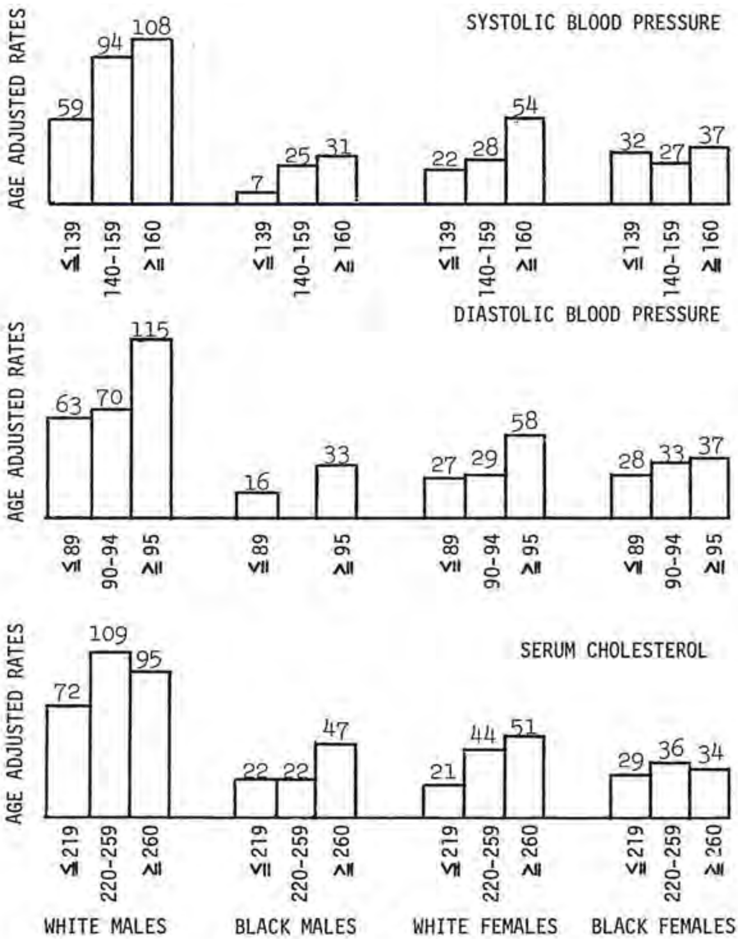


Figure J-14. CHD incidence rates by levels of blood pressure and serum cholesterol in Evans County (rate/1,000). (From Tyroler, Heyden, Bartel, et al., 1971.)

4. Occupational differences exist (Figure J-15). It is suggested that physical activity has a protective effect and that variations in the level of physical activity between the various ethnic and social groups accounted for, at least in part, the difference in their rates (Figure J-16).

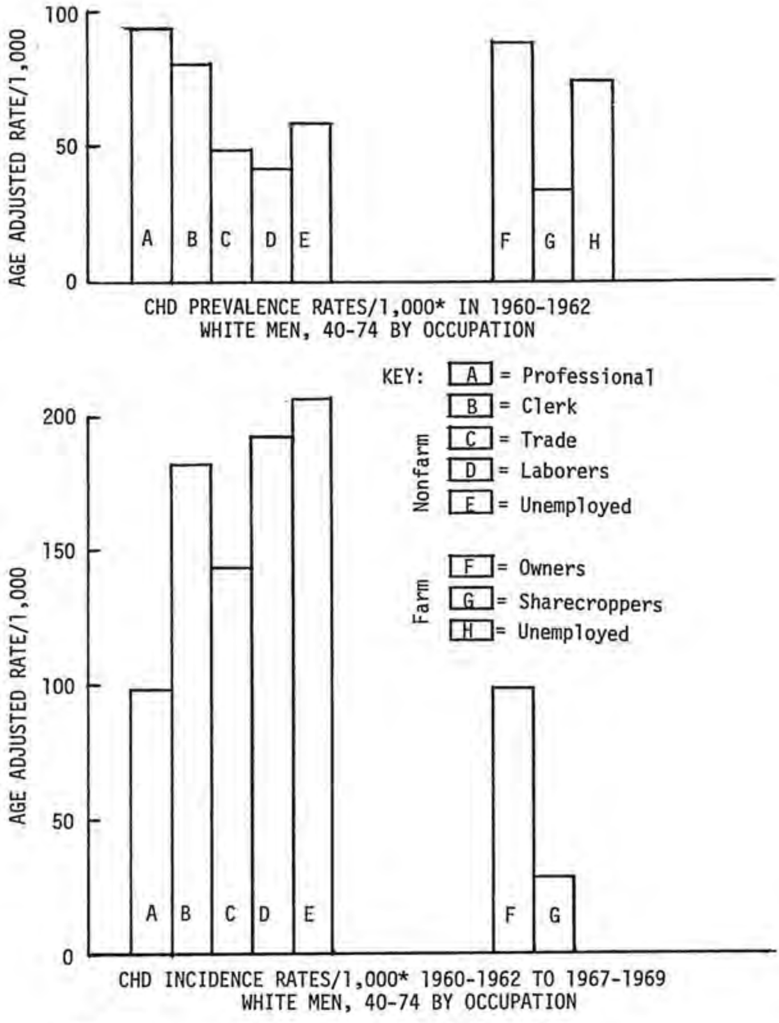
With regard to the last point a study by Paffenbarger, Gima, Laughlin, & Black (1971) also found a relationship between CHD and less activity.

Physical and Hereditary Factors

Perhaps the most convincing relationships between personal variables and CHD are physical and hereditary factors.

A study of 258 male employees of a wire mill (Meigs et al, 1965; 1966) establishes a relationship between fathers' longevity and sons' triglycerides. Regression equations for this relationship showed a significant positive slope for "age at death of father" among fathers with no atherosclerotic or diabetic disease vs. sons' triglyceride. There was a significant negative slope for age at death of father, where there was a history of coronary disease among one or both parents, vs. sons' triglycerides. Mean triglyceride levels for men who had a history of heart disease in one or both parents were significantly higher than for men who had no such history.

Paffenbarger and Wing (1969) reviewed the college records of 3,438 former students to identify characteristics associated with fatal CHD. Among the physical and hereditary factors they examined, increased risk of coronary death was associated with the following characteristics:



*All rates age-adjusted by the indirect method.

Figure J-15. Coronary heart disease prevalence (1960-1962) and incidence (1960-1962 to 1967-1969) for white men (40-47 years) by occupation. (From Cassel, et al., 1971b.)

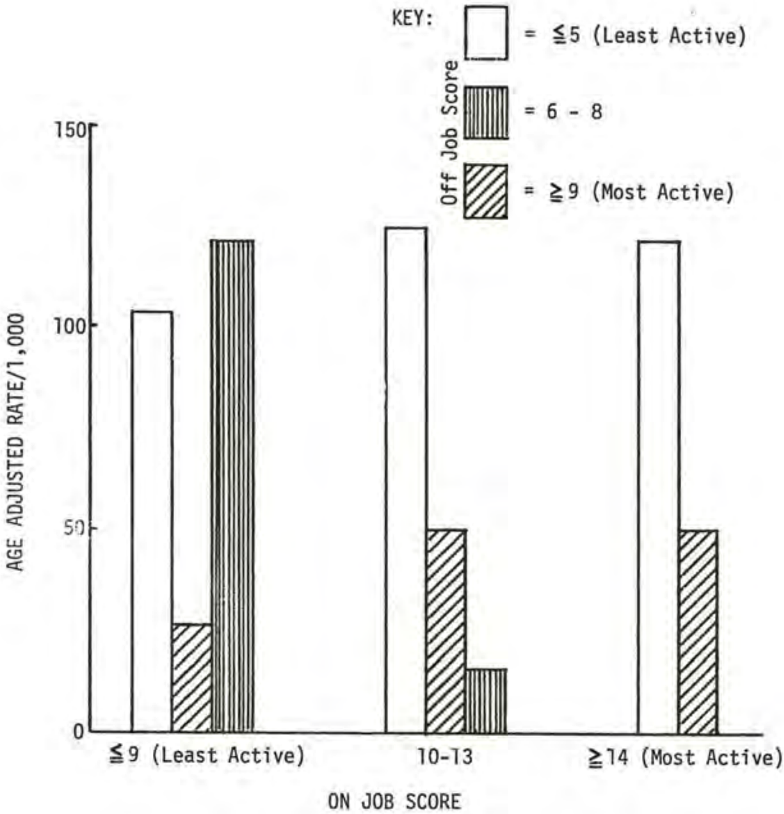


Figure J-16. Age adjusted prevalence rate per 1,000 (1967-1969) coronary heart disease for white men nonfarmers (40-47 years), by "on-the-job" and "off-the-job" physical activity scores. (From Cassel, et al., 1971b.)

1. Systolic blood pressure levels of over 130.

2. A result less than 12.9 when height is divided by the cube root of weight.

3. Height less than 68 inches.

4. Early parental death.

Persons with systolic blood pressure over 130 had 40% more risk of coronary death relative to people with blood pressure lower than this. The other characteristics listed above were associated with 30% increased risk.

SUMMARY OBSERVATIONS

Problems of Research Methodology

House (1974 in print) classifies the empirical evidence relating coronary heart disease to occupational stress into demographic comparisons and focused studies. Standard epidemiological studies compare morbidity or mortality rates for different demographic categories such as race, sex, age, occupation, education, ethnicity region, or place of residence. While useful for suggesting possible hypotheses for testing, such comparisons must be subjected to specific experimental tests to show that stress is indeed differentially distributed across various demographic categories. House divides such specific tests into those using actual disease (heart attacks and such) as measures of health and those which use behavioral and physiological factors (such as cigarette smoking and high blood pressure) known to increase the risk of disease. The former use retrospective and prospective types of research designs; the latter use cross-sectional and occasionally prospective types of designs. The problems of retrospective and prospective designs have been discussed by both House (1974 in print) and by Keith (1966). Briefly they are:

1. Retrospective studies compare people who already have the disease with a control group of persons not manifesting the disease. Differences between the groups may be the result of the disease rather than the cause.

2. In retrospective studies there is a problem when those who manifest the disease are not aware of it and are not detected.

3. Retrospective studies lose the advantage of studying those CHD patients who die. That is, most observations of personality and behavior are made on CHD survivors.

4. Prospective studies examine a sample of people before the presence of a disease is established and are followed until those who incur the disease can be differentiated from those who do not. These studies require large samples and years of study.

In cross-sectional studies, measures of behavior or stress are taken at the same time that measures of risk factors are taken. There is, then, the problem of ascertaining which direction is the causal one. Usually the more plausible one is assumed--as, for example, that blood pressure is affected by job satisfaction rather than the opposite being true.

"Double-blind" experimental designs have become accepted practice in personality and behavioral research, but have been neglected in some CHD studies. Those researchers who categorize personality or behavioral characteristics of the sample should have no knowledge of the results of the physical examination and diagnosis of CHD to avoid the knowledge of one influencing the impressions of the other.

Some studies relating CHD to status inconsistency have provided positive results. However, House (1974 in print) indicates that methods of status inconsistency studies in sociology have been subjected to increased examination and evaluation. The problem is that any effects found when two or more status dimensions interact must be over and above that which can be accounted for by the additive effects of the status dimensions.

Much of the research on CHD emphasizes "stress" as a precursor. House (1974 in print) indicates that many researchers discuss the relation of CHD to some stressful situation without carefully describing what it is about the situation that is stressful. He emphasizes that future studies of occupational stress should specify both objective conditions of work and subjective perceptions of stress.

Hypersusceptibility

That there appears to be some relation of job stress to CHD and to various physiological measures (such as serum cholesterol and blood coagulation time) seems clear. Still unclear is what may constitute the categories of stressful jobs. Low levels of CHD in high management and executive level positions may be the result of persons in those positions being selected because they are able to cope with stress.

Personality and behavior patterns are apparently associated with increased risk of CHD. However, there is so little consistency in findings from one sample to another of different characteristics, that any effort to use the current data for prediction is premature.

Selection and Placement

If it is true that there are personality and behavior patterns associated with increased risk of CHD, then it should be possible to develop methods to identify such persons and assign them to jobs to reduce such risk. Several factors preclude this.

1. Many of the studies which have shown a relation of CHD to personality, behavior, or occupational stress have been with white males in professional and managerial positions. When applied to broader populations the results often do not generalize.

2. Apparently a very large percentage of the working population in the United States can be classified as behavior type A and hence in the group which would be predicted to have a higher incidence of CHD. Perhaps as many as 50% can be so classified. While the incidence of CHD may be much higher for such persons than for behavior type B, the absolute numbers are fairly small. Thus, a very large number of people are classified as being at a higher risk, but fewer will actually suffer.

3. There is considerable work needed before a useable instrument can be developed to measure the behavior pattern types.

4. There is a need to identify high stress jobs and differences in the nature and range of individual worker responses to them.

The last point seems to indicate that when instruments and methods are developed to predict CHD risk from personality and behavioral factors, they will have to provide for individual (rather than group) prediction and will have to provide means for identifying how a given person will interact with the stress of a given job.

Ameliorating Conditions Affecting CHD

There are many variable factors in the etiology of CHD, including diet, exercise, heredity, and stress (House 1974 in print). Ameliorative attempts can alter many of these factors. However, when attempts are undertaken in the context of an industrial or business setting, there may be constraints on what can be done practically. Some employers are able to provide recreational and other facilities where workers can get some exercise during or after the workday. For example, jogging paths and gymnastic equipment are available to some office workers.

House (1974 in print) emphasizes the importance of various aspects of the work situation in defining how a person will react to stress. The social environment of the work situation may be structured to be supportive of the individual in a stressful work situation. House quotes studies in this country and in Japan that seem to indicate that when there are opportunities for social support in the face of stress, the person is apparently much better equipped to deal with the stressful situation.

Identifying and removing unnecessary sources of psychological stress should be a management goal. Employee relations programs conducted at more than superficial levels may aid in accomplishing this.

Predicting high-risk individuals is too uncertain at present to affect selection and placement. However, research evidence does permit the identification of individuals who may profit from education and cautionary actions. Responsible management can alert workers who appear to have a high risk of CHD to actions they can take to reduce the risks, such as exercising, reducing smoking, changing eating habits, and so forth. Organization programs can also be instituted to support these personal actions.

Research Needs

While much is known already concerning the etiology of CHD, the effects of stress and, more particularly the effects of occupational stress need much research. House (1974 in press) has provided a paradigm for stress research and indicates scientists should attempt to answer the following questions:

1. What kinds of adaptive responses of the individual will weaken or negate the effects of stress on the health of the individual, and what kinds will increase such effects?

2. Is the effectiveness of the types of responses people make in the face of stress specific to certain kinds of stress or certain kinds of people in certain situations?

3. What personality, physiological, and situational characteristics determine the kinds of adaptive responses a person will make?

One necessity in research or even in conceptualizing is a closer examination of what constitutes stress. What is stressful for one person may not be stressful for another. In line with this is the need to look more closely at the relation of CHD to one's position in the organization. What are "stressful jobs" and what is it that is stressful about them. Deadlines, for example, are not stressful in and of themselves, but how people define the consequences of not meeting them can introduce severe stress.

Although there are some ameliorative steps that can be taken immediately to reduce stress in occupations and predict high risk individuals, considerably more effort is required to refine currently available techniques and (more importantly) develop new ones. For example, fairly recent achievements in using behavioral modification techniques to condition bodily processes under control of the autonomic nervous system may be applicable to reducing the physiological effects of stress in work situations.

In summary, CHD is a major cause of death in the United States and various aspects of the work situation can play a role in the etiology. There should be major efforts in identifying the extent to which this is true, the contributing factors, and what corrective actions can be taken.

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CORONARY HEART DISEASE

Worker Safety & Health Measures	EMPIRICAL Obs. or Statis-tical	EMPIRICAL Contr. Field or Lab	Theory or Opinion or "Ex-perience"	REVIEWS Critical or Inte-grative	REVIEWS Bibliog. or Sketchy	Unknown
Frequency & Sever-ity Job Accidents						
Agent - Specific Diseases						
Non-Specific Disorders		80 1013 268 1015 706 1016 787 1104 792 1140 872 1141 915 1142 991 1144 1000 1221 1005 1222 1006 1223 1007 1287 1008 1288 1011 1289 1012 1290	872 1090 1295	993 994 1295		
Critical Incidents						
Rate/ Amount of Sick-Absence						
Perform-ance Indices		919 920 1142	919 920			
Strain Indices						
Morale						
Compliance with Rules						
Off Job Problems						
Miscel-laneous		1143				

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