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↙ Relationships Between Wholebody Vibration
and Morbidity Patterns Among Interstate
Truck Drivers

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DEPARTMENT OF
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PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

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RELATIONSHIPS BETWEEN WHOLEBODY VIBRATION AND
MORBIDITY PATTERNS AMONG INTERSTATE TRUCK DRIVERS

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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ABSTRACT

The hypotheses that certain physical disorders develop with undue frequency among interstate truck drivers and that some of this excess morbidity is due in part to the wholebody-vibration factor of their job, have been tested by extracting and comparing morbidity data available in the periodic, certification examination records for 3,205 active interstate truck drivers and 1,137 active air traffic controllers. Chi-square tests of the 24-year incidence rates of some medical conditions for two, industry-representative truck driver populations and two, sedentary comparison groups revealed a number of statistically significant differences in group-specific morbidity patterns. Biodynamic strain, microtrauma, and intraluminal/intra-abdominal pressure fluctuations that are known to be produced by truck vibrations have been postulated as being at least partially responsible for the development of certain musculo-skeletal, digestive, and circulatory disorders among interstate truck drivers with more than fifteen years of service. The combined effects of forced body posture, cargo handling, and improper eating habits along with wholebody vibration cannot be ruled out in considering contributory factors for such truck-driver disorders as vertebrogenic pain syndromes, spine deformities, sprains and strains, appendicitis, stomach troubles, and hemorrhoids.

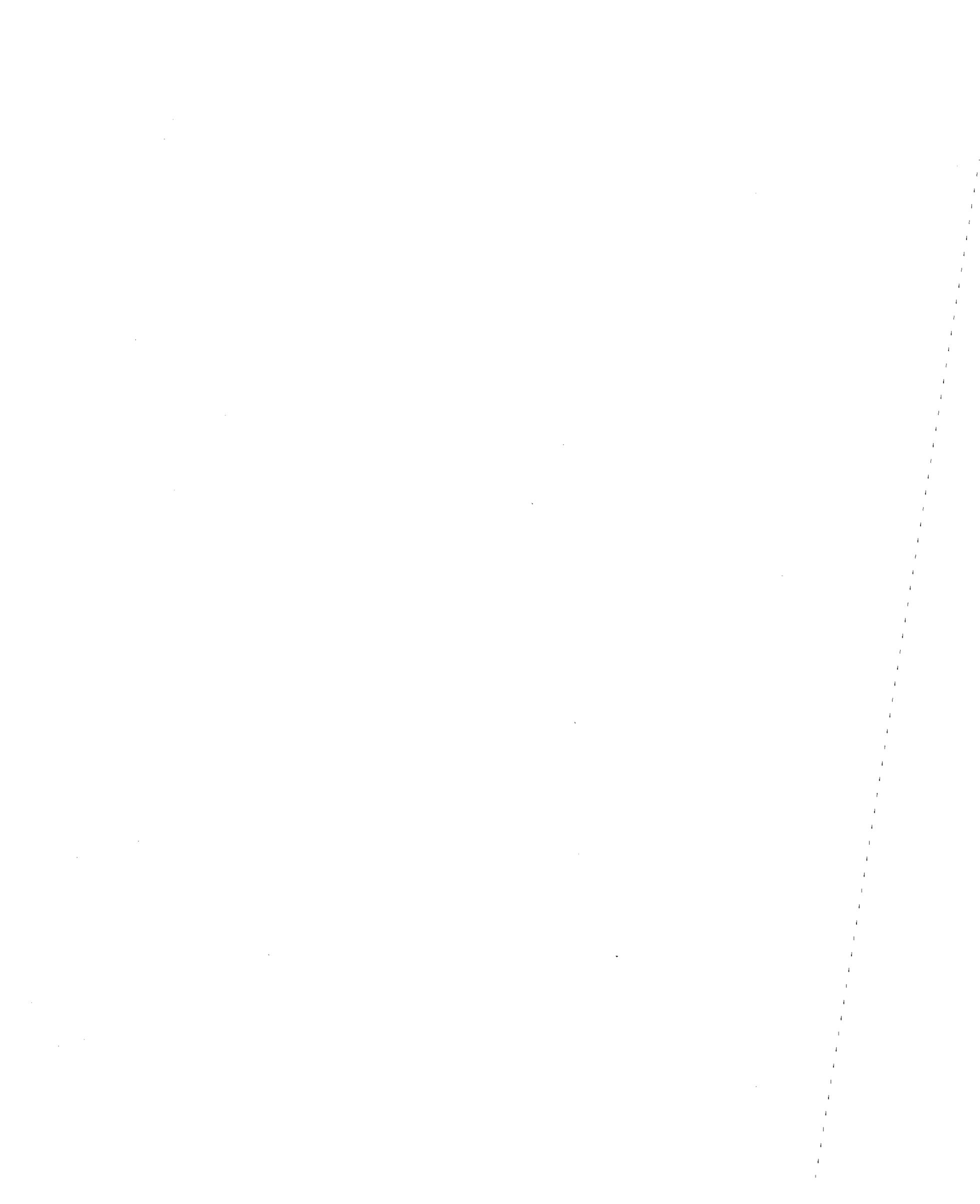
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I. INTRODUCTION

A. Background

Over four million truckdrivers are engaged in interstate commerce as a result of the widespread dependence on surface transportation of shipping general freight and commodities in the United States. Commercial truck driving is a distinct occupation, representing a significant portion of the American workforce which is occupationally exposed to low-frequency, wholebody vibration that could be associated with potential health effects of particular importance to job performance and traffic safety.

The implications of subjecting whole body to vibration have been repeatedly reviewed for occupational safety and health with an eye toward collecting, collating, and identifying significant findings.¹⁻² Present knowledge is somewhat sketchy concerning vibration-related safety and health problems and the associated programs intended for their prevention or reduction with regard to millions of commercial vehicle drivers. The potential health-deteriorating consequences of vibration exposure in the motor carrier industry most effectively can be dealt with by first developing a better understanding of the extent and nature of the wholebody-vibration problem.* In addition to any short-term safety implications there may be adverse, long-term effects of occupational wholebody-vibration exposure on the commercial drivers' health.

Since some eight million workers are exposed to wholebody or segmental vibration in the U.S.,³ the National Institute for Occupational Safety and Health (NIOSH) has determined that there was a need for retrospective, epidemiological studies⁴ which should be designed to detect potential and actual incipient health deteriorations as may be prevalent in workers who have been occupationally exposed to wholebody vibration. Two of such studies have been completed by our group. Interstate

*Wholebody vibration affects the entire body (as in driving a motor vehicle) as opposed to segmental vibration (as in the use of vibrating hand tools).

¹Guignard, J.C. and Guignard, E.: Human Response to Vibration Critical Survey of Published Works, Institute of Sound and Vibration Research, University of Southampton, England, 1970.

²Wasserman, D.E. and Badger, D.W.: Vibration and the Worker's Health and Safety, National Institute for Occupational Safety and Health, Technical Report No. 77, Cincinnati, Ohio, 1973.

³Wasserman, D.E. et al.: Industrial Vibration--An Overview, J. American Society of Safety Engineers, 19, 38-43, 1974.

⁴Wasserman, D.W. and Badger, D.W.: The NIOSH Plan for Developing Industrial Vibration Exposure Criteria, J. Safety Research, 4, 146-154, 1972.

bus drivers were first studied⁵ and that study was followed by the present study of interstate truck drivers who were selected from groups representative of the industry for analyses of their overall ill-health or morbidity experience which had been accumulated over the years of employment on commercial-driving jobs with emphasis on the wholebody-vibration factor. This report contains the results of this second, two-year study.

The first occupational health study of commercial drivers⁵ did not produce unequivocal findings that would have resulted in the derivations of definite conclusions implicating the exclusive role of wholebody vibration in the development of the types of chronic, physical conditions which were frequently recorded by examining physicians for the selected sample of interstate bus drivers. The study concluded that any significant excess morbidity was due instead to probable combinations of physical, chemical, and psychosocial stresses and demands acting together with the wholebody-vibration factor. Although probable causes have been inferred, little has been proven either positively or negatively about the chronic effects of occupational, wholebody-vibration on interstate bus drivers' circulatory, respiratory, digestive, genitourinary, and musculoskeletal systems. To be able to better establish relationships between wholebody-vibration and morbidity patterns, further field and epidemiological studies would be needed and were, therefore, recommended⁵ to include an additional motor-carrier-industry sampling which would provide a broader range of commercial vehicle drivers. Until the environmental stresses, job demands, minimal health requirements, and any other significant variables are more specifically defined for the wide range and scope of work represented by the various commercial driver job classifications, there will be justifiable disagreement as to whether or not wholebody vibration by itself is in fact a significant occupational health hazard in the present-day motor carrier industry. Significant positive correlations which may be determined to exist among job and health variables would, therefore, result in an improved understanding of the possible relationships between any significant development of commercial drivers' physical disorders and wholebody-vibration exposure.

⁵ Gruber, G.J. and Ziperman, H.H.: Relationship Between Wholebody Vibration and Morbidity Patterns Among Motor Coach Operators. Southwest Research Institute, San Antonio, Texas. Center for Disease Control Publication No. 75-104, Cincinnati, Ohio, 1974.

B. Vehicular Vibration

Trucks, earth movers, farm tractors, and buses are standard vehicles which provide common sources of occupational, wholebody vibration of drivers. Off-the-road vehicles are likely to be driven over rough ground and by design, they sacrifice riding comfort in favor of sturdiness and durability requirements when compared with deluxe, intercity buses and modern, over-the-road trucks. There can be no doubt that commercial truck and bus drivers are subjected to wholebody vibrations of various intensities and frequencies which are exaggerated by any inadequacies or insufficiencies in springs, shock absorbers, tires or suspension, and damping of the seat.

Trucks and buses possess similar vibrational frequency-response characteristics, with the major structural resonances occurring in the 1 to 20 Hz frequency region. Mean acceleration levels vary, however, from about 50 cm/sec² or 0.05g for the smooth-riding intercity bus and ranging up to 3 or possibly 5 times this value for the typical over-the-road truck.⁶⁻⁷

Wholebody vibration mainly is applied in the vertical direction to commercial vehicle operators. Studies of mechanical response of the seated person to vibration applied in the vertical direction have shown that maximum biodynamic strain is associated with trunk resonance occurring at about 5 Hz.⁸ The human body dissipates maximum mechanical energy at this frequency, as well as amplifies the input vibrations. Although commercial vehicle and seat designs have steadily improved, the major natural resonance frequencies cannot be 'engineered out' of the critical 3 to 7 Hz frequency region.

C. Effects of Vehicular Vibration

A review of adverse effects of wholebody-vibration exposure on transportation vehicle operators' performance, safety, and health follows.

⁶ Clevenson, A.S. and Leatherword, J.D.: Development of Aircraft Passenger Vibration Ride Acceptance Criteria. Closed Loop, NASA Langley Research Center, Hampton, Virginia, Summer, 1973.

⁷ Mackie, R.R. et al: A Study of Heat, Noise and Vibration in Relation to Driver Performance and Physiological Status. Department of Transportation Contract No. DOT-HS-241-2-420 with Human Factors Research, Inc., Goleta, California, 1974.

⁸ Goldman, D.E. and VonGierke, H.E.: The Effects of Shock and Vibration on Man. Naval Medical Research Institute, Lecture and Review Series No. 60-3, Bethesda, Maryland, 1960.

1. Performance and Safety Effects

The safety implications of truck vibrations may be assessed on the basis of the effects on driver performance. Vibrations of less than 2 Hz are sleep producing and less than 1 Hz cause motion sickness.

Resonance vibrations in the vicinity of 5 Hz interfere with maintenance of the driver's upright, 'alert' posture while driving or with the driver's balance while climbing to inspect, load, or unload the truck, etc., while the diesel engine is running. To dampen the biodynamic strain, drivers continually and often unconsciously alter their erect body posture. Any shifting of the body's fundamental resonance frequency away from existing, prominent vehicular resonance frequencies requires the driver to expend extra muscle activity. Resultant fatigue in certain abdominal, back, or chest muscles can only be minimized at the expense of straining, and eventually fatiguing, other muscle groups. The muscle activity elicited to dampen biodynamic strain produced by wholebody vibration and to maintain balance may be responsible for the early onset of acute physical fatigue normally associated with prolonged commercial driving.

Visual and tracking performance deteriorate because of mirror or eyeball resonance vibrations in the frequency ranges greater than 10 Hz. High-frequency biodynamic strain additionally can "load" the limbs of commercial drivers and impair coordination.

2. Long-term Health Effects

The long-term effects on the drivers' physical health after exposure to such low-frequency, low-to-moderate amplitude vibrations as those associated with the interstate operation of commercial buses and trucks, are not well documented. Various circulatory, digestive, genitourinary, and musculoskeletal disorders have, however, been identified as associated with driving such rough-riding, off-the road vehicles as farm tractors and military vehicles.⁹⁻¹² Little attention has so far been directed

⁹ Paulson, E.C.: Tractor Drivers' Complaints. Minnesota Medicine 386-387, April, 1949.

¹⁰ Rosegger, R. and Rosseger, S.: Health Effects of Tractor Driving. J. Agricultural Engineering Research, 5, 241-275, 1960.

¹¹ Fishbein, W.I. and Salter, L.C.: The Relationship Between Truck and Tractor Driving and Disorders of the Spine and Supporting Structures. Industrial Medicine and Surgery, 19, 444-445, 1950.

¹² Clayberg, H.D.: Pathologic Physiology of Truck and Car Driving. The Military Surgeon, 105, 299-311, 1949.

to the possibility that wholebody-vibration exposure associated with the operation of trucks and buses in interstate commerce as an occupation might impose sustained biodynamic strains and internal pressure fluctuations which may cause physical health deteriorations. Such knowledge is essential for appropriate corrective measures to implement effective programs of prevention.

D. Objectives of Study

If the results of the interstate-bus-driver morbidity study are a valid indicator of possible, long-term, adverse health effects on commercial drivers after occupational exposure to low-frequency, wholebody vibration, then certain physical disorders suspected of wholebody-vibration etiology may be expected to be even more frequent among interstate truck drivers.

The primary objective of this epidemiological study was then to investigate and determine how the morbidity patterns of truck drivers differ from those of two sedentary occupational groups, one within and the other outside the motor carrier industry. Other objectives were to:

develop any significant correlations as may be determined between various measures of physical health and wholebody-vibration exposure from readily-available, periodic physical examination records;

compare differences in morbidity patterns with those in stress patterns as discovered within the four occupational groups evaluated in this study; and

determine whether or not interstate truck drivers over the years on the job developed any specifically different or more kinds of chronic physical disorders than they would have if they had not been subjected to the typical environmental stresses and demands of their jobs.

II. STUDY DESIGN

The development of methodology to achieve the objectives of the study involved decisions concerning the:

nature and size of the population samples in the two study groups,

nature and size of the population samples in the two comparison groups,
stability of the study and comparison groups,
quality of the sources and kinds of morbidity information,
collecting of morbidity data,
data editing and coding procedures,
data manipulating,
measuring of morbidity experience, and
formulating and testing of hypotheses.

These methods are discussed in this chapter and the following three chapters.

A. Study Groups

We recognized that only a retrospective incidence or cohort study of basically healthy and medically-certified truck drivers would permit the determination of morbidity experience accumulated over twenty years on the job within the time and cost constraints of the study. The cohort approach of following two specific truck driver groups for observation of morbidity experience from available physical examination records for as long as possible (over 30 years in some cases!) from the date of employment by the motor carriers was judged to be the most feasible means for obtaining information about the possible, adverse, long-term effects of wholebody vibration on interstate truck drivers' health. This was facilitated by agreement of participating truck companies to provide access to anonymous, properly-sanitized periodic medical examination records from the health (and safety) files maintained as required evidence of medical fitness certification for each of their drivers.

The two main job classifications of truck drivers engaged in interstate commerce are "city" drivers who make local pickups and deliveries and "line" drivers who drive long distances over the road. Determined mainly by the roughness of the road surface, the frequency of stops and starts, and the structural design and maintenance of their trucks, city drivers are subjected to relatively higher levels of wholebody vibration in the critical 1 to 10 Hz frequency range than are line drivers. City and line drivers, therefore, were compared separately and as a total truck driver population with each of two comparison groups for the purpose of detecting any possibly-vibration-

related differences in recorded morbidity experience. The sample populations distributed by driver class and identified by participating motor carrier employers are shown in Table 1.

Table 1. Breakdown of Interstate Truck Driver Populations According to Employing Motor Carrier.

Truck Driver Class	Size of Population		
	Consolidated Freightways	Red Ball Motor Freight	All Motor Carriers
Local-Pickup-and-Delivery ("City")	487	1,349	1,836
Over-the-Road ("Line")	968	401	1,369

Total 3,205

B. Comparison Groups

Retrospective incidence or cohort studies may be biased or skewed in favor of those who are medically fit because they lose those within a sick or injured segment of dropout drivers who have left their job for any reason(s). Observation of morbidity experience recorded on periodic physical examination records have necessarily been made only of currently active truck drivers who have

entered their profession in substantially better health than would be expected in the general population as a result of having passed successfully through the strict, screening, pre-employment physical examination for certification of medical fitness to drive in interstate commerce required by federal regulations,¹³ and

¹³ Federal Motor Carrier Safety Regulations, Part 391, Qualification of Drivers. Federal Highway Administration, Washington, D.C., 1971.

survived elimination by a continuing, weeding-out process which requires qualification through biennial physical examinations for recertification to demonstrate that each driver has withstood the total job stresses and requirements of truck driving without development of any disqualifying medical condition.

It is self-evident that commercial drivers engaged in interstate commerce individually represent a physically and mentally healthy, frequently-examined, select group of workers. Little or no reasons exist for any other sedentary, nonvibrated occupational groups to require evidence of continued physical and mental fitness maintenance by periodic verification through medical examinations.

Careful consideration was given to the selection of suitable groups to serve as controls or comparisons in this study. A survey was initiated to determine the potential qualifications of various populations for these purposes. Several groups were first considered, evaluated, and then eliminated because of biases, unavailability, or unreliability of health records, matching problems, etc. The general population was rejected as unsuitable because of lack of periodic health records and the many uncontrolled variables in patterns of working, eating, or sleeping, among other things. Military populations were also rejected because of too many uncontrolled variables which included exposure to combat as well as unusual living conditions; although, it was recognized that the medical records were relatively periodical in nature. Airline pilots appeared to be a suitable group on first inspection because of the apparently good matching with most of the truck driver variables of health significance. This matching proved to be too close and was cause for rejection of the pilot group because they were also exposed occupationally to wholebody vibration of a degree and kind that is difficult to compare and which had to be a known variable in this study.

Air traffic controllers were finally selected after due consideration as a best choice for our external comparison group (Comparison Group 1). Air traffic controllers are required to annually qualify on the job by passing a comprehensive medical examination for renewal of work certificate. These records were cooperatively made available for the study. Differences and similarities in important variables with health implications between interstate truck drivers and air traffic controllers are presented in Chapter VII, Section A.

Interstate bus drivers were also selected after due consideration as a best choice for our internal comparison group

(Comparison Group 2). The utility and value of having more than one comparison group became increasingly more significant when the differences between the disease-incidence-rate data for the truck drivers and each comparison group began to appear in the various morbidity patterns. Interstate bus drivers made an interesting comparison group because of the striking similarities to the truck driver group and because they are a significantly-less-severely vibrated segment of the interstate commerce driver population of the motor carrier industry. Differences and similarities in important variables with health implications between interstate truck and bus drivers are presented in Chapter VII, Section A.

The selection of the two comparison groups, therefore, was a critical part of the study design. The choice of comparison groups was the best alternative due to the impossibility of providing a theoretically ideal control group which would have consisted of matched pairs of individuals with the only difference between them being the wholebody-vibration factor. The concept of matching important, health-related variables with several comparison groups evolved as the best decision possible to avoid meaningless comparisons or matchings of a large number of uncontrolled variables with a single comparison group. Special care was taken to eliminate to the extent possible any biases caused by dissimilarities of significance between the study groups and any selected comparison group, in order to bring out the truck driver morbidity results more clearly. Matchings for age, job experience or exposure presented no special problems. In order to neutralize the effects of any other significant, uncontrolled variables in determining the adverse effects of wholebody-vibration exposure on truck drivers' health, equalization was provided by selective matching with each of the two comparison groups while giving due consideration to the fact that each uncontrolled variable could have produced a bias of unknown magnitude and direction.

C. Stability of Study and Comparison Groups

The study and comparison groups ideally should be composed of individuals who have remained on one job over many years. Truck and bus drivers engaged in interstate commerce frequently remain in the employment of one motor carrier over a period of many years. The over 4 million interstate truck and bus drivers in the United States form an unusually stable working population which offers good promise for long-term opportunity to observe any health deterioration with time on-the-job. Observations extended over at least 20 years allowed for the development of any chronic physical disorders with wholebody-vibration etiology in which the pathological changes progress slowly. The best apparent occupational-health follow-up period for interstate truck and bus drivers dates back to 1952 when the format represented by the currently-valid, one-page form

of the Physical Examination of Driver was standardized for the motor carrier industry (see Appendix A on page 49). Owing to the consistent physical examination procedures, we were able to provide uniform criteria for extracting morbidity information from the periodic health records of each of our drivers over the individualized follow-up period.

Air traffic controllers were seen to form another, comparably-stable working population of about 15,000 Federal Aviation Administration (FAA) employees. The best apparent occupational-health follow-up period dates back to 1966 when the standardized, currently-valid, two-page, FAA Medical Examination Form was adopted for air traffic control specialists (see Appendix B on pages 50 and 51).

D. Quality of Morbidity Information

Data about the health problems of truck and bus drivers possibly relating to the wholebody-vibration factor on the job, can best be extracted from cumulative medical records which adequately provide a satisfactory description of the state(s) of health for each individual driver. The layout and format of prescribed medical examination forms for interstate commercial drivers and air traffic controllers are somewhat different (see Appendices A and B). Interstate commercial driver applicants by federal regulations must be certified as medically fit to drive and are examined at least once in every two years. Air traffic controllers are examined annually and their medical examiners must be FAA-certified. No certification qualification or special training is required of the medical examiners for interstate commercial drivers.

Under the Health History section of the medical examination forms for commercial drivers and air traffic controllers, a record is established about the applicant's recollection from memory of any past and present illnesses, conditions, abnormalities, symptoms, etc., as demonstrated in the form of "yes" or "no" answers to several questions beginning with such words as "Do you now have or have you ever had ...?" The medical examination form provides a space for the examining physician to record appropriate explanatory comments to qualify any "yes" answer(s).

Under Physical Examination, the physician performs, evaluates, and records a series of physiological measurements and visual observations with accompanying comments as appropriate about them. If the medical examiner determines that discovered or implied conditions so warrant, additional laboratory workups, functional tests, radiologic examinations, etc., may be required and the results of any additional studies must be evaluated before certification of the applicant. Any certification restrictions such as requirement of the applicant to

wear corrective lenses, wear a hearing aid, stay off the job while taking certain medicines, are included as a part of the examination for the benefit of the employer, applicant, and the general motoring public.

III. DATA COLLECTION

All physical examination data were collected while providing strict anonymity for each member of the three vibrated and one nonvibrated worker groups. An attempt was made to obtain a valid sampling of all types of jobs by including all drivers at a given terminal so as to be representative of the truck-driving occupation. The distribution of the 3,205 individual, interstate truck drivers included in this study according to their major "city" or "line" job assignments and according to the employing motor carrier is shown in Table 1 (page 7).

Morbidity information was collected for each member of the two study and two comparison groups from data recorded by medical examiners certifying physical and mental fitness on periodic medical examination records. Samples of the kinds of medical examination forms prescribed in the trucking industry for commercial drivers and designated by the FAA for the air traffic controllers in connection with certifications for renewal of their respective operator's licenses are included for ready reference in Appendices A and B.

Prior to our receiving the health records, the personnel offices of the terminals for each of the two participating carriers and the regional FAA offices for the air traffic controllers sanitized the health records to protect the privileged nature of medical information. A nontraceable, collation-identifying code number was provided for each of the cumulative sets of health records completed for individual drivers and controllers by medical examiners. These sanitized physical examination records were photocopied and delivered to the project staff.

Air traffic controllers who were identified as former pilots, navigators, or crewmembers involving flight duties where they may have been exposed to wholebody vibration for extended periods of time (2 or more years), have been eliminated from Comparison Group 1. Altogether, we received cumulative health history data according to the length of employment or availability of records on 1,137 air traffic controllers who were actively employed on the job up to and including the summer of 1976.

Due to the size of the interstate-bus-driver population in our computerized, morbidity-data files (2,946), the data base for Comparison Group 2 has a relatively greater statistical reliability than that for Comparison Group 1.

IV. DATA EDITING AND CODING

Before the physiological and morbidity data were transferred from the received physical examination records into computer files, they were processed by logging-in, collating, editing, and coding.

A. Editing

About 20,000 periodically-updated health history questionnaires and completed physical examination records cooperatively were made available to the project staff by the participating truck companies for our population of 3,205 individual truck drivers. Some 6,357 of the cumulative total of these medical examination records, representing about every third one, were updated as appropriate and selected as best representative for detailed analysis and entry into computer files. The main criterion for selecting each of the 6,357 sample examination records which are shown as distributed according to age, experience, and job title of the truck drivers in Table 2, was that no more than one medical examination record should be included in each of the 10-year age groups for any given, individual truck driver. Before any of the remaining 13,000 or so unselected physical examination records were discarded, all identified medical conditions, abnormalities, impairments, symptoms or other evidence of morbidity (i.e., "health defects") were checked and verified with recorded entries appearing for each individual driver on any selected sample examination record(s) as required to assure completeness of the health history section of each selected sample examination record when processed to reflect true driver's morbidity experience. All morbidity information of any significance was noted, retained, and retrieved as a result of this editing procedure, which resulted in a substantial saving of time without any loss of morbidity information. Morbidity which was experienced or accumulated before being employed as an interstate commercial driver, during any noted military service or during identified off-duty time as recorded on the medical examination form were excluded to the extent possible from this occupational health study.

Comparable, pertinent morbidity information was extracted from the periodic physical examination records of air traffic controllers, and interstate bus drivers in exact parallel to morbidity data obtained for truck drivers by the same members of the project staff, to provide common bases to the extent possible for the interpretation of the results of morbidity experience comparisons.

B. Coding

Due to the wealth of morbidity information extracted from the selected 14,271 sample examination records of the 7,284

Table 2. Distributions of Truck Drivers' Sample Physical Examination Records According to Age and 0 to 44 Years of Commercial Driving Experience.

Age	Sample Physicals								Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-44	
Under 25	480	-	-	-	-	-	-	-	480
"A": 25-34	315	478	494	3	-	-	-	-	1,290
"B": 35-44	103	176	252	402	226	-	-	-	1,159
"C": 45-54	17	43	45	104	174	147	46	-	576
55 & Over	2	4	8	12	23	34	27	19	129
									<u>Total</u> 3,634

a. Local-Pickup-and-Delivery ("City") Drivers (N=1,836).

Age	Sample Physicals								Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-44	
Under 25	89	-	-	-	-	-	-	-	89
"A": 25-34	113	260	372	1	-	-	-	-	746
"B": 35-44	55	98	232	353	301	-	-	-	1,039
"C": 45-54	12	19	37	105	232	192	83	-	680
55 & Over	2	1	3	9	30	52	51	21	169
									<u>Total</u> 2,723

b. Over-the Road ("Line") Drivers (N=1,369).

Age	Sample Physicals								Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-44	
Under 25	569	-	-	-	-	-	-	-	569
"A": 25-34	428	738	866	4	-	-	-	-	2,036
"B": 35-44	158	274	484	755	527	-	-	-	2,198
"C": 45-54	29	62	82	209	406	339	129	-	1,256
55 & Over	4	5	11	21	53	86	78	40	298
									<u>Total</u> 6,357

c. All Truck Drivers (N=3,205).

individuals who were included in the overall total of the study either as a member of a study group or of a comparison group, two 8-column/10-row replicas or worksheets corresponding to the layout of IBM-punchcards were designed as required to collate and organize the extracted data which had been systematized for computer processing. The use of worksheets allowed ancillary project personnel without clinical background to work with coded medical data.

Morbidity information including chronic or acute medical conditions or symptoms and any surgeries or injuries was identified and promptly coded in conformity with the established and accepted four-digit system of the Eighth Revision International Classification of Diseases Adapted for the United States (ICDA)¹⁴. A different variable (column) and symbol (row) was allocated on worksheets and subsequently on punchcards to accommodate data corresponding to any entry on each of the selected sample examination records (see Appendix C for a sample of this worksheet on page 52). The process was reversed during computerized-data processing to interpret the retrievals from the computer printouts. While the use of worksheets on first inspection may appear to be wastefully time consuming when compared with ICDA-coding directly on the sample examination records themselves, the technique included certain important advantages such as

the keypunch operators could directly process the worksheets without any requirements to make particular decisions which might adversely affect the accuracy of keypunching,

the medical examination records themselves could be stored in the main research office with greater security and protection against compromise or loss of information, and

the morbidity data could be collated and grouped under major morbidity divisions or ailment-area headings such as metabolic, circulatory, digestive, etc., as they appear in the ICDA-ordering to facilitate data analyses according to broad diagnostic breakdowns or disease classifications.

¹⁴Eighth Revision International Classification of Diseases Adapted for the United States. National Center for Health Statistics; Public Health Service Publication No. 1693. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Stock Number 017-001-00295-0.

V. DATA ANALYSIS

Analytical procedures including data manipulation strategies, setting-up of hypotheses, and testing of hypotheses are discussed below.

A. Data Manipulations

After all editing and coding of the collected morbidity data were completed for the 7,284 vibration-exposed or vibration-unexposed, sedentary workers in this study, a large number of tabulations and multivariate distributions were generated for inspection by a CDC CYBER 74 computer, using computer programs in the Statistical Programs for the Social Sciences manual (distributed by Northwestern University, Evanston, Illinois).

As indicated by the age/experience distributions of the selected sample examination records in Table 2 (page 13), the inclusive populations for age groups "21 through 24" and "55 and over" were too small for statistical evaluation of the retrieved morbidity data. Likewise, in the under 35 age groups, the age limited commercial driving experience.

To facilitate the establishment of significant differences in the morbidity patterns for the various study and comparison groups, we concentrated on commercial drivers and air traffic controllers (controllers, for short) in the middle age groups (B and C). It was considered most useful in a meaningful search for possible chronic effects on physical health of wholebody-vibration exposure to provide contrasting bases of years and severity of wholebody vibration exposure but with similar ages and relatively large population sizes. The ten driver and controller populations shown in Table 3 were identified in and retrieved through the computerized, morbidity-data files for comparisons of their morbidity experience. The contrasting commercial driver populations are noted to be relatively homogeneous regarding both age and commercial-driving-experience factors.

B. Basic Hypothesis

The basic hypothesis to be tested was that the proportions of sedentary workers with a history of certain physical disorders are significantly higher among the various truck driver populations than in either one of the age-matched comparison groups.

C. Morbidity Measures

It now remained to correlate the various measures of morbidity experience with the duration and severity of wholebody-vibration exposure.

Table 3. Size, Age and Wholebody-Vibration Exposure Distributions for the Ten Populations Selected for Morbidity-Experience Comparisons.

	Population	Size	Mean Age, Years	Mean Exposure, Years
Age Group "B"	City Drivers	628	41.6	18.6
	Line Drivers	654	42.2	19.1
	All Truck Drivers	1,282	41.9	18.8
	Controllers (Comparison Group 1)	542	40.7	<2
	Bus Drivers (Comparison Group 2)	783	42.1	18.3
Age Group "C"	City Drivers	471	49.6	23.4
	Line Drivers	612	49.8	24.1
	All Truck Drivers	1,083	49.7	23.8
	Controllers (Comparison Group 1)	194	50.4	<2
	Bus Drivers (Comparison Group 2)	1,205	50.4	23.5

The simplest method of accounting for the morbidity experiences of our worker populations is to compute the incidence rates per 1,000 persons over the initial 18- or 24-year period on-the-job (see under the Mean Exposure heading in Table 3) for all frequently-diagnosed disorders. Some health problems which were frequently observed in the commercial driver populations of Table 3 are listed in Table 4. The sequencing is based mainly on the corresponding ICDA-code designation numbers rather than incidence rates.

The entire human body may be adversely affected by occupational exposure to low-frequency, wholebody vibration. The search to identify any aggregate effects of wholebody vibration on the various organ systems of individuals and groups was facilitated by the 13 morbidity indices encompassing medical conditions related to the same organ system. They are listed in Table 5 in the order which follows the World Health Organization's systematized breakdown of the "morbidity spectrum" into several broad diagnostic or ailment areas.

Table 4. Some Frequent Health Problems

Medical Condition	ICDA Codes
1. Obesity	277
2. Nervous stomach	305.5
3. Partial deafness	389.9
4. Essential hypertension	401
5. Varicose veins of lower extremities or operations	454.9, 24.4
6. Hemorrhoids or hemorrhoidectomy	455, 51.3
7. Hypotension	458.0
8. Cardiac arrhythmias	427.9
9. Acute respiratory infections or sinusotomy	460-464, 19.7
10. Influenza	470
11. Pneumonia	486
12. Enlargement of tonsils and adenoids or operations	500, 21
13. Diseases of oral cavity or glossectomy	520-525, 96.2
14. Peptic ulcer or operations	533, 46
15. Hernia of abdominal cavity or repair	550-533, 38
16. Appendicitis or appendectomy	540, 41.1
17. Disease of male genital organs or operations	600-607, 58-61
18. Acute nephritis or operations	580, 54.5
19. Kidney stone or operations	592, 54.1
20. Pyuria	789.1
21. Pilonidal cyst or operations	685, 52
22. Vertebrogenic pain syndrome	728
23. Pain in joint	787.3
24. Diseases of joint or operations	724-729, 87
25. Bone deformities	735-738
26. Dislocations	830-839
27. Sprains or strains	840-848
28. Overweight by 10% or more	---
29. Underweight by 10% or more	---
30. High systolic blood pressure	---
31. Low systolic blood pressure	---
32. High diastolic blood pressure	---
33. Low diastolic blood pressure	---

Table 5. The 13 Morbidity Indices -- The Major Bands of the Morbidity Spectrum.

Ailment Area	ICDA Codes
1. Infective and Parasitic Diseases	000-136
2. Neoplasms	140-239
3. Metabolic Diseases	240-279
4. Mental Disorders	290-316
5. Neurological Disorders	320-358
6. Vision Disorders	360-379
7. Hearing Disorders	380-389
8. Circulatory Diseases (See Table 6)	390-458
9. Respiratory Diseases (See Table 7)	460-519
10. Digestive Diseases (See Table 8)	520-577
11. Genitourinary Diseases (See Table 9)	580-629
12. Skin Diseases	680-709
13. Musculoskeletal Diseases (See Table 10)	710-738

Tables 6 through 10 illustrate components within some of the morbidity indices by listing the circulatory, respiratory, digestive, genitourinary and musculoskeletal ailments in the order of the ICDA Code numbers as diagnosed by the hundred of examiners who have certified the over six thousand commercial drivers included in this study. Chronic conditions are coupled with acute conditions that relate to the same organ system under the heading of each ailment area. Each of the listed medical conditions uniformly was considered to contribute one defect value toward the corresponding morbidity index value. This is based on the premise that each had been discovered and identified by the examining physician and in no way implies any prognosis values which could involve considerable problems for evaluation of seriousness of a condition other than by the examining physician. Hypertension therefore contributes no more and no less toward the circulatory morbidity index than any other circulatory disease such as hypotension. Coarse or broadband morbidity-data breakdowns which are based on the 13 morbidity indices, simultaneously take into account all of the recorded, nondisqualifying conditions of an examined individual which are relatable to the same organ system. These composite measures of any degree of illness may be used to identify

Table 6. Breakdown of Morbidity Index 8 -- Circulatory Ailments of Commercial Drivers.

Medical Condition	ICDA Code
<u>Chronic</u>	
Rheumatic fever	391
Active rheumatic endocarditis	391.1
Diseases of mitral valve	394.9
Essential hypertension	401
Heart murmur	424.9
Enlargement of heart	429.0
Arteriosclerosis	440
Peripheral aneurysm	442
Capillary disease	448
Varicose veins of lower extremities	454
Hemorrhoids	455
Varicocele of scrotum	456.1
Hypotension	458.0
<u>Acute</u>	
Rheumatic fever	390
Valvular insufficiency	397.9
Acute myocardial infarction	410.0
Acute coronary insufficiency	411.9
Angina pectoris	413.9
Acute pericarditis	420
Cardiac arrhythmias	427.9
Cardiac/myocardial insufficiency	428
Subarachnoid hemorrhage	430.0
Aortic aneurysm	441.2
Raynaud's phenomenon	443.0
Aortic occlusion	444.0
Arterial thrombosis of extremities	444.4
Pulmonary embolism and infarction	450
Phlebitis and thrombophlebitis	451.0
Venous embolism and thrombosis	453
Ruptured leg vessel	458.9
Precordial pain	782.0
Syncope, collapse or fainting	782.5
Edema and dropsy	782.6
Excessive sweating	788.1
Hematuria	789.3

Table 7. Breakdown of Morbidity Index 9 -- Respiratory
Ailments of Commercial Drivers.

Medical Condition	ICDA Code
<u>Chronic</u>	
Bronchitis	490
Emphysema	492
Asthma	493
Enlargement of tonsils and adenoids	500
Pharyngitis and nasopharyngitis	502
Sinusitis	503
Deflected nasal septum	504
Nasal polyp	505
Paralysis of vocal cords or larynx	508.0
Polyp of vocal cords or larynx	508.1
Interstitial pneumonia	517
<u>Acute</u>	
Nasopharyngitis	460
Sinusitis	461
Laryngitis and tracheitis	464
Influenza	470
Pneumonia	486
Hay fever	507
Empyema	510
Pleurisy	511
Spontaneous pneumothorax	512
Brochiectasis	518
Collapse of lung	519.0
Edema of lung	519.1
Nose bleed	783.0
Shortness of breath	783.2
Pain in chest	783.7

Table 8. Breakdown of Morbidity Index 10 -- Digestive
Ailments of Commercial Drivers.

Medical Condition	ICDA Code
<u>Chronic</u>	
Disturbance of tooth eruption	520.6
Pyorrhea	523.4
Acquired absence of teeth	525.0
Stone of salivary gland	527.5
Peptic ulcer	533
Diverticulum of appendix	543
Inguinal hernia	550
Umbilical hernia	551.1
Hiatal hernia	551.3
Gastroenteritis or colitis	561
Diverticulitis of colon	562.1
Ulcerative colitis	563.1
Irritable or spastic colon	564.1
Anal fissure or fistula	565
Cirrhosis of liver	571.8
Hepatomegaly	785.1
<u>Acute</u>	
Dental caries	521.0
Periodontal abscess	523.3
Esophageal cardiospasm	530.0
Gastritis or duodenitis	535
Pyloric stenosis	537.0
Appendicitis	540
Intestinal obstruction	560.9
Peritonitis with abscess	567.0
Prolapsed rectum	569.1
Ruptured bowel	569.9
Hepatitis	570
Cholecystitis	575
Pancreatitis	577.0
Loss of appetite	784.0
Nausea or vomiting	784.1
Pylorospasm	784.2
Heartburn	784.3
Hematemesis	784.5
Abdominal pain	785.5

Table 9. Breakdown of Morbidity Index 11 --
Genitourinary Ailments of Commercial
Drivers.

Medical Condition	ICDA Code
<u>Chronic</u>	
Prostatitis	601
Hydrocele	603
Ulceration of penis	607.2
Spermatocele	607.6
Atrophy of testicle	607.8
<u>Acute</u>	
Nephritis	580
Pyelonephritis, pyelitis or pyelocystitis	590.1
Kidney stone	592
Diseases of kidney or ureter	593
Renal obstruction	593.2
Cystitis	595
Bladder disease	596.9
Urethritis	597
Urinary-tract infection	599.0
Urinary-tract hemorrhage	599.9
Orchitis or epididymitis	604
Cyst or atrophy of testis	607.9
Albuminuria	789.0

Table 10. Breakdown of Morbidity Index 13 --
Musculoskeletal Ailments of Commercial
Drivers.

Medical Condition	ICDA Code
<u>Chronic</u>	
Spondylosis	713.1
Arthritis	715
Lumbago	717.0
Torticollis	717.2
Muscular rheumatism, fibrositis or myalgia	717.9
Rheumatism	718
Osteomyelitis or periostitis	720
Aseptic bone necrosis	723.5
Calcaneal spur	723.7
Displacement of intervertebral disc	725
Ankylosis of spine, shoulder, elbow, wrist, finger or ankle	727
Vertebrogenic pain syndrome	728
Disease of the knee	729.8
Bunion	730
Synovitis, bursitis or tenosynovitis	731
Diseases of muscle, tendon or fascia	733.9
Curvature or deformity of spine	735.9
Flat foot	736
Hallux valgus	737
Bone deformities	738.9
<u>Acute</u>	
Affection of sacroiliac joint	726
Contracture of palmar fascia	733.5
Muscle spasm or tremor	780.3
Pain in limb	787.1
Pain in joint	787.3

possible relationships to wholebody-vibration exposure, which might have been overlooked by narrowband analyses, i.e., correlations with the selected health problems of Table 4. They tend to quantify the degree of damage to the various organ systems which occurred following 15 or more years of truck-driving exposure, as well as identify the truck drivers organ systems most strained or deteriorated by the stresses and demands of their jobs.

D. Testing of Hypotheses

Any differences which may be observed as a result of narrowband or broadband morbidity data analyses between the truck-driver and comparison groups of Table 3 will be tested for statistical significance by using the chi-square test at both the "B" and "C" age levels as they may be related to the

incidence rates of specific medical conditions and

proportions of individuals in apparently normal health who have not as yet suffered from any recognized ailment of a given type in any of the major diagnostic areas.

The presence of a certain medical condition ('success') or the absence of it ('failure') in the study and comparison groups may be written in the form of a 2x2 contingency table as follows:

	<u>Study Group</u>	<u>Comparison Group</u>	<u>Total</u>
'Success'	R ₁	R ₂	R
'Failure'	S ₁	S ₂	S
Total	N ₁	N ₂	N

The chi-square statistic is calculated according to the formula¹⁵

¹⁵ Natrella, M.G.: Experimental Statistics. National Bureau of Standards Handbook 91, Washington, D.C., 1966.

$$\chi^2 = \frac{N(|R_1 S_2 - R_2 S_1| - N/2)^2}{RSN_1 N_2}$$

where

χ = critical risk value

N_1 = size of study group,

N_2 = size of comparison group,

$N = N_1 + N_2$,

R_1 = number of impaired truck drivers in a study group,

R_2 = number of impaired individuals in a comparison group,

$R = R_1 + R_2$,

$S_1 = N_1 - R_1$,

$S_2 = N_2 - R_2$, and

$S = S_1 + S_2$.

The critical risk-level values of χ^2 are: 2.71 (10%), 3.84 (5%), and 6.63 (1%).

VI. RESULTS

Epidemiological evidence which was developed for long-term adverse health effects of wholebody-vibration exposure as a result of analyzing the truck-driver morbidity data in a coarse manner as well as in fine detail is presented in the following Sections A through C. The statistical results derived from comparative analyses of the morbidity findings for the ten contrasting populations of Table 3 are discussed in Chapter VII.

A. Health Problem Results -- Comparison Group 1

After incidence-rate data had been compiled for the truck-driver populations of Table 3, disease rates were ranked and the 33 conditions for which sufficient morbidity data existed to warrant inclusion in the narrowband morbidity-data analyses are being referred to as selected health problems (see Table 4). Table 11 contains the results of chi-square testing the incidence rates generated for the "B" and "C" age groups of city, line, and all truck drivers against those for the air traffic controllers. Significant negative and positive correlations at the 1%, 5%, and 10% risk levels (i.e., -3, -2,

Table 11. Significance of Differences in the 18- and 24-Year Incidence Rates of Selected Health Problems Between the Truck-Driver and Controller Populations of Table 3.

Medical Condition (see Table 4)	Significance Level [†]					
	"B" Age Groups			"C" Age Groups		
	City Drivers	Line Drivers	All Truck Drivers	City Drivers	Line Drivers	All Truck Drivers
1	-3	+2	0	-2	0	0
2	-3	-3	-3	-3	0	0
3	-3	-3	-3	-3	-3	-3
4	+3	+3	+3	+3	+3	+3
5	0	0	0	0	0	0
6	-3	0	-3	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	-3	-3	-3	-3	-3	-3
10	-3	-3	-3	-3	-3	-3
11	0	0	0	0	0	0
12	0	+2	+2	+3	+3	+3
13	+3	+3	+3	+3	+3	+3
14	0	0	0	0	+3	+2
15	0	0	0	0	0	0
16	+2	+3	+3	+3	+3	+3
17	-3	-3	-3	-3	-3	-3
18	0	0	0	0	0	0
19	-3	-3	-3	0	0	0
20	+3	+2	+3	0	+1	0
21	0	0	0	0	+1	0
22	0	0	0	0	0	+1
23	-3	-3	-3	-3	-1	-3
24	0	0	0	0	+1	+1
25	0	0	0	+3	+3	+3
26	0	+3	+2	0	0	0
27	0	-2	-1	0	0	0
28	+3	+3	+3	+2	+3	+3
29	+2	0	0	+1	0	0
30	+1	0	+1	+1	+1	+1
31	-3	-3	-3	-3	-3	-3
32	+3	+3	+3	+3	+3	+3
33	0	0	0	0	0	0

† 0($p \geq .10$), 1($p < .10$), 2($p < .05$), and 3($p < .01$)

Positive integers designate that the medical condition was found to be significantly more frequent among truck drivers than air traffic controllers. Negative integers designate the opposite.

-1, +3, +2, and +1, respectively) have been discovered for about fifty percent of the 33 selected health problems as were listed. The meaning attributed to any negative integer is that the selected health problem statistically appears to be more frequent in the vibration-unexposed air traffic controllers than in the vibration-exposed truck drivers. Positive integers have opposite attributes where the truck drivers had significantly higher problem incidence. The great variability in the direction of apparent relationships which existed between job demands/stresses and worker health, suggested some interesting follow-ups to us. We then concentrated our investigation by narrowing the field of interest in truck drivers' health problems from the initially-selected 33 by further eliminations to provide a refined selection of 20, and broadening the base of comparison for the truck drivers' morbidity experience by developing comparable incidence-rate data for the less-severely-vibrated interstate bus drivers who had been selected as our internal comparison group (Comparison Group 2). This additional comparison provided much more interpretive power for our findings about the 20 specific medical conditions listed in Table 14 on page 31. The results of comparisons for truck driver disease-incidence-rate data with both the external and internal comparison groups are presented in Section C (see pages 30 through 32).

B. Morbidity Index Results -- Comparison Group 1

Simple numerical indices were formulated in the broadest possible terms to assess differences in morbidity experience which had been postulated as produced partly by job demands and stresses. Each health problem or abnormality which had been noted by the medical examiners on the periodic physical examination records was allocated to no more than one of the 13 ailment areas listed in Table 5. The coalescing of all health defects into 13 ailment areas was structured according to the established, standard practices of the World Health Organization¹⁴ (see Tables 6 through 10 for the makeup of morbidity indices of special interest). For example, a score which could be applied to measure individual worker's state of circulatory health was obtained by totaling any accumulated circulatory ailments as listed in Table 6. Unit (1) value was assigned to each retrieved health problem to provide for due recognition and computational simplicity. The mean numbers representing development of disorders referable to the specific organ systems of truck drivers and air traffic controllers per 1,000 workers, are shown in Table 12.

It is apparent from Table 12 that air traffic controllers have higher mean health defect values in some ailment areas and lower mean health defect values in other ailment areas. These data were subjected to tests of statistical significance by using the F-statistic.¹⁵ The results of this F-testing for the statistical significance of apparent differences in mean health

Table 12. Comparison of the Total Health Defects Accumulated by the Interstate-Truck-Driver and Air-Traffic Controller Populations of Table 3.

Morbidity Index (see Table 5)	Health Defects per 1,000 Workers							
	"B" Age Groups				"C" Age Groups			
	City Drivers	Line Drivers	All Truck Drivers	Controllers	City Drivers	Line Drivers	All Truck Drivers	Controllers
1	30	32	31	131	43	41	42	119
2	21	51	36	87	45	93	72	98
3	64	170	118	210	117	230	181	325
4	80	141	111	262	108	222	173	253
5	51	89	70	244	74	132	107	217
6	69	78	73	170	100	137	121	206
7	188	173	180	729	314	306	309	959
8	462	512	488	476	777	837	811	634
9	272	349	311	1,096	357	443	405	892
10	994	1,352	1,176	1,107	1,391	1,954	1,709	1,356
11	131	144	137	319	134	255	202	351
12	237	232	235	463	291	312	303	469
13	844	1,011	929	1,076	1,121	1,387	1,272	1,253

defect values between interstate truck drivers and air traffic controllers are shown in Table 13. Any positive numbers designate truck drivers as having a significantly increased number of health problems of a particular type per 1,000 workers than air traffic controllers. Any negative numbers conversely designate air traffic controllers as having a significantly increased number of health problems of a particular type per 1,000 workers than truck drivers. Zero values designate that insignificant statistical differences existed in the mean number of identified health defects per worker between truck drivers and air traffic controllers. The

tabulation of the relatively few zeros indicates that the number of accumulated health defects as extracted from the medical records generally have definite relationships to the differences in the important characteristics of the compared occupational groups (i.e., occupational differences).

Table 13. Significance of Differences in Mean Health Defect Values per Worker Between the Inter-state-Truck-Driver and Air-Traffic Controller Populations of Table 3.

Morbidity Index (see Table 5)	Significance Level [†]					
	"B" Age Groups			"C" Age Groups		
	City Drivers	Line Drivers	All Truck Drivers	City Drivers	Line Drivers	All Truck Drivers
1	-3	-3	-3	-3	-3	-3
2	-3	-2	-3	-2	0	0
3	-3	0	-3	-3	-2	-3
4	-3	-3	-3	-3	0	-2
5	-3	-3	-3	-3	-2	-3
6	-3	-3	-3	-3	-1	-3
7	-3	-3	-3	-3	-3	-3
8	0	0	0	+1	+2	+2
9	-3	-3	-3	-3	-3	-3
10	0	+3	0	0	+3	+3
11	-3	-3	-3	-3	-1	-3
12	-3	-3	-3	-3	-2	-3
13	-3	0	-1	0	0	0

[†] 0 ($p \geq .10$), 1 ($p < .10$), 2 ($p < .05$), and 3 ($p < .01$)

Positive integers designate that the health defects were found to be significantly more frequent among truck drivers than air traffic controllers or bus drivers. Negative integers designate the opposite.

C. Disease Incidence Results -- Comparison Groups 1 and 2.

The results of statistical-significance calculations using the 24-year disease incidence rates of the truck drivers for the 20 specific medical conditions listed in Table 14 in relation to each of the two comparison groups of Table 3, are summarized in Table 15. As shown in Table 3 (page 16), the approximately 50-year old truck drivers with an average of 24 years of service, have been compared for recorded morbidity experience with air traffic controllers and interstate bus drivers of approximately the same mean age. Members of these occupational groups also have qualified after having passed a similar number of medical examinations (about 10-each, for truck drivers, air traffic controllers, and bus drivers) for renewal of their respective professional licenses. The morbidity patterns of truck drivers, air traffic controllers, and bus drivers apparently are differentially affected as evidenced by a distinctive morbidity pattern displayed for each occupational group. Possible reasons for these are discussed in the next chapter (see pages 38 through 44).

VII. DISCUSSION

A. General

We must be cautious in drawing conclusions about causality solely from the results of statistical analyses. The contributory role of occupational wholebody-vibration exposure in the development of chronic physical disorders of interstate truck drivers cannot be assessed properly without postulating mechanisms of wholebody-vibration action and mechanisms of actions for all other significant job stresses/demands having possible etiological significance. Statistical methods alone cannot establish valid proof of a sole causal relationship in an association.

The over 7,000 members of the occupational groups which were selected for comprehensive evaluations of their health problems in this study, have been medically evaluated under widely-varying circumstances by hundreds of examining physicians. These health-monitored workers are by many comparisons generally similar to each other, but they also differ so that one group's morbidity experience can be compared in some important features with the other group to note any possible patterning which may be associated with these features. Identification of truck drivers' vibration-related health problems will then be possible through discovery of occupational differences in the observed morbidity patterns among the four study/comparison groups.

The degree of success in identifying those features in the interstate truck drivers' morbidity experience which are related to the wholebody-vibration factor of their job depends

on three main considerations. These are directly related to our insight into the many possible

significant etiologic factors which may be involved in the development of chronic physical and mental disorders that were frequently observed among truck drivers having 15 or more years of service,

biodynamic strains and pressure fluctuations that could develop in the various organ systems of truck drivers as a result of stressing the drivers' body by vehicular vibrations which if sustained over a prolonged period of time, could lead to the development of chronic physical disorders, and

Table 14. The 20 Specific Medical Conditions.

Ailment Area	Medical Condition	ICDA Code
Metabolic	1. Obesity	277
Mental	2. Nervous stomach 3. Nervous fatigue	305.5 790.0
Neurological	4. Diseases of peripheral nerves	350-358
Hearing	5. Partial deafness	389.9
Circulatory	6. Essential hypertension 7. Hemorrhoids 8. Hypotension	401 455 458.0
Respiratory	9. Respiratory infections	460-464
Digestive	10. Diseases of oral cavity 11. Peptic ulcer 12. Appendicitis 13. Inguinal hernia	520-525 533 540 550
Genitourinary	14. Kidney disease 15. Disease of male genital organs	592 600-607
Skin	16. Pilonidal cyst	685
Musculoskeletal	17. Vertebrogenic pain syndrome 18. Diseases of muscle 19. Bone deformities 20. Sprains or strains	728 730-734 735-738 840-848

Table 15. Significance of Differences in the 24-Year Incidence Rates of Specific Medical Conditions Between Interstate Truck Drivers and the Comparison Groups of Table 3.

Medical Condition (see Table 14)	Significance Level [†]					
	Comparison Group 1			Comparison Group 2		
	City Drivers	Line Drivers	All Truck Drivers	City Drivers	Line Drivers	All Truck Drivers
1	-2	0	0	-3	-3	-3
2	-3	0	0	0	+3	+2
3	-3	-3	-3	-3	-3	-3
4	0	0	0	0	0	0
5	-3	-3	-3	+3	+3	+3
6	+3	+3	+3	+3	+3	+3
7	0	0	0	0	+3	+1
8	0	0	0	+3	+3	+3
9	-3	-3	-3	-3	-3	-3
10	+3	+3	+3	+3	+3	+3
11	0	+3	+2	0	+3	+1
12	+3	+3	+3	0	0	0
13	0	0	0	0	0	0
14	0	0	0	-1	0	0
15	-3	-3	-3	0	0	0
16	0	+1	0	0	0	0
17	0	0	+1	+3	+3	+3
18	-3	0	-2	-2	0	-2
19	+3	+3	+3	+3	+3	+3
20	0	0	0	+3	+3	+3

[†] 0($p \geq .10$), 1($p < .10$), 2($p < .05$), and 3($p < .01$)

Positive integers designate that the medical condition was found to be significantly more frequent among truck drivers than air traffic controllers or bus drivers. Negative integers designate the opposite.

differences or similarities among the various occupational groups within this study in such uncontrollable variables as applicable fitness standards; health-maintenance-examination forms; diagnostic procedures; closeness of medical surveillance; frequency of physical examinations; and any special, certifying qualifications required of medical examiners.

These are discussed below.

1. Job Demands and Work Environment

Most occupational diseases etiologically are not agent-specific in that they may be caused by combinations of contributory job demands and environmental stresses. The overall captured morbidity experience of interstate truck drivers, which was displayed in Table 12, is due in part to aging and to the many demands and stresses associated with truck driving and related tasks rather than simply the wholebody-vibration stress factor, which may or may not have contributed to, caused or aggravated any of the identified, specific physical disorders. All etiologically significant factors must be taken into account in order to determine which particular illness(es), if any, specifically may be attributed to the wholebody-vibration factor or to truck driving.

This epidemiological study has provided the opportunity to make some comparisons of job demands/stresses with worker health in three occupational groups having widely-different, wholebody-vibration stress characteristics. Different kinds of work may be associated with similar and different sets of demands and stresses. The relationships of environmental factors to worker health can be explored in such studies as the present one which includes access to recorded medical data from files of periodic, comprehensive medical examinations.

We expect to observe a certain amount of specificity in these selected-group relations in that different stresses will produce somewhat different adverse effects. Attempts to discover and carefully assess any differences in job demands/stresses should prove valuable for explaining any or all of the significant differences which may exist in group-specific disease incidence rates.

Significant differences obviously exist in the air-traffic-controller and commercial-driver work environments aside from the wholebody-vibration factor. Some of the important features of the drivers' and controllers' jobs and organized, occupational-health programs are reviewed as follow.

a. Interstate Truck Drivers

The physical and mental tasks involved with driving a truck in interstate commerce may be more straining and fatiguing in many respects than piloting of a large aircraft. Interstate freight transportation frequently places heavy mental and physical demands on truck drivers. The interstate truck driver must face adverse environmental stresses and meet all job demands alone and unaided by a copilot, navigator, or air traffic controller. The cause-and-effect relationships between job demands and stresses on one side and strains, fatigue, and morbidity on the other are not simple in nature. The following are partial listings of usual job demands and environmental stresses of interstate truck drivers.¹⁶

(1) Job Demands

General

Abrupt duty hours changes,
Sleep deprivation,
Unbalanced work/rest cycle,
Long driving without eating,
Short notice of assignment to a run,
Tight delivery schedules,
Delays after scheduled departure time,
Delays enroute,
Warning letters following chargeable accidents,
Economic pressures,

Physical

Visual and auditory monitoring,
Upright posture,
Steering, gear shifting, backing, passing, etc.
Vehicle and cargo inspection,
Cargo handling,
Coupling and uncoupling,

¹⁶Gruber, G.J.: Guide for Medical Examiners to Determine Fitness to Drive in Interstate Commerce, Part 2, Job Demands and Hardships. Department of Transportation Contract No. DOT-FH-11-8274A with Southwest Research Institute, San Antonio, Texas, 1976.

Mental

Constant attention to details,
Responsibility,
Trip planning,
'Living" away from home,
Sleeper-berth operations,
Poor layover facilities,
Confusing rules and regulations, and
Excessive administrative requirements.

(2) Environmental Stresses

Physical

Wholebody vibration,
Noise,
Illumination,
Close people contact,
Heat, humidity, and cold,
Weather and roads,

Chemical

Food,
Carbon monoxide,

Psychosocial

Monotony,
Traffic,
Negative life situations, and
Lack of social support.

b. Air Traffic Controllers

These individuals generally work under close supervision (including medical) with backup personnel frequently close at hand. Notable characteristics of the controllers' job are the high degree of

feelings of responsibility for flight safety,
demands for concentration, and

variation in mental workload.

Compared with interstate truck drivers, air traffic controllers in their work situations usually are required to cope with

higher levels of psychosocial stress,
closer physical contact with other people,
low-to-moderate noise levels,
few requirements for lifting, carrying, etc.,
no occupational vibration,
more regular work/rest cycles,
better eating habits,
less monotony, and
no noxious fumes or temperature extremes.

c. Interstate Bus Drivers

Interstate bus drivers work under many of the same stresses and meet many of the same demands as interstate truck drivers. Compared with truck drivers, they are usually required to cope with

higher levels of responsibility,
closer physical contact with other people,
less noise,
less requirements for lifting, carrying, etc.,
less occupational vibration,
more regular work/rest cycles,
better eating habits,
less monotony, and
less exposure to fumes and temperature extremes.

2. Mechanisms-of-Action Considerations

To properly interpret the meaning of any of the statistically, significant, specific morbidity findings which were

summarized in Table 15, one must offer possible explanations for the observed differences based on mechanisms-of-action considerations for significantly important stresses and demands usually associated with the work of interstate truck drivers, air traffic controllers, and interstate bus drivers. Mechanisms for any actions of occupational wholebody-vibration exposure should be discovered and related where feasible in instances when a certain, chronic physical disorder has been found to be associated with truck driving.

3. Health Standards and Monitoring

One can expect to find specific, statistically-significant differences in the incidence rates of certain medical conditions when comparing the morbidity pattern of interstate truck drivers with that of air traffic controllers simply because the controllers in actual practice have somewhat

more selectively screened (certified) medical examiners,

stricter legislated medical fitness standards,

more detailed and standardized medical examination forms, and

closer medical surveillance.

The FAA-certified physicians who examine the controllers, moreover, have a better understanding of the examinees' job demands and stresses, which must have influenced the nature and extent of medical conditions identified on the medical examination records of controllers. The FAA-certified medical examiners' reporting of health history was consistently superior. Completeness of answers was more in evidence on examination records and appeared to indicate substantial cooperation between examiners and applicants. Examiners were assisted to make a more complete medical fitness evaluation of air traffic controllers by relating readily available and updated health history data with current medical findings. Any identified illness therefore could be evaluated from an improved vantage point for possible effects on job performance.

Comparison Group 2 differed somewhat from the air traffic controllers in that the bus drivers and the truck drivers in this study were examined by similar sets of medical fitness standards, company policies, and kinds of physicians employed as medical examiners.

Since all truck driver examination records we received had been prepared for purposes of certifying medical fitness to drive in interstate commerce, it is probable that some medical history and recent physical complaints may have been unreported because drivers being examined for fitness to perform on the job may tend to be guarded in responding and can hardly be expected to volunteer information on the basis of which they might be temporarily or permanently disqualified for their current employment. The presence of this dampening effect on morbidity data extracted from medical examination records obviously was recognized as a potential factor by medical examiners for the truck driver and other occupational groups in this study but the extent is not known. Any biases which could distort the results because of unavailability of health records for those who dropped out from the respective occupations by failure to qualify under minimal health standards, self selection, transfer to other jobs, etc., also cannot be easily determined.

We now turn to the interpretation of the statistically-tested morbidity findings contained in Tables 13 and 15. Table 13 (page 29) comparatively designates long-term accumulation of health defects in specific ailment areas for truck drivers and air traffic controllers in which problems develop at a significant positive or negative rate. Because of the large number of medical conditions which were pooled together under each of the 13 morbidity indices, most differences in morbidity experience between truck drivers and controllers are statistically significant. At first inspection, only a few of the metabolic, circulatory, digestive and musculoskeletal diseases appear to possess good potentials for significant positive correlations with truck driving. This is encouraging since these diseases are among those which were previously suspected to be related to wholebody-vibration exposure. The final detailed analyses of morbidity findings have therefore been directed to these types of physical disorders.

Chi-square tests of the 24-year incidence rates of the 20 medical conditions listed in Table 14 showed a number of positive significant differences for truck drivers in comparison with air traffic controllers and interstate truck drivers (see Table 15 on page 32). The morbidity experience patterns for interstate truck drivers in relation to the comparison groups are observed to be disease specific. They will be discussed in detail, sequentially (see Table 14 on page 31) as follow.

B. Metabolic Diseases

Diabetes mellitus (ICDA Code 250) was subject to certification bias and therefore could not be studied for its incidence among truck drivers.

1. Obesity (ICDA Code 277)--is a disease which is relatively common for sedentary occupational groups, such as our

commercial drivers and air traffic controllers. City drivers are the least obese followed in decreasing-incidence ranking by the controllers and then the bus drivers. Bus drivers are the most obese. It is possible that the increased extent of physical activity which is occupationally associated with the stopping, starting, climbing, lifting, carrying, etc., during local deliveries-and-pickups of city drivers helps them to control potential weight problems. Bus drivers contrastingly have the least physical activity in their work and also tend to regularly eat meals during scheduled rest stops more frequently than truck drivers. Wholebody-vibration does not appear to be a factor in the development of obesity. It may even have a beneficial (i.e., weight-reducing) effect.

C. Mental Disorders

Psychosis (ICDA Code 299), chronic alcoholism (ICDA Code 303), and drug dependence (ICDA Code 304) were disqualifying when evaluated for medical fitness to drive and therefore could not be studied for their incidence among truck drivers.

2. Nervous Stomach (ICDA Code 305.5)--incidence rates were statistically the same for line drivers and controllers, but they were significantly greater for line drivers than bus drivers. Wholebody vibration may be a factor in the development of nervous stomach. This disease is frequently associated with physiological response to sustained psychosocial-stress exposures.

3. Nervous Fatigue (ICDA Code 790.0)--for truck drivers registered the least incidence. Nervous fatigue is frequently associated with emotional response to sustained psychosocial-stress exposures.

D. Neurological Disorders

Epilepsy (ICDA Code 345) was disqualifying when evaluated for medical fitness to drive and therefore could not be studied for its incidence among truck drivers.

4. Diseases of Peripheral Nerves (ICDA Code 350-358)--were infrequent for all occupational groups in this study.

E. Hearing Disorders

5. Partial Deafness (ICDA Code 389.9)-- is a matter-of-degree disorder which was subject to certification and diagnostic biases that were markedly different for the interstate truck driver, air traffic controller and interstate bus driver groups. The significantly higher incidence of hearing loss in the truck driver groups in comparison to bus drivers may owe its origin to the increased use of audiometric measurements on

a large segment of truck drivers in place of the whispered-voice test to assess hearing acuity as well as to the higher noise levels prevailing in truck cabs vs. buses.

F. Circulatory Diseases

Ischemic heart disease (ICDA Codes 410-414), was disqualifying when evaluated for medical fitness to drive and therefore could not be studied for its incidence among truck drivers.

6. Essential Hypertension (ICDA Code 401)--is a matter-of-degree disorder which was subject to certification bias. Applicable medical standards were considerably different for each of the three main occupational groups. The bus companies as a whole required their medical examiners to apply relatively stricter blood pressure standards than required by the truck companies. No commercial driver requirements for blood pressure were as strict as the FAA-standards applied for certification of hypertensive air traffic controllers. As a result of these different requirements, significantly greater proportions of truck drivers with blood pressure levels over 160/90 mm Hg were certified as medically-fit than were air traffic controllers or bus drivers. Excess hypertension among truck drivers probably is an artifact due to selection by medical examiners.

7. Hemorrhoids (ICDA Code 455)--was subject to diagnostic bias since a rectal examination is specifically listed for evaluation on the examination form prescribed for certification of air traffic controllers and therefore could not be studied without bias. Line drivers were observed to have significantly higher incidence of hemorrhoidal problems than bus drivers. Wholebody vibration may be a factor in the development of hemorrhoids. Confinement to a driver's seat and the resonance trunk vibrations have been cited as favoring the development of hemorrhoids. The cyclic buildup of relatively large intraluminal pressures due to resonance wholebody vibration in the 4 to 7 Hz range¹⁷ can be transmitted via the rectum to the hemorrhoidal veins where they can cause damage. Raised intraluminal pressures in the colon may also result from truck drivers' low-residue diet associated with fecal arrest and straining at stool.¹⁸

¹⁷White, G.H., Lange, K.O., and Coermann, R.R.: The Effects of Simulated Buffeting on the Internal Pressure of Man. Human Factors, 275-290, 1962.

¹⁸Burkitt, D.P.: Varicose Veins, Deep Vein Thrombosis, and Hemorrhoids: Epidemiology and Suggested Etiology. British Medical J., 2, 556-561, (1972).

8. Hypotension (ICDA Code 458.0)--is a matter-of-degree disorder which was subject to differential certification bias, resulting in significantly greater proportions of truck drivers who remain on their jobs with blood pressure levels under 100/60 mm Hg. Excess hypotension among truck drivers is an artifact due to selection by medical examiners.

G. Respiratory Diseases

9. Respiratory Infections (ICDA Codes 460-464)--included the common colds, sinus problems, sore throats, etc., and were observed to be most frequent among the air traffic controllers and the bus drivers. These workers obviously have much closer occupational contact with and are therefore exposed to contagious respiratory diseases present in a variety of people than are truck drivers. In the occupations of controllers and bus drivers, frequent transitions to and from air-conditioned areas or hot, humid areas are likely to predispose susceptible individuals to contract acute respiratory infections. Wholebody vibration does not appear to be a factor in the development of respiratory infections.

H. Digestive Diseases

10. Diseases of Oral Cavity (ICDA Codes 520-525)--affect the preservation of teeth which is the least common among truck drivers. Excessive sugar consumption, certain nutritional deficiencies, and other manifestations of bad eating habits are recognized as potent causes of dental caries, abscessed teeth, and root and gum infections. Any adverse vibration effect on diseases of the oral cavity appears to be significantly less than diet or oral-hygiene factors.

11. Peptic Ulcer (ICDA Code 533)--incidence rates associated with a history of healed peptic ulcer among line drivers is significantly higher than those observed among air traffic controllers and bus drivers. The latter occupational groups have relatively better opportunities to take a regular morning or mid-day break for freshly-prepared, easily-digestible, hot meals. Line drivers contrastingly are more likely to skip morning or mid-day meals because they tend to equate lost driving time with less income. Poor quality meals are therefore likely to be eaten more hurriedly and irregularly. The mode of living, lack of physical activity, and psychosocial stress frequently combine with alcohol, caffeine, and nicotine consumption which clearly contribute to the development of peptic ulcers in line truck drivers. Wholebody vibration may be a factor in the etiology of peptic ulcer.

12. Appendicitis (ICDA Code 540)--incidence rates observed among truck drivers is significantly higher than among air traffic controllers. The better eating habits of the

controllers may be the main reason for this. Raised intraluminal pressures associated with low-residue diet, wholebody vibration, and cargo handling of truck drivers may interfere with blood circulation to and from the colon and in the appendiceal mucosa which may contribute to appendicitis. Sustained intraluminal, appendiceal pressures may cause changes in the wall of the appendix.¹⁹ Wholebody vibration may be a factor in the etiology of appendicitis.

13. Inguinal Hernia (ICDA Code 550)--incidence rates were observed to be statistically the same in all three main occupational groups. Wholebody vibration does not appear to be a factor in the development of inguinal hernia.

I. Genitourinary Diseases

14. Kidney Disease (ICDA Code 592)--was not more frequently observed among truck drivers in comparison to air traffic controllers and bus drivers in the present, occupational-health study of city and line truck drivers. The high incidence of this disease among over-the-road ("line") truck drivers has been cited in other studies and was attributed mainly to the wholebody-vibration factor of their job.²⁰ Kidney irritations and frequent urinations with some burning are frequent complaints of drivers of off-the-road vehicles. Strong urges to urinate were noticed even among those farm-tractor drivers whose bladders were relatively empty at the start of the ride. Strong seat vibrations have an apparent diuretic effect. Frequent urination may be stimulated by massage and concussion of bladder against the pelvis and abdominal contents. Morbidity data acquired during the current study do not support a claim for high incidence of kidney disease in interstate truck drivers.

15. Disease of Male Genital Organs (ICDA Codes 600-607)--incidence rates as observed among truck drivers in this study was determined to be significantly lower than among air traffic controllers. A certification bias, however, may have distorted this comparison. A survey of the relationships between wholebody vibration and morbidity patterns among heavy, construction-

¹⁹Wangensteen, O.H. and Bowers, W.F.: The Etiology of Appendicitis. Archs. Surg., Chicago, 34, 496, 1937.

²⁰Dawson, D.: Over the Road to Preventable Disease. Pontiac Medical Science Laboratories, Inc., Pontiac, Michigan, 1972.

equipment operators demonstrated a significantly higher incidence of diseases of the male genital organs in comparison with an appropriate control group.²¹

J. Skin Diseases

16. Pilonidal Cyst (ICDA Code 685)--is the "jeep disease", which was observed to be highly prevalent among drivers of cross-country vehicles. Line drivers in the present study had a barely-significant, higher prevalence of pilonidal cyst than air traffic controllers. The required prolonged periods of sitting coupled with wholebody vibration favors the development of pilonidal cysts, thus both commercial drivers and air traffic controllers may be affected.

K. Musculoskeletal Diseases

Various disorders of the spine and supporting structures were observed to have significantly higher incidence among truck drivers in comparison with air traffic controllers and bus drivers. Vehicular vibrations transmitted via the seats, floors, and steering wheels of trucks (and farm-tractors) to the drivers' buttocks, spines or limbs can "wear and tear" the cartilaginous intervertebral discs or supporting structures of the spine. Strenuous driving activities, faulty body posture, and cargo handling may combine with wholebody-vibration to produce certain musculoskeletal disorders of interstate truck drivers. Some possible etiologic contributions of the wholebody-vibration factor to these disorders are discussed below.

17. Vertebrogenic Pain Syndrome (ICDA Code 728)--incidence rates are significantly higher for truck drivers than were observed in this study for bus drivers. Interstate trucks generally have poorer riding-comfort characteristics than interstate buses as designed for the protection of the commercial drivers' spinal column. Most of the joint-disease problems of truck drivers have been vertebrogenic pain syndrome with displacement of intervertebral disc (ICDA Code 725), affection of sacroiliac joint (ICDA Code 726), and ankylosis of joint being much less common. Vibrations are transmitted to the spine causing microtrauma, with the intervertebral discs having a shock-absorbing effect. When this impacting/jarring action is sustained over prolonged periods, the intervertebral discs

²¹Milby, T.M. and Spear, R.C.: Relationship Between Wholebody Vibration and Morbidity Patterns Among Heavy Equipment Operators. University of California, Berkeley, California. Center for Disease Control Publication No. 74-131, Cincinnati, Ohio 1974.

become fatigued and highly susceptible to displacement or premature, degenerative deformation. Temporary relief from low-back pain may be obtainable by change of posture. When a truck driver's body is positioned in a faulty, non-upright posture, microtrauma is inflicted upon the spine in the vertical and other directions. Additional physiological strain may be imposed on the spine by inferior seat design in some vehicles or heavy manual work which may combine with vibration-induced microtrauma for the development of vertebrogenic pain syndrome.

18. Diseases of Muscle (ICDA Code 730-734)--were observed to be less frequent among truck drivers than among air traffic controllers and bus drivers. Wholebody vibration does not appear to be a factor in the development of muscle disease.

19. Bone Deformities (ICDA Code 735-738)-- of truck drivers mostly have been spine deformities (ICDA Code 735). Truck drivers have a significantly higher incidence of premature, degenerative deformations of the spinal column than air traffic controllers and bus drivers. Spine deformities were nearly twice as prevalent among truck drivers when compared with bus drivers in another study²². Truck vibrations impart microtrauma mainly along the longitudinal axis of the spine. Sustained physiological strain and wear associated with truck drivers' wholebody vibration, forced faulty posture, and heavy manual work may cause stiffening and abnormal curvature of the spine.

20. Sprains and Strains (ICDA Codes 840-848)--incidence rates were observed to be significantly higher among truck drivers when compared with bus drivers. Physiological overstraining while handling cargo or working in a bent position as well as the microtrauma associated with wholebody vibration on the intervertebral discs of the spine may have been responsible.

VIII. CONCLUSIONS

We have weighed new evidence and evaluated published information about long-term effects of occupational wholebody-vibration exposure in attempts to interpret the apparent associations of any excess morbidity with driving trucks in interstate commerce. Available evidence at hand permits one to draw more definite conclusions than heretofore possible⁵ about the adverse health effects of the wholebody-vibration exposures encountered in commercial-driving operations.

²²Barbaso, E.: Incidence of Spine Changes in Drivers of one Bus Company. *Med. d Lavoro*, 49, 10, 1958.

A number of job demands and environmental stresses in addition to wholebody vibration may have been operative, such as forced body posture, cargo handling, lack of exercise, dietary inadequacies, and psychosocial stress for the development of various musculoskeletal, digestive and circulatory diseases as observed for the interstate truck drivers in this study. Identifying the adverse health effects due in large part to any nonvibration stresses and job demands was greatly facilitated by comparisons with two sedentary, medically-supervised occupational groups; one selected from outside and the other within the motor carrier industry. A comprehensive, comparative occupational-health study of interstate truck drivers, air traffic controllers, and interstate bus drivers with emphasis on the wholebody-vibration or other factor(s) has not been conducted until this study. Results of past epidemiological research consequently were not available to help us interpret any differences observed among acquired morbidity patterns. The main conclusions of this study as summarized in Chapter VII (pages 38-44) were based largely on due consideration of observed differences or similarities among the various occupational groups in

morbidity experience,
job demands,
environmental stresses,
medical fitness requirements,
physical examination procedures,
medical supervision,

and postulated mechanisms-of-action of the wholebody-vibration factor. A significant accumulation of evidence currently exists which implicates biodynamic strain, microtrauma, and the intraluminal/intraabdominal pressure fluctuations that are known to be produced by vehicular vibrations in direct association with the development of certain musculoskeletal, digestive and circulatory disorders of truck drivers. The combined effects of forced body posture, cargo handling, psychosocial stress, and improper eating habits along with wholebody vibration cannot be ruled out when considering contributory factors for such truck-driver disorders as vertebrogenic pain syndromes, spine deformities, sprains and strains, appendicitis, stomach troubles, and hemorrhoids.

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APPENDICES

- A. Physical Examination Form for Interstate Truck and Bus Drivers
- B. Medical Examination Form for Air Traffic Controllers
- C. Worksheet for Organizing Physiological and Morbidity Data

PHYSICAL EXAMINATION FORM
(MEETS DEPARTMENT OF TRANSPORTATION REQUIREMENTS)

ATA Form C0730 - Reorder from:
American Trucking Assn., Inc.
1816 F Street, N.W.
Washington, D.C. 20036 3-71

To Be Filled In By Examining Physician (Please Print):

New Certification

Driver's Name _____ Recertification

Soc. Sec. No. _____ Date of Birth _____ Age _____

Health History: Height _____ft. _____in. Weight _____lbs.

Yes <input type="checkbox"/>	No <input type="checkbox"/>	Asthma	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Nervous Stomach	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Head or spinal injuries
<input type="checkbox"/>	<input type="checkbox"/>	Kidney disease	<input type="checkbox"/>	<input type="checkbox"/>	Rheumatic Fever	<input type="checkbox"/>	<input type="checkbox"/>	Seizures, fits, convulsions, or fainting
<input type="checkbox"/>	<input type="checkbox"/>	Tuberculosis	<input type="checkbox"/>	<input type="checkbox"/>	Muscular disease	<input type="checkbox"/>	<input type="checkbox"/>	Extensive confinement by illness or injury
<input type="checkbox"/>	<input type="checkbox"/>	Syphilis	<input type="checkbox"/>	<input type="checkbox"/>	Psychiatric disorder	<input type="checkbox"/>	<input type="checkbox"/>	Any other nervous disorder
<input type="checkbox"/>	<input type="checkbox"/>	Gonorrhoea	<input type="checkbox"/>	<input type="checkbox"/>	Cardiovascular disease	<input type="checkbox"/>	<input type="checkbox"/>	Suffering from any other disease
<input type="checkbox"/>	<input type="checkbox"/>	Diabetes	<input type="checkbox"/>	<input type="checkbox"/>	Gastrointestinal ulcer	<input type="checkbox"/>	<input type="checkbox"/>	Permanent defect from illness, disease or injury

If answer to any of the above is yes, explain: _____

General appearance and development: Good _____ Fair _____ Poor _____

Vision: For Distance: Right 20/ _____ Left 20/ _____

Without corrective lenses With corrective lenses, if worn

Evidence of disease or injury: Right _____ Left _____

Color Test _____

Horizontal field of vision: Right _____° Left _____°

Hearing: Right ear _____ Left ear _____

Disease or injury _____

Audiometric test: (if audiometer is used to test hearing) _____ Decibel loss at 500 Hz _____ at 1,000 Hz _____ at 2,000 Hz _____

Throat: _____

Thorax: Heart _____

if organic disease is present, is it fully compensated? _____

Blood pressure: Systolic _____ Diastolic _____

Pulse: Before exercise _____ Immediately after exercise _____

Lungs _____

Abdomen: Scars _____ Abnormal masses _____ Tenderness _____

Hernia: Yes _____ No _____ If so, where? _____ Is truss worn? _____

Gastrointestinal: Ulceration or other disease Yes _____ No _____

Genito-Urinary: Scars _____ Urethral discharge _____

Reflexes: Romberg _____

Pupillary _____ Light R _____ L _____

Accommodation Right: _____ Left _____

Knee jerks: Right: Normal _____ Increased _____ Absent _____

Left: Normal _____ Increased _____ Absent _____

Remarks: _____

Extremities: Upper _____ Lower _____ Spine _____

Laboratory and Urine. Spec. Gr. _____ Alb. _____ Sugar _____

Other Special Other Laboratory Data (Serology, etc.) _____

Findings: Radiological Data _____ Electrocardiograph _____

MEDICAL EXAMINER'S CERTIFICATE

I certify that I have examined

[Driver's name (Print)]
in accordance with the Motor Carrier Safety Regulations (49 CFR 391.41-391.49) and with the knowledge of his duties, I find him qualified under the regulations.
 Qualified only when wearing corrective lenses
A completed examination form for this person is on file in my office at

Address

(Date of examination) (Name of examining doctor (Print))

(Signature of examining doctor)

(Signature of driver)

(Address of driver)

The following to be completed only when the visual test is conducted by a licensed optometrist.

[Date of Examination]

[Name of Optometrist (Print)]

[Address of Optometrist]

[Signature of Optometrist]

INSTRUCTIONS ON REVERSE SIDE

COPY OF FAA FORM 8500-9 (MEDICAL CERTIFICATE), OR FAA FORM 8420-2 (MEDICAL/STUDENT PILOT CERTIFICATE) ISSUED

AA-0625850

MEDICAL CERTIFICATE 2nd CLASS AND STUDENT PILOT CERTIFICATE

THIS CERTIFIES THAT (Full name and address)
 John James Doe
 5060 West Street
 Easton, Pennsylvania 18042

DATE OF BIRTH	HEIGHT	WEIGHT	HAIR	EYES	SEX
10/10/11	71 in	180	Brown	Brown	Male

has met the medical standards prescribed in Part 67, Federal Aviation Regulations for this class of Medical Certificate

LIMITATIONS
 Holder shall wear correcting glasses while exercising the privileges of his airman certificate.

DATE OF EXAMINATION: 11-28-69
 EXAMINER'S SERIAL NO.: 6035-42-3

EXAMINER SIGNATURE: *John Ames Jr. M.D.*
 TYPED NAME: John Ames, Jr., M.D.

AIRMAN'S SIGNATURE: *John James Doe*

WHEN ISSUED AS A MEDICAL STUDENT PILOT CERTIFICATE, the holder has met standards prescribed in Part 61, FAR's for such certificate, and is prohibited from carrying passengers.

TOTAL PILOT TIME		18. HAS AN FAA AIRMAN MEDICAL CERTIFICATE EVER BEEN DENIED, SUSPENDED, OR REVOKED		19. HAVE YOU, AS A PILOT, HAD AN AIRCRAFT ACCIDENT WITHIN THE PAST 2 YEARS		20. DATE OF LAST FAA PHYSICAL EXAM (If none, state so)	
CIVIL	2500 LOG	17. LAST 6 MOS.	100 LOG	YES	DATE	YES	DATE
MILITARY	1800 EST			NO	6-19-64	NO	11-14-68

21. MEDICAL HISTORY - HAVE YOU EVER HAD OR HAVE YOU NOW ANY OF THE FOLLOWING: (For each "yes" checked, describe condition in REMARKS)

Yes	No	Condition	Yes	No	Condition	Yes	No	Condition
X		a. Frequent or severe headaches	X		g. Heart trouble	X		m. Nervous trouble of any sort
X		b. Dizziness or fainting spells	X		h. High or low blood pressure	X		n. Any drug or narcotic habit
X		c. Unconsciousness for any reason	X		i. Stomach trouble	X		o. Excessive drinking habit
X		d. Eye trouble except glasses	X		j. Kidney stone or blood in urine	X		p. Attempted suicide
X		e. Hay fever	X		k. Sugar or albumin in urine	X		q. Motion sickness requiring drugs
X		f. Asthma	X		l. Epilepsy or fits	X		r. Military medical discharge
								s. Medical rejection from or for military service
								t. Rejection for life insurance
								u. Admission to hospital
								v. Record of traffic convictions
								w. Record of other convictions
								x. Other illnesses

REMARKS (If no changes since last report, so state)
 #18 DENIED FOR SUBSTANDARD DISTANT VISUAL ACUITY (20/200)
 #21: 1966 INDIGESTION

22. HAVE YOU EVER BEEN ISSUED A STATEMENT OF DEMONSTRATED ABILITY (WAIVER)

NO	PHYSICAL DEFECTS NOTED ON STATEMENT OF DEMONSTRATED ABILITY (WAIVER)	WAIVER SERIAL NO.
X YES (Give defects and waiver no.)	SUBSTANDARD DISTANT VISUAL ACUITY (20/200)	48DN6825

23. MEDICAL TREATMENT WITHIN PAST 5 YEARS

DATE	NAME AND ADDRESS OF PHYSICIAN CONSULTED	REASON
3-2-63	DR. GEORGE JOHNS CLEVELAND, OHIO	ROUTINE CHECK-UP

- NOTICE -
 Whoever in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or who makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statements or entries, shall be fined not more than \$10,000 or imprisoned not more than 5 years, or both. (U.S. Code, Title 18, Sec. 1001.)

24. APPLICANT'S DECLARATION
 I hereby certify that all statements and answers provided by me in this examination form are complete and true to the best of my knowledge, and I agree that they are to be considered part of the basis for issuance of any FAA certificate to me.

SIGNATURE OF APPLICANT (In ink): *John James Doe*
 DATE: Nov. 28, 1969

APPLICATION FOR AIRMAN MEDICAL CERTIFICATE AIRMAN MEDICAL AND STUDENT PILOT CERTIFICATE

1. FULL NAME (Last, first, middle): **DOE, JOHN JAMES**

2A. ADDRESS (No. Street, City, State, ZIP No.): **5060 WEST STREET, EASTON, PA. 18042**

2B. SOCIAL SECURITY NO.: **343 12 0600**

2C. PLACE OF BIRTH (Student pilot applicants only): **NORTHAMPTON**

3. DATE OF BIRTH (Mo., day, year): **Oct. 10, 1911**

4. HEIGHT (Inches): **71**

5. WEIGHT (Pounds): **180**

6. COLOR OF HAIR: **BROWN**

7. COLOR OF EYES: **BROWN**

8. SEX: **M**

9A. CLASS OF MEDICAL CERTIFICATE APPLIED FOR: **SECOND**

9B. TYPE OF AIRMAN CERTIFICATE(S) HELD: **ATC SPECIALIST, FLIGHT ENGINEER**

10. OCCUPATION (If ATC Specialist, specify position and facility): **INSURANCE BROKER**

11. EXTENDED ACTIVE DUTY MEMBER OF: **NONE**

12. EMPLOYER: **SELF**

13. LENGTH OF TIME IN PRESENT OCCUPATION: **10 YRS.**

14. PRIMARY TYPE OF FLYING: **BUSINESS**

15. CURRENTLY USE ANY MEDICATION (Including eye drops): **NO**

16. TO DATE: **2500 LOG**

17. LAST 6 MOS.: **100 LOG**

18. HAS AN FAA AIRMAN MEDICAL CERTIFICATE EVER BEEN DENIED, SUSPENDED, OR REVOKED: **NO**

19. HAVE YOU, AS A PILOT, HAD AN AIRCRAFT ACCIDENT WITHIN THE PAST 2 YEARS: **NO**

20. DATE OF LAST FAA PHYSICAL EXAM (If none, state so): **11-14-68**

21. MEDICAL HISTORY - HAVE YOU EVER HAD OR HAVE YOU NOW ANY OF THE FOLLOWING: (For each "yes" checked, describe condition in REMARKS)

22. HAVE YOU EVER BEEN ISSUED A STATEMENT OF DEMONSTRATED ABILITY (WAIVER): **YES**

23. MEDICAL TREATMENT WITHIN PAST 5 YEARS

24. APPLICANT'S DECLARATION

APPENDIX B
(continued)

REPORT OF MEDICAL EXAMINATION																
NOR- MAL	CHECK EACH ITEM IN APPROPRIATE COLUMN (Enter NE if not evaluated)				AB- NOR MAL	NOTES: Describe every abnormality in detail, enter applicable item number before each comment. Use additional sheets if necessary and attach to this form.										
X	25. Head, face, neck and scalp															
X	26. Nose															
X	27. Sinuses															
X	28. Mouth and throat															
X	29. Ears, general (Internal and external canals) (Auditory acuity under item 49)															
X	30. Drums (Performance)															
X	31. Eyes, general (Visual acuity under items 50 & 51)															
X	32. Ophthalmoscopic															
X	33. Pupils (Equality and reaction)															
X	34. Ocular motility (Associated parallel movement, strabismus)															
X	35. Lungs and chest (Including breasts)															
X	36. Heart (Thrust, size, rhythm, sounds)															
X	37. Vasculer system															
X	38. Abdomen and viscera (Including hernia)															
X	39. Anus and rectum (Hemorrhoids, fistula, prostatic)															
X	40. Endocrine system															
X	41. G-U system															
X	42. Upper and lower extremities (Strength, range of motion)															
X	43. Spine, other musculoskeletal															
X	44. Identifying body marks, scars, tattoos			X						#44 scar 2" vertical anterior surface right mid-thigh						
X	45. Skin and lymphatics															
X	46. Neurologic (Tendon reflexes, equilibrium, sensory, coordination, etc.)															
X	47. Psychiatric (Specify any personality deviation)															
X	48. General systemic															
FOR FAA USE - PATHOLOGY CODE NOS.																
49. HEARING		RIGHT EAR		LEFT EAR		50. DISTANT VISION (Standard test types only)			51. NEAR VISION (Use linear values)							
WHISPERED VOICE (STANDING SIDEWAYS DISTANT EAR CLOSED)		15/15 FT		15/15 FT		RIGHT EYE	20/ 100	CORRECTED TO 20/	20	20/ 20	CORRECTED TO 20/	20				
AUDIOMETER (Decibel Loss)		-5	-10	-10	0	5	0	10	10	BOTH EYES	20/ 100	CORRECTED TO 20/	20	20/ 20	CORRECTED TO 20/	20
52. INTRAOCULAR TENSION (Tonometry required for Air Traffic Control Specialists)						53. COLOR VISION (Test used, number of plates missed)										
X	TACTILE	RIGHT EYE	normal		LEFT EYE	normal		ACC - HRR Normal								
X	TONOMETRIC	normal														
54. FIELD OF VISION			55. HETEROPHORIA DIOPTERS (Not required for Class Three)													
RIGHT EYE	LEFT EYE	DISTANCE	ESOPHORIA	EXOPHORIA	RIGHT H	LEFT H										
normal	normal	20'	2	0	0	0										
56. BLOOD PRESSURE				57. PULSE (Wrist)												
RECURRENT MM MERCURY	SYSTEMIC	DIASTOLIC	RESTING	AFTER EXERCISE	2 MINUTES AFTER EXERCISE											
	128	84	76	92	78											
58. URINALYSIS		59. ECG (Date)		60. OTHER TESTS												
ALBUMIN	SUGAR	not done		none												
neg.	neg.															
61. COMMENTS ON HISTORY AND FINDINGS, RECOMMENDATIONS (Attach all consultation reports, ECGs, X-rays, etc to this report before mailing)										FOR FAA USE						
#21 1952 moderate diet and medication for 3 months relieved symptoms -- no recurrence. No other significant findings by history or examination. Certificate issued on basis of Form FAA-779 dated November 24, 1968										CODED						
										PUNCHED						
										VERIFIED						
62. APPLICANT'S NAME										EXAMINER CODES						
John James Doe																
63. DISQUALIFYING DEFECTS (List by item no.)										CLERICAL REJECT						
64. MEDICAL EXAMINER'S DECLARATION																
I hereby certify that I personally examined the applicant named on this medical examination report, and that this report with any attachment embodies my findings completely and correctly.																
DATE OF EXAMINATION		AVIATION MEDICAL EXAMINER'S NAME AND ADDRESS (Type or print)				AVIATION MEDICAL EXAMINER'S SIGNATURE										
11/28/69		John Ames, Jr., M.D. 716 Broad St., Easton, Pa. 18042				John Ames Jr., M.D.										

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Driver Number
Card Number
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Circulatory
Respiratory
Digestive
Genitourinary
Skin
Musculoskeletal
Symptoms

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Driver Number
Card Number
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Age Group
Experience
Experience Group
Weight Ratio
Overweight/Underweight
Lenses
Distance Vision
Vision over 30
Field of Vision
Field under 160
Systolic B. P.
S. B. P. over 160/under 60
Diastolic B. P.
D. B. P. over 90/under 60
P. R. Before Exercise
P. R. over 90
P. R. After Exercise
P. R. Rise over 15%

MORBIDITY EXPERIENCE (Cont'd)