AD-A258 193

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
May 27, 1992

3. REPORT TYPE AND DATES COVERED
THESIS/~~DISSERTATION~~

4. TITLE AND SUBTITLE
A Study of Illness Related Lost Time in Transport Aircraft Crewmembers

5. FUNDING NUMBERS

6. AUTHOR(S)
David Jonathan Louis, Major

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AFIT Student Attending: University of Cincinnati

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/CI/CIA- 92-89

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFIT/CI
Wright-Patterson AFB OH 45433-6583

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release IAW 190-1
Distributed Unlimited
ERNEST A. HAYGOOD, Captain, USAF
Executive Officer

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

012288
92-31205
copy

14. SUBJECT TERMS

15. NUMBER OF PAGES
50

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

89

TO: AFIT/CIME
FROM: Major David Louis
RE: Thesis requirements

Please find one acid free copy of my thesis and two copies of the title page, abstract and bibilography per AFITR 53-1.

David Louis

David J. Louis, USAF, MC, FS

Accesion For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	

Availability Codes	
Dist	Avail and / or Special
A-1	

DTIC QUALITY INSPECTED 2

DAVID JONATHAN LOUIS

A STUDY OF ILLNESS RELATED LOST TIME
IN TRANSPORT AIRCRAFT CREWMEMBERS

MAJOR, USAF
FIFTY PAGES

MASTER OF SCIENCE

University of Cincinnati
College of Medicine
Division of Occupational Medicine
Department of Environmental Health

May 27,1992

ABSTRACT

A STUDY OF ILLNESS RELATED LOST TIME IN TRANSPORT AIRCRAFT CREWMEMBERS

The purpose of this study was to determine if the illness rates of non-pilot air crewmembers are different from pilots.

Interest in aircrew illness rates began when schedulers and flight surgeons noticed that frequently there were insufficient numbers of healthy flight engineers to staff the mission. When the literature on aircrew illness rates was reviewed, few studies were found.

This study involved the compilation of illness data including diagnosis job title (pilot (P), flight engineer (FE), loadmaster (L)), date of illness onset, and date of recovery for a military airlift wing in the southeastern United States over a two year period. Total time lost rates were calculated for each crew position for all illness and the seven most frequent diagnostic categories. Pilots were used as the comparison (referent) group.

The database identified 1976 illnesses (events) in 569,969 person-days at risk. Time lost rates (days lost per 1000 person-days at risk) were significantly higher for flight engineers (56.2, $p<.001$) and loadmasters (64.0, $p<.001$) when compared to pilots (29.8). Incidence rates (new illness events per 1000 person-days at risk) were significantly higher for flight engineers (3.87, $p<.001$) and loadmasters (4.07, $p<.001$) than for pilots (2.76). Mean duration of illness was also longer for flight engineers at 8.4 days, and loadmasters at 9 days, than pilots at 6.6 days.

For flight engineers, statistically increased time lost rates were found for upper respiratory infections (FE=16.6 v. P=12.0 $p<.0001$) back/neck pain (FE=4.4 v. P=0.6, $p<.0001$), other musculoskeletal problems (FE=11.8 v P=3.1, $p<.0001$), dermatologic problems (FE=5.1 v. P=1.9, $p<.0001$), gastroenteritis (FE=1.6 v. P=0.9, $p<.0001$), and dental problems (FE=2.3 v. P=1.2, $p<.0001$).

For loadmasters, statistically increased time lost rates were found for upper respiratory infections (L=17 v. P= 12.0, $p<.0001$), back/neck pain (L=4.4 v. P=0.6, $p<.0001$), other musculoskeletal problems (L=8.5 v. P=3.1, $p<.0001$), dermatologic conditions (L=5.1 v. P=1.9, $p<.0001$), urologic/renal problems (L=4.1 v. P=3.5 $p<.0001$), and dental problems (L=4.8 v. P=2.2, $p<.0001$).

In summary, the time lost rates, incidence rates, and durations of illness for flight engineers and loadmasters are significantly greater than

pilots. Future studies need: 1) larger numbers of person-days at risk to allow a more complete study of the rates of specific diagnoses; 2) more data for analysis including ages, smoking status, number of children at home, and job satisfaction to identify confounders or effect modifiers; and 3) to see if the pilots' apparent "Healthy Worker Effect" is actually due to flying while ill or self-medication. Finally, these results should be presented to flight surgeons and schedulers to better evaluate and manage human resources.

REFERENCES

1. Frolov NI: Methods of Studying Inflight Pilot Performance. Kosmicheskaya Biologiya i Aviakosmicheskaya Meidatina 1978; 1: 3-11.

2. United States Air Force: Flight Management. Dept. of the Air Force (AF Reg 60-1). Washington DC: HQ USAF, Feb 1990.

3. Cooper CL, Sloan SJ: Coping with Pilot Stress: Resting at Home Compared with Resting Away from Home. Aviation, Space, and Environmental Medicine 1987; 58: 1175-1182.

4. Chidester TR: Trends and Individual Differences in Response to Short Haul Flight Operations. Aviation, Space and Environmental Medicine 1990; 59: 199-204.

5. Gasaway DG: Noise Associated with Airborne Operation of C-141 A Aircraft. USAF School of Aerospace Medicine (SAM TR 70-74) Brooks AFB TX: USAFSAM; Dec 1970.

6. Sundback U, Tingvall B: Investigation of the Physical Working Environment for Cabin Attendants with Scandavian Airlines. Proceedings from the 1980 International Conference on Noise Control Engineering 1980; 341-344.

7. Inglesias R, Gonzalez G, Morales S: Occupational Injuries Suffered by Flight Attendants While on Board. Aviation, Space, and Environmental Medicine 1989; 60: 1109-1111.

8. Brooks CJ: Loss of Cabin Pressure in Canadian Forces Transport Aircraft, 1963-84. Aviation, Space, and Environmental Medicine 1987; 58:268-275.

9. Nagda NL, Fortmann RC, et al.: Airliner Cabin Environment: Contaminant Measurements, Health Risks, and Mitigation Options. U.S. Department of Transportation, (DOT report no. DOT-P-15-89-5). Washington DC: U.S. Government Printing Office, Dec 1982.

10. Booze C: Prevalence of Selected Pathology Among Currently Certified Active Airmen. Aviation, Space, and Environmental Medicine 1982; 53: 1198-1201.

11. Hoisberg A, Blood C: Age Specific Morbidity Among Navy Pilots. Aviation, Space, and Environmental Medicine 1983; 54: 912-918.

12. Ungs T, Sangal S: Flight Crews with Upper Respiratory Tract Infections. Aviation, Space, and Environmental Medicine 1990; 61: 938-941.

13. Zwart B: A New Method For Tracking and Analyzing Illness and Morbidity Among Active Duty, Air Force Aviators. Aviation, Space, and Environmental Medicine 1992; publishing pending.

14. Leigh JP: Employee and Job Attributes as Predictors of Absenteeism in a National Sample of Workers. Social Science in Medicine 1991; 33: 127-137.

15. Chevalier A, Luce D, et al.: Sickness Absence at the French National Electric and Gas Company. British Journal of Industrial Medicine 1987; 44: 101-110.

16. Farrell D, Stamm C: Meta-Analysis of the Correlates of Employee Absence. Human Relations 1988; 41: 211-227.

17. Leigh JP: The Effects of Unemployment and the Business Cycle on Absenteeism. Journal of Economics in Business 1985; 37: 170-195.

18. Athanasou J: Sickness Absence and Smoking Behavior and its Consequences. Journal of Occupational Medicine 1975; 17: 441-445.

19. Sexton M, Schumann B: Sex, Race, Age, and Hypertension as Determinants of Employee Absenteeism. American Journal of Epidemiology 1985; 122: 302-310.

20. SAS Institute Inc: Procedure TTEST. In SAS User's Guide: Statistics, Version 5 Edition. Cary NC: SAS Institute Inc., 1985; 795-800.

21. Kelsey JL, Hochberg MC: Musculoskeletal Disorders. In Maxcy Rosenau Last Public Health and Preventive Medicine. Ed. Last JM, Wallace RB. Norwalk CT: Appleton & Lange, 1992; 913.

22. Jennings CL: The Use of Normative Data in the Psychological Evaluation of Flying Personnel. In Psychiatry in Aerospace Medicine Vol.4 International Psychiatry Clinics
Ed. Perry CJ. Boston MA: Little Brown, 1967; 37-52.

A STUDY OF ILLNESS RELATED LOST TIME IN TRANSPORT AIRCRAFT CREWMEMBERS

A thesis submitted to the

Division of Graduate Studies and Research
of the University of Cincinnati

in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

in the Division of Occupational Medicine
in the Department of Environmental Health
of the College of Medicine

1992

by

David Jonathan Louis, Major, USAF, MC, FS

B.S., The Ohio State University 1979

M.D., The Ohio State University 1982

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

First, without The Sovereign, Triune God Who created all things, I could not exist and this project could not have been done.

Second, I thank my wife Kay, and her patience with my own "lost time" from the family, and my sons Kyle and Brian who patiently tolerated my chronic absence from home.

Recognition is also given to my committee of Dr. James Lockey, Dr. Doug Linz, Dr. Raymond Suskind, and chairman Dr. Peter Gartside.

I must also give special thanks to Allan Leach and Dr. Paul Succop for their technical advice on SAS programming and to Dr. Eric Wohlrab, Dr. Ken Gliffort and Dr. Bayard Vermilyea for their encouragement.

Two people were most crucial in the completion of this project. Mrs. Mary Ann Ferguson provided countless hours of assistance in acquiring and trouble shooting the database. Without her perseverance, this project would never have started. Dr. Susan Pinney liberally supplied technical advice, constructive criticism and computer resources that were critical for this project's completion.

David J. Louis
Cincinnati, Ohio
May 27, 1992

ABSTRACT

A STUDY OF ILLNESS RELATED LOST TIME IN TRANSPORT AIRCRAFT CREWMEMBERS

The purpose of this study was to determine if the illness rates of non-pilot air crewmembers are different from pilots.

Interest in aircrew illness rates began when schedulers and flight surgeons noticed that frequently there were insufficient numbers of healthy flight engineers to staff the mission. When the literature on aircrew illness rates was reviewed, few studies were found.

This study involved the compilation of illness data including diagnosis job title (pilot (P), flight engineer (FE), loadmaster (L)), date of illness onset, and date of recovery for a military airlift wing in the southeastern United States over a two year period. Total time lost rates were calculated for each crew position for all illness and the seven most frequent diagnostic categories. Pilots were used as the comparison (referent) group.

The database identified 1976 illnesses (events) in 569,969 person-days at risk. Time lost rates (days lost per 1000 person-days at risk) were significantly higher for flight engineers (56.2, $p < .001$) and loadmasters (64.0, $p < .001$) when compared to pilots (29.8). Incidence rates (new illness events per 1000 person-days at risk) were significantly higher for flight engineers (3.87, $p < .001$) and loadmasters (4.07, $p < .001$) than for pilots (2.76). Mean duration of illness was also longer for flight engineers at 8.4 days, and loadmasters at 9 days, than pilots at 6.6 days.

For flight engineers, statistically increased time lost rates were found for upper respiratory infections ($FE = 16.6$ v. $P = 12.0$ $p < .0001$) back/neck pain ($FE = 4.4$ v. $P = 0.6$, $p < .0001$), other musculoskeletal problems ($FE = 11.8$ v $P = 3.1$, $p < .0001$), dermatologic problems ($FE = 5.1$ v. $P = 1.9$, $p < .0001$), gastroenteritis ($FE = 1.6$ v. $P = 0.9$, $p < .0001$), and dental problems ($FE = 2.3$ v. $P = 1.2$, $p < .0001$).

For loadmasters, statistically increased time lost rates were found for upper respiratory infections ($L = 17$ v. $P = 12.0$, $p < .0001$), back/neck pain ($L = 4.4$ v. $P = 0.6$, $p < .0001$), other musculoskeletal problems ($L = 8.5$ v. $P = 3.1$, $p < .0001$), dermatologic conditions ($L = 5.1$ v. $P = 1.9$, $p < .0001$), urologic/renal problems ($L = 4.1$ v. $P = 3.5$ $p < .0001$), and dental problems ($L = 4.8$ v. $P = 2.2$, $p < .0001$).

In summary, the time lost rates, incidence rates, and durations of illness for flight engineers and loadmasters are significantly greater than pilots. Future studies need: 1) larger numbers of person-days at risk to allow a more complete study of the rates of specific diagnoses; 2) more data for analysis including ages, smoking status, number of children at home, and job satisfaction to identify confounders or effect modifiers; and 3) to see if the pilots' apparent "Healthy Worker Effect" is actually due to flying while ill or self-medication. Finally, these results should be presented to flight surgeons and schedulers to better evaluate and manage human resources.

PURPOSE AND RATIONALE

The purpose of this study was to determine if the total time lost from flying duties due to illness for non-pilot air crewmembers are different from the time lost for pilots. Concern about possible differences was first expressed by flight surgeons and schedulers who noticed that there were frequently insufficient numbers of healthy flight engineers (a non-pilot aircrew position) to complete a full crew. Review of aerospace medical literature was not rewarding in answering this question.

Objectives

The primary objective of this study was to calculate and compare the total time lost due to illness for pilots, and two non-pilot aircrew positions, flight engineer and loadmaster. The time lost was examined for all illness events and seven common diagnostic categories.

There were three secondary objectives. The first was to calculate and compare illness incidence rates for all three crew positions. The second was to calculate and compare the average duration of illness events for all three crew positions. The third was to develop hypotheses for future studies.

Hypotheses

Based on clinical experience, flight engineers and loadmasters seemed to have more frequent and longer illnesses than pilots. Non-pilots also appeared to have more total time lost. The following six null hypotheses were constructed to test the clinical impressions:

1) Total time lost rate for flight engineers is equal to pilots' total time lost rate.

2) Total time lost rate for loadmasters is equal to pilots' total time lost rate.

3) The incidence rate for flight engineers and pilots are equal (incidence rate ratio = 1).

4) The incidence rate for the loadmasters and the pilots are equal (incidence rate ratio = 1).

5) The mean durations of illness for flight engineers and pilots are equal.

6) The mean durations of illness for loadmasters and pilots are equal.

AIR TRANSPORT SYSTEM

Mission and Aircraft

The air transport facility whose records were examined was the 437th Military Airlift Wing (MAW) , Charleston Air Force Base (AFB), South Carolina. This wing utilizes of C-141 heavy transport aircraft. Missions include air land (transporting cargo from one place to another), air drop (parachuting the cargo to its destination) and special operations for both the U.S. Army and the U.S. Navy. Destinations are primarily European but also include Africa, the continental United States, Latin and South America, and southwest Asia.

The C-141 was initially placed into service in the mid 1960's as the Air Force's first jet transport aircraft since the KC-135 (Boeing 707). The current crew compliment for most missions consists of 2 pilots and 2 flight engineers who fly in the cockpit and 1 to 2 loadmasters who ride in the cargo bay. The plane has one lavatory and a very small galley. It has sleeping facilities for four; two in the cockpit and two in the cargo bay. These sleeping areas are not physically or acoustically isolated from the rest of the plane.

Crewmembers

The crews that fly C-141 aircraft at Charleston Air Force Base include both officers and enlisted personnel. They are predominately male caucasians (>80%). They fly missions worldwide ranging in duration from 6 hours to 18 days (in peacetime).

U.S. Air Force pilots are officers and must have a Bachelor's degree and must pass rigorous physical standards to qualify for pilot training. Undergraduate pilot training takes approximately 1 year. At Charleston, the pilot's average age is 30 (range 23-51). Pilot pre-flight duties include mission planning, briefings, weather planning, fuel planning, examining the aircraft including its flight controls, communication, and navigational equipment. The pilots also must re-check all take off and landing calculations, weight distributions and other flight parameters. During flight, one pilot operates the flight controls and the other operates the radios and navigational computers. Post-flight, the pilot is responsible for arranging billeting and transportation for the crew and planning for the next leg of the mission.

U.S. Air Force flight engineers are not pilots (contrasted with most U.S. commercial passenger carriers who use only pilots to fill the "second officer" or engineer position). Their physical standards are somewhat less rigorous as compared to pilot's standards; at Charleston the average age is 32 (range 22-51). They are enlisted men and women who have completed 6-8 months of intense schooling (80 % "wash out" rate) after a minimum of 36 months experience in aircraft maintenance. After schooling is completed, the engineer must complete one year of supervised work before he/she can fly as the mission engineer. The pre-flight duties for the engineer include a thorough examination of all of the airplane's systems including electrical, hydraulic, flight control, braking, navigational, communications, fuel, and engines. The flight engineer must also compute all performance data including take off, landing and cruising speeds. They also monitor the fueling of the aircraft both at the engineers' panel inside and at the fuel truck outside. In flight, the engineer monitors the instrumentation for all the operating systems including cabin pressurization and temperature, hydraulics, and electrical. Also, engine parameters like fuel flow, temperature, and rpm are continually checked. Post flight, he/she must make a complete inspection of the plane's exterior and is also responsible for attaching the auxiliary power unit.

Loadmasters are also enlisted personnel. Their physical standards are the same as flight engineers; the average age is 29 (range 18-46). They usually enter the career field directly from their initial enlistment. The two initial loadmaster schools are completed in about 4 months. This is followed by supervised work for at least 6 months until she/he is fully qualified as a mission loadmaster. The loadmaster's duties include configuring the cargo bay before loading and securing the cargo after loading. Loadmasters must also configure seating and inspect the oxygen supply and life support equipment. They must also set up and maintain a comfort pallet (a device that contains multiple toilets and a small kitchen) when passengers are on board. The loadmasters develop load plans so the plane is loaded properly and an appropriate center of gravity is maintained. At ports where there are no trained loading units, the loadmasters may have to actually operate forklifts and other heavy equipment to load the cargo. In flight, they monitor and manage the cargo, both human and non-human. On airdrop missions they prepare the troop (rear) doors or petal (tail) doors for the exiting of the cargo or parachutists. Airdrop duty is riskier, as the loadmaster may risk his life to free a parachutist or cargo item whose parachute does not deploy properly (a "hung trooper" or "hung load"). Upon landing, the loadmaster usually supervises the unloading of the equipment and inventories all contents.

FLYING-RELATED STRESSORS OF TRANSPORT AIRCREWS

In most vocations, there are work-related stressors and flying is no exception. Flying-related stressors include fatigue, circadian desynchronization, temperature, noise, vibration, lifting, bending, decreased barometric pressure and cosmic rays.

Fatigue is a significant factor in flying and adversely affects crew performance.[1] Single missions can last as long as 30 hours.[2] Night and over-water flying add to the sensation of fatigue. Layovers away from home (also known as "RON's") give some rest but the crews are usually unable to achieve any satisfactory relaxation.[3] Multiple layovers are correlated with increased irritability and layover sleep is associated with poorer performance when compared to sleep at home.[4] Crews frequently complain of noisy layover facilities with poor climate control when they layover outside of the continental United States.

Circadian desynchronization or "jet lag" is another significant stressor. Problems occur more often when a crew flies "into the night" or "against the time zone" (flying west to east) rather than with the sun (east to west) and as the number of time zones crossed increases. A secondary problem is inappropriate food choices relative to the biological clock. For example, if a crew arrives at 7 AM (home station time) it may be 6 PM at their destination and no breakfast food would be available.

Temperature stress is common, especially in the summer where pre-flight cockpit temperatures can easily exceed 110 degrees F. Modern camouflage paint schemes, usually dark green or dark grey absorb much more heat than original silver or white paint. Although the flight uniform ensembles are satisfactory for moderate temperature ranges, their performance is inferior in very hot or cold environments. Unfortunately, in a single mission, the crew can be exposed to a range of 80 degrees F or greater when going from one aerodrome to another.

Noise exposure is present on every flight; exposures over 140 dBA can occur while out on the tarmac. Take off noise level in a C 141 is 90 dBA and cruising noise averages 83 dBA.[5] All military aircrew wear headsets rather than earpieces to reduce noise exposure; about one-half also wear ear plugs. Vibration can also degrade work performance, but significant levels are not usually seen in modern transport aircraft.[6]

Injuries from lifting and bending do occur in flight attendants and loadmasters. Air Mexico reported 422 injuries over a 5 year period with an average lost time of 37 days; 55 % of the injuries involved the trunk or upper extremities.[7]

Normal flying occurs well above ground level and as altitude is attained, barometric pressure falls and the potential for loss of cabin pressure and hypoxia exist. The number two hatch on the C-141 military transport is notorious for unexpected "blowouts" with subsequent rapid decompressions. Over a 20 year period, the Royal Canadian Air Force reported 47 cases of cabin decompression.[8] Special operation missions may also require decompression to complete airdrops from high altitude usually about 28,000 feet. In addition to the risk of rapid decompression, some missions require flying into high altitude aerodromes like John F. Kennedy International at LaPaz, Bolivia (altitude =12,000 ft) where the crews frequently use bottled oxygen when performing ground duties.

Cosmic rays are a potential cause of neoplasia in crewmembers flying large numbers of hours at higher altitudes. Risk assessments performed for the department of transportation predicted 42 excess cancer deaths per 100,000 crewmembers who fly 960 hours per year for 20 years.[9]

Transport aircrew stressors are different than those found in high performance aircraft pilots (exposure to many multiples of gravitational force and abrupt maneuvers are not common in transport planes). Most studies suggest multiple layovers and circadian problems are the most significant stressors in transport crews, but the nature of the loadmasters' work does increase their risk for physical injury.

REVIEW OF THE AEROSPACE LITERATURE

The literature on short term morbidity (acute illnesses) of air crewmembers is very scant. Review of NIOSHTC, MEDLINE, and AEROSPACE databases, plus other sources revealed four journal articles. One article listed the prevalence of chronic, stable diseases in Federal Aviation Administration certified airmen.[10] Hospitalization rates of U.S. Navy flyers and U.S. Navy non-flying personnel have been examined; higher frequencies of extraction of third molars (wisdom teeth), strains/sprains, and musculoskeletal problems were found in flying crews. Navy flyers had a higher hospitalization rate than Navy non-flyers, but no explanations were given to account for this difference. Both Navy groups had a significantly lower rate of hospitalization when compared to civilians.[11] Factors associated with the development of upper respiratory infections in U.S. Coast Guard helicopter pilots were evaluated and there was an association between having children in the family and upper respiratory infections ($p = 0.069$). No measures of relative risk, risk difference or correlation coefficients were given.[12] Zwart[13] examined 15,275 records of U.S. Air Force flyers for all illnesses (usually temporary, ambulatory problems) and tabulated the top 30 diagnoses (based on the total number of days of illness). Median number of days lost and 25%-75% range were calculated. The top 5 diagnoses and median days lost were: upper respiratory infection

(6 days), sinusitis (10 days), gastroenteritis (3 days), bronchitis (9 days), and back pain (7 days). No incidence data was calculated due to a lack of reliable numbers for total person-days at risk.

SICKNESS ABSENCE RESEARCH

Sickness absence research has been performed by occupational medicine physicians, economists, and psychologists. Each field tends to use different analytical methods and select different variables of interest.[14] Such studies indicate that a wide variety of factors that may be contributory.

Increased sickness absence has been associated with blue collar workers and laborers,[15] sleep problems, obesity, dangerous work, inflexible work hours,[14] psychological stress, previous absence history, second or third shift work,[16] union membership,[17] and smoking.[18]

Other variables are negatively associated with sickness absence. These factors include age,[19] managerial status, pay, job satisfaction/ commitment/involvement, job variety, autonomy, and socioeconomic status.[16]

Some of these factors may be significant in the analysis of the aircrew data. Pilots are the aircraft commanders and tend to have the role of a foreman on the crew and have more autonomy. Job satisfaction appears lower for flight engineers and loadmasters; smoking is more common in these groups as well. Socioeconomic status is lower for the non-pilots. Age distribution is similar for all three crew positions but the loadmasters tend to be about 2 years younger than other crewmembers on average (appendix A).

DESIGN AND ANALYTICAL METHODS

Study Design

This study of the incidence and duration of illness in air transport crewmembers was a hybrid repeated measures study. This hybrid consisted of a dynamic cohort study with 759 serial follow-up periods (for a total of two years). The population was dynamic rather than static as there were gradual losses and replacements over time and the population was followed rather than individuals.

Study Population

The study population was the entire population of pilots, flight engineers, and loadmasters assigned to the 437th Military Airlift Wing, Charleston AFB, South Carolina for any days after 31 December, 1988 and before 1 January, 1991 for a total of 569,969 person-days. Each crew position subgroup had similar distribution of ages (appendix A).

Data Collection

i) Illness Data

The "Medical Recommendation for Flying or Special Operational Duty Log" (AF form 1041) was used to abstract the illness data. This log consisted of the last name, rank, social security number, crew position, date medically disqualified from flying, date medically requalified, and diagnosis. The data were entered into an ASCII file. The data were re-entered and the files compared. Any discrepancies were corrected using the original log.

ii) Total Population Data

The personnel section of Headquarters, Military Airlift Command (MAC) provided the total numbers of crewmembers assigned to the wing for each crew position. Personnel data tapes were used to generate the number of pilots. For the loadmasters and flight engineers, the personnel counts were obtained from logs at the MAC personnel center.

iii) Diagnostic Categories

To provide more clinically useful information in the analyses, two types of disease codings were included. First, the diseases were classified by the Computerized Out-Patient Ambulatory Diagnostic System[13], an organ system based method that was developed expressly for the categorization of short term morbidity. The diseases were also classified by 21 diagnostic categories based on clinical experience of caring for aircrews. The categories were:

1. Infections of the upper respiratory tract, ears, and bronchi
2. All other ear, nose, throat, and lung conditions
3. Defective visual acuity
4. All other ocular problems
5. Back and neck pain/spasm
6. All other musculoskeletal problems
7. Dermatologic problems
8. Gastroenteritis including diarrhea and vomiting
9. Other gastrointestinal problems
10. Cardiovascular
11. Sexually transmitted diseases
12. Other urologic/renal/gynecological
13. Obstetric problems
14. Nervous system
15. Psychiatric
16. Dental
17. Physiologic incidents
18. Blood/immunologic/endocrine
19. Other minor illnesses

20.Administrative

21.Major systemic disease and neoplasms

After the data was entered, the total number of days lost and the total number of illness events were calculated for each category. For a category to be included in the stratified analysis, at least 60 illness events were necessary (to avoid small sample bias). The seven categories meeting this criteria were upper respiratory infections, back and neck pain, other musculoskeletal problems, dermatologic problems, dental problems, gastroenteritis, and urologic/renal problems (excluding sexually transmitted diseases). All other illnesses were placed into a collective category of "all other illnesses".

Analytical Methods

i) Total Time Lost

The dependent variable was expressed as a binomial proportion of the total number of person-days lost due to an illness divided by the total number of person-days at risk for the two year period. For example, if pilots were unavailable for flying duties for 600 days because of bronchitis and there were 2000 person days at risk, then the total time lost rate would be 600 divided by 2000 or 0.3; to aid in making comparisons, the proportions were adjusted to a standard 1000 person-days at risk.* The proportions themselves characterize the magnitude of rate. The independent variable of interest was crew position, either pilot, flight engineer, or loadmaster. The data were analyzed for association by chi-square 2x2 tables (using pilots as the referent group). Also, proportions were made for the eight major diagnostic groups; chi-square tests were again used to look for associations between crew positions and specific diseases or diagnostic groups.

ii) Incidence

The dependent variable was the binomial proportion of the number of new, flying duty disqualifying illness events divided by the total number of person-days at risk for the entire two year period. The independent variable of interest was crew position. The data were analyzed for association between crew position and rates of illness by chi-square 2x2 tables (using pilots as the referent group). Incidence rate ratios were also calculated to better describe the differences between the crew positions. Chi-square tests and incidence rate ratios were also calculated for the eight major diagnostic subgroups.

---

*Person-days at risk provided is defined as the number of persons assigned times the number of days assigned to the base. For example, if 20 pilots were assigned for 100 days there would be 20 X 100 = 2000 person-days at risk. The use of 1000 person days at risk was used to avoid showing numbers less than 1.

iii) Duration

The dependent variable was the natural logarithm of the number of days lost for each individual illness. The logarithmic transformation was used because the duration data was not normally distributed (appendix B). The transformation offered a more powerful test than using a non-parametric method like ranking the durations. The independent variable of interest was crew position. The (geometric) mean duration of illness for the flight engineers and loadmasters were individually compared to the pilots using Procedure TTEST by Statistical Analysis Systems.[20] Similar comparisons were performed with the data stratified into the eight major diagnostic subgroups.

RESULTS

Descriptive data

The number of illnesses, total days lost and person-days at risk, by crew position were tabulated.

CREW POSITION	ILLNESS EVENTS	TOTAL PERSON-DAYS LOST	PERSON-DAYS AT RISK
Engineer	732	10,625	189,016
Loadmaster	600	9,441	147,447
Pilot	644	6,961	233,506
TOTAL	1,976	27,027	569,969

Total days lost rates

This table lists the number of person days lost (expressed as days lost per thousand person-days at risk) for each crew position. T tests were used to compare the rate of the flight engineers and loadmaster to the pilots' rate. Except for urologic problems where there was a deficit, flight engineers had a nearly two-fold or greater increase in total days lost when compared to pilots. Loadmasters also had an increased total number of days lost in all diagnostic categories except gastroenteritis.

DIAGNOSTIC GROUP	DAYS LOST PER 1000 PERSON-DAYS AT RISK		
	FLIGHT ENGINEER	LOADMASTER	PILOT
All Illness	56.2****	64.0****	29.8
Upper Resp Inf.	16.6****	17.0****	12.0
Musculoskeletal excl back pain	11.8****	8.5****	3.1
Dermatologic	5.1****	5.1****	1.9
Dental Disease	2.3****	4.8****	1.2
Gastroenteritis	1.6****	1.1	0.9
Back and Neck Pain	4.4****	4.4****	0.6
Urologic/Renal	2.2****	4.1***	3.5
All other illness	12.2****	19.0****	6.6

**** significant at $p<.001$
*** significant at $p<.005$
** significant at $p<.01$
* significant at $p<.05$

Incidence Rates

The incident rates were calculated by dividing the number of new illness events by the total number of days at risk for each crew position.

DIAGNOSTIC GROUP	NEW ILLNESS EVENTS PER PERSON DAY AT RISK		
	FLIGHT ENGINEER	LOADMASTER	PILOT
All Illness	3.87	4.07	2.76
Upper Resp Inf.	1.72	1.60	1.40
Musculoskeletal excl back pain	0.46	0.42	0.20
Dermatologic	0.41	0.35	0.21
Dental Disease	0.28	0.40	0.18
Gastroenteritis	0.22	0.21	0.19
Back and Neck Pain	0.16	0.24	0.08
Urologic/Renal	0.08	0.16	0.18
All other illness	0.55	0.69	0.36

Incidence Rate Ratios

This table lists the incidence rate ratios for all illness and for the major diagnostic categories. All comparisons were made using pilots as the referent group. Overall, both flight engineers and loadmasters showed a 40+%higher morbidity incidence when compared to pilots. Flight engineers and loadmasters both had over twice the incidence of musculoskeletal problems than pilots. Increased incidence of dermatologic disease in flight engineers and dental problems in loadmasters were both very highly significant.

DIAGNOSTIC GROUP	INCIDENCE RATE RATIOS	
	FLIGHT ENGINEER	LOADMASTER
All Illness	1.40****	1.47****
Upper Resp Inf.	1.22**	1.14
Musculoskeletal excl back pain	2.31****	2.13****
Dermatologic	1.98****	1.72**
Dental Disease	1.57*	2.28****
Gastroenteritis	1.15	1.09
Back and Neck Pain	2.13**	3.17****
Urologic/Renal	0.53*	1.04
All other illness	1.55***	1.93****

**** significant at $p<.001$
*** significant at $p<.005$
** significant at $p<.01$
* significant at $p<.05$

Mean Duration of Crew Illness

The mean duration of illness was tabulated for each crew position; stratification was made for all illness events and the major diagnostic categories. All comparisons were made with pilots as the referent group. For all illness, both flight engineers and loadmasters had longer average illness duration. The only flight engineer illness with a very highly increased duration was upper respiratory infection. Loadmasters had longer durations for upper respiratory infections spinal column problems; the back and neck pain duration was double that of pilots.

DIAGNOSTIC GROUP	MEAN (GEOMETRIC) DURATION OF ILLNESS (IN DAYS)		
	FLIGHT ENGINEER	LOADMASTER	PILOT
All Illness	8.4#	9.0#	6.6
Upper Resp Inf.	7.8****	8.2#	6.4
Musculoskeletal excl back pain	14.4	11.5	10.7
Dermatologic	8.8*	9.9**	6.2
Dental Disease	5.6	6.7*	4.0
Gastroenteritis	4.9	4.2	3.6
Back and Neck Pain	10.6	13.5***	6.7
Urologic/Renal	14.2	9.7	12.2
All other illness	9.3	11.6*	8.1

significant at the p <.0001 level
**** significant at the p <.001 level
*** significant at the p <.005 level
** significant at the p <.01 level
* significant at the p <.05 level

DISCUSSION OF RESULTS

The study included 1,976 total illness events, 732 for flight engineers, 600 for loadmasters, and 644 for pilots. The illnesses occurred during 569,969 person-days at risk.

The rates of illness for both flight engineers (FE) and loadmasters (L) were greater than pilots (P) using all three parameters of 1) total time lost, 2) incidence, and 3) duration. Time lost rates (days lost per 1000 person-days at risk) were significantly higher for flight engineers (56.2, $p < .001$) and loadmasters (64.0, $p < .001$) when compared to pilots (29.8 days). The incidence rate ratios (IRR) were 1.40 for flight engineers ($p < .001$) and 1.47 for loadmasters ($p < .001$). The mean (geometric) durations were significantly longer ($p < .0001$) for engineers (8.4 days) and loadmasters (9.0 days) than for pilots (6.6 days).

Upper Respiratory Infections

Infections of the upper respiratory tract (URI's) accounted for 45% of all incident diseases in this study and 31 % of the total days lost. For flight engineers and loadmasters, statistically increased time lost rates were found for upper respiratory infections (FE = 16.6 v. P = 12.0 $p < .001$; L = 17 v. P =

12.0, $p < .001$). The incidence rate for URI was significantly increased for flight engineers but the magnitude was small (IRR = 1.22, 95% CI 1.05, 1.42). The incidence rate for loadmasters was not significantly different with a ratio of 1.14 (95% CI 0.96, 1.35). The durations were longer for both engineers (7.8 days) and loadmasters (8.2 days) than for pilots (6.6 days).

URI's may have accounted for some of the overall increased incidence of illness for both the engineers and loadmasters, but since the URI rates were lower than the total illness rates, upper respiratory tract infections do not appear to be the critical force of increased morbidity. Bronchitis was seen at twice the expected (pilot) rate for both loadmasters and flight engineers. This is not surprising as both groups have a higher percentage of smokers than pilots. Also, both groups have a higher exposure to jet engine exhaust; the flight engineers are exposed on engine start-up while they are outside and the loadmasters are exposed during on/off loading with the engines running.

Musculoskeletal Problems Besides Back and Neck Pain

Musculoskeletal injuries (excluding back and neck pain) were the second leading cause of days lost (15% of all days lost) and 10% of total disease incidence. Total time lost rates for musculoskeletal problems excluding back and neck pain were greater in both engineers (FE = 11.8 v P = 3.1, p < .001) and loadmasters (L = 8.5 v. P = 3.1, p < .001). Higher incidence rates were seen in both flight engineers (IRR = 2.31, 95% CI 1.61, 3.30) and loadmasters (IRR = 2.13, 95% CI 1.46, 3.13). The average duration of these musculoskeletal injuries was 12.3 days; there were no significant differences between the crew positions.

Sprains and strains of the extremities were the largest single diagnosis. Since the age distributions of all crew positions were similar, it is not likely that age was a confounder. Nevertheless, the loadmasters' work is more physically demanding; the configuring of the cargo area, securing cargo with heavy chains, moving pallets, and maintaining the passengers and the cargo place them at increased risk for musculoskeletal injuries.

Dermatologic Disease

Dermatologic illness was the third most common disease category, representing 9% of the total incidence and 8% of the total days lost. Total time lost rates for dermatologic disease were higher for both flight engineers and loadmasters (FE = 5.1 v. P = 1.9, p < .001), (L = 5.1 v. P = 1.9, p < .001). Similarly, there were increased incidence rates for both groups as well (FE

IRR = 1.98; (L IRR = 1.72). The mean durations for both loadmasters (9.9 days) and flight engineers (8.8 days) were longer than pilots (6.2 days).

Pruritic eruptions, urticaria, and contact dermatitis were more common in engineers than the other positions. Exposure to petroleum compounds is usually higher for engineers; however, exposure to common sensitizers for this crew position is not known to be excessive. Still, this finding should be an area for further examination. The duration of cellulitis was particularly high for loadmasters (mean = 20 days) versus 10 days for pilots and 12 days for loadmasters. This may have been due to late recognition of the problem (resulting in a more severe case) or poor compliance with medication.

Dental Disease

Dental problems ranked fourth for incidence and represented 5% of all lost days. The total time lost rates for dental problems were significantly increased for both flight engineers and loadmasters (FE = 2.3 v. P = 1.2, $p < .001$; L = 4.8 v. P = 1.2, $p < .001$). Incidence rates were higher for both as well but more so for loadmasters (L IRR = 2.23, 95% CI 1.53, 3.39; FE IRR = 1.57, 95% CI 1.40, 2.36).

Besides their marked increased rate of dental problems, duration of loadmaster dental problems was longer by 1.5 days (compared to pilots). One jaw reconstruction case of 245 days was the probable cause of this increased duration. Loadmasters also had the most wisdom tooth extractions (n=6) but this was only 10% of the total dental events for loadmasters. No specific dental diagnosis appeared to account for the engineers' increased risk (1.53 times that of pilots). The frequent use of the diagnosis of "dental problem not otherwise specified" probably limited the conclusions reached from this section.

Gastroenteritis

Gastroenteritis was fifth in incidence, representing about 6% of all illnesses but only 2.4 % of total days lost. Only flight engineers had significantly more time lost (FE=1.6 v. P=0.9, $p<.001$) and prolonged duration (FE=4.9 days v. P=3.6). Incidence rates for gastroenteritis were not significantly different for either flight engineers (RR=1.15 95% CI 0.76, 1.76) or loadmasters (RR=1.09 95% CI 0.69, 1.72).

Back and Neck Pain

Back/neck pain was sixth in incidence, representing 4% of the total illnesses but over 6% of the total days lost (1639 out of 27,027). Total time lost for back/neck pain was markedly higher in flight engineers and loadmasters (FE=4.4 v. P=0.6, $p<.001$; L=4.4 v. P=0.6, $p<.001$). Incidence rates were higher for both as well (FE IRR=2.13, 95% CI 1.19, 3.80; L IRR=3.17, 95% CI 1.80, 5.58). Only loadmasters had a significantly longer duration of 13.5 days (versus 6.8 days for pilots).

Studies have shown flight attendants to be at increased risk for back and neck injuries[7] so the increased risk and duration for loadmasters is not surprising. Flight engineers usually sit at their panels during the entire flight (without getting up); this may predispose them to back problems.[21]

Urologic, Renal, and Gynecological (excluding STD's)

Urologic and renal problems were seventh in incidence, representing about 4% of all illnesses but nearly 7 % of total days lost. The total time lost rate due to urologic/renal problems was higher for loadmasters (L=4.1 v. P=3.5 $p<.0001$) but was lower for flight engineers (FE=2.2 v. P=3.5 $p<.0001$); the incidence rate for flight engineers was decreased as well

(RR= 0.56 95% CI 0.32, 1.02). Review of the individual diagnosis counts did not show a specific area of less morbidity in the engineers. The loadmaster incidence rate was not significantly different (RR=1.04 95% CI 0.61, 1.76). Duration of illness was not significantly different.

All Other Diseases

All other diseases represented 288 events, 15% of the total. Time lost rates were significantly elevated for both flight engineers and loadmasters (FE=12.2 and L=19.0 v. P=6.6). Incidence rate ratios were similarly elevated (FE IRR=1.58 95% CI 1.16, 2.07; L IRR=1.93 95% CI 1.44, 2.58). Loadmaster duration was over 3 days longer than pilots (L=11.6 v. P=8.1); engineer duration was not significantly different than pilots.

For other illnesses, a few comments may be useful, especially for future considerations. Loadmasters had nearly 60% (30/51) of the sexually transmitted diseases; their larger numbers in the 18-22 age group may be responsible for this trend. Engineers had over 500 days lost for nervous system disorders; combined, the pilots and loadmasters lost only 89 days. Most of the 500 days could be attributed to a case of Bell's palsy, a seizure disorder, and two cervical radiculopathies. Ninety-two percent of the psychiatric problems occurred in the engineers and loadmasters; these 12 cases represented nearly 1000 days lost. Eight of these 12 cases were alcohol abuse (820 total days lost); six of the eight were flight engineers.

Factors Correlated With Morbidity

To better address the problem of lost time, identification of the factors most responsible for increased lost time is important. Some factors may be disease specific; for example, poor hygiene may predispose to dermatitis. Other factors may increase morbidity in general, rather than a specific disease entity. These variables include inflexibility of hours, shift work, job satisfaction, autonomy in the workplace, smoking, pay, task variety, obesity, and psychological stress.

Some factors affect all crewmembers; the work danger, flexibility of hours, and circadian effects are similar for all crew positions.

Other factors have pilot/non-pilot differential. The most obvious factor is socioeconomic status. The flight engineers and loadmasters are enlisted personnel rather than officers and normally do not have college degrees. Their pay and benefits are substantially lower than pilots of similar age and seniority. They appear to smoke more than pilots. Although the flight engineers' and loadmasters' job satisfaction is high as compared to most Air Force career fields, it appears to be less than pilots. There is markedly less autonomy in the work of the non-pilots (since they are always accountable to the aircraft commander, who, by definition, is a pilot). Still, the causal factors for the excess force of morbidity are probably multiple and may be interactive.

Perhaps the most significant finding may be the apparent lower morbidity in pilots rather than an excess in flight engineers and loadmasters. This "healthy worker effect" could be due to a variety of factors. One factor could be the high physical standards for entry into pilot training. Another could be the psychological nature required to successfully complete pilot training. Pilots are usually first-born males; they are assertive individuals who prefer to conquer their environment rather than adapt.[22] Since they view the airplane as an integral part of their lives, pilots despise being temporarily disqualified from flying due to minor illnesses. Their goal-oriented nature probably drives them to fly in spite of mild or early symptoms of disease. All these factors may contribute to the relatively decreased morbidity of the pilots and apparent increased morbidity of flight engineers and loadmasters. The real problem may be that pilots under report minor illnesses and fly in spite of them.

Limitations

Probably the greatest limitation in this study is the incomplete analysis of potential confounders. Unfortunately, denominator data on ages and sex were not available and no data at all was available on marital status or the number of children at home. Others have criticized the study for using an internal referent (pilots) rather than a national or military morbidity index.

Incomplete analysis of confounders and effect modifiers may not be serious for a number of reasons. First, this is a hypothesis generating study which sets the pattern and direction for future studies. It was not meant to be, and cannot be the definitive study on aircrew illness. Second, the study groups were really large populations rather than samples and the differences in the groups do represent population differences and cannot be dismissed on the basis of sampling bias. Third, the groups were very similar in their median ages and distribution (see appendix A).

Certainly a comparison with some standard morbidity rate would be ideal. Unfortunately, no good standard exists, and if it did, it would probably be biased as the care of military air crewmembers is more meticulous than nearly any other health care environment. Military pilots, flight engineers and loadmasters are seen for every cold, every case of diarrhea, and every "flu-like syndrome." The rest of the world routinely self medicates for all these conditions, but crewmembers are prohibited from doing so. Thus, the rates for non-flyers would likely be under-counted because so many minor illnesses are included in airmen illness rates.

CONCLUSIONS

The data from the transport aircraft flying squadrons showed significant differences in the total days lost, new illness incidence, and duration of illness for both flight engineers and loadmasters when compared to pilots.

For flight engineers, greater time lost rates were found for upper respiratory infections, back/neck pain, other musculoskeletal problems, dermatologic problems, gastroenteritis, and dental problems. Flight engineers also had higher incidence rates of upper respiratory infections, back and neck pain, other musculoskeletal problems, dermatologic diseases, and dental problems. They had less incidence of urologic and renal problems. Duration of dermatologic problems and upper respiratory infections were longer for engineers than pilots.

For loadmasters, greater time lost rates were found for upper respiratory infections, back/neck pain, other musculoskeletal problems, dermatologic conditions, urologic/renal problems, and dental problems. Loadmasters also had higher incidence rates of back and neck pain, other musculoskeletal problems, dermatologic diseases, and dental problems. Duration of upper respiratory infections, dermatologic problems, dental diseases, and back pain were longer for loadmasters than pilots.

RECOMMENDATIONS

1. Prospectively conduct the next study.

2. Other variables may confound the apparent association of crew position and increased lost time. Items such as smoking status, alcohol use, marriage status, age, job satisfaction, and number of children at home should be included in the next database.

3. To better examine the individual diseases, a large increase in power would be necessary. This could be accomplished by increasing the number of person days observed or by matching and the use a conditional maximum likelihood analysis.

4. The results should be presented to flight surgeons and schedulers to better evaluate and manage human resources.

5. Aircraft accident investigation reports should be reviewed for pilot illness or self-medication that may be evidence of a pseudo "healthy worker effect".

REFERENCES

1. Frolov NI: Methods of Studying Inflight Pilot Performance. Kosmicheskaya Biologiya i Aviakosmicheskaya Meidatina 1978; 1: 3-11.

2. United States Air Force: Flight Management. Dept. of the Air Force (AF Reg 60-1). Washington DC: HQ USAF, Feb 1990.

3. Cooper CL, Sloan SJ: Coping with Pilot Stress: Resting at Home Compared with Resting Away from Home. Aviation, Space, and Environmental Medicine 1987; 58: 1175-1182.

4. Chidester TR: Trends and Individual Differences in Response to Short Haul Flight Operations. Aviation, Space and Environmental Medicine 1990; 59: 199-204.

5. Gasaway DG: Noise Associated with Airborne Operation of C-141 A Aircraft. USAF School of Aerospace Medicine (SAM TR 70-74) Brooks AFB TX: USAFSAM; Dec 1970.

6. Sundback U, Tingvall B: Investigation of the Physical Working

Environment for Cabin Attendants with Scandavian Airlines. Proceedings from the 1980 International Conference on Noise Control Engineering 1980; 341-344.

7. Inglesias R, Gonzalez G, Morales S: Occupational Injuries Suffered by Flight Atte..dants While on Board. Aviation, Space, and Environmental Medicine 1989; 60: 1109-1111.

8. Brooks CJ: Loss of Cabin Pressure in Canadian Forces Transport Aircraft, 1963-84. Aviation, Space, and Environmental Medicine 1987; 58:268-275.

9. Nagda NL, Fortmann RC, et al.: Airliner Cabin Environment: Contaminant Measurements, Health Risks, and Mitigation Options. U.S. Department of Transportation, (DOT report no. DOT-P-15-89-5). Washington DC: U.S. Government Printing Office, Dec 1982.

10. Booze C: Prevalence of Selected Pathology Among Currently Certified Active Airmen. Aviation, Space, and Environmental Medicine 1982; 53: 1198-1201.

11. Hoisberg A, Blood C: Age Specific Morbidity Among Navy Pilots. Aviation, Space, and Environmental Medicine 1983; 54: 912-918.

12. Ungs T, Sangal S: Flight Crews with Upper Respiratory Tract Infections. Aviation, Space, and Environmental Medicine 1990; 61: 938-941.

13. Zwart B: A New Method For Tracking and Analyzing Illness and Morbidity Among Active Duty, Air Force Aviators. Aviation, Space, and Environmental Medicine 1992; publishing pending.

14. Leigh JP: Employee and Job Attributes as Predictors of Absenteeism in a National Sample of Workers. Social Science in Medicine 1991; 33: 127-137.

15. Chevalier A, Luce D, et al.: Sickness Absence at the French National Electric and Gas Company. British Journal of Industrial Medicine 1987; 44: 101-110.

16. Farrell D, Stamm C: Meta-Analysis of the Correlates of Employee Absence. Human Relations 1988; 41: 211-227.

17. Leigh JP: The Effects of Unemployment and the Business Cycle on Absenteeism. Journal of Economics in Business 1985; 37: 170-195.

18. Athanasou J: Sickness Absence and Smoking Behavior and its Consequences. Journal of Occupational Medicine 1975; 17: 441-445.

19. Sexton M, Schumann B: Sex, Race, Age, and Hypertension as Determinants of Employee Absenteeism. American Journal of Epidemiology 1985; 122: 302-310.

20. SAS Institute Inc: Procedure TTEST. In SAS User's Guide: Statistics, Version 5 Edition. Cary NC: SAS Institute Inc., 1985; 795-800.

21. Kelsey JL, Hochberg MC: Musculoskeletal Disorders. In Maxcy Rosenau Last Public Health and Preventive Medicine. Ed. Last JM, Wallace RB. Norwalk CT: Appleton & Lange, 1992; 913.

22. Jennings CL: The Use of Normative Data in the Psychological Evaluation of Flying Personnel. In Psychiatry in Aerospace Medicine Vol.4 International Psychiatry Clinics

Ed. Perry CJ. Boston MA: Little Brown, 1967; 37-52.

APPENDIX A: Distribution of Ages

This table demonstrates the similarity of the age distributions for all three crew positions.

CREW POSITION	AGE (IN YEARS)						
	Quantiles					Mean	Std Dev
	5%	25%	50%	75%	95%		
Flt Engineer*	24	28	32.5	37	43	32.8	5.7
Loadmaster#	20	24	29	35	41	29.5	7.0
Pilot+	24	27	29	31	43	30.2	5.5

* N=232
\# N=185
\+ N=228

APPENDIX B. Duration transformation options

Tabulated below were the duration of illness transformation options considered to normalize the variable. Normally distributed data should have similar mean and median values, small skewness and small kurtosis. Also, as the Komogorov Smirnov "D" statistic becomes smaller, the likelihood of normality increases. No transformation and the square root transformation were clearly inferior. Using a rank transformation did improve normality but at a cost in power. Although the Blom transformation forces the data into a high degree of normality, the de-transformation was cumbersome and a mean duration of 0 seems very unnatural. The natural logarithm transformation gave good normality, a non-zero mean, and an easy conversion back to number of days lost.

Transform.	Mean	Median	Skewness	Kurtosis	Komogo. "D"
No Transform	15.3	8.0	7.4	72	.32
Sq. Root	3.3	2.8	3.4	17	.18
Rank	1016	1075	.005	-1.2	.10
Blom	0	0.1	.040	-0.1	.06
Natural Log	2.1	2.1	.538	1.2	.07