# FINAL PERFORMANCE REPORT

**Occupational and Environmental Medicine**

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****BECAUSE THE RESULTS HAVE NOT YET BEEN PUBLISHED, P.49 ONWARDS IS *CONFIDENTIAL*****

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# ABBREVIATIONS

| | |
|---|---|
| BNP | Back or Neck Pain |
| ICD-9 | The 9$^{th}$ revision of the International Classification of Disease |
| JCQ | Job Content Questionnaire (Karasek et al, 1998) |
| LBP | Low back pain |
| LOEXP | Lower Extremity Pain |
| MSD | Musculoskeletal disorder |
| MUNI | San Francisco Municipal Railway |
| MUNI-1 | The San Francisco MUNI Public Transit Operator Study Cohort-1 (1983-1985) |
| MUNI-2 | The San Francisco MUNI Public Transit Operator Study Cohort-2 (1993-1995) |
| NP | Neck pain |
| RTW | Return to Work |
| TAS | Toronto Alexithymia Scale |
| UPEXP | Upper Extremity Pain |

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# ABSTRACT

The independent effects of physical and psychosocial job factors on occupational LBP and disability are still under debate, and their impact during different phases of the disabling and recovery process are essentially unknown. The goal of this project was to prospectively examine the role of physical and psychosocial job factors in the etiology and prognosis of occupational low back pain (LBP) during five successive phases in the course of occupational LBP: (1) the pre-disability symptom phase, (2) the pre-disability formal injury report phase, and (3) three disability phases – acute, subacute, and chronic – defined by increasing durations of lost work time. It was hypothesized that both physical and psychosocial job factors are independent predictors of LBP at all five phases and that their relative effect sizes change across phases. The main objective was to determine phase-specific risk factor profiles with particular focus on the relative impact of psychosocial and biomechanical risk factors. The long-term goal is to yield useful information for the design of workplace interventions which combine organizational and ergonomic job redesign to prevent low back injuries and associated work disability.

This project combines the resources of two existing data sets – two prospective cohorts of San Francisco urban transit operators (n = 1,449, n = 1,640). These two longitudinal studies provide workers' compensation data with up to 7.5 years of follow-up, allowing for the study of each phase of the disability process, including the chronic disability phase (>90 days off work), which accounts for 80% of the costs associated with work-related low back injuries. Both studies provide comparable information on job-related, sociodemographic, injury, medico-legal, and economic factors.

Primary analyses examined the independent effects of physical workload (measured by duration of professional driving, vehicle type, and ergonomic problems) and psychosocial job factors (including self-reported psychological and physical job demands, job control, job strain and social support at work). In addition, unique data on job stressors, assessed by observers with an innovative job analysis instrument independent of worker appraisal, were used as an alternative objective measure of job stress in a sub-study of one-third of transit lines. Secondary analyses aimed to determine the predictive validity of these observational measures for LBP, neck pain, and musculoskeletal disorders of the extremities. Separate analyses were conducted for less and more severe injuries based on medical criteria.

Key findings of this project can be summarized as follows: Both physical and psychosocial job factors were independently associated with all outcomes under study.

Representative for physical job factors, the amount of professional driving in hours per week showed a strong and statistically significant dose-response relationship with 12-month prevalence of LBP and with incidence of a first compensated work-related low back injury during 7.5 years of follow-up, even after controlling for psychosocial job factors and individual demographic and anthropometric variables. Similarly, cable car operators performing heavy physical labor consistently had a higher risk for LBP and work-related injury compared to diesel bus drivers. Self-reported ergonomic problems were also associated with LBP prevalence and low back injury incidence. Furthermore, long weekly driving hours constituted a major barrier to return-to-work after a disabling low back injury during all disability phases. It is noteworthy that the effects of physical job factors were strongest for severe low back disorders confirmed by medical diagnosis such as postlaminectomy syndrome, spinal stenosis, or herniated lumbar disc with myelopathy. The diagnosis of such disorders is based on objective signs of structural and functional damage to the lower spine and, in contrast to less severe low back injuries, is therefore virtually independent of subjective worker or physician appraisal. These findings in particular represent new strong evidence for a causal role of physical job factors in the development of occupational low back injuries.

Among psychosocial job factors, self-reported high psychological job demands and the combination of high psychological demands and low decision latitude at work emerged as risk factors for both low back pain prevalence and injury incidence, independent of physical job demands or individual worker characteristics. Observer-based job stressors showed strong and statistically significant associations with LBP, with odds ratios ranging from 2.76 for vehicle moving barriers to 8.96 for barriers for locomotion and equipment handling. For each increment of 10 minutes of extra work due to all six barrier categories combined, the prevalence of LBP increased by 46%, even after adjustment for age, gender, and physical workload. Other musculoskeletal disorders (with the notable exception of neck pain) were also strongly associated with this observational measure of job stress. The results demonstrate a high predictive validity of this new observer-based measure of job stress and support a causal role of job stress in the development of low back pain and other musculoskeletal disorders independent from the appraisal of the worker and independent from physical workload and demographic factors.

# SIGNIFICANT FINDINGS

The present project examined prospectively the role of physical and psychosocial job factors in the etiology and prognosis of occupational LBP in a cohort of San Francisco public transit operators with 7.5 years of follow-up. The project's main objective was to develop risk factor profiles separately for the following outcomes: (1) the prevalence of low back pain, (2) the incidence of compensated low back injuries, and (3) the duration of disability, separately for the acute (1-30 days), subacute (31-90 days) and chronic (>90 days) disability phases. For each of these outcomes, the independent effects of physical workload and psychosocial job factors were determined while controlling for individual demographic and anthropometric worker characteristics. An additional aim was to examine the predictive validity of a newly developed observer-based measure of job stressors. The significant findings of this project are summarized in the following paragraphs.

## 1. PHYSICAL WORKLOAD AND LOW BACK PAIN

### 1.1 Physical Workload and 12-Month Prevalence of Low Back Pain

All three objective measures of physical workload (years of driving, hours of driving, and vehicle type) showed positive associations with self-reported LBP during the past year even after adjustment for psychosocial job factors, demographic and anthropometric variables. Compared to the reference group driving with less than 5 years of driving, the adjusted odds ratio (OR) was 1.39 for 5-9 years, 1.51 for 10-14 years, 1.48 for 15-19 years, and 2.00 for 20 or more years of professional driving. A 42 percent increased prevalence was observed among 438 operators driving 40-49 hours per week compared to drivers with a 40-hour work week. Cable car operators who perform the physically most demanding tasks among all drivers had a 57% increased risk of LBP compared to diesel bus operators. The results support previous research showing that driving motor vehicles and high physical job demands increase the risk of low back pain.

### 1.2 Physical Workload and 7.5-Year Incidence of Compensated Low Back Injury

Transit operators who had been professional drivers for five years or less had a significantly increased hazard ratio (HR=1.36) for all low back injuries. Analyses stratified by injury severity showed that the increased risk for this group was limited to less severe injuries (HR=1.55) and that there was no relationship with more severe injuries (HR=1.05). Weekly hours of driving showed a strong association with severe low back injury incidence exhibiting an exponential dose-response relationship: For every 10 hour increase in weekly driving, there was a 32% increase in risk of severe low back injury. Full-time drivers (31-50 hours per week) had an hazard rate ratio of 2.33 compared to part-time drivers (20-30 hours per week). Operators driving more than 50 hours per week had a 5.6 fold higher rate of severe low back injuries (HR=5.60) than operators driving 20-30 hours. Cable car operators had a 1.6-fold and 2.8-fold higher risk for less severe and more severe injuries, respectively, compared to diesel bus operators. Drivers who scored high on self-reported ergonomic problems demonstrated a 22% increased risk for every 10-point increase on the scale of ergonomic problems. All hazard ratios were adjusted for age, sex, ethnicity, body height, body weight, and psychosocial job factors (psychological job demands, decision latitude, supervisor support and co-worker support). The findings confirm those from a cross-sectional and prospective cohort study conducted within the same company 10 years earlier, both showing strong associations between biomechanical factors and spinal disorders. The current prospective cohort study provides strong additional evidence for physical workload as a major cause of low back diseases independent of aging , body built, sex, ethnicity, or psychosocial job factors. It is noteworthy that the effect was strongest for low back disorders with structural morphological damage confirmed by medical diagnosis such as postlaminectomy syndrome, spinal stenosis, or herniated lumbar disc with myelopathy.

### 1.3. Physical Workload and Duration of Work Disability

Fifteen or more years of professional driving tended to be associated with a slightly longer time to return-to-work (RTW) after a disabling low back injury compared with driving exposure of less than 15 years, regardless of disability phases, but for more severe injuries only. Part-time drivers (20-30 hours per week) showed a significant faster return-to-work (HR=1.74) compared to full-time drivers (31-50 hours), while drivers with more overtime (50 or more hours) returned to work at a slower pace than full-time drivers (HR=0.77). This relationship between driving hours and duration of work disability was strongest for more severe injuries. Drivers working on railbound vehicles returned to work faster than drivers of street-bound vehicles, however, these effects were limited to drivers who had more than 30 days of work disability and were already in the subacute or chronic disability phases. Self-reported ergonomic problems showed no consistent effects on time to RTW. Although the observed differences between disability phases and between severity groups were not statistically significant because of the small sample of drivers with chronically disabling low back injuries, the results suggest that physical workload is a barrier to return to work and that the impact may differ by phase of disability and by severity of back injury. Future studies with larger sample sizes need to further explore the severity- and phase-specificity of the association between physical job demands and duration of disability.

# 2. JOB STRESS AND LOW BACK PAIN

## 2.1. Job Stress and 12-Month Prevalence of Low Back Pain

Several dimensions of job stress were measured in this study. Three dimensions (psychological job demands, decision latitude, and job strain as the combination of high demands and low decision latitude) were measured by self-report based on the standard Job Content Questionnaire. In addition, six different categories of job stressors (also called task barriers) were assessed by an observer-based job analysis of one third of work places. These task barriers by definition caused extra work efforts for the driver, measured in minutes per 4-hour shift. In this study, drivers had to perform on average 31.5 minutes of extra work per 4-hour shift in order to deal with these barriers. Barriers to vehicle moving (e.g. double parked cars in the street) contributed the largest single amount of extra work time (8.6 minutes).

Drivers in the medium or high tertile of psychological job demands showed a statistically significant association with 12-month prevalence of LBP compared to low demands. Low decision latitude and high job strain were not statistically significant associated with LBP prevalence, probably due to the low variation in decision latitude in this single occupation cohort.

Observer-based job stressors showed strong and statistically significant associations with LBP, with odds ratios ranging from 2.76 for vehicle moving barriers to 8.96 for barriers for locomotion and equipment handling. For each increment of 10 minutes of extra work due to all six barrier categories the prevalence of LBP increased by 46% even after adjustment for age, gender, and physical workload. Other musculoskeletal disorders (with the notable exception of neck pain) were also strongly associated with this observational measure of job stress. The results demonstrate a high predictive validity of this new observer-based measure of job stress and support a causal role of job stress in the development of low back pain and other musculoskeletal disorders independent from the appraisal of the worker and independent from physical workload and demographic factors.

## 2.2. Job Stress and 7.5 Year Incidence of Low Back and Neck Injury

Originally, the aim to prospectively examine the role of job stress for the incidence of compensated work-related musculoskeletal injuries was limited to injuries of the lower back. In the course of the study we supplemented this aim to also evaluate neck injuries because they were relatively frequent in this population and also to investigate any disease-specificity of risk factors. The 1294 participants in this prospective study experienced a total of 533 low back and 487 neck injuries during the 7.5 year period. Only first injuries (351 low back and 334 neck) were included in the analyses. All analyses were adjusted for individual demographic and anthropometric factors, and physical workload (measured objectively by vehicle type,years and weekly hours of driving, and subjectively by self-reported physical demands). All psychosocial variables were analyzed continuously and in low, medium, and high categories based on tertiles of the distribution.

Psychological job demands and decision latitude (job control) showed weak and statistically not significant associations with low back injuries, however, job strain (i.e., the combination of high demands and low control) increased the hazard rate ratio of low back injuries by 35 percent (HR= 1.35, 95% CI = 1.01-1.81, $p<0.05$). Analyses stratified by severity of injury indicated the relatively stronger impact of job strain on less severe (HR= 1.51) compared with more severe (HR=1.19) low back injuries.

When neck injuries were examined, low decision latitude emerged as a predictor with borderline statistical significance (HR=1.27), 95% CI 0.97-1.67, $p<.10$). Job strain was a significant predictor of neck injuries (HR 1.61, 95% CI 1.20-2.16) as was iso-strain , the combination of job strain with low social support at work (HR1.77, 95% CI 1.25-2.51) When the analysis of job strain was stratified by severity of neck injury, a higher hazard ratio emerged among drivers with less severe injuries (HR = 1.39) compared with those who had more severe injuries (HR = 0.96). When the predictor was iso-strain, however, the hazard ratio for neck injury was smaller among those with less severe (HR = 1.32) compared with more severe neck injuries (HR = 1.42). There was evidence of a dose-response relationship for the iso-strain scale such that an increase of 10 units of iso-strain resulted in a 10% increase in risk for neck injury (HR = 1.10, $p < .05$).

In summary, self-report measures of job strain predicted both back and neck injuries and the associations were in general stronger for neck injuries and for more severe injuries. Analyses of observer-based job stressors are still in progress at the time of this report. Preliminary analyses (not yet reported) show strong positive associations between specific job stressors and low back injury and weaker associations for neck injury.

## 2.3. Job Stress and Duration of Work Disability

The associations between different self-reported dimensions and job stress show complex and partially unexpected patterns which await further analyses and interpretation. Briefly, high psychological demands and job strain were associated with a slower rate of return to work in the acute phase of disability (< 30 days), but a faster return to work (RTW) in the subacute and chronic phases. Low decision latitude (control) was weekly associated with a faster RTW across all phases. When analyses were stratified by severity of injury, high demands, high job strain, and high iso-strain were associated with a slower RTW in the acute phase for less severe back injuries. Low decision latitude was associated with a slower RTW in the subacute and chronic phases for less severe injuries but with a faster RTW for more severe injuries. Among those with more severe injuries, high work demands was associated with a faster RTW rate in the acute , and with a slower RTW in the subacute and chronic phases. High job strain and low control were both associated with a faster RTW after severe injury across all three phases. Iso-strain was associated with a faster RTW in the acute and chronic phases, but a slower RTW in the subacute phase. The effects of job-related demand, control, and job strain varied in their effect sizes and their direction (hastening or inhibiting) across each phase of disability. Given the small sample of drivers with disabling conditions, these results are rarely statistically significant and need to be considered exploratory. Future analyses will also attempt to study the effect of observational job stressors on disability outcomes. Nevertheless, the preliminary findings cited in this report support previous research showing that occupational risk factors may have disability- and disease severity specific effects on disability due to low back pain.

# 3. SOCIAL SUPPORT AT WORK AND LOW BACK PAIN

## 3.1. Social Support and 12-Month Prevalence of Low Back Pain

In analyses adjusted for demographic physical workload, and job strain, levels of supervisor support were statistically significantly associated with increasing LBP prevalence. Coworker support was not associated with LBP, partly reflecting the isolation from coworkers in this occupation.

## 3.2. Social Support and 7.5-Year incidence of Low Back and Neck Injury

A low level of supervisor support did not predict back injury (HR=1.10, 95% CI=0.84,-1.44). Only when support was treated as a continuous variable in the analyses, supervisor support approached statistical significance. Every one point increase in supervisor support was associated with a 4% decrease in risk of low back injury (HR = 0.97, $p < 0.10$).

For neck injuries, a different picture emerged: Low supervisor support (HR = 1.40, $p < 0.05$) and low total support (HR = 1.40, $p < 0.05$) were significant predictors of neck injuries, even after adjustment for physical workload and for sociodemographic factors. Low coworker support (HR = 1.25, $p < 0.10$) was of borderline significance in predicting incidence of neck injury. There was a dose-response relationship for social support, such that there was a 6% reduction in neck injuries rates for every one point increase on either the supervisor support scale, or the co-worker support scale.

## 3.3. Social Support and Duration of Work Disability

Low supervisor support had no effect on RTW as long as the analyses were not stratified for injury severity. Low co-worker support was significantly associated with lower RTW rates in the subacute disability phase while there were no substantial effects during other phases.

In analyses limited to more severe injuries, low supervisor support was associated with a faster RTW rate in the acute phase and a slower RTW rate in the subacute phase. Low co-worker support was associated with a reduced RTW rate in the acute and subacute disability phases and an increased RTW rate in the chronic disability phase. For less severe injuries low coworker support reduced RTW rates particular in the subacute phase, and supervisor support did so in the chronic phase.

Again, most associations were not statistically significant due to the small sample of workers with disabling low back injuries. These results indicate the effects of low social support on the disability recovery process are not uniformly negative, and that supervisor support may have a more important role in this process than co-worker support, at least in this isolated work environment. Also, the effects of low support vary according to phase of disability being studied.

## USEFULLNESS OF FINDINGS

Among urban transit operators, physical workload, especially, years and weekly hours of professional driving exposures were consistently associated with LBP prevalence, predicted incidence of compensated low back injury and the duration of associated work disability. These effects were strongest for more severe low back disorders and emerged even after adjusting for age, sex, ethnicity, and psychosocial factors such as job stress and social support. In addition, operators of cable cars performing physically more demanding tasks than any other transit operator had the highest risk for LBP and work-related injury. Clearly, this study provides strong additional evidence for the independent effects of objectively measured physical workload on prevalence of low back pain and incidence of work-related injury.

Low back pain was also more prevalent among those drivers who reported more work related stress, and among drivers who were observed to encounter more job stressors or task barriers. A high level of job strain (high demands and low decision latitude) predicted the incidence of low back and neck injuries. High levels of job strain appear to also have a significant impact on rate of return to work, particularly in the acute phase of disability. These effects were all observed in analyses adjusted for the potentially confounding effects of physical workload, sociodemographic, and anthropometric factors. Thus, job stress was related to low back pain and injury independently of these factors.

Social support on the job, particularly from supervisors, was associated with reduced prevalence of low back pain, and was implicated as a potential factor contributing toward increased incidence of low back injury. Low supervisor support may also inhibit faster return to work following a disabling low back injury, particularly in the acute and chronic phases of disability.

Three additional secondary aims, newly formulated in the course of this project need to be mentioned here. First, many analyses were stratified by severity of low back pain. Second, the effects of self-reported job stress and social support were also analyzed for neck injuries. Third, the effects of observer-based job stress were also analyzed for neck pain and musculoskeletal disorders of the upper and lower extremities. These additional analyses identified disease- and severity-specific risk patterns not previously reported in the literature. The lack of a disease-, severity-, and disability phase-specific approach in previous research may in part explain inconsistencies found in the extant literature on musculoskeletal disorders. Together with the prospective design of this study, adequate control of relevant confounders, and use of objective measures for both exposure and outcome variables, this project has provided evidence for the independent role of physical and psychosocial job factors in the causation of musculoskeletal disorders which is of unusual high methodological quality.

The analytical approach and empirical evidence provided by this project will be useful for prevention of occupational low back pain. The general risk factors (physical workload, ergonomic problems, job stress, and social support at work) identified in this study point to promising target areas for workplace interventions aimed at the reduction of work-related low back injuries and workers' compensation costs. The fact that these risk factors were relevant for different outcome measures and phases in the course of this disease makes them prime targets for efficient interventions. In instances were the effect sizes of these factors differed between the acute, subacute, and chronic disability phases, this information can be used for the most efficient timing of intervention efforts. Clearly, the disability phase-specific approach of this research can improve both epidemiological assessment of risk and design and timing of workplace interventions.

Furthermore, the industry-specific risk factors identified through questionnaires and company record review (weekly driving hours, vehicle type, specific ergonomic problems) and the long list of task-specific job stressors (task barriers) identified in the observational job analyses can be extremely useful for the selection and implementation of concrete workplace changes at the study site and elsewhere in the public transportation industry.

# SCIENTIFIC REPORT

## 1. BACKGROUND

Low back pain (LPB) is a leading cause of disability for people under age 45, and it is the second leading cause of industrial absenteeism. Work-related low back injuries account for approximately 25% of compensable work injuries and 33% of all workers' compensation costs in the US, totaling about $13-20 billion annually. About 7% of workers with LBP develop chronic work disability of more than one year duration, and this group alone accounts for 75% of all workers compensations costs associated with low back injuries. However, the determinants of duration of disability associated with LBP injuries are poorly understood. Existing literature has focused on risk factors for acute episodes of LBP, but there are few studies that identify risk factors associated with the persistence of LBP or work disability.

There is evidence that risk factors for the onset of symptoms differ from risk factors which determine the prognosis of LBP, and that the effects of the latter may in turn be different during the acute, subacute, and chronic phases of disability according to a phase-model of occupational disability applied in this research project. Of course, some risk factors may influence outcomes through the entire course of low back disorders, from first occurrence of symptoms until recovery from chronic work disability. Such common risk factors would be prime targets for efficient interventions to reduce both the incidence of low back injuries and the high burden of disability.

Physical and psychosocial job factors may both play a role in the onset and course of occupational LBP because both categories of risk factors often occur simultaneously in the work environment. However, it has been difficult to establish any independent role for them. Physical factors such as heavy manual labor, driving motor vehicles, whole body vibration, prolonged sitting, trunk bending and twisting, and pulling or pushing have been identified as risk factors for LBP in several reviews on the subject. Psychosocial factors such as job stress and lack of supervisory support have also been implicated in the development of LBP, but only few studies were able to adequately control for physical workload as a possible confounding factor. These methodological problems are compounded by the fact that - in contrast to physical job factors - psychosocial factors have been measured exclusively by self-report instruments which may reflect more the individual's reaction to psychosocial job factors than the presence or absence of the relevant job characteristics themselves. Especially if self-reported measures of job conditions are related to self-reported LBP as the only outcome measure, this common measurement method may produce spurious associations due to a common tendency among responders to either report or deny uncomfortable perceptions of both the work environment and their low back. These are the main reasons why it has remained unclear if and to what degree physical and psychosocial factors independently influence the onset and course of LBP in the workplace. Even less is understood about the possible impact of these factors on the duration of work disability due to low back pain. However, it is conceivable that both physical and psychosocial demands of the pre-injury job may cause low back pain and also act as major barriers to return-to-work after a disabling low back injury.

## 2. SPECIFIC AIMS

The present project examined prospectively the role of physical and psychosocial job factors in the etiology and prognosis of disabling occupational LBP in a cohort of San Francisco public transit operators with 7.5 years of follow-up. This project's main objective is to develop risk factor profiles separately for the following three outcomes: (1) the prevalence of low back pain (LBP) at the pre-disability symptom phase, (2) the incidence of LBP injuries at the pre-disability reporting phase, and (3) duration of disability, or time to return to work after a LBP injury, separately for the acute (1-30 days), subacute (31-90 days), and chronic (>90 days) disability phases. Another objective is to compare the risk factor profiles for low back pain with neck pain (NP) and with other musculoskeletal disorders (MSD). For each of the three outcomes, risk factors associated with low back pain may likewise be associated with pain and injury to other regions of the spine.

Analyses are divided into primary and secondary. Primary analyses focus on the study of the effect of job-level physical and psychosocial work demands on each of the three outcomes, with incremental adjustment for additional factors. Secondary analyses explore the methodological issue of observational vs. self-report measures of job stress in a sub-sample of the study population.

The specific aims of the primary basic analyses are to:

1) Determine the effects of cumulative past and current **physical workload** on the three outcome measures, with adjustment for age, sex, and anthropometric variables.
2) Determine the effects of **job stress/strain** on the three outcome measures, with adjustment for age, sex, and anthropometric variables, where **job "stress"** is defined by the frequency of self-reported stressors, or objectively, as observer-assessed barriers to completing work tasks, time pressure, tightness of work schedule, and monotonous work. **Job "strain"** is defined as self-reported, high psychological job demands combined with low worker control.
3) Assess the **independent and combined effects of physical workload and concurrent job stress/job strain** for the three outcome measures, with adjustment for age, sex, and anthropometric variables.
4) Measure the main effects of **supervisory and coworker support** for the three outcome measures, with adjustment for age, sex, and anthropometric variables, and explore their modifying effects, if any, on job stress/strain and physical workload.

Additional, secondary analyses will explore methodological issues, specifically studies of **observational vs. self-reported measures of job stress/strain** to evaluate the predictive validity of epidemiological instruments for measuring these job factors in large populations where direct worksite observations are not feasible.

# 3. METHODS AND PROCEDURES

## 3.1 Overview

The present cohort study of San Francisco public transit operators overcomes the methodological research problems mentioned above in the background section of this report. In this research, exposure to past and current physical workload and psychosocial stress were assessed simultaneously in order to examine the independent and joint contributions of these two classes of risk factors on LBP. Physical workload was measured objectively at the individual level based on employment records. Moreover, for the first time in LBP research, job stress has been assessed objectively by a newly developed observer-based job analysis instrument in addition to two self-report measures of job stress. The study was not limited to self-reported data on LBP but used also administrative data of compensated low back injuries and work disability based on physician's medical diagnosis as shown on billing records submitted to the workers' compensation insurer and reviewed by a third party bill review company. Risk factors are examined for several outcomes including non-disabling LBP, compensated injury, and the acute, subacute, and chronic phases of disability. Low back injuries were also ranked and studied by severity based on medical diagnosis. Finally, the effects of job stress and social support at work were examined not only for LBP but also for neck pain other musculoskeletal disorders. A detailed description of study methods follows.

## 3.2. Study Population

This project combines the resources of two prospective cohort studies of San Francisco Municipal transit operators (MUNI) with baseline data collection in 1983-85 for the first (MUNI-1) and ten years later in 1993-95 for the second (MUNI-II) cohort. Follow-up data was gathered for both cohorts until 2001 and included company employment records and worker's compensation insurance records. The research plan called for separate analysis of LBP-prevalence and low back injury incidence in the second cohort (the first cohort had been previously analyzed), and for pooling the data for the disability-phase specific analysis of duration of work-disability after low back injury. Therefore, both cohorts are described in the following sections. After reviewing follow-up data obtained for both cohorts, the research team decided against a pooled analysis because of the amount of missing information for the earlier years of follow-up until 1993. A change in third party administration of Worker's Compensation Insurance in 1993 had resulted in abandonment and disorganization of earlier records to a degree that was not repairable despite substantial efforts. Therefore, disability outcomes were only studied in the second (MUNI-2) cohort, of course with a regrettable loss of statistical power.

### 3.2.1 MUNI-1 Cohort.

The San Francisco MUNI Public Transit Operator Study Cohort-1 (MUNI-1) is a prospective cohort study of 1,871 transit vehicle operators employed by the San Francisco Municipal Railway (MUNI) who completed physical examinations and extensive medical history forms required for commercial drivers' license renewal during 1983-1985. Of these, 1,463 (78%) participated in this study by completing an additional (optional) occupational and psychosocial questionnaire immediately after their medical examination. Fourteen participants and three nonparticipants were excluded from the study because of incomplete employment history, yielding 1,449 total participants and 405 nonparticipants. For this sample, 5 years of follow-up workers' compensation claims data was collected. Preliminary analyses of follow-up claims data indicate 614 compensated spinal injuries among the 1,449 study participants over a 5-year follow-up period (Krause et al, 1997a).

During the follow-up period the majority of first injuries reported were low back injuries (58.4%; see Table 1). Similarly, the cumulative percentage of second to sixth injuries reported were also predominantly low back injuries (60%). Approximately 25% of first injuries were neck injuries, and 24% of the cumulative second to sixth injuries reported were neck injuries (Krause et al, 1998c).

Table 1. Frequency of Spinal Injuries by Observation Period, Order of Occurrence, and Location among 1449 Participants of MUNI-I Cohort (1983-1988).

| | Pre-examination (previous injury) [n (%)] | | Post-examination: First Injury [n (%)] | | Post-examination: Second to Sixth Injury [n (%)] | | Total (all injuries) [n (%)] | |
|---|---|---|---|---|---|---|---|---|
| Neck | 41 | (24.3) | 79 | (24.7) | 30 | (24.0) | 150 | (24.4) |
| Mid back[1] | 15 | ( 8.9) | 31 | ( 9.7) | 7 | ( 5.6) | 53 | ( 8.6) |
| Low back | 107 | (63.3) | 187 | (58.4) | 75 | (60.0) | 369 | (60.1) |
| Neck and back[2] | 6 | ( 3.6) | 22 | ( 6.9) | 12 | ( 9.6) | 40 | ( 6.5) |
| Neck and low back | 0 | ( 0.0) | 1 | ( 0.3) | 1 | ( 0.8) | 2 | ( 0.3) |
| All spinal injuries | 169 | (100.0) | 320 | (100.0) | 125 | (100.0) | 614 | (100.0) |

[1]Midback includes injuries in the thoracic area and back injuries not otherwise specified.

[2]Injuries involving both neck and back but back injury location not specified.

*3.2.1.1 Comparison of Responders and non-responders (MUNI-1).*

With respect to the MUNI-1 cohort, the 1,449 total participants and 405 nonparticipants were compared on major demographic and anthropometric measures by applying either chi-square or t-test statistics (see Table 2). There were no statistically significant differences between the two groups for age, gender, ethnicity, marital status, education, type of vehicle driven during the past year, body mass index, sickness days, and work injuries days during the past year. Back or neck pain, number of other symptoms, number of self-reported doctor's diagnoses, and lower ratings of perceived general health were more frequent among participants compared with nonparticipants (Krause et al, 1997a).

Table 2. Comparison of Responders and Nonresponders: MUNI-1 Cohort Study (1983-1988).

| Variable | Responders (n=1449) | Nonresponders (n=405) | |
|---|---|---|---|
| **Age (mean years)** | 42.4 | 42.4 | |
| **Sex (% male)** | 91.0 | 91.4 | |
| **Ethnicity (%)** | | | |
| Black | 61.6 | 64.0 | |
| White | 17.3 | 16.7 | |
| Hispanic | 7.9 | 10.0 | |
| Asian and Pacific Islanders | 7.5 | 4.7 | |
| Filipino | 3.8 | 2.7 | |
| American Indian | 1.9 | 2.0 | |
| **Education (%)** | | | |
| Less than 11th grade | 8.5 | 10.8 | |
| High school graduate | 33.5 | 36.5 | |
| Some technical school or college | 48.0 | 43.4 | |
| College graduate | 10.0 | 9.3 | |
| **Married (%)** | 69.3 | 64.1 | |
| **Vehicle type (%)** | | | |
| Diesel bus | 47.8 | 45.3 | |
| Trolley bus | 31.5 | 32.4 | |
| Light rail | 14.1 | 15.2 | |
| Cable car | 6.6 | 7.1 | |
| **Back or neck pain now (%)** | 14.8 | 10.8 | * |
| **Perceived health (range 1-4)** | 2.3 | 2.2 | * |
| **Co-morbidity (no. of diagnoses)** | 0.4 | 0.3 | * |
| **Co-symptoms (no. of symptoms)** | 1.8 | 1.3 | * |
| **Body mass index (kg/m$^2$)** | 26.3 | 26.6 | |
| **Sick days past year** | 6.5 | 6.8 | |
| **Work injury days past year** | 6.1 | 5.8 | |

* Difference significant at $p < 0.05$; a Student's *t* test was used for continuous variables, and a Pearson's $\chi^2$ statistic was used for categorical variables.

### 3.2.2 MUNI-2 Cohort

The San Francisco MUNI Public Transit Operator Study Cohort-2 (MUNI-2) is a second prospective cohort study of 2,048 transit vehicle operators employed by MUNI. This cohort completed a physical exam and extensive medical history forms required for a commercial driver's license renewal between August, 1993 and September 1995. Seventy-three participants were excluded because a review of their data indicated that they were certainly or very likely not active transit operators, but held other jobs such as supervisor. An additional 60 participants were excluded because their Social Security number was missing, thereby prohibiting linkage to the worker's compensation injury dataset. Thus, the total eligible study population was 1,841 transit operators. Of the eligible participants, 1,502 (81.6%) responded to an additional (optional) occupational questionnaire immediately after their medical examinations.

#### *3.2.2.1 Comparison of Responders and Non-Responders (MUNI-2)*

With respect to the MUNI-2 cohort, responders and nonresponders were compared on major demographic and anthropometric measures, as well as for type and severity of injury by applying either chi-square or t-test statistics (see Table 3). There were no differences between responders and nonresponders with respect to age, gender, height, weight, years of professional driving experience, type of vehicle driven, type of first low back injury, severity of first low back injury, first neck injury, type of first neck injury, or severity of first neck injury. Groups did differ on ethnicity ($\chi^2 = 26.88$, $p < .001$) and cumulative incidence of first low back injury ($\chi^2 = 5.57$, $p < .05$). Twenty seven percent of responders and thirty percent of nonresponders experienced a first low back injury during 2.5 years of follow up.

Table 3. Comparison of Responders and Non-Responders: MUNI-2 Cohort Study (1993-2001).

| | Responders [a] (n=1,502) | | Non-Responders (n=339) | | | |
|---|---|---|---|---|---|---|
| **Variable** | **Mean or n** | **(SD or %)** | **Mean or n** | **(SD or %)** | **t or $\chi^2$** | **p** |
| **Age (years)** | 46.7 | (7.8) | 47.2 | (7.2) | 1.14 | 0.25 |
| **Sex** | | | | | | |
| Men | 1266 | (84.3%) | 281 | (82.9%) | | |
| Women | 236 | (14.6%) | 58 | (17.1%) | 0.40 | 0.53 |
| **Ethnicity** | | | | | | |
| African American | 845 | (56.3%) | 217 | (66.4%) | | |
| Asian/Pacific Islander | 277 | (18.4%) | 35 | (10.7%) | | |
| Hispanic | 185 | (12.3%) | 23 | (7.0%) | | |
| Caucasian | 174 | (11.6%) | 41 | (12.5%) | | |
| Other | 21 | (1.4%) | 11 | (3.4%) | 26.88 | <0.001 |
| **Height (cm)** | 173 | (8.8) | 174 | (8.9) | 1.21 | 0.23 |
| **Weight (kg)** | 88 | (19.1) | 89 | (20.0) | 1.21 | 0.23 |
| **Years of professional driving** | 13.4 | (8.1) | 14.1 | (7.4) | 1.45 | 0.15 |
| **Vehicle type** | | | | | | |
| Diesel bus | 692 | (46.1%) | 142 | (51.1%) | | |
| Trolley bus | 497 | (33.1%) | 79 | (28.4%) | | |
| Light rail | 192 | (12.8%) | 30 | (10.8%) | | |
| Cable car | 121 | (8.1%) | 27 | (9.7%) | 4.36 | 0.23 |
| **First low back injury** | 409 | (27.2%) | 114 | (33.6%) | 5.57 | 0.02 |
| **Type of first low back injury** | | | | | | |
| Postlaminectomy syndrome | 1 | (0.3%) | 1 | (0.9%) | | |
| Spinal stenosis | 13 | (3.2%) | 2 | (1.8%) | | |
| Herniated disc with myelopathy | 9 | (2.2%) | 2 | (1.8%) | | |
| Herniated disc without myelopathy | 72 | (17.6%) | 15 | (13.2%) | | |
| Sciatia | 32 | (7.8%) | 7 | (6.1%) | | |
| Possible instability | 1 | (0.2%) | 1 | (0.9%) | | |
| Probably degenerative changes | 15 | (3.7%) | 8 | (7.0%) | | |
| Non-specific backache | 266 | (65.0%) | 78 | (68.4%) | 6.41 | 0.49 |
| **Severity of first low back injury** | | | | | | |
| less severe | 281 | (68.7%) | 86 | (75.4%) | | |
| more severity | 128 | (31.3%) | 28 | (24.6%) | 1.93 | 0.17 |
| **First neck injury** | 385 | (25.6%) | 81 | (23.9%) | 4.44 | 0.51 |
| **Type of first neck injury** | | | | | | |
| Postlaminectomy syndrome | 2 | (0.5%) | 2 | (2.5%) | | |
| Spinal stenosis | 11 | (2.9%) | 0 | (0.0%) | | |
| Herniated disc with myelopathy | 4 | (1.0%) | 0 | (0.0%) | | |
| Herniated disc without myelopathy | 35 | (9.1%) | 4 | (4.9%) | | |
| Brachial neuritis or radiculitis | 32 | (8.3%) | 6 | (7.4%) | | |
| Possible instability | 1 | (0.3%) | 0 | (0.0%) | | |
| Probably degenerative changes | 18 | (4.7%) | 8 | (9.9%) | | |
| Non-specific neckache | 282 | (73.3%) | 61 | (75.3%) | 11.06 | 0.14 |
| **Severity of first neck injury** | | | | | | |
| less severe | 300 | (77.9%) | 69 | (85.2%) | | |
| more severity | 85 | (22.1%) | 12 | (14.8%) | 2.14 | 0.14 |

[a] Responders with complete information on all variables under study. Responders (n=208) with missing values are excluded from this table, however, they showed a similar distribution in all variables listed.

*3.2.2.2 Participants in observer-based job analysis (sub-sample of MUNI-2 cohort).*

A sub-sample of the MUNI-2 cohort participated in observer-based measurement of job stressors. The sampling for the observer-based job analysis was completed in two stages. First, 27 transit lines were chosen out of a total of 90 lines operated by MUNI, on the bases of interviews with management, union representatives, and drivers to include all vehicle types (rail, bus, and cable car) and a variety of task requirements and stressors. The goal was to include lines as diverse as possible with regard to potential level and type of stress factors. The 27 selected lines, were operated by six different divisions with different types of work tasks, (for example bus operators had to deal directly with passengers while train operators did not have direct contact with passengers) and different levels of close supervision. The sub-study included about one third of all lines of the transit company. Second, after the lines were selected, a convenience sample of 81 volunteer operators was selected and contacted by shop-stewards to connect them with researchers. The researchers performed observer-based job analyses while the operator performed his or her usual work. (for details of the sampling strategy see Greiner et al, 1997)

*3.2.2.3. Comparison of sub-sample with complete MUNI-2 cohort.*

Compared with the rest of the MUNI-2 cohort, participants in the observer-based job analysis sub-sample were predominately male (79%), had a mean age of 47.7 years, had worked an average 15.1 years as a professional driver, and their weekly driving hours averaged to 47.0 (Greiner et al, 1997). The sub-sample included operators working on diesel bus driving lines (48%), electrical trolley lines (26%), light rail driving lines (11%), cable car driving (7%) and cable car conducting (7%). This breakdown does not differ significantly from the distribution of operators across the different vehicle types within the larger MUNI-2 sample (Greiner et al, 1997).

## 3.3 Data Sources, Data Collection, and Measurement of Exposures and Outcomes.

### 3.3.1. Overview

Final data sets of both cohorts provided key information on current and past physical workload, psychosocial job factors, sociodemographic factors, injuries, low back pain, and duration of work disability necessary to accomplish the primary research objectives. Baseline data was obtained from (1) a medical history and medical examination required of all drivers during their biannual licensing examination; (2) an occupational questionnaire and (3) an interview on health-behaviors. An additional data set provided an observer-based measure of job stressors for approximately a third of all workplaces. Follow-up data for up to 7.5 years to assess low back injury incidence and disability duration were obtained from (1) workers' compensation insurance records, (2) third party medical bill review records, and (3) company employment records.

Physical workload was measured in five ways: number of years of professional driving, current hours of driving per week, vehicle type driven, self-rated physical job demands, and a self-report measure of ergonomic problems. Job stress was measured in three ways (1) by the 27-item Job Content Questionnaire to assess the following dimensions of job stress: psychological demands, job decision latitude, job strain (the combination of high demands and low decision latitude) and social support, (2) a questionnaire assessing the frequency of 19 different specific job problems and their perceived impact (this instrument had been developed from focus group discussions), and (3) a novel observer-based job analysis instrument assessing job stressors as technological or organizational barriers for task performance that cause extra work efforts quantified in minutes per shift.

The effect of these job factors on prevalence of low back pain and other musculoskeletal disorders was analyzed in logistic regression models, and the effect on incidence of workers' compensation injuries and duration of work disability (time to return-to-work) was analyzed with Cox proportional hazard models which took the disability phase-specificity of risk factors into account.

### 3.3.2. Baseline Data.

Baseline data were obtained from three different sources. First, a medical examination of all MUNI drivers between August 30th, 1993 and September 29th, 1995 that was administered during the mandatory biannual medical re-licensing examination including a medical history form and physical examination. Second, a voluntary baseline occupational questionnaire and interview were administered after completion of the medical examination and after the decision on the driver's license renewal had been made. Third, a sub-sample of MUNI-cohort-2 participated in observational job analysis and filled out a short health survey at the time of the observation.

*3.3.2.1 Medical history form (Appendix A).*

During the baseline medical re-licensing examination all operators filled out a medical history form. This data source provided information on demographic (age, sex, ethnicity), total years of professional driving, vehicle type the participant was operating, and ergonomic problems. MUNI-cohort-2 forms also provided information about prevalent musculoskeletal disorders of the back, neck, lower and upper extremities.

*3.3.2.2. Medical examination.*

This data source provided additional information on anthropometric (height and weight) variables.

*3.3.2.3. Occupational Questionnaire (Appendix B).*

This questionnaire asked about a variety of work-related activities and problems, as well as psychosocial job factors. Specifically, participants were asked about their professional driving history, daily work schedule, and occupational stress factors. These factors included schedule-related problems (e.g., delays due to heavy traffic, equipment malfunctions, too many passengers). Psychosocial factors measured included job strain using the Job Content Questionnaire (Karasek, 1985; Karasek et al, 1998), coping strategies, alexithymia (i.e., lack of awareness of emotional states), stressful life events, job burnout, discrimination (based on race, skin color, or sex), and demographic variables (date of birth, education, ethnicity, marital status).

*3.3.2.4. Epidemiological Interview (Appendix C).*

In this interview, participants were asked for detailed information about the transit lines they had driven in the past 12 months (how frequently the same line was driven, problems experienced on most frequently driven line). In addition, they were asked about general health behaviors including smoking, alcohol use, amount of physical activity (outside of work), and medications used. This interview was originally designed for a study on workplace culture and drinking behavior and included an extensive set of questions about alcohol consumption.

*3.3.2.5. Observer-based job analysis.*

A semi-standardized job analysis instrument was used for worksite observations. The instrument was fine-tuned in interviews with both management and operators, and was pre-tested at several workplaces.

The observational analyses were conducted during regular working hours by eight trained job analysts (Greiner et al, 1997). Training of job analysts included two days of theoretical orientation to job analysis, and one closely supervised practice job analysis with transit operators. The term 'observation' may be interpreted that the observers did not talk with the operator at all. However, observers did ask questions, which were guided by a written protocol in the observer's manual. All questions addressed work-related situations that could not be directly observed but not feelings towards work. For example, one question asked how often the drivers experience accidents during a given week. The observations and interviews were conducted for approximately four hours at each workplace, each with a single operator.

**3.3.3. Follow-up Data.**

Three administrative sources of follow-up data were used in this study: (1) Company employment and separation records (2) Workers' Compensation insurance records (3) Third party medical review records. Workers' Compensation insurance records were attained from the City of San Francisco for the entire study period in order to determine incidence rates of low back pain, neck pain, and duration of disability due to these disorders. These data files are described in greater detail below.

*3.3.3.1. Company Employment and Separation Records.*

Company employment records for all drivers provided information on dates of hire, company division, vehicle type, demographics, and separation dates between March 1st, 1986 and April 28th, 2001. These records were used (1) to verify (cross-check) demographic information contained in surveys and worker's compensation data, (2) to determine job seniority, and (3) to obtain separation dates during follow-up. Information on separation dates is necessary for the accurate measurement of driving exposure time and observation time after the baseline surveys.

*3.3.3.2. Workers Compensation Insurance Records.*

The workers' compensation insurer's databases contained information on work-related injuries sustained by MUNI drivers from 1986 until February 13th, 2001, The information of these databases stems mostly from the First Report of a Work-Related Injury Form, yielding information on the injured body part and the type of injury. Additional information was obtained from several specific files that were all merged based on claim numbers.

*3.3.3.2.1. Claim files.*

Workers' Compensation Claim files were used to collect information on history of previous injuries, nature of each injury, cause of injury, presence of litigation, and total costs of injury.

*3.3.3.2.2. Payment history files.*

Worker's Compensation Payment History files contained information on the length of disability benefit payment throughout the history of each worker's compensation claim, total indemnity costs, total medical costs, and total non-allocated costs.

*3.3.3.3. Third Party Medical bill review records.*

Third-party medical bill review files contained all medical bills submitted in the course of a claim they were the only source of physician diagnoses made throughout the history of each workers' compensation claim. Medical diagnoses were coded based on the 9th revision of the International Classification of Disease (ICD-9) for all injuries in the workers' compensation database.

**3.3.4. Measurement of Low Back Disorders.**

*3.3.4.1. Phase model of disability.*

A primary objective of this project was to determine the effects of physical and psychosocial job factors on the incidence and prognosis of LBP in terms of duration of disability and return to work. Work disability is not the direct consequence of a medical condition, but needs to be conceptualized as a developmental phenomenon that is influenced by a multitude of physical, psychological, and social factors which act at different points in time after the onset of symptoms. Similarly, the process leading to return to work (Verbrugge, 1995) is not simply a consequence of medical intervention alone but is influenced by legal, economic, employer, and employee factors, which all may change over the course of the disease. Because of these time-dependent influences, the investigation of prognostic risk factors needs to consider several stages or phases in the development of long-term work disability, as has been suggested in different ways by several authors (Polatin, 1991; Spitzer et al, 1987; Krause, 1993; Frank et al, 1998).

There is growing evidence that prognostic risk factors may differ for each phase in the disabling process, including even the most basic variables such as age and gender. In fact, it has been shown that individual risk factors may change their specific impact, i.e., effect size or direction of association, depending on disability phase. For example, Oleinick and colleagues (1996a) reported different risk factors for the acute (less than or equal to 8 weeks) and chronic (greater than 8 weeks) phases of work disability after low back injury. During the acute phase, female gender, older age, higher number of dependents, industry, occupation, and accident type predicted continued work disability. During the chronic phase, older age, smaller employer size, and higher wage compensation rate predicted duration of work disability (Oleinick et al, 1996a) The failure to clearly differentiate between different phases in LBP research may in part be responsible for the conflicting results in the literature on workplace risk factors. We therefore investigated the etiology and prognosis of LBP within a phase-model approach, allowing for this phase-specificity in terms of outcome definition and risk factor modeling.

We defined five consecutive phases of disability for study. Phase 1 is defined as non-disabling LBP referring to self-reported symptoms or complaints without formal reporting and without any work disability, where work disability is defined as at least one day or shift of missed work. Phase 2 is defined as formally reported LBP, i.e., work-related low back injury. Phase 3 is defined as acute disability (1-30 days of work disability). Phase 4 is defined as subacute disability (31-90 days of work disability). Finally, Phase 5 is defined as chronic disability (>90 days of work disability). Although different researchers have proposed slightly different cut-points for each phase, these five phases reflect the major stages in the natural course of disabling LBP (Frank et al, 1998; Krause et al, 1994; Spitzer et al, 1987).

Etiologic determinants of LBP symptoms (phase 1) and of work-related injury (phase 2) are an integral part of this prognostic model because: (a) they comprise a necessary first step in the development of occupational disability; (b) we anticipate overlap between etiologic and prognostic risk factors; and (c) it is an explicit goal of the proposed research to identify risk factors which contribute to both the etiology and prognosis of LBP. We regard these areas of overlap as prime targets for the development of efficient work site interventions.

We hypothesized that some etiologic risk factors are at the same time prognostic risk factors in that they also predict duration of work disability and return to work. High physical workload, high psychological demands, low job control, and poor social support at work have been shown to be related to LBP symptoms and are hypothesized as barriers to return to work in this study. Other work-environment factors such as the availability of light duty, union membership, wage replacement, and unemployment rates are viewed primarily as prognostic factors influencing the return to work rate more than the incidence of LBP itself. A range of individual (non-occupational), injury-related, medico-legal, economic, and claims adjustment factors need to be considered as additional contributing and potential moderating factors in the disabling process, especially during phases 3-5 (Polatin, 1991). Some of the examples of factors for which data are available in our two study populations include physical demands, past cumulative workload (years of professional driving experience), current workload (e.g., hours of work/week), vehicle type, ergonomic problems, psychological demands, job control, job stress, supervisor and co-worker support; type of injury, severity of injury, and litigation. We planned to treat these factors as covariates in multivariate analyses to assess their individual impact on disability, and to also investigate how they modify the effects of physical and psychosocial job factors on disability.

*3.3.4.2. Self-reported prevalence of LBP (Phase 1).*

At the time of the medical examination participants of the MUNI-2 cohort completed a medical history form. In a section on musculoskeletal pain, participants were asked "Have you had pain, ache, or discomfort in the following areas or your body?" and "Lower Back" was one of the specific body regions listed. The response choices were "Ever (no/yes)" and "In the last 12 months (no/yes)". This latter question was used as the measure of 12-month period prevalence of LBP. Similar questions were asked for musculoskeletal disorders of the mid-back, neck, upper and lower extremities. (See Medical History Form in Appendix A). The earlier MUNI-1 cohort baseline questionnaire included only 1 item for the presence of "back or neck pain" at the time of the physical examination (point-prevalence of back or neck pain) (Krause et al, 1997a; Krause et al, 1998c). All drivers who were examined were active in their job, because drivers on sick leave or worker's compensation were not scheduled for examination. Drivers on modified duty also were later excluded from the study population.

*3.3.4.3. Incidence of compensated work-related low back injury (Phase 2).*

Within the MUNI-2 cohort, low back injuries were ascertained by linking the 1,841 eligible transit operators by their Social Security number to the workers' compensation file that included all claims from MUNI employees in the follow up period from August 30$^{th}$, 1993 to February 13$^{th}$, 2001. The claims of these drivers were then linked by the claim number to the medical bill review file to obtain the ICD-9 codes of the claim.

The first occurrence of a low back injury during a 7.5-year follow up period was recorded. The observation time for each participant started with the day of the baseline health survey and medical examination and was censored by the day of the injury, the day of separation from active duty as a transit operator, or by date of last observation (i.e., February 13$^{th}$, 2001, the day the workers' compensation database was downloaded), whichever came first.

*3.3.4.4. Medical diagnosis based on ICD-9 codes from medical billing records.*

Low back injury cases were defined by matching the following administrative and diagnostic criteria: (1) A date of injury after the baseline medical examination and (2) an ICD-9 code indicating a non-traumatic injury relating to the lumbar or sacral region of the spine, according to a list of codes compiled by Cherkin and coworkers (Cherkin et al, 1992). This list contains codes indicative of both "possible" and "definite" spinal injuries in the low back area. While the former include unspecified sites of the spine and ambiguously defined sites (e.g., "lumbar or thoracic"), the latter codes pertain explicitly and exclusively to the lumbar or sacral region. Only cases with a "definite" diagnostic ICD-9 code on any physician bill record during the course of the claim were included. (Please see Appendix D for a complete list of definite and probable diagnoses). A physician was defined as a medical doctor, an osteopathic physician, or a chiropractic doctor. ICD-9 codes were preferred to ANSI injury codes in the MUNI-2 cohort because the latter may result in misclassification in identifying low back injuries (Oleinick et al, 1996a). Medical bill review files were not available prior to 1993. Therefore, the follow-up data of the MUNI-1-cohort had to be based on ANSI injury codes (Krause et al, 1998c).

Cases were excluded if in the life of the claim (1) any ICD-9 code indicated a vertebral fracture, neoplasm, infection, or inflammatory disease, or if (2) the "nature of accident" or "nature of injury" code indicated a burn, open wound, or fracture. In other words, any low back injury caused by an acute trauma visibly disrupting the structural integrity of skin or bones was excluded. A complete list of excluded ICD-9 codes can be found in Appendix D.

*3.3.4.5. Severity based on ICD-9 codes.*

Severity of low back injury was defined by the most severe definite low back medical diagnoses recorded in the history of the claim. Cases with ICD-9 codes indicating postlaminectomy syndrome, spinal stenosis, herniated disc, sciatica, or spinal instability were classified as "more severe". Cases with ICD-9 codes indicating degenerative changes of the lumbar spine, or non-specific low back pain were classified as "less severe." (Please refer to Appendix D for severity rankings). The severity ranking system was developed by the Principal Investigator based on his clinical experience in the treatment and rehabilitation of musculoskeletal disorders. The severity ranking system showed good predictive validity in an earlier prospective cohort study of 433 California low back pain Workers' Compensation claimants (Dasinger et al, 1999)

### 3.3.5. Measurement of other musculoskeletal disorders, especially of the neck.

The first incidence of neck injury during the 7.5-year follow up period was recorded and censored the same way as low back injuries as described in Section 3.3.4.3. Because observation time was calculated separately for low back and neck injuries, it was possible for an individual to be both a low back and a neck injury case.

Neck injury cases were defined by the same administrative criteria and by similar diagnostic criteria described above in Section 3.3.4.4 for low back injuries. Non-traumatic injuries of the neck occurring after the baseline examination and with "definite" ICD-9 codes were included. The list of neck injury codes was developed by the Principal Investigator in a fashion parallel to the list of low back pain codes described in Section 3.3.4.4 above. (Please see Appendix D for a complete list).

Severity of neck injury was defined in a similar way as described in Section 3.3.4.5 above for low back injuries (see Appendix D). With the exception of pregnancy, the same list of traumatic or non-mechanical indicators of spinal injuries of the neck were excluded for low back pain (see Appendix D).

The medical history at the time of re-licensing examination provided information on the 12-month period prevalence of additional musculoskeletal disorders. All disorders were analyzed in six groups: (1) Any pain in upper and/or lower back, neck, upper extremities, lower extremities and/or the legs (MSD); (2) lower back pain (LBP); (3) back (upper, lower) and/or neck pain (BNP); (4) neck pain (NP); (5) pain of the upper extremities including shoulder, upper arm, elbow, forearm, wrist or hand (UPEXP); and (6) pain of the lower extremities including legs, knees or foot (LOEXP). These groups were not mutually exclusive. MSD included all of the other 5 groups and served as a general measure of any musculoskeletal pain. BNP and NP were overlapping.

Back and neck pain were grouped together as BNP to compare our results with findings from earlier studies of the same population using self-report data on job stressors. These studies of the earlier cohort of transit operators (MUNI-1) could not differentiate between neck and lower or upper back pain (Krause et al, 1997a; Krause et al, 1998c).

### 3.3.6. Measurement of Physical Workload and Ergonomic Problems.

#### *3.3.6.1 Introduction.*

The mechanical load on the spine among transit drivers is largely determined by the amount of sitting or standing, movement of the trunk while driving, operating hand and foot controls, and whole body vibration. The amount of professional driving measured in years and hours serves as a proxy for exposure to all these biomechanical factors. To assess amount of driving, the following were recorded: (1) Lifetime years of professional driving in the transportation industry inside and outside MUNI, and weekly hours of both (2) regular and (3) overtime driving during the 12 months preceding the date of the medical examination. Therefore, three parameters are combined to create a measure of physical work load: years of professional driving, regular weekly driving hours, and weekly hours of overtime. These measures are described in greater detail below.

*3.3.6.2 Cumulative past workload: Driving years.*

Lifetime years of professional driving in the transportation industry inside and outside MUNI were collected through the occupational health questionnaire and company records. In addition to years as a conductor in the public transport systems, all jobs held in the transport industry that required regular driving of trains, trucks, delivery vans, taxi cabs, or other motor vehicles were included in the calculation of driving years. Interruptions of employment with MUNI were subtracted unless the person indicated professional driving during that time.

*3.3.6.3 Current workload: Weekly hours of driving during past 12 months.*

In the occupational questionnaire, current exposure to professional driving was measured by asking participants to describe (a) their regular weekly driving hours, and (b) weekly hours of overtime driving during the 12 months preceding the date of the medical examination (MUNI-cohort-1). In MUNI-cohort-2 only the total number of hours driven per week was available.

*3.3.6.4. Ergonomic factors: Vehicle type, height, weight, and ergonomic problems.*

To assess ergonomic misfit, the following information was used: (1) The driver's gender, weight, and height as determined by physical examination during the re-licensing examination; (2) type of vehicle operated at time of examination; (3) an evaluation of the MUNI vehicle fleet by an ergonomist; and (4) a self-report questionnaire on ergonomic factors .

*3.3.6.4.1. Vehicle type.*

This factor was ascertained from company re-licensing examination records. Participants in this study operated four different vehicle types: Diesel buses, electric trolley buses, light rail trains, or the historic cable cars of San Francisco. Each type of vehicle exposes drivers to different types and levels of physical demands. For example, bus and light rail drivers perform their job predominately in a sitting position, although bus drivers engage in slightly more frequent trunk flexion and rotation in order to operate the steering wheel and mechanical door openers. Cable cars are operated in a predominately standing position and require very heavy physical labor involving frequent trunk bending, pushing and pulling of mechanical levers, and manually moving the entire cable car on turntables at the end of the line.

*3.3.6.4.2. Height and Weight.*

Height in centimeters and weight in kilograms were recorded at the medical examination. Height and weight were categorized according to their distribution among three groups: In the lower ten percent, the upper ten percent, and in the reference group, which encompassed the remaining 80 percent of the distribution. Rather than using body mass index as a single measure, height and weight are used separately in analyses as this strategy more accurately captures any problems related to ergonomic misfit (Krause et al, 1997a). The extremes in height and weight are expected to result in an ergonomic misfit between the body of the driver and the average workstation layout.

*3.3.6.4.3. Ergonomic evaluation of vehicle fleet and focus groups.*

An evaluation of the MUNI vehicle fleet was conducted at baseline of Cohort MUNI-1 by an ergonomist (Thompson, 1991a). Additional ergonomic evaluations of limited scope were done by other ergonomists outside of this research project throughout the follow-up period, however, no systematic effort has been made to obtain or analyze their reports made to management.

*3.3.6.4.4. Self-reported ergonomic problems.*

This was an eight-item questionnaire developed on the ergonomic evaluation of the vehicle fleet by an ergonomist and focus groups in an earlier study (Krause et al, 1997a; Thompson, 1991a). Questions asked include: "Think of the type of vehicle you usually drive: how much of a problem is each of the following for you: 1) seeing out of the vehicle, 2) adjusting the seat, 3) seat rocking while driving, 4) steering, 5) reaching across the steering wheel, 6) reaching and operation controls, and 7) braking." The answer options were no problem at all; very little problem; somewhat of a problem; and a big problem, scored as 0, 1, 2 and 3, respectively. The scores were summed up to producing a single score, categorized in quartiles.

### 3.3.7. Measurement of Job Stress.

*3.3.7.1. Introduction.*

Stress has been defined as a situation in which "environmental demands tax or exceed the adaptive capacity of an organism, resulting in psychological and biological changes that may place persons at risk for disease" (Cohen et al, 1995). There are three broad frameworks in which the association between stress and disease risk have been studied. Within the environmental (*objective*) framework, stress is measured by assessing significant life events or other experiences that normally require significant adaptive demands. These events are often referred to as 'environmental demands', 'stressors', or 'events'. Within the psychological framework, it is not the event itself that is regarded as taxing, but rather how an individual *subjectively perceives* the event that determines whether it demands an adaptive response. Individuals are thought to perceive an event as taxing or not after evaluating their ability to effectively respond to it. Thus, an individual's perceived level of available coping resources also plays a key role in this model. Accordingly, the level of stress an individual perceives is measured (i.e., perceived stress). Frequently, preferred coping styles and coping resources (i.e., social support) are measured concurrently with perceived stress. Within the biological framework, specific physiological systems are activated when a physically or psychologically demanding event occurs. The effects of stress are indicated by physiological responses (e.g., heart rate, blood pressure, hormone levels) that can be monitored for changes in response to an event. Biological activation to stressful events are often called 'stress responses' to distinguish them from "stressors" and "perceived stress" (Cohen et al, 1995).

Within the current study, the primary measures of stress were (1) environmental demands (job-stressors) and (2) psychological stress. Two different methods for measuring job stressors were used: a self-report measure of job-specific problems, and an observer-based measure of stress performed by a trained job analyst. The standard Job Content Questionnaire (JCQ) was used as a self-report generalized measure of perceived stress.

This combination of different assessment strategies (environmental and psychological) and methodologies (self-report and observer-based) is noteworthy for several reasons. It is highly desirable to have measures of stress that can be generalized to other populations, work environments, and to other countries. Thus, the use of the JCQ, a construct-valid, widely used measure of perceived stress will permit comparison of our results with other study populations. One drawback of a generalized measure of stress, however, is that it may fail to measure significant, job-specific stressors within a single job or occupation. Therefore, it is desirable to have job-specific measures of stress to ensure that any important correlations between low back pain and stress are not missed. This goal is fulfilled by our use of a self-report measure of job-related problems in addition to an (objective) observer-based measure of stress.

The use of an observer-based measure of job stress is another strength of our assessment strategy. Previous studies of bus drivers linking self-reported stress and hypertension have found inverse associations between job stress and hypertension (Winkelby et al, 1988; Netterstrøm et al, 1993). These unexpected results may be due to the distortions caused by relying on a single method (self-report) of stress measurement. The use of observational methods helps to avoid problems due to common method variance, which may potentially produce spurious associations among self-reported stress and self-reported LBP. Of course, this is not a problem for administrative outcome measures such as compensated injury and disability.

*3.3.7.2. General self-report measure of job strain (JCQ).*

General psychosocial workplace factors were measured with the Job Content Questionnaire (JCQ) developed by Karasek (Karasek, 1985; Karasek et al, 1998), and include the following sub-scales: Psychological demands (5 items, for example: "My jobs requires working very fast"), decision latitude (6 items for skill discretion, for example: "My job requires that I learn new things", and 3 items for decision authority, for example: "I have a lot of say about what happens on my job"), supervisor support (4 items, for example: "Superintendents/dispatchers pay attention to what I am saying") and coworker support (4 items, for example: "People I work with are helpful in getting the job done"). Response categories for all items were on a four point scale ranging from "strongly agree", over "agree" and "disagree" to "strongly disagree".

Theoretical Basis of the JCQ: Psychosocial stress exposure was defined in accordance with the demand-control-support-model by Karasek (Karasek et al, 1990; Theorell et al, 1996) based on theoretical considerations from psychology, sociology and stress research, and is the most widely used approach to measure potential health-hazardous psychosocial workplace conditions. The model allows the calculation of specific exposure constellations for the mismatch between high psychological demands and low job control (called "job strain") or high demands, low control and low social support at the workplace (called "iso-strain"). Both job strain and iso-strain have been found to be predictive for the incidence of cardiovascular disease in several cohort studies (Amick et al, 1998; Bongers et al, 1993; Cheng et al, 2000; Schnall et al, 2000; Schnall et al, 1994; Theorell et al, 1996).

Psychological demands and decision latitude scales were created following standard procedures from the literature (Karasek, 1985; Karasek et al, 1998), and ranged from 12 to 48 points and from 24 to 92 points, respectively. Scales for supervisor support and coworker support were created by summing up the items resulting in scales from to 4 to 16 points each. Total social support was defined as the sum of supervisor support and coworker support.

As recommended in the literature (Landsbergis et al, 1994), we calculated job strain and iso-strain by both median splits and by using the upper and lower tertiles of the respective sub-scales. "Job strain based on median split" was assigned to those participants who scored simultaneously above the median on the psychological demand (above 32 points) and below the median on the decision latitude scale (below 62 points). If these participants also scored below the median on the total support scale (below 21 points), they were assigned as having "iso-strain based on median split". "Job strain based on tertiles" was assigned to those participants who scored simultaneously in the upper tertile of the psychological demands scale (above 34 points) and the lower tertile of the decision latitude scale (below 58 points). If these participants also scored in the lower tertile of the total support scale (below 20 points), they were assigned as having "iso-strain based on tertiles". Continuous scales were calculated as psychological demands minus decision latitude for job strain (range –74 to 16) and as psychological demands minus decision latitude minus total support for iso-strain (range –104 to 3) (Landsbergis et al, 1994).

*3.3.7.3. Job-specific self-report measure of work problems (Winkelby et al., 1998).*

The frequency of potentially stressful problems at work was assessed by a 19-item questionnaire. Based on individual interviews and focus groups among the study population, a list of typical job problems had been developed that was specific to situations encountered by MUNI drivers (Winkelby et al, 1988). Drivers were asked to rate both the frequency and significance of each job problem. The questions and answer options for each item were (i) "How often does this happen to you? Daily, weekly or monthly, yearly or less often, never" and (ii) "How upsetting is this to you? Extremely, very, slightly, not at all". Answers were coded from 1 to 4 and two different average scores were developed, one for frequency of job problems, and one for reaction to job problems. Each average score was based on the items checked by the respondent. The complete list of job problems contained in the job problem score had been published previously (Krause et al, 1997b).

*3.3.7.4. Observer-based measure of job stressors.*

The observational analyses were conducted during regular working hours by seven trained job analysts. The job analysts followed a Structured protocol that guided the observation and interview and documented all information in standardized answer forms. The method yielded good inter-rater reliability as reported earlier (Greiner and Krause, 2000; Greiner et al., 1997). The method of job analysis is based on Action Regulation Theory (Volpert, 1982; Leitner et al., 1987). The first step in a job analysis was to differentiate and describe individual task elements necessary to carry out the job such as perceiving driving- and vehicle-related information, perceiving and processing customer-related information, providing passenger service, moving vehicle, operating controls, handling equipment (e.g. money collecting box, turntables for cable car drivers) and locomotion (Greiner et al, 1998). In this step, the observers described the work task as a sequence of work steps in detail on response sheets provided. This was crucial to the analysis, because the same job title (e.g., driver) included different responsibilities depending on the specific work organization. The protocol guided the investigator step by step in describing the work organization, physical setting of the workplace, the temporal structure of the task, the use of tools and equipment, necessary information to perceive and process, and necessary interaction with supervisors and coworkers. On the basis of this information, the observer documented in detail those factors that hindered the progression of work. These factors were then classified into defined categories. In the second step, the observer quantified stress factors. Analyses resulted in four quantitative measures: barriers, time pressure, monotonous working conditions, and time binding. Barriers measured the extent to which work performance is impeded or interrupted because of work obstacles and is expressed in minutes of extra time necessary to overcome the barrier. Time pressure, measured in minutes of possible detachment periods from the task execution or mini breaks, is a measure of how fast the operator has to work to complete the assigned task. Monotonous working conditions demand continuous visual attention during work performance, in combination with repetitive movements or information processing for at least 30 consecutive minutes. Time binding measures restrictions in operator autonomy in time management, independent of the pace of the work. The level of time binding depends on the tightness of points in time to which a certain result must be accomplished. In transit driving, the most restrictive level (5) is given when the operator has to be exactly on time at each stop. A less restrictive level is given if the operation has to be on time at the terminal, but not at each stop. For information on inter-rater reliability and validity of this procedure, please refer to Greiner et al. (1997).

Job stressors were conceptualized as barriers to these task elements. Barriers were defined as events or conditions that impede or interrupt the task progression without efficient worker control over these obstacles. They are due to either poor organizational, technical or environmental design, and put extra demands on the worker without adequate resources. Extra work efforts are needed to overcome these barriers. Each barrier was described in detail by the analyst and classified in one of the theoretical barrier categories. Obstacles were rated as "true" barrier only if the worker lacked sufficient resources to control the obstacle. Obstacles that could be controlled or had no or only minor impact on the working activity were not considered a barrier. The observed amount of extra work in minutes per 4-hour shift performed to overcome the barrier served as the quantitative measure. Extra work included additional work steps or intensified effort. Whereas additional work steps could be directly observed and their duration precisely be registered by the analyst, intensified effort such as applying higher force to operate a stiff pedal, intensified concentration or split attention was often not directly measurable. In such cases a default value of 7 minutes per 4-hour shift was computed if the barrier was present at least once a day; if it happened less often, a corresponding fraction of 7 minutes was imputed.

Minor barriers, requiring less than 10 minutes of extra work and/or occurring less than once a week, were excluded. To facilitate the interpretation of the results in the logistic regression models, one unit was set to 10 or 20 minutes.

Job barriers were classified into seven different groups according to what task activities they were obstructing. The following exposure measures were used: (1) The sum of extra work in minutes across seven different barrier categories and (2) seven individual barrier measures. Barrier measures included the following: (a) Sight barriers: obstacles that impede vision of the traffic situation due to poor mirrors, overcrowding of the vehicle, poor vehicle design, or "blind corners" in the traffic environment. Typically, extra work included driving slow, frequently adjusting mirrors, and bending over to catch a better view of the situation. (b) Vehicle-moving barriers: obstacles that impede moving or maneuvering of the vehicle such as physical obstacles in the street, double parking, blocked stops, mal-designed stops, narrow and sharp turns, and use of transit lane by unauthorized vehicles. Extra work consisted usually of increased maneuvering effort, circumventing obstacles, or waiting, e.g., in case of blocked stops. (c) Being-on-time barriers: obstacles for starting the run on time (blocked exit of the garage, no vehicle available at the beginning of the run), and missing leading vehicles on the same line, so that the operator had to pick up more passengers than normal and argue with disgruntled passengers. (d) Providing-passenger-service barriers: obstacles for passenger loading and unloading such as malfunctioning doors, kneelers, and wheelchair ramps; blocked passenger access at the stop due to environmental design; broken microphones, stop request signals and destination signs to provide passenger information. Extra work included manual operation of the doors, waiting for passengers to enter the vehicle, and arguing with disgruntled passengers who missed their stop due to a non-functional stop request signal. (e) Barriers for focusing attention on driving, e.g., unruly behavior of passengers in the back of vehicle that requires split attention of the operator while driving or disciplinary action. (f) Operating-controls barriers such as hand controls that are hard to reach or stiff foot pedals usually leading to the application of more force. (g) Movement-and-handling barriers: obstacles that obstructed movement, locomotion, maintenance of bodily posture or handling of equipment such as physical obstacles that impede driver access to the vehicle, passengers standing very close to the driver and impeding driver movement, equipment that is hard to handle. Extra work usually included maintenance of awkward positions and application of more force.

## 3.3.8. Measurement of Demographic, Anthropometric, Psychological, and Behavioral Factors.

*3.3.8.1. Demographic variables.*

Sociodemographic variables, such as age, gender, ethnicity, level of education and income were collected at baseline from either the medical examination or through the occupational questionnaire. Company records and Workers' compensation records were used to fill in missing values in questionnaires.

*3.3.8.2 Anthropometric variables.*

Height and weight were measured at the baseline physical examination.

*3.3.8.3 Behavioral factors.*

Smoking, Alcohol, and leisure time physical activity. Health behaviors and physical activity were assessed in the epidemiological interview (See Appendix C).

*3.3.8.4. Psychological factors.*

*3.3.8.5 Coping behavior.*

Coping strategies were assessed with the COPE, a valid and reliable measure of stable coping styles (Carver et al, 1989).

*3.3.8.6. Alexithymia.*

The Toronto Alexithymia Scale (TAS) is the best-validated instrument for the subject of emotional awareness that can be included into larger epidemiological studies (Kauhanen et al, 1994; Kauhanen et al, 1996). The TAS is a 20-item scale with a 4 Likert-type response choice (Taylor et al, 1985). The TAS may be used as either a continuous summary scores of all 20-items, or separated into three sub-scales that include difficulty identifying feelings (TAS-1), difficulty describing feelings (TAS-2), and external-oriented thinking (TAS-3) . This scale has acceptable internal consistency (Cronbach's $\alpha = 0.81$; (Bagby et al, 1994a & 1994b); test-retest reliability (0.74, $p < 0.001$, at 3 months; (Kooiman et al., 2002). The mean inter-item correlation coefficient is 0.17 (Bagby et al., 1994a & 1994b). Inter-method reliability estimates compared to other self-report scales has been documented (Bagby et al., 1994a & 1994b). Convergent and discriminant construct validity, are acceptable (Bagby et al., 1994a & 1994b). The internal consistency of the TAS-3 subscale is unsatisfactory low (Kooiman et al., 2002), but this may be due in part to cultural differences and linguistic problems. Validity studies of the TAS were conducted primarily with samples of college students, and samples of psychiatric patients.

# **CONFIDENTIAL** FROM THIS POINT FORWARD (Results have not been published yet.)

## 4. RESULTS AND DISCUSSION

### 4.1 The independent effects of physical workload on low back disorders.

AIM #1: "Determine the effects of cumulative past and current physical workload on the three outcome measures, with adjustment for age, sex, and anthropometric variables."

Status: To determine the independent effects of physical workload on low back pain (LBP), the effects of physical workload have been assessed for all three outcomes, prevalence of LBP, incidence of work-related low back injury, and duration of work disability after low back injury. To investigate the independent effects of physical work factors on low back pain, we regarded it as important to control for the potential influence of psychosocial factors on the reporting of LBP. Previous investigations have found that job-related psychosocial factors effect LBP, independent of physical job factors (Bigos et al, 1991; Krause et al, 1998c). Thus, in the multivariate analyses we also controlled for psychological demands, decision latitude, supervisor support and coworker support. These factors were measured using the Job Content Questionnaire (described in Section 3.3.7.2 above).

The results for each of the three outcomes will be presented and discussed separately in the following sections. One manuscript is currently in preparation ("Physical and Psychosocial Job Factors Associated with the Prevalence of Low Back Pain in Urban Transit Operators"). The independent effects of physical workload on the incidence of low back pain are described in an unpublished manuscript titled "Physical workload, ergonomic problems, and incidence of low back injury: A 7.5-year prospective study of San Francisco transit operators." This manuscript has been submitted to and was reviewed by the American Journal of Industrial Medicine. A revised manuscript is in preparation. The associations between physical job factors and three phases of disability (acute, subacute, chronic) are currently under investigation. The analyses for this study are complete, and a manuscript based on the results is currently in preparation.

**4.1.1. Prevalence of LBP (cross-sectional analyses).**

12-month prevalence of LBP prevalence was assessed at baseline in the MUNI-2 cohort. From the sample of 1,502 eligible cases in the MUNI-2 cohort, 204 cases were excluded due to missing data on one or more variables in the univariate and multivariate analysis, yielding a sample of 1298 participants. Within this sample, differences between responders and nonresponders were comparable to those presented in Table 3. There was no significant difference in reporting of LBP between responders and nonresponders (responders = 32.0%; nonresponders = 35.1%; $\chi^2$= 1.21).

Physical work factors investigated were total years of professional driving, total hours of weekly driving during the past 12 months, and type of vehicle most frequently driven. These factors were described in detail in Section 3.3.6.

Low back pain was assessed from a questionnaire item collected from the medical history, self-report questionnaire. Specifically, participants were asked if they had pain, ache, or discomfort in their lower back during the last 12 months. Those who answered "yes" were regarded as cases.

In univariate analyses, the distribution of LPB was analyzed by Pearson's $\chi^2$ test for nominal scaled predictors (sex, vehicle type) and by Cuzick's z-test for trend for ordinal scaled predictors (age, years of professional driving, and weekly driving hours). Univariate associations between LBP prevalence and demographic or physical factors are presented in Table 4. Low back pain declined with increasing age ($p<0.01$ for trend) and was more prevalent in women than in men ($p<0.01$). There was no significant association between LBP and any of the physical work factors. Our next step was to investigate the association between LBP prevalence and physical work factors in multivariate models adjusting for demographic and psychosocial factors.

Table 4. Univariate Associations Between Low Back Pain Prevalence and Age, Sex, and Physical Factors

| Variables | n | Low back pain cases n (%) | $\chi^2$ or z for trend |
|---|---|---|---|
| **Demographic Factors** | | | |
| **Age** | | | |
| under 30 | 9 | 5 (55.6) | |
| 30 – 39 | 249 | 92 (37.0) | |
| 40 – 49 | 578 | 193 (33.4) | |
| 50 – 59 | 409 | 112 (27.4) | |
| 60 and older | 53 | 13 (24.5) | 3.13 ** |
| **Sex** | | | |
| Male | 1105 | 326 (29.5) | |
| Female | 193 | 89 (46.1) | 20.85 ** |
| **Physical Factors** | | | |
| **Years of professional driving** | | | |
| Less than 5 | 260 | 82 (31.5) | |
| 5-9 | 211 | 74 (35.1) | |
| 10-14 | 288 | 94 (32.6) | |
| 15-19 | 249 | 74 (29.7) | |
| 20-24 | 138 | 47 (34.1) | |
| 25 or more | 152 | 44 (29.0) | 0.65 |
| **Hours of weekly driving** | | | |
| Less than 20 | 56 | 16 (28.6) | |
| 20-39 | 130 | 40 (30.8) | |
| 40 | 306 | 85 (27.8) | |
| 41-49 | 438 | 153 (34.9) | |
| 50 or more | 368 | 121 (32.9) | 1.60 |
| **Vehicle type** | | | |
| Diesel bus | 580 | 170 (29.3) | |
| Trolley bus | 444 | 52 (30.6) | |
| Light rail | 170 | 154 (34.7) | |
| Cable car | 104 | 39 (38.0) | 5.00 |

*p < 0.05. **p < 0.01.

*4.1.1.1. Multivariate associations among low back pain, demographic, and physical factors.*

Table 5 shows the odds ratios and 95% confidence intervals for the association between low back pain and age, sex and physical factors. In Model 1, all variables were adjusted for age and sex. In Model 2 psychosocial factors measured with the JCQ (psychological demands, decision latitude, supervisor support and coworker support) were added. Finally, in Model 3 all variables were adjusted for each other and for psychosocial factors.

In contrast to the univariate analyses, all three physical factors were associated with a prevalence of low back pain in the multivariate analyses. For years of professional driving, the probability for low back pain increased gradually over the categories with the peak at 24 years of driving. This association was present across all three models. When professional driving was analyzed as a continuous variable, an increase of 5 years in driving was associated with odds ratios of 1.12 in model 1 (95% CI: 1.02-1.24), 1.12 in model 2 (95% CI: 1.02-1.24) and 1.19 in model 3 (95% CI: 1.00-1.22).

For weekly hours of driving, 40 hours was set as the reference group. Participants with less than 40 hours did not differ significantly in the prevalence of low back pain. Driving 41 to 49 hours per week, however, was associated with a statistically significant increase in low back pain across all three models with odds ratios of 1.45 (model 1), 1.41 (model 2) and 1.42 (model 3). Drivers with 50 or more hours of driving per week had higher odds ratios than the reference group, but the differences were not statistically significant. When hours of weekly driving was treated as a continuous variable, an increase of 10 hours in driving was associated with odds ratios of 1.11 in model 1 (95% CI: 1.00-1.22), 1.09 in model 2 (95% CI: 0.99-1.21), and 1.09 in model 3 (95% CI: 0.98-1.21).

Compared to diesel bus drivers, light rail and cable car operators had a higher probability of low back pain with odds ratios of 1.32 and 1.76 respectively, when adjusted for age and sex. Adjusting for psychosocial factors resulted in virtually unchanged odds ratios of 1.73 and 1.30. Additional adjustment for driving years reduced the odds ratios for cable car operators to 1.56 while the odds ratios for light rail operators remained unaffected.

Age and sex remained significantly associated with low back pain prevalence across all three models. The effect sizes did not change substantially when psychosocial factors were introduced, and became stronger when physical factors were added. For every 10 years increment of age, the odds ratio was 0.84 when adjusted for psychosocial factors only, and 0.72 when adjusted for both psychosocial and physical factors. For women, the addition of physical factors increased the odds ratio from 1.85 to 2.33.

Table 5. Multivariate Association between Low Back Pain Prevalence and Age, Sex and Physical Factors

| | | Model 1[a] | | | Model 2[b] | | | Model 3[c] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variables | n | Odds Ratio | 95% CI[d] | | Odds Ratio | 95% CI[d] | | Odds Ratio | 95% CI[d] | |
| **Age** (Increments of 10 years) | 1298 | 0.82 | 0.71 | 0.96 | 0.84 | 0.72 | 0.98 | 0.72 | 0.58 | 0.88 |
| **Sex** | | | | | | | | | | |
| Male (Reference) | 1105 | 1.00 | --- | --- | 1.00 | --- | --- | 1.00 | --- | --- |
| Female | 193 | 1.89 | 1.37 | 2.59 | 1.85 | 1.34 | 2.55 | 2.33 | 1.66 | 3.29 |
| **Physical Factors** | | | | | | | | | | |
| **Driving years** | | | | | | | | | | |
| Less than 5 (Reference) | 260 | 1.00 | --- | --- | 1.00 | --- | --- | 1.00 | --- | --- |
| 5-9 | 211 | 1.43 | 0.95 | 2.13 | 1.36 | 0.91 | 2.05 | 1.39 | 0.92 | 2.11 |
| 10-14 | 288 | 1.65 | 1.09 | 2.48 | 1.58 | 1.04 | 2.39 | 1.51 | 0.99 | 2.33 |
| 15-19 | 249 | 1.65 | 1.06 | 2.59 | 1.58 | 1.00 | 2.49 | 1.48 | 0.91 | 2.38 |
| 20-24 | 138 | 2.25 | 1.34 | 3.78 | 2.13 | 1.26 | 3.61 | 2.00 | 1.15 | 3.46 |
| 25 or more | 152 | 2.10 | 1.19 | 3.70 | 2.14 | 1.20 | 3.80 | 2.00 | 1.09 | 3.69 |
| **Weekly driving hours** | | | | | | | | | | |
| Less than 20 | 56 | 1.00 | 0.53 | 1.90 | 0.96 | 0.50 | 1.83 | 0.91 | 0.47 | 1.73 |
| 20-39 | 130 | 1.00 | 0.63 | 1.58 | 1.02 | 0.64 | 1.62 | 1.17 | 0.72 | 1.88 |
| 40 (Reference) | 306 | 1.00 | --- | --- | 1.00 | --- | --- | 1.00 | --- | --- |
| 41-49 | 438 | 1.45 | 1.05 | 2.00 | 1.41 | 1.02 | 1.96 | 1.42 | 1.02 | 1.97 |
| 50 or more | 368 | 1.33 | 0.95 | 1.87 | 1.28 | 0.91 | 1.80 | 1.26 | 0.89 | 1.78 |
| **Vehicle type** | | | | | | | | | | |
| Diesel bus (Reference) | 580 | 1.00 | --- | --- | 1.00 | --- | --- | 1.00 | --- | --- |
| Trolley bus | 444 | 1.32 | 0.90 | 1.95 | 1.29 | 0.87 | 1.91 | 1.22 | 0.81 | 1.83 |
| Light rail | 170 | 1.32 | 1.01 | 1.73 | 1.30 | 0.99 | 1.72 | 1.30 | 0.99 | 1.72 |
| Cable car | 104 | 1.76 | 1.13 | 2.75 | 1.73 | 1.10 | 2.72 | 1.57 | 0.98 | 2.53 |

[a]Model 1: All variables in the model are adjusted for age and sex.

[b]Model 2: Model 1 including adjustment for psychosocial factors (psychological demands, decision latitude, supervisor support and coworker support).

[c]Model 3: All variables in the model are adjusted for psychosocial factors and for each other.

[d]CI = confidence intervals.

*4.1.1.2. Discussion.*

This study indicates that physical factors are associated with differences in prevalence among professional transit operators, even after controlling for demographic and psychosocial factors.

An increase in years of professional driving was associated with an increase in prevalence of LBP. The odds ratio (OR) for those who had been driving for 5-9 years was 1.39 compared with those with less than 5-years experience. Prevalence seems to plateau among those with 10-14 years (OR = 1.51) and those with 15-19 (1.48) years of experience. Driving professionally for over 20 years (OR = 2.00, for both 20-24 yrs. and >25 yrs.) is associated with a two-fold increase in prevalence of LBP compared with the most inexperienced drivers, and about a 50% increase over those with between 10-19 years of experience. These results support other studies that have found professional driving as a risk factor for spinal disorders. Studies indicating a link between driving and back pain, including sciatica and herniation of lumbar disks are numerous (Gruber et al, 1974; Johanning et al, 1991; Krause, 1991; Bovenzi et al, 1992; Pietri et al, 1992; Krause et al, 1997a).

A previous study by (Krause et al, 1997a) among the MUNI-1 cohort also found that that back pain was more prevalent among drivers with more driving exposure. The comparable questionnaire item from the MUNI-1 cohort study asked about both back and neck pain (BNP) in a single question, thus it is impossible to directly compare any differences in prevalence of low back pain between these two cohorts. Nevertheless, for every 10 years of driving experience there was 2.55 times increase in prevalence of BNP, controlling for ergonomic problems, vehicle type, height, weight, age and sex (Krause et al, 1997a). While this estimate is greater than that found in the present study, the estimate of prevalence in this more recent cohort is in a comparable range. Especially when one considers the contribution of neck pain paired with other, non-specific back pain included in the estimate based on the MUNI-1 study.

An increase in number of weekly driving hours during the past 12 months was associated with an increased prevalence of LBP. This association was statistically significant only for those who drove between 41-49 hours per week (OR = 1.42, 95% CI = 1.02-1.97). Driving 50 or more hours showed a weaker association with LBP (OR=1.26, 95% CI = 0.89-1.78). Those who drive in excess of 50 hours per week are doing so voluntarily, and may represent a healthier group of drivers. This may produce a spuriously lowered estimate due to the 'healthy worker' effect (Fox et al, 1976). The lack of statistical significance of this finding is due to the small number of drivers in this sub-group. Also, those working >50 hours may have been doing so for a shorter period of time compared with other groups of drivers, and that noticeable, chronic low back pain had not yet developed. The likely explanation of the lower risk in this group is selection: those who drove less than 40 hours per week may have chosen to work shorter hours, and this may be associated with a less rapid development of LBP. Those who regularly worked overtime of 41-49 hours may include those who used to drive a greater number of hours (i.e., 50+), but who have scaled back their hours due to development of pain or other problems. The previous study of drivers in the MUNI-1 cohort (Krause et al, 1997a) found a dose-response between prevalence of BNP and number of hours worked (measured in 20-unit change for weekly work hours, and 10 units change for overtime driving). This analyses was adjusted for age, gender, vehicle type, years of driving and overtime driving. Even so, this result was nonsignificant. The association between prevalence of LBP and regular hours of work requires additional investigation in prospective studies.

The prevalence of LBP was comparable across different vehicle types, ranging from 29.3% among diesel bus drivers to 38% among cable car operators. In the multivariate analyses, the odds ratio for cable car operators was 1.57 (95% CI: 0.98-2.53) compared with 1.30 for light rail drivers and 1.22 for streetcar (trolley) operators). Although the OR for cable car operators was statistically nonsignificant, the observed increased risk of LBP in cable car drivers is consistent with observations that operation of cable cars involves a greater amount of physical exertion.

Greater age (OR = 0.72) was associated with an approximately 30% decrease in prevalence of LBP. Low back pain was also more prevalent among women drivers (46.1%) compared with male drivers (29.5%). Female operators demonstrated a greater than 2-fold prevalence of LBP compared with the male counterparts (OR = 2.3). It is possible that the daily operation of the vehicles represented in this study is associated with greater strain on the lower back for female operators. The design of MUNI's diesel buses, for example, includes a 22" drivers wheel, which requires stretching to reach the 12 o'clock position, even for drivers of average height

(Thompson, 1991a). Viewing mirrors and other ergonomic factors (e.g., seat height) are likely to have been designed with the average male in mind. Until recently, with few exceptions transit operators were traditionally male, and the design of controls and driver's position may be biased towards those attributes that one associates with males, such as muscular strength and greater height. However, a previous study of MUNI-1-cohort found persisting elevated odds ratios for LBP among some even after controlling for body height and weight (Krause et al, 1997a). Population based studies of LBP indicate that women and men report LBP with equal frequency (Deyo et al, 1987). Thus, it is likely that other unmeasured factors associated with driving of municipal transit vehicles is associated with LBP among women.

One of the limitations of this study was that it is cross-sectional, and the temporal associations between exposure and LBP cannot be established with certainty, limiting causal interpretation. However, certain factors, such as gender, and years of driving clearly preceded assessment of LBP, and therefore support a causal relationship with LBP.

Another limitation is that less healthy drivers, and particularly those who had developed LBP, may have selected out of the study. Those drivers on disability or on sick leave were excluded from the sample. It has been demonstrated that bus drivers with LBP leave the job at higher rates compared with healthy co-workers (Backman et al, 1983). Therefore, our estimates of prevalence may represent an underestimate of the actual rate.

Misclassification of exposure may have occurred since driving history was partly collected through self-report, which may have introduced errors resulting from inaccurate or incomplete job histories. In addition, the association between vehicle history and LBP was based on drivers' description of the vehicle they drove most frequently during the past 12 months. Drivers, however, may change the line they drive quarterly, and can switch to different vehicle types annually. In addition, within their assigned route drivers may change vehicle driven from one day to the next. Thus, the full strength of association between vehicle type and prevalence of LBP may have been obscured by variations in exposure to different work conditions within and between vehicle types and transit routes.

Assessment of low back pain was also based on self-report, although this is typical of epidemiologic studies of LBP. It is doubtful, however, that expert examination of the spine would have been more accurate since the associations between spinal pain and physical or radiologic exams is weak (Krause et al, 1994; Spitzer et al, 1987; Vällfors, 1985; Wiesel et al, 1984).

Despite these limitations, we note that if these results are biased in any way, it is towards a more conservative estimate of the prevalence of LBP among this cohort of operators. The positive association between LBP and physical workload (years of professional driving, weekly work hours, and vehicle type, as were demonstrated even after adjusting for the potentially confounding influence of psychosocial factors, i.e. psychological demands, decision latitude, and levels of supervisor or co-worker support. Thus, this study supports the presence of the independent effects of physical work factors on the prevalence of low back pain.

Overall the risk for prevalent low back pain among urban transit drivers is associated with greater number of years of professional driving and with over-time driving. These physical work factors were significant risk factors even after adjustments for age, sex, and psychosocial factors. These results concur with previous studies indicating professional driving as a risk factor for low back pain, including the development of serious spinal disorders. Interventions might be aimed at reducing, or alternating work schedules to reduce overtime driving as a method to limit the long-term impact of driving on LBP. The increased rates of LBP in female drivers deserve further study.

**4.1.2. Incidence of low back injury (prospective analyses).**

The independent effects of physical workload on the incidence of low back pain are described in an unpublished manuscript titled "Physical workload, ergonomic problems, and incidence of low back injury: A 7.5-year prospective study of San Francisco transit operators." This manuscript has been submitted to and was reviewed by the American Journal of Industrial Medicine. A revised manuscript is in preparation.

*4.1.2.1. Results and Discussion.*

The data for this study comes from the MUNI-2 cohort, described in greater detail in Section 3.2.2. Of the 1,841 eligible participants, 339 drivers declined to participate (the differences between these two groups are presented in Table 3 of this report.) An additional 221 cases were eliminated because they were missing data required for the multivariate analyses. We also excluded from this study drivers who worked less than 20 hours per week (n = 48) because they are most likely supervisors or assigned to modified duty because of a pre-existing health condition. This yielded a sample size of 1,233 cases on which to model LBP incidence. A comparison of this sample of drivers (participants) with nonparticipants is presented in Table 6.

Table 6. Characteristics of Study Participants Compared with Non-Responders.

| Variable | Study participants [1] (n=1,233) Mean or n | (SD or %) | Non-Responders (n=338) Mean or n | (SD or %) | t or $\chi^2$ | p |
|---|---|---|---|---|---|---|
| **Age (years)** | 46.7 | ( 7.8) | 47.2 | ( 7.2) | 0.92 | 0.36 |
| **Sex** | | | | | | |
| Men | 1055 | (85.6%) | 280 | (82.8%) | | |
| Women | 178 | (14.4%) | 58 | (17.2%) | 1.54 | 0.21 |
| **Ethnicity** | | | | | | |
| African American | 671 | (54.4%) | 217 | (66.6%) | | |
| Asian/Pacific Islander | 236 | (19.4%) | 35 | (10.7%) | | |
| Hispanic | 157 | (12.7%) | 22 | ( 6.8%) | | |
| Caucasian | 148 | (12.0%) | 41 | (12.6%) | | |
| Other | 18 | ( 1.5%) | 11 | ( 3.4%) | 30.84 | <0.001 |
| **Height (centimeter)** | 173.2 | ( 8.7) | 173.7 | ( 8.9) | 0.94 | 0.35 |
| **Weight (kilogram)** | 87.4 | (18.7) | 88.9 | (20.0) | 1.30 | 0.20 |
| **Years of professional driving** | 13.3 | ( 8.1) | 14.1 | ( 7.4) | 1.48 | 0.14 |
| **Vehicle type** | | | | | | |
| Diesel bus | 555 | (45.0%) | 142 | (51.3%) | | |
| Trolley bus | 421 | (34.1%) | 78 | (28.2%) | | |
| Light rail | 160 | (13.0%) | 30 | (10.8%) | | |
| Cable car | 97 | ( 7.9%) | 27 | ( 9.8%) | 6.17 | 0.10 |
| **Ergonomic Problem Score** | 15.8 | (5.9) | 15.3 | (6.4) | 1.48 | 0.14 |
| **Drivers with a low back injury during the follow-up period** | 331 | (26.8%) | 114 | (33.7%) | 6.19 | 0.01 |

Table 6 (continued). Characteristics of Study Participants Compared with Non-Responders.

| Variable | Study participants [1] (n=1,233) Mean or n | (SD or %) | Non-Responders (n=338) Mean or n | (SD or %) | t or $\chi^2$ | p |
|---|---|---|---|---|---|---|
| **Type of first low back injury in follow-up period** | | | | | | |
| Postlaminectomy syndrome | 1 | ( 0.3%) | 1 | ( 0.9%) | | |
| Spinal stenosis | 19 | ( 2.7%) | 2 | ( 1.8%) | | |
| Herniated disc with myelopathy | 8 | ( 2.4%) | 2 | ( 1.8%) | | |
| Herniated disc without myelopathy | 61 | (18.4%) | 15 | (13.2%) | | |
| Sciatica | 23 | ( 7.0%) | 7 | ( 6.1%) | | |
| Possible instability | 1 | ( 0.3%) | 1 | ( 0.9%) | | |
| Probably degenerative changes | 12 | ( 3.6%) | 8 | ( 7.0%) | | |
| Non-specific backache | 216 | (65.3%) | 78 | (68.4%) | 5.49 | 0.60 |
| **Severity of first low back injury in follow-up period[2]** | | | | | | |
| less severe | 228 | (68.9%) | 86 | (75.4%) | | |
| More severe | 103 | (31.1%) | 28 | (24.6%) | 1.75 | 0.41 |

1) Responders with complete information on all variables under study. Responders with missing values (n=221) are excluded from this table, however, they showed a similar distribution in all variables listed.

2) Severity was classified by ICD-9 codes as listed in Appendix D.

In this sample, there was no difference between responders and nonresponders regarding age, sex, height, weight, years of driving experience, type of vehicle driven, or ergonomic problems. Nonresponders were more likely to be African Americans and less likely, Asian/Pacific Islander or Hispanics. Occurrence of a low back injury during the follow-up period was higher among non-responders (34 vs. 27%). There were no differences, however, between responders and nonresponders with respect to type of first low back injury, or with severity of low back injury.

In this follow-up study, low back injury was measured without relying on self-report of participants. As described in greater detail in Section 3.3.3 of this report, low back injury data was collected from a combination of workers' compensation databases and medical bill review records. In this sample, there were 507 incidences of low back injuries (see Table 7). 336 (66%) were first low back injuries.

Table 7. Frequency of Low Back Injuries and Order of Occurrence Among 1,233 Study Participants of MUNI-2 Cohort (1993-2001).

| | **First Injury** | **Second Injury** | **Third Injury** | **Fourth Injury** | **Fifth Injury** | **Sixth Injury** | **Seventh Injury** | **Eighth Injury** | **All Injuries** |
|---|---|---|---|---|---|---|---|---|---|
| | n | n | n | n | n | n | n | n | n |
| **Low Back Injury** | 336 | 115 | 41 | 12 | 2 | 1 | 1 | 1 | 507 |

In multivariate analyses, a series of Cox proportional hazard models were applied. In the first model, each physical job factor was analyzed with controls for age, sex, and ethnicity. In the second model, the physical job factors were controlled for each other and age, sex, and ethnicity. Finally, in the third (full) model, psychosocial factors such as psychological demands, decision latitude, supervisor support, coworker support were additionally included as covariates.

In the full model, driving 31-50 or more than 50 hours per week was associated with low back injury (HR = 1.54, 2.17, respectively; see Table 8). Driving a cable car was also a significant risk factor for low back injury (HR =1.82). Ergonomic problems were associated with increased risk particularly, in the $3^{rd}$ (HR = 1.48) and $4^{th}$ quartiles (HR = 1.54). Greater age (over 50) was associated with a decreased risk of low back injury (HR = 0.72), as was Asian/Pacific Islander ethnicity (HR = 0.55). Female drivers demonstrated a high association with low back injury (HR = 1.52) compared with male drivers.

Table 8. Adjusted Low Back Injury Hazard Ratios[1)] for Physical Workload, Ergonomic Problems, Anthropometric and Demographic Factors. San Francisco Transit Operator Cohort from 1993 – 2001 (n=1,233).

| | | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|---|
| **Variable** | **n** | **Hazard Ratio** | **95% Confidence Interval** | **Hazard Ratio** | **95% Confidence Interval** | **Hazard Ratio** | **95% Confidence Interval** |
| **Years of professional driving** | | | | | | | |
| 5 or less | 262 | 1.15 | 0.86-1.54 | 1.36 | 1.00-1.83 | 1.36 | 1.01-1.83 |
| 6-15 | 566 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| >15 | 405 | 0.90 | 0.67-1.22 | 0.86 | 0.63-1.18 | 0.86 | 0.63-1.18 |
| **Total driving hours per week** | | | | | | | |
| 20-30 | 107 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| 31-50 | 990 | 1.52 | 1.00-2.33 | 1.54 | 0.98-2.39 | 1.51 | 0.96-2.36 |
| >50 | 136 | 2.05 | 1.24-3.37 | 2.24 | 1.33-3.76 | 2.17 | 1.28-3.68 |
| **Vehicle type** | | | | | | | |
| Diesel bus | 555 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Trolley bus | 421 | 1.03 | 0.81-1.31 | 0.95 | 0.74-1.21 | 0.96 | 0.75-1.23 |
| Light rail | 160 | 0.75 | 0.48-1.14 | 0.80 | 0.52-1.24 | 0.79 | 0.51-1.23 |
| Cable car | 97 | 1.58 | 1.05-2.37 | 1.93 | 1.26-2.98 | 1.82 | 1.17-2.84 |
| **Ergonomic Problems** | | | | | | | |
| 1st Quartile (low) | 298 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| 2nd Quartile | 267 | 1.20 | 0.84-1.70 | 1.28 | 0.90-1.82 | 1.26 | 0.88-1.80 |
| 3rd Quartile | 322 | 1.35 | 0.97-1.86 | 1.52 | 1.08-2.13 | 1.48 | 1.05-2.09 |
| 4th Quartile (high) | 346 | 1.42 | 1.03-1.95 | 1.58 | 1.13-2.20 | 1.54 | 1.09-2.17 |
| **Height** | | | | | | | |
| Small (<162 cm) | 115 | 0.86 | 0.58-1.28 | 0.86 | 0.57-1.28 | 0.84 | 0.56-1.26 |
| Reference (162-183 cm) | 984 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Tall (>183 cm) | 134 | 1.28 | 0.92-1.80 | 1.26 | 0.90-1.77 | 1.26 | 0.90-1.77 |
| **Weight** | | | | | | | |
| Light (<67 kg) | 129 | 0.82 | 0.55-1.24 | 0.88 | 0.59-1.33 | 0.91 | 0.60-1.38 |
| Reference (67-112 kg) | 979 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Heavy (>112 kg) | 125 | 1.00 | 0.71-1.41 | 0.92 | 0.65-1.31 | 0.92 | 0.64-1.30 |
| **Age (years)** | | | | | | | |
| <40 | 234 | 1.24 | 0.95-1.61 | 1.15 | 0.86-1.54 | 1.16 | 0.86-1.55 |
| 40-50 | 610 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| >50 | 389 | 0.62 | 0.47-0.82 | 0.72 | 0.53-0.97 | 0.72 | 0.53-0.97 |
| **Sex** | | | | | | | |
| Men | 1055 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Women | 178 | 1.39 | 1.05-1.83 | 1.52 | 1.10-2.11 | 1.52 | 1.10-2.11 |
| **Ethnicity** | | | | | | | |
| African American | 671 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Asian/Pacific Islander | 239 | 0.49 | 0.35-0.70 | 0.54 | 0.38-0.78 | 0.55 | 0.38-0.79 |
| Hispanic | 157 | 0.93 | 0.68-1.28 | 0.98 | 0.70-1.37 | 0.97 | 0.70-1.36 |
| Caucasian | 148 | 0.87 | 0.61-1.26 | 0.81 | 0.55-1.21 | 0.82 | 0.55-1.21 |
| Other | 18 | 0.44 | 0.14-1.39 | 0.43 | 0.14-1.35 | 0.43 | 0.14-1.37 |

[1)] Based on multivariate Cox proportional regression analyses:
Model 1: Adjusted for age, sex, ethnicity.
Model 2: All variables adjusted for each other.
Model 3: Model 2 + adjustment for psychosocial job factors (psychological demands, decision latitude, supervisor support, coworker support).

The data permitted analysis of low back injuries stratified by level of severity. As described in greater detail in Section 3.3.4.5, cases with ICD-9 codes indicating degenerative changes of the lumbar spine, or non-specific low back pain were classified as less severe low back injuries. Cases with ICD-9 codes indicating postlaminectomy syndrome, spinal stenosis, herniated disc, sciatica, or spinal instability were classified as more severe injuries. Multivariate models included the same covariates as described in the 'full' model described above.

Five years or less of professional driving (HR=1.55) or having a high number (4$^{th}$ quartile) of ergonomic problems (HR = 1.65) was associated with greater risk of sustaining a less severe back injury (see Table 9). Among those who sustained more severe back injuries, those who drove more than 30 hours per week, cable car drivers, and female drivers demonstrated significantly higher risk. In contrast, Asian/Pacific Islander ethnicity was associated with a significantly lower risk (HR = 0.23) of sustaining a severe low back injury.

Table 9. Adjusted[1)] Low Back Injury Hazard Ratios[2)] for Physical Workload, Ergonomic Problems, Anthropometric and Demographic Factors. Stratified by Severity of Injury[3)]

| | Less severe injuries Cases: 228 Non-Cases: 902 | | | More severe injuries Cases: 103 Non-Cases: 902 | | |
|---|---|---|---|---|---|---|
| **Variable** | **n** | **Hazard Ratio** | **95% Confidence Interval** | **n** | **Hazard Ratio** | **95% Confidence Interval** |
| **Years of professional driving** | | | | | | |
| 5 or less | 241 | 1.55 | 1.08-2.21 | 192 | 1.05 | 0.59-1.87 |
| 6-15 | 509 | 1.00 | Reference | 466 | 1.00 | Reference |
| >15 | 380 | 0.91 | 0.62-1.34 | 347 | 0.69 | 0.40-1.20 |
| **Total driving hours per week** | | | | | | |
| 20-30 (part-time) | 103 | 1.00 | Reference | 86 | 1.00 | Reference |
| 31-50 (full-time) | 914 | 1.40 | 0.85-2.30 | 809 | 2.34 | 0.80- 6.78 |
| >50 (overtime) | 113 | 1.62 | 0.86-3.04 | 110 | 5.60 | 1.79-17.51 |
| **Vehicle type** | | | | | | |
| Diesel bus | 512 | 1.00 | Reference | 446 | 1.00 | Reference |
| Trolley bus | 381 | 0.92 | 0.68-1.24 | 341 | 1.08 | 0.69-1.67 |
| Light rail | 151 | 0.68 | 0.40-1.17 | 143 | 1.13 | 0.52-2.46 |
| Cable car | 86 | 1.64 | 0.96-2.78 | 75 | 2.76 | 1.24-6.14 |
| **Ergonomic Problems** | | | | | | |
| 1st Quartile (low) | 277 | 1.00 | Reference | 258 | 1.00 | Reference |
| 2nd Quartile | 252 | 1.41 | 0.92-2.15 | 217 | 0.92 | 0.47-1.80 |
| 3rd Quartile | 290 | 1.51 | 0.99-2.30 | 259 | 1.63 | 0.90-2.96 |
| 4th Quartile (high) | 311 | 1.65 | 1.08-2.50 | 271 | 1.49 | 0.81-2.74 |
| **Height** | | | | | | |
| Small (<162 cm) | 106 | 0.88 | 0.54-1.43 | 92 | 0.69 | 0.33-1.47 |
| Reference (162-183 cm) | 902 | 1.00 | Reference | 812 | 1.00 | Reference |
| Tall (>183 cm) | 122 | 1.35 | 0.91-2.02 | 101 | 1.07 | 0.56-2.05 |
| **Weight** | | | | | | |
| Light (<67 kg) | 123 | 0.96 | 0.60-1.54 | 107 | 0.72 | 0.30-1.71 |
| Reference (67-111 kg) | 891 | 1.00 | Reference | 802 | 1.00 | Reference |
| Heavy (>111 kg) | 116 | 1.03 | 0.68-1.56 | 96 | 0.69 | 0.34-1.40 |
| **Age (years)** | | | | | | |
| <40 | 212 | 1.22 | 0.86-1.73 | 172 | 1.04 | 0.60-1.83 |
| 40-50 | 552 | 1.00 | Reference | 488 | 1.00 | Reference |
| >50 | 366 | 0.69 | 0.47-1.00 | 345 | 0.71 | 0.42-1.20 |
| **Sex** | | | | | | |
| Men | 975 | 1.00 | Reference | 873 | 1.00 | Reference |
| Women | 155 | 1.38 | 0.92-2.05 | 132 | 2.02 | 1.15-3.55 |
| **Ethnicity** | | | | | | |
| African American | 607 | 1.00 | Reference | 532 | 1.00 | Reference |
| Asian/Pacific Islander | 234 | 0.65 | 0.43-0.98 | 203 | 0.23 | 0.09-0.58 |
| Hispanic | 134 | 0.80 | 0.51-1.25 | 131 | 1.40 | 0.83-2.37 |
| Caucasian | 138 | 0.86 | 0.54-1.37 | 123 | 0.68 | 0.33-1.40 |
| Other | 17 | 0.40 | 0.10-1.64 | 16 | 0.42 | 0.06-3.12 |

[1)] All variables adjusted for each variable shown in the table and for psychosocial job factors (psychological demands, decision latitude, supervisor support, coworker support; same covariates as in Model 3 of Table 3).
[2)] Based on Cox proportional hazard model.
[3)] Severity was classified by ICD-9 codes as listed in the Appendix.

The purpose of this study was to examine the impact of physical workload and ergonomic problems on the incidence of low back injuries. All predictor variables were adjusted for each other, psychosocial job factors, demographic, and anthropometric factors. The main results can be summarized as follows: 1) Transit operators who had been professional drivers for five years or less had a significantly increased 1.4-fold risk for all low back injuries. A stratified analysis showed that the increased risk for this group was limited to less severe injuries (HR=1.55). 2) There was a dose-response relationship between hours of weekly driving and injury risk. Compared to the reference group, those who drove 31-50 hours had a 1.5-fold increased risk, whereas those who drove over 50 hours had a 2.2-fold increased risk for all low back injuries. Those who drove over 50 hours had a 5.6-fold increased risk of a severe injury. A continuous analysis showed that for every 10 hour increase in weekly driving there was a multivariate controlled 32% increase in risk of severe low back injury. 3) Cable car operators performing heavy physical labor had a significantly increased 1.6 -fold and 2.8-fold higher risk of less and more severe injuries, respectively. 4) Drivers who scored high on the ergonomic problem scale had a significantly increased higher risk for low back injury, with a 22% increased injury risk for every 10-point increase on the ergonomic problem scale. Reducing ergonomic problems to the low level currently experienced by 25 percent of employees would result in a 28% reduction of all less severe and 21% reduction of all more severe low back injuries. 5) Younger drivers and women had a significantly increased injury risk.

*4.1.2.1.1 Strengths and Limitations*

The prospective design is a major strength of this study and allows for a causal interpretation of the findings (Rothman, 1986). The use of Cox regression models ensured that risk estimates took the length of the injury-free periods between baseline examination and first injury into account. Multivariate analyses also adjusted for potential confounders including worker characteristics and psychosocial job factors, thereby overcoming a major limitation of earlier studies (Bongers et al, 1993; Krause et al, 1997a).

The outcome measure in this study was based on administrative medical bill review records containing all physician's diagnoses made throughout the life of a claim coded according to the standard International Classification of Disease. This method of assessing outcome has several advantages. First, it reduces misclassification observed in studies based on workers' compensation ANSI codes or body part injured (Oleinick et al, 1996b). Second, inclusion and exclusion procedures made use of all medical diagnoses in the entire history of a claim thereby taking into account diagnostic findings not available at the time of the first injury report. For example, confirmation and further specification of initial diagnoses through radiographic imaging techniques typically occurs only during subsequent doctor visits and after some trial therapy. Third, it avoids common method bias, i.e., the tendency to find spurious associations in studies measuring both predictors and outcome by self-report. Fourth, it allowed to classify and analyze injuries by their severity based on strictly medical diagnostic criteria. While the public health significance of mild low back pain may be disputed, severe low back injury has been recognized as a major burden. In fact, it has been shown that the 7 percent of severe low back injuries are responsible for about 75 percent of all costs associated with work-related back pain (Hashemi et al, 1998). The use of medical diagnoses and stratified analyses identified a severity-specific risk factor pattern in this study: Compared to less severe injuries, more severe injuries show a weaker association with age or seniority, and are stronger associated with increased work hours, heavy physical work on cable cars, and female gender.

The absence of individual observer-based measurements of whole-body vibration or biomechanical modeling of spinal loads may be considered a weakness in a study of ergonomic risk factors. In fact, this is a typical limitation of large-scale epidemiological studies because of the high costs associated with individual standardized measurements. However, individual physical demands do not vary as much between transit operators as they do between or within other occupations, at least not for those drivers that operate the same vehicle, a variable that was accounted for in this study. Furthermore, at this company, drivers are often assigned another vehicle every day (although of the same vehicle type) so that a one-time observation would not substantially improve accuracy of the assessment of biomechanical risk factors. Therefore, we believe that additional information gained from direct measurements of spinal load, would have been limited.

To compensate for limitations in the ergonomic assessment of physical workload, we applied a multi-method approach. The biomechanical forces acting on the drivers' spine are characterized and vary considerably by vehicle type and by duration of driving. Therefore, vehicle type and driving measured in years and weekly hours constitute the main determinants of physical workload in this population. Low back injury in transit operators needs to be conceptualized as a combination of chronic cumulative biomechanical stressors such as repeated upper body twisting movements or whole body vibration which lead to fatigue of the spine, and repetitive or singular biomechanical stressors such as contusions, abrupt movements, and sudden increases in mechanical loads, acting on the fatigued spinal structures, and precipitating the onset of pain with or without temporal or permanent structural damage. Accordingly, cumulative past (long-term) and current (short-term) exposure to biomechanical forces need to be taken into account, which was achieved by measuring past years and current weekly hours of driving.

This information was easy to obtain from drivers but we mainly relied on company records to reduce recall error and to increase the objectivity of the measurement. The indirect assessment of physical workload through company records on vehicle type and driving history may appear as a limitation compared to experimental studies with individual ergonomic assessments. On the other hand, and especially in comparison with self-reported measures of physical work load in epidemiological studies, our measures have the advantage of constituting an objective description of workload, assessed independently from the appraisal by the worker or an expert. Nevertheless, we utilized additional self-reported information from the ergonomic questionnaire to further account for variation in biomechanical factors.

The individual assessment of ergonomic problems through self-report instead through observation has its advantages and disadvantages. The ergonomic items in the occupational questionnaire were based on an on-site evaluation of the vehicle fleet by an ergonomist, which strengthens the validity of the ergonomic scale used in this study (Thompson, 1991a; Krause et al, 1997a; Thompson, 1991b). In addition, the driver who has to deal with the ergonomic problems every day is a valuable source of information, especially if the questionnaire allows the driver to rate the extent of the problem on a scale. On the other hand, an ergonomic observation has the advantage to evaluate in more detail any ergonomic misfit.

To account for any major systematic ergonomic misfit of the physical dimensions of the workstation and the physical size of the individual driver, we added two anthropometric dimensions, extremes of body height and weight, in the multivariate model. Based on the report of the ergonomist and an earlier cross-sectional study we hypothesized that very small and very tall drivers would both be subject to an ergonomic misfit with the standard vehicle equipment (Thompson, 1991a), (Krause et al, 1997a; Thompson, 1991b). In the fully adjusted model of this prospective study these anthropometric factors however did not account for much additional risk, supporting the notion that the indirect measures of physical workload and ergonomic factors utilized in this study captured much of the relevant exposure.

Like most prospective studies, this study is limited by measuring the predictor variables only once, at the beginning of the study. Repeated measure during the follow up period would have allowed us to adjust for changes in the predictor variables. This limitation is of less relevance for the vehicle type variable, because the drivers in this public transportation company rarely switch from one vehicle type to the other, and the vehicle fleet remained largely unchanged throughout the follow-up. However, other factors such as hours of weekly driving or specific ergonomic problems may have changed during follow-up. These limitations of the on-time assessment of predictor variables might have resulted in non-differential misclassification. Non-differential misclassification of the predictor variable usually biases the results towards the null hypothesis (Rothman et al, 1998a). Therefore, the hazard ratios of physical workload and ergonomic problems reported in this study potentially represent an underestimation of the true effect sizes.

*4.1.2.1.2 Discussion of Findings, Comparison with Previous Studies, and Implications for Prevention.*

The findings of this study need to be discussed in terms of their contribution to the occupational epidemiology of low back injury and of musculoskeletal disorders in general, and in terms of their implications for the prevention of low back injury in the high risk group of professional drivers and public transit operators in particular.

The finding suggest that physical job demands and ergonomic problems involved in operating motor vehicles are strong predictors of low back injuries, especially more severe injuries, even after adjustment for possibly confounding psychosocial risk factors such as psychological demands, decision latitude, and social support at the workplace. This study confirms findings from an earlier cross-sectional and prospective cohort study conducted within the same company 5-10 years earlier, both showing strong associations between biomechanical factors and spinal disorders (Krause et al, 1997a; Thompson, 1991b; Krause et al, 1998b; Krause et al, 1997a). The findings are also consistent with several recent prospective studies conducted in different study populations (Krause et al, 1998b; Thorbjornsson et al, 2000; Torp et al, 2001), a larger body of earlier high quality cross-sectional and case-control studies reviewed in 1997 (Bernard, 1997) and a recent case-control study (Kerr et al, 2001). Inconsistent findings were reported from two prospective studies, however, they lacked adequate individual measurements of physical workload (Bigos et al, 1991; Hoogendoorn et al, 2000a).

Years of Professional Driving. The increased injury risk for drivers with five years or less of professional driving could be due to several causes. It is possible that drivers with health problems are more often leaving this very demanding profession after a few years (Backman et al, 1983), resulting in a selection effect that is commonly known as the healthy worker effect (Eisen, 1995). It is also possible that more senior drivers tend to have a higher acceptance of low back pain and therefore are underreporting work-related low back injuries. The latter interpretation would be in accordance with our findings that the higher risk among less senior drivers was limited to less severe injuries.

In addition to selection and underreporting, alternative explanations need to be considered, especially if they would indicate complementary approaches to prevention. Senior drivers are maybe less exposed to potential hazardous situation, because they have more choices in picking less demanding routes and schedules. Their higher level of experience might also enable them in dealing more successfully with high-risk situations. It is interesting to note that the lower risk of injury among senior drivers has declined over the last two decades. In a previous prospective study in the same company spanning the years 1983-1988 (Krause et al, 1998c), a much higher relative risk (RR=6.07) for spinal injuries was found in drivers with five years or less of professional driving than in the current study from 1993-2001 (RR=1.35). While this remarkable difference might be partly caused by the different case-definition and by other methodological differences in the two studies, part of the difference may also be attributable to ergonomic improvements made in the 1990's (e.g., installation of better seats in parts of the bus fleet) or a change in attitude towards newer drivers reducing the seniority differential in reported injuries. Further qualitative analyses of such changes could point to an important preventive potential in transportation companies.

Weekly Driving Hours. The strong association between weekly driving hours and low back injury, especially for more severe injuries, replicates findings from previous cross-sectional and prospective studies in the same company (Krause et al, 1998b; Krause et al, 1997a) and confirms previous evidence for a causal role of motor vehicle driving in work-related spinal disorders (Kelsey et al, 1975; Netterstrøm et al, 1989; Johanning, 1991; Bovenzi et al, 1992; Pietri et al, 1992; Bovenzi et al, 1992; Gluck et al, 1998; Jensen et al, 1996; Johanning, 1991; Kelsey et al, 1975; Netterstrøm et al, 1989; Pietri et al, 1992). It shows that the prolonged weekly exposure to driving takes its toll. As other studies have shown, the high risk of this occupation is not restricted to low back injuries, but also includes cardiovascular and gastrointestinal disease (Winkleby et al, 1988; Albright et al, 1992; Belkic et al, 1994; Evans, 1994; Tüchsen et al, 1999; Winkleby et al, 1988). Based on these findings a review on health problems in bus-drivers recently stated that "it seems that it is usually not possible for transit operators to work full-time in their profession throughout their occupational career" (Tränkle et al, 1996).

Potential for Prevention. With respect to prevention, our findings suggest that reducing weekly driving hours could substantially lower the risk of low back injury. Assigning all full time drivers to part-time driving of 20 to 30 hours per week would eliminate 26% of all less severe and 59% of all more severe low back injuries. Limiting weekly driving hours to a maximum of 50 hours would still prevent 2% of less severe and 13% of more severe injuries. Reduced driving hours can be achieved by offering job rotation between driving and non-driving assignments (e.g., supervisory, maintenance, and administrative jobs), by creating more part-time jobs, and by reducing overtime through the hiring of more employees. Such interventions imply not only a certain amount of effort, but at the beginning also additional costs for the company, especially if the changes are implemented in a fashion preserving customary income levels for transit operators. However, given the high costs of sickness absence, especially for severe injuries, there is a good chance that the medium- and long-term financial benefits of such a change would outweigh the short-term costs. Recent reviews of intervention studies in public transportation companies in Europe have shown that work organizational changes, including reduction in weekly driving hours, can lead to a significant decrease in sickness absence, increase in productivity, and subsequently in cost savings for the company (Aust, 2001; Kompier et al, 2000).

The higher risk of cable car operators is in accordance with a previous study in the same population (Krause et al, 1998c) and independently supports the role of physical factors in the etiology of low back injuries. This new study also shows, that the risk is especially high for more severe injuries. Similar elevated risks were observed for both motormen and conductors of cable car crews in stratified analyses (not shown in tables). While the motorman has to bend frequently and pull and push mechanical levers, both cable car operators have to stand most of the day, and both have to manually turn the cable car around at the end of the line involving heavy pushing and pulling. Unfortunately, the legally protected historic features of cable cars limit the options for ergonomic prevention in this subgroup of operators. In addition of carefully investigating every possibility for changes in workplace conditions for cable car operators, offering job rotation and reduced work hours are the main options for prevention.

Significance and Conclusions. This study overcomes several methodological limitations of previous studies and provides strong evidence for a causal role of ergonomic factors for the incidence of occupational low back injuries. Physical workload, duration of work, and ergonomic workplace conditions were significant predictors of low back injury in this study among urban transit operators, even after taking individual and psychosocial risk factors into account. Most of these work conditions are amenable to change and therefore indicate a substantial potential for prevention at the workplace. The actualization of this potential could prevent low back injuries and associated work disability in this high risk occupation, and reduce the substantial human and economic costs associated with low back injury.

### 4.1.3. Duration of disability.

The associations between physical job factors and three phases of disability (acute, subacute, chronic) were investigated. Analyses have been completed and a manuscript based on the results is currently in preparation.

#### *4.1.3.1. Methods*

This is a prospective study of the predictors of duration of disability due to low back injuries based on a sample of 292 transit vehicle operators who sustained a disabling first low back injury during 7.5 years of follow-up. Please refer to the Methods section for injury incidence (pp.23-48) for details regarding the study population, data sources and collection, and measurement of low back injury. The sample originated from the MUNI-2 cohort study, which was a sample of 1,974 transit vehicle operators employed by the San Francisco Municipal Railway.

Among the 1,841 eligible study participants a total of 3,688 workers' compensation claims were observed during the 7.5-year follow up period. Of these claims, 910 (28.5%) had at least one ICD-9 code that was indicative of definite low back diagnosis. There were up to 46 different ICD-9 codes per claim (at the 5-digit level), with a mean of 7.8 for low back injuries. Based on these additional codes and on further information from the workers' compensation file, 132 injuries were excluded, because at least one ICD-9 code indicated a traumatic or other disqualifying type of injury. Of the 778 low back injuries that remained after applying the inclusion criteria, 523 were first time injuries and 255 were repeated injuries (there were up to 8 low back injuries per subject during the observation period). A detailed presentation of the exclusion process has been given elsewhere (see Section 3.2.2.).

Time on disability was operationalized as the total number of workdays on temporary disability calculated from workers' compensation indemnity benefit information in the workers compensation payment file. Among the 523 drivers with a first time injuries, 446 had at least one day of disability, 358 among responders and 88 among non-responders of the occupational questionnaire. Among the responders, we excluded 14 subjects with less than 20 hours of driving per week (which could been an indicator for modified work due to a previous injury), and 52 subjects with missing data, yielding a final study sample of 292 subjects.

Differences between the study sample and transit operators who had not responded to the occupational questionnaire were calculated based on t-tests for independent samples and Pearson's $\chi^2$-tests.

Cox proportional hazard regression was conducted to estimate the effect of each predictor variable on duration of disability in the study sample. Cox regression are usually used to calculate the "hazard" for a adverse outcome like death or onset of disease at any point during the follow-up period, given the individual has survived until that time, relative to a baseline reference group. Since we are modeling not an adverse but a positive outcome (time to "return to work"), we use the term "return to work" (RTW) ratios instead of hazard ratio in reporting our results. In this context, return to work ratios greater than one reflect a shorter duration of disability relative to the reference group.

The analytic approach used in this study takes into account risk-factor phase-specificity by conducting analyses for different phases of disability (Krause, 1993; Krause et al, 1994; Krause et al, 1999). We analyzed outcomes for (1) the acute disability phase (up to 30 days lost of work days), the subacute phase (31 to 90 days), and the chronic phase (more than 90 days). The goal of this phase-specific analysis is not to determine risk factors for the transition from one phase to next phase, but rather to determine the phase-specific impact of risk factors given an individual has reached the respective disability phase. In other words, the goal was to determine which set of risk factors is associated with more disability days in each given phase.

The analytic model contained physical (driving years, weekly driving hours, vehicle type, ergonomic problems) and psychosocial (psychological demands, job control, supervisor support, co-worker support, job strain iso-strain) workplace factors as well as demographic variables (sex, age, height, and weight). Physical workplace factors were adjusted for psychosocial workplace factors, for demographic variables and for each other. Demographic variables were adjusted for physical and psychosocial workplace factors and for each other. Psychosocial workplace factors were adjusted for physical workplace factors and for demographic variables, but not for each other, since the psychosocial variables are not thought to be independent from each other. We analyzed the return to work ratios for all injuries combined as well as stratified for less severe and more severe injuries. Potential phase-specific differences of the return to work ratios were analyzed for each variable in all models.

Analyses were performed for three different phases of disability and for all disability plans combined. Results across phases will be presented by physical and then by demographic factors. While job stress and social support are integral parts of these models, results for these factors will be discussed separately under the respective aim.

4.1.3.2 Results

*4.1.3.2.1 All Low Back Injuries*

Driving Years: Across all phases of disability, 15 or more years of professional driving was associated with a slightly slower RTW compared with driving less than 15 years (see Table 10). At all phases of disability, those cases with professional driving had a 16% (HR = 0.86) reduced rate of return to work.

Driving Hours: Compared with drivers working 31-50 hours per week, driving 20-30 hours was associated with a 74% higher rate of RTW for all phases (HR = 1.74), and with a 97% increased rate for acute (HR = 1.97) or a 53% (HR = 1.53) increased rate for subacute phases of disability. This pattern was reversed in the chronic disability phase, however, with driving 20-30 hours resulting in a 15% decrease in RTW (HR = 0.87). Driving more than 50 hours per week varied in direction across the three phases, but across all phases, this level of driving was associated with an approximately 30% (HR = 0.77) reduced RTW.

Vehicle Type: In the acute phase of disability, driving a rail-bound vehicle (street car or cable car) was associated with a 18% reduced RTW rate. In the subacute and chronic phases, driving this type of vehicle was associated with an increased RTW rate (HR = 1.62, subacute; HR = 1.72, chronic), compared with drivers of street bound vehicles (diesel or trolley bus).

Ergonomic Problems: In the acute phase of disability, having a high number of ergonomic problems was associated with an increased RTW (HR = 1.26) compared with drivers who reported lower ergonomic scores. In the subacute and acute phases, however, a higher number of ergonomic problems was associated with a decreased RTW (HR = 0.95, subacute; HR = 0.69, chronic).

Gender: Across all phases of disability, sex (female) was associated with a reduced rate of RTW.

Age: The direction and effect size associated with age (in 10 year increments) was inconsistent across disability phases. In the subacute phase, a 10 year increment in age was significantly associated with a 56% faster RTW (HR = 1.56). Age was associated with a slower

RTW among those in the chronic disability phase (HR = 0.89). These differences approached statistical significance ($\chi^2 = 5.47$; $p < 0.10$).

Height and weight: Height and weight were not associated with any change in rate of RTW.

Table 10. Return to work ratios after low back injury for physical, psychosocial, and demographic variables (n=292 transit operators)

| | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **chi2 / p** |
| **Driving Years** | | | | | | | | | |
| Less than 15 | 149 | Reference | 149 | Reference | 104 | Reference | 67 | Reference | |
| 15 ore more | 143 | 0.86 (0.60-1.23) | 143 | 0.75 (0.46-1.21) | 103 | 0.98 (0.60-1.62) | 60 | 0.92 (0.40-2.11) | 0.77/0.68 |
| **Driving Hours** | | | | | | | | | |
| 20-30 | 23 | **1.74 (1.02-2.96)** | 23 | **1.97 (0.99-3.93)** | 13 | 1.53 (0.64-3.67) | 7 | 0.87 (0.47-1.64) | |
| 31-50 | 223 | Reference | 223 | Reference | 158 | Reference | 97 | Reference | |
| 50 or more | 46 | 0.77 (0.50-1.18) | 46 | 0.73 (0.37-1.44) | 36 | 1.42 (0.31-6.60) | 23 | 0.56 (0.16-1.97) | 0.73/0.95 |
| **Vehicle Type** | | | | | | | | | |
| Street bound (diesel bus & trolley) | 239 | Reference | 239 | Reference | 170 | Reference | 111 | Reference | |
| Rail bound (light rail & cable car) | 53 | 1.24 (0.84-1.82) | 53 | 0.85 (0.47-1.53) | 37 | **1.62 (0.95-2.76)** | 16 | 1.72 (0.64-4.58) | 3.25/0.20 |
| **Ergonomic Problem Score** | | | | | | | | | |
| Low score (<=15 points) | 132 | Reference | 132 | Reference | 95 | Reference | 57 | Reference | |
| High score (>15 points) | 160 | 1.04 (0.76-1.41) | 160 | 1.26 (0.81-1.96) | 112 | 0.95 (0.60-1.49) | 70 | 0.69 (0.30-1.57) | 1.90/0.39 |
| **High Demands** | 138 | 0.99 (0.73-1.33) | 138 | 0.75 (0.48-1.17) | 105 | 1.20 (0.77-1.88) | 62 | 1.39 (0.60-3.24) | 2.91/0.23 |
| **Low Control** | 129 | 1.12 (0.83-1.51) | 129 | 1.19 (0.77-1.84) | 91 | 1.02 (0.65-1.61) | 56 | 1.24 (0.54-2.85) | 0.29/0.86 |
| **Low Supervisor Support** | 156 | 1.00 (0.74-1.35) | 156 | 1.03 (0.67-1.59) | 111 | 1.00 (0.64-1.57) | 69 | 0.90 (0.40-2.06) | 0.08/0.96 |
| **Low Coworker Support** | 171 | 0.82 (0.60-1.12) | 171 | 1.08 (0.69-1.69) | 123 | **0.56 (0.35-0.88)** | 86 | 1.16 (0.46-2.93) | **4.98/0.08** |
| **High Job Strain** | 71 | 1.21 (0.85-1.72) | 71 | 0.84 (0.48-1.47) | 55 | **1.51 (0.93-2.45)** | 30 | 2.14 (0.75-6.10) | 3.65/0.16 |
| **High Iso-Strain** | 53 | 1.34 (0.91-1.96) | 53 | 1.20 (0.68-2.11) | 38 | 1.41 (0.81-2.43) | 21 | 1.83 (0.52-6.47) | 0.42/0.81 |
| **Sex (female)** | 61 | 0.72 (0.46-1.14) | 61 | 0.77 (0.41-1.44) | 46 | 0.67 (0.36-1.25) | 31 | 0.74 (0.31-1.79) | 0.13/0.94 |
| **Age (increment of 10 years)** | 292 | 1.20 (0.95-1.53) | 292 | 1.01 (0.74-1.37) | 207 | **1.56 (1.13-2.17)** | 127 | 0.89 (0.45-1.76) | **5.46/0.07** |
| **Height (increment of 10 cm)** | 292 | 1.01 (0.83-1.24) | 292 | 1.03 (0.79-1.33) | 207 | 1.05 (0.80-1.38) | 127 | 0.85 (0.54-1.34) | 0.71/0.70 |
| **Weight (increment of 10 kg)** | 292 | 0.98 (0.90-1.06) | 292 | 0.92 (0.81-1.05) | 207 | 1.07 (0.95-1.20) | 127 | 0.87 (0.71-1.07) | 4.37/0.11 |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

**bold=p<0.10.**

*4.1.3.2.2. Stratified analyses by severity of injury*

When analyses were stratified by severity of low back injury, different patterns of associations between physical work factors and disability phase emerged (see Tables 11 & 12). Few of these associations reached statistical significance because of small sample sizes. Nevertheless, general patterns of the direction and size of effects can be discerned in the MUNI-2-cohort data. Risk factors and the direction of their effects on increasing of decreasing return to work rates will be noted.

*3.1.3.2.2.1. Less severe low back injuries.*

Driving years: For all phases of disability, driving more than 15 years was associated with a slight increase in RTW (HR = 1.08).

Driving hours: Across the three categories of disability, 30 hours or less was associated with a faster RTW (37%, HR = 1.37) compared with driving 50 hours or more, which was associated with a slower RTW (35%; HR = 0.74) for all phases of disability.

Vehicle type: Driving a rail-bound vehicle was associated with an increase in RTW across all phases of disability (HR = 1.12).

Ergonomic problems: Having a high number of ergonomic problems was associated with a faster RTW in the acute phase (HR = 1.20), but with a 69% slower RTW (HR = 0.13) in the chronic disability phase.

Sex: Gender was not associated with duration of disability (HR = 1.00, all phase disability).

Age: There was an overall positive association between age and RTW. This was particularly evident in the subacute phase in which there was a 56% faster RTW for every 10 unit increase in age (HR = 1.56). ). A chi-square test of the association between RTW at each phase with age approached significance ($\chi^2 = 4.64$; $p < 0.10$).

Height: For each 10 cm increase in height, there was a 16% (HR = 1.16) increase RTW when all phases of disability were analyzed. Height was associated with faster RTW in the acute phase (HR = 1.16) and subacute phases (HR = 1.21), but a slower RTW in the chronic phase (HR = 0.72).

Weight: For each 10 kg increase in weight, there was an 5% decrease in RTW rate when all phases of disability were analyzed. The direction of the effect of weight was inconsistent across each of the three phases (HR = 0.88, acute; HR = 1.05, subacute; and HR = 0.64 in the chronic phase). There was a significant difference between phases with respect to weight ($\chi^2 = 8.45$; $p < .05$).

Table 11. Return to work ratios after less severe low back injury for physical, psychosocial, and demographic variables (n=198 transit operators)

| | **All phases** | | **Acute phase** | | **Subacute phase** | | **Chronic phase** | | **test for phase-specific difference** |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **chi2 / p** |
| **Driving Years** | | | | | | | | | |
| less than 15 | 107 | Reference | 107 | Reference | 70 | Reference | 36 | Reference | |
| 15 ore more | 91 | 1.08 (0.71-1.64) | 91 | 0.93 (0.55-1.58) | 57 | 1.21 (0.70-2.09) | 23 | 3.90 (0.35-43.03) | 1.71/0.43 |
| **Driving Hours** | | | | | | | | | |
| 20-30 | 20 | 1.37 (0.77-2.46) | 20 | 1.57 (0.76-3.28) | 11 | 1.13 (0.47-2.71) | 5 | 1.57 (0.76-3.28) | |
| 31-50 | 154 | Reference | 154 | Reference | 98 | Reference | 44 | Reference | |
| 50 or more | 24 | 0.74 (0.42-1.30) | 24 | 0.67 (0.28-1.57) | 18 | 0.77 (0.36-1.67) | 10 | 1.05 (0.14-8.10) | 0.57/0.90 |
| **Vehicle Type** | | | | | | | | | |
| Street bound (diesel bus & trolley) | 164 | Reference | 164 | Reference | 106 | Reference | 54 | Reference | |
| Rail bound (light rail & cable car) | 34 | 1.12 (0.71-1.76) | 34 | 0.80 (0.42-1.51) | 21 | 1.49 (0.81-2.74) | 5 | 4.57 (0.38-54.96) | 3.37/0.14 |
| **Ergonomic Problem Score** | | | | | | | | | |
| low score (<=15 points) | 88 | Reference | 88 | Reference | 56 | Reference | 23 | Reference | |
| High score (>15 points) | 110 | 0.98 (0.67-1.42) | 110 | 1.20 (0.73-1.96) | 71 | 0.85 (0.51-1.42) | 36 | **0.13 (0.01-1.35)** | 3.95/0.14 |
| **High Demands** | 88 | 0.93 (0.66-1.31) | 88 | **0.61 (0.37-1.01)** | 65 | 1.32 (0.81-2.15) | 27 | 2.40 (0.41-14.23) | **5.88/0.05** |
| **Low Control** | 95 | 0.86 (0.61-1.22) | 95 | 1.01 (0.63-1.63) | 62 | 0.75 (0.45-1.22) | 32 | 0.62 (0.09-4.28) | 0.91/0.63 |
| **Low Supervisor Support** | 106 | 0.89 (0.63-1.27) | 106 | 0.82 (0.51-1.32) | 71 | 1.02 (0.62-1.67) | 33 | 0.53 (0.08-3.52) | 0.71/0.70 |
| **Low Coworker Support** | 119 | **0.72 (0.51-1.03)** | 119 | 1.10 (0.68-1.80) | 77 | **0.43 (0.26-0.72)** | 46 | 1.38 (0.14-13.64) | **7.65/0.02** |
| **High Job Strain** | 41 | 0.92 (0.63-1.36) | 41 | 0.61 (0.33-1.15) | 39 | 1.23 (0.74-2.05) | 16 | 1.36 (0.23-8.12) | 3.03/0.22 |
| **High Iso-Strain** | 36 | 1.19 (0.78-1.83) | 36 | 0.94 (0.49-1.81) | 25 | 1.37 (0.77-2.43) | 9 | 6.27 (0.36-100.60) | 2.06/0.36 |
| **Sex (female)** | 40 | 1.00 (0.58-1.73) | 40 | 1.03 (0.50-2.11) | 28 | 0.95 (0.48-1.88) | 14 | 1.50 (0.25-8.91) | 0.25/0.88 |
| **Age (increment of 10 years)** | 198 | **1.25 (0.97-1.61)** | 198 | 1.00 (0.72-1.38) | 127 | **1.56 (1.12-2.17)** | 59 | 1.56 (0.54-4.54) | **4.64/0.09** |
| **Height (increment of 10 cm)** | 198 | 1.16 (0.91-1.49) | 198 | 1.16 (0.86-1.57) | 127 | 1.21 (0.88-1.67) | 59 | 0.72 (0.33-1.60) | 1.66/0.44 |
| **Weight (increment of 10 kg)** | 198 | 0.95 (0.86-1.05) | 198 | **0.88 (0.76-1.02)** | 127 | 1.05 (0.93-1.19) | 59 | **0.64 (0.43-0.93)** | **8.45/0.02** |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

**bold=p<0.10.**

*3.1.3.2.2.2. More severe low back injuries.*

There were fewer numbers of cases of severe low back injuries, and therefore, there were few statistically significant associations between risk factors and different stages of disability. Nevertheless, different patterns of associations between physical work factors and disability duration can be noted.

Driving years: For all phases of disability, driving more than 15 years was associated with a 64% slower RTW rate (HR = 0.61).

Driving hours: For the acute and subacute phases of disability, driving 50 hours per week or more was associated with a faster RTW (acute: HR = 1.70; subacute: HR = 2.37). Among those returning to work in the chronic phase, however, there was an 8.09 percent slower RTW (HR = 0.11, $p < 0.10$).

Vehicle type: Driving a rail-bound vehicle was associated with a 3.9-fold, significantly faster RTW in the subacute phase.

Ergonomic problems: With the exception of the chronic phase of disability, (HR =0.83), having higher ergonomic problem score was associated with increasing RTW in the acute and subacute phases (HR = 2.59 and HR = 1.98, respectively).

Sex: Across all phases of disability, being female was associated with slower RTW rate (HR = 0.41 for all phases, $p < 0.10$).

Age: Duration of disability increased with age (HR = 1.20), especially during the subacute phase (HR 2.13). However none of these results were significant. There was no significant association between age and any of the three phases of disability.

Height: A 10 cm increment in height was associated with slower RTW across all three phases of disability (HR=0.72).

Weight: A 10 kg increment in weight appeared to be associated with a slightly slower RTW in the chronic phase (HR = 0.73, $p < 0.10$) but not during entire days of disability.

Table 12. Return to work ratios after more severe low back injury for physical, psychosocial, and demographic variables (n=94 transit operators)

| | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **chi2 / p** |
| **Driving Years** | | | | | | | | | |
| less than 15 | 42 | Reference | 42 | Reference | 34 | Reference | 31 | Reference | |
| 15 or more | 52 | 0.61 (0.26-1.42) | 52 | 0.38 (0.11-1.32) | 46 | 1.38 (0.31-6.20) | 37 | 0.61 (0.19-1.98) | 2.10/0.35 |
| **Driving Hours** | | | | | | | | | |
| 20-30 | 3 | 3.03 (0.65-14.19) | 3 | 4.37 (0.47-40.93) | 2 | # | 2 | 2.16 (0.31-15.04) | |
| 31-50 | 69 | Reference | 69 | Reference | 60 | Reference | 53 | Reference | |
| 50 or more | 22 | 1.03 (0.44-2.41) | 22 | 1.70 (0.50-5.80) | 18 | 2.37 (0.66-8.46) | 13 | **0.11 (0.01-1.06)** | 5.79/0.12 |
| **Vehicle Type** | | | | | | | | | |
| Street bound (diesel bus & trolley) | 75 | Reference | 75 | Reference | 64 | Reference | 57 | Reference | |
| Rail bound (light rail & cable car) | 19 | 1.73 (0.72-4.17) | 19 | 0.79 (0.16-3.92) | 16 | **3.89 (1.08-14.02)** | 11 | 1.52 (0.38-6.11) | 2.81/0.25 |
| **Ergonomic Problem Score** | | | | | | | | | |
| low score (<=15 points) | 44 | Reference | 44 | Reference | 39 | Reference | 34 | Reference | |
| High score (>15 points) | 50 | 1.50 (0.72-3.12) | 50 | 2.59 (0.73-9.14) | 41 | 1.98 (0.55-7.16) | 34 | 0.83 (0.28-2.41) | 2.34/0.31 |
| **High Demands** | 50 | 1.33 (0.69-2.57) | 50 | **3.51 (0.94-13.18)** | 40 | 0.88 (0.26-2.91) | 35 | 0.86 (0.29-2.60) | 3.15/0.21 |
| **Low Control** | 34 | 1.43 (0.68-3.00) | 34 | 1.37 (0.43-4.36) | 29 | 1.32 (0.38-4.67) | 24 | 1.63 (0.48-5.57) | 0.07/0.97 |
| **Low Supervisor Support** | 50 | 0.98 (0.48-2.00) | 50 | 2.48 (0.66-9.30) | 40 | 0.46 (0.13-1.61) | 36 | 0.80 (0.26-2.47) | 3.53/0.17 |
| **Low Coworker Support** | 52 | 0.85 (0.41-1.73) | 52 | 0.72 (0.24-2.23) | 46 | 0.69 (0.20-2.30) | 40 | 1.27 (0.37-4.31) | 0.65/0.72 |
| **High Job Strain** | 20 | 2.15 (0.84-5.46) | 20 | 2.37 (0.67-8.46) | 16 | 1.37 (0.28-6.81) | 14 | 3.33 (0.62-17.90) | 0.66/0.72 |
| **High Iso-Strain** | 17 | 1.74 (0.66-4.63) | 17 | 2.79 (0.80-9.66) | 13 | 0.73 (0.09-5.96) | 12 | 1.60 (0.25-10.36) | 1.27/0.53 |
| **Sex (female)** | 21 | **0.41 (0.15-1.15)** | 21 | 0.56 (0.12-2.59) | 18 | 0.18 (0.02-1.61) | 17 | 0.47 (0.14-1.57) | 0.88/0.64 |
| **Age (increment of 10 years)** | 94 | 1.20 (0.61-2.34) | 94 | 0.96 (0.39-2.33) | 80 | 2.13 (0.78-5.83) | 68 | 0.78 (0.25-2.38) | 2.48/0.29 |
| **Height (increment of 10 cm)** | 94 | 0.72 (0.44-1.19) | 94 | 0.61 (0.31-1.19) | 80 | 0.90 (0.43-1.86) | 68 | 0.72 (0.34-1.52) | 0.71/0.70 |
| **Weight (increment of 10 kg)** | 94 | 0.90 (0.72-1.14) | 94 | 0.97 (0.69-1.36) | 80 | 1.01 (0.72-1.42) | 68 | **0.73 (0.50-1.06)** | 2.19/0.34 |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

# odds ratio could not be calculated, because no participant in the group returned to work at this phase.

**bold=p<0.10.**

*4.1.3.2.3. Discussion.*

The goal of this study was to determine which set of risk factors is associated with more disability days in each given phase. Therefore, the findings will be discussed by phase of disability.

Acute phase (up to 30 lost work days). Years of professional driving was associated with slower rate of return to work, even when back injury was stratified by level of severity. This is consistent with earlier research that indicates that professional driving is associated with disability resulting from low back injury (Pope et al, 1991; Bernard, 1997; Krause et al, 1998c; National Research Council, 2001). It is noteworthy that driving 20-30 hours per week was associated prospectively with a 97% faster rate of returning to work compared with those who work longer hours. In contrast, driving more hours was associated with a lower rate of return to work. These results are parallel findings for less severe back injury. Driving a rail-bound vehicle (light rail or cable car) was associated with a faster rate of return to work in the subacute and chronic phase, and this effect was observed among cases with both less and more severe injuries. Drivers reporting more ergonomic problems were found to have somewhat faster rates of return to work.

Subacute phase (31-90 lost work days). Fifteen or more years of driving was associated with a faster rate of return to work for both less severe (HR = 1.21) and more severe injuries (HR = 1.38). Driving fewer hours (20-30) per week appears to be associated with a faster return to work across all classifications of injury severity. Driving overtime (50 hours or more is associated with a faster return to work for more severe (HR = 2.37) injuries and with a slower rate of return to work among those with less severe back injury (HR = 0.77).

In contrast to the results for vehicle type in the acute phase, operating a rail-bound vehicle was associated with a faster return to work in the subacute phase across all levels of injury severity.

With regard to ergonomic problems, higher levels of ergonomic problems were associated with a slightly slower return to work (HR = 0.95) in the analyses of all back injuries and less-severe injuries, although a higher score was associated with a faster rate among those with more severe back injuries.

<u>Chronic phase (90 or more lost work days)</u>. A greater number of years of professional driving was associated with a slightly slower rate of return to work across all back injuries, a faster rate among less severe injuries, and a slower rate among more severe injuries. Driving fewer hours per week (20-30) was associated with a faster return to work rate for all back injuries and less severe injuries, but a slower rate for more severe injuries. While overtime driving (>50 hrs/wk) was associated with a slightly faster rate of return among those with less severe back injuries, this factor was clearly associated with reduced rate of recovery among those with more severe back injuries (HR = 0.11).

Similar to the results for vehicle type in the subacute phase, driving a rail-bound vehicle was associated with a faster rate of return in both levels of back injury severity and across all back injuries. Again, this is in contrast to the findings for vehicle type in the acute phase analyses.

Across all back injuries and in the analyses stratified by severity, a higher number of ergonomic problems is unequivocally associated with a slower rate of return to work among those with a chronic disability.

Professional driving exposure emerged as an important predictor of slower rate of recovery particularly in the acute phase of recovery. It may be that drivers with more experience are at risk for injuries that are more complicated, or that otherwise take a longer time to heal. This suggests that the cumulative effect of driving may influence the duration of disability once an injury occurs.

Driving a few number of hours per week (20-30) appear to be positively associated with a quicker return to work rate in several of the phase-specific analyses and when stratified by injury severity. Driving more than 50 hours per week appeared to have largely inhibit a quick return to work particularly in the chronic disability phase.

The effect of vehicle type across phases of disability is difficult to interpret. Rail-bound vehicles include cable car driving, which may be the most physically demanding job in the MUNI fleet. Driving a rail-bound vehicle, however, was associated with a faster rate of return in the subacute and chronic phases of disability.

The results for ergonomic problems were mixed. A high number of ergonomic problems would be expected to deter a quick return to work following a disabling back injury. In several categories (acute phase, all back injuries; acute phases, less severe injuries; acute and subacute phases among more severe injuries), however, a higher number of ergonomic problems was associated with a faster return to work.

One of the limitations of this study was the small number of low back injuries cases with work disability. Originally, this study was planned to incorporate disability data from both the MUNI-1 and MUNI-2 cohort, but this plan was abandoned because of missing follow-up data up to 1993. Small sample size produced unstable effects.

## 4.2. The independent effects of job stress on low back disorders

AIM #2: Determine the effects of job stress/strain on the three outcome measures, with adjustment for age, sex, and anthropometric variables, where job "stress" is defined by the frequency of self-reported stressors, or objectively, as observer-assessed barriers to completing work tasks, time pressure, tightness of work schedule, and monotonous work. Job "strain" is defined as self-reported, high psychological job demands combined with low worker control.

Status: The investigation of the independent effects of job stress on LBP have been assessed for all three outcomes, prevalence of LBP, incidence of work-related low back injury, and duration of work disability after low back injury. In addition to investigating the effects of job stress on incidence of low back injury, the effects of stress on neck injury were also studied. The effects of job stress and job strain demonstrated different effects depending on whether the outcome was low back injury or neck injury. Once again, these effects were observed when the potential covarying effects of physical workload were adjusted in the analyses.

Three manuscripts have been prepared that relate directly to Specific Aim #2. The first manuscript on LBP prevalence is described in a manuscript titled "Physical and Psychosocial Job Factors Associated with the Prevalence of Low Back Pain in Urban Transit Operators." The analyses for this manuscript have been completed and the writing of the manuscript is in progress. The second manuscript is titled "Job Strain, iso-strain, and the incidence of low back and neck injuries: A 7.5-year prospective study of San Francisco transit operators." It has been submitted for publication and is currently under review.

### 4.2.1 Prevalence of LBP (cross-sectional analyses).

The prevalence of LBP is described in a manuscript titled "Physical and Psychosocial Job Factors Associated with the Prevalence of Low Back Pain in Urban Transit Operators." The association between prevalence of LBP and physical work factors will be presented in the following section.

#### *4.2.1.1. Prevalence of LBP and Job Strain*

The analysis of LBP prevalence and job stress used the same cohort (MUNI-2) as described in Section 3.2.2. Briefly, this was a sample of 1,298 participants. The three physical work factors investigated were total years of professional driving, total hours of weekly driving during the past 12 months, and type of vehicle most frequently driven. These work factors were described in detail in Section 3.3.6.

Job stress was measured with the Job Content Questionnaire (see Section 3.3.7.2). Low back pain was assessed from a questionnaire item collected from the medical history, self-report questionnaire. Specifically, participants were asked if they had pain, ache, or discomfort in their lower back during the last 12 months. Those who answered "yes" were regarded as cases.

In univariate analyses, the distribution of LPB was analyzed by Pearson's $\chi^2$ test for nominal scaled predictors (sex, vehicle type) and by Cuzick's z-test for trend for ordinal scaled predictors (age, years of professional driving, and weekly driving hours). Univariate associations between LBP prevalence and job stress factors are presented in Table 13. Low back pain was statistically significantly more prevalent in participants with high psychological demands ($p<0.01$ for trend) and low supervisor support ($p=0.02$ for trend). Low back pain was not significantly associated with decision latitude or job strain.

Table 13. Univariate Associations Between Psychosocial Factors and Low Back Pain Prevalence.

| Variables | n | Low back pain cases n (%) | $\chi^2$ or z for trend |
|---|---|---|---|
| **Psychological demands** | | | |
| Low | 491 | 130 (26.5) | |
| Medium | 420 | 141 (33.6) | |
| High | 387 | 144 (37.2) | 3.45 ** |
| **Decision latitude** | | | |
| High | 368 | 115 (31.3) | |
| Medium | 478 | 141 (29.5) | |
| Low | 452 | 159 (35.2) | 1.33 |
| **Supervisor support** | | | |
| High | 432 | 123 (28.5) | |
| Medium | 477 | 151 (31.7) | |
| Low | 389 | 141 (36.3) | 2.37 ** |
| **Coworker support** | | | |
| High | 547 | 164 (30.0) | |
| Medium | 312 | 119 (38.1) | |
| Low | 439 | 132 (30.1) | 0.26 |
| **Job strain** | | | |
| No | 1125 | 353 (31.4) | |
| Yes | 173 | 62 (35.8) | 1.37 |
| **Iso-strain** | | | |
| Low | 1189 | 380 (32.0) | |
| High | 109 | 35 (32.1) | 0.00 |

* $p<0.05$. **$p<0.01$.

Next, the association between risk factors for LBP prevalence and job stress factors were examined in multivariate models. Psychological demands were associated with a gradual increase in the prevalence of low back pain (see Table 14). Compared to participants with low psychological demands, medium demands were associated with a 1.43 and high demands with a 1.54 higher odds of low back pain after adjusting for age and sex (Model 1). These associations remained significant after adjusting for physical factors (total years of driving, total hours of driving and vehicle type) in Model 2. In a continuous model, a one point increase in psychological demands was associated with an increase of low back pain of 1.07 (95% CI = 1.02-1.12) when controlled for age and sex and a 1.06 increase when controlled for age, sex and physical factors (95% CI = 1.01-1.12). Decision latitude, job strain and iso-strain were unassociated with low back pain prevalence in both models.

Table 14. Multivariate Association Between Psychosocial factors and Low Back Pain Prevalence

| | N | Model 1 Odds Ratio | 95% Confidence Interval | | Model 2 Odds Ratio | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| **Psychological demands** | | | | | | | |
| Low | 491 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 420 | 1.43 | 1.07 | 1.90 | 1.39 | 1.04 | 1.86 |
| High | 387 | 1.53 | 1.14 | 2.04 | 1.49 | 1.10 | 2.00 |
| **Decision latitude** | | | | | | | |
| High | 368 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 478 | 0.91 | 0.68 | 1.23 | 0.91 | 0.68 | 1.23 |
| Low | 452 | 1.17 | 0.87 | 1.57 | 1.16 | 0.86 | 1.57 |
| **Supervisor support** | | | | | | | |
| High | 432 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 477 | 1.17 | 0.88 | 1.56 | 1.14 | 0.85 | 1.52 |
| Low | 389 | 1.40 | 1.04 | 1.89 | 1.33 | 0.98 | 1.80 |
| **Coworker support** | | | | | | | |
| High | 547 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 312 | 1.43 | 1.06 | 1.92 | 1.42 | 1.05 | 1.91 |
| Low | 439 | 0.97 | 0.74 | 1.28 | 0.96 | 0.72 | 1.27 |
| **Job strain** | | | | | | | |
| No | 1125 | 1.00 | --- | --- | 1.00 | --- | --- |
| Yes | 173 | 1.13 | 0.80 | 1.59 | 1.13 | 0.80 | 1.59 |
| **Iso-strain** | | | | | | | |
| Low | 1189 | 1.00 | --- | --- | 1.00 | --- | --- |
| High | 109 | 0.94 | 0.61 | 1.44 | 0.94 | 0.60 | 1.44 |

Model 1: All variables in the model adjusted for age and sex.

Model 2: Model 1 + adjustment for physical factors (total years of driving, total hours of driving, vehicle type).

*4.2.1.2. Further Analyses on the Psychological Demands Variable.*

In a recently published paper (Kerr et al, 2001) it has been argued that the psychological demand scale of the JCQ is measuring more physical than psychological demands at least in some working populations. In a case-control study with mostly blue collar workers in a Canadian automobile manufacturing complex the association between psychological demands and low back pain incidence vanished when items on self-reported physical demands were introduced into the model. It could been argued that the proxy measures for physical demands in our study (years of driving, hours of weekly driving and vehicle type) are only covering specific aspects of physical workload and that therefore the confounding effect of physical workload is insufficiently controlled. One of the items used in the Canadian study to measure self-reported physical workload was from the JCQ ("my jobs requires lots of physical effort") which was also asked in our study. When we introduced this item in the physical models, the odds ratios for medium and high psychological demands were only slightly reduced (to 1.36 and 1.42 respectively) and remained statistically significant. The dose-response relationship between increasing psychological demands and probability of low back also remained largely unaffected (odds ratio = 1.06; 95% CI = 1.00-1.11; p=0.04).

Participants with high psychological demands had a 49% higher probability of low back pain even after adjusting for physical workload and a dose-response relationship between these two variables was observed. The association holds, when self-reported physical demands were controlled for, showing that, at least in our population, psychological demand items from the JCQ are not reflecting physical demands.

In the demand-control model it is hypothesized that the combination of high psychological demands and low decision latitude causes job strain and will result in a higher risk for disease. In our study, however, neither decision latitude nor job strain were related to low back pain. These results are consistent with findings from earlier studies on neck and back pain prevalence and incidence in San Francisco transit operators (see discussion below), but stays in marked contrast to recently published studies on other occupations. The null findings in our study are probably due to lack of variation in decision latitude among public transit operators.

*4.2.1.3. Prevalence of LBP and Job problem Frequency (Winkelby et al., 1998).*

To date, the association between low back pain prevalence and job problem frequency has yet to be analyzed.

*4.2.1.4. Prevalence of LBP and Observer-based Task Barriers.*

The prevalence of low back and other musculoskeletal disorders and their associations with the observer-based measure of job stress are described in a manuscript titled "Observational stress factors and musculoskeletal disorders in urban transit operators".

In this study, observational methods were used to measure psychosocial job stressors and to investigate the associations of both individual stressors and a sum score of stressors with musculoskeletal disorders while simultaneously adjusting for physical workload in a subset of the MUNI-2 cohort of urban transit operators. This occupational group is known for a high prevalence of both job stress and musculoskeletal disorders (Evans, 1994; Kompier et al, 1995; Krause et al, 1997b), and high rates for disablement due to musculoskeletal disorders (Kompier et al, 1990).

A sub-sample of 81 MUNI-2 drivers were used for observer-based job analysis, as a complete analysis of the full cohort of 81 drivers (1,841) would have been prohibitively expensive. This subsample of drivers was described in greater detail in Section 2.1.2.2. Briefly, the sampling was done in two stages. First, 27 transit lines were chosen out of a total of 90 lines operated by the company, on the basis of interviews with management, union representatives, and drivers to include all vehicle types, rail, bus and cable car, and a variety of task requirements and stressors. After the lines were selected, a convenience sample of 81 operators was chosen and contacted by the shop-stewards (for details of the sampling strategy seeGreiner et al, 1997). Participants in this sample were predominately male (79%), had a mean age of 47.7 years, had worked on average 15.1 years as a professional driver, and their weekly driving hours averaged to 47.0.

*4.2.1.5. Methods*

*4.2.1.5.1. Measurement of observational job stressors*

See measurement section in Methods, Section 2.2.6.4.

*4.2.1.5.2. Musculoskeletal disorders*

In this sub-study all musculoskeletal disorders were analyzed rather than just low back pain because of the small sample (n=66). Medical history forms obtained during each driver's biennial medical relicensing examination were used to determine the 12-month period prevalence of musculoskeletal disorders. These disorders were analyzed in six groups: (1) Any pain in upper and/or lower back, neck, upper extremities, lower extremities and/or the legs (MSD); (2) lower back pain (LBP); (3) back (upper, lower) and/or neck pain (BNP); (4) neck pain (NP); (5) pain of the upper extremities including shoulder, upper arm, elbow, forearm, wrist or hand (UPEXP); and (6) pain of the lower extremities including legs, knees or foot (LOEXP). These groups were not mutually exclusive. MSD included all of the other 5 groups and served as a general measure of any musculoskeletal pain. BNP and NP were overlapping. We grouped back and neck pain in one group to be able to compare our results with findings from earlier studies of the same population using self-report data on job stressors. These studies of an earlier cohort of transit operators could not differentiate between neck and lower or upper back pain (Krause et al, 1998b; Krause et al, 1997b).

*4.2.1.5.3. Control variables*

Analyses were adjusted for gender, age, and physical workload. An overall measure of past and current physical workload which was operationalized by three parameters: (a) lifetime years of professional driving in the transportation industry, (b) weekly driving hours including overtime in the current job over a twelve month period, and (c) vehicle type as ascertained by company relicensing examination records. Vehicle type was grouped into rail-bound versus street-bound vehicles based on the observation that the odds ratios derived from univariate analyses of each vehicle type were similar for light rail and cable car drivers on the one hand, and for diesel and trolley bus drivers on the other hand.

*4.2.1.5.4. Data analyses*

First we conducted descriptive analyses to determine the average duration of extra work for each barrier type and for the barrier summary measure. Second, we examined the distribution of each measure for musculoskeletal disorders, sociodemographic variables, and physical workload variables.

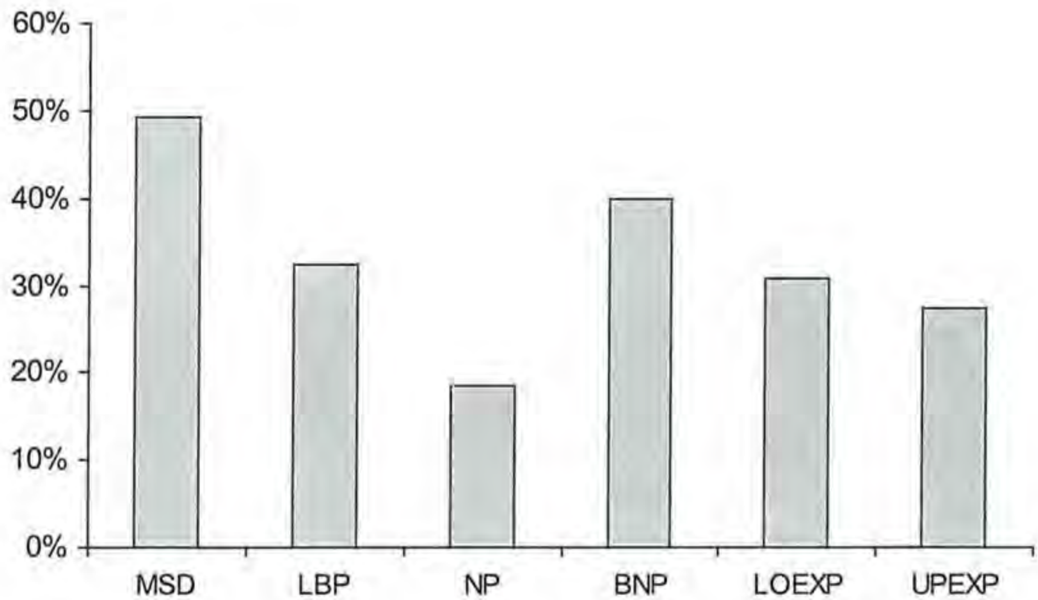
The third set of analyses consisted of logistic regression models for the six groups of musculoskeletal outcomes. The stressor and control variables were entered simultaneously into logistic regression models to describe independent effects of risk factors by adjusted odds ratios (OR) with 95% confidence intervals for each estimate. All analyses were conducted using the STATA program, Version 6 (StataCorp, 1997).

*4.2.1.6. Results*

*4.2.1.6.1. Prevalence of musculoskeletal disorders*

Figure 1 shows the 12-month period prevalence for six groups of musculoskeletal disorders. A total of 49.2 percent of operators reported that they had any MSD within the past 12 months. The prevalence of BNP (40%) was mostly driven by back disorders, 32.3% reported LBP and 18.5% NP. Problems of the lower extremities were reported by 30.8%, and of the upper extremities by 27.3%

Figure 1. Self-reported 12-months period prevalence of different musculoskeletal disorders in urban transit operators, n=66




Sociodemographic characteristics, physical work load, and musculoskeletal disorders. The 12-month period prevalence of musculoskeletal disorders, broken down by sociodemographic characteristics and physical work load, is displayed in Table 15 (for spinal disorders) and table 16 (for musculoskeletal disorders of the extremities).

Table 15. Musculoskeletal disorders of the spine by sociodemographic characteristics and indicators of physical workload in urban transit operators, n=66.

| | N | MSD % | BNP % | LBP % | NP % |
|---|---|---|---|---|---|
| Gender | | | | | |
| male | 52 | 43.1 | 33.3 | 25.5 | 15.7 |
| female | 14 | 71.4 | 64.3 | 57.1 | 28.6 |
| Age | | | | | |
| <40 | 8 | 50.0 | 25.0 | 12.5 | 25.0 |
| 40-50 | 37 | 48.6 | 40.5 | 35.1 | 16.2 |
| >50 | 21 | 50.0 | 45.0 | 35.0 | 20.0 |
| Driving years as professional driver | | | | | |
| <10 years | 12 | 41.7 | 33.3 | 25.0 | 8.3 |
| 10-19 years | 36 | 47.2 | 36.1 | 33.3 | 13.9 |
| 20 and more years | 16 | 62.5 | 26.3 | 37.5 | 37.5 |
| Weekly driving hours | | | | | |
| 40 hours and less | 20 | 52.6 | 41.1 | 31.6 | 15.8 |
| 41-45 hours | 24 | 37.5 | 33.3 | 29.2 | 20.8 |
| More than 45 hours | 22 | 59.1 | 45.5 | 36.4 | 18.2 |
| Vehicle type | | | | | |
| Rail-bound | 14 | 42.9 | 28.6 | 21.4 | 14.3 |
| Street-bound | 50 | 52.0 | 44.0 | 36.6 | 20.0 |

Females had higher rates for all musculoskeletal outcomes than males. 71.4% of the women had any MSD over the past 12 months as compared to 43.1% of the men. MSD prevalence did not substantially vary between the different age groups, however for LBP, the prevalence was lowest in the age group under 40 years. With respect to life-time years working as a professional driver, there was a clear gradient with increasing driving years for all musculoskeletal outcomes except BNP and LOEXP. Drivers working more than 45 hours per week showed the highest rates for MSD, BNP, LBP, and LOEXP. Bus drivers (street-bound vehicles) were affected by all musculoskeletal disorders to a higher degree than light rail and cable car (rail-bound) operators.

Table 16. Musculoskeletal disorders of the upper extremities (UPEXP) and the lower extremities (LOEXP) by sociodemographic characteristics and indicators of physical workload in 66 urban transit operators

| | N | UPEXP % | LOEXP % |
|---|---|---|---|
| Gender | | | |
| male | 51 | 19.2 | 27.5 |
| female | 14 | 57.1 | 42.9 |
| Age | | | |
| <40 | 8 | 11.1 | 37.5 |
| 40-50 | 37 | 55.6 | 35.1 |
| >50 | 20 | 33.3 | 20.0 |
| Driving years as professional driver | | | |
| <10 years | 12 | 16.7 | 25.0 |
| 10-19 years | 36 | 27.0 | 33.3 |
| 20 and more years | 16 | 37.5 | 31.3 |
| Weekly driving hours | | | |
| 40 hours and less | 19 | 25.0 | 21.1 |
| 41-45 hours | 24 | 29.2 | 29.2 |
| More than 45 hours | 22 | 27.3 | 40.9 |
| Vehicle type | | | |
| Rail-bound | 14 | 21.4 | 28.6 |
| Street-bound | 51 | 29.4 | 32.0 |

*4.2.1.6.2. Frequency of job barriers.*

Table 17 shows means, standard deviations, and ranges for a barrier summary measure and each individual barrier category. Participants had an average of 31.5 minutes of extra work per 4-hours shift, with a maximum of 122 minutes. Among the individual barrier categories, vehicle-movement barriers were responsible for the highest amount of extra work (8.6 minutes per 4 hour shift), followed by barriers for providing passenger service (5.6 minutes), and sight barriers (4.9 minutes).

Table 17. Mean, standard deviation, and range of extra work because of job barriers observed among 66 public transit operators (1 unit = 10 minutes of extra work per 4 hour shift)

| Barrier measure | Mean | Standard deviation | Range |
|---|---|---|---|
| Barrier summary | 31.5 | 2.57 | 0.0-122 |
| Vehicle movement barriers | 8.6 | 0.72 | 0.0-35 |
| Providing passenger service barriers | 5.6 | 1.23 | 0.0-87 |
| Sight barriers | 4.9 | 0.65 | 0.0-26 |
| Operating control barriers | 3.9 | 0.56 | 0.0-28 |
| Being-on time barriers | 3.2 | 0.87 | 0.0-66 |
| Movement and handling barriers | 1.3 | 0.40 | 0.0-21 |

Associations of observational job barriers with MSD outcomes. Table 18 shows crude and adjusted odds ratios (OR) with 95% confidence intervals of the association between the summary barrier measure and all outcome variables. All analyses were adjusted for age, gender, years of driving as professional driver, weekly driving hours, and vehicle type.

Table 18. Effects of observational job barriers (summary measure) on 12 month prevalence of musculoskeletal disorders in 66 urban transit operators: crude and adjusted odds ratios (OR) with 95% confidence intervals (CI)

| Outcome | Crude OR | 95% CI | Adjusted OR[1] | 95% CI |
|---|---|---|---|---|
| MSD | 1.34* | 1.04-1.72 | 1.55* | 1.10-2.18 |
| BNP | 1.26* | 1.01-1.58 | 1.41* | 1.03-1.91 |
| LBP | 1.34* | 1.05-1.69 | 1.46* | 1.06-2.00 |
| NP | 0.97 | 0.75-1.25 | 0.96 | 0.73-1.25 |
| UPEXP | 1.18 | 0.96-1.45 | 1.24 | 0.95-1.63 |
| LOEXP | 1.37* | 1.08-1.76 | 1.43* | 1.09-1.90 |

p=<0.05
[1] Adjusted for age, gender, years of driving as professional driver, vehicle type (street-bound versus rail-bound), and weekly working hours.

After adjustment, the strength of all associations increased, indicating some degree of confounding by sociodemographic and physical workload variables. Ten minutes of extra work per four hour shift because of observed barriers increased the adjusted likelihood of any MSD in the past 12 months by 55% (Adj. OR=1.55, 95%CI; 1.10-2.18), of BNP by 43%% (Adj. OR=1.43, 95%CI: 1.09-1.90), of LBP by 46% (Adj. OR=1.46, 95%CI:1.06-2.00), and of LOEXP by 43% (Adj. OR=1.43, 95% CI 1.09-1.90). The odds ratio for UPEXP was elevated by 24 %, but this result was not statistically significant (Adj. OR=1.24, 95% CI:0.95-1.63). There was no association with NP.

Table 19 displays the adjusted odds ratios estimating the effect of specific barrier categories on all outcomes. All analyses were adjusted for age, gender, years of driving as professional driver, weekly driving hours, and vehicle type.

Table 19. Effects of Individual Observational Job Barriers on 12-month Prevalence of Musculoskeletal Disorders in 66 Urban Transit Operators: Crude and Adjusted Odds Ratios (OR) with 95% Confidence Intervals (CI)

| **Barrier categories**[1] | **Adjusted OR**[2] **95% CI** | | | | | |
|---|---|---|---|---|---|---|
| | **MSD** | **BNP** | **LBP** | **NP** | **LOEXP** | **UPEXP** |
| Sight barriers[3] | 6.41*<br>1.53-26.95 | 2.11<br>0.74-5.99 | 1.62<br>0.62-4.22 | 1.08<br>0.35-3.33 | 3.79*<br>1.24-11.61 | 1.72<br>0.63 - 4.69 |
| Vehicle moving barriers[4] | 2.74*<br>1.16-5.24 | 2.23*<br>1.09-4.53 | 2.76*<br>1.33-5.73 | 0.97<br>0.45-2.10 | 1.61<br>0.85-3.06 | 1.90<br>0.92-3.93 |
| Barriers for focused attention on driving[5] | 1.58<br>0.71-3.51 | 1.63<br>0.74-5.59 | 1.71<br>0.77-3.77 | 0.37<br>0.03-5.16 | 1.41<br>0.68-2.96 | 1.05<br>0.37-2.98 |
| Providing passenger service barriers[6] | 2.56<br>0.14-46.06 | 1.71<br>0.18-16.41 | 2.55<br>0.19-33.82 | 0.10<br>0.00-36.50 | 4.16<br>0.28-62.86 | 23.60<br>0.21-2653.72 |
| Being-on-time barriers[7] | 8.87*<br>1.30-60.58 | 6.17*<br>1.15-32.98 | 5.83 *<br>1.15-29.45 | 0.52<br>0.11-2.40 | 2.24<br>0.55-9.04 | 2.24<br>0.55-9.04 |
| Barriers for movement, maintenance of posture and equipment handling [8] | 8.32*<br>1.05-65.96 | 29.21*<br>2.15-396.04 | 8.96*<br>1.34-60.00 | 7.17(*)<br>0.98-52.25 | 2.69<br>0.65-11.09 | 3.60<br>0.60-22.79 |
| Operating controls barriers[9] | 1.24<br>0.37-4.18 | 1.90<br>0.69-5.18 | 1.85<br>0.65-5.24 | 1.68<br>0.62-4.56 | 1.55<br>0.60-3.99 | 1.46<br>0.49 - 4.36 |

p=<0.05

[1] Adjusted for age, gender, years of driving as professional driver, vehicle type (street-bound versus rail-bound), and weekly working hours.

[2] Barriers are measured in 10-minute increments of extra work per 4 hours.

[3] Adjusted for age, gender, years of driving as professional driver, vehicle type (rail versus bus) and weekly driving hours

[4] Sight barriers include: blocked view due to vehicle design, due to bad mirrors, due to design of traffic environment, due to crowding

[5] Vehicle moving barriers include (narrow turns, lane not wide enough, double parking, transit lane used by others, physical obstacle in street, stop not long enough or not wide enough)

[6] Barriers for focussing attention on driving include: illegal behaviour of passengers after boarding

[7] Providing passenger service barriers include: obstacles for passenger loading and unloading, obstacles for verbally providing information, blocked passenger access, obstacles for displaying information to passengers and for processing passenger-related information.

[8] Being-on-time barriers include missing leading vehicles on the same or parallel lines

[9] Barriers for movement and equipment handling include obstacles for locomotion, obstacles that impede access to vehicle, obstacles maintenance of bodily posture, equipment handling problems

[10] Operating controls barriers include impeded vehicle acceleration, stiff foot pedals, and hand controls that are hard to reach.

All individual barrier categories showed a consistent and strong positive association with MSDs, BNP, LBP, and UPEXP. No consistent pattern of association was seen for NP. Four out of seven barrier categories had at least one statistically significant positive association with an MSD outcome measure. For example, each 10 minutes of extra work during a four hour shift due to vehicle-moving barriers observed in the streets were associated with a statistically significant 2.7 fold increase for both LBP alone and all MSDs combined, and a 2.23-fold increase for BNP. The associations with UPEXP, although strong for six (adjusted ORs ranging from 1.7 to 23.6) out of 7 barriers, did not reach statistically significance. Barriers for movement and equipment handling and barriers for being-on time exhibited the strongest effect sizes, with most statistically significant odds ratios ranging between 6 and 9. Operators on transit lines rated high on vehicle-moving barriers showed higher prevalence of MSD, LBP, and BNP. For sight barriers, a significantly elevated OR was found for MSD, and clearly elevated but statistically not significant odds ratios for LBP and BNP. Barriers regarding focused attention on driving, operating controls, and providing passenger service had clearly elevated but no significant associations with outcomes. All barrier types were unrelated to neck pain except barriers for movement and equipment handling, with a marginally significant association.

*4.2.1.7. Discussion*

This study shows significant associations between observer-based psychosocial job stressor measures and musculoskeletal outcomes. The sum of extra work across different work barriers as well as extra work due to individual barrier types were strongly and statistically significant associated with all musculoskeletal disorders except neck pain.

This study strongly supports findings from the literature that job stress is associated with musculoskeletal disorders in general (Ariens et al, 2001; Bernard, 1997; Bongers et al, 1993; Davis et al, 2000; Hoogendoorn et al, 2000b) and in this study population in particular (Krause et al, 1998b; Krause et al, 1997b). In fact, this study provides qualitative new evidence from observer-based measurement of stressors successfully addressing the thorny issue of the possibility of spurious associations due to common method variance bias in earlier studies using self-report measures of job stress. In addition, this study controlled for physical workload, a major strength compared to most earlier studies. Of course, prospective studies are needed to confirm the causal interpretation of the link between job stress and musculoskeletal disorders observed in this study.

Physiological pathways. The literature suggests that work characteristics may have an effect on musculoskeletal pain through two types of mechanisms. One, biomechanical mechanisms postulate that increased physical workload leads to increased tissue loading, tissue failure, and pain (National Research Council, 2001). Two, psychophysiological mechanisms postulate that work stress leads to lowered pain thresholds (Theorell et al, 1993) or increased muscle tension (Theorell et al, 1991; Ursin et al, 1988; Waersted et al, 1991). Both types of mechanisms were represented in our job barrier categories to varying degrees. Biomechanical processes were assumed to operate in movement/handling barriers and barriers for operating controls. Psychophysiological mechanisms were hypothesized as main pathway in barriers for providing passenger service, barriers for focussed driving, and on-time barriers. For example, an insufficient number of vehicles available on the line, or failure to replace missing drivers on time, resulted in cancelled runs and being-on-time-barriers. The operator driving behind a cancelled run has to pick up higher numbers of passengers than usual and is exposed to increased anger levels of passengers who have been waiting at the stop for longer than expected. Barriers for focussed attention on driving included, for example, situations where the operator has to divide his attention between watching the traffic situation and observing unruly passengers in the rear of the vehicle.

Biomechanical and psychophysiological processes might also be simultaneously operative, for example in vehicle-moving barriers. Physical obstacles in the street may force the driver to perform elaborate maneuvers with the vehicle leading to increased physical workload (e.g., extra trunk twisting while steering the vehicle around an obstacle). They might also result in dangerous maneuvers (e.g., steering the vehicle into oncoming traffic in an attempt to pass an obstacle) and, hereby, put higher mental and emotional loads on drivers. Likewise, sight barriers might initiate both pathways. They might put extra biomechanical postural demands on the workers due to awkward postures in order to compensate for poor mirrors and obstructed views. In addition, psychological stress is induced when operators continuously fear that they are not able to see all necessary information in the traffic environment.

With respect to the different musculoskeletal outcomes, back pain accounted for most of the statistically significant associations with stressors, whereas NP and UPEXP were not significantly related to stressors. These results suggest that research needs to differentiate between specific musculoskeletal outcomes, especially between back and neck pain. It is possible that stressors act anatomically specific on the musculoskeletal system. A study of engineering workers showed some evidence that the activation of stress-related and physical work-load-related mechanism might be anatomically specific (Randall, Griffiths, & Cox, 2002). Biomechanical mechanisms were evident for the reporting of pain in the lower body regions while both biomechanical and psychophysiological mechanisms were operative in the report of pain in the upper body region. With respect to inner psychological processes linking job stressors to musculoskeletal disorders, it is not known whether the experience of stress partly mediates (provides the pathway for) the association of job stressors and pain or moderates (amplifies) the effects of stressors on pain. For example, one study found that the report of pain was moderated but not mediated by well-being correlates of stress (Randall et al., 2002).

Measurement of job barriers. Several theoretical assumptions were made in the generation of barrier measures. One assumption was that "minor barriers", i.e. barriers that occur less than once a week and/or require less than 2 minutes of extra work per day, are negligible. Therefore they were excluded from the barrier measures. To test the appropriateness of this assumption we computed an alternative summary barrier measure including the extra work of minor barriers. When this variable was entered in to the logistic regression models the associations with the outcomes became slightly smaller, however, remained statistically significant. This finding suggests that minor barriers are indeed not very important for predicting MSDs. We also felt more confident to use measures that excluded minor barriers because they had been previously excluded from the inter-rater reliability estimations (Greiner et al, 1997). Another assumption was to assign a default value of 7 minutes extra work per 4-hour shift for intensified effort that was not measured directly. To test the appropriateness of this assumption we computed another summary barrier measure excluding barriers with intensified effort. Logistic regression analyses with this modified measure showed slightly attenuated effects, however, the associations remained statistically significant. This finding suggests that the estimate of 7 minutes of extra work for intensified effort is an acceptable proxy measure that increased the predictive power of the measurement instrument slightly.

Limitations of the study. Several limitations of this study need to be considered. This was a cross-sectional study and therefore the temporal relationship between stressors and outcomes is not defined by study design, limiting causal inference. However, it is reasonable to assume that job stressors were present on these lines before symptoms were reported, given the fact that neither vehicle type nor tracks changed in the years preceding the study. Therefore a causal interpretation of the observed associations is plausible. However, to test this interpretation we are currently conducting a prospective study of formally reported musculoskeletal injuries in the same study population.

The measurement instrument was developed mainly for the assessment of stressors caused by the organizational, social, psychological, and traffic environment of driving tasks, and allowed for only crude estimates of ergonomic stressors. Movement and handling barriers, including ergonomic factors that operate through biomechanical mechanisms, exhibited very high effect sizes with all four outcomes. However, these estimates were imprecise as indicated by the wide confidence intervals. This is probably due to limitations of the work analysis procedure to accurately determine the intensity of stressors predominately caused by ergonomic factors. Extra work caused by movement and handling barriers included mainly intensified effort, specifically the application of more physical force. Increased force was estimated by the default value of 7 minutes because the analyst was neither trained nor equipped to perform direct measures of these factors. This procedure resulted in imprecise measurement and low variance of the estimated amount extra work regarding this barrier type. Clearly, the parallel use of observational ergonomic instruments to measure physical force more precisely could greatly complement our observational methods in future job analyses.

This study did not exhaustively cover all psychosocial stress factors in this occupational group. It focussed on stressors that could appropriately be assessed by observational task analysis and that were likely to vary within this occupational group. Other stressful work characteristics prevalent among urban transit operators such as shift work, prolonged sitting, or social isolation were not considered. Therefore, current risk estimates associated with psychosocial stressors need to be considered conservative.

*4.2.1.7.1 Strengths of the study.*

To our knowledge this is one of the first studies that shows significant associations between job stressors and musculoskeletal disorders which measured psychosocial job stressors by observational methods rather than self-report. The advantage of the observational measures of job stressors is that bias due to common methods variance, potentially inflating the associations between job characteristics and musculoskeletal disorders in studies using self-report measures of job stress and MSDs, can be ruled out. In contrast to studies using self-reported stressor measures we can also rule out reverse causality, i.e. that the prevalence of musculoskeletal pain impacted the measurement of job stressors. All analyses were adjusted for past and current physical workload thereby overcoming a major methodological limitation of most earlier studies on job stress and musculoskeletal disorders.

*4.2.1.7.2. Implications for Measurement methods*

Biomechanical and psychophysiological pathways leading from work stressors to impaired musculoskeletal health are closely intertwined and difficult to separate. As shown in a recently published study with 410 white-collar and blue-collar workers, physical and psychological job stressors often coexist suggesting that these stressors manifest from common work organization factors that govern the structure of work (MacDonald et al., 2001). Isolating the separate effects of both physical and psychological stressors on the development of MSD, though important for the establishment of their independent causal roles maybe of limited practical value when combined exposure conditions are prevalent. Thus the parallel use of instruments to measure both ergonomic stressors and psychosocial job stressors based on the same theoretical and methodological framework would be of greater practical value for planning comprehensive worksite interventions. The method of observational job analysis presented here utilizes detailed mapping and detailed observational analysis of task activities, and thereby follows similar principles as the ergonomic instrumentation used in ergonomic field studies. The method of task analysis might serve as basis for combined analyses of biomechanical and psychosocial stress factors in the future.

*4.2.1.7.3 Implications for Prevention of work-related musculoskeletal disorders*

Observational job analysis data from stress research can complement questionnaire and ergonomic data in the development of detailed suggestions for job redesign aiming at the prevention of work-related musculoskeletal disorders. Job stressors specified in this study were caused by different environmental factors including work organization, ergonomics of the vehicle, street traffic conditions, and the social environment. Interventions to reduce musculoskeletal disorders in transit operators should address these factors and simultaneously target stressors operating through biomechanical or psychophysiological pathways. Specifically, our results suggest vehicle redesign to insure unimpeded sight (e.g., better mirrors, improve design of windshield). Barriers for movement, maintenance of bodily posture, and equipment handling also require improvements in vehicle and equipment design. Being-on-time barriers were mostly caused by lack of functioning vehicles on the line so that drivers had to pick up more passengers than projected. To tackle this problem, organizational changes would be necessary, e.g., better communication between drivers and central control to immediately replace missing vehicles, authorization of the driver to drive ahead of schedule in order to reduce waiting times for passengers, and purchase of enough vehicles to meet the number of runs required by the schedule. Most of the changes for reducing vehicle movement barriers involve changes in the traffic environment and require collaboration with public authorities and community groups, for example to initiate construction of transit lanes and better enforcement when these lines are blocked by unauthorized vehicles. Reduction of barriers on focussed driving requires collaboration with the social environment, e.g., building liaisons with schools, and information and education of passengers (Ragland et al, 1998).

Currently, there is insufficient evidence from intervention studies with transit drivers to demonstrate that reductions of psychosocial work stressors actually result in reduced musculoskeletal disorders. Zero effects on musculoskeletal health were found in a study with Stockholm's bus drivers, while the intervention resulted in significant effects on systolic blood pressure and heart rate. In this study, stressor reduction was mainly focussed on changes in the traffic environment to take pressure off the driver, e.g., construction of separate bus lanes, reconfiguration of parts of the route to minimize difficult turns and bottlenecks, construction of passenger peninsulas to avoid pullovers to the curb, installation of a traffic priority system favoring the bus, and the design and installation of an electronic passenger information system (Evans, Johansson and Rystedt, 1999; Rystedt et al, 1999).

A review of 13 case studies on stress intervention programs for mass transit drivers, showed significant reductions in sickness absences for some companies, however, no numbers were provided specifically for musculoskeletal disorders (Kompier & Aust, 1999). Similarly, a compilation of intervention case studies in German mass transit companies showed decreases in general absenteeism rates in several companies, but no data were provided specifically for musculoskeletal disorders (Aust, 2001). Interventions reviewed included a wide range of organizational, environmental and behavioral stressor reduction programs such as participation of drivers in designing the routes and shift plan, mixed work, and reduced driving hours. Considering the high percentage of sickness absences and disability cases in mass transit operators that are due to musculoskeletal disorders (Kompier et al, 1990; Aust 2001), it is likely, that the reported reductions in absenteeism are partially due to a reduction in musculoskeletal disorders.

To our knowledge, the current literature is void of well-controlled published intervention studies addressing specifically psychosocial job factors and MSDs in any occupational group (for reviews see Battie, 1992, and Frank et al., 1996). However, indirect evidence for the potential of these interventions is provided by studies evaluating the effectiveness of ergonomic and organizational work modifications in facilitating return-to-work for workers who experienced a disabling occupational injury or illness of the musculoskeletal system (Krause et al, 1998a). Clearly, our results also suggest a considerable potential for primary prevention of MSDs through worksite interventions addressing specific psychosocial job stressors. Observational job analysis can contribute to the development of specific intervention strategies for the primary prevention of MSDs. The specificity of observer-based job analysis can be a valuable tool in the identification and operationalization of task and equipment redesign to be employed in future intervention studies.

### 4.2.2. Job Strain and Incidence of Low Back and Neck Injuries (prospective analyses).

*4.2.2.1. Status.*

Analyses completed. The effects of job strain as a risk factor for changes in incidence of low back injury are described in a manuscript titled "Job Strain, iso-strain, and the incidence of low back and neck injuries: A 7.5.-year prospective study of San Francisco transit operators." The results of this study will be described in the following sections. The manuscript has been submitted for publication. The manuscript has been reviewed and is and is currently be revised for re-submission.

*4.2.2.2. Results and Discussion.*

Among the 1,841 eligible study participants a total of 3,688 workers' compensation claims were observed during the 7.5-year follow up period. Mean time of observation was 1,744 days (4.8 years; range: 2 days to 7.5 years) with regard to low back injuries and 1,793 days (4.9 years; range: 4 days to 7.5 years) with regard to neck injuries. ICD-9 codes were missing for 497 of the claims (13.5%), leaving a total number of 3,191 claims. Of these claims, 910 (28.5%) had at least one ICD-9 code that was indicative of definite low back diagnosis and 807 (25.3%) had at least one ICD-9 code that was indicative of definite neck diagnosis. There were up to 46 different ICD-9 codes per claim (at the 5-digit level), with a mean of 7.8 for low back and 8.3 for neck injuries.

Based on all available ICD-9 codes per claim, 127 low back injuries and 119 neck injuries were excluded, because at least one ICD-9 code indicated the presence of neoplasm (n=10 for low back and n=4 for neck), diffuse disease of connective tissue (n=1/n=1), arthropathy associated with infections (n=0/n=2), arthropathy associated with other underlying endocrine and metabolic disorders (n=1/n=1), osteomyelitis (n=2/n=2), pathologic or spontaneous fractures (n=0/n=1), other fractures (n=45/n=34), dislocations (n=44/n=45), open wounds (n=6/n=6), crushing injury (n=1/n=3), burns (n=7/n=6), spinal cord, plexus, and root injuries (n=9/n=13), inflammatory spondylarthropathies (n=0/n=1) and pregnancies (n=1/n=0). In addition, five low back injuries and 10 neck injuries were excluded, because the workers' compensation claim file indicated that the type of injury was abrasion (n=1/n=2) or skin lesion (n=1/n=1) or was caused by contact to electricity (n=1/n=1), temperature (n=1/n=1), fire (n=1/n=3) a knife or razor (n=0/n=1) or a weapon (n=0/n=2).

After applying all these exclusion criteria, 778 low back injuries and 677 neck injuries remained. Of these injuries, 533 (low back) respective 487 (neck) occurred among the 1,294 study participants. The remaining injuries occurred in 208 drivers with missing data (76 low back and 74 neck) and in 339 subjects who did not respond to the occupational questionnaire (169 low back and 116 neck).

Table 20 shows low back and neck injuries for 1,294 study participants by order of occurrence. There were 351 first low back and 334 first neck injuries, which are the outcomes in the following analyses. The mean time between baseline examination and first injury was 2.5 years for low back injury (range: 2 days to 6.9 years, median=2.2 years) and also 2.5 years for neck injury (range: 4 days to 6.6 years, median=2.2 years). Among the 351 first low back and the 334 first neck injuries, 112 were from the same injury claim, that is the claim had ICD-9 codes for both first low back and first neck injury. In addition, 23 participants with a first low back injury had a concurrent neck injury, which was not the first neck injury in the observation period. For neck injuries, there were an additional 24 participants that had a concurrent low back injury, which was not the first low back injury in the observation period.

Table 20. Frequency of Low Back and Neck Injuries by Order of Occurrence Among 1,294 Study Participants

| | **First Injury** | **Second Injury** | **Third Injury** | **Fourth Injury** | **Fifth Injury** | **Sixth Injury** | **Seventh Injury** | **Eighth Injury** | **All Injuries** |
|---|---|---|---|---|---|---|---|---|---|
| | n | n | n | n | n | n | n | n | n |
| **Injury location** | | | | | | | | | |
| Low Back | 351 | 124 | 40 | 12 | 3 | 1 | 1 | 1 | 533 |
| Neck | 334 | 110 | 31 | 7 | 4 | 1 | 0 | 0 | 487 |

Table 21 shows the hazard ratios and 95% confidence intervals of low back injury associated with psychosocial workplace factors. There were no significant effects for psychological demands, decision latitude, supervisor support, coworker support or total support. Job strain and iso-strain based on median split were also not associated with injuries. However, when job strain was defined as scoring in the upper tertile of the demands and the lower tertile of the decision latitude scale, there was a fully adjusted 1.35-fold higher low back injury rate for subjects with job strain ($p<0.05$). If these subjects also scored in the lower tertile of the total support scale (iso-strain), the fully adjusted hazard ratio was 1.45 ($p<0.05$). The hazard ratios remained substantially unchanged when we further adjusted for self-reported ergonomic problems or excluded the 135 low back injury cases who had also ICD-9 codes for neck injury (data not shown). Stratified analyses by severity of injury, showed a stronger impact of job strain (based on tertiles) on less severe injuries than on more severe injuries (HR: 1.51 vs. 1.19), while iso-strain showed similar effect sizes for less severe and more severe injuries (HR: 1.50 vs. 1.59) in the fully adjusted model (data not shown).

When we analyzed the psychosocial factors as continuous variables, we did not find a statistical significant association with low back injury. The only variable that approached statistical significance was supervisor support. A one point increase in supervisor support was associated with a 4% decrease in low back injury risk (HR=0.97, 95% CI=0.93-1.01, p=0.10).

Table 21. Psychosocial Workplace Factors as Predictors for Low Back Injuries in 1,294 Transit Operators

| Variable | n | Unadjusted Hazard Ratio | 95% Confidence Interval | Model 1 Adjusted Hazard Ratio | 95% Confidence Interval | Model 2 Adjusted Hazard Ratio | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|
| **Psychological Demands** | | | | | | | |
| Low | 385 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 504 | 1.10 | 0.85-1.44 | 1.11 | 0.85-1.45 | 1.12 | 0.85-1.47 |
| High | 405 | 1.27 | 0.97-1.66 | 1.11 | 0.84-1.45 | 1.11 | 0.83-1.48 |
| **Decision Latitude** | | | | | | | |
| High | 437 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 476 | 0.93 | 0.73-1.19 | 0.90 | 0.70-1.15 | 0.92 | 0.72-1.18 |
| Low | 381 | 0.87 | 0.66-1.13 | 0.86 | 0.66-1.12 | 0.89 | 0.68-1.17 |
| **Supervisor Support** | | | | | | | |
| High | 431 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 478 | 1.00 | 0.78-1.30 | 0.95 | 0.74-1.23 | 0.95 | 0.74-1.23 |
| Low | 385 | 1.18 | 0.91-1.53 | 1.10 | 0.85-1.43 | 1.10 | 0.84-1.44 |
| **Coworker Support** | | | | | | | |
| High | 548 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 316 | 0.98 | 0.75-1.28 | 0.93 | 0.71-1.22 | 0.97 | 0.74-1.27 |
| Low | 430 | 1.02 | 0.80-1.30 | 0.99 | 0.78-1.26 | 1.03 | 0.80-1.32 |
| **Total Support** [a] | | | | | | | |
| High | 325 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 548 | 0.90 | 0.69-1.18 | 0.88 | 0.67-1.15 | 0.90 | 0.68-1.18 |
| Low | 421 | 1.14 | 0.86-1.49 | 1.06 | 0.81-1.40 | 1.08 | 0.81-1.42 |
| **Job Strain based on Median Split** [b] | | | | | | | |
| No | 991 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 303 | 1.06 | 0.83-1.35 | 0.99 | 0.77-1.26 | 1.00 | 0.78-1.29 |
| **Job Strain based on Tertiles** [c] | | | | | | | |
| No | 1139 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 155 | 1.43 | 1.08-1.91 | 1.30 | 0.97-1.73 | 1.35 | 1.01-1.81 |
| **Iso-Strain based on Median Split** [d] | | | | | | | |
| No | 1088 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 206 | 1.17 | 0.89-1.54 | 1.11 | 0.84-1.47 | 1.14 | 0.86-1.50 |
| **Iso-Strain based on Tertiles** [e] | | | | | | | |
| No | 1199 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 95 | 1.52 | 1.08-2.14 | 1.39 | 0.98-1.97 | 1.45 | 1.02-2.06 |

Model 1: Adjusted for age, sex, ethnicity, height, weight

Model 2: Model 1 + adjusted for years of professional driving, driving hours per week, vehicle type (diesel bus, trolley bus, light rail, cable car) and self-reported physical demands

[a] Supervisor Support + Coworker Support
[b] Job Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude
[c] Job Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude
[d] Iso-Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude and total support
[e] Iso-Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude and total support

Table 22 shows the crude and multivariate adjusted hazard ratios and 95% confidence intervals of neck injury. Low supervisor support (HR=1.40, $p<0.05$) and low total support (HR=1.40, $p<0.05$) predicted neck injuries in the fully adjusted model that controlled for sociodemographic (age, sex, ethnicity), anthropometric (height, weight), and physical workload variables (years of professional driving, driving hours per week, vehicle type, self-reported physical workload). Low coworker support (HR=1.25, p=0.08) and low decision latitude (HR=1.27, p=0.08) were of borderline significance. Job strain and iso-strain both significantly predicted neck injuries, regardless of the variables being defined by median split or by the upper and lower tertiles of the respective subscales. Drivers with job strain had a 1.28-fold (based on median split, $p<0.05$) respective 1.61-fold (based on tertiles, $p<0.01$) higher hazard rate, compared to those without job strain. For iso-strain, the hazard ratios were 1.32 (median split, $p<0.05$) and 1.77 (tertiles, $p<0.01$) respectively. The hazard ratios remained substantially unchanged when we further adjusted for self-reported ergonomic problems and increased slightly, when we excluded the 136 neck injury cases who had also ICD-9 codes for low back injury (data not shown). Injuries of low severity had, compared to injuries of high severity, higher hazard ratios for job strain based on median split (HR: 1.39 vs. 0.96), job strain based on tertiles (HR: 1.80 vs. 1.15) and iso-strain based on tertiles (HR: 1.93 vs. 1.47), but a lower hazard ratio for iso-strain based on median split (HR: 1.32 vs. 1.42).

Table 22. Psychosocial Workplace Factors as Predictors for Neck Injuries in 1,294 Transit Operators

| Variable | n | Unadjusted Hazard Ratio | 95% Confidence Interval | Model 1 Adjusted Hazard Ratio | 95% Confidence Interval | Model 3 Adjusted Hazard Ratio | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|
| **Psychological Demands** | | | | | | | |
| Low | 385 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 504 | 1.02 | 0.78-1.34 | 1.02 | 0.78-1.34 | 1.08 | 0.82-1.41 |
| High | 405 | 1.19 | 0.91-1.56 | 1.08 | 0.82-1.43 | 1.18 | 0.88-1.59 |
| **Decision Latitude** | | | | | | | |
| High | 437 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 476 | 1.01 | 0.78-1.31 | 1.01 | 0.78-1.31 | 1.01 | 0.78-1.32 |
| Low | 381 | 1.20 | 0.92-1.57 | 1.22 | 0.93-1.59 | 1.27 | 0.97-1.67 |
| **Supervisor Support** | | | | | | | |
| High | 431 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 478 | 1.21 | 0.93-1.57 | 1.21 | 0.93-1.57 | 1.25 | 0.96-1.64 |
| Low | 385 | 1.33 | 1.01-1.74 | 1.32 | 1.01-1.74 | 1.40 | 1.06-1.86 |
| **Coworker Support** | | | | | | | |
| High | 548 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 316 | 1.21 | 0.92-1.58 | 1.17 | 0.89-1.53 | 1.23 | 0.93-1.62 |
| Low | 430 | 1.21 | 0.94-1.55 | 1.18 | 0.91-1.50 | 1.25 | 0.97-1.62 |
| **Total Support** [a] | | | | | | | |
| High | 325 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 548 | 1.03 | 0.77-1.36 | 1.02 | 0.77-1.36 | 1.07 | 0.81-1.43 |
| Low | 421 | 1.34 | 1.01-1.78 | 1.30 | 0.98-1.74 | 1.40 | 1.05-1.88 |
| **Job Strain based on Median Split** [b] | | | | | | | |
| No | 991 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 303 | 1.28 | 1.01-1.63 | 1.23 | 0.96-1.56 | 1.28 | 1.01-1.64 |
| **Job Strain based on Tertiles** [c] | | | | | | | |
| No | 1139 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 155 | 1.62 | 1.22-2.16 | 1.51 | 1.13-2.01 | 1.61 | 1.20-2.16 |
| **Iso-Strain based on Median Split** [d] | | | | | | | |
| No | 1088 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 206 | 1.32 | 1.01-1.74 | 1.26 | 0.96-1.66 | 1.32 | 1.00-1.74 |
| **Iso-Strain based on Tertiles** [e] | | | | | | | |
| No | 1199 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Yes | 95 | 1.70 | 1.21-2.39 | 1.65 | 1.17-2.33 | 1.77 | 1.25-2.51 |

Model 1: Adjusted for age, sex, ethnicity, height, weight

Model 2: Model 1 + adjusted for years of professional driving, driving hours per week, vehicle type (diesel bus, trolley bus, light rail, cable car) and self-reported physical demands

[a] Supervisor Support + Coworker Support
[b] Job Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude
[c] Job Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude
[d] Iso-Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude and total support
[e] Iso-Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude and total support

Analyses with psychosocial workplace factors as continuous predictors for neck injuries showed significant dose-response relationships for the iso-strain scale and all support scales, and a borderline significant association for the job strain scale. There was a 6% reduction in neck injury rates for every one point increase on either the supervisor support scale (HR=0.94, 95% CI=0.90-0.98, $p<0.01$) or the coworker support scale (HR=0.94, 95% CI=0.89-1.00, $p<0.05$). For iso-strain, an increase of 10 units on the scale resulted in a 10% increased hazard rate for neck injury (HR=1.10, 95% CI=1.02-1.19, $p<0.05$). A 10 unit increase on the job strain scale increased the hazard rate at 9% (HR=1.09, 95% CI=1.00-1.19, p=0.06).

### *4.2.2.3. Discussion*

#### *3.2.2.3.1.Summary of findings*

The purpose of this study was to examine the impact of the psychosocial work environment on the incidence of low back and neck injuries. All predictor variables were adjusted for demographic and anthropometric factors as well as for objective and subjective measures of physical workload. The main results can be summarized as follows: 1) Job strain, iso-strain, and lack of support from supervisors predicted the incidence of neck injuries among the drivers in fully adjusted analyses. A borderline significant association was found for decision latitude and for coworker support. 2) Iso-strain and lack of support (from both supervisors and coworkers) showed a significant dose-response relationship with neck injury risk. Every one point increase on either support scale predicted a 6% reduction in neck injuries. For iso-strain, an increase of 10 units on the scale resulted in a 10% increased risk for neck injuries. A 10 unit increase on the job strain scale resulted in a 9% increased neck injury risk, which was of borderline significance. 3) All associations hold, when injuries during the first six months of follow-up were excluded, making it unlikely that the association between psychosocial workplace factors and neck injury risk was due to undetected subclinical neck disorders at baseline. 4) For low back injuries, only the 155 subjects with very high job strain (upper tertile in demands and lower tertile in decision latitude) respective the 95 subjects with very high iso-strain (upper tertile in demands, lower tertile in decision latitude and lower tertile in total support) were at elevated risk. Job strain and iso-strain defined by median split of the subcomponents and the subcomponents themselves (with the exception of supervisor support as a continuous variable) had no substantial impact on the incidence of low back injury.

*3.2.2.3.2. Strengths and Limitations*

The prospective design is a major strength of this study and allows for a causal interpretation of the findings (Rothman et al, 1998a). The use of Cox regression models ensured that risk estimates took the length of the injury-free periods between baseline examination and first injury into account. Multivariate analyses also adjusted for potential confounders, including individual characteristics and exposure to physical demands, thereby overcoming a major limitation characteristic of most earlier studies (Ariens et al, 2001; Davis et al, 2000).

Another strength of the study is the use of validated scales that are based on a well-defined and widely tested theoretical psychosocial stress model (Karasek et al, 1990). While the use of several single, unrelated items has its merits in exploring potential psychosocial hazards at the workplace, our approach allowed us to test the hypotheses that neck and low back injuries are determined by specific, a priori defined hazardous constellations of the psychosocial work environment (i.e., the mismatch between high psychological demands and low control, respective the mismatch between high psychological demands, low control and low social support). The instrument also allowed to calculate the dose-response relationship between exposure to an adverse psychosocial work environment and the risk of injury.

While psychosocial work conditions were measured by self-report, the outcome was assessed objectively through physician's diagnoses made throughout the life of a workers' compensation claim coded according to the standard International Classification of Disease. By doing this, we avoided bias through common method variance, i.e. the tendency to find spurious associations in studies measuring both predictors and outcome by self report. In addition, the inclusion and exclusion of an injury was based on all medical diagnoses in the entire history of a claim thereby taking into account diagnostic findings not available at the time of the first injury report. For example, confirmation and further specification of initial diagnoses through radiographic imaging techniques typically occurs only during subsequent doctor visits and after some initial trial therapy.

The absence of individual observer-based measurements of whole-body vibration or biomechanical modeling of spinal loads may be considered a weakness in the assessment of potential confounders. In fact, this is a typical limitation of large-scale epidemiological studies, because of the high costs associated with individual standardized measurements. However, individual physical demands do not vary as much between transit operators as they do between or within other occupations, at least not for those drivers that operate the same vehicle, a variable that was accounted for in this study. Furthermore, at this company, drivers are often assigned another vehicle every day (although of the same vehicle type) so that a one-time observation would not substantially improve accuracy of the assessment of biomechanical risk factors. Therefore, we believe that hours and years of driving and information of vehicle type provide a good proxy measure for current and past (cumulative) physical workload, as has been shown in previous prospective and cross-sectional studies (Krause et al, 1998b; Krause et al, 1997a)

Like most prospective studies, this study is limited by measuring the predictor variables only once, at the beginning of the study. Repeated measures during the follow-up period would have allowed us to adjust for changes in the predictor variables and therefore to measure exposure more accurately. In addition, one has to note that the job content questionnaire was originally designed to assess psychosocial workplace conditions across different occupations with substantial variations of psychological demands and decision latitude (Karasek et al, 1990). When used in a single occupation, like transit operators, its ability to detect potential hazardous aspects of the psychosocial work environment might be limited by a reduced exposure variance in the population. Both the one-time assessment as well as the single occupation approach would have biased the results towards an underestimation of the true effect size (Rothman et al, 1998b).

*3.2.2.3.3. Theoretical implications of the findings*

Since it has been firstly introduced in early 1979 (Karasek, 1979), the theoretical assumptions and empirical findings of the demand-control-support model have created stimulating and controversial discussions, mostly in cardiovascular research (de Jonge et al, 1997; Karasek et al, 1990; Kasl, 1998; Kristensen, 1996; Kristensen, 1999; Schnall et al, 2000). Recent reviews have shown that while decision latitude is consistently predictive for incidence of cardiovascular disease, psychological demands are not (Rugulies et al, 2002; Schnall et al, 2000). Subsequently, the combined variables job strain respective iso-strain predicted cardiovascular disease in only six out of 12 cohort studies (Rugulies et al, 2002). For musculoskeletal outcomes findings are also not consistent and difficult to interpret, due to the lack of prospective studies and insufficient control for physical workload (Ariens et al, 2001; Bongers et al, 1993; Davis et al, 2000)

In a previous prospective study of 1,449 San Francisco transit operators (MUNI-1-cohort), we found a statistically significant association between high psychological demands and spinal injury (OR: 1.50, 95% CI=1.13-1.99), no association with decision latitude (OR: 1.02, 95% CI=0.78-1.34), and a moderate, although not statistical significant association in high job strain based on tertile split of the demand and control scales (OR: 1.28, 95% CI=0.85-1.92). (Krause, 1998). In our current study of a new cohort of transit operators (MUNI-2), the effect of job strain based on tertile splits was nearly identical for low back injuries (HR: 1.35), but stronger for neck injuries (HR: 1.61) and both results were statistically significant ($p<0.05$ and $p<0.01$ respectively). Moreover, for neck injuries, we were able to show a borderline significant dose-response-relationship between job strain as a continuous scale and increased injury risk. These results confirm our previous study and support the two-dimensional concept of the job strain model. In addition, we were able to show the predictive validity of the three-dimensional iso-strain model, which, until now, has only been used in very few prospective studies, mainly on cardiovascular outcomes and changes in self-rated health (Amick et al, 1998; Cheng et al, 2000; Johnson et al, 1996).

In a recent study, Kerr et al. (2001) have pointed out that the psychological demands scale might rather be a measure of physical than psychosocial demands. In their case-control study with automobile workers, the association between psychological demands and low back pain vanished, when the analysis was controlled for self-reported physical demands. When we adjusted for self-reported physical demands in our study, however, the hazard ratios of psychological demands as well as of the other psychosocial variables remained virtually unchanged. We think that these different patterns can be explained by differences in the study populations. In automobile workers, physical workload like heavy lifting, frequent bending, or prolonged standing, are physical characteristics of the job, so specific items from the psychological demands scale (e.g., "do you work hard?"), might be understood by the respondent as a measure of physical demands. Determinants of physical workload in transit operators, like prolonged sitting, constant body vibration, and body twisting while steering, are less obvious, so transit operators might be more likely to understand the psychological demands items in the way they are intended (e.g., as a measure of time pressure, work overload etc.)

While our results confirm the value of the demand-control-support model for the prediction of neck injuries, and, to a certain extent, also of low back injuries, it need to be acknowledged that effect sizes of 1.28 to 1.77 are moderate. This might be partly due to the above mentioned problem of lack of variation in this single occupation study. However, it is also possible that a broader assessment of potential hazardous aspects of the psychosocial work environment would have resulted in stronger effect sizes. The psychological demands scale of the job content questionnaire has been criticized for being to much focussed on quantitative demands while lacking other demands that are crucial in the human service sector (de Jonge et al, 1999; Söderfeldt, 1997). With regard to our study, it has to be noted that important aspects of the daily work of a transit operator, like constant high concentration in maneuvering a vehicle through the traffic in a major city (cognitive and sensorial demands), dealing with sometimes aggressive or even threatening passengers (emotional demands) or the necessity not to show their own feelings to the customers (demands of being courteous and of hiding negative emotions) are not covered by the demand-control-support model. In an earlier study, we had found that a scale consisting of transit-operator-specific questions were predictive for the incidence of spinal injuries (Krause et al, 1998b). In this study, however, this finding could not be replicated (data not shown). Despite of these inconsistencies in our findings, we think that it would be useful to extent the measures of demands in the demand-control model. The recently developed Copenhagen Psychosocial Questionnaire (COPSOQ), which is using five demand dimensions, could be a promising new instrument in this area (Kristensen, 2001).

Another approach, measuring job stressors through observation has been applied to subgroups of drivers who participated in this study (Greiner et al, 2000; Greiner et al, 1997b). Observed job stressors predicted musculoskeletal injuries in these subgroups, validating the self-reported measures of job stress (see section 3.3.7.2).

In addition to a more comprehensive measurement of psychological demands, a broadening of the conceptual definition of a health-hazardous psychosocial work environment could also help to improve our understanding of the causes for neck and low back injuries in transit operators. There is increasing evidence that the mismatch between high efforts and low rewards (in terms of wages/salary, respect and job security/promotion prospect) increases the risk of disease, independent from job strain (Bosma et al, 1998; Siegrist, 1996). Like the demand-control-support model, the effort-reward imbalance model, has mainly been tested in cardiovascular research. However, proxy measures for effort-reward imbalance predicted a 2-fold increase in self-reported musculoskeletal symptoms in a cross-sectional study with German transit operators (Peter et al, 1998). While this finding has to be interpreted with caution, because of the potential bias due to common method variance, it suggest that it would be valuable to extent the measurement of the psychosocial work environment beyond the demand-control-support model.

*3.2.2.3.4. Possible Psychophysiological Pathways*

The mechanism and pathways through which the psychosocial work environment might increase the likelihood of musculoskeletal injuries are not well understood. It has been argued, mainly in connection with cardiovascular research, that psychosocial stress results in a dysregulation of the autonomic nervous system and the hypothalamic-pituitary-adrenocortical axis (Belkic et al, 2000; Wolfe et al, 2000). While these physiological changes have been found to be associated with cardiovascular reactivity like changes in blood pressure, artery spasm, and decreased heart rate variability, little is known of the impact of stress hormones on soft tissues, muscles and joints. Theorell et al. (1993) have speculated that high cortisol levels might increase the vulnerability of muscles to mechanical load. Other physiological models suggest that a stressful psychosocial work environment increases muscle tension which in turn leads to biomechanical stress, reduced blood flow, accumulation of metabolites, local inflammatory changes, and pain. Psychosocial stress may also decrease pain thresholds (Theorell et al, 1993) or change the perception and attribution of symptoms (Cioffi, 1996; Sauter et al, 1996). A psychosomatic theory could postulate that psychosocial stress may lead to sub-optimal body posture and movement patterns causing additional biomechanical stress.

Clearly more research is needed on the psychophysiological pathways that are linking exposure to an adverse psychosocial work environment with the incidence of musculoskeletal injuries. In the light of our findings that the psychosocial work environment had a stronger impact on the incidence of neck injuries compared to low back injuries, it would be also important to focus on the body-part specific musculoskeletal consequences of work stress-induced physiological changes.

*3.2.2.3.5. Potential for Prevention*

With respect to prevention, our findings suggest that reducing exposure to specific aspects of the psychosocial work environment could substantially lower the risk of neck injury and to a certain extent also prevent low back injuries in transit operators. Recent reviews of intervention studies in public transportation companies in Europe have shown, that changes in the psychosocial work environment can have a substantial impact on health outcomes (Aust, 2001; Kompier et al, 2000). In Germany, several intervention projects have recently aimed to increase decision latitude of drivers by introducing self-governed groups and giving drivers more decision authority in picking the shifts during a work week. Also, so called health-circles have been implemented to discuss and solve problems in the companies, including strained relationships between drivers and supervisors. A recent review has shown a significant decrease in sickness absence, an increase in productivity, and cost savings for the companies as a result of these kinds of interventions (Aust, 2001).

*3.2.2.3.6. Job problem Frequency (Winkelby et al., 1998) and Incidence of Low Back Injury*

Currently the associations among low back injury and job stress as measured by the Job Problem Frequency scale remain to be studied.

*3.2.2.3.7. Observer-based Task Barriers and Incidence of Low Back Injury*

The association of low back injury incidence and job stress as measured by the observer-based job analysis of task barriers remains to be studied.

*3.2.2.3.8. Significance and Conclusions.*

This prospective study confirms the etiologic role of job strain for back and neck injuries identified in an earlier prospective cohort study of transit operators. In addition, this is the first time a prospective study has shown that iso-strain increases the risk of injury for the neck and the low back, while adjusting for subjective and objective measures of physical workload. The study also suggests that the impact of the psychosocial work environment is substantially stronger on neck injuries compared to low back injuries. Since reviews have shown that hazardous aspects of the psychosocial work environment in public transit companies are amenable to change, and that the psychosocial variables investigated here may also be linked to cardiovascular disease risk, the findings of this study indicate a substantial potential for disease prevention at the workplace.

### 4.2.3. Job Strain and Duration of Disability

*4.2.3.1. Status.*

The analyses have been completed and a manuscript based on this research is currently in progress.

*4.2.3.2. Results and Discussion*

The methods for this research were described in detail in section 3.3.7.2, but the results related specifically to job strain will be presented in this section.

*4.2.3.2.1. Data analysis.*

Differences between the study sample and transit operators who had not responded to the occupational questionnaire were calculated based on t-tests for independent samples and Pearson's $\chi^2$-tests.

Cox proportional hazard regression was conducted to estimate the effect of each predictor variable on duration of disability in the study sample. Cox regression are usually used to calculate the "hazard" for a adverse outcome like death or onset of disease at any point during the follow-up period, given the individual has survived until that time, relative to a baseline reference group. Since we are modeling not an adverse but a positive outcome (time to "return to work"), we use the term "return to work" (RTW) ratios instead of hazard ratio in reporting our results. In this context, return to work ratios greater than one reflect a shorter duration of disability relative to the reference group.

The analytic approach used in this study takes into account risk-factor phase-specificity by conducting analyses for different phases of disability. We analyzed outcomes for (1) the acute disability phase (up to 30 days lost of work days), the subacute phase (31 to 90 days), and the chronic phase (more than 90 days). The goal of this phase-specific analysis is not to determine risk factors for the transition from one phase to next phase, but rather to determine the phase-specific impact of risk factors given an individual has reached the respective disability phase. In other words, the goal was to determine which set of risk factors is associated with more disability days in each given phase.

The analytic model contained physical (driving years, weekly driving hours, vehicle type, ergonomic problems) and psychosocial (psychological demands, job control, supervisor support, co-worker support, job strain iso-strain) workplace factors as well as demographic variables (sex, age, height, and weight). Demographic variables were adjusted for physical and psychosocial workplace factors and for each other. Psychosocial workplace factors were adjusted for physical workplace factors and for demographic variables, but not for each other, since the psychosocial variables are not thought to be independent from each other. We analyzed the return to work ratios for all injuries combined as well as stratified for less severe and more severe injuries. Potential phase-specific differences of the return to work ratios were analyzed for each variable in all models.

Table 23. Job Strain and Return to Work Ratios After Low Back Injury for Psychosocial and Demographic Variables (n=292 Transit Operators)

| Variable | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | chi2 / p |
| **High Demands** | 138 | 0.99 (0.73-1.33) | 138 | 0.75 (0.48-1.17) | 105 | 1.20 (0.77-1.88) | 62 | 1.39 (0.60-3.24) | 2.91/0.23 |
| **Low Control** | 129 | 1.12 (0.83-1.51) | 129 | 1.19 (0.77-1.84) | 91 | 1.02 (0.65-1.61) | 56 | 1.24 (0.54-2.85) | 0.29/0.86 |
| **Low Supervisor Support** | 156 | 1.00 (0.74-1.35) | 156 | 1.03 (0.67-1.59) | 111 | 1.00 (0.64-1.57) | 69 | 0.90 (0.40-2.06) | 0.08/0.96 |
| **Low Coworker Support** | 171 | 0.82 (0.60-1.12) | 171 | 1.08 (0.69-1.69) | 123 | **0.56 (0.35-0.88)** | 86 | 1.16 (0.46-2.93) | **4.98/0.08** |
| **High Job Strain** | 71 | 1.21 (0.85-1.72) | 71 | 0.84 (0.48-1.47) | 55 | **1.51 (0.93-2.45)** | 30 | 2.14 (0.75-6.10) | 3.65/0.16 |
| **High Iso-Strain** | 53 | 1.34 (0.91-1.96) | 53 | 1.20 (0.68-2.11) | 38 | 1.41 (0.81-2.43) | 21 | 1.83 (0.52-6.47) | 0.42/0.81 |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

**bold=p<0.10.**

In the analysis of low back injury, high demands was associated with 33% slower RTW rate in the acute phase of disability (HR = 0.75), but faster rate for the subacute and chronic phases (See Table 23, above). Low control was associated with a faster return to work across all phases, although this effect was slight in the subacute phase (HR = 1.02). Job strain, a measure of high demands and low job control, was associated with a slower RTW rate in the acute phase, but a faster RTW in the subacute and chronic phases (HR = 1.51 and HR = 2.14, respectively). High iso-strain, a condition characterized by high demand and low support and low control, was associated with a slower RTW in the acute phase, but a faster RTW in both the subacute (HR = 1.37) and the chronic (HR = 6.27) phases.

When data were stratified by severity of low back injury, those with high demands demonstrated a 64% slower RTW in the acute phase (HR = 0.61), but a faster RTW in the subacute and chronic phases (see Table 24, below). Low control was associated with a slower RTW in both the subacute and chronic phases of disability.

High job strain and high iso-strain followed similar patterns, since bother were associated with a slower RTW in the acute phase, and a faster RTW in the subacute and chronic phases.

When data were stratified by severity of low back injury, those with high demands demonstrated a 64% slower RTW in the acute phase (HR = 0.61), but a faster RTW in the subacute and chronic phases (see Table 24, below). The test for phase specific differences indicated a significant difference in RTW among the three phases. Low control was associated with a slower RTW in both the subacute and chronic phases of disability.

High job strain and high iso-strain followed similar patterns, since bother were associated with a slower RTW in the acute phase, and a faster RTW in the subacute and chronic phases.

Table 24. Job Strain and Return to Work Ratios After Less Severe Low Back Injury for Psychosocial and Demographic Variables (n=198 Transit Operators)

| Variable | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | chi2 / p |
| **High Demands** | 88 | 0.93 (0.66-1.31) | 88 | **0.61 (0.37-1.01)** | 65 | 1.32 (0.81-2.15) | 27 | 2.40 (0.41-14.23) | **5.88/0.05** |
| **Low Control** | 95 | 0.86 (0.61-1.22) | 95 | 1.01 (0.63-1.63) | 62 | 0.75 (0.45-1.22) | 32 | 0.62 (0.09-4.28) | 0.91/0.63 |
| **Low Supervisor Support** | 106 | 0.89 (0.63-1.27) | 106 | 0.82 (0.51-1.32) | 71 | 1.02 (0.62-1.67) | 33 | 0.53 (0.08-3.52) | 0.71/0.70 |
| **Low Coworker Support** | 119 | **0.72 (0.51-1.03)** | 119 | 1.10 (0.68-1.80) | 77 | **0.43 (0.26-0.72)** | 46 | 1.38 (0.14-13.64) | **7.65/0.02** |
| **High Job Strain** | 41 | 0.92 (0.63-1.36) | 41 | 0.61 (0.33-1.15) | 39 | 1.23 (0.74-2.05) | 16 | 1.36 (0.23-8.12) | 3.03/0.22 |
| **High Iso-Strain** | 36 | 1.19 (0.78-1.83) | 36 | 0.94 (0.49-1.81) | 25 | 1.37 (0.77-2.43) | 9 | 6.27 (0.36-100.60) | 2.06/0.36 |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

**bold=p<0.10.**

Among those who had more severe injuries, high work demands was associated with faster RTW rate in the acute phase, but with an approximately 15% slower RTW in both the subacute and the chronic phases. Low control was associated with a faster RTW rate in all three phases. High job strain was also associated with a faster RTW across all three phases of disability. High iso-strain was associated with slower RTW only in the subacute phase.

Table 25. Job Strain and Return to Work Ratios After More Severe Low Back Injury for Psychosocial, and Demographic Variables (n=94 Transit Operators)

| **Variable** | **All phases** | | **Acute phase** | | **Subacute phase** | | **Chronic phase** | | **test for phase-specific difference** |
|---|---|---|---|---|---|---|---|---|---|
| | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **n** | **HR (95% CI)** | **chi2 / p** |
| **High Demands** | 50 | 1.33 (0.69-2.57) | 50 | **3.51 (0.94-13.18)** | 40 | 0.88 (0.26-2.91) | 35 | 0.86 (0.29-2.60) | 3.15/0.21 |
| **Low Control** | 34 | 1.43 (0.68-3.00) | 34 | 1.37 (0.43-4.36) | 29 | 1.32 (0.38-4.67) | 24 | 1.63 (0.48-5.57) | 0.07/0.97 |
| **Low Supervisor Support** | 50 | 0.98 (0.48-2.00) | 50 | 2.48 (0.66-9.30) | 40 | 0.46 (0.13-1.61) | 36 | 0.80 (0.26-2.47) | 3.53/0.17 |
| **Low Coworker Support** | 52 | 0.85 (0.41-1.73) | 52 | 0.72 (0.24-2.23) | 46 | 0.69 (0.20-2.30) | 40 | 1.27 (0.37-4.31) | 0.65/0.72 |
| **High Job Strain** | 20 | 2.15 (0.84-5.46) | 20 | 2.37 (0.67-8.46) | 16 | 1.37 (0.28-6.81) | 14 | 3.33 (0.62-17.90) | 0.66/0.72 |
| **High Iso-Strain** | 17 | 1.74 (0.66-4.63) | 17 | 2.79 (0.80-9.66) | 13 | 0.73 (0.09-5.96) | 12 | 1.60 (0.25-10.36) | 1.27/0.53 |

Physical workload variables (driving years, driving hours, vehicle type, ergonomic problems) are adjusted for psychological variables (psychological demands, control, supervisor support, coworker support), demographic variables (sex, age, height, weight), and for each other

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

Demographic variables (sex, age, height, weight) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems), psychosocial variables (psychological demands, control, supervisor support, coworker support), and for each other.

# odds ratio could not be calculated, because no participant in the group returned to work at this phase

**bold=p<0.10**

*4.2.3.2.1.1. Job problem Frequency (Winkelby).*

Status: To date, the effects of self-reported specific job problems on duration of disability phase remain to be analyzed.

*4.2.3.2.1.2. Observer-based Task Barriers.*

Status: The associations between duration of disability phase and job stressors measured by the observer-based assessment of task barriers has not been investigated.

## 4.3 The combined effects of job stress and psychosocial factors on low back disorders.

Status: To date plans to investigate the combined impact of physical workload and psychosocial risk factors on low back pain outcomes have not been carried out.

## 4.4. The independent effects of co-worker and supervisory support on low back disorders

### 4.4.1. Social Support and Prevalence of LBP (cross-sectional analyses)

Status: Analyses have been completed and a manuscript titled "Physical and Psychosocial Job Factors Associated with the Prevalence of Low Back Pain in Urban Transit Operators" is in preparation.

*4.4.1.1. Prevalence of LBP and Co-work and Supervisor Support: Results and Discussion.*

The analysis of LBP prevalence and job stress used the same cohort (MUNI-2) as described in Section 3.2.2. Briefly, this was a sample of 1,298 participants. Co-worker and supervisor support were measured with the Job Content Questionnaire (Karasek et al., 1998; see Section 3.3.7.2). Low back pain was assessed from a questionnaire item collected in the medical history. Specifically, participants were asked if they had pain, ache, or discomfort in their lower back during the last 12 months. Those who answered "yes" were regarded as cases.

In univariate analyses, the distribution of LPB was analyzed by Pearson's $\chi^2$ test for nominal scaled predictors (sex, vehicle type) and by Cuzick's z-test for trend for ordinal scaled predictors (age, years of professional driving, and weekly driving hours). Univariate associations between LBP prevalence and social support are presented in Table 26. Low back pain was significantly more prevalent among those who reported low supervisor support (36.3%; p=0.02 for trend). Low back pain was more prevalent among those who reported a medium amount of co-worker support. Those reporting either high (30.0%) or low (30.1%) co-worker support had nearly the same levels of LBP prevalence.

Table 26. Univariate Associations Between Psychosocial Factors and Low Back Pain Prevalence.

| **Variables** | **n** | **Low back pain cases n (%)** | **$\chi^2$ or z for trend** |
|---|---|---|---|
| **Supervisor support** | | | |
| High | 432 | 123 (28.5) | |
| Medium | 477 | 151 (31.7) | |
| Low | 389 | 141 (36.3) | 2.37 ** |
| **Coworker support** | | | |
| High | 547 | 164 (30.0) | |
| Medium | 312 | 119 (38.1) | |
| Low | 439 | 132 (30.1) | 0.26 |

*** p<0.05; **p<0.01**

To capture the independent effects of social support on prevalence of LBP, two sets of logistic regression models were applied. The first model was adjusted for the influence of demographic factors, and the second model was adjusted for both demographic and physical work factors. In both models, decreasing levels of supervisor support were associated with a gradual increase in the prevalence of low back pain (see Table 27). For co-worker support, a medium amount of support was associated with a higher prevalence of LBP in both models.

Table 27. Multivariate Association Between Psychosocial factors and Low Back Pain Prevalence

| | | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|---|
| | N | Odds Ratio | 95% Confidence Interval | | Odds Ratio | 95% Confidence Interval | |
| **Supervisor support** | | | | | | | |
| High | 432 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 477 | 1.17 | 0.88 | 1.56 | 1.14 | 0.85 | 1.52 |
| Low | 389 | 1.40 | 1.04 | 1.89 | 1.33 | 0.98 | 1.80 |
| **Coworker support** | | | | | | | |
| High | 547 | 1.00 | --- | --- | 1.00 | --- | --- |
| Medium | 312 | 1.43 | 1.06 | 1.92 | 1.42 | 1.05 | 1.91 |
| Low | 439 | 0.97 | 0.74 | 1.28 | 0.96 | 0.72 | 1.27 |

Model 1: All variables in the model adjusted for age and sex.

Model 2: Model 1 + adjustment for physical factors (total years of driving, total hours of driving, vehicle type).

**4.4.2. Social Support and Incidence of low back injury and neck injury (prospective analyses) .**

The associations between supervisor and co-worker support and the incidence of low back injury are described in a manuscript titled "Job Strain, iso-strain, and the incidence of low back and neck injuries: A 7.5.-year prospective study of San Francisco transit operators. Methods were presented in greater detail in Section 3.2.2. In this section the analyses pertaining to the independent effects of co-worker and supervisor social support will receive greater attention.

Incidence of low back injury. Table 28 shows the hazard ratios and 95% confidence intervals of low back injury associated with co-worker, supervisor, and total social support. There were no significant effects for supervisor support, coworker support or total support. When we analyzed the psychosocial factors as continuous variables, we did not find a statistical significant association with low back injury. The only variable that approached statistical significance was supervisor support. A one point increase in supervisor support was associated with a 4% decrease in low back injury risk (HR=0.97, 95% CI=0.93-1.01, p=0.10

Table 28. Psychosocial Workplace Factors as Predictors for Low Back Injuries in 1,294 Transit Operators

| Variable | n | Unadjusted Hazard Ratio | 95% Confidence Interval | Model 1 Adjusted Hazard Ratio | 95% Confidence Interval |
|---|---|---|---|---|---|
| **Supervisor Support** | | | | | |
| High | 431 | 1.00 | Reference | 1.00 | Reference |
| Medium | 478 | 1.00 | 0.78-1.30 | 0.95 | 0.74-1.23 |
| Low | 385 | 1.18 | 0.91-1.53 | 1.10 | 0.85-1.43 |
| **Coworker Support** | | | | | |
| High | 548 | 1.00 | Reference | 1.00 | Reference |
| Medium | 316 | 0.98 | 0.75-1.28 | 0.93 | 0.71-1.22 |
| Low | 430 | 1.02 | 0.80-1.30 | 0.99 | 0.78-1.26 |
| **Total Support** [a] | | | | | |
| High | 325 | 1.00 | Reference | 1.00 | Reference |
| Medium | 548 | 0.90 | 0.69-1.18 | 0.88 | 0.67-1.15 |
| Low | 421 | 1.14 | 0.86-1.49 | 1.06 | 0.81-1.40 |

Model 1: Adjusted for age, sex, ethnicity, height, weight

Model 2: Model 1 + adjusted for years of professional driving, driving hours per week, vehicle type (diesel bus, trolley bus, light rail, cable car) an

[a] Supervisor Support + Coworker Support
[b] Job Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude
[c] Job Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude
[d] Iso-Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude and tot
[e] Iso-Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude and total

<u>Incidence of neck injury</u>. Table 29 shows the crude and multivariate adjusted hazard ratios and 95% confidence intervals of neck injury. Low supervisor support (HR=1.40, p<0.05) and low total support (HR=1.40, p<0.05) predicted neck injuries in the fully adjusted model that controlled for sociodemographic (age, sex, ethnicity), anthropometric (height, weight), and physical workload variables (years of professional driving, driving hours per week, vehicle type, self-reported physical workload). Low coworker support (HR=1.25, p=0.08) was of borderline significance.

Analyses with psychosocial workplace factors as continuous predictors for neck injuries showed significant dose-response relationships for all of the support scales. There was a 6% reduction in neck injury rates for every one point increase on either the supervisor support scale (HR=0.94, 95% CI=0.90-0.98, p<0.01) or the coworker support scale (HR=0.94, 95% CI=0.89-1.00, p<0.05).

### 4.4.3. Social Support and Duration of disability.

*4.4.3.1. Results and Discussion*

Across all categories of low back injuries, low supervisor support was associated with almost no effect on RTW in either the acute of subacute phases, but was associated with a slower RTW rate in the chronic phase (See Table 30). Low co-worker support was associated with a faster RTW in the acute phase, a significantly lower RTW in the subacute phase, and a higher RTW in the chronic phase.

When analyses were stratified by severity of injury, low supervisor support was associated with a slower RTW in the acute phase, a somewhat neutral effect in the subacute phase, and a slower RTW in the chronic phase (see Table 31). Low co-worker support was associated with a faster RTW in the acute phase, a significantly lower RTW in the subacute phase, and a higher RTW in the chronic phase. The results for low co-worker support were mixed, with a faster RTW associated with low co-worker support in the acute phase, significantly lower RTW in the subacute phase, and a greater RTW in the chronic phase.

Among those with more severe low back injuries, low supervisor support was associated with a speedier RTW in the acute phase, a reduced RTW rate in the subacute and chronic phases of disability (see Table 32). Low co-worker support was associated with a slower RTW in the acute and subacute phases, and a faster RTW in the chronic phases.

Table 29. Psychosocial Workplace Factors as Predictors for Neck Injuries in 1,294 Transit Operators

| Variable | n | Unadjusted Hazard Ratio | 95% Confidence Interval | Model 1 Adjusted Hazard Ratio | 95% Confidence Interval | Model 3 Adjusted Hazard Ratio | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|
| **Supervisor Support** | | | | | | | |
| High | 431 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 478 | 1.21 | 0.93-1.57 | 1.21 | 0.93-1.57 | 1.25 | 0.96-1.64 |
| Low | 385 | 1.33 | 1.01-1.74 | 1.32 | 1.01-1.74 | 1.40 | 1.06-1.86 |
| **Coworker Support** | | | | | | | |
| High | 548 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 316 | 1.21 | 0.92-1.58 | 1.17 | 0.89-1.53 | 1.23 | 0.93-1.62 |
| Low | 430 | 1.21 | 0.94-1.55 | 1.18 | 0.91-1.50 | 1.25 | 0.97-1.62 |
| **Total Support** [a] | | | | | | | |
| High | 325 | 1.00 | Reference | 1.00 | Reference | 1.00 | Reference |
| Medium | 548 | 1.03 | 0.77-1.36 | 1.02 | 0.77-1.36 | 1.07 | 0.81-1.43 |
| Low | 421 | 1.34 | 1.01-1.78 | 1.30 | 0.98-1.74 | 1.40 | 1.05-1.88 |

Model 1: Adjusted for age, sex, ethnicity, height, weight

Model 2: Model 1 + adjusted for years of professional driving, driving hours per week, vehicle type (diesel bus, trolley bus, light rail, cable car) and self-reported physical demands

[a] Supervisor Support + Coworker Support
[b] Job Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude
[c] Job Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude
[d] Iso-Strain, median split = Scoring simultaneously above the median on psychological demands and below the median on decision latitude and total support
[e] Iso-Strain, tertile split = Scoring simultaneously in the upper tertile on psychological demands and the lower tertile on decision latitude and total support

Table 30. Social Support and Return to Work Ratios After a Low Back Injury for Psychosocial, and Demographic Variables (n=292 Transit Operators)

| Variable | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | chi2 / p |
| **Low Supervisor Support** | 156 | 1.00 (0.74-1.35) | 156 | 1.03 (0.67-1.59) | 111 | 1.00 (0.64-1.57) | 69 | 0.90 (0.40-2.06) | 0.08/0.96 |
| **Low Coworker Support** | 171 | 0.82 (0.60-1.12) | 171 | 1.08 (0.69-1.69) | 123 | **0.56 (0.35-0.88)** | 86 | 1.16 (0.46-2.93) | **4.98/0.08** |

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

***bold=p<0.10.***

Table 31. Social Support and Return to Work Ratios After a Less Severe Low Back Injury for Psychosocial, and Demographic Variables (n=198 Transit Operators)

| Variable | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | chi2 / p |
| **Low Supervisor Support** | 106 | 0.89 (0.63-1.27) | 106 | 0.82 (0.51-1.32) | 71 | 1.02 (0.62-1.67) | 33 | 0.53 (0.08-3.52) | 0.71/0.70 |
| **Low Coworker Support** | 119 | **0.72 (0.51-1.03)** | 119 | 1.10 (0.68-1.80) | 77 | **0.43 (0.26-0.72)** | 46 | 1.38 (0.14-13.64) | **7.65/0.02** |

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight)

**bold=p<0.10.**

Table 32. Social Support and Return to Work Ratios After More Severe Low Back Injury for Physical, Psychosocial, and Demographic Variables (n=94 Transit Operators)

| Variable | All phases | | Acute phase | | Subacute phase | | Chronic phase | | test for phase-specific difference |
|---|---|---|---|---|---|---|---|---|---|
| | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | n | HR (95% CI) | chi2 / p |
| **Low Supervisor Support** | 50 | 0.98 (0.48-2.00) | 50 | 2.48 (0.66-9.30) | 40 | 0.46 (0.13-1.61) | 36 | 0.80 (0.26-2.47) | 3.53/0.17 |
| **Low Coworker Support** | 52 | 0.85 (0.41-1.73) | 52 | 0.72 (0.24-2.23) | 46 | 0.69 (0.20-2.30) | 40 | 1.27 (0.37-4.31) | 0.65/0.72 |

Psychosocial variables (psychological demands, control, supervisor support, coworker support, job strain, iso-strain) are adjusted for physical variables (driving years, driving hours, vehicle type, ergonomic problems) and demographic variables (sex, age, height, weight) .

**bold=p<0.10.**

Social support is commonly regarded as a buffer of the negative health effects of stress. In the research on research, only main effects of social support were studied. In this series of studies, social support demonstrated several important associations with low back pain prevalence and incidence. There was a lower prevalence of low back pain among drivers with more supervisor social support (see Table 13 and 14). Low social support from supervisor demonstrated a significant main effect on the incidence of neck injury (see Table 22), such that a lower level of supervisor support was associated with a 32% increase in risk of neck injury (HR = 1.32; 95%CI = 1.01-1.74). In fact, supervisor support, and total support (co-worker and supervisor support combined) demonstrated a dose-response relationship with risk of neck injury (see Table 22).

While the exact process by which social support affects back or neck pain is unclear, several hypothetical pathways may explain the reduced risk of low back pain prevalence or incidence. Cohen (1988) proposes that one of the main effects of social support on health may be due to the exchange of information among those with more supportive networks. In the context of transit vehicle driving, drivers with more supportive co-workers or supervisors may receive more information about actions that can be taken to reduce back pain or back injury on the job. For example, a concerned supervisor may make check on drivers under his/her supervision to make sure that seat height, mirrors, and other factors are adjusted for optimal comfort and safety for each driver. Drivers with more support may exchange information about different routes or shifts that are less physically demanding. In San Francisco, several lines transverse steep hills, which could require hard braking, or other actions that require exerting pressure to control the vehicle. Some routes may typically contain a greater number of physical obstacles in the street which may force drivers to perform elaborate maneuvers with the vehicle leading to increased physical workload (e.g., extra trunk twisting while steering the vehicle around an obstacle). If drivers share information about these routes, the impact on low back pain could have a cumulative, protective, or risk-reducing impact. The process by which social support has main effects on low back disorders merits further attention.

## 4.5 Individual worker characteristics and low back disorders

Age. Age demonstrated an inverse relationship with most outcomes, consistent with previous studies of low back pain. Low back pain was more prevalent among drivers who were less than 30 years old (55.6%) and prevalence declined with age (see Table 4). Low back pain was reported by only a quarter (24.5% ) of drivers who were older than 60. Low back pain was significantly less prevalent with increasing age, even after adjusting for psychosocial factors (see Table 5). This pattern was also observed in the results for incidence (see Table 8), with younger drivers (< 40 yr.) having a 16% greater incidence of low back injuries compared to the reference group (40-50 yrs). Drivers over 50 years of age were at reduced risk for low back injury (HR = 0.72). These results were observed in multivariate models adjusted for sex, ethnicity, physical work factors and psychosocial factors.

Gender. Low back pain was more prevalent among women (46.1%) compared with men (29.5%) in this sample of drivers (See Table 4). In multivariate analyses adjusted for psychosocial factors, low back pain was 2.3 times more prevalent among women compared to men (see Table 5). Women were also at increased risk for low back injuries (HR = 1.52) compared with men (see Table 8), even in models adjusted for height and weight as well as physical and psychosocial job factors. This pattern was also observed when analyses were stratified by severity of injury, and women appeared to be at twice the risk of men for incidence of more severe injuries (HR = 2.02, 95% CI 1.15-3.55). Compared with men, women were also found to have a slower rate of return to work across all phases of disability.

These patterns demonstrating higher risk for low back pain injury and slower return to work among women are consistent with many health surveys that find higher rates of physical illness and more disability days among women compared with men (Verbrugge, 1989). Generally, this phenomenon appears in part to be due to greater exposure to different types of risk factors (risk exposure) or to differential responses by sex given the same level exposure to specific risk factors (risk responsiveness). For example, women generally engage in less strenuous leisure time physical activity, and they tend to be more overweight compared to men (see Verbrugge, 1989 for a review). In the case of MUNI-transit drivers, greater exposure to either of these risk factors among women may partially account for an increased risk for back pain among women. On the other hand, given the same type of mass transit vehicle, the levels and types of biomechanical activities required to operate a bus, for example, may produce more strain on the lower back for women versus men, thereby producing a differential risk of injury for women. These potential explanations for the observed difference in risk for women compared with men could be explored in further analyses of the MUNI cohort datasets.

Ethnicity. In prospective studies, Asian/Pacific Islanders demonstrated a significantly reduced risk for incidence of low back injury (HR = 0.55; CI = 0.38-0.79) compared with African-Americans (the reference group), Hispanics, Caucasians, and other ethnicities. This association was observed even in the analyses stratified by severity of injury (see Tables 8 and 9). It is unclear why this particular ethnic group demonstrates lower risk for low back injury, especially since height and weight were also adjusted in all the analyses.

Anthropometric variables. In the analyses of incidence of low back injury, being heavier was not associated with either an increased or decreased risk for injury, even in analyses stratified by severity of injury (see Tables 8 and 9). Greater height (> 183 cm) , however, was associated with increased risk for low back injury (HR = 1.26; 95% CI = 0.90 - 1.77) compared with the reference group (162-183) and with shorter drivers (HR = 0.84, 95% CI = 0.56-1.26). This pattern was also observed when incidence was stratified by severity of injury.

## 3.6 Psychological factors

### 3.6.1 Alexithymia.

Analyses are in preparation. Preliminary results on alexithymia and low back pain have been presented as a poster at the 9th Annual NRSA Trainees Research Conference, June 27-29, 2003, Nashville TN (Mehling & Krause, 2003).

### 3.6.2 Coping behavior

Analyses of coping behavior remain to be performed.

### 3.6.3 Job dissatisfaction.

Analyses of job dissatisfaction and low back pain are in preparation.

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# Appendix A

## Medical History Form

# CENTER FOR MUNICIPAL OCCUPATIONAL SAFETY AND HEALTH INTERIM EXAM

Name ______________________ EHS# ______________ Date ______________

Home address ______________________

______________ zipcode ______

Home phone ______________________

Work address ______________________

Work phone ______________________

Please list the Job Class/Title this exam is for:

______________________

Is this a new position? _____ yes _____ no

If no, date of first employment at **this** job title ____/____/____
Mo. Da. Yr.

## 1. MEDICAL HISTORY

Since your last exam, have you:

| | No | Yes | #times | |
|---|---|---|---|---|
| a. | [ ] | [ ]→ | ______ | Seen a doctor about your health |
| b. | [ ] | [ ]→ | ______ | Been hospitalized |
| | | | **total # days** | |
| c. | [ ] | [ ]→ | ______ | Missed work due to illness |
| d. | [ ] | [ ]→ | ______ | Been off work for work-related illness or injury |
| e. | [ ] | [ ]→ | ______ | Been off work for non-work-related illness or injury |
| f. | [ ] | [ ] | | Been placed on a new medication |
| g. | [ ] | [ ] | | Developed an allergy |
| h. | [ ] | [ ] | | Developed a new symptom |
| i. | [ ] | [ ] | | Had a family member who developed a serious illness or died ______ illness |
| j. | [ ] | [ ] | | Been told you have diabetes |
| k. | [ ] | [ ] | | Been told you have heart disease |
| l. | [ ] | [ ] | | Been told you have high blood pressure (hypertension) |
| m. | [ ] | [ ] | | Had any lapse of consciousness or a seizure or a blackout |
| n. | [ ] | [ ] | | Had any nervous system problems including stroke or loss of blood to brain |
| o. | [ ] | [ ] | | Had any problems with drugs or alcohol |
| p. | [ ] | [ ] | | Had a health problem these questions have missed? If yes, please list: |

______________________

q. What medicines are you taking now?

______________________

## 2. HIGH BLOOD PRESSURE

| | No | Yes | |
|---|---|---|---|
| a. | [ ] | [ ] | Have you ever been told by a doctor that you had high blood pressure (hypertension)? |

IF "NO" TO 2a, THEN SKIP TO QUESTION 3.

| | No | Yes | |
|---|---|---|---|
| b. | [ ] | [ ] | **If yes**, has a doctor prescribed medicine for your high blood pressure? |
| c. | [ ] | [ ] | Are you now taking any medicine prescribed by a doctor for your high blood pressure? |

d. If yes, how often do you take your blood pressure medication?

[ ] daily [ ] only when I feel I need it
[ ] not every day [ ] never

## 3. MUSCULOSKELETAL

Have you had pain, ache, or discomfort in the following areas o your body?

| | Body Region | Ever | | In last 1 months | |
|---|---|---|---|---|---|
| | | No | Yes | No | Y |
| a. | neck | [ ] | [ ] | [ ] | [ |
| b. | shoulder or upper arm | [ ] | [ ] | [ ] | [ |
| c. | elbow, forearm, wrist or hand | [ ] | [ ] | [ ] | [ |
| d. | upper back | [ ] | [ ] | [ ] | [ |
| e. | lower back | [ ] | [ ] | [ ] | [ |
| f. | leg, knee or foot | [ ] | [ ] | [ ] | [ |

↓

IF ALL "NO" CHECKED, THEN GO TO QUESTION 4.

## 4. GENERAL SYMPTOMS

How often do you have the following symptoms?

**(Circle the number)**

| | | Often | Some-times | Rarely | Neve |
|---|---|---|---|---|---|
| a. | getting tired in a very short time | 1 | 2 | 3 | 4 |
| b. | sweaty hands which feel damp and clammy | 1 | 2 | 3 | 4 |
| c. | feeling nervous, fidgety or tense | 1 | 2 | 3 | 4 |
| d. | poor appetite | 1 | 2 | 3 | 4 |
| e. | trouble getting to sleep | 1 | 2 | 3 | 4 |
| f. | trouble staying asleep | 1 | 2 | 3 | 4 |
| g. | fatigue in neck, shoulder or arm | 1 | 2 | 3 | 4 |
| h. | fatigue in back | 1 | 2 | 3 | 4 |
| i. | fatigue in leg or foot | 1 | 2 | 3 | 4 |

Checked by ______________ (initia

## 5. OCCUPATIONAL HISTORY

Since your last exam have you:

No Yes

a. [ ] [ ] Been exposed to any loud noises
b. [ ] [ ] Been exposed to any chemicals (paints, solvents, acids, caustics, etc.)
c. [ ] [ ] Been exposed to any dust such as asbestos or silica
d. [ ] [ ] Been exposed to any welding or soldering fumes
e. [ ] [ ] Been exposed to any radiation
f. [ ] [ ] Started to work with VDT's (video display terminals, computer terminals)
g. [ ] [ ] Needed to use a respirator for any reason
h. [ ] [ ] Worked in confined spaces
i. [ ] [ ] Been exposed to an infectious disease at work
j. [ ] [ ] What do you think is a health hazard at work?

______________________________

______________________________

k. How long have you been a professional driver?________yrs

l. What type of vehicle do you usually drive?

[ ] Motor coach    [ ] Light Rail
[ ] Trolley coach    [ ] Articulated
[ ] Street car    [ ] Cable car
[ ] Other→____________

Think of the type of vehicle you usually drive: How much of a problem is each of the following?

| | | no prob. | small prob. | some prob. | a big prob. |
|---|---|---|---|---|---|
| m. | adjusting the seat | 1 | 2 | 3 | 4 |
| n. | back support | 1 | 2 | 3 | 4 |
| o. | vibration, rocking, or bouncing of seat | 1 | 2 | 3 | 4 |
| p. | steering | 1 | 2 | 3 | 4 |
| q. | reaching across the wheel | 1 | 2 | 3 | 4 |
| r. | position of the cash box and transfer cutter | 1 | 2 | 3 | 4 |
| s. | adjusting mirrors | 1 | 2 | 3 | 4 |
| t. | heat, cold or draft | 1 | 2 | 3 | 4 |

## 6. LIFESTYLE

No Yes

a. [ ] [ ] Have you **ever** smoked cigarettes/cigars or a pip regularly?

**IF "NO" TO 6a, THEN GO TO QUESTION 6n.**

b. At what age did you start smoking? _________
c. Do you smoke at the present time?

**[ ] YES ⇓**

d. **If Yes,** how many cigarettes do you smoke per day?
[ ] less than 1/2 pack
[ ] 1/2 pack
[ ] 1 pack
[ ] 1 1/2 packs
[ ] 2 packs or more

e. # cigars a day _________
f. # pipes a day _________
g. How many total years have you been smoking? _____

**[ ] NO ⇓**

h. **If No,** how many cigarett did you **USED** to smoke per da
[ ] less than 1/2 pack
[ ] 1/2 pack
[ ] 1 pack
[ ] 1 1/2 packs
[ ] 2 packs or more

i. # cigars a day _________
j. # pipes a day _________
k. How many total years did you smoke? _____
l. How long ago did you stop smoking? # yrs ___
m. If under 1 yr., # mos _

In an average week, how much of the following do you drink?

n. Wine: ______# of glasses a week
o. Beer: ______# cans or bottles a week
p. Liquor: ______# drinks a week (gin, rum, vodka, whiske

On the average, about how many hours a week do you spend in least moderately hard physical activity such as walking fast, usi a lawnmower, bicycling, dancing or playing sports?

q. # hour per week ______________

## 7. DEMOGRAPHICS

a. What is your race or ethnic group?
[ ] American Indian    [ ] Filipino
[ ] Asian or Pacific Islander    [ ] Hispanic
[ ] African American    [ ] Caucasian
[ ] Other→describe __________________

b. What is the highest grade of school that you have completec
[ ] 0-6th grade    [ ] 7-9th grade
[ ] 10-11th grade    [ ] High school graduate
[ ] Technical or business school
[ ] Some college (including junior college)
[ ] College graduate (4 years or more)

c. What is your current marital status?
[ ] Married living with spouse    [ ] Separated
[ ] Living with partner, not married    [ ] Divorced
[ ] Single, no partner    [ ] Widowed

**I CERTIFY THAT ALL STATEMENTS MADE IN THIS MEDICAL HISTORY FORM ARE TRUE AND COMPLETE.**
**I UNDERSTAND THAT ANY MISSTATEMENTS OF MATERIAL FACTS MAY SUBJECT ME TO DISQUALIFICATION.**

Applicants signature ______________________ Date ______________________

CA drivers license # ______________________ SSN ______________________

EXAMINER COMMENTS: ____________________________________________

Checked by____________________(initials)    **(VERSION 11/7/94)**

# Appendix B

# Epidemiological Questionnaire

# 1993-1994 Muni Survey

## Questionnaire

### Occupation, Coping, and Demographics


Muni Health and Safety Project

with

School of Public Health
University of California, Berkeley

## A. DRIVING HISTORY

1. **When were you first employed by Muni as a driver?** ________/________ month year

2. **Since you were first employed as a driver, have there been any times when you were not working as a Muni driver?**

   a. ______yes ______no **(if no, skip to question 3).**

   b. **What is the total amount of time you were not employed as a Muni driver?**

   ______# years (if less than 1 year, _______# months)

3. **What is your current Division?**
   **(Check only one)**

   1 Flynn (Army)
   2 Potrero
   3 Green (Geneva)
   4 Kirkland
   5 Wood
   6 Presidio
   7 Cable Car (Motorman)
   8 Cable Car (Conductor)
   9 Geary

4. **In the past 12 months, have you regularly worked another job in addition to your Muni job?**

   1 Yes hours/week_____
   2 No

5. **Did your additional job involve:**
   (CIRCLE ALL THAT APPLY)

   1 Taxi or transportation service
   2 Truck driving or delivery
   3 Frequent or heavy lifting

6. **During the last 12 months, have you worked as a Muni driver mainly full or part time?**

   1 Full time
   2 Part time

7. **During the last 12 months, did you mostly drive a split or straight through run?**

   1 Straight through run
   2 Split run
   3 Both split and regular the same amount
   9 Did not work as a driver

8. **During the last 12 months, have you mostly worked:**

   1 A regular scheduled run
   2 A block
   3 The floating extra board
   4 The extra board
   9 Did not work as a driver

9. **During which shift have you mostly worked during the last 12 months?**

   1 AM
   2 Twilight
   3 Night
   4 Owl
   5 No regular shift
   6 A combination of the above
   9 Did not work as a driver

## B. DAILY SCHEDULE

10. **Think of the average work week in the last 12 months. For this one week period indicate: Total hours driving____________**

11. **Thinking of the past 12 months, answer the questions below about schedule problems. (Answer Parts 1 and 2 for each problem. If the answer to Part 1 is "Almost Never" your answer in Part 2 should be "Not at all")**

| | HOW OFTEN DOES THIS HAPPEN TO YOU? | | | | | HOW MUCH DOES THIS BOTHER YOU? | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Almost Always | More than half the time | Half the time | Less than half the time | Almost Never | Ex-tremely | Very | Slightly | Not at all |
| a. Driving time more than 10 hours a day | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| b. The spread on your shift is more than 10 hours a day | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| c. You work either partly or completely through your recovery time | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| d. Recovery time you are actually able to take is <u>less than 5 minutes</u> | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| e. Your run requires that you <u>drive straight through</u> for more than 6 hours | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |

## B. DAILY SCHEDULE--CONTINUED

| | HOW OFTEN DOES THIS HAPPEN TO YOU? | | | | | HOW MUCH DOES THIS BOTHER YOU? | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Almost Always | More than 1/2 the time | Half the time | Less than 1/2 the time | Almost Never | Ex-tremely | Very | Slightly | Not at all |
| f. Your run requires that you drive straight through for more than 8 hours | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| g. You do not know your personal driving schedule 24 hours in advance | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| h. You have less than 10 hours between ending a shift and beginning a new one | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |

12. **Think of the average work day. How much time do you spend in the following time period during each working day?**

| | Time period | Hours | Minutes |
|---|---|---|---|
| a. | Arrive at work before shift | ____ | ____ |
| b. | Recovery time (total per day) | ____ | ____ |
| c. | Split time | ____ | ____ |
| d. | After work at the barn or with coworkers | ____ | ____ |
| e. | Commuting (round-trip) | ____ | ____ |

13. **How many "miss outs" did you have in the last 12 months? (if none, mark 0)** __________ NUMBER OF DAYS

If 0, then skip to Q15.

14. **What were the reasons for these miss outs? (check all that apply)**

| | | YES | NO |
|---|---|---|---|
| a. | I felt sick | 1 | 2 |
| b. | Child care | 1 | 2 |
| c. | To do errands and home repairs | 1 | 2 |
| d. | Because of a hangover | 1 | 2 |
| e. | Because of exhaustion | 1 | 2 |
| f. | To do doctor visits | 1 | 2 |
| g. | Other | 1 | 2 |

____________________
SPECIFY

| C. | JOB PROBLEMS |
|---|---|

15. **Thinking <u>of all lines</u> you have driven, answer the questions below about job problems. (Answer Parts 1 and 2 for each problem. If the answer to Part 1 is "Almost Never", your answer in Part 2 should be "Not at all")**

| | | HOW OFTEN DOES THIS HAPPEN TO YOU? | | | | | HOW MUCH DOES THIS BOTHER YOU? | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Daily | Weekly | Monthly | Yearly or less often | Almost Never | Ex-tremely | Very | Slightly | Not at all |
| a. | Equipment problems | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| b. | Problems with fares and transfers | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| c. | Too many passengers | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| d. | Problems caused by passengers | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| e. | Problems caused by coworkers | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| f. | Problems with supervisor | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| g. | Long or odd hours | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| h. | Written up for rule violation | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| i. | Unfairly written up for rule violation | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| j. | Minor accident with no injuries. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |

## C. JOB PROBLEMS--CONTINUED

| | | HOW OFTEN DOES THIS HAPPEN TO YOU? | | | | | HOW MUCH DOES THIS BOTHI YOU? | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Daily | Weekly | Monthly | Yearly or less often | Almost Never | Ex-tremely | Very | Slightly | Not at al |
| k. | Serious accident with injuries | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| l. | Accident that is your fault. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| m. | Serious traffic or road problems | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| n. | Problems with other vehicles | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| o. | Crimes against you while on duty | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| p. | Crimes against your passengers. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| q. | Problems communicating with central control | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| r. | Poor access to restrooms | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| s. | Not maintaining run schedule. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |

## D. SCHEDULE PROBLEMS

**16. When you can't keep the schedule, what are the reasons?**

| | Almost Always | Often | Sometimes | Almost Never |
|---|---|---|---|---|
| a. Heavy traffic | 1 | 2 | 3 | 4 |
| b. Irregular traffic situation (e.g., accident on the road, construction, traffic jams) | 1 | 2 | 3 | 4 |
| c. Too many passengers | 1 | 2 | 3 | 4 |
| d. Too many inquiries from passengers (e.g., about the fare and transfers) | 1 | 2 | 3 | 4 |
| e. Passengers need specific attention (e.g., people with wheel chairs, old people) | 1 | 2 | 3 | 4 |
| f. Difficult passengers (e.g., fare cheaters or evaders, intoxicated people) | 1 | 2 | 3 | 4 |
| g. Equipment malfunction | 1 | 2 | 3 | 4 |
| h. Schedule unrealistic | 1 | 2 | 3 | 4 |
| i. Missing buses | 1 | 2 | 3 | 4 |
| j. Other | 1 | 2 | 3 | 4 |

_______________________
Specify

## E. YOUR JOB SITUATION

17. **For each statement below, circle the number that comes closest to describing your job situation.**

| | | Strongly Agree | Agree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| a. | My job requires that I learn new things | 1 | 2 | 3 | 4 |
| b. | My job involves doing a lot of things over and over again | 1 | 2 | 3 | 4 |
| c. | My job requires me to be creative | 1 | 2 | 3 | 4 |
| d. | My job allows me to make a lot of decisions on my own | 1 | 2 | 3 | 4 |
| e. | My job requires a high level of skill | 1 | 2 | 3 | 4 |
| f. | On my job, I have very little freedom to decide how I do my work | 1 | 2 | 3 | 4 |
| g. | I get to do a variety of different things on my job | 1 | 2 | 3 | 4 |
| h. | I have a lot of say about what happens on my job | 1 | 2 | 3 | 4 |
| i. | I have an opportunity to develop my own special abilities | 1 | 2 | 3 | 4 |
| j. | My job requires working very fast | 1 | 2 | 3 | 4 |
| k. | My job requires working very hard | 1 | 2 | 3 | 4 |
| l. | My job requires lots of physical effort | 1 | 2 | 3 | 4 |
| m. | I am not asked to do an excessive amount of work | 1 | 2 | 3 | 4 |

## E. YOUR JOB SITUATION--CONTINUED

| | | Strongly Agree | Agree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| n. | I have enough time to get the job done | 1 | 2 | 3 | 4 |
| o. | I am free from conflicting demands that others make on me | 1 | 2 | 3 | 4 |
| p. | Superintendent/dispatchers are concerned about the welfare of those under them | 1 | 2 | 3 | 4 |
| q. | Superintendents/dispatchers pay attention to what I am saying | 1 | 2 | 3 | 4 |
| r. | Superintendents/dispatchers are helpful getting the job done | 1 | 2 | 3 | 4 |
| s. | Superintendents/dispatchers are successful in getting people to work together | 1 | 2 | 3 | 4 |
| t. | People I work with are competent in doing their jobs | 1 | 2 | 3 | 4 |
| u. | People I work with take a personal interest in me | 1 | 2 | 3 | 4 |
| v. | People I work with are friendly | 1 | 2 | 3 | 4 |
| w. | People I work with are helpful getting the job done | 1 | 2 | 3 | 4 |
| x. | My job security is good | 1 | 2 | 3 | 4 |

## F. COPING

18. When you think of all the job stress situations you have been in during the past 12 months, what were your experiences when you tried to do something about them? Indicate for each statement how true it is for you:

| | Almost Always True | Often True | Sometimes True | Almost Never True |
|---|---|---|---|---|
| a. I tried to change my work situation but gave up | 1 | 2 | 3 | 4 |
| b. I was encouraged to say what was bothering me at work | 1 | 2 | 3 | 4 |
| c. I learned to live with the stress because there was nothing I could do about it | 1 | 2 | 3 | 4 |
| d. I was usually able to solve the problem | 1 | 2 | 3 | 4 |
| e. I had some bad experiences when I made suggestions on how to improve my work | 1 | 2 | 3 | 4 |
| f. When I complained about the stress, things improved | 1 | 2 | 3 | 4 |

| F. | COPING--CONTINUED |
|---|---|

**19.** **When you are under work stress, what do you usually do?**
**I usually do this.....**

| | | A lot | A medium amount | A little bit | Not at all |
|---|---|---|---|---|---|
| a. | Pretend that this hasn't really happened | 1 | 2 | 3 | 4 |
| b. | Just give up trying to reach my goal | 1 | 2 | 3 | 4 |
| c. | Try to come up with a strategy about what to do | 1 | 2 | 3 | 4 |
| d. | Smoke cigarettes | 1 | 2 | 3 | 4 |
| e. | Think hard about what steps to take | 1 | 2 | 3 | 4 |
| f. | Drink alcohol or take drugs in order to think about it less | 1 | 2 | 3 | 4 |
| g. | Act as though it hasn't even happened | 1 | 2 | 3 | 4 |
| h. | Engage in physical activity or sports | 1 | 2 | 3 | 4 |
| i. | Give up the attempt to get what I want | 1 | 2 | 3 | 4 |
| j. | Admit to myself that I can't deal with it and quit trying | 1 | 2 | 3 | 4 |
| k. | Reduce the amount of effort I'm putting into solving the problem | 1 | 2 | 3 | 4 |
| l. | Think about how I might best handle the problem | 1 | 2 | 3 | 4 |
| m. | Say to myself "this isn't real" | 1 | 2 | 3 | 4 |
| n. | Make a plan of action | 1 | 2 | 3 | 4 |
| o. | Eat | 1 | 2 | 3 | 4 |
| p. | Talk to a friend | 1 | 2 | 3 | 4 |
| q. | I refuse to believe that it has happened | 1 | 2 | 3 | 4 |

## G. EMOTIONS

20. Using the scale provided as a guide, indicate how much you agree or disagree with each of the following statements by circling the corresponding number. Give only one answer for each statement.

| | Strongly Agree | Moderate Agree | Moderate Disagree | Strongly Disagree |
|---|---|---|---|---|
| a. I am often confused about what emotion I am feeling | 1 | 2 | 3 | 4 |
| b. It is difficult for me to find the right words for my feelings | 1 | 2 | 3 | 4 |
| c. I have physical sensations that even doctors don't understand | 1 | 2 | 3 | 4 |
| d. I am able to describe my feelings easily | 1 | 2 | 3 | 4 |
| e. I prefer to analyze problems rather than just describe them | 1 | 2 | 3 | 4 |
| f. When I am upset, I don't know if I am sad, frightened or angry | 1 | 2 | 3 | 4 |
| g. I am often puzzled by sensations in my body | 1 | 2 | 3 | 4 |
| h. I prefer to just let things happen rather than to understand why they turned out that way | 1 | 2 | 3 | 4 |
| i. I have feelings that I can't quite identify | 1 | 2 | 3 | 4 |
| j. Being in touch with emotions is essential | 1 | 2 | 3 | 4 |

## G. EMOTIONS--CONTINUED

| | | Strongly Agree | Moderate Agree | Moderate Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| k. | I find it hard to describe how I feel about people | 1 | 2 | 3 | 4 |
| l. | People tell me to describe my feelings more | 1 | 2 | 3 | 4 |
| m. | I don't know what's going on inside me | 1 | 2 | 3 | 4 |
| n. | I often don't know why I am angry | 1 | 2 | 3 | 4 |
| o. | I prefer talking to people about their daily activities rather than their feelings | 1 | 2 | 3 | 4 |
| p. | I prefer to watch "light" entertainment shows rather than psychological dramas | 1 | 2 | 3 | 4 |
| q. | It is difficult for me to reveal my innermost feelings, even to close friends | 1 | 2 | 3 | 4 |
| r. | I can feel close to someone, even in moments of silence | 1 | 2 | 3 | 4 |
| s. | I find examination of feelings useful in solving personal problems | 1 | 2 | 3 | 4 |
| t. | Looking for hidden meanings in movies or plays distracts from their enjoyment | 1 | 2 | 3 | 4 |

## H. LIFE EVENTS

21. Below are some things that happen to many people during their lives. For each question, mɛ when the event happened. (If the event happened more than one time, mark the most recent

| | | Within the past year | 1-2 Years ago | More than 2 years ago | Never |
|---|---|---|---|---|---|
| a. | Trouble with boss | 1 | 2 | 3 | 4 |
| b. | Change in health of family member | 1 | 2 | 3 | 4 |
| c. | Death of spouse or child | 1 | 2 | 3 | 4 |
| d. | Death of a close family member | 1 | 2 | 3 | 4 |
| e. | Personal illness or injury | 1 | 2 | 3 | 4 |
| f. | Changes in financial state | 1 | 2 | 3 | 4 |
| g. | Divorce, marital separation or separation from significant other | 1 | 2 | 3 | 4 |
| h. | Minor violation of the law | 1 | 2 | 3 | 4 |
| i. | Accident at work | 1 | 2 | 3 | 4 |
| j. | Assault at work | 1 | 2 | 3 | 4 |

## I. BURNOUT

22. **How often do you feel the following:**

| | Every day | A few times a week | Once a week | A few times a month | Once a month or less | A few times a year or less | Never |
|---|---|---|---|---|---|---|---|
| a. I feel emotionally drained from my work | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| b. I feel used up at the end of the work day | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| c. I feel fatigued when I get up in the morning and have to face another day on the job | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| d. Working with people all day is really a strain for me | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| e. I feel burned out from my work | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| f. I feel frustrated by my job | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| g. I feel I'm working too hard on my job | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| h. Working with people directly puts too much stress on me | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| i. I feel like I'm at the end of my rope | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## J. DISCRIMINATION

23. **We are going to ask you a number of questions related to discrimination at work and outside work. Please select one response.**

    a. **If you feel you have been treated unfairly, do you usually:**

        1 Accept it as a fact of life
        2 Try to do something about it

    b. **If you have been treated unfairly, do you usually:**

        1 Talk to other people about it
        2 Keep it to yourself

**Have you ever experienced discrimination, been prevented from doing something or been hassled or made to feel inferior in any of the following situations?**

| | Q24. Because you are a man or woman. | | Q25. Because of your race or color. | |
|---|---|---|---|---|
| | YES | NO | YES | NO |
| a. At school | 1 | 2 | 1 | 2 |
| b. Getting a job | 1 | 2 | 1 | 2 |
| c. At work | 1 | 2 | 1 | 2 |
| d. At home | 1 | 2 | 1 | 2 |
| e. Getting medical care | 1 | 2 | 1 | 2 |
| f. From the police or in the courts | 1 | 2 | 1 | 2 |
| g. In your job as a bus driver | 1 | 2 | 1 | 2 |

## J. DISCRIMINATION--CONTINUED

**26. Considering your job at Muni, have you ever experienced discrimination because of gender, race or color in the following:**

| | | YES | NO |
|---|---|---|---|
| a. | In dealing with passengers | 1 | 2 |
| b. | In dealing with the public other than passengers | 1 | 2 |
| c. | Promotion | 1 | 2 |
| d. | Disciplinary actions | 1 | 2 |
| e. | Other<br>If other, specify: | 1 | 2 |

______________________________

______________________________

______________________________

## K. DEMOGRAPHICS

**27. What is your date of birth?** _____/_____/_____
Mo. Day Year

**28. What is your race or ethnic group?**

1 American Indian or Alaskan Native
2 Asian or Pacific Islander
3 African American
4 Filipino
5 Hispanic
6 Caucasian
9 Other ________________________
Describe

**29. What is the <u>highest</u> grade of school that you have completed?**

1 0-6 Grade
2 7-8 Grade
3 10-11 Grade
4 High School Graduate
5 Technical or Business School
6 Some College (including Junior College)
7 College Graduate (4 years or more)

**30. About what is your total family income before taxes? (Include wages, child support or alimon received, income from rental property, welfare benefits and any other income)**

1 Under $40,000
2 $40,000-49,999
3 $50,000-59,999
4 $60,000-69,999
5 $70,000-79,999
6 $80,000-89,999
7 $90,000-99,999
8 $100,000 or over

## K. DEMOGRAPHICS--CONTINUED

31. What is your present marital status?

    1 Married, living with spouse
    2 Living with partner, not marrried
    3 Separated
    4 Divorced
    5 Widowed
    6 Single, never married

32. What is your sex?

    1 Female
    2 Male

**THANK YOU. THIS CONCLUDES THE QUESTIONNAIRE. WE APPRECIATE YOUR COOPERATION. THE INFORMATION YOU HAVE GIVEN US WILL BE VERY HELPFUL**

(version. 10/4/93)

# Appendix C

# Epidemiological Interview

# 1993-1994 Muni Survey

## Interview

### Bus Line Variables, Health Behavior, and Patterns of Alcohol Consumption


Muni Health and Safety Project

with

School of Public Health
University of California, Berkeley

## A. LINE INFORMATION

First I want to ask you some specific questions about the lines you have driven most.

1. Consider the bus lines you drove during the last 12 months. (BUS LINE REFERENCE CARD)

| | Which line did you drive most often? | How many days per week on that line? | Which line did you drive second most often? | How many days per week on that line? |
|---|---|---|---|---|
| a. In this current sign-up period | A.________ | B.________ | C.________ | D.________ |
| b. In the sign-up period before this one | A.________ | B.________ | C.________ | D.________ |
| c. In the period before that (more than half a year ago) | A.________ | B.________ | C.________ | D.________ |
| d. In the period before that (starting about one year ago) | A.________ | B.________ | C.________ | D.________ |

2. Over the entire past year, which line have you driven most? ____________________

## A. LINE INFORMATION--CONTINUED

3. Compared to other Muni lines you know about, how much of a problem are the following events on the line you've driven most in the past 12 months? (HAND CARD 1)

| | A big problem | Somewhat of a problem | Very little problem | No problem at all |
|---|---|---|---|---|
| a. Accidents | 1 | 2 | 3 | 4 |
| b. Crime | 1 | 2 | 3 | 4 |
| c. Traffic or road problems | 1 | 2 | 3 | 4 |
| d. Too many passengers | 1 | 2 | 3 | 4 |
| e. Problems caused by passengers | 1 | 2 | 3 | 4 |
| f. Maintaining the run schedule | 1 | 2 | 3 | 4 |

## B. GENERAL HEALTH HABITS AND SOCIAL LIFE

4. **I want to ask you about your general health habits and social life:**

**Which number best describes how the following has changed for you <u>since you began driving for Muni</u>? (HAND CARD 2)**

| | A lot more | A little more | No change | A little less | A lot less |
|---|---|---|---|---|---|
| a. Amount of smoking | 1 | 2 | 3 | 4 | 5 |
| b. Amount of alcohol drinking | 1 | 2 | 3 | 4 | 5 |
| c. Your weight | 1 | 2 | 3 | 4 | 5 |
| d. Amount of physical activity | 1 | 2 | 3 | 4 | 5 |
| e. Amount of sleep each 24 hours | 1 | 2 | 3 | 4 | 5 |
| f. Frequency or seriousness of health problems | 1 | 2 | 3 | 4 | 5 |
| g. Problems with family and friends | 1 | 2 | 3 | 4 | 5 |

5. **Which number best describes how much time it actually takes to unwind and relax after work. (HAND CARD 3)**

| | |
|---|---|
| Less than an hour | 1 |
| About an hour | 2 |
| Several hours | 3 |
| I can rarely unwind or relax | 4 |

6. **How many times a week do you skip your regular meals (breakfast, lunch, dinner) during your work shift?**

Times a week ________________

7. **How many times a week do you eat on the bus or "on the run" (breakfast and lunch on the same day means two times)?**

Times a week ________________

8. **On the average, about how many hours a week do you spend in at least moderately hai physical activity such as walking fast, using a lawnmower, bicycling, dancing or playing sport:**

# hours a week ________________

9. **In the past 12 months, have you participated in any workplace recreational programs or sport: activities?**

Yes 1

No 2

If so, what activities ? ______________________________

______________________________

______________________________

## C. MEDICATIONS

**10. Now I want to ask about any medication you took either occasionally or regularly during the past 12 months. Please include prescribed drugs as well as over the counter drugs. Which number best describes how often you take the following? (HAND CARD 4) :**

| | (SHOW LIST OF MEDICATIONS ON CARD 5 FOR EACH CATEGORY--HAND CARD 4) | Daily | Two to Five Days per Week | One or Two Days per Week | One to Three Times a Month | A Few Times a Year (Less than Once a Month) | Never |
|---|---|---|---|---|---|---|---|
| a. | Pain killers, over the counter | 1 | 2 | 3 | 4 | 5 | 6 |
| b. | Pain killers, prescribed | 1 | 2 | 3 | 4 | 5 | 6 |
| c. | Anti-inflammatory prescription pain killers | 1 | 2 | 3 | 4 | 5 | 6 |
| d. | Muscle relaxants | 1 | 2 | 3 | 4 | 5 | 6 |
| e. | Sleeping aids, over the counter | 1 | 2 | 3 | 4 | 5 | 6 |
| f. | Sleeping aids, prescribed | 1 | 2 | 3 | 4 | 5 | 6 |
| g. | Pills to help you stay awake and alert | 1 | 2 | 3 | 4 | 5 | 6 |
| h. | Pills for anxiety and nervousness | 1 | 2 | 3 | 4 | 5 | 6 |
| i. | Pills for depression | 1 | 2 | 3 | 4 | 5 | 6 |
| j. | Diet pills | 1 | 2 | 3 | 4 | 5 | 6 |

10.1 INTERVIEWER ASSESSMENT | yes | no |

## D. ALCOHOL CONSUMPTION: SCREENING QUESTIONS

11. **Does your philosophy of living or religious beliefs restrict your use of alcoholic beverages?**

Yes 1
No 2

12. **During the last 12 months, I had at least one beverage containing alcohol, including beer, wine or liquor:**

Yes 1 ====> **Go to Q. 13**

No 2 ====> **Have you ever had beverages containing alcohol?**

↓↓

**12a. Yes 1** =====> But I quit drinking alcohol all together.
When was that? __________year

**(ASK QUESTION 13 - PART A AND 14 - PART A USING INSTRUCTIONS FOR NON-DRINKERS, THEN SKIP TO QUESTION 18, PAGE 13)**

**No 2** =====> I have never had any beverages containing alcohol.

**(ASK QUESTION 13 - PART A AND 14 - PART A USING INSTRUCTIONS FOR NON-DRINKERS, THEN SKIP TO QUESTION 22, PAGE 15)**

## E. ALCOHOL CONSUMPTION: STRUCTURED DIARY (FREQUENCY AND AMOUNT BY SETTING)

13. In this section we want to know more about the setting and amount of your alcohol consumption. We first want to ask you about activities including those with other people such as friends relatives and coworkers. Which number in CARD 6 best describes how often you participated in the following activities in the past 12 months. In CARD 7, how often you had an alcoholic drink while doing each activity?

**INSTRUCTIONS TO READ TO NON-DRINKERS: In this section we want ask you about your activities with other people such as friends, relatives and coworkers. Which number in the first column best describes how often you participated in the following activities in the past 12 months before quitting?**

| Code for A (HAND CARD 6) | Code for B (HAND CARD 7) |
|---|---|
| 1 More than once a week | 1 Always |
| 2 Once a week | 2 More than half the time |
| 3 A few times a month (1-3 times a month) | 3 Half the time |
| 4 A few times a year (less than once a month) | 4 Less than half the time |
| 5 Never (SKIP TO NEXT ROW) | 5 Never (SKIP TO NEXT ROW) |

| READ ACROSS FOR EACH ROW | PART A<br>Which number in the first column best describes how often you _______? (HAND CARD 6) | PART B<br>Which number in the 2nd column best describes how often you usually drink alcoholic beverages when you _______? (HAND CARD 7) | PART C<br>How many drinks do you usually have when you _______? |
|---|---|---|---|
| a. Spend time at someone else's house | A. ________ | B. ________ | C. ___ ___ drinks |
| b. Have friends, coworkers or relatives visit your home | A. ________ | B. ________ | C. ___ ___ drinks |
| c. Go to a restaurant in the evening (excluding fast food) | A. ________ | B. ________ | C. ___ ___ drinks |
| d. Go to a restaurant for lunch (excluding fast food) | A. ________ | B. ________ | C. ___ ___ drinks |

## E. ALCOHOL CONSUMPTION: STRUCTURED DIARY (FREQUENCY AND AMOUNT BY SETTING)--CONTINUED

| | READ ACROSS FOR EACH ROW | PART A Which number in the first column best describes how often you _______? (HAND CARD 6) | PART B Which number in the 2nd column best describes how often you usually drink alcoholic beverages when you _______? (HAND CARD 7) | PART C How many drink do you usually ha when you _____ |
|---|---|---|---|---|
| e. | Go to a bar/tavern | A. ________ | B. ________ | C. ___ ___ drink |
| f. | Go to a meeting or club | A. ________ | B. ________ | C. ___ ___ drink |
| g. | Meet friends or coworkers in a public place, such as a park, street or parking lot or in a car | A. ________ | B. ________ | C. ___ ___ drink |
| h. | Spend an evening at home with family | A. ________ | B. ________ | C. ___ ___ drink |
| i. | Spend an evening at home alone | A. ________ | B. ________ | C. ___ ___ drink |
| j | Other activities (e.g., regular visits of concerts, outdoor activities, etc.) | A. ________ | B. ________ | C. ___ ___ drink |

| E. | ALCOHOL CONSUMPTION: STRUCTURED DIARY (FREQUENCY AND AMOUNT BY SETTING)--CONTINUED |
|---|---|

14. Which number best describes how often you did these activities with coworkers in the past 12 months?

INSTRUCTIONS FOR NON-DRINKERS: Ask same question as above but only ask PART A

| Code for A (HAND CARD 6) | Code for B (HAND CARD 7) |
|---|---|
| 1 More than once a week | 1 Always |
| 2 Once a week | 2 More than half the time |
| 3 A few times a month (1-3 times a month) | 3 Half the time |
| 4 A few times a year (less than once a month) | 4 Less than half the time |
| 5 Never (SKIP TO NEXT ROW) | 5 Never (SKIP TO NEXT ROW) |

| READ ACROSS FOR EACH ROW | PART A<br>Which number in the first column best describes how often you _______?<br>(HAND CARD 6) | PART B<br>Which number in the 2nd column best describes how often you usually drink alcoholic beverages when you _______?<br>(HAND CARD 7) | PART C<br>How many drinks do you usually have when you _______? |
|---|---|---|---|
| a. Spend time at a coworker's house | A. ________ | B. ________ | C. ___ ___ drinks |
| b. Have coworkers visit your home | A. ________ | B. ________ | C. ___ ___ drinks |
| c. Go to a restaurant in the evening with coworkers (excluding fast food) | A. ________ | B. ________ | C. ___ ___ drinks |
| d. Go to a restaurant for lunch with coworkers (excluding fast food) | A. ________ | B. ________ | C. ___ ___ drinks |
| e. Go to a bar/tavern with coworkers | A. ________ | B. ________ | C. ___ ___ drinks |
| f. Go to a meeting or club with coworkers | A. ________ | B. ________ | C. ___ ___ drinks |

## E. ALCOHOL CONSUMPTION: STRUCTURED DIARY (FREQUENCY AND AMOUNT BY SETTING)--CONTINUED

| READ ACROSS FOR EACH ROW | PART A<br>Which number in the first column best describes how often you _______?<br>(HAND CARD 6) | PART B<br>Which number in the 2nd column best describes how often you usually drink alcoholic beverages when you _______?<br>(HAND CARD 7) | PART C<br>How many drir do you usually when you ___ |
|---|---|---|---|
| g. Meet coworkers in a public place, such as a park, street parking lot or in a car | A. ________ | B. ________ | C. ___ ___ dri |
| h. Have a party at work, e.g., promotion or birthday party | A. ________ | B. ________ | C. ___ ___ drir |
| i. Other activities with coworkers (e.g., regular visits of concerts, outdoor activities, etc.) | A. ________ | B. ________ | C. ___ ___ drir |

15. **When you drink, how often do you drink with supervisors?**

| | |
|---|---|
| Nearly every time | 1 |
| More than half the time | 2 |
| Less than half the time | 3 |
| Once in a while | 4 |
| Never | 5 |

## F. ALCOHOL CONSUMPTION: FREQUENCY AND AMOUNT

16. This question is about various types of drinks.
Thinking of the last 12 months: (HAND CARD 8)

| | |
|---|---|
| 1 | Three or more times a day |
| 2 | Two times a day |
| 3 | Once a day |
| 4 | Nearly every day |
| 5 | Three or four times a week |
| 6 | Once or twice a week |
| 7 | Two or three times a month |
| 8 | About once a month |
| 9 | Less than once a month but at least once a year |
| 10 | Never (SKIP TO NEXT ITEM) |

| | | Which number best describes how often you drink _______? (HAND CARD 8) | What is the usual amount you drink per occasion? |
|---|---|---|---|
| a. | Wine/wine coolers | A. _______ | B. ___ ___ drinks |
| b. | Beer | A. _______ | B. ___ ___ drinks |
| c. | Malt liquor | A. _______ | B. ___ ___ drinks |
| d. | Liquor (drinks including cognac whiskey, scotch, bourbon, gin, vodka, rum, etc.) | A. _______ | B. ___ ___ drinks |

17. Think of all the times that you have had alcoholic beverages (wine, wine coolers, beer, whiskey or liquor) recently. When you drink, how often do you have as many as five or more drinks?

| | |
|---|---|
| Nearly every time | 1 |
| More than half the time | 2 |
| Less than half the time | 3 |
| Once in a while | 4 |
| Never | 5 |

## G. ALCOHOL CONSUMPTION: HABITS

| | | Q18. Thinking of <u>your entire life</u>, has the following ever occurred? | | Q19. Has this happened in <u>the last 12 months</u>? | |
|---|---|---|---|---|---|
| | | YES ↓ (ASK Q. 19) | NO ↓ (SKIP TO NEXT ROW) | YES | NO |
| a. | Have you ever felt you ought to cut down on your drinking | 1 | 2 | 1 | 2 |
| b. | Have people annoyed you by criticizing your drinking? | 1 | 2 | 1 | 2 |
| c. | Have you ever felt bad or guilty about your drinking? | 1 | 2 | 1 | 2 |
| d. | Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (eye opener)? | 1 | 2 | 1 | 2 |

## H. ALCOHOL CONSUMPTION: DRINKING CONSEQUENCES

| | | Q20. When you think of <u>your entire life,</u> was there ever a time when you felt <u>your</u> drinking had a harmful effect on ________? | | Q21. Was that during <u>the last 12 months</u>? | |
|---|---|---|---|---|---|
| | | YES (ASK Q.21) | NO (SKIP TO NEXT ROW) | YES | NO |
| a. | Your friendships and social life | 1 | 2 | 1 | 2 |
| b. | Your health | 1 | 2 | 1 | 2 |
| c. | Your outlook on life | 1 | 2 | 1 | 2 |
| d. | Your home life or marriage | 1 | 2 | 1 | 2 |
| e. | Your work and employment opportunities | 1 | 2 | 1 | 2 |
| f. | Your financial position | 1 | 2 | 1 | 2 |
| g. | Your attendance at work (i.e., absenteeism) | 1 | 2 | 1 | 2 |
| h. | Your safety at work | 1 | 2 | 1 | 2 |
| i. | Your safety off work | 1 | 2 | 1 | 2 |
| j. | Your sex life | 1 | 2 | 1 | 2 |

22. How often during the last 12 months did you observe or were you told about the following? (Two different coworkers on the same day means two times.) (HAND CARD 6)

| | | More than Once a Week | Once a Week | A Few Times a Month (1-3 times a month) | A Few Times a Year (less than once a month) | Neve |
|---|---|---|---|---|---|---|
| a. | A coworker/supervisor reporting to work with a hangover | 1 | 2 | 3 | 4 | 5 |
| b. | A coworker/supervisor was drinking alcohol during work hours (breaks included) | 1 | 2 | 3 | 4 | 5 |
| c. | A coworker/supervisor got drunk on duty | 1 | 2 | 3 | 4 | 5 |
| d. | A coworker/supervisor reported to work drunk | 1 | 2 | 3 | 4 | 5 |
| e. | A coworker/supervisor drank during layover time | 1 | 2 | 3 | 4 | 5 |
| f. | A coworker/supervisor drank when she/he was on split | 1 | 2 | 3 | 4 | 5 |

22.1 INTERVIEWER ASSESSMENT | yes | no |

| | | Yes | No |
|---|---|---|---|
| 23. | Do you think it is OK to have a drink within four hours of reporting for work, as long as it does not affect your driving the next day? | 1 | 2 |
| 24. | Do you think it is OK to drink to unwind after work, as long as it does not affect your driving the next day? | 1 | 2 |
| 25. | Do you think it is OK to drink during your split, as long as it does not affect your driving? | 1 | 2 |
| 26. | Do you think it is OK to drink "on the job", that is during your layovers, recovery times, lunch breaks, etc., as long as it does not affect your driving? | 1 | 2 |

27. **Which number best describes how many times <u>during the past 12 months</u> you did the following: (HAND CARD 6) (SKIP IF THE ANSWER TO QUESTION 12 WAS "NO")**

| | | More than once a week | Once a week | 1-3 times a month | Less than once a month | Never |
|---|---|---|---|---|---|---|
| a. | Bring alcohol to work | 1 | 2 | 3 | 4 | 5 |
| b. | Drink during work hours (breaks included) | 1 | 2 | 3 | 4 | 5 |
| c. | Report to work with a hangover | 1 | 2 | 3 | 4 | 5 |
| d. | Drink within four hours before work | 1 | 2 | 3 | 4 | 5 |

27.1 INTERVIEWER ASSESSMENT | yes | no |

## J. WORKPLACE ENVIRONMENT

28. Which number best describes A) how you react, B) how your coworkers react and C) how t superintendents and dispatchers in your division react when a coworker obviously drinks much that their personal life or work might be affected?
(HAND CARD 9) (ASK COLUMN BY COLUMN)

| | |
|---|---|
| 1 | VERY LIKELY |
| 2 | LIKELY |
| 3 | NOT LIKELY |
| 4 | NOT LIKELY AT ALL |

| | | A<br>How do <u>you</u> react | B<br>How your <u>coworkers</u> react | C<br>How yo <u>superinten</u> <u>dispatcher</u> |
|---|---|---|---|---|
| a. | Do nothing as long as work gets done properly | A. ___ | B. ___ | C. ___ |
| b. | Ignore it because it's no one else's business | A. ___ | B. ___ | C. ___ |
| c. | Encourage him/her to call in sick | A. ___ | B. ___ | C. ___ |
| d. | Do nothing because the person with the problem might loose his/her job | A. ___ | B. ___ | C. ___ |
| e. | Do nothing because I (or they) don't know what to do | A. ___ | B. ___ | C. ___ |
| f. | Confront the person with his/her behavior (e.g., point out negative consequences for family life or job security) | A. ___ | B. ___ | C. ___ |
| g. | Tell the supervisor | A. ___ | B. ___ | C. ___ |
| h. | Tell the union representative | A. ___ | B. ___ | C. ___ |
| i. | Urge him/her to get counseling | A. ___ | B. ___ | C. ___ |
| j. | Talk about it with him/her in a quiet moment | A. ___ | B. ___ | C. ___ |

## J. WORKPLACE ENVIRONMENT--CONTINUED

| | |
|---|---|
| 1 | VERY LIKELY |
| 2 | LIKELY |
| 3 | UNLIKELY |
| 4 | VERY UNLIKELY |

| | | A How do you react | B How your coworkers react | C How your superintenden dispatcher rea |
|---|---|---|---|---|
| k. | Restrict alcohol consumption when around this person | A. ___ | B. ___ | C. ___ |
| l. | Offer support | A. ___ | B. ___ | C. ___ |
| m. | Show understanding for his/her personal situation | A. ___ | B. ___ | C. ___ |
| n. | Go out and have drinks with the person | A. ___ | B. ___ | C. ___ |
| o. | Play it down | A. ___ | B. ___ | C. ___ |
| p. | Threaten with job loss | N/A | N/A | C. ___ |
| q. | Announce alcohol test for the next time | N/A | N/A | C. ___ |

## K. ALCOHOL TREATMENT AT MUNI

29. **How many people in your division do you know or have heard of, who separated from Muni because of alcohol?**

_______________
NUMBER OF PEOPLE

30. **How many people do you know or have heard of, in your division who separated from Muni because of stress?**

_______________
NUMBER OF PEOPLE

31. **How many people in your division do you know or have heard form, who returned to their MUNI job after having successfully completed an alcohol program?**

_______________
NUMBER OF PEOPLE

32. **If you or one of your coworkers had an alcohol problem, whom at work would you consult? (CODE ALL THAT APPLY)**

| | | YES | NO |
|---|---|---|---|
| a. | Superintendent | 1 | 2 |
| b. | Dispatcher | 1 | 2 |
| c. | Coworker | 1 | 2 |
| d. | Union representative | 1 | 2 |
| e. | EAP (Employee Assistance Program) | 1 | 2 |
| f. | Other | | |

_______________
SPECIFY

37. **Aside from the treatment program, what helped you most to successfully complete the program?**
(CODE ALL THAT APPLY)

| | Yes | No |
|---|---|---|
| a. Support and confrontation from family and friends | 1 | 2 |
| b. Support and confrontation from coworkers | 1 | 2 |
| c. Support and confrontation from supervisors | 1 | 2 |
| d. The fact that I was able to keep my job | 1 | 2 |
| e. Other | 1 | 2 |

______________________________
SPECIFY

## L. SUGGESTIONS FOR IMPROVING HEALTH OF MUNI DRIVERS

**38. Do you have any suggestions for improving health of Muni Drivers?**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

(version 10/4/93

# Appendix D

## ICD-9 Code Diagnoses Definitely or Possibly Associated with Low Back Problems and Severity Rank. Also, Codes Indicative of Traumatic or Non-Mechanical Spinal Injuries.

## Diagnoses Definitely[1] or Possibly Associated with Low Back Problems, and Severity Rank

| Clinical Category | ICD-9 Code(s) | Diagnosis | Severity Rank[2] | Severity Group[3] |
|---|---|---|---|---|
| Herniated disc | 722.1 | Displacement of thoracic or lumbar disc without myelopathy | 4 | 2 |
| | ***722.10*** | Displacement of lumbar disc without myelopathy | 4 | 2 |
| | 722.2 | Displacement of unspecified disc without myelopathy | 4 | 2 |
| | 722.7 | Disc disorder with myelopathy, site unspecified | 3 | 1 |
| | ***722.73*** | Lumbar disc disorder with myelopathy | 3 | 1 |
| Probably degenerativ e changes | ***721.3*** | Lumbosacral sypondylosis without myelopathy | 7 | 3 |
| | 721.5-6 | Unique or unusual forms of spondylosis | 7 | 3 |
| | 721.8-9 | Unique or unusual forms of spondylosis | 7 | 3 |
| | ***722.52*** | Degeneration of lumbar or lumbosacral disc | 7 | 3 |
| | 722.6 | Degeneration of disc, site unspecified | 7 | 3 |
| | 722.90 | Other and unspecified disc disorder, site unspecified | 7 | 3 |
| | ***722.93*** | Other and unspecified lumbar disc disorder | 7 | 3 |
| | 720.10 | spinal enthesiopathy | 7 | 3 |
| Spinal Stenosis | ***721.42*** | Spondylogenic compression of lumbar spinal cord | 2 | 1 |
| | 721.91 | Spondylogenic compression of spinal cord unspecified | 2 | 1 |
| | 724.00 | Spinal stenosis, unspecified site (not cervical) | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| | 724.09 | Spinal stenosis, other | 2 | 1 |
| | ***724.02*** | Lumbar stenosis | 2 | 1 |
| Radiating back pain | ***724.3*** | Sciatica | 5 | 2 |
| Possible instability | ***724.6*** | Disorders of sacrum (including lumbosacral joint instability) | 6 | 2 |
| | 738.4 | Acquired spondylolisthesis | 6 | 2 |
| | ***756.11*** | Spondylolysis, lumbosacral region | 6 | 2 |
| | 756.12 | Spondylolisthesis | 6 | 2 |
| Nonspecific backache | 307.89 | Psychogenic backache | 8 | 3 |
| | ***724.2*** | Lumbago | 8 | 3 |
| | 724.5 | Backache, unspecified | 8 | 3 |
| | ***846.0-9*** | Sprains and strains, sacroiliac | 8 | 3 |
| | 847.1 | Sprains and strains, dorsal (spine) | 8 | 3 |
| | ***847.2*** | Sprains and strains, lumbar | 8 | 3 |
| | ***847.3*** | Sprains and strains, sacral | 8 | 3 |
| | 847.9 | Sprains and strains, unspecified region | 8 | 3 |
| Sequelae of previous back surgery | 722.80 | Postlaminectomy syndrome, unspecified region | 1 | 1 |
| | ***722.83*** | Postlaminectomy syndrome, lumbar | 1 | 1 |
| | 737.12 | Kyphosis postlaminectomy | 2 | 1 |
| | ***737.21*** | Lordosis postlaminectomy | 2 | 1 |
| | 996.4 | Mechanical complication of internal orthopedic device, implant and graft | 1 | 1 |
| Miscellaneo us | 722.30 | Schmorl's nodes, unspecified region | 9 | 3 |
| | ***722.32*** | Lumbar Schmorl's nodes | 9 | 3 |

| | | | | |
|---|---|---|---|---|
| | 724.4 | Thoracic or lumbosacral neuritis or radiculitis, unspecified | 5 | 2 |
| | 724.8 | Other symptoms referable to back | 9 | 3 |
| | 724.9 | Other unspecified back disorders | 9 | 3 |
| | 737.10 | Kyphose acquired (postural) | 9 | 3 |
| | ***737.20*** | Lordosis acquired (postural) | 9 | 3 |
| | 737.30 | Idiopathic scoliosis | 9 | 3 |
| | 737.40 | Curvature of spine, unspecified | 9 | 3 |
| | 737.41 | Kyphosis | 9 | 3 |
| | ***737.42*** | Lordosis | 9 | 3 |
| | 737.43 | Scoliosis | 9 | 3 |
| | 737.8 | Other curvatures of spine | 9 | 3 |
| | 737.9 | Unspec. Curvature of spine | 9 | 3 |
| | 738.5 | Other acquired deformity of back or spine | 9 | 3 |
| | ***739.3*** | Nonallopathic lesions, lumbar region | 8 | 3 |
| | ***739.4*** | Nonallopathic lesions, sacral region | 8 | 3 |
| | ***741.3*** | Spina bifida, lumbar region | 9 | 3 |
| | 756.10 | Anomaly of spine, unspecified | 9 | 3 |
| | 756.13 | Various congenital anomalies | 9 | 3 |
| | 756.14 | Various congenital anomalies | 9 | 3 |
| | 756.15 | Various congenital anomalies | 9 | 3 |
| | 756.16 | Various congenital anomalies | 9 | 3 |
| | 756.17 | Various congenital anomalies | 9 | 3 |
| | 756.19 | Various congenital anomalies | 9 | 3 |

1) Codes in ***bold italic*** type are classified as "definitely" low back
2) Severity clinically ranked on ordinal scale from most severe (1) to least severe (9) by Krause:

   1 = "Postlaminectomy syndrome"

   2 = "Spinal stenosis"

   3 = "Herniated disc with myelopathy"

   4 = "Herniated disk without myelopathy"

5 = "Sciatica"

6 = "Possible instability"

7 = "Probably degenerative changes"

8 = "Nonspecific backache"

9 = "Miscellaneous"

3) Severity ranks grouped as high severity (1), middle severity (2), and low severity (3) by Krause:

   1 = "Postlaminectomy syndrome, spinal stenosis, or herniated disc with myelopathy" (1-3)

   2 = "Possible instability, sciatica, herniated lumbar disc without myelopathy" (4-6)

   3 = "Nonspecific backache, degenerative changes, and miscellaneous" (7-9)

# ICD-9 codes indicative of traumatic of non-mechanical spinal injuries (low back and other spinal).

| | |
|---|---|
| Chordotomy | 03.2 - 03.29 |
| Neoplasms | 140-239.9 |
| Intraspinal abscess | 324.1 |
| Pregnancy | 630-676 |
| Inflammatory spondylarthropathies | 720.0, 720.2 - 720.9 |
| Traumatic Spondylopathy | 721.7 |
| Osteomyelitis | 730 - 730.99 |
| Pathological fractures | 733.10-733.19 |
| Curvature of spine due to radiation | 737.11, 737.33 |
| Fractures of back or neck | |
| Closed vertebral fractures without spinal cord injury | 805.0, 805.2, 805.4, 805.6, 805.8 |
| Open vertebral fractures without spinal cord injury | 805.1, 805.3, 805.5, 805.7, 805.9 |
| *3.1.3.1.3.1.4.2. Vertebral fractures* with spinal cord injury | 806.0 - 806.9 |
| Vertebral dislocations | 839 - 839.59 |
| Open wound | 870.0 – 879.7 |
| Crushing injury | 925.0 - 929.9 |
| Burns | 940.0 – 949.5 |
| Spinal cord, plexus, peripheral and root nerve traumatic injuries (any part, with open wound) | 952-956.9 |

# PUBLICATIONS

## Publications

### Manuscripts under Review

1. Rugulies, Reiner, & Krause, Niklas. Job strain, iso-strain, and the incidence of low back and neck injuries: A 7.5-year prospective study of San Francisco transit operators. Submitted to Social Science & Medicine.

2. Krause, Niklas & Rugulies, Reiner. Physical workload, ergonomic problems, and incidence of low back injury: A 7.5-year prospective study of San Francisco transit operators. Submitted to American Journal of Industrial Medicine.

3. Greiner, Birgit A., & Krause, Niklas. Observational stress factors and musculoskeletal disorders in urban transit operators. Submitted to Work and Stress.

### Manuscripts in Preparation

1. Krause, Niklas. Physical and psychosocial job factors associated with the prevalence of low back pain in urban transit operators.

2. Krause, Niklas. Physical and psychosocial determinants of duration of disability after low back injury: A 7.5-year prospective study of San Francisco transit operators.

3. Mehling, Wolf E.,& Krause, Niklas. Are difficulties perceiving and expressing emotions a risk factor for low back pain?