Risks of Occupational Vibration Exposures

VIBRISKS

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Summary

Exposure to whole-body vibration (WBV) in professional drivers of industrial machines and/or vehicles is associated with an excess risk for back symptoms and disorders of the lumbar tract of the spine. This study reports the findings of a prospective cohort survey of dose-response relationship for low back disorders in Italian WBV-exposed drivers recruited within the EU VIBRISKS project. The aim of this study was to investigate the association over time between low back disorders, WBV exposure, physical load factors, and psychosocial variables was investigated while controlling for potential individual confounders recognised as risk factors for low back pain. In this survey, the study population at the cross-sectional survey (survey 1: 2003-04) included 598 male professional drivers employed in several industries and public utilities located in Lucca, Massa Carrara, Siena, and Viareggio (Tuscany Region), Chiavari (Liguria Region), Modena (Emilia Romagna Region) and Trieste (Friuli Venezia Giulia Region). Since the cohort was of dynamic type, drivers entered and left the cohort during the 1st follow-up survey (survey 2: 2004-05) and the 2nd follow-up survey (survey 3: 2005-06). In details, 283 drivers had only a cross-sectional survey (145 at survey 1, 86 at survey 2, and 52 at survey 3), 321 drivers participated in one follow-up survey (109 at survey 1 and 2, 57 at survey 1 and 3, and 155 at survey 2 and 3), and 317 drivers had two follow-up investigations (i.e. at survey 1, 2, and 3). As a whole, 921 drivers participated in the VIBRISKS study, and 638 drivers underwent at least one follow-up investigation. Reasons for leaving the cohort were change of job (23%), change of residence (15%), organisational difficulties associated with job-linked time schedules (18%), sickness on the day of the investigations (20%), refusal to participate in the follow-up studies (10%), and undetermined causes (14%). Daily vibration exposure in terms of Av(8) ranged from 0.28 (drivers of garbage machines) to 0.61 ms-2 r.m.s. (drivers of earth moving machines), ($p<0.001$). Similarly, daily vibration exposure in terms of VDVsum ranged from 5.5 ms-1.75 (drivers of garbage machines) to 12.4 ms-1.75 (drivers of earth moving machines). It should be noted that when daily vibration exposure was expressed as Adom(8) according to the EU Directive on mechanical vibration, no driver group exceeded, on average, the daily exposure action value established by the Directive (0.5 ms-2 r.m.s.). On the contrary, when daily

vibration exposure was expressed as VDVdom, the EU daily exposure action value (9.1 ms-1.75) was exceeded, on average, in the marble industry and dockyards. At the cross-sectional survey, the point prevalence of the various LBP symptoms varied from 16.6% (acute LBP) to 40.1% (unspecific LBP). High pain intensity in the lower back in the previous 12 months (Von Korff pain score > 5) was reported by 28.7% of the subjects. About 19% of the subjects complained LBP disability (Roland & Morris disability scale score > 12) in the previous 12 months. Health care use for LBP (visit to a doctor, treatment) was reported by 25 – 30% of the subjects. Overall, low back symptoms were complained by 64.4% of the drivers at the cross-sectional survey. Sick leave due to LBP in the previous 12 months was reported by 3.2% (> 15 days) and 12.6% (> 7 days) of the subjects. Self-reported degeneration in the lumbar disks were reported by 13.6% of the drivers. This figure was consistent with that based on MRI examination (10.1%). Over the follow-up period (2004-2006), the cumulative incidence of the various LBP symptoms ranged from 7.3% (acute LBP) to 47.8% (unspecific LBP). The cumulative incidence of high pain intensity and LBP disability was 28.8 and 23.8%, respectively. Two-year incidence of sick leave due to LBP was 4.9% (> 15 days) and 9.0% (> 7 days). There were 40 new cases reporting troubles in the lumbar disks (incidence 14.6%). Of them, 17 were supported by MRI examination (incidence 6.0%). In the professional drivers, the occurrence of several LBP outcomes (e.g. 12-month LBP, sciatica, LBP disability) significantly increased with increasing cumulative vibration exposure. Several alternative measures of vibration exposure were found to be associated associated with LBP outcomes. In multivariate data analysis, individual characteristics (e.g. age, body mass index) and a physical load index (derived from combining manual materials handling and awkward postures) were significantly associated with LBP outcomes, while psychosocial work factors (e.g. job decision, job support) showed a marginal relation to LBP. This study tends to confirm that professional driving in industry is associated with an increased risk of work-related LBP. Exposure to WBV and physical loading factors at work are important components of the multifactorial origin of LBP in professional drivers.

1. Introduction

Exposure to whole-body vibration (WBV) in professional drivers of industrial machines and/or vehicles is associated with an excess risk for back symptoms and disorders of the lumbar tract of the spine [1-5]. Reviews of the epidemiological literature have reported that the occurrence of low back pain and early degeneration of the lumbar spine, including intervertebral disc disorders, is greater in professional drivers than in controls groups unexposed to WBV [6, 7]. In a critical review of musculoskeletal disorders and workplace factors, investigators of the National Institute of Occupational Safety and Health (NIOSH, 1997) judged that after adjusting for potential confounders (e.g. age, smoking, physical and psychosocial work-related factors) there is strong evidence of a positive association between exposure to WBV and (low) back disorders [8].

The role of WBV in the aetiopathogenesis of low back disorders is not yet fully clarified, as driving of vehicles involves not only exposure to harmful WBV but also to several ergonomic risk factors which can affect the spinal system, such as prolonged sitting and awkward postures. Experimental studies have shown that WBV exposure, combined with a constrained sitting posture, can provoke failure of the lumbar intervertebral disc [9]. Moreover, some driving occupations involve heavy lifting and manual handling activities (e.g. drivers of delivery trucks), which are known to strain the lower part of the back. Individual characteristics (e.g. age, body mass, and smoking) and psychosocial factors are also suggested as potential predictors for low back pain [8, 10, 11]. It follows that injuries in the lower back of professional drivers may be considered a complex of health disorders of multifactorial origin involving both occupational and non-occupational stressors.

Owing to the several factors potentially involved in the occurrence of low back pain, it is difficult to outline a clear exposure-response relationship between WBV exposure and low back disorders.

This study reports the findings of a prospective cohort survey of dose-response relationship for low back disorders in WBV-exposed drivers recruited in a four-year research project entitled "*Risks of Occupational Vibration Injuries* (VIBRISKS)" and funded by the EU Commission.

VIBRISKS is a European research project which seeks to improve understanding of the risk of injury from occupational exposures to mechanical vibration by means of epidemiological studies supported by fundamental laboratory research [12]. Specific objectives of the project are: (i) to establish dose-response relationships between vibration exposures and injury; (ii) to investigate the interaction between vibration and other environmental, ergonomic and individual factors; (iii) to develop common methods for health surveillance; (iv) to improve methods for preventing disorders; and (v) to disseminate current knowledge on health surveillance and prevention to industry, occupational health professionals and end-users across Europe.

The aim of this study was to investigate the prevalence and incidence of low back pain outcomes in various groups of Italian professional drivers. Vibration measurements were performed on a representative sample of the machines and vehicles used by the various driver groups. Finally, the association between low back disorders, WBV exposure, physical load factors, and psychosocial variables was investigated while controlling for potential individual confounders recognised as risk factors for low back pain.

2. Subjects and methods

2.1. STUDY POPULATION

The VIBRISKS project includes a work package devoted to epidemiological studies of the effects of WBV on musculoskeletal system. Researchers from four European countries are involved in WBV epidemiological work (Italy, Sweden, the Netherlands, United Kingdom).

In Italy, the study population at the cross-sectional survey (survey 1: 2003-04) included 598 male professional drivers employed in several industries and public utilities located in Lucca, Massa Carrara, Siena, and Viareggio (Tuscany Region), Chiavari (Liguria Region), Modena (Emilia Romagna Region) and Trieste (Friuli Venezia Giulia Region).

Since the cohort was of dynamic type, drivers entered and left the cohort during the 1st follow-up survey (survey 2: 2004-05) and the 2nd follow-up survey (survey 3: 2005-06). In details, 283 drivers had only a cross-sectional survey (145 at survey 1, 86 at survey 2, and 52 at survey 3), 321 drivers participated in one follow-up survey (109 at survey 1 and 2, 57 at survey 1 and 3, and 155 at survey 2 and 3), and 317 drivers had two follow-up investigations (i.e. at survey 1, 2, and 3). As a whole, 921 drivers participated in the VIBRISKS study, and 638 drivers underwent at least one follow-up investigation. Reasons for leaving the cohort were change of job (23%), change of residence (15%), organisational difficulties associated with job-linked time schedules (18%), sickness on the day of the investigations (20%), refusal to participate in the follow-up studies (10%), and undetermined causes (14%).

At the cross-sectional survey, the rate of participation in the study was 92 to 97% for the drivers employed in the surveyed companies which were randomly selected among those sited in the provinces where the study was carried out.

Informed consent to the study was obtained from employers and employees at each company. As an incentive to participate in the study, a document providing a risk assessment for WBV exposure at workplace, according to article 4 of the EU Directive 2002/44/EC on mechanical vibration [13], was promised to the management and the representatives of workers at each company.

This VIBRISKS report provides information on the findings of the epidemiological surveys of the drivers with complete follow-up (i.e. those who participated in survey 1, 2, and 3, n=317).

The WBV-exposed population included 76 drivers of earth moving machines and articulated trucks employed in marble quarries, 43 drivers of fork-lift trucks and mobile cranes employed in marble laboratories, 32 drivers of fork-lift trucks, container stake trucks and freight-container tractors employed in dockyards, 32 drivers of fork-lift trucks employed in paper mills, 50 drivers of garbage trucks, garbage compactors and track-type loaders employed in public utilities, and 84 bus drivers of mini-buses and city buses.

A minimum of one year of professional driving in current job was established as the basic criterion for the inclusion of drivers in the study population.

Table 1 reports the distribution of the study population by industry and machinery in Italy.

2.2. The questionnaire

The questionnaire used in this study was originally developed within the european project VINET (*Vibration Injury Network*), [12]. The questionnaire has been undergoing a process of improving revisions on the basis of the findings of pilot studies and epidemiological surveys conducted across some European countries [14].

The questionnaire consisted of four major sections:

2.2.1. Personal and general information

The first section of the questionnaire included items on the subject's personal characteristics such as age, height, weight, education, marital status, physical activity or sport, smoking and drinking habits.

2.2.2. Occupational history

The second section of the questionnaire requested information on occupational history in the current and previous companies with details about job titles, duration of employment, types of machines or vehicles driven, daily and cumulative duration of driving on specific machine or vehicle, physical load during an average working day (walking and standing, sitting, non-neutral postures, digging, lifting), and aspects related to psychosocial factors at work (job decision, job support from supervisors or co-workers, job satisfaction). Work-related physical load was graded by rating the frequency and/or the duration of manual activities during a typical working day. Job decision and job support were measured on a 4-point scale ("never/almost never", "seldom", "sometimes", "often"), as well as job satisfaction ("very dissatisfied", "dissatisfied", "satisfied", "very satisfied").

2.2.3. Personal medical history

The third section of the questionnaire focused on health complaints which were investigated using a modified version of the Nordic questionnaire on musculoskeletal symptoms [15]. The workers were questioned on the occurrence of neck, shoulder, and low back pain (LBP) in the last 7 days and the last 12 months. Workers who reported musculoskeletal symptoms were requested to answer to additional questions concerning duration, frequency, pain radiation, pain intensity and disability, health care use because of symptoms, treatment (e.g. anti-inflammatory drugs or physical therapy), and sick leave due to symptoms in the previous 7 days and 12 months. Pain intensity was rated on a 11-point scale, where 0 is "no pain at all" and 10 is "pain as bad as it could be" according to the pain scale proposed by Von Korff *et al.* [16]. Disability due to the last episode of LBP was measured by means of the Roland & Morris disability scale [17]. The workers were requested to answer 24 questions concerning daily life activities which were impaired by LBP, such as standing up, walking, bending, getting dressed, getting out of a chair, etc. A disability scale score for each worker suffering from LBP was obtained by summing up the number of disability conditions experienced by the affected worker.

2.2.4. Other symptoms and feelings

The fourth section of the questionnaire contained items on musculoskeletal symptoms in the upper and lower extremities, other health disorders, and psychological feelings of workers about their life conditions and the consequences of LBP on their health status and work activity.

Workers were interviewed by certified occupational health personnel who were trained to conduct the interview in a standardised way. For this purpose, specific meetings were organised to test the method of administration of the questionnaire to workers.

On the basis of the items included in the medical section of the questionnaire, LBP outcomes were defined as follows:

(i) **LBP**: pain or discomfort in the low back area between the twelfth ribs and the gluteal folds (indicated in a figure), with or without radiating pain in one or both legs, lasting one day or longer in the previous seven days (7-day LBP) or the previous twelve months (12-month LBP).

(ii) **High pain intensity**: LBP in the previous 12 months associated with a pain score ≥ 5 (Von Korff scale).

(iii) **LBP disability**: last episode of LBP associated with a disability score ≥ 12 (Roland & Morris scale).

(iv) **Sciatic pain**: radiating pain in one or both legs in the previous 12 months.

(v) **Acute LBP**: sudden attack of low back pain producing abnormal or locked posture of the back in the previous 12 months.

(vi) **Treated LBP**: low back pain treated with anti-inflammatory drugs or physical therapy in the previous 12 months.

(vi) **Sick leave**: sick leave > 7 days due to LBP in the previous 12 months.

2.4. Measurement and assessment of vibration exposure

Vibration measurements were made on representative samples of industrial machines and vehicles (n=74) used by the professional drivers. Vibration was measured at the driver-seat interface during actual operating conditions according to the recommendations of the International Standard ISO 2631-1 [18]. The vibration time histories were stored in a digital recorder (DAT HEIM DATa Rec-A80) and then analysed in the laboratory by a signal analyser (IMC FAMOS).

2.4.1. Frequency-weighted acceleration of vibration

From one-third octave band frequency spectra (1-80 Hz) recorded from *x*-, *y*-, and *z*-directions, frequency-weighted root-mean-square (r.m.s.) accelerations (a_{wx}, a_{wy}, a_{wz}) were obtained by using the weighting factors suggested by ISO 2631-1.

The root-sums-of-squares (sometimes referred to as the “vector sum” or “total value”) of the r.m.s. values of the weighted accelerations, a_{ws}, was calculated according to the following formula:

$$a_{ws} = [(1.4a_{wx})^2 + (1.4a_{wy})^2 + a_{wz}^2]^{½} \qquad (\mathrm{ms}^{-2}) \qquad \text{(Eq. 1)}$$

The frequency-weighted root-mean-quad (r.m.q.) accelerations of vibration was calculated from the Vibration Dose Value (*VDV*, see below) by dividing the *VDV* by the fourth root of the exposure duration (in seconds).

The root-sums-of-quads of the r.m.q. values of the weighted accelerations, a_{wq}, was calculated according to the following formula:

$$a_{wq} = [(1.4a_{wx})^4 + (1.4a_{wy})^4 + a_{wz}^4]^{¼} \qquad (\mathrm{ms}^{-2}) \qquad \text{(Eq. 2)}$$

2.4.2. Calculation of daily vibration exposure

For each operator, questionnaire data and company records were used to estimate daily exposure to WBV expressed in driving hours, as well as the total duration of exposure to WBV in full-time driving years.

Daily vibration exposure was expressed in terms of 8-h energy-equivalent frequency-weighted acceleration magnitude ($A(8)$) according to the EU Directive on mechanical vibration [13]:

$$A(8) = a_w \, (T/T_0)^{½} \qquad (\mathrm{ms^{-2}\ r.m.s.}) \qquad \text{(Eq. 3)}$$

where T is the total daily duration of exposure to the vibration a_w, and T_0 is a reference duration of 8 h.

In Eq. (3), a_w was included as either the vibration total value ($A_v(8)$), or the highest (dominant) value of the frequency-weighted r.m.s. accelerations determined on the three orthogonal axes ($A_{dom}(8)$), as required by the EU Directive [13].

Daily vibration exposure was also expressed in terms of Vibration Dose Value (VDV), according to the fourth power vibration dose method:

$$VDV = \left\{ \int_0^T [a_w(t)]^4 \, dt \right\}^{1/4} \qquad (\mathrm{ms^{-1.75}}) \qquad \text{(Eq. 4)}$$

where $a_w(t)$ is the instantaneous frequency-weighted acceleration, and T is the duration of measurement.

The VDV measures were expressed as either summation over axes (VDV_{sum}), or the highest (dominant) directional component (VDV_{dom}), as required by the EU Directive [13].

2.4.3. Calculation of measures of cumulative vibration dose

Frequency-weighted acceleration of vibration and duration of exposure were used to construct measures of cumulative vibration dose estimated as:

$$dose = \sum_i [a_i^m t_i] \tag{Eq. 5}$$

where a_i is the vibration total value of either the frequency-weighted r.m.s. accelerations (a_{ws}) or the frequency-weighted r.m.q. accelerations (a_{wq}) measured on machine i driven for time t_i in hours (h/d × d/yr × years).

In these doses, the relative importance of the frequency-weighted acceleration, *a,* and the total exposure duration, *t*, depends on the value of *m*. If *m* has the value 2, the relationship between *a* and *t* is that assumed in root-mean-square averaging (as suggested in current standards to evaluate vibration exposure over a working day). Assigning values of 1 or 4 to *m* decreases or increases, respectively, the 'importance' of the vibration magnitude, *a*, relative to that of exposure duration, *t*. With *m* = 0, the dose takes no account of vibration magnitude. Doses with *m* = 0, 1, 2, and 4 were computed for each driver.

2.5. Assessment of physical load

A combined approach consisting of both direct observation of working conditions and the subject's self-assessment during the interview was used to evaluate physical load in the controls and the professional drivers. Photos and videos were taken at the workplace to analyse drivers' postures during a working day.

Heavy physical work was graded by rating the frequency of manual activities on a 3-point response scale (e.g. lifting loads > 15 kg with trunk bent and twisted: "not at all", "1-10 times", "more than 10 times"). Awkward postures were graded by rating the duration of each posture on a 4-point time scale (e.g. working with trunk bent > 40°: "never", "less than 1 h", "1-2 h", "more than 2 h"). A mean value of physical load variables during a typical working day was calculated for each subject. In the total sample, the average physical load index was divided into quartiles (q) which were assumed to correspond to four grades of increasing physical load: 1st q=mild load grade, 2nd q=moderate load grade, 3rd q=hard load grade, 4th q=very hard load grade.

2.6. Data analysis

The statistical analysis of data was performed with the Stata software, version 9.2 SE (Stata Corporation, 2006).

Continuous variables were summarised with the mean or median as measures of central tendency and the standard deviation (SD) or quartiles as a measure of dispersion.

The difference between groups was tested with either one-way analysis of variance (ANOVA) or the Kruskal Wallis test. The difference between categorical data cross-tabulated into contingency tables was tested by chi-square statistic.

Point prevalence, period prevalence, and cumulative incidence of low back symptoms over the follow-up period were estimated by means of traditional statistical methods for epidemiological data.

The association between LBP outcomes and several independent variables over time was assessed by random-intercept logistic regression analysis (program xtlogit in Stata). Odds ratios (OR) and 95% confidence intervals (95% CI) were estimated from the logistic regression coefficients and their standard errors. When data were sparse, 95% exact confidence intervals for the odds ratios were obtained by means of exact logistic regression methods provided by the LogXact software, version 6 [19].

Initially, univariate associations were examined to study the effect of various predictors on the occurrence of low back complaints. Then, multivariate random-intercept logistic regression models were used to assess the association between LBP outcomes over time and exposure variables (vibration and physical load) while controlling for the influence of personal and psychosocial factors. Both exposure variables and confounding factors entered in the logistic model as categorical covariates, except for age, which was used as a continuous covariate. The significance of additional variables in the model was tested by the likelihood ratio (LR) chi-square statistic. Independent variables were retained in the model when their probability value was < 0.25. Age was included in each model regardless of the level of statistical significance. The magnitude of the LR statistic was used to assess the "importance", in statistical terms, of the alternative measures of vibration exposure for the prediction of the outcome. The Bayesan Information Criterion was used as a measure of overall fit and a means to compare regression models including alternative measures of cumulatime vibration dose [20]. The guidelines suggested by Raftery was adopted to compare the fit of non-nested regression models by means of the difference (Δ) in the Bayesan Information Criterion (BIC): (i) weak evidence (Δ BIC=2 to 6); (ii) positive evidence (Δ BIC=2 to 6); (iii) strong evidence (Δ BIC=6 to 10); (iv) very strong evidence (Δ BIC > 10), [20].

3. Results

3.1. Vibration measurements

Table 2 reports the mean (SD) values of the frequency-weighted r.m.s. accelerations measured at the driver-seat interfaces on the machines and vehicles used by the professional drivers. The *z*-axis (vertical) weighted acceleration was the dominant directional component of vibration measured in most of the machines and vehicles. In marble quarries, the vibration total value (a_v) of the weighted r.m.s. accelerations averaged 0.57 to 0.69 ms^{-2} r.m.s. in earth moving machines and 0.5 to 1.1 ms^{-2} r.m.s. in transport vehicles. The lowest a_v values were measured on garbage machines (0.29-0.31 ms^{-2} r.m.s.) and on mobile cranes used in marble laboratories (0.32 ms^{-2} r.m.s.). Vibration from buses varied from 0.51 (minibus) to 0.61 ms^{-2} r.m.s. (city bus). The average a_v measured on fork-lift trucks used in marble laboratories was two to three times greater (1.1 ms^{-2} r.m.s.) than those measured on fork-lift trucks driven in dockyards (0.54 ms^{-2} r.m.s.) and paper mills (0.36 ms^{-2} r.m.s.). This finding may be ascribed to differences in vehicle design and power, items to be lifted, operating conditions, and seat quality between the fork-lift trucks used in the various industries.

Frequency analysis showed that the vibration frequencies with the highest r.m.s. accelerations were 1.25 to 5 Hz (*z*-axis) for most of the machines, with additional acceleration peaks at 8 and 16 Hz in the excavators and fork-lift trucks.

3.2. Characteristics of the study groups

Preliminary data analysis showed significant differences between the several study groups with respect to age, anthropometric characteristics, drinking habit, level of education, and physical activity (Table 3). Smoking habit and marital status did not differ between groups.

The distribution of previous jobs with heavy physical demands was similar in the various groups (results not shown).

There were significant differences in vibration exposure between the driver groups (Tables 4a and 4b). Total duration of exposure to WBV in either full-time driving years or total driving hours were significantly greater in bus drivers and drivers employed in marble quarries and paper mills compared with the other groups. Daily vibration exposure in terms of $A_v(8)$ ranged from 0.28 (drivers of garbage machines) to 0.61 ms^{-2} r.m.s. (drivers of earth moving machines), ($p<0.001$). Similarly, daily vibration exposure in terms of VDV_{sum} ranged from 5.5 $ms^{-1.75}$ (drivers of garbage machines) to 12.4 $ms^{-1.75}$ (drivers of earth moving machines). It should be noted that when daily vibration exposure was expressed as $A_{dom}(8)$ according to the EU Directive on mechanical vibration [13], no driver group exceeded, on average, the daily exposure action value established by the Directive (0.5 ms^{-2} r.m.s.). On the contrary, when daily vibration exposure was expressed as VDV_{dom}, the EU daily exposure action value (9.1 $ms^{-1.75}$) was exceeded, on average, in the marble industry and dockyards.

Vibration doses estimated as either $\sum[a_{wsi}{}^{m}t_i]$ or $\sum[a_{wqi}{}^{m}t_i]$ were significantly higher in the drivers of earth moving machines (marble quarries), fork-lift trucks (marble laboratories and dockyards) and, at least partially, buses than in the other driver groups (p<0.001).

Previous jobs with WBV exposure were more frequently reported by drivers employed in public utilities (p<0.01).

3.3. Low back pain and individual, occupational, and psychosocial variables

3.3.1. Prevalence and incidence of LBP symptoms

Table 5 report the point prevalence at the cross-sectional survey (2003-2004), the prevalence over the study period (2003-2006), and the cumulative incidence over the follow-up period (2004-2006) for low back disorders in the driver population. At the cross-sectional survey, the point prevalence of the various LBP symptoms varied from 16.6% (acute LBP) to 40.1% (unspecific LBP). High pain intensity in the lower back in the previous 12 months (Von Korff pain score > 5) was reported by 28.7% of the subjects. About 19% of the subjects complained LBP disability (Roland & Morris disability scale score ≥ 12) in the previous 12 months. Health care use for LBP (visit to a doctor, treatment) was reported by 25 – 30% of the subjects. Overall, low back symptoms were complained by 64.4% of the drivers at the cross-sectional survey. Sick leave due to LBP in the previous 12 months was reported by 3.2% (> 15 days) and 12.6% (> 7 days) of the subjects. Self-reported degeneration in the lumbar disks were reported by 13.6% of the drivers. This figure was consistent with that based on MRI examination (10.1%).

Over the follow-up period (2004-2006), the cumulative incidence of the various LBP symptoms ranged from 7.3% (acute LBP) to 47.8% (unspecific LBP). The cumulative incidence of high pain intensity and LBP disability was 28.8 and 23.8%, respectively. Two-year incidence of sick leave due to LBP was 4.9% (> 15 days) and 9.0% (> 7 days). There were 40 new cases reporting troubles in the lumbar disks (incidence 14.6%). Of them, 17 were supported by MRI examination (incidence 6.0%).

3.3.2. INDIVIDUAL VARIABLES

Univariate analysis showed that in the overall study population severe LBP outcomes (acute LBP, sciatic pain, LBP disability) tended to increase over time with the increase of age (Tables 6a and 6b). After adjustment for age, there were no clear associations between LBP outcomes and smoking, marital status, and private car driving. An increased occurrence of some forms of LBP symptoms was found for drinking habit and level of formal education. The occurrence of acute LBP, high pain intensity, LBP disability, and sick leave due to LBP tended to increase with increasing body mass index (BMI), and significant associations were found for overweighted persons (BMI > 27). Regular physical activity was associated with a lower risk of 12-month LBP, LBP disability, treated LBP, and sick leave due to LBP.

3.3.3. PHYSICAL VARIABLES

The various LBP outcomes were not significantly associated with previous jobs with either WBV exposure or heavy physical demands (Tables 6a and 6b). Overall, work-related physical load factors, treated as dichotomous variables, were positively related to LBP. Awkward postures at work, such as trunk twisting while lifting loads and back bent forward or twisted while driving, showed significant associations with pain intensity and disability, treated LBP, and sciatic pain. Back trauma was a highly significant predictor of the occurrence of 12-month LBP (age-adjusted OR: 3.57; 95% CI: 1.34 to 9.48), sciatic pain (age-adjusted OR: 3.14; 95% CI: 1.09 to 9.01), and LBP disability (age-adjusted OR: 3.49; 95% CI: 1.22 to 10.0). Back trauma was also associated, even though not significantly, with an excess risk for self-reported lumbar hernia (age-adjusted OR: 2.86; 95% CI: 0.65 to 12.6), and not with lumbar hernia detected by means of MRI (age-adjusted OR: 0.95; 95% CI: 0.13 to 6.74).

3.3.4. Psychosocial variables

No clear pattern of association between LBP and psychosocial factors at work was observed in the study population (Tables 7a and 7b). LBP in the last 7 days and the last 12 months showed significant associations with some items for job decision. Sciatic pain, LBP disability, treated LBP and sick leave due to LBP showed a positive trend, although not significant, with job dissatisfaction.

3.3.5. LBP outcomes in the driver groups

Table 8 reports the cumulative incidence of LBP outcomes and the risk estimates for LBP over time in the various driver groups. Assuming the the driver group with the lower WBV exposure (public utilities, garbage) as an internal reference category, almost all other driver groups showed a greater incidence of LBP outcomes over the follow-up period. When compared with the internal reference group, excess risks for 12-month LBP, sciatic pain and sick leave due to LBP were observed in the other driver groups, even though signficantly increased ORs were found only for drivers employed in the dockyards. After adjustment for age and survey, significantly increased ORs for LBP disability were found in the drivers employed in marble quarries, dockyards, paper mills, and public utilities (bus).

3.4. Low back pain and vibration exposure

To assess possible exposure-response relationship for LBP outcomes in the professional drivers, measures of vibration exposure, such as $A(8)$, VDV, duration of exposure in years, and vibration doses of the form $\sum[a_i^m t_i]$, were divided into quartiles assuming the lowest quartile as the reference category.

Tables 9a to 16b report the results of random-intercept logistic analysis for the relation over time between LBP oucomes and daily and cumulative vibration exposures, while adjusting for several covariates such as individual characteristics (age, BMI), physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey.

In general, the relation LBP outcomes and the various measures of daily vibration exposure was poor, with the exception for LBP disability which showed a significantly increasing trend of occurrence with the increase of $A_v(8)$ and VDV_{sum} (Table 14a). Some significant associations were also observed between sciatic pain and daily driving time, $A_v(8)$, and $A_{dom}(8)$, (Table 12a). Prolonged daily driving time was significantly associated with 12-month LBP (Table 10a), high pain intensity in the lower back (Table 13a), and treated LBP (Table 15a).

No significant association was observed between the occurrence of LBP in the previous 7 days and the various measures of cumulative vibration dose (Table 9b).

The occurrence of LBP in the previous 12 months was significantly associated only with $\sum[t_i]$, (Table 10b). A trend, although not significant, of increasing ORs for 12-month LBP was observed for $\sum[a_{wqi}t_i]$.

Episodes of acute LBP were associated with $\sum[t_i]$, $\sum[a_{wsi}t_i]$, and $\sum[a_{wqi}t_i]$ (Table 11b), but the association was significant only for $\sum[a_{wsi}t_i]$.

The occurrence of sciatic pain in the previous 12 months was significantly related to all measures of cumulative vibration dose (Table 12b). The associations were stronger for $\sum[t_i]$, $\sum[a_{wsi}t_i]$, $\sum[a_{wqi}t_i]$, and $\sum[a_{wqi}^2t_i]$.

Patterns of an increased risk for high pain intensity (Table 13b) and LBP disabilty (Table 14b) with the increase of vibration exposure were observed for all measures of cumulative vibration dose. The occurrence of both high pain intensity in the lower back and LBP disability was mainly associated with $\sum[t_i]$, $\sum[a_{wqi}t_i]$, and $\sum[a_{wqi}^2 t_i]$.

Some trends of increasing ORs with the increase of cumulative vibration exposure were observed for treated LBP (Table 15b) and sick leave due to LBP (Table 16b), but most of the associations were not significant.

3.5. LOW BACK PAIN AND OTHER PHYSICAL LOAD FACTORS

Owing to differences in the frequency and duration of awkward postures at work between the various driver groups, no specific posture showed an evident trend of association with LBP outcomes (Table 17).

Walking and standing at work, as well as sitting more than 3 h/d other than when driving (results not shown), were not related to any LBP outcome.

After adjustment for potential confounders, the likelihood ratio statistic showed that the occurrence of LBP in the last 12 months was significantly associated with working with trunk bent > 40° and with driving with back bent forward or twisted. This latter was also predictive for LBP disability.

When the several physical load variables were averaged within each subject to obtain a combined physical load index (see methods), the adjusted ORs showed a clear pattern of increasing risk over time for 12-month LBP, sciatic pain, LBP disability, and treated LBP with the increase of physical load grade from mild to very hard (Table 18).

No significant interaction between postural load index and vibration exposure was observed when a two-product term for these variables was added to logistic regression models.

4. Discussion

The frequency-weighted acceleration magnitudes of vibration measured on the machines and vehicles investigated in this survey are very similar to those published in other reports, books and Internet resources [2, 3, 21-27]. Overall, the vibration total value, a_v, measured on the vehicles of the various companies ranged 0.2 to 1.3 (mean 0.56) ms^{-2} r.m.s. and the most severe axis acceleration ($1.4a_{wx}$, $1.4a_{wy}$, or a_{wz}) ranged 0.2 to 1.1 (mean 0.44) ms^{-2} r.m.s. Paired data comparison showed that the difference between a_v and the most severe axis acceleration was highly significant (p<0.001). This finding has important repercussions on the estimation of daily vibration exposure, $A(8)$. In this study, we have estimated $A(8)$ using either a_v ($A_v(8)$) or the highest r.m.s. value of the dominant axis of vibration ($A_{dom}(8)$) as the measure of frequency-weighted acceleration magnitude to be included in Eq. (3). In each driver group of this study, $A_v(8)$ was significantly greater than $A_{dom}(8)$, (Table 4, p<0.001). The EU Directive on mechanical vibration has established a daily exposure action value $A_{dom}(8)$ of 0.5 ms^{-2} r.m.s. above which the employer must implement a programme of technical and/or organisational measures intended to reduce to a minimum exposure to mechanical vibration and the associated risks [13]. Moreover, workers exposed to WBV in excess of the action value are entitled to appropriate health surveillance. In this study, 75 drivers (23.7%) were exposed to $A_v(8)$ greater than the daily exposure action value of 0.5 ms^{-2} r.m.s., while this figure reduces to 33 drivers (10.4%) when daily vibration exposure was estimated as $A_{dom}(8)$. As a result, if $A_{dom}(8)$ is adopted as the basic indicator for the assessment of daily vibration exposure, in our study about 13% of the drivers would be excluded from health surveillance in case this latter is considered compulsory only for workers exposed to $A_{dom}(8)$ above the action value. It should be noted that most of the EU Countries have adopted the $A(8)$ criterion instead of the VDV criterion for the definition of daily action value and daily exposure limit value. In this study, 108 drivers (34.1%) were exposed to VDV_{dom} greater than the daily exposure action value of 9.1 $ms^{-1.75}$. This is a matter of concern for the occupational health physician because the adoption of the VDV_{dom} criterion for the definition of daily action value would result in a higher level of health protection for the drivers of this study since health surveillance would involve 34% of the drivers (VDV_{dom} criterion) vs 10% of the drivers ($A_{dom}(8)$ criterion).

The findings of this study on LBP occurrence in the various driver groups seem to be consistent with those reported in other investigations. In a German study of professional drivers, the prevalence of “lumbar syndrome” (defined as "any kind of symptoms in the lumbar region and in the sacral area for which a vertebral cause could be assumed after differential diagnosis") was around 60% in operators of earth moving machines, truck drivers, and fork-lift truck drivers [23]. In a study of 169 fork-lift truck drivers from 13 companies in Copenhagen metropolitan area, the point prevalence (i.e. on the day of health examination) and the 12-month prevalence of LBP were 21 and 65%, respectively [29]. Moreover, there was an association between the occurrence of LBP and the length of employment (driving years) during the year preceding the survey. In Finland, Riihimäki et al [30] found very high prevalence of 7-day and 12-month low back troubles (51 and 82%, respectively) in machine operators (541 longshoremen and 311 earthmover operators), but no significant relation between duration of employment and occurrence of low back symptoms. In our previous study of port machinery operators exposed to WBV and postural load, the overall 12-month prevalence of LBP was 63% [31]. Among the machine operators, LBP prevalence was greater in fork-lift truck drivers (79.5%) than in straddle carrier drivers (51.8%) and crane operators (54.4%). Bus drivers have been investigated in several epidemiological studies performed in U.S. and European countries. A personal review of the available literature showed that the range of the prevalence of musculoskeletal disorders in the lower back of bus drivers was very wide between studies, from 40 to 82% [22]. In our epidemiological study of 234 urban bus drivers, low back symptoms occurred at WBV exposure levels (0.4 ms^{-2} r.m.s.) that were lower than the health-based exposure limits proposed by the International Standard ISO 2631-1 [18].

In this study, the cumulative incidence of LBP symptoms over the follow-up period varied from 7.3% (episodes of acute LBP) to 35% (treated LBP). The cumulative incidence of all LBP symptoms was about 48%, and that of lumbar hernia detected by means of MRI was 6%. It is difficult to compare these figures with those of other studies, because the number of reports on WBV-exposed drivers based on incident data is very limited in the literature.

In summary, the findings of the present investigation, as well as those of other epidemiological studies, tend to confirm the notion that driving occupations are associated with an increased risk for LBP. The variability of the risk estimates for LBP between studies of professional drivers may be due to differences in the study design, the characteristics of the study populations, the selection of control groups, the definition of LBP outcomes, and the assessment of exposure to WBV and other physical load factors. In spite of these limitations, there is a general agreement among experts that occupational exposure to WBV is one of the most important physical load risk factor for the occurrence of work-related low back disorders [7, 8, 11, 28].

The epidemiological findings of an excess risk for LBP outcomes in the WBV-exposed professional drivers of this longitudinal study seem to be consistent with the experimental findings of WBV laboratory investigations and biodynamic modelling reported in VIBRISKS WP6. Combining experimental laboratory data, field measurements of WBV, posture, and anthropometry, as well as FE-modelling based on real anatomy, an increased risk of fatigue failure of the vertebral endplate due to repeated compression may be predicted for workers driving forklift trucks in paper mills and dockyards, and forklift trucks, wheel loaders, and truck excavators in marble quarries and laboratories surveyed in this epidemiological study.

According to annex B to International Standard ISO 2631-1 ("Guide to the effects of vibration on health"), "*increased duration (within the working day or daily over years) and increased vibration intensity mean increased vibration dose and are assumed to increase the risk, while periods of rest can reduce the risk. There are not sufficient data to show a quantitative relationship between vibration exposure and risk of health effects. Hence, it is not possible to assess* *whole-body vibration in terms of the probability of risk at various exposure magnitudes and durations*" [18]. The ISO statement is based on the results of some scientific reviews which concluded for the existence of a strong association between WBV exposure and disorders of the lumbar spine, but also pointed out that the cross-sectional design of most of the published epidemiological studies, as well as the heterogeneity of the reported risk estimates for LBP disorders, hampered to draw a clear relationship between occupational exposure to WBV and the occurrence of adverse health effects on the lower back [2, 4, 6]. Some authors have argued that, although dose-response trend were seen in several epidemiological studies, the observed effect might be due to exposure to either WBV or other physical load factors since driving occupations involve prolonged sitting in a constrained posture, non-neutral movements while driving, and sometimes weight lifting and carrying [2, 7, 11]. Therefore, it may be difficult to differentiate the relative role of WBV and other physical load factors in the aetiology of low back disorders and pathological changes in the spinal system of drivers [7].

In this study, we attempted to explore some preliminary elements of dose-response relationship for LBP outcomes by pooling exposure and health data from the whole driver population. Moreover, we examined the accuracy of the prediction of the outcomes using alternative measures of vibration exposure as explanatory variables while adjusting for other risk factors known to be potentially associated with the occurrence of low back disorders.

In this study, multivariate data analysis showed that the currently recommended measures of daily vibration exposure, $A(8)$ or VDV, were poorly associated with most of the LBP outcomes, expect for sciatic pain and LBP disability. Duration of exposure in terms of total driving hours ($\sum[t_i]$) was a better predictor of LBP than full-time driving years. Of the several measures of cumulative vibration dose computed from weighted acceleration magnitude (a_{wsi} *or* a_{wqi}) and total driving hours (ti), dose measures which gives equal weight to a_i and t_i, i.e. $\sum[a_{\mathrm{wsi}}t_{\mathrm{i}}]$ and $\sum[a_{\mathrm{wqi}}t_{\mathrm{i}}]$, were significantly associated with several LBP outcomes investigated in this study. Some significant associations were also found between dose $\sum[a_{wqi}^2 t_i]$ and selected LBP outcomes (12-month sciatic pain, high intensity pain in the lower back, LBP disability). Based on the LR and BIC statistics, as well on the patterns of the ORs, in general lifetime exposure duration (total driving hours, $\sum[t_i]$) gave better predictions for 12-month LBP and sciatic pain than dose measures obtained by combining weighted acceleration magnitude and total exposure duration. On the other hand, dose measures of the form $\sum[a_{wqi} t_i]$ and $\sum[a_{wqi}^2 t_i]$ were better predictors of LBP disability than dose determined solely by lifetime exposure duration (without consideration of the vibration magnitude).

The weak association between daily vibration exposure, $A(8)$ or VDV, and LBP in the drivers of this study may depend on the chronic nature of low back symptoms or disorders whose appearance and development require a gradual accumulation of vibration-induced injuries over time. This may explain our findings that measures of vibration dose which include lifetime exposure duration were better predictors of LBP than a dose measure, such as $A(8)$ or VDV, that takes into account only current daily exposure time. Laboratory studies have provided biological plausibility for the chronic effects of vibration on the anatomical structures of the spine. Vibration can provoke spinal pathology through mechanical damage and interference with tissue nutrition which lead to degeneration and microfracturing of the vertebral end-plates, increase of intradiscal pressure, and rupture of disc fibres [32, 33]. Moreover, electromyographic studies have shown than vibration exposure can induce fatigue and exhaustion of the paravertebral muscles of the lower back resulting in increased instability of the lumbar tract of the spine [32].

In this study, non-neutral trunk postures while driving were significant predictors of LBP. A physical load index, derived from combining manual materials handling and awkward postures, was significantly related (on a log-scale) to various LBP outcomes. After adjusting for vibration exposure and other individual and work-related risk factors, the excess risk of LBP was significantly increased for hard and very hard physical load grade when compared with mild grade. These findings are consistent with those of several epidemiological studies, reviews and meta-analyses which concluded that there is a strong evidence for a positive relationship between (low) back disorders and lifting loads, frequent trunk bending and twisting, and WBV exposure at workplace [7, 8, 11, 28, 30, 32]. This view is also supported by the findings of experimental investigations which showed that non-neutral trunk postures can combine with seated WBV exposure to increase the risk of degenerative changes in the spine [1, 3, 9, 32]. On the contrary, in this study prolonged sitting in an unconstrained posture was not associated with LBP and this is consistent with the finding that sitting-while-working is poorly correlated with low back symptoms [34].

In our study, daily and lifetime exposure durations were determined by interviewing employees and employers. As a result, recall bias cannot be ruled out. However, a recent national survey in Great Britain [35] has shown a good agreement between reported and observed duration of exposure to WBV in a sample of drivers of industrial and agricultural machines (median ratio of reported to observed time: 1.1). In our study, personal time schedules were available for drivers employed in public utilities, and this allowed a more objective estimation of daily exposure duration for these job categories. Vibraton doses were estimated on the basis of exposure duration (total hours) in current jobs and this may have lead to understimation of cumulative vibration exposure in drivers with previous jobs with WBV exposure. To adjust, at least partially, for this exposure bias, years of previous employment as a driver were included as an independent variable in multivariate logistic data analysis. Dose models showed that total exposure duration (in hours) was a better predictor of LBP outcomes than exposure duration in full-time driving years, suggesting that lifetime exposure in hours discriminates between short and prolonged daily exposure time. A further uncertainty in the estimation of lifetime vibration exposure may arise because vibration measurements were made on currently available machines or vehicles, even though a limited number of vibration measurements were also performed on old machinery, mainly in dockyards.

Nevertheless, the weighted r.m.s. acceleration magnitude of vibration measured in the vehicles of the present study are highly comparable with those reported in recent and past investigations [1-3, 21, 24, 26, 27].

In this study, work-related physical loading other than mechanical vibration was evaluated by a mixed approach based on both direct observation of working conditions and subjective judgement of the frequency and duration of awkward postures and heavy manual work. Since the association between LBP outcomes and physical load risk factors was evaluated mainly on the basis of self-reported working postures and manual material handling, potential bias for spurious associations between exposures and symptoms cannot be ruled out. Previous studies, however, found that individuals with musculoskeletal disorders did not tend to overestimate their physical work load when questionnaire data were compared with systematic observations [36]. Moreover, ergonomic investigations have shown a good agreement between self-reported and observed frequency, duration, and magnitude of physical demands [37]. Although the role of the questionnaire as an instrument for assessing occupational physical stressors is still controversial [38-40], questionnaire methods may offer benefits for studying cumulative exposure over time, a variable which cannot be estimated by direct observations or measurements [41].

This study showed no clear relationship between LBP outcomes and work-related psychosocial factors. After adjustment for age, the occurrence of 7-day and 12-month LBP was marginally associated with job decision. Job dissatisfaction showed some positive, not significant, trend with various LBP outcomes. Multivariate data analysis did not show substantial changes in the associations. The link between (low) back symptoms and psychosocial factors at work is still a controversial matter. In a series of reviews and meta-analyses conducted by Dutch investigators, it was concluded for a positive evidence of low workplace social support, low job satisfaction, and low job decision latitude as risk factors for musculoskeletal disorders (back pain included), even though the magnitude of this evidence varied across different studies and study designs [10, 11, 28, 42]. On the contrary, a recent systematic review of 40 prospective cohort studies found moderate evidence for no positive association between perception of work, organisational aspects of work, and social support at work and LBP, as well as insufficient evidence for a positive association between stress at work and LBP [43]. Similar findings, even in a more negative direction, were reported for the association between workplace psychosocial factors and consequences of LBP (sick leave, delayed return to work, disability pension, etc.). The authors pointed out the heterogeneity of the reviewed studies, mainly with reference to the different definitions of LBP and psychosocial factors used in the various investigations, the variety of instruments to collect exposure and outcome data, and the lack of standardisation for the metric utilised to quantify psychosocial variables. By the light of these major methodological problems, and considering that the possible aetiological mechanisms are poorly understood, the reviewers concluded that randomness for the associations reported in some studies cannot be excluded. The findings of the present prospective cohort study tend to support the conclusion of a weak association between work-related psychosocial factors and LBP outcomes in a population of WBV-exposed drivers.

5. Conclusion

This prospective cohort study tends to confirm that professional driving in industry and public utilities is associated with an increased risk of work-related LBP. Occupational exposure to WBV and physical loading factors at work are important components of the multifactorial origin of LBP in professional drivers. In multivariate data analysis, individual characteristics (e.g. age, body mass index) and back trauma were also significantly associated with LBP outcomes, while psychosocial work factors (e.g. job decision, job support) showed a marginal relation to LBP.

These findings are consistent with the prediction of spinal stress suggested by the experimental investigations conducted in VIBRISKS WP6.

Even though the follow-up period of this prospective study may be considered too short for health outcomes with possible long time latency such as LBP, nevertheless our findings of may contribute to improve knowledge of the exposure-response relationship between whole-body vibration and the occurrence of low back disorders, and to advance understanding of the other physical and psychosocial factors that combine to result in the progression of low back symptoms.

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Table 1. Distribution of the study populations investigated at both cross-sectional (2003-2004) and follow-up surveys (2004-2006) by industry and machinery in Italy (n=317) .

Industry	Number of drivers	Machine/vehicle
Marble quarries	76	Wheel loader Excavator Track-type loader Articulated truck Rock crusher Off-road car
Marble laboratories	43	Fork-lift truck Mobile crane
Dockyards	32	Container stake truck Fork-lift truck Freight-container tractor
Paper mills	32	Fork-lift truck
Public utilities	50	Garbage truck Garbage compactor Track-type loader
Public transport	84	Bus

Table 2. Frequency-weighted root-mean-square (r.m.s.) acceleration magnitude (a_w) of vibration measured in the *x*-, *y*-, and *z*-directions on the seat of industrial machines and vehicles. The vibration total value of frequency-weighted r.m.s. accelerations (a_v) is calculated according to International Standard ISO 2631-1 (1997). Data are given as means (standard deviations).

Machine/vehicle	Sector	Number of vehicles measured	Frequency-weighted acceleration magnitude			
			a_{wx} (ms^{-2} r.m.s.)	a_{wy} (ms^{-2} r.m.s.)	a_{wz} (ms^{-2} r.m.s.)	a_v (ms^{-2} r.m.s.)
Wheel loader	Marble quarries	6	0.21 (0.04)	0.25 (0.06)	0.35 (0.09)	0.57 (0.11)
Excavator	Marble quarries	4	0.24 (0.10)	0.20 (0.10)	0.52 (0.11)	0.69 (0.19)
Rock crusher	Marble quarries	1	0.07 (0.01)	0.07 (0.02)	0.66 (0.07)	0.67 (0.12)
Articulated truck	Marble quarries	1	0.14 (0.04)	0.18 (0.10)	0.38 (0.12)	0.50 (0.15)
Off-road car	Marble quarries	1	0.33 (0.08)	0.38 (0.09)	0.85 (0.10)	1.1 (0.11)
Mobile crane	Marble laboratories	5	0.06 (0.01)	0.07 (0.02)	0.29 (0.06)	0.32 (0.06)
Fork-lift truck	Marble laboratories	5	0.30 (0.03)	0.28 (0.07)	0.95 (0.12)	1.1 (0.10)
Fork-lift truck	Paper mill	8	0.11 (0.02)	0.11 (0.02)	0.28 (0.05)	0.36 (0.04)
Fork-lift truck	Dockyard	8	0.20 (0.08)	0.15 (0.06)	0.40 (0.14)	0.54 (0.17)
Track-type loader	Dockyard	3	0.29 (0.15)	0.30 (0.15)	0.49 (0.26)	0.76 (0.39)
Freight-container tractor	Dockyard	1	0.16 (0.01)	0.21 (0.01)	0.57 (0.03)	0.68 (0.03)
Garbage truck	Public utilities	5	0.10 (0.02)	0.10 (0.02)	0.24 (0.03)	0.31 (0.03)
Garbage compactor	Public utilities	1	0.08 (0.02)	0.12 (0.06)	0.21 (0.02)	0.29 (0.05)
Bus	Public transport	18	0.07 (0.02)	0.09 (0.04)	0.30 (0.09)	0.34 (0.10)

Table 3. Characteristics of the study populations at the cross-sectional survey. Data are given as means (standard deviations) for age and anthropometric characteristics, or as numbers (%) for smoking, drinking, marital status, education and physical activity.

	Driver groups					
	Marble quarries (n=76)	Marble laboratories (n=43)	Dockyards (n=32)	Paper mills (n=32)	Public utilities (garbage) (n=50)	Public transport (bus) (n=84)
Age (yr)	41.3 (8.5)	41.4 (9.9)	37.4 (7.0)	40.4 (7.9)	41.9 (8.4)	42.8 (6.4)[b]
Height (cm)	176 (7.1)	174 (6.7)	175 (5.7)	174 (5.2)	174 (8.2)	177 (6.1)[a]
Weight (kg)	82.1 (12.9)	84.5 (21.0)	79.2 (12.7)	78.0 (8.5)	84.7 (14.5)	83.0 (11.3)
Body mass index (kg/m^2)	26.6 (3.6)	27.7 (6.3)	25.9 (3.7)	25.8 (2.6)	27.9 (3.9)	26.4 (3.3)[a]
Smoking (n): never	37 (48.7)	14 (32.6)	15 (46.9)	14 (43.8)	18 (36.0)	45 (53.6)
ex-smokers	18 (23.7)	11 (25.6)	7 (21.9)	7 (21.9)	17 (34.0)	17 (20.2)
current smokers	21 (27.6)	18 (41.9)	10 (31.3)	11 (34.4)	15 (30.0)	22 (26.2)
Drinking (n)	49 (64.5)	33 (76.7)	23 (71.9)	23 (71.9)	38 (76.0)	45 (53.6)[c]
Married (n)	63 (82.9)	34 (79.1)	23 (71.9)	20 (62.5)	40 (80.0)	60 (71.4)
Education (n): ≤ 6 yr	9 (11.8)	5 (11.6)	0 (0)	0 (0)	6 (12.0)	2 (2.4)
7-12 yr	46 (60.5)	33 (76.7)	23 (71.9)	6 (18.8)	40 (80.0)	55 (65.5)
>12 yr	21 (27.6)	5 (11.6)	9 (28.1)	26 (81.3)	4 (8.0)	27 (32.1)[c]
Physical activity (n): never	36 (47.4)	33 (76.7)	11 (34.4)	13 (40.6)	23 (46.0)	25 (30.0)
<1 per week	7 (9.2)	1 (2.3)	4 (12.5)	4 (12.5)	7 (14.0)	17 (20.2)
1-2 per week	23 (30.3)	5 (11.6)	11 (34.4)	7 (21.9)	11 (22.0)	27 (32.1)
≥3 per week	10 (13.1)	4 (9.3)	6 (18.7)	8 (25.0)	9 (18.0)	15 (17.8)[c]

F test (one-way ANOVA): [a]*p*<0.05; [b]*p*<0.01
Chi-square test: [c]*p*<0.01

Table 4a. Measures of daily exposure to whole-body vibration (WBV) in the professional drivers at the cross-sectional survey (see text for definitions of WBV exposure). Data are given as means (standard deviations). Previous jobs with WBV exposure are given as numbers (%).

Measures of daily vibration exposure	Driver groups					
	Marble quarries (n=76)	Marble laboratories (n=43)	Dockyards (n=32)	Paper mills (n=32)	Public utilities (garbage) (n=50)	Public transport (bus) (n=84)
Daily driving time (h)	6.1 (2.7)	4.2 (3.2)	6.7 (1.4)	6.8 (1.7)	5.5 (0.9)	6.0 (0.9)[a]
$A_v(8)$ (ms^{-2} r.m.s.)	0.61 (0.19)	0.50 (0.27)	0.42 (0.06)	0.33 (0.05)	0.28 (0.04)	0.29 (0.03)[a]
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.41 (0.14)	0.41 (0.23)	0.29 (0.06)	0.26 (0.04)	0.21 (0.03)	0.26 (0.03)[a]
VDV_{sum} ($ms^{-1.75}$)	12.4 (3.3)	11.6 (4.3)	11.8 (0.7)	7.5 (0.6)	5.5 (0.5)	5.9 (0.5)[a]
VDV_{dom} ($ms^{-1.75}$)	10.9 (3.3)	10.8 (4.3)	11.5 (0.7)	7.0 (0.6)	5.1 (0.4)	5.8 (0.5)[a]
Previous jobs with WBV exposure (n)	22 (29.0)	13 (30.2)	11 (34.4)	9 (28.1)	38 (76.0)	53 (63.1)[b]

Kruskall-Wallis one-way analysis of variance: [a]$p<0.001$; chi-square test: [b]$p<0.01$

Table 4b. Measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers at the cross-sectional survey (see text for definitions of cumulative WBV exposure). Data are given as medians (quartiles).

Measures of cumulative WBV exposure	Driver groups					
	Marble quarries (n=76)	Marble laboratories (n=43)	Dockyards (n=32)	Paper mills (n=32)	Public utilities (garbage) (n=50)	Public transport (bus) (n=84)
Duration of exposure (yr)	14 (7 – 23)	10 (2 – 18)	13 (2 – 21)	5 (0.2 – 9)	7 (2 – 9)	18 (7 – 23)
$\sum[t_i]$ (h $\times 10^3$)	15.1 (4.8 – 27.7)	7.2 (2.4 – 15.1)	18.6 (3.8 – 30.2)	13.4 (6.0 – 23.7)	8.6 (3.0 – 11.5)	25.2 (8.1 – 32.6)[a]
$\sum[a_{wsi}t_i]$ (ms^{-2}h $\times 10^3$)	9.9 (3.6 – 21.3)	5.4 (1.9 – 9.7)	8.4 (1.7 – 13.6)	4.8 (2.2 -8.5)	2.9 (1.2 – 3.8)	8.6 (2.8 – 11.1)[a]
$\sum[a_{wsi}^2t_i]$ (m^{2}s^{-4}h $\times 10^3$)	6.9 (2.8 – 15.4)	3.0 (1.4 – 9.9)	3.8 (0.8 – 6.1)	1.7 (0.8 – 3.1)	1.0 (0.4 – 1.4)	2.9 (0.9 – 3.8)[a]
$\sum[a_{wsi}^4t_i]$ (m^{4}s^{-8}h $\times 10^3$)	3.8 (1.4 – 9.6)	2.2 (0.6 – 10.9)	0.8 (0.2 – 1.2)	0.2 (0.1 – 0.4)	0.09 (0.04 – 0.2)	0.3 (0.1 – 0.4)[a]
$\sum[a_{wqi}t_i]$ (ms^{-2}h $\times 10^3$)	14.0 (4.9 – 29.7)	7.5 (2.7 – 16.2)	17.8 (3.7 – 28.9)	8.1 (3.6 – 14.2)	3.9 (1.5 – 5.3)	12.3 (4.0 – 16.0)[a]
$\sum[a_{wq}{}^2{}_it_i]$ (m^{2}s^{-4}h $\times 10^3$)	15.7 (5.3 – 33.8)	5.6 (2.6 – 18.4)	16.9 (3.5 – 27.5)	4.9 (2.2 – 8.6)	1.9 (0.8 – 2.6)	6.0 (2.0 – 7.8)[a]
$\sum[a_{wqi}^4t_i]$ (m^{4}s^{-8}h $\times 10^3$)	18.4 (4.5 – 44.3)	7.6 (2.0 – 40.2)	15.4 (3.2 – 25.1)	1.8 (0.8 – 3.1)	0.4 (0.2 – 0.6)	1.5 (0.5 – 1.9)[a]

Kruskall-Wallis one-way analysis of variance: [a]p<0.001

Table 5. Point prevalence at baseline (2003-04), period prevalence (2003-06) and cumulative incidence (2004-06) of low back pain (LBP) symptoms in the professional drivers with complete follow up (n=317). Data are given as numbers (%).

Outcome	Point prevalence (2003-04)	Period prevalence (2003-06)	Cumulative incidence (2004-06)
LBP in the previous 7 days	55 (17.4)	89 (28.1)	34 (13.0)
LBP in the previous 12 months	127 (40.1)	184 (58.0)	57 (30.0)
Episodes of acute LBP in the previous 12 months	43 (13.6)	63 (19.9)	20 (7.3)
Episodes of sciatica in the previous 12 months	70 (22.1)	133 (42.0)	63 (25.5)
Any low back symptoms in the previous 12 months	204 (64.4)	258 (81.4)	54 (47.8)
Duration of LBP > 30 d in the previous 12 months	21 (6.6)	55 (17.4)	34 (11.5)
High pain intensity in the lower back in the previous 12 months (Von Korff pain score > 5)	91 (28.7)	156 (49.2)	65 (28.8)
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	61 (19.2)	122 (38.5)	61 (23.8)
Visit to a doctor for LBP in the previous 12 months	95 (30.0)	164 (51.7)	69 (31.1)
LBP treated with medication and/or physical therapy in the previous 12 months	79 (24.9)	162 (51.1)	83 (34.9)
LBP sick leave > 7 d in the previous 12 months	40 (12.6)	65 (20.5)	25 (9.0)
LBP sick leave > 15 d in the previous 12 months	10 (3.2)	26 (8.2)	16 (4.9)
Back trauma	18 (5.7)	28 (8.8)	10 (3.3)
Lumbar discopathy (self reported)	43 (13.6)	83 (26.2)	40 (14.6)
Lumbar hernia (self-reported)	34 (10.7)	52 (16.4)	18 (6.4)
Lumbar hernia (MRI)	32 (10.1)	49 (15.5)	17 (6.0)

Table 6a. Random-intercept logistic regression for the association between low back pain (LBP) symptoms (7-day LBP, 12-month LBP, high pain intensity in the lower back (Von Korff pain scale score > 5) during the previous 12 months, disability (Roland & Morris disability scale score ≥ 12) during the last episode of LBP) and various individual and work-related risk factors in the professional drivers (n=317) over two-year follow-up period. Odds ratios (OR) and 95% confidence intervals (95% CI) are adjusted by age and survey.

Factors		7-day LBP	12-month LBP	High pain intensity	LBP disability
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (yr)	≤35	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	36-41	1.63 (0.78-3.42)	0.80 (0.40-1.60)	1.11 (0.54-2.31)	2.79 (1.20-6.50)
	42-48	1.29 (0.60-2.80)	0.70 (0.34-1.46)	0.69 (0.32-1.51)	2.02 (0.84-4.89)
	>48	1.62 (0.74-3.55)	0.72 (0.33-1.56)	0.77 (0.34-1.75)	2.10 (0.82-5.40)
BMI (kg/m^2)	<25	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	25-27	1.11 (0.60-2.05)	0.80 (0.46-1.42)	1.35 (0.73-2.50)	1.14 (0.56-2.29)
	>27	0.98 (0.51-1.87)	0.63 (0.34-1.18)	2.04 (1.04-4.01)	2.78 (1.33-5.81)
Smoking	no smoking	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	ex-smoker	1.12 (0.59-2.12)	0.76 (0.40-1.46)	0.98 (0.49-1.96)	1.0 (0.47-2.12)
	current smoker	1.08 (0.59-1.99)	0.99 (0.54-1.82)	0.63 (0.32-1.22)	0.62 (0.30-1.29)
Drinking (unit/week)	0	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	1-3	0.81 (0.45-1.46)	0.98 (0.56-1.73)	1.42 (0.77-2.59)	1.23 (0.62-2.42)
	4-6	0.50 (0.17-1.48)	1.71 (0.70-4.19)	2.10 (0.78-5.63)	3.08 (1.10-8.60)
	>6	1.0 (0.48-2.07)	1.18 (0.57-2.48)	2.50 (1.16-5.39)	2.17 (0.92-5.11)
Education (yr)	≤ 6	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	7-12	1.50 (0.50-4.52)	2.0 (0.64-6.27)	2.66 (0.77-9.22)	1.58 (0.42-6.01)
	>12	1.12 (0.34-3.74)	3.40 (0.99-11.6)	2.39 (0.63-9.03)	1.60 (0.38-6.74)
Physical activity	never	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	< 1/week	1.14 (0.56-2.32)	1.50 (0.78-2.87)	1.43 (0.72-2.82)	0.86 (0.40-1.82)
	1-2/week	1.18 (0.65-2.14)	0.99 (0.56-1.75)	1.11 (0.61-2.05)	0.82 (0.43-1.60)
	3-5/week	0.45 (0.17-1.17)	0.74 (0.34-1.59)	1.30 (0.59-2.86)	0.55 (0.22-1.37)
	everyday	1.40 (0.41-4.82)	0.77 (0.23-2.60)	0.90 (0.23-3.46)	0.32 (0.05-1.87)
Married	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	0.85 (0.46-1.59)	1.56 (0.82-2.95)	1.68 (0.84-3.35)	1.21 (0.57-2.53)
Car driving (km/yr)	<8000	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	8-24000	0.83 (0.47-1.46)	1.32 (0.76-2.31)	0.83 (0.46-1.50)	0.47 (0.25-0.90)
	>24000	0.53 (0.18-1.52)	0.75 (0.28-2.03)	0.74 (0.26-2.13)	0.38 (0.12-1.21)
Previous jobs with	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
WBV exposure	yes	1.25 (0.75-2.11)	1.02 (0.60-1.75)	1.17 (0.66-2.06)	1.27 (0.68-2.37)
Previous job with	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
heavy physical load	yes	1.85 (0.99-3.45)	1.76 (0.90-3.45)	1.34 (0.65-2.76)	0.97 (0.44-2.18)
Sitting > 3h at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.13 (0.20-6.46)	0.69 (0.16-2.88)	0.83 (0.17-4.08)	0.23 (0.03-1.67)
Trunk bent at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.0 (0.60-1.63)	1.28 (0.83-1.98)	1.28 (0.81-2.03)	1.51 (0.92-2.49)
Trunk twisted at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.31 (0.79-2.19)	1.22 (0.78-1.91)	1.34 (0.84-2.15)	1.51 (0.91-2.51)
Lifting at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	0.76 (0.34-1.69)	0.60 (0.30-1.18)	0.65 (0.33-1.30)	0.81 (0.38-1.72)
Lifting & bending	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
at work	yes	0.93 (0.55-1.55)	1.02 (0.64-1.63)	1.15 (0.71-1.86)	1.47 (0.87-2.49)
Lifting & twisting	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
at work	yes	1.08 (0.61-1.93)	0.84 (0.50-1.41)	1.55 (0.91-2.65)	2.18 (1.23-3.85)
Back bent forward or	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
twisted while driving	yes	1.95 (1.09-3.47)	1.29 (0.82-2.02)	1.91 (1.17-3.12)	1.73 (1.00-2.95)

Table 6b. Random-intercept logistic regression for the association between low back pain (LBP) symptoms in the previous 12 months (acute LBP, sciatica, treated LBP, sick leave due to LBP) various individual and work-related risk factors in the professional drivers (n=317) over two-year follow-up period. Odds ratios (OR) and 95% confidence intervals (95% CI) are adjusted by age and survey.

Factors		Acute LBP	Sciatica	Treated LBP	Sick leave (>7 days)
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (yr)	≤35	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	36-41	2.35 (0.83-6.66)	3.11 (1.36-7.12)	1.89 (0.85-4.22)	1.97 (0.73-5.27)
	42-48	3.18 (1.10-9.19)	2.32 (0.98-5.54)	1.92 (0.84-4.43)	2.51 (0.92-6.89)
	>48	1.76 (0.56-5.54)	1.92 (0.75-4.89)	1.94 (0.80-4.70)	1.43 (0.48-4.30)
BMI (kg/m^2)	<25	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	25-27	0.87 (0.71-1.87)	1.74 (0.89-3.40)	1.49 (0.79-2.82)	0.63 (0.25-1.60)
	>27	2.45 (1.02-5.88)	1.77 (0.85-3.66)	1.99 (0.99-3.99)	4.98 (2.13-11.6)
Smoking	no smoking	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	ex-smoker	1.06 (0.45-2.52)	1.56 (0.75-3.24)	1.21 (0.59-2.47)	1.35 (0.57-3.20)
	current smoker	0.74 (0.31-1.74)	0.58 (0.28-1.20)	0.59 (0.29-1.18)	1.24 (0.55-2.82)
Drinking (unit/week)	0	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	1-3	0.93 (0.41-2.11)	1.09 (0.57-2.10)	2.19 (1.16-4.13)	1.76 (0.80-3.88)
	4-6	2.03 (0.59-6.99)	1.19 (0.41-3.43)	4.72 (1.72-12.9)	1.81 (0.53-6.24)
	>6	1.82 (0.68-4.85)	1.81 (0.79-4.15)	2.10 (0.92-4.77)	1.58 (0.57-4.38)
Education (yr)	≤ 6	1.0 (-)	1.0 (-)	1.0 (-)	0.0 (-)
	7-12	1.88 (0.37-9.45)	1.91 (0.50-7.15)	1.41 (0.41-4.90)	5.55 (0.80-38.4)
	>12	2.16 (0.39-11.9)	0.98 (0.24-4.09)	0.94 (0.25-3.62)	2.80 (0.37-21.4)
Physical activity	never	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	< 1/week	1.98 (0.79-4.98)	1.16 (0.56-2.42)	0.97 (0.47-1.99)	0.76 (0.29-1.97)
	1-2/week	1.80 (0.82-3.97)	1.01 (0.53-1.93)	0.67 (0.36-1.26)	0.99 (0.46-2.16)
	3-5/week	0.48 (0.13-1.71)	0.90 (0.38-2.15)	0.70 (0.30-1.61)	1.17 (0.42-3.24)
	everyday	2.77 (0.58-13.3)	0.71 (0.16-3.08)	0.25 (0.05-1.19)	0.42 (0.06-3.01)
Married	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	0.65 (0.28-1.52)	1.28 (0.62-2.67)	1.20 (0.59-2.44)	1.03 (0.45-2.38)
Car driving (km/yr)	<8000	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	8-24000	0.91 (0.42-1.96)	0.61 (0.33-1.13)	0.82 (0.45-1.49)	1.02 (0.48-2.16)
	>24000	1.04 (0.27-3.99)	0.50 (0.16-1.60)	1.79 (0.62-5.21)	0.68 (0.18-2.67)
Previous jobs with	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
WBV exposure	yes	0.97 (0.48-1.99)	1.37 (0.75-2.53)	1.30 (0.72-2.36)	0.75 (0.37-1.51)
Previous job with	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
heavy physical load	yes	1.07 (0.42-2.70)	0.66 (0.29-1.47)	1.12 (0.53-2.39)	0.73 (0.29-1.86)
Sitting > 3h at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	2.16 (0.29-16.0)	0.27 (0.04-2.05)	0.14 (0.02-1.08)	-
Trunk bent at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.04 (0.55-1.97)	1.31 (0.80-2.12)	1.27 (0.88-2.30)	1.49 (0.81-2.74)
Trunk twisted at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.20 (0.63-2.30)	1.53 (0.94-2.50)	1.31 (0.81-2.11)	1.23 (0.65-2.33)
Lifting at work	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
	yes	1.17 (0.46-2.99)	1.29 (0.64-2.58)	0.65 (0.31-1.34)	0.87 (0.34-2.22)
Lifting & bending	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
at work	yes	1.06 (0.55-2.05)	1.34 (0.81-2.23)	1.80 (1.09-2.98)	1.16 (0.62-2.19)
Lifting & twisting	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
at work	yes	1.35 (0.66-2.77)	1.47 (0.84-2.56)	2.36 (1.36-4.12)	1.78 (0.89-3.57)
Back bent forward or	no	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
twisted while driving	yes	1.77 (0.88-3.56)	2.18 (1.28-3.72)	1.80 (1.09-2.97)	1.14 (0.59-2.20)

Table 7a. Random-intercept logistic regression for the association between low back pain (LBP) symptoms (7-day LBP, 12-month LBP, high pain intensity in the lower back (Von Korff pain scale score > 5) during the previous 12 months, disability (Roland & Morris disability scale score ≥ 12) during the last episode of LBP) and psychosocial factors in the professional drivers (n=317) over two-year follow-up period. Odds ratios (OR) and 95% confidence intervals (95% CI) are adjusted by age and survey.

Factor	7-day LBP	12-month LBP	High pain intensity	LBP disability
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Job decision:				
(i) how to do your work:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	0.78 (0.39-1.56)	1.50 (0.85-2.66)	0.75 (0.40-1.43)	0.97 (0.49-1.93)
seldom	0.53 (0.18-1.61)	0.56 (0.26-1.41)	1.24 (0.50-3.06)	1.74 (0.66-4.62)
never/almost never	1.40 (0.75-2.62)	1.41 (0.78-2.57)	1.33 (0.70-2.53)	1.30 (0.64-2.64)
(ii) what to do at work:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	0.90 (0.42-1.94)	2.61 (1.38-4.96)	0.49 (0.23-1.03)	0.42 (0.19-0.96)
seldom	1.04 (0.37-2.88)	0.86 (0.35-2.08)	1.20 (0.49-2.92)	0.80 (0.30-2.13)
never/almost never	1.93 (1.10-3.41)	2.21 (1.28-3.82)	1.33 (0.75-2.37)	1.19 (0.63-2.25)
(iii) timetable & breaks:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	0.84 (0.40-1.75)	1.52 (0.80-2.90)	1.29 (0.64-2.61)	0.83 (0.39-1.74)
seldom	0.51 (0.16-1.66)	0.61 (0.24-1.58)	1.48 (0.56-3.94)	0.89 (0.31-2.54)
never/almost never	1.60 (0.85-3.01)	1.32 (0.74-2.34)	1.77 (0.94-3.31)	1.24 (0.63-2.42)
Job support:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	1.19 (0.67-2.14)	1.14 (0.67-1.94)	1.04 (0.60-1.82)	1.24 (0.67-2.30)
seldom	1.04 (0.35-3.08)	1.45 (0.57-3.73)	3.90 (1.45-10.5)	2.75 (0.97-7.84)
never	0.62 (0.11-3.45)	0.43 (0.10-1.90)	1.20 (0.27-5.40)	0.46 (0.08-2.62)
Job satisfaction:				
very satisfied	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
satisfied	2.52 (1.38-4.60)	1.36 (0.82-2.26)	0.82 (0.48-1.42)	1.06 (0.57-1.94)
dissatisfied	0.99 (0.35-2.79)	0.79 (0.35-1.77)	1.20 (0.53-2.75)	3.43 (1.39-8.48)
very dissatisfied	-	0.44 (0.05-3.64)	2.85 (0.39-20.9)	2.25 (0.29-17.7)

Table 7b. Random-intercept logistic regression for the association between low back pain (LBP) symptoms in the previous 12 months (acute LBP, sciatica, treated LBP, sick leave due to LBP) and psychosocial factors in the professional drivers (n=407) over one-year follow-up period. Odds ratios (OR) and 95% confidence intervals (95% CI) are adjusted by age and follow-up time.

Factor	Acute LBP	Sciatica	Treated LBP	Sick leave (>7 days)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Job decision:				
(i) how to do your work:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	1.51 (0.65-3.51)	0.62 (0.31-1.25)	0.63 (0.32-1.22)	0.91 (0.41-2.03)
seldom	1.53 (0.47-5.02)	2.18 (0.86-5.51)	1.35 (0.53-3.47)	1.10 (0.34-3.52)
never/almost never	1.84 (0.81-4.19)	1.28 (0.65-2.50)	1.66 (0.86-3.18)	0.43 (0.17-1.08)
(ii) what to do at work:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	0.34 (0.11-1.07)	0.31 (0.13-0.71)	0.61 (0.29-1.27)	0.47 (0.18-1.22)
seldom	0.75 (0.19-2.96)	1.66 (0.65-4.23)	0.75 (0.29-1.93)	1.28 (0.43-3.81)
never/almost never	1.72 (0.82-3.57)	0.84 (0.45-1.56)	1.25 (0.69-2.27)	0.50 (0.23-1.07)
(iii) timetable & breaks:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	0.74 (0.29-1.93)	0.70 (0.33-1.50)	0.82 (0.40-1.65)	0.44 (0.18-1-07)
seldom	0.30 (0.06-1.58)	2.43 (0.88-6.71)	1.11 (0.41-2.98)	0.59 (0.17-2.05)
never/almost never	1.65 (0.73-3.73)	1.80 (0.93-3.47)	1.30 (0.70-2.43)	0.62 (0.29-1.34)
Job support:				
often	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
sometimes	1.45 (0.69-3.04)	1.22 (0.68-2.21)	1.13 (0.63-2.02)	0.61 (0.27-1.37)
seldom	1.68 (0.44-6.49)	1.70 (0.62-4.65)	2.35 (0.86-6.42)	0.97 (0.25-3.80)
never	3.66 (0.70-19.2)	1.88 (0.43-8.21)	1.65 (0.38-7.21)	1.44 (0.24-8.64)
Job satisfaction:				
very satisfied	1.0 (-)	1.0 (-)	1.0 (-)	1.0 (-)
satisfied	0.53 (0.26-1.07)	0.81 (0.45-1.44)	0.79 (0.45-1.40)	0.99 (0.48-2.04)
dissatisfied	0.97 (0.33-2.84)	2.33 (0.98-5.54)	2.61 (1.11-6.18)	2.59 (0.92-7.26)
very dissatisfied	1.28 (0.09-19.3)	3.30 (0.45-24.5)	3.74 (0.46-30.5)	7.93 (0.85-74.2)

Table 8. Random-intercept logistic regression of low back pain (LBP) symptoms (7-day LBP, 12-month LBP, and high pain intensity (Von Korff pain scale score > 5), LBP disability (Roland & Morris disability scale score ≥ 12), treated LBP, sick leave due to LBP in the previous 12 months) on groups of professional drivers over two-year follow-up period, assuming the driver group with the lowest WBV exposure (public utilities) as the reference category. Odds ratios (OR) and 95% confidence intervals (95% CI) are adjusted by age and survey. Two-year incidence of LBP outcomes (%) within each driver group is also given.

Outcome	Driver groups					
	Public utilities (garbage) (n=50)	Marble quarries (n=76)	Marble laboratories (n=43)	Dockyards (n=32)	Paper mills (n=32)	Public transport (bus) (n=84)
7-day LBP (%)	7.5	18.2	5.0	4.3	15.4	17.9
OR	1.0	1.49	0.43	1.79	1.22	1.97
(95% CI)	(-)	(0.63 – 3.48)	(0.13 – 1.39)	(0.63 – 5.08)	(0.42 – 3.54)	(0.87 – 4.47)
12-month LBP (%)	26.3	58.8	31.8	75.0	70.0	45.0
OR	1.0	1.79	0.51	5.21	2.0	4.05
(95% CI)	(-)	(0.72 – 4.40)	(0.18 – 1.43)	(1.60 – 16.9)	(0.66 – 6.09)	(1.63 – 10.0)
Acute LBP (%)	4.3	6.5	0	7.1	14.3	11.3
OR	1.0	2.91	0.57	3.42	3.16	4.34
(95% CI)	(-)	(0.82 – 10.4)	(0.11 – 3.07)	(0.74 – 15.7)	(0.70 – 14.3)	(1.26 – 14.9)
Sciatica (%)	5.0	25.8	16.7	47.6	36.0	32.2
OR	1.0	1.75	1.14	9.18	2.12	5.42
(95% CI)	(-)	(0.60 – 5.07)	(0.33 – 3.93)	(2.62 – 32.1)	(0.60 – 7.56)	(1.93 – 15.2)
High pain intensity (%)	12.1	33.9	10.3	61.9	50.0	25.9
OR	1.0	1.21	0.13	4.50	1.92	1.10
(95% CI)	(-)	(0.50 – 2.94)	(0.04 – 0.42)	(1.51 – 13.3)	(0.65 – 5.63)	(0.46 – 2.64)
LBP disability (%)	4.7	22.3	15.8	52.4	39.3	26.4
OR	1.0	6.12	1.78	30.2	5.61	3.20
(95% CI)	(-)	(2.02 – 18.6)	(0.48 – 6.54)	(8.06 – 113)	(1.50 – 20.9)	(1.06 – 9.65)
Treated LBP (%)	15.2	44.3	16.1	50.0	46.2	35.4
OR	1.0	1.54	0.81	2.80	1.16	1.60
(95% CI)	(-)	(0.59 – 4.02)	(0.26 – 2.49)	(0.86 – 9.18)	(0.35 – 3.83)	(0.62 – 4.12)
Sick leave (> 7d) (%)	4.3	13.2	10.8	11.5	7.4	6.8
OR	1.0	2.38	2.27	5.75	2.30	1.84
(95% CI)	(-)	(0.69 – 8.14)	(0.57 – 9.01)	(1.40 – 23.5)	(0.52 – 10.1)	(0.54 – 6.31)

Table 9a. Random-intercept logistic regression of low back pain in the previous 7 days on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR (95% CI)	1.0 (-)	1.13 (0.56 – 2.27)	1.32 (0.62 – 2.80)	1.56 (0.74 – 3.29)	0.99 (p=0.80)	772
$A_v(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	0.74 (0.35 – 1.58)	1.57 (0.0.78 – 3.15)	1.70 (0.0.86 – 3.37)	4.27 (p=0.23)	769
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	1.45 (0.72 – 2.91)	1.45 (0.72 – 2.91)	1.60 (0.76 – 3.36)	1.31 (p=0.73)	772
VDV_{sum} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	0.84 (0.0.42 – 1.69)	1.03 (0.49 – 2.16)	1.57 (0.76 – 3.22)	1.96 (p=0.58)	771
VDV_{dom} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	0.89 (0.44 – 1.80)	1.05 (0.49 – 2.22)	1.32 (0.65 – 2.68)	0.30 (p=0.96)	773

Table 9b. Random-intercept logistic regression of low back pain in the previous 7 days on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR (95% CI)	1.0 (-)	1.41 (0.0.68 – 2.95)	0.86 (0.40 – 1.89)	0.73 (0.29 – 1.82)	2.64 (p=0.45)	770
$\sum[t_i]$ (h)						
OR (95% CI)	1.0 (-)	1.52 (0.73 – 3.18)	2.05 (0.99 – 4.24)	0.94 (0.40 – 2.21)	6.30 (p=0.098)	767
$\sum[a_{wsi}t_i]$($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	1.24 (0.58 – 2.64)	1.51 (0.69 – 3.29)	1.48 (0.66 – 3.32)	1.29 (p=0.73)	772
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	0.60 (0.27 – 1.32)	1.23 (0.57 – 2.62)	1.37 (0.63 – 2.99)	5.13 (p=0.16)	768
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	0.75 (0.35 – 1.59)	0.96 (0.45 – 2.05)	1.24 (0.57 – 2.68)	1.79 (p=0.62)	772
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	1.37 (0.65 – 2.87)	1.55 (0.70 – 3.43)	1.41 (0.63 – 3.14)	1.30 (p=0.73)	772
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	0.85 (0.41 – 1.76)	0.89 (0.41 – 1.94)	1.64 (0.78 – 3.46)	3.15 (p=0.37)	770
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	1.33 (0.62 – 2.83)	0.77 (0.34 – 1.76)	1.86 (0.83 – 4.17)	5.51 (p=0.14)	768

Table 10a. Random-intercept logistic regression of low back pain in the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR	1.0	1.76	1.92	2.19	5.08	1161
(95% CI)	(-)	(0.91 – 3.38)	(0.93 – 3.97)	(1.05 – 4.57)	(p=0.17)	
$A_v(8)$ (ms^{-2} r.m.s.)						
OR	1.0	0.92	1.18	0.76	3.64	1163
(95% CI)	(-)	(0.47 – 1.82)	(0.60 – 2.31)	(0.37 – 1.58)	(p=0.30)	
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.0	1.63	1.39	0.74	4.64	1162
(95% CI)	(-)	(0.84 – 3.20)	(0.72 – 2.67)	(0.35 – 1.57)	(p=0.20)	
VDV_{sum} (ms$^{-1.75}$)						
OR	1.0	1.33	1.29	0.82	2.16	1163
(95% CI)	(-)	(0.67 – 2.65)	(0.60 – 2.73)	(0.37 – 1.82)	(p=0.54)	
VDV_{dom} (ms$^{-1.75}$)						
OR	1.0	1.31	1.08	0.61	3.71	1163
(95% CI)	(-)	(0.65 – 2.62)	(0.52 – 2.28)	(0.28 – 1.33)	(p=0.29)	

Table 10b. Random-intercept logistic regression of low back pain in the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR (95% CI)	1.0 (-)	1.60 (0.70 – 3.66)	1.95 (0.82 – 4.66)	1.24 (0.45 – 3.43)	2.94 (p=0.40)	1164
$\sum[t_i]$ (h)						
OR (95% CI)	1.0 (-)	1.20 (0.59 – 2.41)	3.90 (1.76 – 8.64)	2.29 (0.94 – 5.56)	13.9 (p=0.003)	1153
$\sum[a_{wsi}t_i]$($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	1.30 (0.64 – 2.62)	1.84 (0.83 – 4.06)	1.75 (0.77 – 3.98)	2.51 (p=0.47)	1164
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	1.06 (0.53 – 2.13)	1.14 (0.52 – 2.51)	1.07 (0.48 – 2.39)	0.06 (p=0.99)	1166
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	1.34 (0.64 – 2.83)	1.19 (0.54 – 2.60)	0.68 (0.30 – 1.52)	3.40 (p=0.33)	1163
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	1.46 (0.73 – 2.93)	1.98 (0.88 – 4.47)	2.11 (0.93 – 4.82)	3.67 (p=0.30)	1163
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	1.15 (0.57 – 2.30)	1.33 (0.60 – 2.92)	1.48 (0.66 – 3.36)	0.93 (p=0.82)	1166
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	1.16 (0.54 – 2.50)	0.85 (0.39 – 1.88)	0.89 (0.37 – 2.10)	0.67 (p=0.88)	1166

Table 11a. Random-intercept logistic regression of acute low back pain in the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR	1.0	1.55	2.11	1.82	2.45	652
(95% CI)	(-)	(0.61 – 3.90)	(0.79 – 5.66)	(0.66 – 5.05)	(p=0.48)	
$A_v(8)$ (ms^{-2} r.m.s.)						
OR	1.0	2.81	1.91	1.10	6.33	648
(95% CI)	(-)	(0.1.15 – 6.84)	(0.74 – 4.94)	(0.40 – 3.05)	(p=0.10)	
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.0	2.24	1.66	1.47	2.82	652
(95% CI)	(-)	(0.88 – 5.71)	(0.65 – 4.19)	(0.51 – 4.21)	(p=0.42)	
VDV_{sum} ($ms^{-1.75}$)						
OR	1.0	1.59	1.20	0.87	1.55	653
(95% CI)	(-)	(0.67 – 3.81)	(0.45 – 3.21)	(0.30 – 2.52)	(p=0.67)	
VDV_{dom} ($ms^{-1.75}$)						
OR	1.0	1.56	1.69	1.15	1.65	653
(95% CI)	(-)	(0.64 – 3.83)	(0.62 – 4.62)	(0.41 – 3.26)	(p=0.65)	

Table 11b. Random-intercept logistic regression of acute low back pain in the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR (95% CI)	1.0 (-)	1.57 (0.51 – 4.81)	2.64 (0.84 – 8.27)	3.63 (0.99 – 13.4)	4.46 (p=0.22)	650
$\sum[t_i]$ (h)						
OR (95% CI)	1.0 (-)	1.17 (0.39 – 3.45)	2.89 (1.02 – 8.19)	3.51 (1.08 – 11.4)	6.85 (p=0.08)	648
$\sum[a_{wsi}t_i]$($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	2.04 (0.69 – 6.04)	3.36 (1.13 – 10.1)	3.48 (1.12 – 10.8)	8.85 (p=0.031)	649
$\sum[a_{wsi}^2 t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	2.03 (0.71 – 5.79)	3.03 (1.03 – 8.91)	2.22 (0.72 – 6.82)	4.14 (p=0.25)	651
$\sum[a_{wsi}^4 t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	2.82 (1.01 – 7.83)	2.50 (0.88 – 7.10)	1.95 (0.64 – 5.97)	4.40 (p=0.22)	650
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR (95% CI)	1.0 (-)	1.99 (0.68 – 5.83)	3.90 (1.28 – 11.9)	3.46 (1.12 – 10.7)	6.77 (p=0.08)	648
$\sum[a_{wqi}^2 t_i]$ ($m^2s^{-4}h$)						
OR (95% CI)	1.0 (-)	1.54 (0.55 – 4.35)	3.38 (1.16 – 9.83)	2.62 (0.87 – 7.88)	5.81 (p=0.12)	649
$\sum[a_{wqi}^4 t_i]$ ($m^4s^{-8}h$)						
OR (95% CI)	1.0 (-)	2.76 (0.98 – 7.76)	1.93 (0.65 – 5 69)	2.38 (0.76 – 7.48)	3.96 (p=0.27)	651

Table 12a. Random-intercept logistic regression of sciatica in the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR	1.0	2.28	2.69	2.31	7.89	1035
(95% CI)	(-)	(1.12 – 4.63)	(1.27 – 5.66)	(1.07 – 5.01)	(p=0.048)	
$A_v(8)$ (ms^{-2} r.m.s.)						
OR	1.0	2.0	1.87	1.22	7.84	1035
(95% CI)	(-)	(1.01 – 3.98)	(0.92 – 3.84)	(0.55 – 2.69)	(p=0.049)	
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.0	3.0	2.56	1.62	10.5	1032
(95% CI)	(-)	(1.48 – 6.09)	(1.27 – 5.18)	(0.70 – 3.75)	(p=0.015)	
VDV_{sum} (ms$^{-1.75}$)						
OR	1.0	1.63	2.02	1.13	4.56	1038
(95% CI)	(-)	(0.82 – 3.24)	(0.93 – 4.40)	(0.48 – 2.70)	(p=0.21)	
VDV_{dom} (ms$^{-1.75}$)						
OR	1.0	2.29	1.71	1.07	6.65	1036
(95% CI)	(-)	(1.15 – 4.57)	(0.79 – 3.68)	(0.46 – 2.49)	(p=0.08)	

Table 12b. Random-intercept logistic regression of sciatica in the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR	1.0	1.45	4.72	3.08	14.7	1028
(95% CI)	(-)	(0.59 – 3.55)	(1.93 – 11.6)	(1.06 – 8.96)	(p=0.002)	
$\sum[t_i]$ (h)						
OR	1.0	0.86	5.49	5.82	31.5	1011
(95% CI)	(-)	(0.37 – 1.98)	(2.44 – 12.4)	(2.30 – 14.7)	(p<0.001)	
$\sum[a_{wsi}t_i]$ ($ms^{-2}h$)						
OR	1.0	1.30	5.32	4.18	19.0	1021
(95% CI)	(-)	(0.57 – 2.94)	(2.32 – 12.2)	(1.74 – 10.1)	(p<0.001)	
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	1.85	3.71	3.44	11.2	1032
(95% CI)	(-)	(0.83 – 4.09)	(1.60 – 8.58)	(1.42 – 8.31)	(p=0.01)	
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	2.40	3.08	1.38	9.80	1033
(95% CI)	(-)	(1.10 – 5.23)	(1.37 – 6.91)	(0.57 – 3.33)	(p=0.02)	
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR	1.0	0.96	4.63	4.41	22.9	1020
(95% CI)	(-)	(0.43 – 2.14)	(2.01 – 10.7)	(1.84 – 10.5)	(p<0.001)	
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	2.34	5.30	4.57	17.7	1025
(95% CI)	(-)	(1.07 – 5.14)	(2.29 – 12.3)	(1.88 – 11.1)	(p<0.001)	
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	2.96	2.66	3.23	8.43	1034
(95% CI)	(-)	(1.31 – 6.70)	(1.14 – 6.20)	(1.28 – 8.14)	(p=0.04)	

Table 13a. Random-intercept logistic regression of high pain intensity in the lower back (Von Korff pain scale score > 5) during the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR (95% CI)	1.0 (-)	1.80 (0.93 – 3.49)	1.77 (0.83 – 3.39)	2.19 (1.06 – 3.39)	4.95 (p=0.18)	1132
$A_v(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	1.07 (0.55 – 2.06)	1.65 (0.84 – 3.23)	1.12 (0.54 – 2.35)	2.89 (p=0.41)	1134
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	1.09 (0.0.57 – 2.10)	1.0 (0.52 – 1.91)	0.96 (0.45 – 2.07)	0.14 (p=0.99)	1137
VDV_{sum} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	1.03 (0.54 – 1-98)	1.28 (0.62 – 2.67)	1.12 (0.51 – 2.48)	0.49 (p=0.92)	1137
VDV_{dom} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	1.08 (0.55 – 2.11)	1.95 (0.94 – 4.06)	1.13 (0.52 – 2.47)	4.14 (p=0.25)	1133

Table 13b. Random-intercept logistic regression of high pain intensity in the lower back (Von Korff pain scale score > 5) during the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=407) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR	1.0	1.68	2.99	2.94	6.94	1130
(95% CI)	(-)	(0.72 – 3.91)	(1.26 – 7.14)	(1.05 – 8.25)	(p=0.07)	
$\sum[t_i]$ (h)						
OR	1.0	1.75	4.91	4.17	17.9	1119
(95% CI)	(-)	(0.83 – 3.66)	(2.23 – 10.8)	(1.69 – 10.3)	(p<0.001)	
$\sum[a_{wsi}t_i]$($ms^{-2}h$)						
OR	1.0	1.55	2.68	3.45	9.70	1127
(95% CI)	(-)	(0.74 – 3.23)	(1.21 – 5.94)	(1.51 – 7.92)	(p=0.021)	
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	1.67	1.69	2.34	4.32	1133
(95% CI)	(-)	(0.82 – 3.43)	(0.77 – 3.73)	(1.04 – 5.30)	(p=0.23)	
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	1.27	2.03	1.04	4.89	1132
(95% CI)	(-)	(0.62 – 2.62)	(0.96 – 4.32)	(0.46 – 2.33)	(p=0.18)	
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR	1.0	2.41	1.75	5.31	18.92	1118
(95% CI)	(-)	(1.18 – 4.95)	(0.78 – 3.93)	(2.32 – 12.1)	(p<0.001)	
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	1.75	1.74	3.79	10.5	1126
(95% CI)	(-)	(0.86 – 3.55)	(0.79 – 3.84)	(1.67 – 8.59)	(p=0.015)	
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	1.09	1.80	2.07	4.24	1133
(95% CI)	(-)	(0.51 – 2.32)	(0.82 – 3.94)	(0.88 – 4-85)	(p=0.24)	

Table 14a. Random-intercept logistic regression of disability (Roland & Morris disability scale score ≥ 12) during the last episode of LBP on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over one-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR	1.0	1.11	1.60	1.63	2.46	989
(95% CI)	(-)	(0.54 – 2.30)	(0.74 – 3.44)	(0.74 – 3.58)	(p=0.48)	
$A_v(8)$ (ms^{-2} r.m.s.)						
OR	1.0	2.13	4.10	4.16	18.9	972
(95% CI)	(-)	(0.99 – 4.55)	(1.92 – 8.78)	(1.82 – 9.50)	(p<0.001)	
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.0	1.70	1.59	2.62	5.17	986
(95% CI)	(-)	(0.81 – 3.58)	(0.76 – 3.30)	(1.13 – 6.09)	(p=0.16)	
VDV_{sum} ($ms^{-1.75}$)	5.9					
OR	1.0	1.31	3.33	2.88	9.95	981
(95% CI)	(-)	(0.63 – 2.71)	(1.49 – 7.44)	(1.21 – 6.88)	(p=0.019)	
VDV_{dom} ($ms^{-1.75}$)						
OR	1.0	1.44	2.82	2.70	7.23	984
(95% CI)	(-)	(0.69 – 3.04)	(1.26 – 6.30)	(1.15 – 6.33)	(p=0.06)	

Table 14b. Random-intercept logistic regression of disability (Roland & Morris disability scale score ≥ 12) during the last episode of LBP on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over one-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr)						
OR	1.0	2.73	4.20	2.80	9.02	982
(95% CI)	(-)	(1.07 – 6.93)	(1.63 – 10.8)	(0.91 – 8.63)	(p=0.03)	
$\sum[t_i]$ (h)						
OR	1.0	1.15	4.28	2.63	15.2	976
(95% CI)	(-)	(0.50 – 2.65)	(1.85 – 9.89)	(1.01-6.83)	(p<0.005)	
$\sum[a_{wsi}t_i]$($ms^{-2}h$)						
OR	1.0	2.13	3.27	3.44	7.80	982
(95% CI)	(-)	(0.94 – 4.79)	(1.38 – 7.75)	(1.41 – 8.42)	(p=0.05)	
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	1.91	2.93	4.38	10.8	980
(95% CI)	(-)	(0.84 – 4.33)	(1.21 – 7.06)	(1.77 – 10.9)	(p=0.013)	
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	2.31	2.29	3.28	7.14	984
(95% CI)	(-)	(1.02 – 5.24)	(0.97 – 5.37)	(1.33 – 8.08)	(p=0.07)	
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$)						
OR	1.0	2.62	2.44	7.07	19.7	971
(95% CI)	(-)	(1.17 – 5.89)	(0.99 – 6.0)	(2.84 – 17.6)	(p<0.001)	
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$)						
OR	1.0	2.53	2.50	8.11	21.5	969
(95% CI)	(-)	(1.13 – 5.67)	(1.03 – 6.08)	(3.24 – 20.3)	(p<0.001)	
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$)						
OR	1.0	1.54	3.39	4.36	12.2	979
(95% CI)	(-)	(0.65 – 3.65)	(1.43 – 8.06)	(1.69 – 11.2)	(p<0.01)	

Table 15a. Random-intercept logistic regression of treated LBP in the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR (95% CI)	1.0 (-)	1.78 (0.90 – 3.51)	2.09 (1.0 – 4.37)	2.29 (1.08 – 4.86)	5.65 (p=0.13)	1100
$A_v(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	1.38 (0.69 – 2.78)	1.20 (0.60 – 2.41)	1.11 (0.53 – 2.36)	1.84 (p=0.61)	1104
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	1.10 (0.55 – 2.19)	0.98 (0.50 – 1.93)	1.16 (0.54 – 2.52)	0.31 (p=0.96)	1106
VDV_{sum} ($ms^{-1.75}$)						
OR (95% CI)	1.0 (-)	1.0 (0.50 – 1.96)	1.17 (0.55 – 2.50)	1.22 (0.54 – 2.76)	0.40 (p=0.94)	1106
VDV_{dom} ($ms^{-1.75}$)						
OR (95% CI)	1.0 (-)	0.83 (0.41 – 1.67)	1.22 (0.58 – 2.56)	1.14 (0.51 – 2.54)	0.98 (p=0.81)	1105

Table 15b. Random-intercept logistic regression of treated LBP in the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr) OR (95% CI)	1.0 (-)	1.56 (0.65 – 3.77)	1.75 (0.71 – 4.28)	2.11 (0.73 – 6.08)	2.12 (p=0.55)	1104
$\sum[t_i]$ (h) OR (95% CI)	1.0 (-)	0.57 (0.26 – 1.23)	2.12 (0.97 – 4.64)	1.48 (0.61 – 3.62)	11.8 (p=0.008)	1095
$\sum[a_{wsi}t_i]$($ms^{-2}h$) OR (95% CI)	1.0 (-)	0.99 (0.47 – 2.13)	1.74 (0.77 – 3.90)	1.97 (0.85 – 4.59)	4.04 (p=0.26)	1102
$\sum[a_{wsi}^2t_i]$ ($m^2s^{-4}h$) OR (95% CI)	1.0 (-)	0.89 (0.42 – 1.88)	1.47 (0.66 – 3.29)	1.31 (0.57 – 3.02)	2.05 (p=0.56)	1104
$\sum[a_{wsi}^4t_i]$ ($m^4s^{-8}h$) OR (95% CI)	1.0 (-)	0.77 (0.35 – 1.68)	1.68 (0.76 – 3.70)	1.08 (0.47 – 2.49)	4.63 (p=0.20)	1102
$\sum[a_{wqi}t_i]$ ($ms^{-2}h$) OR (95% CI)	1.0 (-)	1.15 (0.55 – 2.44)	1.42 (0.61 – 3.26)	2.70 (1.16 – 6.28)	6.60 (p=0.086)	1100
$\sum[a_{wqi}^2t_i]$ ($m^2s^{-4}h$) OR (95% CI)	1.0 (-)	0.99 (0.47 – 2.11)	1.81 (0.80 – 4.07)	2.19 (0.94 – 5.10)	5.33 (p=0.15)	1101
$\sum[a_{wqi}^4t_i]$ ($m^4s^{-8}h$) OR (95% CI)	1.0 (-)	1.01 (0.45 – 2.25)	1.05 (0.47 – 2.37)	1.80 (0.74 – 4.35)	2.70 (p=0.44)	1104

Table 16a. Random-intercept logistic regression of sick leave (> 7 days) due to LBP in the previous 12 months on alternative measures of daily exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of daily WBV exposure	Quartiles of measure of daily WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Daily driving time (h)						
OR (95% CI)	1.0 (-)	2.40 (0.96 – 6.02)	1.42 (0.51 – 3.92)	2.51 (0.93 – 6.79)	5.19 (p=0.16)	645
$A_v(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	0.86 (0.32 – 2.32)	1.99 (0.81 – 4.87)	1.31 (0.51 – 3.40)	6.85 (p=0.08)	643
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR (95% CI)	1.0 (-)	3.24 (1.30 – 8.11)	1.52 (0.60 – 3.87)	1.66 (0.60 – 4.62)	7.01 (p=0.072)	643
VDV_{sum} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	0.63 (0.23 – 1.71)	2.22 (0.84 – 5.86)	1.40 (0.49 – 3.98)	6.20 (p=0.10)	644
VDV_{dom} (ms$^{-1.75}$)						
OR (95% CI)	1.0 (-)	1.28 (0.50 – 3.29)	2.28 (0.86 – 6.06)	1.64 (0.60 – 4.51)	2.78 (p=0.43)	647

Table 16b. Random-intercept logistic regression of sick leave (> 7 days) due to LBP in the previous 12 months on alternative measures of cumulative (lifetime) exposure to whole-body vibration (WBV) in the professional drivers (n=317) over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, physical load factors, psychosocial factors, back trauma, previous jobs at risk, and survey). Each measure of WBV exposure was included as a quartile based design variable, assuming the lowest quartile as the reference category. The likelihood ratio (LR) test for the measures of WBV exposure and the Bayesan Information Criteria (BIC) for comparison between models are given.

Measures of cumulative WBV exposure	Quartiles of measure of cumulative WBV exposure				LR test (χ^2, 3*df*)	BIC
	Q1	Q2	Q3	Q4		
Exposure duration (yr) OR (95% CI)	1.0 (-)	1.76 (0.62 – 5.02)	1.82 (0.61 – 5.41)	1.58 (0.44 – 5.73)	1.42 (p=0.70)	648
$\Sigma[t_i]$ (h) OR (95% CI)	1.0 (-)	0.48 (0.16 – 1.37)	1.94 (0.74 – 5.07)	2.09 (0.69 – 6.29)	9.0 (p=0.029)	641
$\Sigma[a_{wsi}t_i]$($ms^{-2}h$) OR (95% CI)	1.0 (-)	0.92 (0.34 – 2.48)	1.70 (0.62 – 4.69)	1.84 (0.65 – 5.23)	2.51 (p=0.47)	647
$\Sigma[a_{wsi}^2t_i]$ ($m^2s^{-4}h$) OR (95% CI)	1.0 (-)	1.80 (0.67 – 4.86)	2.66 (0.95 – 7.44)	1.76 (0.60 – 5.18)	3.49 (p=0.32)	646
$\Sigma[a_{wsi}^4t_i]$ ($m^4s^{-8}h$) OR (95% CI)	1.0 (-)	1.42 (0.50 – 4.06)	2.74 (1.01 – 7.41)	1.20 (0.40 – 3.61)	5.41 (p=0.14)	644
$\Sigma[a_{wqi}t_i]$ ($ms^{-2}h$) OR (95% CI)	1.0 (-)	0.96 (0.36 – 2.57)	1.87 (0.65 – 5.40)	2.16 (0.77 – 6.08)	3.36 (p=0.34)	646
$\Sigma[a_{wqi}^2t_i]$ ($m^2s^{-4}h$) OR (95% CI)	1.0 (-)	1.39 (0.51 – 3.81)	3.03 (1.05 – 8.69)	2.75 (0.95 – 7.69)	5.78 (p=0.12)	644
$\Sigma[a_{wqi}^4t_i]$ ($m^4s^{-8}h$) OR (95% CI)	1.0 (-)	2.66 (0.90 – 7.82)	3.05 (1.05 – 8.88)	2.62 (0.83 – 8.33)	4.77 (p=0.19)	645

Table 17. Random-intercept logistic regression of 12-month LBP and LBP disability (Roland & Morris disability scale score ≥ 12) on work-related physical load variables in the professional drivers over a two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, vibration exposure, back trauma, previous jobs at risk, and survey).

Variable		12-month LBP	LBP disability
		OR (95% CI)	OR (95% CI)
Walking & standing at work	never	1.0 (-)	1.0 (-)
	<1 h/d	0.81 (0.37-1.76)	1.60 (0.68-3.77)
	1-3 h/d	1.08 (0.48-2.43)	1.79 (0.74-4.33)
	>3 h/d	1.09 (0.45-2.62)	1.23 (0.47-3.24)
Trunk bent 20° to 40°	never	1.0 (-)	1.0 (-)
	<1 h/d	1.41 (0.81-2.46)	1.49 (0.83-2.69)
	1-2 h/d	2.87 (1.45-5.70)	1.81 (0.89-3.68)
	>2 h/d	1.66 (0.60-4.63)	0.68 (0.22-2.09)
Trunk bent > 40°	never	1.0 (-)	1.0 (-)
	<1 h/d	1.87 (1.06-3.33)	1.63 (0.89-2.99)
	1-2 h/d	2.12 (1.06-4.26)	1.39 (0.67-2.87)
	>2 h/d	2.27 (0.69-7.41)	1.32 (0.40-4.38)
Trunk twisted & bent 20° to 40°	never	1.0 (-)	1.0 (-)
	<1 h/d	2.20 (1.23-3.92)	1.83 (1.0-3.36)
	1-2 h/d	1.75 (0.78-3.93)	1.12 (0.49-2.56)
	>2 h/d	2.85 (0.95-8.58)	0.85 (0.30-2.42)
Trunk twisted & bent > 40°	never	1.0 (-)	1.0 (-)
	<0.5 h/d	2.59 (1.43-4.68)	1.92 (1.05-3.52)
	0.5-2 h/d	1.24 (0.50-3.07)	0.77 (0.29-2.06)
	>2 h/d	5.10 (0.94-27.6)	1.54 (0.39-6.16)
Arms raised & hands above shoulders	never	1.0 (-)	1.0 (-)
	<1 h/d	2.17 (1.22-3.84)	1.51 (0.85-2.70)
	1-3 h/d	2.90 (0.80-10.5)	0.08 (0.01-0.91)
	>3 h/d	0.63 (0.07-6.0)	1.25 (0.11-13.8)
Lifting loads >15 kg	never	1.0 (-)	1.0 (-)
	1-15 min/d	0.41 (0.18-0.94)	0.52 (0.20-1.35)
	15-45 min/d	3.26 (0.52-20.5)	1.74 (0.37-8.18)
	> 45 min/d	1.27 (0.19-8.66)	1.54 (0.24-9.74)
Back bent forward or twisted while driving	never	1.0 (-)	1.0 (-)
	seldom	1.85 (1.10-3.11)	1.68 (0.92-3.07)
	often	2.92 (1.67-5.13)	1.88 (1.0-3.52)

Table 18. Random-intercept logistic regression of low back pain (LBP) symptoms (7-day LBP, 12-month LBP, and high pain intensity (Von Korff pain scale score ≥ 5), LBP disability (Roland & Morris disability scale score ≥ 12), treated LBP, sick leave due to LBP in the previous 12 months) on postural load index in the professional drivers over two-year follow-up period. Odds ratio (OR) and 95% confidence interval (95% CI) are adjusted for several covariates (individual characteristics, vibration exposure, psychosocial factors, back trauma, previous jobs at risk, and survey). The likelihood ratio (LR) test for postural load index is given.

Outcome	Postural load index (grade)				LR test (χ^2, 3*df*)
	Score 1 (Mild)	Score 1 – 1.9 (Moderate)	Score 2 – 2.9 (Hard)	Score 3 – 4 (Very hard)	
7-day LBP					
OR	1.0	1.67	0.94	1.09	3.18
(95% CI)	(-)	(0.84 – 3.29)	(0.44 – 2.12)	(0.55 – 2.14)	(p=0.37)
12-month LBP					
OR	1.0	1.71	2.80	2.97	12.9
(95% CI)	(-)	(0.91 – 3.20)	(1.39 – 5.66)	(1.56 – 5.67)	(p=0.005)
Acute LBP					
OR	1.0	0.72	0.93	1.0	0.76
(95% CI)	(-)	(0.29 – 1.75)	(0.35 – 2.45)	(0.43 – 2.33)	(p=0.86)
Sciatica					
OR	1.0	1.74	2.71	2.63	9.28
(95% CI)	(-)	(0.85 – 3.57)	(1.28 – 5.75)	(1.32 – 5.25)	(p=0.026)
High pain intensity					
OR	1.0	1.10	1.30	1.20	0.60
(95% CI)	(-)	(0.58 – 2.08)	(0.65 – 2.60)	(0.64 – 2.25)	(p=0.90)
LBP disability					
OR	1.0	1.62	2.02	2.11	4.80
(95% CI)	(-)	(0.78 – 3.39)	(0.93 – 4.38)	(1.03 – 4.30)	(p=0.19)
Treated LBP					
OR	1.0	1.67	2.62	2.07	7.51
(95% CI)	(-)	(0.85 – 3.30)	(1.26 – 5.42)	(1.06 – 4.04)	(p=0.057)
Sick leave due to LBP (> 7d)					
OR	1.0	1.97	1.82	1.44	2.53
(95% CI)	(-)	(0.80 – 4.87)	(0.68 – 4.88)	(0.59 – 3.52)	(p=0.47)