Faculty of Health Sciences, Department of Community Medicine

A study of occupational health among mine workers in Murmansk Oblast, Russia

Morten Skandfer

A dissertation for the degree of Philosophiae Doctor – February 2014

UNIVERSITY OF TROMSØ UIT

THE ARCTIC UNIVERSITY OF NORWAY

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TABLE OF CONTENTS

PREFACE

During the early months of the revitalized Barents initiative in 2006, a group from Department of Occupational and Environmental Medicine (AMA) at the University Hospital of North Norway (UNN) decided to explore what opportunities this initiative could have for cooperation, development and eventually science. We embarked on a fact-finding mission to Murmansk Oblast (MO), visiting key persons in the administration and in the academic institutions. This led us to the mining town of Kirovsk and the Kirovsk Research Laboratory of Occupational Health (KRLOH) where joint interests and mutual understanding led to an intention to conduct some work together. With plans and Russian partners, it was possible to apply for funding. Soon we found ourselves on new visits to Kirovsk, carrying out exposure measurements and studying medical reports with Russian colleges. Those were colourful times, full of discovery, excitement and Russian hospitality. Long hours in the office were mixed with hiking trips and social life in Kirovsk. I got new friends and saw Russian life through them. This was inspiring and energizing. So with letters of great intentions, I decided to embark on a more extensive study, suited for a PhD. With help from supervisors, the protocol was approved for the EPINOR programme, and the work could begin. Some years and several PhD and Russian language courses later, I look back on a project which started from scratch with network building and turned out to be a large epidemiological study of mine workers. It has indeed been a remarkable journey. The experience I have acquired during this project period can serve as a foundation for future initiatives for studies in occupational health. Indeed, the current EU project termed 'MineHealth' collect data in high north mine workers in four countries by use a modified version of the questionnaire developed for this epidemiological study. In Kirovsk, that can serve as a follow-up study of mine workers health. The development in the Barents region will most likely call for more knowledge on the connections between occupation, exposure and health, as the work continues in order to safeguard the mine workers of the high north.

The author at the Kirovsk mines in 2009. (Photo: Arild Øvrum)

Front page picture: Kirovsk, Murmansk oblast. (Photo: Arild Øvrum)

ACKNOWLEDGEMENTS

This project would not have been possible without the support and efforts of many people. First of all I would like to thank my supervisor Arild Vaktskjold, for inspirational support and encouragement in every phase of the work, attention to details and restlessness balanced with patience. I am also greatly indebted to my supervisor Tormod Brenn for assistance, advice, help and guidance. I also thank Tohr Nilsson for valuable assistance and encouragement throughout this work. This study would not have been started without the enthusiasm and skills of Arild Øvrum, with whom I visited many mines and solved several obstacles. His comradeship, inspiration and optimism have been highly appreciated and were vital for starting up the project. The colleges in Russia, particularly Ljudmila Talykova and the staff (Lena Karya, Timofei Khoklov, Natasja Serebryakova and Sergei Gulin) at the scientific department at Kirovsk Research Laboratory of Occupational Health (KRLOH) have been of great importance, putting down many hours and days in study preparations and conduction of data collection and recording, for which I am very grateful. I would also like to thank Sergei Siurin at KRLOH who was always available for questions and provided relevant literature and reports. The study would not have been possible without the support from Aleksander Nikanov, head of the KRLOH and from Valery Chaschin at Northwest Institute of Occupational Health in St Petersburg. I also highly value the positive attitude to this study from the Joint Stock Company (JSC) Apatit mining company in Kirovsk, granting access to both facilities. I thank Oleg Siderenko for valuable help in the translation of the questionnaire and Emil Rakoczy for assistance with computer problems. The work presented in this thesis was carried out within the framework of the EPINOR research school at the Department of Community Medicine at the University of Tromsø, The Arctic University of Norway. The study would not have been possible without the generous framework provided by Jan Haanes at the Department of Occupational and Environmental Medicine (AMA) at the University Hospital of North Norway (UNN), where I have held a position these years. I am also grateful to Ingemar Rødin, for patience and flexibility as the project overlapped with tasks in the Mine Health project. I thank Magne Johnsen in the UNN leadership for being a door opener both in Russia and in Norway. The study was made possible through the support from the University Hospital of North Norway, the Troms Council, the Barents Secretariat, The Ministry of Health and Care and the Nordic Council of Ministers.

SUMMARY IN ENGLISH

The largest mining communities in Europe are located in the Murmansk Oblast (MO) in North Russia. Exposure to whole body vibration (WBV) from operating heavy vehicles and cold working conditions in the mines is frequent for many mine workers in the north. Musculoskeletal conditions such as low back pain (LBP) have been reported as frequent problems particularly in professional drivers of heavy vehicles. Knowledge about miners' health in the high north, particularly in cold working conditions, is essential in order to meet the challenges of operating in these areas. The aim of this study was to describe how occupational health is assessed in miners in the MO, assess the frequency and character of LBP in miners, and investigate the associations between occupational exposures and LBP.

In the MO, several institutions are involved in assessing miners' health, calculating exposure levels as hazard grades and making recommendations for further employment, as described in Paper I. Risk assessment is based on measured exposures which are weighted in accordance with national regulations and graded from 1 to 4. In Paper II we describe how we measured WBV exposure during work cycles in a mine in Kirovsk in MO, and performed a risk assessment by expressing the exposure values in accordance to European and Russian risk assessment systems as means to quantify and communicate risk. This illustrates how WBV exposure assessment in the Russian system relates to the action and limit values in the European system. It is by our knowledge the first time that risk assessment of WBV exposure by both European and Russian systems has been published.

The central institution in this work in the MO is Kola Research Laboratory of Occupational Health (KRLOH) to which miners are summoned to a periodical, obligatory medical examination. In Paper I we describe how this is determined and how, based on a wide set of exposure and clinical information, decisions are made on topics as the ability to continue work, the grading of disability, determination of occupational disease and qualification for economic compensation. The emphasis is more on control and repair than on prevention of disease. Since recommendations from the health assessment may be experienced as

unfavourable by the employees, they may be motivated to underreport their health problems at the examination.

The large numbers of workers employed in the mines in MO provide great opportunities for epidemiological studies on miners' health. In 2010 3680 workers employed in four mines in Kirovsk were summoned for periodic health examination at the KRLOH and were invited to take part in this epidemiological study. Our hypotheses were that WBV from driving heavy vehicles, heavy lifting, working with wet clothes and cold working conditions affect the risk of LBP. In total, 3530 (96%) signed an informed consent to participate. Data in this cross-sectional study were collected by questionnaire, filled in by 3530 workers who had given informed consent. Workers were asked about exposures in their current and past occupations, whether they had experienced LBP during the last 12 months, and inquired about pain characteristics. Work place characteristics were also observed on site. The aim of the study presented in Paper III was to investigate the association between work tasks that involve WBV, cold environment, heavy lifting and wet clothing and the occurrence of LPB in a cohort of miners, adjusted for individual factors. Workers who reported that they drove a vehicle in a typical work week were defined as exposed to WBV. One-half of the workers in the mines reported LBP. This is higher than previously reported for workers in the mines in Kirovsk but closer to numbers reported in other studies. Heavy lifting was reported by more than half of the workers and two thirds had worked in a cold environment on a weekly basis. One-half reported working with wet clothes for at least five hours per week. Despite levels of WBV above action values, wet clothing, cold working conditions, heavy lifting, and previous work as a driver were more strongly associated with LBP. The strongest adjusted association was found for working with wet clothes (OR=1.82). For WBV exposure defined as driving time per week the adjusted OR for LBP per category increase in time was 1.08. Driving TORO 400 trucks and K10 and K14 underground trains were the only vehicles associated with LBP, these drivers are exposed to both a twisted working position and low temperature in the open cabins, underlining the importance of vehicle-type specific analyses.

The second part of the epidemiological study, described in Paper IV had a two-fold study aim: to investigate characteristics of LBP symptoms (frequency, intensity, duration and radiation to the leg) in miners, and how back pain with radiation relates to occupation, type of vehicle driven, past driving, heavy lifting, wet work clothes and cold work environment among miners with LBP. Paper IV describes characteristics of LBP with and without pain radiation in the population of miners. Pain intensity, frequency duration and radiation were assessed by questionnaire. LBP was classified as LBP without and LBP with radiation. The associations were assessed in bivariate and multiple logistic regression analyses among the workers who reported LBP.

Cold environment was the most prevalent of the studied exposure factors in several groups of the miners. More than 80% of the train drivers, Toro 400 drivers and blasters reported exposure to temperatures below 10˚C. Drill-rig operators, blasters, and drivers of Toro 40, Toro 400 and trains reported the highest prevalence of working with wet clothing. Of those with LBP, 34.8% reported LBP with radiation, most frequently among blasters (49%), drill rig operators (40%) and drivers (36.5%), in particular drivers of Toro 400 and trains, 77.9% and 66.0% respectively. In the adjusted analysis, LBP with radiation was statistically significant for wet clothes (OR=1.44), cold environment (OR=1.49) and past driving (OR=1.50).

The main shortcoming of the epidemiological part of the study was its cross-sectional design, which does not provide cause-effect relationships. Our results show that many workers in these mines are exposed to several possible risk factors. Information was self-reported, and thus subjective. The cut-offs chosen for some study factors may have the outcome of the analysis. Healthy worker effect is always present when work populations are studied, and its magnitude is generally unknown. Our study suggests that cold work environment contributes to the risk of LBP. For better prevention of LBP, we recommend increased emphasis on improved cabin conditions and clothing.

SAMMENDRAG (SUMMARY IN NORWEGIAN)

De største gruvesamfunnene i Europa ligger i Murmansk oblast (MO) nord i Russland. Eksponering for helkroppsvibrasjon fra tunge kjøretøy er karakteristiske yrkeseksponeringer for gruvearbeidere samt kaldt arbeidsmiljø i nord. Muskelskjelett tilstander som korsryggsmerter er beskrevet som vanlige, særlig blant sjåfører av tunge kjøretøy. Kunnskap om gruvearbeideres helse i nord bør fremmes for å møte utfordringene knyttet til gruvedrift i disse områdene. Hensikten med studien var å beskrive hvordan gruvearbeideres helse vurderes i MO, bestemme forekomsten og karakteristika ved korsryggsmerter blant gruvearbeidere og undersøke sammenhenger mellom yrkeseksponering og korsryggsmerter.

I MO er flere institusjoner involvert i vurderingen av gruvearbeiders helse, gjennom risikovurdering, helseundersøkelser og bedømmelse av arbeidsevne. Risikovurdering baserer seg på målte eksponeringer som vektes i henhold til nasjonale forskrifter og graderes fra 1 til 4. Artikkel II beskriver hvordan vi målte helkroppsvibrasjons- eksponering fra tynge kjøretøy i en av gruvene i byen Kirovsk i MO. Artikkelen beskriver også hvordan verdiene i en risikovurdering kan relateres til tiltaks- og grenseverdier i det europeiske systemet og risikogradering i det russiske systemet. Artikkelen viser også hvordan risikograder i det russiske systemet samsvarer med tiltaksverdi og grenseverdi i det europeiske systemet. Etter vår kjennskap er det første gang vibrasjonseksponering er publisert med en risikovurdering ved bruk av begge disse to systemene.

Den sentrale institusjonen for vurderinger av eksponering og helse hos ansatte i MO er Kola Yrkeshygieniske Institutt (KRLOH), dit alle gruveansatte kommer for en obligatorisk helseundersøkelse med regelmessige mellomrom, vanligst som en årlig undersøkelse, som beskrevet i Artikkel I. Basert på et bredt sett av eksponeringsfaktorer og klinisk informasjon treffes det anbefalinger for det videre arbeidet, eventuell uførhetsgrad eller om en medisinsk tilstand kvalifiserer for yrkessykdomserstatning. Det er langt mer vekt på kontroll og reparasjon enn forebygging av sykdom. Ettersom anbefalinger fra helsekontrollene kan oppleves som ugunstige av den enkelte arbeidstaker kan det motivere til en underrapportering av heleplager under helseundersøkelsen.

Det store antall ansatte i gruveindustrien i MO gir gode muligheter for epidemiologiske studier av gruvearbeideres helse og yrkeseksponering. I 2010 ble 3680 ansatte i de fire gruvene i Kirovsk innkalt til sin regelmessige, obligatoriske helseundersøkelse og ble invitert til å delta i denne epidemiologiske undersøkelsen. Våre hypoteser var at helkroppsvibrasjon under kjøring av tunge kjøretøy, tunge løft, arbeid med våte klær og kaldt arbeidsmiljø påvirker risikoen for korsryggsmerter.

Data i denne tverrsnittsundersøkelsen ble innsamlet ved bruk av spørreskjema som ble fylt ut av 3530 (96%) ansatte etter informert samtykke. De ansatte ble spurt om deres nåværende og tidligere yrke, eksponeringer og om de hadde opplevd LBP i løpet av de siste 12 månedene samt smertekarakteristika. Karakteristika ved arbeidsplassene, typer kjøretøy og organisering av arbeidet ble observert i gruvene og innhentet fra arbeidsgiver. Formålet med studien som presenteres i Paper III var å undersøke sammenhengen mellom arbeidsoppgaver som involverer WBV, kaldt arbeidsmiljø, tunge løft og våte klær og forekomsten av LBP i en kohort av gruvearbeidere, justert for individuelle faktorer.

Vi beskriver i Paper III at halvparten av de ansatte svarte at de hadde korsryggsmerter. Dette er høyere enn tidligere rapportert for gruvearbeidere i Kirovsk, men nærmere tall som er rapportert i andre studier. Tunge løft var rapportert av mer enn halvparten og tre av fire hadde arbeidet i kalde omgivelser på hver uke. To av tre rapporterte at de arbeidet i våte klær minst en time i uka og nesten halvparten hadde jobbet i våte klær i minst fem timer i uka. Til tross for målte nivåer av helkroppsvibrasjoner over tiltaksverdi, var våte klær, kalde omgivelser, tunge løft og tidligere arbeid som sjåfør sterkere assosiert med korsryggsmerter. Den sterkeste assosiasjonen ble funnet for våte klær (OR=1.82). For helkroppsvibrasjon definert som kjøretid per uke var den justerte OR for korsryggsmerter per økning i tidskategori 1.08. Blant dem som oppgav å være nåværende sjåfører var det kun arbeid med lastekjøretøyet Toro 400 og de små undergrunnslokomotivene K10 og K14 som var assosiert med korsryggsmerter. Førere av disse kjøretøyene sitter i rett vinkel til kjøreretningen i åpne førerhus med både en rotert stilling i overkroppen og eksponering for de kalde arbeidsforholdene i gruva.

Paper IV beskriver forekomsten korsryggsmerter i mer detalj, med og uten smerteutstråling, i den samme populasjonen av gruvearbeidere. Smerteintensitet, frekvens, varighet og utstråling ble rapportert i spørreskjema. Korsryggsmerter de siste 12 måneder var klassifisert som med og uten utstråling. Analysene ble gjort med bivariat og multippel logistisk regresjonsanalyse av de ansatte som rapporterte lave ryggsmerter. Kalde omgivelser var den hyppigst forekommende av de studerte eksponeringsfaktorene i flere grupper av gruveansatte. Mer enn 80% av de som førte gruvelokomotiver, sjåfører av Toro 400 og sprengere rapporterte eksponering for temperaturer under 10˚C. Boreriggoperatører, sprengere og sjåfører av Toro 40, Toro 400 og gruvelokomotivene K10 og K14 rapporterte også den høyeste utbredelsen av arbeid med våte klær.

Blant ansatte med korsryggsmerter rapporterte en av tre ryggsmerter med utstråling. Blant ansatte med korsryggsmerter var andelen som hadde opplevd smerter med utstråling høyest blant sprengere (49%), operatører av boreplattformer (40%) og sjåfører (36.5%), særlig dem som kjørte Toro 400 og gruvelokomotiv, henholdsvis 77.9% og 66.0%. I den justerte analysen var assosiasjonen med LBP med utstråling statistisk signifikant for våte klær (OR=1.44), kalde omgivelser (OR=1.49) og tidligere arbeid som sjåfør (1.50). Assosiasjonene med tidligere arbeid som sjåfør antyder at det å kjøre kjøretøy er en risikomarkør og at noen ansatte kan ha endret yrke fra sjåfør til andre yrker grunnet korsryggsmerter med utstråling.

Den viktigste svakheten ved denne epidemiologiske studien er dens tverrsnittsdesign som ikke gir mulighet for å trekke konklusjoner om årsak-virkning sammenhenger. Våre resultat viser at mange ansatte i disse gruvene er eksponert for mange mulige risikofaktorer. Informasjonen gitt i spørreskjemaet var selvrapportert og derfor subjektiv. Avgrensningene som ble valgt for studiefaktorene kan ha ført til feilklassifikasjon av eksponerte og ikke eksponerte og kan slik ha påvirket resultatene av analysene. Derfor må de beregnede OR for eksponering for våte klær og kalde omgivelser tolkes med forsiktighet. Seleksjon av friske ansatte i en arbeidsstokk er alltid til stede når populasjoner av ansatte studeres, og omfanget av dette er ukjent.

Resultatene fra studien tyder på at kalde omgivelser og våte klær bidrar til risiko for korsryggsmerter, også med utstråling. For å bedre forebygging bør det være økt fokus på utforming av kjøretøy og bekledning.

LIST OF PAPERS

The thesis is based on the following papers:

1. Skandfer M., Siurin S., Talykova L., Øvrum A., Brenn T., Vakstskjold A. How occupational health is assessed in mine workers in Murmansk oblast. Int J Circumpolar Health , 2012 May 10;71(0):1-8

2. Øvrum A., Skandfer M., Siurin S.A., Talykova L.V., Nikanov A.N. European and Russian methods for exposure assessment applied on whole body vibration values in short haul dump trucks Human Ecology - Ecologiia tsjeloveka. 2012 (10):11-5.

3. Skandfer M., Talykova L.V., Brenn T., Nilsson T., Vaktskjold A. Low back pain among mine workers in relation to driving, cold environment and ergonomics. *Accepted manuscript, Ergonomics*

4. Skandfer M., Talykova L.V., Brenn T., Nilsson T., Vaktskjold A. Characteristics of low back pain in relation to physical job task exposures among arctic mine workers.
Submitted manuscript, BMC Musculoskeletal disorders

LIST OF ABBREVIATIONS (ALPHABETICAL)

AMA- Department of Occupational and Environmental Medicine

BMI - Body Mass Index

ISO - International Standardization Organization

JSC - Joint stock company

K14 - Electrical underground mine train model 14

K10 - Electrical underground mine train model 10

KRLOH - Kirovsk Research Laboratory of Occupational Health

LBP - Low back pain

LHD - Load - haul - dump

MO - Murmansk Oblast

MRI - Magnetic resonance imaging

MSEK - Special Medical Social Committee

NWPHRC - Northwest Public Health Research Centre

OR - Odds ratio

REK Nord - Regional committee for medical and health research ethics North

RF- Russian Federation

SD - Standard deviation

SHD - Surface haul dump truck

UNN - University Hospital North Norway

VAS - Visual analogue scale

VDV - Vibration dose value

WBV - Whole body vibration

1. INTRODUCTION

1.1 Background for the study

Mining is one of the prerequisites for modern society, in delivering minerals and metals for construction and production. It provides employment and creates values that are important for many communities. The mining industry is expanding as global demands increase. Mining consists of several operations and processes (exploration, drilling and development, mine operation with extraction, and hauling and transport) and is a multidisciplinary industry which employs numerous professions and trades. It is carried out under very diverse conditions in a world-wide perspective. As demands for commodities increase, new mines are opened, existing ones are expanded and more people are employed. This is also the situation in the Barents region (northern Finland, Norway and Sweden, and northwest Russia), where some 30000 people are employed in the industry. Existing mines are expanding and new mines are opened. The region has some of the largest mining enterprises in Europe. The mining industry in northwest Russia is far more extensive than in the rest of the region, by far the largest population of workers in the mining industry is in Murmansk Oblast (MO) in the Russian Federation (RF) with some 22000 employees.

Norway has had the lowest number of workers employed in the mining industry in the region. With new mineral extraction legislation in place from 2012 and extensive on-going prospecting, the mining industry in Norway, and particularly in the north, is expected to grow in the years ahead. This will affect the environment and local communities. It is important to increase competence on the impact of mining on a wide number of fields in order to meet future challenges and opportunities. Several factors are different between the countries, while others are similar, such as remoteness and cold climate. Knowledge about mining in the high north should be promoted in order to meet the challenges of operating in these areas.

Mining poses several concerns over the health and safety of the workers. Working in mines has long been recognised as associated with elevated risk of traumatic injuries and disease, despite technological improvements [1]. Some health and safety challenges are specific for certain types of mining, others are shared across the industry and across borders. The efforts to prevent mining disasters and fatalities are currently often supplemented by a broader occupational health and safety focus [2].

Worldwide, mine workers' health differ among types of mining, underground or over ground operations, or according to the commodity being mined. Physical hazards like falls, fires, explosions, collapse of shafts and heat remain a problem and can cause incidents that may be fatal. Continued systematic work has reduced the risk from these events. One of the most common exposures in mining is noise, causing hearing loss [3]. Heat and humidity are encountered in tropical regions, whereas low temperatures can be challenging in northern locations. Vibration is commonly experienced from operating heavy vehicles and vibration from hand-held tools can cause hand-arm-vibration syndrome [4, 5].

In some mines, the presence of silica has long been a hazard, causing silicosis and chronic obstructive pulmonary disease COPD) [6, 7]. Prolonged exposure to silica may also increase the risk for lung cancer [8]. Technical improvements have reduced this risk, but the problem remains in developing nations. Mineral dust has been a major hazard to mine workers, in particular those working in coal mines, causing pneumoconiosis and COPD [6]. Improved respiratory protection and ventilation have improved the exposure situation. The mining of asbestos continues in some countries although it is now banned in most industrial countries. The exposure to asbestos increases the risk of asbestosis, pleural plaques and pulmonary cancer [9]. In concealed mining environments, diesel particulates stem from vehicles and generators. It is a probable carcinogen and can pose a possible excess risk of pulmonary cancer [10, 11]. Arsenic, which can be encountered as contaminant in metal ores also carries a risk of pulmonary cancer [12]. Metal ores with lead, platinum, manganese, cadmium and cobalt pose a health risk especially during metallurgical processing. In coal mines, methane gas represents a health risk by explosion. In some developing nations, mercury is still used in mercury-amalgam gold extraction, and the vapour can be toxic when fumes are inhaled [13]. Biological hazards to the health of mine workers can be infectious agents in the general environment or in water used in the industrial processes. Increased risk for tuberculosis in mine workers has also been reported in some areas [14].

Despite an increased mechanization in the mining industry, manual handling, trauma and awkward postures remain a challenge, causing musculoskeletal distress and disorders. Longer shifts, fatigue sedentary work, increased loads in fixed positions and whole body vibration (WBV) have been identified as possible risk factors for reduced health and safety but the effect of combined exposure is not clear [4, 15]. Fatigue from sleep deprivation can cause cognitive and motor impairments. In addition, psychosocial factors, stress, drug and alcohol abuse add to the combined load of possible exposures that increase the risk for accidents and disease [1].

In the high north, some major aspects of mining are shared, and some differ from mining in other parts of the world. Working in cold conditions is one major dimension that is characteristic in the region. Musculoskeletal problems are frequently reported health problems and have costs for the employed, the employer and society. Their causes are believed to be multifactorial [16]. The independent impact from cold climate as co-exposure is undetermined. To meet the future with better prevention practices, more knowledge is required about the health problems of high north mine workers, their combined exposures and risk factors. Norwegian mining activities are on the rise but there are still few existing mines and small worker populations. Knowledge should thus be promoted through international cooperation with occupational medicine specialists and particularly across the Barents region, both by learning from previous epidemiological studies on high north miners and by carrying out new joint studies. As mining companies plan to recruit more workers from all four countries in the region, there is a growing need to promote knowledge about several aspects of health and work environment of mine workers across the Barents region. By identifying regional similarities and differences, new knowledge is relevant in a broader regional and international context.

The largest mining region in Europe is the cluster of mines and processing facilities in the Kola Peninsula in Murmansk Oblast (MO), in the north-western part of the Russian Federation (RF). MO has 794.800 inhabitants and is the least populated region in Russia (0.6%), but the largest population in the circumpolar north (21% of the total). The region is also the most urbanized in Russia, with 92.8% of it population living in cities or towns, compared to 73% in the RF [17]. Thirty-seven percent of the MO population live in Murmansk city, the rest live in industrial towns (monogorods) (Figure 1), where single industrial plants provide employment and community services. Workers are employed in mines in several industrial towns, extracting a wide array of minerals and metals (Table1).

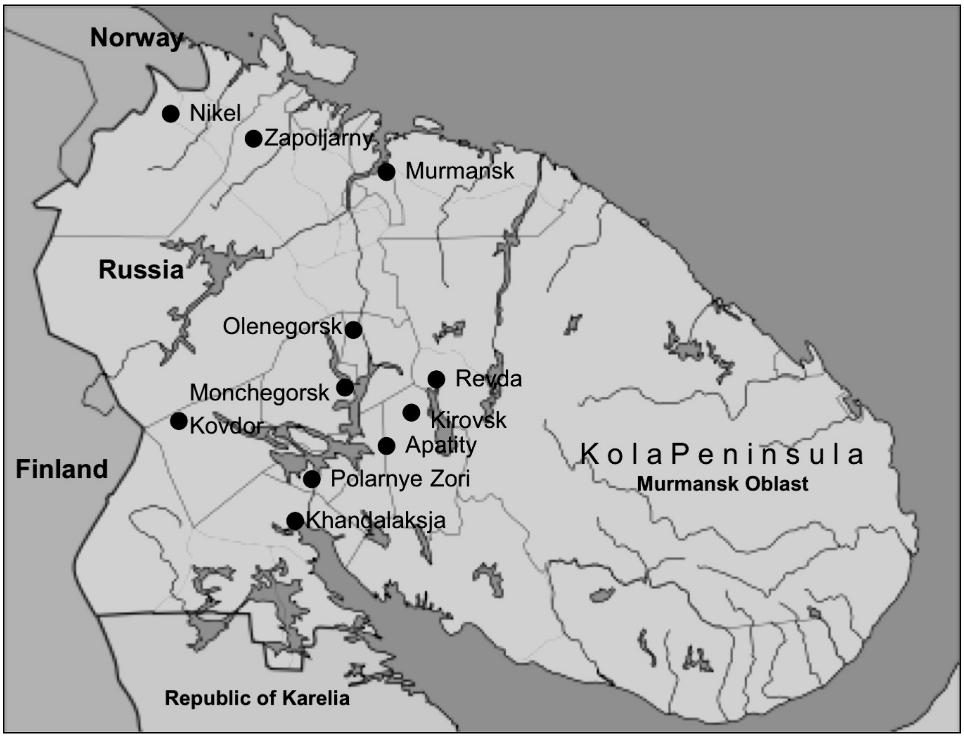

Figure 1. Industrial towns and Murmansk city in Murmansk Oblast.

Table 1. Main industrial towns and industry in Murmansk Oblast

Industrial town	Main industry
Polarnye Zori	Nuclear power plant
Nikel	Nickel mine and smelters
Monchegorsk	Nickel and copper refineries
Kirovsk	Apatite-nepheline mines
Apatity	Ore processing plant
Kovdor	Iron, apatite, mixed ore mines, ore processing plant
Olenegorsk	Iron mines, smelters
Khandalaksja	Aluminum smelters
Zapoljarny	Nickel mine, concentrate production plant
Revda	Rare earth metals, titanium mines

An industrial cluster is formed by the apatite mining and processing complex in Kirovsk and Apatity, and the mining company JSC Apatit is currently one of the largest producers of phosphate in the world.

The MO region is located in the high north, characterized by short, cool summers and long, cold winters. This pose challenges to the health and safety of the mine workers, in addition to the working conditions. For five decades, the health and work place exposures of mine workers have been studied and assessed by the Kola Research Laboratory of Occupational Health (KRLOH) in in the town of Kirovsk. KRLOH is a branch of Northwest Public Health Research Centre (NWPHRC) in St Petersburg. Annual health examinations have revealed increasing numbers of occupational disease and compensation claims since 2000. Occupational accidents and diseases are increasing, but probably underreported. The prevalence of occupational musculoskeletal disorders is higher than reported for Russian Federation [18, 19]. In 2006 the incidence of occupational disease in MO was twice that in 1999. This is also the trend in the industrial towns of MO [20]. On the other hand, from 1991 to 2003 the number of accidents decreased [21]. Noise and vibration have been reported as the most common causes (36.6%) of occupational disease in MO mine workers [22]. Only 12% of miners working underground and 13.6% of miners working in open pit mines had never been diagnosed with some form of medical condition, and musculoskeletal problems and diseases caused by mechanical vibration have been identified as the most frequent health problems [23]. Direct comparison is very difficult from national statistics. Numbers for Norway for the same period does not show high numbers of occupational disease of musculoskeletal type, since the category is not generally approved as an occupational disease. By employing similar criteria and tools for data collection across the high north, the data can more easily be compared between countries.

Compared with the relatively small mining communities in North Norway, the many more mine workers in Kirovsk provided an excellent setting for large-scale epidemiological study. Through cooperation with Russian specialists, we could learn about the challenges to the health of mine workers. This can be beneficial for the development of better prevention procedures and standards. Medical records of workers in the Kirovsk mines, official statistics and previous publications on the health of the workers were studied together with Russian specialists. We made several technical visits to the different mines in Kirovsk to experience and learn about the mining process, the enterprise and the daily work. Several weeks were spent in underground and open pit mines. This gave a first-hand experience of the physical work conditions, work garment, safety equipment, the shifts and work cycles. We also spent several days riding along in heavy trucks, experiencing the working conditions first hand as we measured the exposure to WBV. Reports were written about the levels of WBV exposure and risk assessment in both underground mines and open pit mines on the most used vehicles. The reports were also presented to the leadership of the mining company JSC Apatit. Together with the specialists at KRLOH, we chose to focus on musculoskeletal pain and the complex of possible contributing exposure factors as the most relevant issues for a large study. In order to understand the context for this investigation, we also decided to study in detail how occupational health is assessed in mine workers in MO.

1.2. Low back pain

Low back pain (LBP) is a frequently occurring pain condition in the general population [24-27]. Studies from around the world show that most adults will experience an episode of LBP during their lifetime; reported at 60-84% in industrialized countries [28, 29]. Studies have shown that 20 to 30% of adults report LBP at a given point of point of time [30-32]. More suitable than such than point prevalence numbers to describe the population burden of LBP are period prevalence numbers, due to the episodic nature of LBP. The 12-months LBP prevalence is reported in the 40 to 60% range in several studies and 6-months LBP at 50%, dependent on the definition of LBP [30-32]. In Norway and Sweden lifetime prevalence has been reported at 60 and 69%, one-year prevalence at 41 and 47% and point prevalence at 13 and 18% respectively [33]. LBP with duration up to 4 weeks is often described as acute, and sub acute if the duration lasts from 4 to 12 weeks. LBP is labelled chronic if the duration exceeds 12 weeks. The majority of cases are short term or not severe, but annual prevalence of severe LBP has been reported as 10-12% [34]. A study has shown that the incidence of LBP is highest in the third decade of life [35]. The prevalence of LBP increase until age 60 to 65 years, and then decline gradually [31]. Among persons under age 65, low back pain is the most common condition [36, 37]. Some studies have reported higher prevalence of LBP in women; others have not found any sex difference [32, 38].

As a cause of healthcare consultations, work absence and disability, LBP poses a large burden to individuals, employers, and health, social and welfare systems [34, 39]. In the UK and Sweden, 12-19% of all sick days have been attributed to LBP [36]. In Norway, LBP accounts for 11% of sick leaves and 9% of medical disability cases [40]. Some 25% of Swedish construction workers reported that LBP had hindered their work during the last year [41]. Most cases of LBP resolve within 12 weeks, but in some 15% of patients it may become chronic with significant physical impairment and activity limitations. The chronic LBP cases accounts for a majority of disability and costs associated with LBP [36].

LBP episodes may present with various duration and intensity. For the majority of persons who experience LBP, the condition improves over time; a minority recovers completely but 70 to 80% report recent pain one year after the debut. Some studies indicate that the presence of radiating pain and severe loss of function are indicators for poor prognosis [42, 43]. High pain intensity has also been cited as associated with poor prognosis [44].

A specific cause of LBP can usually not be established, despite current diagnostic methods. Many patients have degenerative changes or abnormalities in their spine without LBP symptoms. Other patients suffer from chronic LPB without any visible abnormalities. Only in 6-10 % of all cases of LBP has an underlying pathological process been determined [45, 46].

1.3 Low back pain with radiation

Some persons experience back pain only, others experience back pain with radiation to the leg below the knee and may radiate into the foot and toes, a condition often termed sciatica. Sciatica is a symptom, rather than a specific diagnosis. Clinical findings as muscle weakness and reflex changes may be present. The radiating pain follows a dermatomal pattern and patients may also report sensory deficits. A clinical picture with typical radiating pain in one leg combined with a positive neurological test (the straight-leg-raising test, Lasegue, is most commonly used) is considered typical for sciatica. The clinical course of acute sciatica is favourable, with pain and disabilities resolving within two weeks. Within a year the majority (70%) have recovered with conservative treatment [47]. LBP with radiation is a common condition [48, 49]. A study on municipal workers found that radiating pain was predicted by manual labour in both sexes and by previous pain in the lower back in men, while psychosocial and physical working conditions had no predictive value [50].

Radiating pain is considered associated with disc hernia, still, the risk factors for LBP with radiation are not well understood. Inflammatory processes close to the nerve roots may cause radiating pain in the absence of a herniated disc [47]. The most effective treatment of LBP with radiation is still undetermined. Analgesics, muscle-relaxant and anti-inflammatory medication, physical therapy and light exercises are the major conservative treatments. For LBP with radiation disc herniation, surgery may be indicated [37]

1.4 Risk factors for low back pain

LBP seems to be a multi-factorial condition. Both work-related and not work-related factors appear to cause or contribute to LBP. Although LBP is common in the general population, it is often more frequently reported in some occupations. Work-related risk factors [51], psychosocial factors [52, 53] and individual characteristics and life style factors [28, 50] may be involved in causing or contributing to LBP. Employment and workplace factors have been associated with LBP, both physical (vibration, heavy lifting, awkward postures) and psychosocial factors (job demands, control, stress and dissatisfaction). A review concludes that there is a possible causal relationship between operating heavy industrial equipment and LBP [54]. Also, some professions have been reported to increase the risk of LBP. Professional driving has been reported in several studies to increase the risk of LBP [55-57]. A high prevalence of low back pain has also been reported in mine workers [58, 59]. In a Finnish register study of people hospitalised for back pain, mine workers were the second largest profession category [60].

Several studies have indicated an association between professional driving and LBP [61-64]. Driving heavy vehicles is a multifactor exposure, involving WBV, prolonged sitting, awkward postures, different ambient work temperatures and sometimes lifting. The relative contribution from the various factors to the risk of LBP is still undetermined.

Exposure to WBV or sudden mechanical shocks from driving are reported to be associated with LBP in several studies [54, 62, 65, 66], especially in drivers of heavy vehicles [67, 68]. A dose-response relationship between WBV and the risk of LBP has not been established, but both the characteristics and the duration of vibration exposure may play a role [16]. A review concluded that driving-related WBV is associated with LBP, sciatic pain and degenerative changes in the spine [69]. However, there are contradicting results. LBP in drivers may also be influenced by other factors in the work environment, such as type of work process and machinery, heavy lifting, work postures, cold working conditions, biodynamic factors as well as various individual characteristics and stress [51, 63, 70]. Another review concluded that the evidence for whether LBP is due to driving-related WBV alone or other factors such as heavy lifting or working postures, is inconclusive [71]. A Swedish study found that the associations between WBV and LBP might be confounded by lifting and posture [27].

The changing practices in mine work also change the exposures for workers in mines. Increased mechanization has led to more sedentary work, making the workers less fit for the lifting of heavy loads which is still part of this work. One study has reported association between daily heavy lifting and back pain, and a weak association with driving industrial vehicles [51]. A Finnish cross-sectional study reported a prevalence of physician-diagnosed sciatica at 5.4% and no relationship with professional car driving in general (OR 1.42 (95% CI 0.92-2.18), but driving combined with strenuous physical work increased the risk for sciatica threefold and for LBP in general twofold. [46]. Other studies have reported a strong association between heavy lifting, prolonged sitting, twisting and bending and LBP [51, 63]. Increased risk of LBP from heavy physical workload and awkward postures has also been found in adolescents [72]. A review states that no causality has been demonstrated between WBV exposure and abnormal spinal imaging findings [73].

An increased rate of injuries has been described in other populations of mine workers operating in low temperatures [74]. Subjective musculoskeletal symptoms have also been found more frequently in cold indoor working environment, and symptoms have been reported to be more frequent in winter than summer [75, 76]. A recent study on Swedish construction workers showed an increased risk of developing LBP and neck pain by decreasing outdoor temperature [41]. A review concluded that there is reason to believe that cold is a risk factor for developing musculoskeletal disorders at the workplace. The impact and effects of low temperature on short term muscular function are quite well understood, but long term function gas received little attention [77]. Increased frequency of musculoskeletal symptoms by longer working time in cold environment has been reported [78]. Some studies have addressed the impact of wet clothes on health and human function [79-81]. One study reported elevated levels of perceived job stress from exposure to wet clothes in cement construction workers [82].

In addition to risk factors at work, pre-disposition, obesity and smoking may also increase the risk for LBP [52, 53, 83]. Psychosocial factors such as anxiety, stress, depression, job dissatisfaction and somatisation have been suggested as risk factors [84-86], however, this is disputed in later reviews [53, 87]. The association with leisure time physical activities has been reported as weak and conflicting in several reviews [62, 88, 89] and another review found no reduced level of physical activity in persons with LBP [90].

Risk factors for LBP with radiation

Although sciatica is considered to be associated with disc hernia, the risk factors for LBP with radiation are not well understood. Obesity seems to be associated, and the onset of LBP with radiation may be affected by low physical activity and smoking [49, 50]. A twin study did not find more disc degeneration among occupational drivers than in their non-exposed siblings [91]. A study on municipal workers found that radiating pain was predicted by manual labour in both sexes and by previous pain in the lower back in men, while psychosocial and physical factors in the working conditions had no predictive value [50]. A review concludes that cold exposure in work seems associated with increased risk for degenerative changes in the intervertebrate discs but seems associated with other physical factors as well [78].

Since LBP is a diverse and nonspecific condition, it is important to study the association of work-related exposures and types of LBP. This applies to LBP with and without radiation, as it implies different pathophysiological processes and clinical developments [46]. Various factors may affect the duration and intensity of LBP.

To assess the subgroups of LBP and their associations with exposure factors, large population studies are required. Our study allowed for a detailed description of LBP, both in character and duration, as well as analysis of associations with combined work-related exposures.

1.5 Planning and management of the project

A group from AMA at UNN had meetings with occupational health specialists at KRLOH in June 2006 during which it was concluded that a joint Norwegian-Russian project proposal should be created. We decided to focus on musculoskeletal conditions and WBV for mine workers operating in cold conditions, since this was an occupational health problem shared in both countries and in need for more scientific investigations. In late 2006 we made the first visit to the Kirovsk mines, conducting pilot measurements of WBV and HAV. New exposure measurements were carried out in the Kirovsk mines in spring 2007. An agreement of scientific collaboration between UNN and Northwest Public Health Research Centre (NWPHRC) in St Petersburg was signed at the initiative of this author. During the project period, these agreements were reiterated twice. The funding for the early visits to Russia was granted by UNN. Later we applied for, and received, funding from several sources (see Acknowledgements). I was the main person in the planning, grant application, grant management and contract negotiations which turned the initial ideas into a funded bilateral research project. During several visits to KRLOH and the Kirovsk mines, I took part in exposure measurements and risk assessment as well as observations of work conditions and characteristics in the mines, over several weeks. Together with specialists at KRLOH we compiled reports from these investigations in the mines and presented the reports to the management of the mines, with whom it was agreed that our project group would be granted access to further investigations of the occupational exposures and health of the workers. I also spent much time with Russian specialists studying medical records at the KRLOH archives. Knowledge about how occupational health is assessed in MO was also developed during these week-long study periods at KRLOH. This was the background for the project description leading to my enrolment in the EPINOR PhD programme. In order to create the questionnaire, I spent time with scientists who had created the VIBRISKS questionnaire [66, 92, 93]. The questionnaire was then adapted to the context in the Kirovsk mines in close cooperation with the KRLOH scientists and other specialists in the field. Together with the KRLOH scientists and my supervisors I decided to use the regular medical health examination of the miners as the platform for data collection procedures. I had the main role in developing these information letters, project proposals and application documents to the regional committee for medical and health research ethics North (REK Nord) and the regional committee for medical and health research ethics in Northwest Russia. This also applied to the testing and revisions of the questionnaire and the instruction of the team ahead of and during the first week of the data collection by questionnaire. The database was created by scientists at KRLOH and entered by their experienced personnel. I received the dataset mine by mine as the data collection proceeded throughout 2010, and checked the dataset for inconsistencies, extreme and missing values. These were checked with the filled-in original questionnaires in paper format and corrected when possible. The data analysis and writing of the manuscripts were carried out with advice from my supervisors. In addition to the scientific work, I believed it was necessary to develop skills in Russian language by studying Russian for two years, from basic training via an intensive language course in Russia to a university exam.

2. AIM OF THE THESIS

The aim was to describe how occupational health is assessed in mine workers in Murmansk Oblast, assess the frequency and character of LBP in miners, and investigate the associations between occupational exposures and LBP.

3. MATERIAL

3.1 Context

The main mining communities in the MO are the neighboring boroughs Apatity and Kirovsk, which have a combined population of 110000. The population has decreased 20% since 1990 [17]. The apatite-nepheline mining and processing enterprise JSC Apatit operates four mines, mine transportation lines and two concentrate plants in the middle of Kola peninsula. The mines are located in the Khibiny mountains, with two underground mines (Kirovsky and Zentralny) and three open pit mines (Vostochny, Zentralny and Rasvumchorrsky). Apatite is a phosphorous-rich mineral used in fertilizers, and JSC Apatit is the largest producer of apatit in the world. After the ore is extracted in the mines, it is transported by train to the concentrate factories nearby where the ore is crushed and apatite extracted by a flotation technique. The product from this process, the apatite concentrate white powder, is the transported to the markets by train. The company employs 13500 workers (20% of all industrial workers in the MO) in the Apatit-Kirovsk area, of which 3947 were employed in four mines in early 2010 (Table 2).

Table 2. Mines and number of mine workers in Kirovsk.

Mine	Type	Number of workers (2010)
Kirovsky	Underground	2034
Vostochny	Open pit	650
Zentralny	Open pit/underground	587
Rasvumchorrsky	Underground	676
Total		3947

Women constitute 5.5% of the employees and 85% are ethnic Russians [21]. The employees work 8 hour shifts in the underground mines 5 days per week and 12 hour shifts in the open pit mines. The mines are operated round the clock, every weekday throughout the year.

Underground mines

In the underground mines, workers are organized in teams with several professions (mine drivers, truck drivers, mine workers, drill rig operators, electricians, blasters, timbermen) and a foreman. This team advances the extraction tunnels by first drilling bore holes at rock wall at the end of the tunnel with a drill rig (of the brand Simba). The drill rig operator works standing in a semi-covered hut on a parked platform operating several drilling arms that are water cooled. The drilling typically takes place in the second half of the work week. Timbermen secure the tunnels with supports to roof and walls. Electricians wire the tunnels, providing energy to the drilling rigs and several electrical vehicles. After holes have been drilled, the blasters install the explosives and fuses. On Fridays, the explosions are set off, allowing fumes and dust to settle and be removed by ventilation during the weekend. Starting on Mondays, rocks from the blast are removed by mine drivers and truck drivers from the site by use of Sandvik Tamrock Toro 400 load haul dump (LHD) vehicles; these are low trucks with a bucket and drives in both directions, some powered by electricity, others by diesel. The operator sits in a semi-covered cabin, perpendicular to the driving directions. The ore is transported in the Toro 400 bucket to a nearby shaft where it is dumped to a lower level in the mine where ore is loaded on small mine trains (pulled by K10 and K14 locomotives) or Sandvik Tamrock Toro 40 trucks.

Figure 2. Toro 400 in operation in an underground mine (Photo: Arild Øvrum)

The Toro 40 is a diesel truck where the driver sits in a covered, temperate cabin, on a cushioned seat in the driving direction. The professional labels mine driver, mine truck driver, mine load driver and truck drivers do not precisely define which vehicle they operate, they can operate both Toro 40 and Toro 400 as well as other vehicles. Even workers in the professional category mine workers may operate a variety of vehicles in their work, although this not frequent and not their primary task.

The K10 and K14 are low locomotives pulling trains carrying ore on steel tracks in narrow tunnels. The K10 and K14 (also called trains) are from the Soviet era, they are the oldest vehicles used in the underground mines and the only vehicles in this study not operating on rubber tyres. The electric train drivers sit in a semi-covered cabin, perpendicular to the driving direction on non-cushioned seats. The Toro 40 and K10 and K14 trains bring the ore to the cracker machine, crushing it to smaller parts which are transported by conveyor belt to the tumbler machine where the ore is crushed into even smaller size.

Figure 3. K10 and K 14 trains operating in narrow underground mines. (Photo: Morten Skandfer)

This ore is then transported out of the mine to the concentration plant by larger mine trains, operating day and night all year round. Underground mine workers are transported into the mines by elevators and by small passenger trains, also pulled by K10 and K14 locomotives on a five minute journey at the start and end of the shift. Mechanics and welders mostly work in repair shops above ground, performing supportive maintenance tasks for the underground mines.

Workplace exposure levels and characteristics were obtained from onsite inspections and measurements together with Russian specialists in the field. The temperatures in the underground mines are at a stable + 5 to 8˚C, this is the ambient work temperature for all underground workers not sitting in covered heated cabins. The surfaces on which the vehicles operate are uneven and consist of rocks and gravel. Ground water and water from drill rigs make the tunnels humid with wet ground, ponds and streams. Water is dripping from the roof of the tunnels.

Open pit mines

Contrary to the underground mines, the open pit mines are in continuous operation. Drill rigs prepare the holes for the blasters to carry out the explosions, and excavators load the ore on large surface haul dump (SHD) trucks. There are two models of such trucks from different producers in use: the US-made Caterpillar and Belorussian-made Belaz trucks. The drivers operate the trucks from a covered, heated cabin, sitting on a cushioned seat. The work shifts are 12 hours. The trucks run on heavy gravel and dirt roads running steep into the bottom of the open pit. The surface conditions vary through the seasons, from ice- or snow-covered to wet and muddy. Dozers are used to level the road surface.

Figure 4. Open pit mine Vostochny (Photo: Arild Øvrum)

Rocks not used for ore is transported out of the open pit to dumping areas, whereas ore is transported to the concentrate plant by trains. In the open pits there are seasonal weather variations, characterized by short, cool summers and long, cold winters with temperatures down to -40 ˚C. The open pit mines are located in the mountains, at high altitudes (400 to 1000 meters). There are repair shops at each open pit mine, where mechanics and welders maintain the machinery and vehicles indoors in temperate halls. Some drivers operate other smaller vehicles of various brands used for maintenance and supervision, like lorries and cars. Bus drivers carry workers to and from the mines.

JSC Apatit also runs public transport, several leisure and sports complexes in Kirovsk, and a nearby sanatorium for restitution of its workers. There is also an educational programme for future miners at the Khibiny Technical College in Kirovsk. In contrast to the early years of mining with use of forced labor (1929-1950), Kirovsk is now a more demographically diverse community.

3.2 Assessment of mine workers health in MO

Occupational medicine deals with the health of workers with regards to workplace exposures, and it is a field of medicine which is affected by the technological development of work life in general and industrial development in particular. Occupational medicine is also a part of the national systems of work place protection, including exposure standards, prevention strategies and financial compensation in the case of occupational disease. National legislation differences can therefore affect how occupational health is assessed in the countries of the Barents region. In order to interpret available statistics and the results of epidemiological occupational health studies, it is therefore not sufficient to understand the exposure factors and biomedical mechanisms, but also needed to know how occupational health is assessed in a population of a given country.

The assessment of occupational health performed by the Kola Research Laboratory of Occupational Health (KRLOH) is the background for the official numbers of mine workers health in MO; such as categories, prevalences and relative distributions. In addition, medico-legal systems that involve consequences for employment and compensation may affect the degree to which health problems are reported, and thus influence the data. All employees in the four mines in this study are summoned to a periodical, obligatory medical examination at the KRLOH. In MO there are three centers for epidemiology and hygienic surveillance which measure and assess risk factors (physical, biological, chemical and psychosocial) in workplaces. [94, 95].

Information about occupational health in Northwest Russia was obtained by search for articles available on PubMed, as well as through manual search in relevant publications which were not indexed in PubMed. The majority of articles found in online search were in Russian language, with English abstract and not available in full text online. These articles were collected in analogue full text in Russian occupational health institution libraries and their relevant content was translated to English language. In addition, search was carried out in online sources for reports, regional and federal statistics. Because the assessment of occupational health is influenced by national legislation, knowledge of the laws, orders, decrees, standards and regulations governing the assessment of occupational health in RF, it was necessary to collect information on these matters. This was carried out at KRLOH, the central institution for occupational health in MO, from documents and reports important to this topic but not available online.

3.3 Study population and population under study

Recruitment of participants

In early 2010, 3947 workers were reported to be employed in mining in the four JSC Apatit mines and these constituted the study population. All workers are subject to periodic health examinations, but at different intervals. Depending on the risk assessment of the work exposures, some categories of workers are summoned for mandatory health examinations each year. This is the case for most categories workers in the mines. Other categories, such as administrative staff are summoned for health examinations every fifth years [94]. The 3680 workers summoned for periodic health examination at the KRLOH in 2010 were invited on the day of their examination to take part in our study. The recruitment was carried out through the same procedures used to summon all workers to the mandatory health examination. Based on records of workers provided by the employer, groups of workers were assigned for examination on predefined days, in groups of thirty to forty workers. The date of examination and list of workers who should attend was announced to the workers at the workplace by the JSC Apatit health care services. All workers attending the health examination were informed about the study and invited to participate on the same morning as the periodic health examination, both by written posters, individual handout letters, as well as by the trained staff present (Appendix III and IV). Care was taken to underline that participation was a voluntary annex to the mandatory periodic examination. Those who agreed to participate signed a letter of informed consent. In total, 3530 (96%) signed an informed consent to participate. This was the population under study (Table 3).

Table 3. Number of workers in the study

Population	**n**
Study population	3947
Workers summoned for periodic health examination in 2010	3680
Workers who gave consent to participate	3530
Population under study	3530

Some 89.3% were males. This figure includes workers who were summoned and did not show up, but were given a later appointment and after invitation accepted to participate. Failure to attend the mandatory health examination could lead to a loss of necessary certificates, incomplete background information for salary calculations and occupational health considerations.

4. METHODS OF DATA COLLECTION

4.1 Data collection for description of occupational health assessment in MO

Data and information for description of occupational health assessment in MO was obtained by online and local sources. We started with a search on PubMed for scientific publications using combinations of search words ("occupational health", "north", "Russia", "assessment" and "Kola"). The majority of the publications found were in Russian language, with English abstracts only. Most of them were not available in full text online. The articles were collected in full text in analogue libraries in Russian occupational health institutions. Working with Russian colleges, the content of the articles was translated to English language. Some 20 of the articles found in the online search were published in *Occupational Medicine and Industrial Ecology/Meditsina Truda I Promyshlennaya Ecologiya*. In addition, we carried out a manual search for the period 2006-2010 in *Human Ecology/Ekologiya Cheloveka*, for relevant publications. This journal was not indexed in PubMed. We also carried out search in other online sources for federal and regional statistics, reports and legal documents (laws, orders, regulations and standards). At the KRLOH, the central institution for occupational health in MO, we obtained information from documents and reports which are central to this topic but were not available online.

4.2 Measurement of exposure factors

Data regarding health and professions were collected by both a questionnaire and observations in the mines. Work place characteristics and the type of vehicles and machinery used were observed and recorded, also on video, during several visits to the open pit and underground mines. This was later used for developing the questionnaire, as described below. Information about how work was organised and the type of jobs involved was obtained from the employer JSC Apatit and from the company health services.

Occupational exposure was also measured in both underground mines and open pit mines. This collection of data was carried out together with those Russian occupational health specialists who carry out such measurements and assess the occupational health of mine workers in MO. Ambient workplace temperature was measured during typical work cycles throughout daily work shifts. Exposure measurements (n=17) of WBV were performed in the Vostochny mine in on 14 Surface Haul Trucks (SHD) of models Caterpillar 785C (n=2) and Belaz 75 (n=12). We performed more than one measurement for 3 of the vehicles. Measurements were performed on-site in a non-simulated situation, during typical work cycles, with each measurement period lasting one work cycle and with measurement periods ranging between 13 to 58 minutes. The WBV measurements were performed in three axis at the operator seat interface as required in the ISO Standard 8041 [96, 97].

Exposure measurements of WBV were also performed on-site in the Kirovsky mine in on a series of Toro 40 and Toro 400 LHD vehicles during typical work cycles [98].

Figure 5. Russian-Norwegian team preparing for WBV measurement on a Toro 400 in the Kirovsky mine.

4.3 Questionnaire development

The questionnaire was written in Russian language and specially developed by this author for this study. The questionnaire was inspired from the Nordic Musculoskeletal Questionnaire [68, 99, 100]. Parts of it were also based on the questionnaire which was developed in the VIBRISKS multi-centre project [66, 92, 93]. Questions about lifestyle factors were imported from the Arkhangelsk study and questions concerning working in cold conditions from the FinRisk study [101, 102]. Items on ergonomic factors were included based on a study by Porter and Gyi [68]. Authors of the VIBRISKS questionnaire contributed in adapting it for our study's purpose. The volume and content were constrained by the need for accurate questions in an appropriate, short format.

The questionnaire (Appendix I and II) was structured as follows: Section 1 concerned age and sex. In section 2, the workers were asked about their current and past occupation in 14 specified occupations in the mines. The list of occupations was based on the main occupation categories in the four JSC Apatit mines in Kirovsk plus one 'other' category. There were also illustrated questions about posture, lifting, sitting and physical demands. Vehicle driven in their current and past work was inquired by a list of seven vehicle categories, based on the most frequent used vehicles in the mines. For other vehicles, two 'other' categories were added with the possibility of specifying vehicle. Questions concerning work in a cold environment were adapted from the FINRISK study [102]. Separate questions addressed discomfort from mechanical shocks and frostbite and hand problems when exposed to cold. Initially, more questions concerning hand-arm problems and hand-held vibrating tools were included, but had to be traded away in the development process due to need to limit the volume of the questionnaire.

Section 3 contained questions about LBP, shoulder pain and neck pain during the last 12 months. To ease the respondents' task of reporting, questions concerning all three locations had identical structure. Details about pain characteristics (localisation, radiation, debut, duration, and frequency of episodes), sick leave duration and accidents were included. A visual analogue scale VAS with ten points was chosen to measure pain intensity [103, 104].

Finally, information about personal characteristics, life-style factors and stress were collected using questions concerning body weight, height, stress level and physical activity from the Arkhangelsk study in section 4 [101].

The questionnaire was translated to Russian language and back-translated to check for inconsistencies. The translated questionnaire was tested out by a panel of mine workers, and their feedback used for modifications. The employed version was named 'Workers health 2010' and Здоровье человека 2010 года in Russian.

4.4 Data collection by questionnaire

The data collection took place throughout the year 2010. Each worker filled in the questionnaire individually in a room set aside for the purpose. Trained staff was present to clarify uncertainties and to check for inconsistencies and completeness when the questionnaire was returned at the end. The questionnaire took between 20 and 30 minutes to answer, and was completed by all 3530 workers who had given consent to participate.

4.5 Reporting low back pain

The presence of LBP was measured with the following question: *Have you felt pain or discomfort during the last 12 months in the body area shown in the figure (as depicted in the questionnaire)? (Yes/No)*, hereafter named 12-month LBP. Localisation was measured with the question: *If yes, where was the pain or discomfort localised?* Answer options were: back only, radiating in the leg only and back and radiating in the leg. Pain intensity was reported on a 10 grade, visual analogue scale (VAS). The frequency and duration was measured in predetermined time and frequency categories by the questions: *How many episodes have you had?* and *How long did they typically last?* The respondents were also asked to report the first experience of an episode with back pain (year and month).

Measurement of shoulder pain and neck pain was also included in the questionnaire, with questions asked in a similar way as for low back pain. These health outcomes have not been subject for analysis in the papers presented in this study, and are not elaborated further upon.

4.6 Exposure assessment

Driving a vehicle was used as a marker of exposure, and workers who responded that they were presently driving a vehicle during a typical work week were defined as exposed to WBV. Cumulative exposure was defined as hours of driving reported per week, classified into four categories: 1 to19 hours, 20 to 29 hours, 30 to 39 hours and 40 or more hours per week. According to the observed, combined work exposure depending on the type of vehicle, the workers were categorized in subgroups based on the vehicle operated. Vehicles driven were classified into six categories: Toro 400 LHD trucks, Toro 40 dump trucks, Caterpillar and Belaz SHD trucks, K10 and K 14 trains, lorries and buses and cars of various brands. This last heterogeneous group was merged with the remaining vehicles to form an extended 'other' category (Table 4).

Table 4. Vehicle categories in the four mines in Kirovsk

Vehicle category	**Type of vehicle**
Toro 400	LHD truck
Toro 40	Dump truck
Caterpillar, Belaz	SHD truck
K10, K14	Electrical locomotives
Other	Lorries and buses, cars of various brands and other

The workers were classified by their current and past occupation, by the question: *What is your current and past occupation?* Only one current occupation was reported for each worker.

The workers were also asked when they were employed in their present job. Past job as a driver was chosen as a measure of past WBV exposure.

Operators of open pit excavators were not included as a separate category (low numbers), and were defined into the 'other' category. Drill rig operators in underground mines and open pit mines were defined as a separate category.

Lifting was measured by the questions *How many times in a typical working day do you lift loads greater than 15 kg and 30 kg, respectively?* with five frequency categories for each question. In addition the following question was posed: *Does your work ever involve lifting or moving loads more than 50 kg?*

Working with wet clothes and in a cold work environment was recorded by the questions: *How many hours per week have you been exposed to cold environment (below +10˚ C) during this/last winter, indoors or underground? and with wet clothing?* [102, 105]. Questions were included where respondents should report as hours per week whether they were working with wet clothing and touching cold objects, respectively.

4.7 Life style factors

Information concerning weight, height, stress level and physical activity were also obtained, as adjustment factors. Stress was reported as a five level ordinal variable. Physical exercise in leisure time was reported as yes/no response to four described levels [101].

5. STATISTICAL ANALYSES

In Article III we used two models (1 and 2) in the binary logistic-regression analysis to analyse for possible associations between LBP and the exposure factors. In the main analysis (model 1), the WBV-exposure time in current profession was classified according to the four categories as hours driven per week (0 hrs, 1 to 15 hrs, 16 to 30 hrs and above 30 hrs). Relevant interaction variables between the individual exposure factors (except past WBV) and between duration of employment in present job and current driving were included in the model. In model 2 each vehicle category (six groups defined by vehicle types) was included as the WBV exposure. In both models, the associations between the study factors and LBP were adjusted for stress, physical exercise, BMI, duration of present occupation (in years) and sex as possible confounders. Stress was reported as a five level ordinal variable, the cut-off was set at the level termed 'a little' in the analyses. Physical exercise in leisure time was reported as yes/no response to four predetermined and described levels in the questionnaire [101]. The cut-off for physical exercise in the analyses was set at recreational sports at least 4 times per week. We chose to not adjust for age since this was highly correlated with the duration of present occupation. In model 2, driving other vehicles was also included as a confounder.

In Article IV the exposure factors included the type of vehicle driven (Toro 40, Toro 400, trains and other vehicle) and the following occupations: driver, mechanic, blaster, electrician, foreman, drill-rig operator, and other occupation. These exposure factors were included as exposure categories in the analysis. As dependent variable LBP was classified as LBP without radiation and LBP with radiation (including pain radiating in the leg only). The associations with the different exposure and worker categories were assessed in bivariate and multiple logistic regression analyses of the workers who reported LBP. Only occupation categories that were associated with LBP with radiation in the bivariate analyses were included in the multiple regression model. Adjustment was made in the multiple model for the factors: duration of employment, BMI, physical activity and stress level. We chose not to adjust for age since this was strongly correlated with the duration of employment. Heavy lifting, cold and wet clothing were dichotomised, with cut-offs set at more than 15 kg ten or more times/day for heavy lifting, over 20 hours/week for cold, and over 5 hours/week for wet clothing. Stress was included as a five level ordinal variable, and physical activity and BMI were dichotomised with more than 4 hours/week and 30 kg/m^2 as reference categories respectively. Duration of employment in years was categorised as below 2, 2 to 5, 6 to 14 and above 14.

For the analyses in both Article III and IV the significance level was set at five percent. The associations were reported as odds ratio (OR) with 95% confidence interval (CI). 78 questionnaires were missing information about one or more of the included factors. IBM SPSS version 18 was used for the analysis.

6. SUMMARY OF PAPERS WITH MAIN RESULTS

Paper I

How occupational health is assessed in mine workers in MO

The paper describes the system for assessing occupational health in MO, based on available literature, statistics, current practice, laws and decrees, as well as by personal communication with employees at KRLOH. Several institutions are involved in assessing mine workers health, calculating exposure levels as hazard grades and making recommendations for further employment. Hazard grades are calculated from combined measured values of exposures (levels 2, 3.1 to 3.4 and 4) and affect the frequency of medical examinations, salary level and recommendations concerning fitness to work. Health is assessed at a mandatory regular medical examination annually and every second or fifth year, depending on the hazard grade. The aim of the examination is to diagnose latent or manifest occupational disease. Based on a wide set of information, a committee of specialists can give three possible outcomes: a) the employee can continue to work; b) the employee must be relocated because of suspected development of occupational disease in a work environment with hazard grade of 3.1 or above; and c) the employees must be relocated due to diagnosed manifest occupational disease.

Disability is graded in four levels, also with recommendations for further work. For a medical condition to be approved as occupational disease, a consultative group of doctors in specialized institutions decide whether four criteria are present: a) the condition must be among the qualifying diseases; b) the exposure must be known to be present in the work environment; c) there must be a causal link between exposure and disease; and d) the exposure must precede the onset of disease by a reasonable amount of time. Being diagnosed with an occupational disease will also lead to a lower retirement age, a higher pension, free treatment of the occupational disease and qualifies for applying for compensation as a one-time payout, decided by the local Special Medical Social Committee (MSEK). The ruling can be reconsidered at a regional and central level. The emphasis is more on control and repair than on prevention of disease. The recommendations from the health assessment may be experienced as unfavourable by the employee, such as forced relocation to a position with lower salary, which may motivate workers to underreport their health problems at the mandatory periodic health examination.

Paper II

European and Russian methods for exposure assessment applied on whole body vibration values in short haul dump trucks.

The systems of risk assessment of WBV (termed *general vibration* in Russia) and its consequences differ between Russia and other European countries. Understanding how these systems relate to each other and to measured values is important for the interpretation of exposure levels. The aim of this study was to determine WBV exposure levels from heavy vehicles in an open mine, perform the corresponding risk assessment levels by applying European and Russian WBV risk assessment methods and study how the values in the two systems relate.

Exposure measurements of WBV (n=17) were performed in an open mine in Kirovsk, Russia on fourteen Surface Haul Trucks (SHD) of models Caterpillar 785C (n=2) and Belaz 75 (n=12). For three vehicles, more than one measurement was performed. Measurement periods ranged between 13 to 58 minutes. Measurements were performed on-site in a non-simulated situation, during typical work cycles, with each measurement period lasting one work cycle. The WBV measurements were performed in three axis at the operator seat interface when operating in non-simulated work situations adhering to the requirements of ISO Standard 8041 [97]. The processing, analysis and exposure assessment methods followed the guidelines of the ISO standard and Russian methods and standards [106, 107]. In the Russian system, levels of exposure of all kinds are categorized in the general system of hazard classes from 0 to 4, which are used to grade the level of exposure [107].

Grade 1 is not harmful exposure and grade 2 refers to a level termed allowable. Grade 3 is subdivided into four (3.1 to 3.4) levels of increasing hazard. Level 4 refers to extreme exposures which is dangerous to health. In the Russian system high hazard grades lead to increased salary, higher pension or possibly relocation. In the European system, exposure values above action value are considered possible harmful to health, and such values would lead to practical preventive measures at the workplace; seeking to reduce the exposure level below action value. Exposures above limit value would cause immediate preventive action to reduce exposure levels at the workplace.

In our analysis, WBV vibration was first expressed as frequency weighted root mean square acceleration level over 8 hours: A(8)rms. In order to compare these calculated A(8)rms values to hazard categories in Russian regulations, the dB values used to differentiate the hazard categories in the Russian regulations were converted (A (m/s^2) = 20 log X (dB), A = acceleration value expressed as m/s^2, X = acceleration value expressed as decibel. Risk assessment terms *Above action value* and *Above limit value* and hazard categories were designated to the actual measured exposure values. The mean A(8)rms WBV exposure (frequency-weighted rms) on the most severe (z) axis was 1.0 m/s^2 (SD±0,23). By comparing corresponding exposure levels, the Russian system of hazard grades considers WBV levels below 0,56 m/s^2 in the vertical (z) axis as allowable (hazard grade 2). WBV exposure levels in the z axis between 0.56 m/s^2 and 8.9 m/s^2 are termed hazardous by the Russian assessment method, on a graded scale (3.1 to 3.4). WBV levels in the z axis above 8,9m/s^2 are termed extreme and dangerous with hazard grade 4. The limits for the hazard grades are ranges, not single values as in the European system, so the action and limit values fall within the ranges. Exposures at action value are in the range that defines hazard grade 3.1 (0.56 to1.12 m/s^2). Exposures at or above limit values is in the range that defines hazard grade 3.2 (1.12 to 2.23 m/s^2), and close to the lower limit of this range. Thus it can be claimed that limit value (1.15 m/s^2) and hazard grade 3.2 are corresponding expressions of risk levels, though the Russian system, however, is a more fine-graded system. The two systems differ in the consequences from the risk assessment. Both systems are, however, efforts to categorize the risk and ease the process of assessing and communicating risk.

Paper III

Low back pain among mine workers in relation to driving, cold environment and ergonomic factors

Mine workers driving heavy vehicles are exposed to multiple factors in the work environment. LBP is frequently reported, but the prevalence differs between populations. Our hypotheses were that WBV from driving heavy vehicles, heavy lifting, working with wet clothes and in cold working conditions affect the risk of LBP. We aimed to investigate the association between jobs that involve WBV, cold environment, heavy lifting and wet clothing and the risk of LPB in a cohort of mine workers in north Russia.

Health and personal data were collected by a questionnaire (Workers health 2010') specially developed for the study, based on previously used questionnaires. The study was cross-sectional and performed throughout 2010 among full-time employed workers in the mines. Altogether, 3530 workers from four mines agreed by informed consent to participate in the study during the winter season and they all completed the questionnaire. The presence of LBP was measured with a question of whether the respondents had experienced pain or discomfort in the lower back during the last 12 months. They were also inquired about present and past occupations, vehicles operated and exposure to cold, lifting, posture, wet clothes and personal factors. Work place characteristics, organization, type of occupations, vehicles and machinery were also observed in the mines or obtained from the employer.

We used two models in binary logistic-regression analysis to analyse for possible associations between LBP and the exposure factors. In both models, the associations between the study factors and LBP were adjusted for physical exercise, stress, sex, BMI, and duration of present occupation (in years) as possible confounders.

Some 51% of the workers reported LBP within the last 12 months. The majority of drivers (59.0%), blasters (65.2 %) and drill-rig operators (61.7 %) reported LBP. The prevalence of

LBP among those who worked with wet clothes for at least one hour per week was 61.2% and 65% among those working with wet clothes at least 5 hours/week. The crude odds ratio for having worked with wet clothes (OR = 2.38) in cold environment (OR = 1.88) and lifting heavy (OR = 2.01) showed an association with LBP, whereas for WBV the crude OR was 1.14. Crude OR for drivers of load-haul-dump vehicles (Toro 400) was 3.63 and for trains crude OR was 1.98.

These associations remained when adjusted. The strongest adjusted association was found for wet clothes (OR=1.82). Cold working conditions and heavy lifting were also associated with LBP. Wet clothes and cold working conditions were independently associated with LBP and we found no interaction between the two factors. There was also an adjusted association for previous job as a driver (OR= 1.79), whereas the adjusted OR for WBV was 1.08 per category increase in time driving a vehicle, which suggests that driving time is a weak risk factor. Still, the association between previous work as a driver and LBP suggest that drivers are at some elevated risk of LBP. Levels of WBV in Toro 400 and K10 and K 14 had been determined previously as above action values. Driving the TORO 400 (OR=2.65) and the K10 and K14 trains (OR=1.69) were the only vehicles associated with LBP, which may in part be explained by the twisted working position combined with low temperature in the open cabins, features that are particular for these vehicles. This indicates that vehicle-type specific analyses are needed when assessing the risk of musculoskeletal problems due to occupational driving. For better prevention of LBP, we recommend that improved cabin conditions and clothing should be emphasised.

Paper IV

Low back pain symptoms in relation to self-reported physical exposures among arctic mine workers: a cross-sectional population study

High prevalence of LBP has been reported in mine workers. LBP episodes may show various manifestations, intensities and durations. Operating heavy vehicles in mines expose the drivers to several factors. We have reported (Paper III) that wet clothing, cold working conditions, heavy lifting and previous work as a driver are associated with LBP. Some persons experience back pain only, others experience back pain with radiation to the leg, a condition often termed sciatica. Our hypothesis was that working in wet clothes increase the risk of LBP with radiation. This warranted a more detailed study of subgroups of LBP with and without pain radiation as well as other characteristics.

The study aim was twofold: to investigate characteristics of low back pain symptoms (frequency, intensity, duration and radiation) in mine workers, and how back pain with radiation relates to occupation, type of vehicle driven, past driving, heavy lifting, wet work clothes and cold work environment among workers with LBP. The study was cross-sectional, and data were collected throughout 2010 by both observations in the mines and the questionnaire 'Workers health 2010', which was completed by the workers at their periodical medical examination. Workplace characteristics and the types of vehicles and machinery used were observed and recorded for inclusion in the questionnaire, and the groups of professions were defined. The population under study consisted of 3530 workers employed in four mines in Kirovsk, participating after giving their informed consent. The presence of LBP during the last 12 months and its localisation, frequency, duration, intensity and whether it was radiating was assessed by questionnaire, using predetermined categories for frequency and duration, and visual analogue scale (0 to 10) to assess pain intensity. The workers were classified by their reported current occupation, driving a vehicle in a typical work week was defined as being exposed to WBV. Duration of driving was recorded in predetermined categories, and lifting, cold environment and wet clothing was inquired. Stress and physical activity was assessed by questionnaire. Height and weight was measured.

The associations of LBP with and without radiation to the different exposures and worker categories were assessed in bivariate and multiple logistic regression analyses of the workers who reported LBP. Only occupation categories that were associated with LBP with radiation in the bivariate analyses were included in the multiple regression model. Significance levels were set at five percent. Adjustment was made for the following factors in the multiple model: duration of employment, BMI, physical activity and stress level.

Cold was the most prevalent of the exposure factors studied; 85.8% of the train drivers, 81.6% of the Toro 400 truck drivers and 84.8% of the blasters reported exposure to temperatures below +10˚C more than 20 hours/week. Of those 51% reporting LBP, 34.8% reported LBP with radiation. Among workers with LBP the proportion that experienced back pain with radiation of pain to the leg was highest among blasters (49%), drill rig operators (40%) and drivers (36.5%). Radiation to the leg was most commonly reported by drivers of Toro 400 trucks (44%) among those with LBP.

The mean VAS rating of worst pain was 2.3 (median 2) among workers with back pain only during the last month, and 4.2 (median 4) for those with back pain radiating to the leg. A crude risk above unity for LBP with radiation (including radiating pain to the leg only) among workers with LBP was observed for wet clothes, cold environment, heavy lifting, being past driver, driving Toro 400 and working as blaster. This suggests that several factors contribute to LBP with radiation. The adjusted association was statistically significant for wet clothes (OR=1.44), cold environment (OR=1.49) and past driving (OR=1.50). The results suggest that cold and wet work environment were the main risk factors for radiating pain. The association with being a past driver suggests that driving vehicles might be a risk factor or a marker, and that some workers may have changed profession from driver to other professions due to painful, radiating back problems, as a healthy worker effect.

The highest prevalence of LBP with radiation was found among the blasters, who work in the open and do not operate vehicles, but are exposed them to wet and cold conditions. Our results show that many workers in these mines are exposed to several possible risk factors, but the study did not allow for further specification of the temporal relationship of the exposure factors and the outcomes. The main weakness of this study was the cross-sectional design, which does not allow for analysis of cause-effect relationships. Information was self-reported, and thus subjective. The lack of an association with heavy lifting may be due to our classification of exposure or a healthy worker selection. The study suggests that cold work environment and wet clothes contribute to the risk of LBP with radiation.

7. GENERAL DISCUSSION

7.1 Study design and methodological considerations

In the cross-sectional epidemiological study, the aim was to study the population of workers employed in the four mines in Kirovsk: Rasvumchorrsky, Vostochny, Zentralny and Kirovsky. These workers were defined as the study population. Since there already was a system of mandatory, periodical medical examination of these workers, this was chosen as the framework for enrolment into the study.

Recruitment and inclusion

When the medical examination for 2010 was being planned by KRLOH, the JSC Apatit reported having 3947 employees in the four mines. Through 2010 the numbers of employees were adjusted down, due to changes in the workforce. The recruitment was carried out by the same procedures used to summon all workers to the health examination. Included in the study were those summoned and attending the health examination at KRLOH who also signed the letter of informed consent to participate (Appendix III and IV). Working in the mines, transport or production lines has combined exposure levels that give hazard grades above 2; employees with hazard grade 2 or below are administrative staff. Workers with hazard grades 2 or below (low risk exposure) are summoned only every fifth year. This explains the discrepancy of 267 employees between the initial numbers from JSC Apatit and the 3680 summoned to the KRLOH for examination.

Since the health examination is mandatory, regulated by law, and the workers receive full pay for the day of examination, a very high attendance rate is the norm for these examinations. In total, 3530 (96%) of the 3680 summoned agreed to participate in the study, this was 89% of the population of workers (n=3947) who initially were reported as employed in early 2010. The participation rate was high for questionnaire studies. There is no record of what characterised those 4% who were summoned but chose not to participate in the study.

This is a population previously not exposed to this kind of study, so 'fatigue' towards data collection by questionnaire was presumably not an issue in this population. Also, the framework in which the data collection took place has likely contributed to the high level of consent to participate: the filling in of the questionnaire was a part of the day's programme, with time set aside for this activity. The day of periodic health examination included some waiting time, so filling in a questionnaire may not have been so unattractive to the waiting workers. In addition, the facilities likely contributed to a setting that was favourable for consenting to participate in the study. The fact that this was a Norwegian-Russian study also added some curiosity and enthusiasm among the potential responders, probably making them more inclined to consent to participate and respond more thoroughly in the questionnaire.

Creating the questionnaire

Based on our observations in the mines, information from the mining company and records in the medical cards at KRLOH, a list of current and past occupations was defined, including an *other* category. Only one current occupation was inquired. Despite our efforts, the category mechanics was left out of the printed questionnaire, which neither was discovered during the pre-testing procedures of the questionnaire. Shortly before starting the data collection, instructions were upgraded, so mechanics would be occupation category 15 and other would be entered as a new category 16.

Based on information from the mining company, experience and records at KRLOH and our own observations from several mine visits, a list of main vehicle categories used in the mines was created. Some categories were vehicle type specific for the larger uniform vehicle groups such as Caterpillar and Belaz trucks, Toro 400 load haul dump vehicle (LHD) and Toro 40 trucks. The K10 and K 14 trains were also included as a category since they were commonly used. Although drilling platforms are vehicles that are stationary when in use, Simba drill platform was also included as a vehicle category since it exposes the operator to WBV. Other types of vehicles were not specified other than *lorry or bus* and *car*. *Other vehicle* categories were included for vehicles not mentioned in the predetermined categories. These categories of occupation and vehicles were specific for this study, and not based on previously used questions in other studies. The questions regarding *activities in your work* were based on previously used categories in the VIBRISKS, but illustrations created specifically for 'Workers Health 2010' were added, in an effort to help clarify the questions. Collecting ergonomic information by questionnaire is however, not an optimal method and more advanced recording by video and positiometers would have been desirable. This was, however, not technically feasible at the time. Lifting was inquired by mutually exclusive predetermined weight categories based on experience from VIBRISKS, not on observation of the work in the mines. The subjective nature of the values reported is a source of uncertainty.

For the collection of information on work in a cold environment, questions used in other population surveys were used [108]. Applying the cold environment definition of +10° C was in accordance with the limits defined in the ISO Standard and relevant to the temperature ranges (+5 – 7° C) we had measured in previous exposure assessments in the underground mines in Kirovsk [105, 109]. The term *underground* should avoid having respondents define underground mines as outdoors.

When we created the questionnaire, we knew from our measurements that the exposure levels of WBV from operating heavy vehicles were above action value for several major vehicle categories, possibly increasing the risk for adverse health effects. Based on the assumption of high prevalence of musculoskeletal pain, the questionnaire focused on low back, shoulder and neck pain in detail. In addition, questions concerning finger problems in cold environment were included. Only data concerning LBP was used in the publications presented here (Paper III and IV). Other possible clinical outcomes were traded away in the process, to limit the volume and complexity of the questionnaire. Questions concerning pain in the neck and shoulders could also have been removed, making the questionnaire easier to answer overall. However, we decided to include questions for these outcomes for future analysis. Illustrations and questions concerning clinical outcomes were developed from previous VIBRISKS questionnaires.

Data collection by predetermined categories of exposure and health outcome limits the variation in possible answers to categories of expected relevance and importance. Care was taken to make the categories relevant to the actual exposure and health outcomes, including an *other* or *describe* category if the predetermined categories did not fit. Complex questions and questions which demanded calculations were attempted to be avoided. Still, a question concerning rating *pain on average* was included. The term on average may have different connotations to the investigator and the respondents, which may have affected the response, but possibly as both over- and underestimation.

Supplementary information was inquired at the last page of the questionnaire. Questions concerning educational level, stress and physical activity was included as asked in other relevant questionnaires, and not adapted to the local conditions except for the terms used for education levels [101]. Stress was defined as a term, since this may be culturally sensitive or prone to wide interpretation.

The questionnaire draft in English was translated to Russian and retranslated by two different persons, and except minor details in wording, the content and meaning was intact. The discrepancies in question was tested on a group of randomly selected mine workers at KRLOH, and their feedback on wording, complexity and volume of the questionnaire led to revisions and reductions. The concept of VAS scale seemed, however, not to be a problem, but reported time fatigue convinced us to reduce the length of the questionnaire.

The use of questionnaire in studies of musculoskeletal health problems

A questionnaire can be defined as a tool designed to record, or guide the recording of recalled exposures and health related information from subjects in an epidemiological study. A questionnaire often represents a compromise between a tool that obtains measurements of variables, a minimum of errors and is easy to use, process and analyse. Basically, a questionnaires design and content are trade-offs between two factors: the objectives of the study and the limitations in what is practically feasible, like length and complexity. The objectives determine which factor should be included and the measurement level. A plan for the analysis should also be used when designing a questionnaire, as it should include potential modifiers and confounders of the associations between exposures and effects one plans to investigate. The length of the questionnaire limits the volume of topics and details to be included. It is necessary to limit the volume of topics and details included to avoid a too lengthy questionnaire. The compliance and the quality of the answers from the respondents can also be impaired by questions that demand recall over a long time, questions that are complex and involve calculations. This can lead to non-completion of a self-administered questionnaire, reduce the quality of the data, lower response rate and 'study fatigue' in the population making respondents less inclined to take part in future studies.

Questions can be put forward as open-ended or close-ended. Close ended questions are used more often in self-administered questionnaires because it needs to be simple to complete and allow for tick-off boxed, which also makes data entry and analyses easier. These answer options should be simple and brief and mutually exclusive if only one is to be selected. An 'other' category should be included so all respondents can select an answer when other options are not relevant. The answer options should be relevant to the actual situation inquired, and appear in a logical sequence. Sensitive questions should be put at the end. Too many response alternatives increase the probability that one of the response options listed first will be selected [110].

During the development of a questionnaire, specialists should be consulted and the draft questionnaire should be pre-tested on a test panel of respondents that are representative for the study population. In a pre-test, unclear questions can be identified for later revision. A preliminary translation into the language that will be used in the study should be done by someone who knows the overall objective and intent, and is fluent in both languages. Then, it should be translated back by someone who does not know the original version translation, and the original and back-translated versions should be compared for consistency in meaning and content. Although the reliability and validity of the questionnaire may not be completely preserved after the translation, this change may in part be due to cultural differences between two study populations [110].

One limitation of the questionnaire approach is the subjective nature of the reporting. Still, questionnaires such as the Nordic Musculoskeletal Questionnaire can be appropriate tools to sample information about musculoskeletal disorders [99, 100, 111-113]. The pathology behind musculoskeletal problems is difficult to identify, so subjective reporting on health problems may be a more appropriate approach. When large cohorts are available for study, it is inconvenient to use objective testing, and the approach by questionnaire may be more efficient and cost-effective. For large population studies on clinical problems that are subjective in nature, questionnaires can be appropriate and the data reported with such methods may well be in concordance with the actual situation [57]. The Nordic Musculoskeletal questionnaire has been tested for reliability and validity [114, 115]. Questionnaires may be modified, as in the Archangelsk study where questionnaires were also translated in order to study a Russian population [101]. The experience of that study was helpful in planning our study.

Data collection

The data collection by questionnaire took place in a designated room with trained staff present and time set aside in the program for this data collection. Answering a questionnaire like this was a new experience to the responders. The trained staff guided and assisted the responders, but care was made through the instructions to the staff not to aid the responders in such a way that answers were influenced. Whether this still could happen can not be ruled out completely, and the magnitude can not be determined. For the completeness of the filling in of the questionnaire, the staff looked through the questionnaire for unanswered questions, so the respondents could fill them in. This method of data collection was chosen over other (distribution by mail, filling in questionnaire at work), as it was considered the optimal solution in this context.

Data entry

Four experienced persons entered the data, working individually, and the work was reviewed by a senior researcher at the end of every day for inconsistencies. The data were entered in a database (EpiInfo) and exported to the SPSS database at the end. Variation in interpretation and amount of random errors between the persons entering the data can not be ruled out. Thus, random errors can only be assumed for the individual person entering the data.

7.2 Internal validity

Selection bias

When there is a systematic difference between the characteristics of the people selected for a study and the characteristics of those who are not, selection bias may occur [116]. Such bias leads to a distortion in the estimate of effect [117]. Investigators may pick populations of convenience rather than representative ones. An obvious source of selection bias occurs when participants select themselves for a study, for some particular reasons [116]. To avoid this, we decided that all employees at JSC Apatits four mines in Kirovsk should be invited to the study when having their periodic medical examination. This way, the choice of study population was both convenient and representative. A posteriori check on the information given on current job in the questionnaire versus the information on current job in the medical records in KRLOH revealed a discrepancy of 5%.

However, the choice of studying one workplace population makes it less representative of the other work places and the general population, making generalisation of the results difficult. The subjects were not informed about the study before they arrived for the periodic medical examination, providing equal conditions for making the determination whether to participate in the study or not. Those in the study population who chose to not participate did not contribute possible selection bias, but possibly non-response bias. Most of those 4% who refrained to take part in the study explained it by having profession as administrative staff and not perceiving their participation as relevant for the study objectives, or being motivated to participate. Unfortunately, the individuals in the latter category were not counted. The non-response rates are often much higher than in this study.

Healthy worker effect refers to selection mechanisms when workers who suffer most from the exposures tend to leave their jobs, so that individuals who are not medically fit for the work are not employed or are relocated to another job. This can be due to the workers' own choice, or decided by the employer. Relocation or retirement is a possible recommendation from the periodical medical examination itself. In this population, pre-study investigations had showed that there was about 10% new recruitment to the workforce every year due to workers leaving their work, changing profession or went into pension for various unknown reasons. Another source for healthy worker effect may be that persons are too ill to show up for the study. All those who failed to appear at the examination day at KRLOH were given a later assignment. No data were available to quantify the possible influence of healthy worker effect on our results. But we can assume that health problems are underrepresented in the working population studied, so the prevalence of health problems identified may be underestimated. In addition, workers may have tended to underreport their health problems due to the risk of relocation from a well-paid work or eventually entering unemployment. This would reduce the impact from a healthy worker effect. Thus, determination of the magnitude of the healthy worker effect is difficult.

Information bias and misclassification

Whenever there are systematic errors in the measurement of subjects or in the information given by the subjects, information bias is present. Misclassification of exposure variables can be non-differential and differential. Non-differential misclassification in cohort studies occurs when the probability of being misclassified is the same for all study subjects (not dependent of the outcome variable). This usually underestimates the effect estimate. Differential misclassification occurs when the probability of being misclassified differs between groups of study objects. This can lead to either over- or underestimation of the effect estimate [117]. How this could apply to our data collection by the questionnaire is discussed below in section 5.2.4.

In this study, workers were reporting their exposure duration and perceived exposure level as well as presence and character of muscle pain, so the possibility of answers influencing subsequent response, and thereby inducing bias, was present. The workers were asked to report occupational exposure as profession and vehicles driven for the years preceding the study. Also, they were asked to report the presence, duration and character of muscle pain during the last year. This allowed the workers to let the perceived levels of exposure affect the reporting of health problems. The up to twelve-month recall time could have resulted in a failure to accurately remember past exposure or muscle pain and thereby giving inaccurate or false information, as has been pointed out in the literature [82]. Another information bias occurs when subjects are asked to report on exposures that are socially desirable or unacceptable, which may affect how the subject wants to appear. Smoking, level of stress or physical activity may be such factors affected by subject bias. Based on previous experience with underreporting alcohol consumption questionnaire based studies in Russia, questions concerning alcohol were left out during the design phase [118, 119].

Another kind of subject bias is cultural bias. When a questionnaire is created in one cultural context and translated to be used in another cultural context, cultural differences may apply. In this case, a western style questionnaire was used in a Russian context. To minimize the cultural bias the questionnaire was created by a team of Norwegian, Swedish and Russian scientists, based on existing western questionnaires but modified for local relevance to the population studied and its work exposure. In order to avoid unclear or incorrect language, the English language questionnaire final draft was first translated to Russian and then translated back to English by independent translators. The questionnaire was also tested on a panel of randomly selected mine workers who after completing it gave feedback on the content. Personal and lifestyle factor questions were left to the end of the questionnaire, in order to not let the presumed culturally sensitive questions of stress, physical activity and smoking affect the attitude towards answering the rest of the preceding questions. For the participants to understand the term when asking for stress level in the questionnaire, stress was defined as a tense, restless, nervous or anxious feeling with troubles to sleep and troubles on the mind. Trained staff was present in the room where the participants filled in the questionnaires, instructed to assist the participants and clarify uncertainties. Still, cultural bias can not be excluded.

Confounding

Confounding arises because non-random distribution of risk factors in the source population also occurs in the study population, providing misleading estimations of causal and non-causal relationships [116]. This can occur when an exposure factor is associated with both the outcome under investigation and another exposure that influence the risk of the outcome. An appropriate statistical analysis may enable us to discern whether the effect is due to one variable rather than the other. Confounding may lead to over- and underestimations, as well as change the direction of an association [117]. We controlled for possible confounding by adjusting for factors that are known to be associated with the risk of low back pain (BMI, physical exercise, stress and duration of present occupation) in multivariate regression models (Paper III and IV). Still, confounding may be present, since some potential confounders were not measured or had to be left out of the analysis due to the quality of the response, such as work postures. We chose to not control for age since this was closely correlated with duration of occupation. We also chose not to control for smoking. For the question concerning daily smoking there were 1001 missing. Of those 2529 who responded 1738 (49.2%) were smokers.

7.3 External validity

External validity refers to the extent to which the results are possible to generalize and apply to the source population and to other populations [116]. Internal validity is a prerequisite for a result to have external validity. The population studied were all Russian workers in a mining company; those working in the mines and the administrative staff. The age groups and risk factors studied are thus most relevant to compare with other Russian populations of workers in mine companies. However, similarities in exposure factors (type of vehicles and low temperatures) and ethnicity (Caucasian) make the results most applicable to other populations of mine workers in the European part of northern Russia. Persons in the study population working as administrative staff are assumed to be under-represented in the study by not consenting to participate or not being summoned to the health examination. Administrative staff is part of the group which is non-exposed to the study factors. Thus, the control groups would have been larger with their participation. Supposing a lower prevalence of LBP or LBP with radiation among administrative staff, larger control groups could have increased the effect estimates. On the other hand, a higher prevalence of LBP or LBP with radiation among administrative staff could have decreased the effect estimates. This could have differed from study factor to study factor. Since almost all from the study population participated in the study, the external validity towards the study population was close to the internal validity.

7.4 Discussion of the main results in Paper I

The fact that the medical examinations of most mine workers in MO were performed by a single institution implies stable quality and continuity of the work and gives added value to the numbers. MO adheres to the same legal framework as all of the RF, so our findings concerning requirements, procedures and standards can be generalized to the rest of the country. The main limitation of the study was the poor availability of information sources. Internationally published information is very scarce, and material published in Russia is not readily located through databases and usually not accessible electronically. Therefore we also used informants. Methodological factors (improvements in diagnosis, occupational health care systems, and registration regimes at KRLOH) might explain the observed increase in number of cases of approved occupational disease in this mining population. To what degree the built-in mechanisms in the system have led to under-ascertainment of disease and injury would be difficult to evaluate. The character of the periodic medical examinations was control-based and mandatory. This does not solve the issue of possible underreporting at periodic medical examinations. The system did provide employees with extensive health assessments, which may be regarded as a fringe benefit. Still, this check-up activity might also have taken place at the expense of prophylactic approaches.

7.5 Discussion of the main results in Paper II

By comparing corresponding measured levels of WBV exposure, the Russian system of hazard grades considers WBV levels below 0,56 m/s^2 in the vertical (z) axis as unharmful and thus termed allowable (hazard grade 2). WBV exposure levels in the z axis between 0.56 m/s^2 and 8.9 m/s^2 are termed hazardous by the Russian assessment method, on a graded scale (3.1 to 3.4). WBV levels in the z axis above 8,9m/s^2 are termed extreme and dangerous with hazard grade 4. The limits for the hazard grades are ranges, not single values as in the European system, so we related the action and limit to the ranges. Exposures at action value are in the range that defines hazard grade 3.1 (0.56 to1.12 m/s^2). Exposures at or above limit values is in the range that defines hazard grade 3.2 (1.12 to 2.23 m/s^2), and close to the lower limit of this range. Thus it can be claimed that limit value (1.15 m/s^2) and hazard grade 3.2 are corresponding expressions of risk levels, though the Russian system, however, is a more fine-graded system. Both systems are efforts to categorize the risk and ease the process of assessing and communicating risk. The two systems differ in the consequences from the risk assessment. The series of measurements could have been more extensive, including more cycles and more vehicles, this would have made the WBV assessment more representative.

7.6 Discussion of the main results in Paper III and IV

We described the proportion of workers (51%) who reported LBP in the last 12 months in this population. The proportion was higher than that reported in official figures for mine workers in Kirovsk, but closer to other studies [20, 33, 57, 68, 69, 120]. Our finding of a self-reported prevalence in drivers of 59% is similar to that reported in other studies [45, 50, 121]. In Paper IV the overall prevalence of LBP without radiation (33%) was almost twice as high as that of LBP with radiation (18%). Of those with LBP, 34.8% reported LBP with radiation. More than one-third of the blasters, drill rig operators, foremen and drivers, in particular the drivers of Toro 400, reported back pain with radiation in the last twelve months. The number of episodes and their duration indicate that LBP and back pain with radiation typically are recurring conditions of short duration. This coincides with the time frame for acute inflammation in the musculoskeletal system, which subside after some days.

Cold environment was the most prevalent of the studied exposure factors in several groups of the mine workers. More than 80% of the train drivers, Toro 400 drivers and blasters reported exposure to temperatures below 10˚C. Drill-rig operators, blasters, and drivers of Toro 40, Toro 400 and trains were also those with the highest prevalence of working with wet clothing.

In Paper III working with wet work clothes, working in cold conditions, previous job as a driver and lifting heavy and were associated with LBP during the last 12 months, the strongest adjusted association was found for wet clothes (OR=1.82). Wet clothes and cold working conditions were independently associated with LBP and no interaction was found between the two factors. Increasing OR for LBP by decreasing working temperature has been showed in a recent study in Sweden [41]. Finnish studies have reported that painful conditions in the low back are common in cold storage workers and in the general population in cold conditions [78, 122, 123].

A study of concrete workers also has reported an association between wet work clothes and LBP [82]. Wet clothes can aggravate cold exposure through convection (transfer of heat through a fluid) [124]. Wet clothes close to the skin has a cooling effect on thermoregulatory responses and thermal comfort [125]. Heat loss attributed to evaporation at 10˚ C has been reported as higher than from evaporation at 34˚ C. This has been attributed to condensation within the clothing and to increased conductivity of the layers of wet clothing [126]. Cold exposure reduces tissue temperature and increase muscle tension and exhaustion which may lead to overuse injuries and a sensation of pain [127]. Our study suggests that wet clothes is an independent risk factor for LBP. The mining is often carried out under wet conditions owing to water-cooled machinery, precipitation outdoors and ground water leaking from the walls and roof of the underground mines, as we observed during several mine visits.

Some 13% of the workers had previously been employed as a driver. The reported association in Paper III between having worked as a driver previously and LBP (OR=1.79) suggest that drivers were at elevated risk of LBP. In Paper IV we reported an association between previous job as a driver and radiating back problems (crude and adjusted risk OR=1.5). The association probably did not express the magnitude among current drivers, as workers with persisting LBP likely will change work or job tasks, often termed 'healthy worker effect' [128]. Some 10.1% of the participating workers had been employed for a year or less. This corresponds with numbers found in a pre-study survey, with about 10% recruitment and 10% termination of work in the mines annually. Healthy worker effect is always present when work populations are studied. Its magnitude is generally unknown. Some workers may even be required to change job dependent on the results from the annual health examinations. With 26.5% current drivers and 12.8 % past drivers, this may indicate some flexibility both by the work force and the employer with regard to professional tasks. Health problems may require a change of work, since the health services can relocate workers with health problems away from a workplace with known high WBV exposure levels [94]. All these mechanisms may contribute to a selection of healthy workers to certain jobs over time. Thus, the worker population in a given profession can be assumed to be healthier than if the general population was similarly exposed.

Heavy lifting was reported most commonly by drill-rig operators, blasters and drivers of Toro 400, and by the group driving 'other vehicles'. Heavy lifting was surprisingly common for drivers but the study did not allow for a detailed description of the lifting. Our finding that lifting heavy was associated with LBP supports other studies which also report associations between heavy lifting and LBP [51, 57]. Driving in combination with exposure to physical work has been reported to increase the risk for physician-diagnosed LBP with radiation [46]. The lack of an association with heavy lifting in Paper IV may be due to our classification of exposure or a healthy worker selection.

Compared to being cold and lifting heavy, WBV seemed to not be an exposure of importance in terms of LBP. WBV exposure was defined as driving time per week. The adjusted OR for LBP per category (1 to 19 hours, 20 to 29 hours, 30 to 39 hours and 40 hours or more per week) increase in time was 1.08. This suggests that driving time is a weak risk factor, also when adjusted for the duration of the present occupation. However, our measurements of WBV exposure showed levels acceleration levels root-mean-square over 8 hours [A(8)rms] at 1.00 m/s^2 in Caterpillar/Belaz and mean vibration dose value (VDV) at 10.35 $m/s^{1,75}$ [96]. The WBV level in TORO 400 was A(8)rms 0.82 m/s^2 and in TORO 40 A(8)rms 1.02 m/s^2

[98]. These levels were below limit value (1.15 m/s^2) but above action value (0.5m/s^2), levels considered to increase the risk for LBP according to the European Directive on WBV [129]. The WBV levels we describe in Paper II are comparable to those found in previous studies in these mines [23, 95].

When being a driver (in the model 1 in Paper III) was substituted in model 2 with the 6 vehicle groups driven in current work (model 2), the associations between LBP and previous driving and heavy lifting respectively, did not substantially change. The association between wet clothes and LBP also remained while the association with cold work environment decreased from OR = 1.52 in model 1 to OR = 1.30 in model 2. This was probably due to the introduction of new 'cold' variables in model 2; the vehicles with known cold working conditions (TORO 400, K10 and K14). Since the OR for other exposure variables generally persisted from model 1 to model 2, we can conclude that being a driver as a factor in model 1 represented well the vehicle categories in model 2 for assessment of the associations between cold environment, wet clothes, lifting, and previous driving and LBP.

But among the current drivers only operation of TORO 400 and K10 and K14 trains were associated with LBP. These are only used in the underground mines, operating in temperatures measured at 4.8 to 8.2˚C and with relative humidity at 63 to 91% (Øvrum 2007). Both the TORO 400 and K10 and K14 trains share a particular feature: the drivers sit in 90˚ angle to the driving directions in open cabins, exposed to the temperature of the underground mines.

The drivers work with torso, shoulders and neck in a twisted position. Thus, driving the Toro 400 and trains may be considered a marker for awkward posture. In contrast to the TORO 400 and trains, drivers of Caterpillar, Belaz and TORO 40 trucks, work in temperate cabins without the twisted position. Other studies have shown an association between professional driving with awkward working postures and LBP (Hoy et al 2005, Hoogendoorn et al 1999). The drivers' position also prevents them from getting proper support from the back rest in the Toro 400 seats [130]. The drivers' seats of K 10 and K 14 trains do not even have any springs. Thus, unlike the drivers of other vehicles, drivers of TORO 400 and K10 and K14 trains have a combined exposure of WBV, cold working conditions and awkward postures. The vehicle-group differences in association with LBP indicate that vehicle-type specific analyses are needed when assessing the risk of musculoskeletal problems due to occupational driving.

Since cold working conditions was included as a covariate in the model, the particular work posture in these vehicles seems the most reasonable explanation for the adjusted association with LBP for drivers of these vehicles. Several studies have reported associations between heavy lifting, prolonged sitting, twisting and bending and LBP [51, 54, 63]. None of these studies have considered the possible contribution from cold working conditions. The trains in the mines operate with steel wheels on steel tracks, as opposed to rubber tyres used by the heavy trucks such as TORO 400. WBV exposure levels from trains have been shown to exceed action values [131]. Our measurements of WBV levels for K10 and K14 trains (0.4 m/s^2) however, were not above action value [109].

The Nagelkerke R^2 from the logistic regression analysis in Paper III indicates that about 15 percent of the variance in LBP was explained by the factors and confounders included in the models, but this estimate is imprecise. All the included confounders were associated with LBP, except sex, and in the direction expected.

In Paper IV our results on how LBP with radiation relates to occupation, type of vehicle driven, past driving, heavy lifting, wet clothes and cold work showed that in the crude analysis, wet clothes, cold environment, heavy lifting, being past driver, working as a blaster, and driving Toro 400 were associated with LBP with radiation. This suggests that several factors contribute to this condition. The OR for Toro 400 is close to that in a Finnish study which reported a crude risk ratio of OR=1.6 for machine and vehicle operators [132]. However, only wet clothes, cold work conditions and being a past driver remained associated with LBP with radiation in our adjusted analysis.

Surprisingly, the highest prevalence of LBP with radiation was found among the blasters. A post hoc analysis of blasters showed a crude OR for LBP at 1.86 (CI 1.36-2.53); the adjusted OR for radiation was 1.43 (CI: 0.94-2.17). Blasters are in charge of all procedures having to do with explosions in the mine. This exposes them to wet and cold conditions. Drill rig operators were the group that second most frequently reported LBP with radiation to the leg. They are exposed to mechanical vibration transmitted through their feet, to the low temperatures in the mine and to water mist from the drills.

The estimated ORs for wet clothing and exposure to cold should be interpreted with care, as the chosen cut-offs may have caused misclassification of the exposed and non-exposed. For frequently occurring outcomes, such as LBP and LBP with radiation, the revealed ORs can overestimate the magnitude of the risks.

Strengths and weaknesses

The cold work conditions of these mines and the large study population allowed for studying the relationship between cold exposure and back pain. Another advantage with this study was the high response-rate and the completeness of the questionnaire responses. The main weakness of this study was the cross-sectional design, which does not allow for analysis with conclusions of cause-effect relationships. Our results show that many workers in these mines are exposed to several possible risk factors, but the study did not allow for further specification of the temporal relationship of the exposure factors and the outcomes. The validity of self-reported exposure at work has been shown to be reliable [133]. However, posture was left out in the analysis since the data indicated that the questions addressing work posture had insufficient validity.

Lifting loads was recorded as the frequency of lifting loads. However, load factors in manual handling is more than the weight in kilos, it is also influenced by the distance of the load from the body (moment), the range through which the weight is lifted, the origin and destination of the lifts, postures assumed in order to lift, and the speed of the movement [15]. This could have been addressed in more detail through observations, measurements and recordings. Identification of high risk manual tasks and demands that exceed the workers capabilities would also have added to a more comprehensive picture of the exposure factors.

Past driving was chosen as an exposure variable since workers may change their work tasks while employed in the mining company due to a number of reasons, including health. There is also 10% recruitment into the workforce annually. At the time of answering the questionnaire, information on current work task might not well describe exposure in the past; workers may have changed their work tasks long or shortly before answering the questionnaire.

The variable wet clothing could be subject to interpretation by the responders, in that the question does not differentiate between what part of the clothing is wet: the inner layer clothes close to the skin, wet outer layer or wet on the clothes surface only. Wet could also be interpreted as humid inner layers.

The mean reported number of hours of weekly exposure to cold for drivers of Toro 400 and underground trains was just over 30 hours. Having observed how the underground work for these drivers is carried out, the reported duration of exposure to cold is considered a good estimate. Observations of the work tasks in the mines as well as the exposure measurements in the relevant mines were advantages when the reported data were interpreted.

The occupation label or profession was ambiguous for the driver categories. Having information on both occupation and vehicles operated revealed that occupation was not vehicle specific, even workers with occupations other than drivers reported driving a vehicle. Vehicle used was, however, specific information, and mutually exclusive. Thus, the exposure groups for drivers were defined by the vehicle driven in current occupation rather than the occupation itself. In Paper IV we did not analyse for possible interaction between the factors under study, but as described in Paper III we did not find statistically significant interaction between the exposures and the risk of LBP. However, that analysis did not include possible interaction between the exposure factors and vehicles driven.

For frequently occurring outcomes, such as LBP, ORs likely overestimate the magnitude of the risks. The exposure factors could have been penetrated in more detail. Information was self-reported by questionnaire, and thus subjective. Still, for large population studies on clinical problems that are subjective in nature, questionnaires can be appropriate and the data reported with such methods are well in concordance with the situation under study. Healthy worker selection may have led to an underestimation of the actual odds. Thus, a revealed association may be stronger than the numbers indicate. Clinical testing by trained physicians could have diagnosed low back pain in a more objective manner.

Cut offs and definitions

The cut-offs chosen for the study factors wet, cold and lifting may have caused misclassification of the exposed and non-exposed and affected the outcome of the analysis. However, the cut-offs in the questionnaire and statistical analyses were chosen *a priori*. Lifting was measured by the questions on frequency (five categories) and load (greater than 15 kg and 30 kg) and a question concerning ever lifting or moving loads more than 50 kg. The weight categories in the questionnaire were not mutually exclusive. By choosing to include heavy lifting as a binary variable in the analyses with cut-off at lifting loads weighing more than 15 kg ten or more times/day or not our choice may have affected the analysis outcome. A choice of a higher frequency cut-off for heavy lifting would have led to a smaller heavy-lifting group and an OR-estimate with lower precision. The same would have been the case for wet clothing and cold exposure. Thus, the estimated ORs for wet clothing, exposure to cold and lifting should be interpreted with care.

Current exposure to WBV was defined as driving a vehicle in the present work; we defined groups by vehicle types. Reported driving time was divided into four categories based on number of hours of driving during a typical work week (0 hrs, 1 to 15 hrs, 16 to 30 hrs and above 30 hrs). This allowed for OR for WBV to be calculated per category increase in time driving a vehicle. Past WBV exposure included workers who previously worked as drivers, these data were dichotomous, so no choice was made for the analyses.

Adjustment factors were physical exercise, stress, sex, BMI, and duration of present occupation. We chose not to adjust for age since this was strongly correlated with the duration of employment. Physical exercise was set at *recreational sports (at least 4 times per week).* A choice of a different cut-off for physical exercise could have influenced the ORs of the studied factors, since physical exercise was associated with the outcome of the analyses. The same can be said about stress, BMI and duration of employment.

8. LEGAL AND ETHICAL CONSIDERATIONS

The questionnaire contained no personal identifier, only a running number that linked the questionnaire to the database. The name list of all workers required to undergo the health examination was only used for administrative purposes by the KRLOH. The study was approved by the regional committees for medical research in North Norway and North-West Russia.

9. CONCLUSIONS

Several institutions are involved in assessing mine workers health in MO, calculating exposure levels as hazard grades and making recommendations for further employment. Medical examinations of most mine workers in MO were performed by a single institution (KRLOH) and this implies stable quality and continuity of the occupational health assessment and adds value to the numbers. The emphasis is more on control and repair than on prevention of disease. Mine workers may be motivated to underreport their health problems at the mandatory periodic health examination. We showed how WBV exposure levels in a Kirovsk mine are risk assessed by the Russian system and how this relates to risk assessment in the European system of risk assessment.

In our epidemiological study, one-half of the workers in the mines reported LBP. Exposure to cold environment and wet clothes was common. Wet clothing, cold working conditions, heavy lifting, and previous work as a driver were associated with LBP. Driving the TORO 400 and the K10 and K14 trains were the only vehicle specific exposures associated with LBP, which may be explained by the twisted working position combined with low temperature in the open cabins – features that are particular for these vehicles. LBP with radiation was experienced by more than one-third of blasters, drill-rig operators and drivers. LBP with radiation was associated with exposure to wet clothes, cold work environment and being a past driver, and was not associated with current employment as a driver or driving a vehicle.

The study suggests that exposure to cold and wet clothes contribute to the risk of LBP and LBP with radiation. The cross-sectional study design did not allow for cause-effect conclusions. The study also did not characterize the exposure to wet clothes, cold conditions and posture in great detail; this should be emphasised in further studies. For better prevention of LBP and LBP with radiation in mine workers, we recommend focusing on improved cabin conditions and clothing.

The ‘Miners health 2010’ questionnaire was easy to administer and generated data that are useful for screening and epidemiological purposes. Despite being based on existing questionnaires, validation of the ‘Miners health 2010’ questionnaire is recommended.

The study brought together scientists in occupational medicine in the far north of Europe. This group has expanded and initiated a project termed ‘Mine Health’ which uses a modified version of the ‘Miners health 2010’ questionnaire, in an ongoing investigation of mine workers’ health in northern Norway, Finland, Sweden and Russia. This includes data collection in Kirovsk as a follow-up to the study presented here. Increased knowledge of mine workers’ health and work environment should promote health, work ability and well-being and prevent sick-leave among mine workers and other related professions.

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Paper I

ORIGINAL RESEARCH ARTICLE

COACTION PUBLISHING

How occupational health is assessed in mine workers in Murmansk Oblast

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***Objectives*.** We aimed to describe how work exposure and occupational health is assessed for mine workers in Murmansk Oblast, Russia.

***Study design*.** A descriptive study based on current practice, laws and available literature.

***Methods*.** The information and data were obtained from scientific publications, reports, regional and federal statistics, legal documents, through personal visits and onsite inspections.

***Results*.** Several institutions are involved in these assessments, but all mine workers have been examined by specialists at one institution, which helps to ensure that the work is of stable quality and adds reliability value to the numbers. Workplace risks are assigned hazard grades, which influence the frequency of periodic medical examinations and salary levels. The examinations are aimed to diagnose latent or manifest occupational disease. This may lead to relocation to a workplace with lower exposure levels, free medical treatment, compensation and a lower pension age.

***Conclusions*.** Regulations and systems to protect the health of mine workers have more emphasis on control and repair than on prevention. Since relocation can lower the salary, some workers may under-report medical problems. To what degree this happens is unknown. The mining enterprises pay the medical service provider for periodic medical examinations, which could potentially weaken their independent role. This framework is important to understand when studying and assessing the health of working populations in the circumpolar region.

Keywords: *occupational health*; *work environment*; *mine workers*; *Russia*; *Murmansk Oblast*

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Working as a miner is associated with health impairment and mortality from factors in the work environment (1). This affects the individual, the mining enterprise and society as a whole. The Barents region is the most important mining area in Europe. The many large mines located in the Kola Peninsula make this region (Murmansk Oblast, MO) the most heavily industrialised region in the Russian Federation (RF). The MO's population of 794.800 constitutes only 0.6% of the total population of RF (2), but 21% of the population in the circumpolar north. Industrialisation and militarisation have urbanised the MO with 92.8% living in cities and towns (3) compared to 73% in the RF (2). Thirty-seven percent of the MO population lives in Murmansk city; the rest of the urban population lives in industrial towns or "monogorods" based on a single industrial plant, which provides employment and community services (Table I). Considering the relative magnitude of this industrial population, the health implications of working conditions in MO are large in an Arctic public health perspective.

The apatite mining and processing complex of the company Joint Stock Company (JSC) Apatit forms an industrial cluster in Kirovsk and Apatity (Fig. 1). The company's activities include the extraction and transport of ore and the physical and chemical processes that make phosphate-rich concentrate (4). Founded as a state enterprise in 1929, this industry was later privatized and adapted to the global market economy. Between 1950 and 1990, the annual ore extraction increased from 3 to 55 million metric tons (5), and the company is currently one of the largest producers of phosphate in the world.

Both working conditions and climate have posed challenges to the health and safety of the mine workers.

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Table I. Main industrial towns and industry in Murmansk Oblast

Industrial town	Main industry
Polarnye Zori	Nuclear energy
Nikel	Nickel mine and smelters
Monchegorsk	Nickel and copper refineries
Kirovsk	Apatite-nepheline mines
Apatity	Ore processing plant
Kovdor	Iron, apatite, mixed ore mines, ore processing plant
Olenegorsk	Iron mines, smelters
Khandalaksja	Aluminum smelters
Zapoljarny	Nickel mine, concentrate production plant
Revda	Rare earth metals, titanium mines

After the use of forced labour in the mining industry was abandoned in the late 1950s, the focus on occupational health and safety increased (6), with both research on and diagnosis of occupational diseases. These are medical conditions considered to be caused by exposures at the workplace and may qualify the worker for compensation or have other consequences.

Occupational health in MO

The incidence of occupational disease in MO has increased during the past decade, after a downwards trend during the preceding years. The incidence in 2006 was twice that in 1999, passing the level in RF. This is also the trend in the industrial towns of MO (7). The most common causes (36.6%) of occupational disease were noise and vibration (8). Musculoskeletal problems and diseases secondary to mechanical vibration have been identified as the most frequent health problems in Kola mine workers. Only 12% of miners working underground and 13.6% of miners working in open mines had never been diagnosed with some form of medical condition (9). The number of accidents decreased over the period 1991–2003 (10).

An improved understanding of how occupational health and risk is assessed in MO is crucial in order to explain mine workers' health in the region and to be able to compare different regions within the circumpolar north in terms of occupational health and overall morbidity. The aim of this study was to describe how occupational health and work exposure is assessed for mine workers in MO.

Material and methods

Information and data were obtained starting from search on PubMed for scientific publications, using combinations of the search words "occupational health," "Russia," "north," "Kola" and "assessment." Of the articles available on PubMed, the majority were in Russian language, with English abstracts only, and not available in full text online. Some 20 were published in

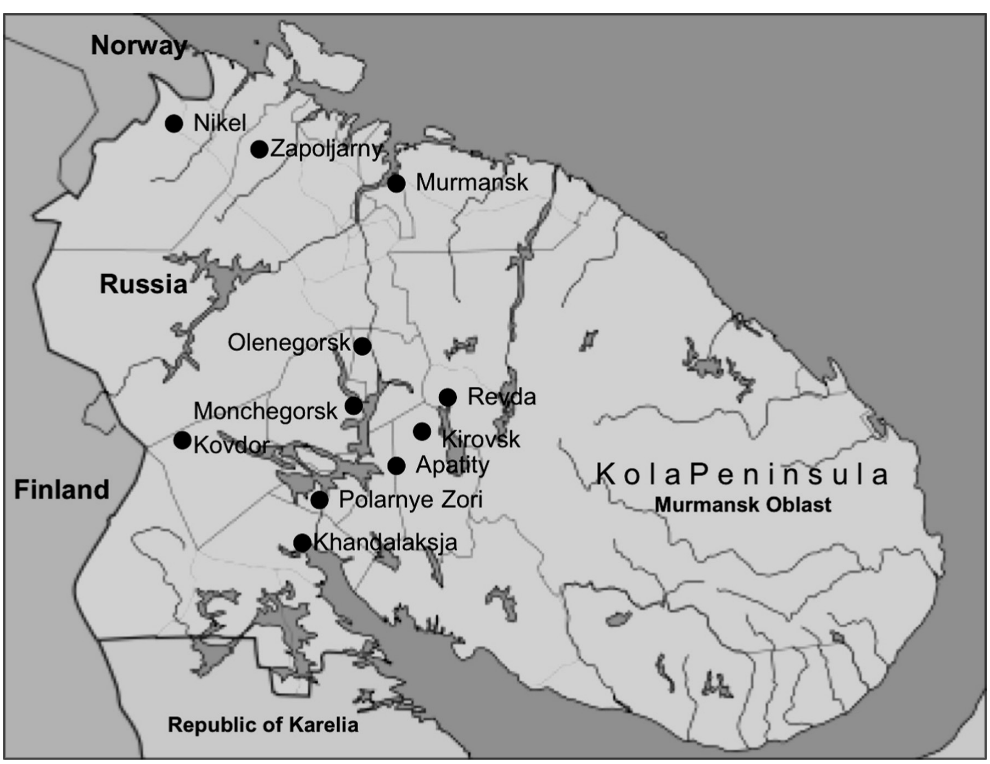

Fig. 1. Industrial towns and Murmansk city in Murmansk Oblast.

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Occupational Medicine and Industrial Ecology/Meditsina Truda i Promyshlennaya Ecologiya. The articles were collected in full text in analog libraries at occupational health institutions in Russia and, working together with Russian colleges, their relevant content was translated to English language. In addition, we carried out a manual search for relevant publications issued during the last 5 years (2006–2010) in *Human ecology/Ekologiya cheloveka*, which is another major journal for occupational health in northwest Russia, but not indexed in PubMed. In addition to information from scientific journals, search was carried out in other online sources for reports, available regional and federal statistics and legal documents governing the assessment of workers' exposure and occupational health in the RF (laws, orders, standards and regulations). Information was also obtained at the central institution for occupational health in MO from documents and reports that are not online but are central to this topic. Information on workplace condition evaluation and assessment was also obtained from onsite inspections in the mines together with those Russian occupational health specialists who are carrying out the assessment of occupational health in mine workers in this region. We describe the system and principles for diagnosis and assessment of occupational disease and the principles for workplace risk assessment and hazard grading. However, a full description of the procedures for diagnosing occupational diseases and calculating hazard grades is beyond the scope of this study. The legal framework is only mentioned in general terms. No ethical approval was needed for this study since no observation of individuals was included in the material.

Context

Apatity and Kirovsk have a combined population of 110,000; a decrease of 20% since 1990 (2). The apatite-nepheline mining and processing enterprise JSC Apatit operates 4 mines, transportation lines and 2 concentrate plants in the area. JSC Apatit employs 13,500 workers (20% of all industrial workers in MO), of which some 4,000 are directly employed in mining (Table II). Women constitute 5.5% of the employees and 85% are ethnic Russians (10).

Table II. Mines and number of mine workers in Kirovsk

Mine	Type	Number of workers (2010)
Kirovsky	Underground	2,034
Vostochny	Open pit	650
Zentralny	Open pit/underground	587
Rasvumchorrsky	Underground	676
Total		3,947

Joint Stock Company Apatit also runs public transport, several leisure and sports complexes and a sanatorium for recreation and rehabilitation of its workers. There is also an education program for future miners at the Khibiny Technical College in Kirovsk. In contrast to the early years of this mining community, Kirovsk is now a more demographically diverse community.

Results

Work exposure risk assessment, disease prevention, diagnosis of occupational disease and adjudication of compensation issues are central elements in the health care system for workers in MO. Several institutions are involved. The mine workers undergo an annual health examination with thorough anamnesis and clinical investigations and tests involving physicians specialized on various organ systems. A committee of doctors concludes whether a medical condition should be classed as a confirmed occupational disease, a suspected occupational disease (person in an "at risk group"), or a non-occupational disease. For the worker, this can lead to relocation, compensation or coverage of medical treatment. These health and workplace assessments are performed on both a local and regional level and involve the institutions described below.

Rospotrebnadzor

This is the regional body of the Russian Board of Health Supervision and has the authority to intervene to improve conditions in a workplace and to shut it down (11). The institution provides annual reports for every region and education programs in occupational health.

Centers for epidemiology and hygienic surveillance

These centers exist on local and regional levels (located in Kirovsk, Monchegorsk and Murmansk) and assess risk factors in workplaces. The findings are used in the characterization of workplace environment and then related to health conditions (details follow below).

Kola Research Laboratory for Occupational Health (KRLOH)

The KRLOH is the Kola Peninsula branch of the Northwest Public Health Research Center in St. Petersburg and is the central institution for competence and assessment regarding workers' conditions and health in MO. The KRLOH also runs out- and in-patient clinics, a research department and a clinical chemical laboratory. The staff includes physicians specialized in occupational health. It is funded through the budget of the federal Northwest Public Health Research Center and by payments from the enterprises that make use of the specialist services. The KRLOH receives workers from several mines in the region: the 4 apatite mines in Kirovsk (Table II), the Kaula Kotselvaara mine in Nikel, the Severny mines in Zapoljarny and from mines in Kovdor. The workers spend 1 day at the KRLOH with full pay. The examination includes laboratory tests and clinical examination by organ specialists and specialists in occupational medicine; data are recorded on a standardized chart and entered into an electronic database. Information on the exposure characteristics of each type of workplace is also available at KRLOH. This is used for assessments of associations between exposure and disease. KRLOH cooperates closely with specialists at the municipal hospital in Kirovsk in diagnostics and treatment and can refer workers to the local sanatorium. KRLOH also sends specialized staff and equipment to carry out periodical medical examination in nearby industrial towns (so-called ''komandirovka''). KRLOH's access to the industry, the workplaces and the workers is regulated through federal law (12), and it reports occupational health statistics to the Federal State Statistics Service (Goskomstat) and to Rospotrebnadzor.

Medical institutions authorized for medical examination of workers in MO

In addition to KRLOH, the municipal hospitals in Monchegorsk, Zapoljarny and Olenegorsk are authorized to perform regular medical examinations of workers. However, no miners are examined in the Monchegorsk hospital (as no miners live and work in the Monchegorsk area). The assessment of workers' health consists of both an initial medical examination and periodic check-ups. These are conducted according to federal laws (12,13) and decree (14). These medical examinations include all employees, though at different intervals. Potential new employees undergo pre-employment examinations to check if whether they fill the medical requirements. The assessed risk in the work environment determines the frequency of later periodic examinations: every year or every fifth year. If municipal hospitals do not have the full team of specialists to fulfill the legal requirements, they must invite specialists from other qualified institutions. Miners who have their check-ups at municipal hospitals are also examined by specialists from KRLOH every fifth year, as a minimum requirement (14). Approved institutions outside MO can also compete for the contract to conduct periodic medical examinations. Although this has not yet happened, Rospotrebnadzor has expressed concerns over the possibility that such examinations might be of lower quality (11). The central documents governing the field of occupational health are presented in Table III. Note that a guideline has been developed for the assessment of occupational health in a regional context.

Assessment of work environment

The Center for Epidemiology and Hygienic Surveillance carries out characterization of working conditions. For each profession and workplace, there is a list of factors (physical, biological, chemical and psychosocial) that are measured or quantified. This characterization provides the basis for the KRLOH's assessment of workplace risk. The weighted sum of the factors is used to calculate hazard grades from 0 to 4 (15). The interpretation of the numerical values of hazard grades is listed in Table IV. Additional details concerning hazard grades in the mining industry have been presented by Chaschin and Askarova (16).

Calculated hazard grade for WBV has been 3.1–3.2 for load-haul-dump vehicle drivers in an underground mine in Kirovsk (17). For other groups of underground mine workers, vibration levels corresponded to hazard grade 2–3.3 (18). The hazard grades do not correspond directly with the European limit and action values. However, yet unpublished comparative studies indicate that the whole body vibration exposure levels classed as hazard grade 3.2 in load-haul-dump vehicles are similar to the limit value in the European system (19). The Order № 90 (14) states which hazard grades can be allowed for various professions and workplaces. Hazard grades are also part of the basis for calculation of salary, with higher hazard grades rendering higher pay. Work at hazard grade 4 is only allowed for short time periods, as in emergency situations.

Table III. The main regulations governing the occupational health issues in Russian Federation

Type of document	Title
Federal laws	Federal Law № 181-FL on November 24 1995 (12); Federal Law of March 30 1999, № 52-FZ (13).
Federal decree order	The order of the Ministry of Public Health and Medical Industry № 90 on 14.03.1996 (14).
Federal sanitary norm	Guide on Hygienic Assessment of Factors of Working Environment and Work Load. Criteria and Classification of Working Conditions, Guide P 2.2.2006 – 05 (15).
Regional methodical medical recommendations	Methodical recommendations: Organization of pre- and periodic examinations of the people who are working for enterprises and institutions and being exposed to dangerous and harmful industrial factors. Methodical recommendations for treatment- and prophylactic institutions, state sanitary-epidemiological supervision centers and departments of labour protection and safety of the Murmansk region enterprises (20).

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Table IV. Grading system for assessment of health hazard

Hazard grade	Interpretation
0	No exposure to health hazardous factors
1	Exposure without health hazard
2	Exposure with acceptable health hazard
3.1, 3.2, 3.3, 3.4	Exposures with increasing health hazard
4	Exposure with high/extreme hazard

Medical examination of mine workers

Pre-employment examination

This is carried out to assess whether an applicant is medically fit. All categories of workplaces are listed in the Order № 90 with corresponding medical recommendations and conditions that disqualify for employment (14). As mentioned, all workplaces are characterized in terms of hazard grades, and these grades are compared with the medical profile of the person seeking employment. The Order № 90 also specifies which clinical and laboratory tests and specialist examinations are required. A medical profile is compiled from the results. The document follows the worker throughout his or her career and is updated at later medical examinations.

Periodic medical examination

All workers have to undergo periodic medical check-ups to renew their work certificates at a frequency that depends on the hazard grade of the individual's workplace. Employees with an overall hazard grade of 3.1 or more undergo medical examination annually, while employees with hazard grade 2 or below have an examination every fifth year. The Order № 90 lists the examinations, equipment, clinical and laboratory tests and specialists required for these check-ups (14). KRLOH has assembled and published the methodical recommendations for medical examinations, how to interpret the results of the periodic medical examinations and how to prepare individual medical advice (20). The purpose of the check-up is to identify possible occupational disease during the period of employment. The findings may affect the worker's possibility to continue in the work position. There are 3 possible outcomes (recommendations) from this periodic check-up: (a) if no work-related health problems are found, the employee can continue to work, (b) if the check-up suggest that the employee may be developing occupational disease, the employee cannot continue to work in the current work environment and should be relocated and (c) if a condition is diagnosed and approved as being occupational disease, the employee should be relocated and can apply for compensation. These final decisions are based on a wide set of information, evaluated by a consultative group of 8 doctors. The group consists of the chief and deputy physician and physicians in several specialties, as specified in the Order № 90. Their main tasks are to identify pathological conditions at an early stage and to prevent a condition from progressing through advice and relocation. The examining institution receives payment from the workers' employer for the work (14).

For a medical condition to be approved as occupational disease, 4 conditions must be present: (a) the condition must be among the diseases that may qualify, as listed in the Order № 90, (b) the exposure must be known to be present in the work environment, (c) this exposure must have a recognized causal link to the disease in question and finally, (d) the exposure must precede the onset of disease by a reasonable amount of time. These conditions must be considered and assessed in institutions that are specialized in occupational medicine (14), such as KRLOH in the case of mine workers in MO. The consultative group of doctors decides whether the criteria are met. If the condition is considered to meet the criteria and is approved as an occupational disease, the worker must apply for occupational disease compensation from the government. Workers who have private insurance may apply for compensation as well, but such insurance is not mandatory. A person with an occupational disease is entitled to a 1-time compensation payout. The decision whether to grant compensation is made by the local special medical social committee MSEK (Russian abbreviation МСЭК). A negative local ruling can be reassessed at the regional level in MO or appealed to the MSEK committees in St. Petersburg or Moscow (14). The level of disability is graded as: (a) disability that precludes work, (b) disability that does not preclude work and (c) reversible disability that does not preclude work but necessitates relocation. Doctors may be subject to compensation claims if a worker who is exposed to hazardous factors at the workplace is not relocated due to mistakes or negligence on the part of the doctors and goes on to develop an occupational disease.

Hazard grades of 3.1 and above can motivate relocation of persons at particular risk of developing an occupational disease to a workplace where exposure to the harmful factor is lower. If possible, the worker is relocated within the same company. The employee is obliged to accept relocation. Failure to do so may lead to loss of rights to receive compensation. If no suitable position is available, the person can be laid off. If relocation or loss of job leads to a reduction or loss of salary, this is partly compensated by monthly payments (14). Being diagnosed with an occupational disease will also lead to a lower retirement age and a higher pension. However, the pension is less than the salary of a mine worker, especially if the workplace environment has high hazard grades. The diagnosis will qualify the worker for free treatment of the occupational disease, also in sanatoriums (12,13). Workers with an occupational disease that is considered to be in an early stage can be referred for early intervention to prevent further progress or to reverse a pathological process. Workers may also be referred by physicians to other sanatoriums or to health resorts.

Discussion

This study provides insight into how occupational health is organized and assessed in MO, both in general and in mine workers specifically, and how the official figures on occupational health are collected. Given the large and growing number of mine workers in the region, this is a topic of high relevance when studying health issues and interpreting health indicators in this population. Occupational health of mine workers in MO is investigated through a battery of tests and examinations of individual health and workplace. These systematic procedures can affect the mine workers medically and economically, as there are both advantages and disadvantages to being diagnosed with occupational disease or working in an environment with a health hazard. If a work environment is declared hazardous to health, this would increase the worker's salary or cause relocation, rather than obliging the employer to reduce the exposure to safe levels, as in most other European countries. Relocation might be an expression of a greater focus on recuperation from than on prevention of health problems.

Since relocation to a work environment with lower hazard grades leads to lower salary, the system could make the workers prone to conceal their health problems by under-reporting or even taking medication prior to the examination to improve test results. This applies especially to medical conditions for which the diagnosis is based on information from the employees themselves and not on objective tests. To what degree the built-in mechanisms in the system have led to under-ascertainment of disease and injury would be difficult to evaluate. The character of the periodic medical examinations is control based and mandatory rather than based on trust. This does not solve the issue of possible under-reporting. The system does provide employees with extensive health assessments, which may be regarded as a fringe benefit. Still, this check-up activity might also take place at the expense of prophylactic approaches (21). Some employers, feeling they have little to gain from the annual examination, might have made little effort to facilitate the examination. In practice, many smaller firms have not been offering the medical examinations as legislated (11). In the mine industry in the MO, however, the medical examinations have been a part of the workplace routine and the participation rates of both employers and employees have been high. In KRLOH, the MO appears to have a well-qualified center to perform periodic medical examinations of mine workers and diagnose occupational disease, as the staff at KRLOH has the required skills and experience. However, since the occupational health institutions receive payment for these examinations from the employer, there is a risk of financial dependency in this relationship. Thus, the free and independent status of the medical institutions performing the medical assessment of workers could be undermined. The number of workers diagnosed with occupational disease might therefore depend not only on hazardous exposure levels in the workplaces but also on factors arising from the relationships between the enterprise, employees and the medical institutions (18).

Despite the past decade's improvements in work conditions due to more modern technology, exposure levels have remained high. The Russian norms for exposure levels were exceeded in MO for 39% of male and 25% of female workers (9). In addition, methodological factors (improvements in diagnosis, occupational health care systems and registration regimes at KRLOH) might explain the observed increase in number of cases of approved occupational disease in this mining population (7). However, the fact that the medical examinations of most mine workers in MO have been performed by a single institution implies stable quality and continuity of the work and gives added value to the numbers. MO adheres to the same legal framework as all of the RF, so our findings concerning requirements, procedures and standards can be generalized to the rest of the country. The main limitation of the study has been the poor availability of information sources. Internationally published information is very scarce, and material published in Russia is not readily located through databases and usually not accessible electronically. Therefore, we also have used informants.

Our findings concerning the regulations, procedures and institutions involved in the assessment of occupational health and work places in MO show the importance of understanding this framework when studying the health of working populations and interpreting official health statistics in the circumpolar regions and countries. Our study disclosed the existence of thorough regulations and well-established systems to protect and follow up the health of workers in mines and industry in Russia. However, the system appears to emphasise control and repair more than prevention of occupational disease and injury. The economic incentives for the workers and the close economic ties between the medical institutions that provide the check-ups and the mining enterprises in MO may not be optimal for protection of health of this population of workers.

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Two of the authors (Siurin and Talykova) are employed in one of the institutions presented in the study.

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Paper II

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ЕВРОПЕЙСКИЙ И РОССИЙСКИЙ МЕТОДЫ ОЦЕНКИ ОБЩЕЙ ВИБРАЦИИ У ВОДИТЕЛЕЙ БОЛЬШЕГРУЗНЫХ КАРЬЕРНЫХ САМОСВАЛОВ

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В настоящее время в Баренц-регионе нет унифицированных методов оценки рисков здоровью, связанных с воздействием общей вибрации (ОВ). Задача исследования заключалась в измерении характеристик ОВ, возникающей при эксплуатации большегрузных карьерных самосвалов (БКС), а также в обсуждении и сравнении результатов оценки рисков здоровью методами, принятыми в странах Европы и России. Было выполнено 17 измерений ОВ на поверхности сиденья водителя на 14 разных БКС на одном из открытых рудников Северо-Запада России. Продолжительность периодов измерения ОВ составляла от 13 до 58 минут в реальных производственных циклах в течение 8 часов управления автомобилем. По данным проведенных исследований, средний уровень ОВ (эквивалентный уровень виброускорения – А8) составил для 14 БКС (1,0 ± 0,23) м/с^2, среднее значение пик-фактора – 12,78 ± 5,26, средняя величина дозы вибрации – (10,35 ± 2,61) м/с^{1,75}. Установлено, что нижняя граница значений ОВ, определяющих класс вредности 3.2 (Россия), близка к значению предельного уровня ОВ, составляющего 1,15 м/с^2 (страны Европы).

Ключевые слова: вибрация, водители карьерных самосвалов, оценка рисков

Воздействие механической вибрации, возникающей при эксплуатации транспортных средств, характерно для работников горно-добывающей промышленности, и особенно для водителей. В соответствии с российской терминологией такое воздействие на весь организм человека определяется как общая вибрация (ОВ). С воздействием ОВ связывается развитие ряда нарушений здоровья, причем наиболее часто — заболеваний костно-мышечной системы [3].

В иностранной литературе отражены некоторые противоречия, касающиеся уровня экспозиции к вибрации, вызывающего развитие нарушений здоровья. Несмотря на то, что в России существует обширная литература по данному вопросу, только немногие из этих работ хорошо известны за пределами страны. Частично это объясняется различиями методик оценки рисков здоровью при воздействии вредных факторов. В доступной нам литературе мы не нашли описания отличий и сходства этих методов. Практические и экономические последствия результатов оценки степени рисков здоровью также отличаются в наших странах. В настоящее время наблюдается рост горно-добывающей промышленности в Евро-Арктическом Баренц-регионе (северные районы Норвегии, Швеции и Финляндии, а также Европейский север России). В таких условиях лучшее понимание двух систем оценки рисков вредных производственных воздействий на рабочих местах является жизненно важным фактором, необходимым для улучшения защиты здоровья работников отрасли. Применение принципов двух систем оценки рисков в серии исследований уровней ОВ дает хорошую возможность для их сравнения, понимания и интерпретации.

Цель исследования заключалась в определении уровней воздействия ОВ, возникающей при добыче апатитонефелиновой руды открытым способом, и их сравнении с показателями ОВ при добыче рудного сырья в подземных рудниках. Также нашей целью было сравнение европейского и российского методов оценки воздействия ОВ при проведении серийных измерений.

Методы

Измерения уровней ОВ были проведены в открытом руднике «Восточный» (ОАО «Апатит»), расположенном вблизи г. Кировска Мурманской области. Всего подвергались воздействию ОВ 250 работников рудника, среди которых были водители большегрузных карьерных самосвалов (БКС). На руднике эксплуатировались 65 БКС марок БелАЗ и Caterpillar грузоподъемностью 120—130 т. Измерения ОВ были выполнены на 14 машинах. Продолжительность рабочей смены составляла 12 часов с 8-часовыми периодами вождения. Измерения осуществлялись норвежско-российской группой специалистов в области гигиены труда из отдела профессиональной и экологической медицины Университетской больницы Северной Норвегии (г. Тромсё) и научно-исследовательской лаборатории Северо-Западного научного центра гигиены и общественного здоровья (г. Кировск Мурманской области) в течение рабочей смены при цикличном выполнении реальных производственных задач. Уровень ОВ определялся на поверхности сиденья водителя. Продолжительность периодов измерения ОВ составляла от 13 до 58 минут во время одного рабочего цикла, количество которых колебалось от 2 до 7. Общее количество измерений – 17 (табл. 1). Измерения выполнялись на двух БКС типа Caterpillar 785C и двенадцати БКС типа БелАЗ 75 (модели 121, 131, 141 и 145) в зимний период года. Методики измерения, обработки и анализа параметров ОВ полностью отвечали положениям стандартов Международной организации по стандартизации (ISO) [10, 11] и соответствующего российского стандарта [1]. Использовался измеритель вибрации у людей (Larson-Davis Model HVM100, WBV Triaxial Seat Pad Accelerometer Larsen Davis), отвечающий требованиям стандарта ISO 8041 [11]. Общая продолжительность исследований составила одну неделю. Все числовые данные представлены как mean ± SD.

Таблица 1

Общая характеристика проведенных измерений общей вибрации

Тип самосвала	Число самосвалов	Число измерений	Длительность периода измерений, мин	Число рабочих циклов
Caterpillar 785C	2	2	31–37	1
ВЕЛАЗ 75 121	2	2	34–45	1
ВЕЛАЗ 75 131	4	6	21–25	1
ВЕЛАЗ 75 145	6	7	13–58	1

Методика оценки риска воздействия ОВ, применяемая в странах Европы. Европейская система использует два основных критерия оценки уровня воздействия ОВ в виде среднеквадратичной величины виброускорения, рассчитанной для продолжительности рабочей смены 8 часов. Уровень ОВ 0,5 м/с² считается допустимыми, а 1,15 м/с² – предельным. С ними сравниваются фактические параметры уровней воздействия: ниже 0,5 м/с², в пределах 0,50–1,15 м/с² или выше 1,15 м/с², как регламентировано Директивой 2002/44/ЕС [9]. Интенсивность экспозиции выше допустимого уровня означает повышенный риск развития нарушений здоровья. В таких случаях работодатель обязан принять меры для его снижения. Интенсивность экспозиции выше предельного уровня недопустима, и рабочий процесс должен быть остановлен. В таких ситуациях работодатель обязан принять все необходимые меры для снижения до минимума (за счет как укорочения продолжительности, так и уменьшения интенсивности воздействия) экспозиции к механической вибрации. Они включают определение возможности использования иных технологий, иного оборудования и средств индивидуальной защиты, новых эргономических решений, оптимизированного графика работы, повышения информированности работника о характере действия вредного производственного фактора и мерах техники безопасности.

Методика оценки риска воздействия ОВ, применяемая в России. Согласно российской системе уровни интенсивности воздействия всех вредных производственных факторов классифицируются по классам вредности: от первого (класс 1) до четвертого (класс 4) [5]. Класс 1 обозначает оптимальные, а класс 2 – допустимые условия труда. Класс 3 обозначает вредные условия труда и подразделяется на четыре степени (от 3.1 до 3.4) по мере увеличения интенсивности действия производственного фактора. Класс 4 характеризует условия труда как экстремально опасные для здоровья работника. Регулярная работа в условиях класса 4 не допускается, но возможно выполнение кратковременных заданий (ликвидация последствий аварий или тушение пожаров).

Степень вредности условий труда определяет для работника ряд последствий: частоту периодических медицинских осмотров, уровень заработной платы и пенсии, пенсионный возраст, размер компенсаций в случае развития заболевания профессиональной этиологии. Также возможен перевод на работу в допустимых условиях труда, с более низким, но компенсируемым размером заработной платы [6, 7].

В качестве единицы измерения уровня вибрации в России наравне со значениями виброскорости и виброускорения используется dB. Для сравнения рассчитанных значений A(8) с российскими классами условий труда величина dB была преобразована следующим образом: A (м/с²) = 20 log X (dB), где

Таблица 2

Уровень виброускорения (м/с²), соответствующий российскому классу условий труда

Класс вредности условий труда	Z	X, Y
1. Оптимальный	0	0
2. Допустимый	<0,56	<0,4
3.1. Вредный первой степени	0,56–1,12	0,4–0,79
3.2. Вредный второй степени	1,12–2,23	0,79–1,6
3.3. Вредный третьей степени	2,23–4,46	1,6–3,2
3.4. Вредный четвертой степени	4,46–8,9	3,2–6,3
4. Экстремальный (недопустимый для выполнения рутинных работ)	>8,9	>6,3

Таблица 3

Российские классы условий труда в сравнении с предельными и допустимыми уровнями виброускорения (европейская директива 2002/44/ЕС)

Европейская директива 2002/44/ЕС (Европейский союз)		Классы условий труда по степени вредности (Россия)	
	Красный	4	Экстремальные условия
		3.4	Вредные условия с подразделением на степени 3.1–3.4
		3.3	
Предельный уровень 1,15 м/с²	Желтый	3.2	
		3.1	
Допустимый уровень 0,5 м/с²	Зеленый	2	Допустимые условия
		1	Оптимальные условия

A – уровень ускорения, представленный как м/с², X – уровень вибрации, выраженный в dB (табл. 2).

В табл. 3 представлено сравнение используемых в России классов условий труда со значениями допустимого и предельного уровней ОВ в соответствии с европейским стандартом (Директива 2002/44/EC).

Результаты

Уровни общей вибрации изучены на 14 БКС (табл. 4). Воздействие оценивалось по дозе вибрации, рассчитанной для 8-часового вождения машины. Средний уровень воздействия ОВ, представленный в величинах эквивалентного виброускорения (A8) по оси Z, составил (1,00 ± 0,23) м/с². Усредненная величина пик-фактора (ПФ – отношение максимального и среднеквадратичного значений виброускорения) для 14 БКС равнялся 12,78 ± 5,26. Так как международный стандарт рекомендует использование величины дозы вибрации (ВДВ) в случае, когда ПФ более 9, была рассчитана средняя ВДВ, составившая (10,35 ± 2,61) $м/с^{1,75}$.

Оценка риска, основанная на серии реально измеренных уровней вибрации, представлена в табл. 5. Для оценки использованы российские нормативы по ОВ и европейские стандарты. Термины «выше допустимого» и «выше предельного» уровней предназначены для оценки фактически измеренных значений, выраженных в dB и м/с².

Обсуждение результатов

Зафиксированные уровни вибрации в открытом руднике Восточный (см. табл. 4) с соответствующими классами вредности условий труда (см. табл. 5) вполне сопоставимы с результатами других исследований в российской горно-добывающей промышленности, полученными И. П. Карначевым с соавт. [2, 3], В. П. Чащиным и З. Ф. Аскаровой [8]. Есть основания считать полученные данные репрезентативными, и они вполне сравнимы с результатами других иностранных исследований [12–14].

Сравнение европейского и российского методов оценки риска. Согласно российской системе классов вредности уровни ОВ, соответствующие виброускорению ниже 0,56 м/с² в вертикальной (Z) оси, считаются невредными и названы допустимыми (класс вредности 2). Уровни воздействия ОВ по оси Z между 0,56 и 8,9 м/с² относятся к вредным и оцениваются по классам вредности в интервале от 3.1 до 3.4. Уровни ОВ по оси Z выше 8,9 м/с² называют чрезвычайно вредными. Уровни ОВ, которые определяют класс опасности по оси X и оси Y, ниже, чем уровни по оси Z.

Таблица 4

Взвешенные по частоте значения виброускорения и дозы вибрации на различных типах БКС

Тип самосвала	Число БКС (число измерений) (n=14)	Продолжительность измерений, мин	Ось наибольшего ускорения, м/с² rms				Ось наибольшей дозы вибрации, $м/с^{1,75}$			
			Средняя	Min	Max	SD	Средняя	Min	Max	SD
Catepillar 785C	2 (2)	31–37	1,12	1,09	1,15	0,04	13,65	13,5	13,8	0,21
БелАЗ 75 121	2 (2)	34–45	1	1,05	0,96	0,06	10,95	10,4	11,5	0,78
БелАЗ 75 131	4 (6)	21–25	0,83	0,7	0,92	0,1	8,26	6,89	9,91	0,99
БелАЗ 75 145	6 (8)	13–58	1,1	0,73	1,57	0,29	11,04	7,24	14,4	2,92

Таблица 5

Уровни вибрации при эксплуатации различных типов БКС в открытом руднике (безопасные и предельно допустимые), соответствующие различным классам условий труда

Тип самосвала	Уровень эквивалентного виброускорения A(8)				Предельный (1,15 м/с²) и допустимый (0,5 м/с²) уровень A(8)	Класс вредности		
	A(8)X	A(8)Y	A(8)Z	Основная ось		Z	X	Y
Catepillar 785C, 136	0,71	0,43	1,15	Z	Предельный	3,2	3,1	3,1
	0,64	0,43	1,09	Z	Допустимый	3,1	3,1	3,1
БЕЛАЗ 75 145	0,48	0,55	0,96	Z	Допустимый	3,1	3,1	3,1
	0,71	0,74	1,05	Z	Допустимый	3,1	3,1	3,1
БЕЛАЗ 75 131	0,45	0,49	0,72	Z	Допустимый	3,1	3,1	3,1
	0,6	0,6	0,92	Z	Допустимый	3,1	3,1	3,1
	0,6	0,55	0,7	Z	Допустимый	3,1	3,1	3,1
	0,8	0,57	0,9	Z	Допустимый	3,1	3,1	3,1
	0,57	0,62	0,85	Z	Допустимый	3,1	3,1	3,1
	0,53	0,56	0,88	Z	Допустимый	3,1	3,1	3,1
БЕЛАЗ 75 145	0,36	0,47	0,68	Z	Допустимый	3,1	3,1	3,1
	0,52	0,62	0,96	Z	Допустимый	3,1	3,1	3,1
	0,44	0,55	0,73	Z	Допустимый	3,1	3,1	3,1
	0,7	0,84	1,57	Z	Выше предельного	3,2	3,1	3,1
	0,4	0,58	0,8	Z	Допустимый	3,1	3,1	3,1
	0,85	0,74	1,12	Z	Допустимый	3,1	3,1	3,1
	0,71	0,76	1,27	Z	Выше предельного	3,2	3,1	3,1
	0,57	0,68	1.25	Z	Выше предельного	3,2	3,1	3,1

Оценка рисков с использованием российских и европейских стандартов создала возможность для проведения сравнения двух систем (см. табл. 4). Важно отметить, что класс вредности условий труда характеризуется определенным диапазоном показателей, а не одним значением, как это установлено в европейской системе, а также то, что допустимые и предельные значения ОВ укладываются в эти диапазоны. В табл. 5 показано, что экспозиция на допустимом уровне соответствует показателям класса 3.1 (0,56—1,12 м/с^2). Экспозиция на предельном уровне или превышающая его соответствует показателям класса 3.2 (1,12—2,23 м/с^2), находясь на нижней границе указанного диапазона. Можно утверждать, что предельный уровень ОВ и класс 3.2 характеризуют одну и ту же степень риска развития нарушений здоровья. В европейской системе оценки рисков здоровью безопасный уровень принято называть «зеленым», выше безопасного, но ниже предельного — «желтым», выше предельного уровня — «красным». Такой подход, задуманный для облегчения передачи информации, имеет сходство с российской системой градации условий труда. Хотя, надо признать, российский метод позволяет дать им более тонкую оценку. Сходные результаты оценки связи между допустимыми и предельными уровнями ОВ и классами условий труда были получены A. Øvrum at al. [4] при исследованиях ОВ, возникающей при эксплуатации транспортных средств в условиях подземного апатитового рудника.

Выполненные исследования показывают, что значения ОВ на уровне российского класса 3.2 или его превышающие, соответствуют европейскому предельному уровню (1,15 м/с^2). В России для лиц, работающих в условиях класса вредности 3.2, устанавливаются льготы в виде увеличенного размеры заработной платы, более продолжительного ежегодного отпуска и выхода на пенсию в более раннем возрасте. Также возможен перевод на другие работы с допустимыми или оптимальными условиями труда. В европейских странах экспозиция выше допустимого уровня считается потенциально вредной для здоровья, что ведет к практическому внедрению профилактических мер на рабочем месте, направленных на снижение экспозиции до допустимого уровня. Экспозиция выше предельного уровня влечет применение неотложных профилактических мер для ее снижения. В этом аспекте две системы отличаются по последствиям оценки рисков. Однако и та и другая системы направлены на улучшение и облегчение процесса оценки рисков здоровью от воздействия вибрации на рабочем месте.

Заключение

В результате проведенных в открытом руднике исследований были выявлены уровни ОВ, которые являются репрезентативными и сопоставимыми с данными измерений в других рудниках с открытым способом добычи руды. Полученные данные показывают, что уровень ОВ, соответствующий нижней границе диапазона для класса 3.2, близок к значению предельного уровня ОВ, составляющего 1,15 м/с^2. Несмотря на существующие между двумя системами различия, которые были представлены в данной работе, оценка рисков здоровью по европейской и российской методикам дает схожие результаты. Однако практические последствия существенно отличаются. Более глубокое понимание двух оценочных систем полезно при проведении сравнения результатов оценки рисков. Это справедливо при изучении как частного случая экспозиции к ОВ, так и в целом воздействия различных вредных производственных факторов на рабочем месте.

Полученные знания применимы как в научных, так и в практических целях в ситуации, когда работники и работодатели меньше ограничены национальными границами. Они могут улучшить представления о процедуре проведения оценки рисков, необходимые в практической работе по профилактике нарушений здоровья и его укрепления в условиях реального производства. Также представленная работа может повысить интерес к дальнейшему изучению рисков здоровью, связанных с воздействием общей вибрации.

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EUROPEAN AND RUSSIAN METHODS FOR EXPOSURE ASSESSMENT APPLIED ON WHOLE BODY VIBRATION VALUES IN SHORT HAUL DUMP TRUCKS

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Operating Surface Haul Trucks (SHT) exposes mineworkers to whole body vibration (WBV), but risk assessment methods are not uniform in the Barents Region. We intended to measure WBV exposure from SHT, and discuss and compare risk assessment outcome by European and Russian methods. 17 WBV measurements were performed at the operator seat interface on 14 SHTs in an open cast mine in Northwest Russia. Measurement periods ranged from 13 to 58 minutes in real work cycles during 8 hours of driving. It was found that mean WBV exposure (A(8) rms) for the 14 SHT's was (1.0 ± 0.23) m/s^2, mean crest factor - (12.78 ± 5.26) and mean vibration dose value — (10.35 ± 2.61) m/s$^{1.75}$. The study shows that WBV levels defining the lower limit of hazard class 3.2 (Russia) is close to the limit value 1.15 m/s^2 (European countries).

Keywords: vibration, dump truck drivers, risk assessment

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European and Russian methods for exposure assessment applied on whole body vibration values in short haul dump trucks

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ABSTRACT

Operating Surface Haul Trucks (SHT) expose mineworkers to whole body vibration (WBV), but risk assessment methods are not uniform between several countries. We intended to measure WBV exposure from SHT, and discuss and compare risk assessment outcome by European and Russian methods. Some 17 WBV measurements were performed at the operator seat interface on 14 SHTs in an open cast mine in Northwest Russia. Measurement periods ranged from 13 to 58 minutes in real work cycles during 8 hours driving. The measurement, processing, analysing and exposure assessment methods follow the guidelines of the ISO standard (ISO 2631-1 1997), and Russian methods and standards (The Russian vibration regulation, 1997 and Russian Hazard class, 2006). Mean WBV exposure (A(8)rms) for the 14 SHT's was 1 m/s^2 (SD±0,23). Mean crest factor (CF) for the 14 SHTs was 12.78 (SD±5.26). Since the ISO standard recommends using vibration dose value (VDV) if the crest factor (CF) is above 9, mean VDV was also calculated: 10.35 $m/s^{1,75}$ (SD±2.61). The material was used to compare exposure assessment by Russian hazard classes and European action and limit values. The study shows that WBV levels defining the lower limit of hazard class 3.2 is close to the limit value 1,15m/s^2. A similar pattern has previously also been described in underground apatite mines.

BACKGROUND

Exposure to mechanical vibration from vehicles is common for workers in the mining industry, particularly those working as drivers. This whole body vibration (WBV) exposure is termed general vibration in Russia. The exposure is associated with several health complaints, most commonly in the musculoskeletal system [1]. Some controversy exists in the international literature concerning the level of exposure needed for the development of health problems. Despite a large body of literature in Russia on the subject, few of these studies are well known outside Russia. This is partly due to differing methods of assessing the risk. How these methods differ and relate to each other has not previously been described in the literature, to our knowledge. The practical and economic consequences from the outcomes of the risk assessments also differ between the two systems. Both have profound implications on the workplaces. In a situation with a growing mining industry in the Euro-Arctic Barents region (Northern Sweden, Norway, Finland and Russia) better knowledge of the system of workplace risk assessment is vital to improve the safeguarding of mineworkers health. Employing the principles of risk assessment in the two systems on a set of WBV exposure values provides an opportunity to compare, understand and interpret them.

OBJECTIVES

The aim of this study was to determine WBV exposure levels in an open cast mine and study whether these were comparable to levels in similar mines. We also aimed to compare European and Russian risk assessment methods of WBV exposure when applied on this series of WBV measurements.

METHODS

The exposure measurements were performed in the Vostochni open cast mine run by Joint Stock Company (JSC) Apatit, close to Kirovsk, Murmansk Oblast. 250 mine workers were exposed to WBV in this mine. These workers were drivers of Surface Haul Trucks (SHT) vehicles.

The total number of SHTs in operation in this mine was 65. WBV exposure measurements were carried out on 17 of these. The SHTs were the models Caterpillar 785C and Belaz 75, both with 120-130 tons loading capacity. The lengths of the shifts were 12 hours, with driving periods 8 hours. Measurements of WBV were carried out by a Norwegian–Russian group of occupational hygienists and specialists from the Department of Occupational and Environmental Medicine at the University Hospital of North Norway and Kola Research Laboratory for Occupational Health (KRLOH) in Kirovsk, Murmansk Oblast, Russia. The WBV exposure was measured on a number of the most frequently used open pit SHT vehicles that were available for measurement on the shifts during one week. Measurements were performed in a non-simulated situation, during typical work cycles, on site, with gravel and wet mud surface conditions. Measurement periods ranged between 13 to 58 minutes. The number of measurements were n=17 (Table 1). Measurements were performed onboard 2 Caterpillar 785C trucks and 12 Belaz 75 (models 121, 131, 141 and 145) trucks The time measurement period ranged from 13 to 58 minutes, each measurement period lasting one cycle. The number of cycles varied from 2 to 7. The measurements, processing, analysis and exposure assessment methods followed the guidelines of the ISO standard and Russian methods and standards [3, 4, 7]. The WBV measurements were performed at the operator seat interface when operating in non-simulated work situations using human vibration meter (Larson-Davis Model HVM100, WBV Triaxial Seat Pad Accelerometer Larsen Davis), adhering to the requirements of ISO Standard 8041 [8].

Table 1: Vehicle types, numbers of vehicles and numbers of measurements including time of measurements and number of work cycles.

Vehicle	**Numbers of vehicles**	**Number of measurments**	**Time of measurment periode**	**Work cycles pr. measurment periode**
Caterpillar 785C	2	2	31-37 min	1
Belaz 75 121	2	2	34-45 min	1
Belaz 75 131	4	6	21-25 min	1
Belaz 75 145	6	7	13-58 min	1

Employing European methods for risk assessment

WBV vibration was measured according to European ISO standard 2631-1:1997 [7]. The European system use the terms action value (0.5 m/s^2) and limit value (1.15 m/s^2) to which exposure levels A(8) are related (below, at or above) in the risk assessment, as described by the EU Directive 2002/44/EC [2]. Exposure levels above action value implies elevated health risk, in this situation action should be taken by the employer to bring the level down. Exposure levels above limit value are not allowed, and work can not continue at these levels. In this situation, the employer is obliged to take all the necessary measures to reduce to a minimum the exposure to mechanical vibrations, taking into account in particular other working methods, ergonomic design, equipment, information to workers, limitation of duration and intensity of exposure, work schedules and provide appropriate clothing.

Employing Russian methods for risk assessment

In the Russian system, levels of exposure of all kinds are categorized in the general system of hazard classes [4] from 0 to 4, which are used to grade the level of exposure. Grade 1 – no exposure and grade 2 refers to a level considered unharmful and allowable. Grade 3 is subdivided into four (3.1 to 3.4) levels of increasing hazard. Level 4 refers to extreme exposures which is dangerous to health. This is generally not allowed, but may be so in short or very specialized work tasks (as for fire fighters). The grades have several possible consequences: the frequency of health controls of workers, salary level, pension age, pension level, relocation to a lower exposure level and benefits for the exposed workers who are diagnosed with occupational disease [5, 6]. The Russian regulation use dB as a unit. In order to compare the calculated A(8) values to hazard categories in Russian regulations, the dB values in the Russian regulations were converted (A (m/s2) = 20 log X (dB), (A = acceleration value expressed as m/s2, X = acceleration value expressed as decibel) (Table 2).

Table 2: Vibration exposure in m/s^2 related to hazard classes in the Russian regulations.

Russian standard	z (m/s^2)	x, y (m/s^2)
1: No harmful exposure, optimal	0	0
2: Not harmful, allowable	< 0,56	< 0,4
3.1: Hazardous, grade 1	0,56 – 1.12	0,4 – 0,79
3.2: Hazardous, grade 2	1,12 – 2,23	0,79 – 1,6
3.3: Hazardous, grade 3	2,23 – 4,46	1,6 – 3,2
3.4: Hazardous, grade 4	4,46 – 8,9	3,2 – 6,3
4: Extreme, dangerous, not allowed for routine work	> 8,9	> 6,3

Figure 1 is a visual presentation of the comparison of the Russian hazard grades system and the limit and action values in the EEC Directive 2002/44/EC.

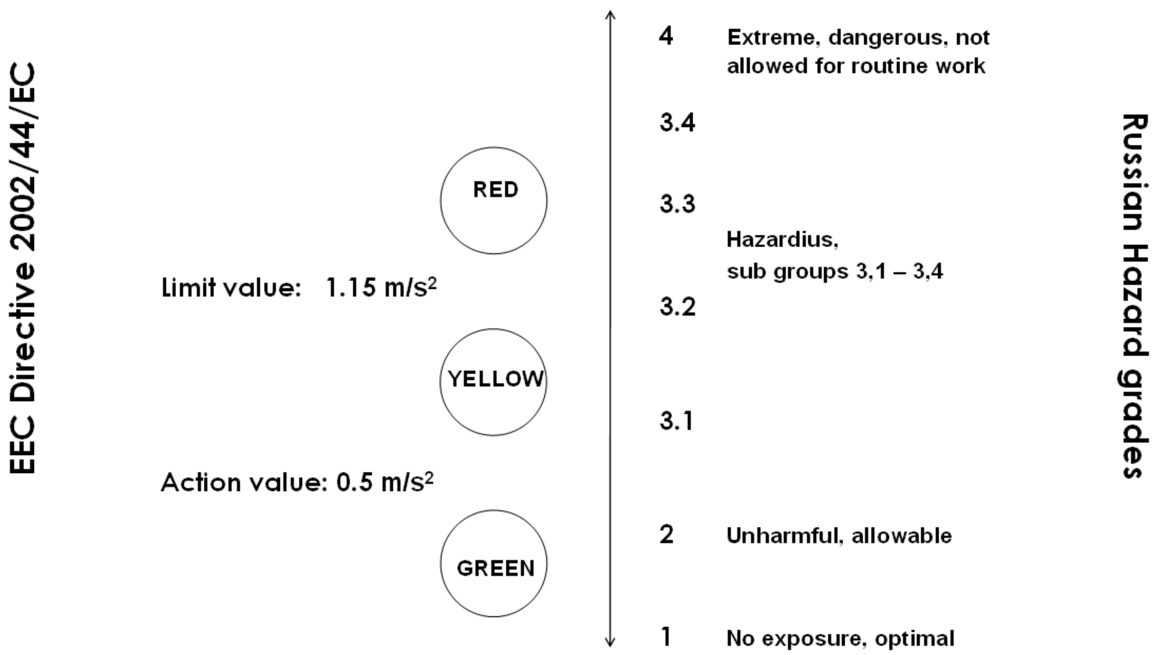

Figure 1: Russian hazard grad system and limit – and action values.

RESULTS

WBV exposure values are reported for 14 SHTs (Table 3). The exposure represents the vibration dose related to 8 hour of driving. The Mean A(8) WBV exposure (frequency-weighted rms) on the most severe axis was 1.0 m/s^2 (SD±0,23). Mean crest factor (CF) for the 14 SHTs was 12.78 (SD±5.26). Since the ISO standard (ISO 2631-1, 1997) recommends using vibration dose value (VDV) if the crest factor (CF) is above 9, mean VDV was calculated: 10.35 m/$s^{1,75}$ (SD±2.61).

Table 3: Frequency-weighted rms acceleration and vibration dose value measured at the operator/seat interface for 4 types of SHT's large transport trucks (120/130 ton) in "Vostochni" open mine JSC Apatity, Kirovsk,. (Murmansk Oblast, Russia.)

Vehicle type	**Number of vehicles (number of measurments)**	**Measurment duration (min.)**	**Most severe axis acceleration (m/s2 rms)**				**Most severe axis Vibration dose value (m/s-1,75)**			
			Mean	**Min.**	**Max**	**St.Dev.**	**Mean**	**Min.**	**Max**	**St.Dev.**
Catepillar 785C	2 (2)	31-37	1,12	1,09	1,15	0,04	13,65	13,5	13,8	0,21
Belas 75 121	2 (2)	34-45	1	1,05	0,96	0,06	10,95	10,4	11,5	0,78
Belas 75 131	4 (6)	21-25	0,83	0,7	0,92	0,1	8,26	6,89	9,91	0,99
Belas 75 145	6 (8)	13-58	1,1	0,73	1,57	0,29	11,04	7,24	14,4	2,92

*Crest Factor (CF) (SHT Dumpers n=14): Mean=12,78 (SD=5,26)

Based on the actual measured set of exposure values, risk assessments are presented in Table 4, performed by the use of the two systems: Russian regulations for general vibration and European Directive 2002/44/EC, 2002. Risk assessment terms *Above action* (value) and *Above limit* (value) and hazard categories are designated to the actual measured exposure values, presented in m/s^2.

Table 4: Vibration exposure SHT's open mine related to hazard grades in the Russian regulations and action and limit values in the European regulations.

Vehicle types	Vibration standardized to an eight-hour reference.				Directive 2002/44/EC Limit value: 1.15 m/s^2 Action value: 0.5 m/s^2 related to A(8)	Hazard categories - Russian regulations		
	A(8)x	A(8)y	A(8)z	Major axis		z	x	y
Catepillar 785C, 136	0,71	0,43	1,15	z	At limit	3,2	3,1	3,1
	0,64	0,43	1,09	z	Above action	3,1	3,1	3,1
БЕЛАЗ 75 145	0,48	0,55	0,96	z	Above action	3,1	3,1	3,1
	0,71	0,74	1,05	z	Above action	3,1	3,1	3,1
БЕЛАЗ 75 131	0,45	0,49	0,72	z	Above action	3,1	3,1	3,1
	0,6	0,6	0,92	z	Above action	3,1	3,1	3,1
	0,6	0,55	0,7	z	Above action	3,1	3,1	3,1
	0,8	0,57	0,9	z	Above action	3,1	3,1	3,1
	0,57	0,62	0,85	z	Above action	3,1	3,1	3,1
	0,53	0,56	0,88	z	Above action	3,1	3,1	3,1
БЕЛАЗ 75 145	0,36	0,47	0,68	z	Above action	3,1	3,1	3,1
	0,52	0,62	0,96	z	Above action	3,1	3,1	3,1
	0,44	0,55	0,73	z	Above action	3,1	3,1	3,1
	0,7	0,84	1,57	z	Above limit	3,2	3,1	3,1
	0,4	0,58	0,8	z	Above action	3,1	3,1	3,1
	0,85	0,74	1,12	z	Above action	3,1	3,1	3,1
	0,71	0,76	1,27	z	Above limit	3,2	3,1	3,1
	0,57	0,68	1.25	z	Above limit	3,2	3,1	3,1

DISCUSSION

The results compared to other studies:

The WBV exposure levels in this open pit mine (Table 3) with corresponding hazard grades (Table 4) are comparable with findings in other studies of the Russian mining industry as presented by Chachin and Askarova in 2008 [9] and Karnatchev, Efimov and Nikanov in 2006 [10], and are considered representative. The results are also comparable to exposure values found in other international studies [11, 12, 13].

Comparing the European and the Russian risk methods

According to the Russian system of hazard grades, WBV levels below 0,56 m/s^2 in the vertical (z) axis are considered unharmful and thus termed allowable (hazard grade 2). WBV exposure levels in the z axis between 0,56 m/s^2 and 8,9 m/s^2 are termed hazardous in this assessment, on a graded scale (3.1 to 3.4). WBV levels in the z axis above 8,9m/s^2 are termed extreme and dangerous. The exposure levels that define the hazards grade limits in the x and y axis are lower than those in the z axis.

Note that the limits for the hazard grades are ranges, not single values as in the European system, and that the action and limit values fall within the ranges. Table 4 shows how exposures at action value are in the range that defines hazard grade 3.1 (0,56-1,12 m/s^2). Exposures at or above limit values is in the range that defines hazard grade 3.2 (1,12 – 2,23 m/s^2), and close to the lower limit of this range. Thus it can be claimed that limit value and hazard grade 3.2 are corresponding expressions of risk levels. In European risk assessment, it is common to term safe exposure levels “green”, levels above action level but below limit value “yellow” and values above limit value “red”. This labeling, meant to ease the communication of risk levels has some resemblance to the use of hazard grades in the Russian system, which is however a more fine-graded system. A similar result of corresponding levels for hazard grades and limit- and action values has been presented on WBV data for vehicles in an underground apatite mine by Øvrum and co-workers in 2009 [14].

For WBV, a hazard grade at or above 3.2 corresponds to WBV levels above limit value (1,15 m/s^2). In the Russian system this would lead to increased salary, higher pension or possibly relocation. In the European system, exposure values above action value are considered possible harmful to health, and such values would lead to practical preventive measures at the workplace; seeking to reduce the exposure level below action value. Exposures above limit value would cause immediate preventive action to reduce exposure levels at the workplace. In this way, the two systems also differ in the consequences of the risk assessment. Both systems, however, are efforts to categorize and facilitate the process of assessing risk from vibration at the workplace.

CONCLUSION

The WBV levels reported in this study from the open apatite mines are representative and comparable to levels in other open mines. The study shows that WBV levels defining the lower limit of hazard class 3.2 is close to the limit value 1,15m/s^2. Despite differences in the two systems described here, comparing the outcomes from European WBV risk assessment and Russian hazard grading in this material provide corresponding expressions of assessments, although the practical consequences are not similar. A deeper understanding of the two systems of risk assessment is useful when comparing the risk assessment from WBV specifically and workplace exposures in general. This applies for both scientific and practical purposes in a situation where employees and employers are less restricted within national borders. It can improve the understanding of risk assessment procedures in practical prevention and health promotion at the workplaces, and help promote further studies of WBV exposure and health risks.

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No ethical approval was required for this study, since it contains no personal data.

Statement of conflicting interests

The authors have no conflicting interests to declare.

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Paper III

LOW BACK PAIN AMONG MINE WORKERS IN RELATION TO DRIVING, COLD ENVIRONMENT AND ERGONOMICS

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Abstract

Objectives: We aimed to study the association between low back pain and exposure to low temperature, wet clothes, heavy lifting and jobs that involve whole body vibration (WBV) in a population of miners.

Methods: Health and personal data were collected in a population study by a questionnaire. 3530 workers from four mines participated in the study.

Results: 51% of the workers reported low back pain within the last 12 months. The adjusted odds ratio for low back pain was above unity for working with wet clothes (1.82), working in cold conditions (1.52), lifting heavy (1.54), having worked as a driver previously (1.79), and driving Toro400 (2.61) or train (1.69).

Conclusion: Wet clothing, cold working conditions, heavy lifting, previous work as a driver, and driving certain vehicles were associated with LBP, but vehicles with WBV levels above action value were not. For better prevention of low back pain, improved cabin conditions and clothing should be emphasised.

Key words

Vehicle ergonomics, whole body vibration, back pain, thermal comfort, injury/illness epidemiology

1. Introduction

Self reported musculoskeletal pain in general and low back pain (LBP) in particular are widespread in the general population (Picavet and Schouten 2003, Picavet and Hazes 2003, Manchikanti et al. 2009, Hagberg et al. 2006). Studies have reported that back pain is frequent among professional drivers (Picavet, Schouten and Smit 1999, Robb and Mansfield 2007). Occupational exposure to whole body vibration (WBV) appears to be associated with LBP (Bovenzi 2002, Burdorf and Sorock 1997, Tiemessen, Hulshof and Frings-Dresen 2008), especially in drivers of heavy vehicles (Bovenzi and Betta 1994, Porter and Gyi 2002, Bovenzi and Hulshof 1999). A dose-response relationship between WBV and LBP is not established but both the characteristics of vibration exposure and the duration of exposure may play a role (Burström, Nilsson and Wahlström 2010).

LBP in drivers may also be influenced by other factors in the work environment, such as type of work process and machinery, work postures, heavy lifting, and biodynamic factors, cold working conditions, as well as various individual characteristics and stress (Hagberg *et al*. 2006, Palmer *et al*. 2003, Hoy *et al*. 2005, Hoogendoorn *et al*. 1999). The ISO 15734 2008 standard defines temperatures below 10˚C as an unfavourable condition for human function and may lead to increased risk of musculoskeletal symptoms and injuries (ISO 15734 2008, Hassi et al. 2000, Bang et al. 2005, Inaba and Mirbod 2010, Burstrom *et al.* 2012, Pienimaki 2002). Cooling affects all components of muscular performance; power, velocity, endurance and co-ordination (Oksa 2002). Cold stress causes shivering response, and can lead to a loss of dexterity and manual strength as well as exhaustion from increased energy costs (Thompson and Hayward 1996). Musculoskeletal related symptoms and complaints from cold exposure include pain, stiffness, swelling and restriction of movements (Makinen and Hassi 2009). Exposure to cold may be aggravated by wet clothes and increased convective heat loss, and wet clothes has also been reported to impact the risk of LBP (Makinen and Hassi 2009, Goldsheyder *et al.* 2004). Our hypotheses were that WBV from driving heavy vehicles, heavy lifting, working with wet clothes and cold working conditions affect the risk of LBP.

In the mining industry, the workers' tasks have been increasingly mechanized with more time spent operating machinery and driving vehicles (McPhee 2004), but still physically demanding, adding to a complex of exposure factors. One of the largest mining populations in Europe is in the Kola Peninsula (KP) in North-West Russia. Thousands of workers are working in open pit and underground mines. The systematic health surveillance at these workplaces and the large populations provide unique possibilities for studying the health of mine workers (Skandfer *et al.* 2012). Occupational accidents and diseases are increasing in KP, but probably underreported (Dudarev, Karnachev and Odland 2013). The prevalence of occupational musculoskeletal disorders is higher than reported for Russian Federation (Dudarev, Talykova and Odland 2013). Self reported musculoskeletal pain has been reported at 30% of which 8% was considered to be due to mechanical vibration (Kola Research Laboratory of Occupational Health 2009). Vibration has been recognized as a frequent cause of reduced health among these mine workers (Skripal 2008). The multiple exposures can also include low temperatures, unlike for miners in temperate parts of the world. Thus, it is important to investigate the association between several exposure factors present in the work environment and LBP. The present study, which is the first part of a large investigation in this population, facilitated for that.

2. Aim

The aim of our study was to investigate the association between jobs that involve WBV, cold environment, heavy lifting and wet clothing and the occurrence of LPB in a cohort of mine workers, adjusted for individual factors.

3. Material / Methods

3.1 Context

The main mining communities in the Kola Peninsula (KP) in North-West Russia are the neighboring boroughs Apatity and Kirovsk, which have a combined population of 110 000. The apatite-nepheline mining and processing enterprise JSC Apatit operates four mines (two underground and two open pits), mine transportation lines and two concentrate plants in the area, and employs more than 13 000 workers (20% of all industrial workers in the KP). The annual turnover of workers in the mines has been about 10%. The employees work 8 and 12 hour shifts. All employees in these four mines are summoned to an annual, obligatory medical examination at the Kola Research Laboratory of Occupational Health (KRLOH). We have previously described the context and the regional occupational health system in detail (Skandfer *et al.* 2012). Temperatures in the underground mines are at a stable 5-8˚C, whereas in the open mines there are seasonal and latitudinal variations, with some locations qualifying for a true arctic climate, characterized by short, cool summers and long, cold winters with temperatures down to -40 ˚C.

3.2 Study Design

The study was cross-sectional and performed throughout 2010 among full-time employed mine workers who participated after giving an informed written consent. The questionnaire contained no personal identifier, only a running number. The study was approved by the regional committees for medical research in North Norway and North-West Russia.

3.3 Study population and enrolment

The study population was all 3680 workers employed in four mines, whereof 3530 (96%) signed an informed consent to participate (89.3% males).

3.4 Data collection

Data were collected by questionnaire. Work place characteristics, organization, type of occupations, vehicles and machinery were observed in the mines or obtained from the employer. The questionnaire was specially developed for this study, based on the Nordic questionnaire (Dickinson *et al.* 1992, Kuorinka *et al.* 1987) and the VIBRISKS questionnaire (Tiemessen, Hulshof and Frings-Dresen 2008, Lundström *et al.* 2004). Section 1 concerned age and sex. In section 2, the workers were asked about their current and past occupation, posture, lifting, vehicle driven in their current and past occupation and work in a cold environment (Raatikka *et al.* 2007). Section 3 contained questions about LBP during the last 12 months. Details about pain characteristics (localisation, radiation, debut, duration, and frequency of episodes) were also inquired. Information concerning weight, height, stress level and physical activity were obtained in section 4. The questionnaire was translated to Russian language, back-translated, and tested out by a panel of mine workers. The employed version was named ‘Workers health 2010’. The data collection took place as a voluntary annex to the annual medical examination at the KRLOH. Each worker filled in the questionnaire individually with trained staff present. The questionnaire was completed by all 3530 workers who had given consent to participate.

3.5 Determination of low back pain

The presence of LBP was measured with the following question: “*Have you felt pain or discomfort during the last 12 months in the body area shown in the figure (as depicted in the questionnaire)?”* (Yes/No), hereafter named LBP.

3.6 Vibration exposure

Workers reporting that they drove a vehicle in a typical work week were defined as exposed to WBV. Cumulative exposure was defined as hours of driving reported per week, classified into four categories: 1-19 hours, 20-29 hours, 30 – 39 hours and ≥ 40 hours per week. Since the observed combined work exposure depended on the type of vehicle, the workers were categorized in subgroups based on the vehicle operated. Vehicles driven were classified into six categories: TORO 400 load haul dump (LHD) vehicles, TORO 40 dump trucks, Caterpillar and Belaz heavy trucks, K10 and K 14 trains, lorries and buses and cars of various brands. This last heterogeneous group was merged with the remaining vehicles to form an extended ‘other’ category. Belaz is a Belorussian made equivalent to the Caterpillar 700 series heavy truck. Past WBV exposure was defined as driving in the previous job (yes/no).

3.7 Exposure to cold environment, wet clothing and lifting

Cold working conditions were expressed in hours per week exposed to cold environment during this/last winter, with cold environment defined as below +10˚C (ISO 15743 2008) and as used in other studies of cold work conditions (Raatikka *et al.* 2007). Questions were included where respondents should report as hours per week whether they were working with wet clothing and touching cold objects, respectively. Lifting was measured by the questions "*How many times in a typical working day do you lift loads greater than 15 kg and 30 kg, respectively?"*, with five frequency categories for each question.

3.9 Data analyses

The exposure factors were present or past WBV, heavy lifting, wet clothing, and cold working environment. Current exposure to WBV was defined as driving a vehicle in current work, divided into four categories based on number of hours of driving during a typical work week (0 hrs, 1-15 hrs, 16-30 hrs and above 30 hrs) and in six groups defined by vehicle types. Past exposure included workers who previously worked as drivers. Heavy lifting was included as a binary variable: lifting loads weighing more than 15 kg ten or more times/day or not. Cold working conditions and working with wet clothes were both dichotomized, with 20 hours/week as the cut-off for cold and 5 hours/week for wet clothes.

We used two models in binary logistic-regression analysis to analyse for possible associations between LBP and the exposure factors. In the main analysis (model 1), the WBV-exposure time was classified according to the four categories (hours driven per week) described above. Relevant interaction variables between the individual exposure factors (except past WBV) and between current driving and duration of employment in present job were included in the model. In model 2 each vehicle category was included as the WBV exposure. In both models, the associations between the study factors and LBP were adjusted for physical exercise, stress, sex, BMI, and duration of present occupation (in years) as possible confounders. Stress was reported as a five level ordinal variable, cut-off was set at 'a little' in the analyses. Physical exercise in leisure time was reported as yes/no response to four described levels (Averina *et al.* 2003). The cut-off for physical exercise in the analyses was set at recreational sports (at least 4 times per week). We chose to not adjust for age since this was highly correlated with the duration of present occupation. In model 2, driving other vehicles was also included as a confounder. IBM SPSS version 18 was used for the analysis. The significance level was set at five percent. The associations are reported as odds ratio (OR) with 95% confidence interval (CI). 78 questionnaires were missing information about one or more of the included factors.

4. Results

There were 936 (26.5%) drivers defined by occupation. Their mean age was 38.9 (standard deviation 10.7) and all were men. Their median employment time in the present job was 10 years. A higher proportion of the drivers reported heavy lifting than among the other occupations in total. Some 451 (12.8 %) had been drivers in their previous job. The other two major groups of occupations were mechanics (17.9 %) and electricians (17.7 %). In addition 634 workers in other occupations operated vehicles one or more hours in at typical work week. By vehicle category, the most frequently operated category was K10 and K 14 electrical trains which were reported by 309 drivers, followed by Caterpillar/Belaz trucks (250) and TORO 400 vehicles (217).

Heavy lifting was reported by 2025 (57.4%) and 2643 (74.9%) had worked in a cold environment on a weekly basis. 1674 (63.3%) had wet clothes for at least one hour per week and 1196 (45.3%) for at least 5 hours (33.9% of all workers). Characteristics of drivers and non-drivers are presented in Table 1.

LBP was reported by 1801 workers (51%). The majority of drivers (59.0%), blasters (65.2 %) and drill-rig operators (61.7 %) reported LBP. The prevalence of LBP among those who worked with wet clothes for at least one hour per week was 61.2% and 65% among those working with wet clothes at least 5 hours/week.

Table 1. Characteristics of drivers and non-drivers employed in the mines in Kirovsk.

Characteristic	Drivers			Other occupations		
	n	%	SD [A]	n	%	SD [A]
Number of workers	936	.	.	2594[B]	.	.
Duration of present occupation (median years)	10	.	.	9	.	.
Mean age (years)	38.9	.	10.7	40.0	.	12.0
Work in cold environment (<10˚C)[C]	514	54.9	.	1154	44.5	.
Lifting heavy (>15kg >9 times/day)	648	69.2	.	1377	53.1	.
Working with wet clothes [D]	358	38.2	.	838	32.3	.
Body mass index (kg/m^2)	26.5	.	4.0	26.5	.	4.3
Males	936	100	.	2219	85.5	.
Females	-	-	·	375	14.5	·
Stress level above 'a little' [D]	102	10.9	.	306	11.8	.
Physical activity level [E]	617	65.9	.	1692	65.2	.
Education level [F]	299	31.9	.	1335	51.5	.
Ever smoked	729	77.9	.	1804	69.5	.

[A] Standard deviation. [B]The main occupations were mechanics (n=632), electricians (n=623) and foremen (n=267). [C]≥20 hours per week. [D] Information missing for 2 drivers and 6 others. [E] Physical activity as recreational sports or training.
[F] Completed education beyond secondary school. Information missing for 1 driver and 5 others.

Detailed results of the statistical analyses of models 1 and 2 are presented in Table 2. All five exposure variables in model 1 were associated with LBP. The strongest adjusted association was found for wearing wet clothes (OR=1.82, 95% CI: 1.55 – 2.15) and previous job as a driver (OR= 1.79, 95% CI: 1.49 – 2.14). The OR for WBV was 1.08 (95% CI: 1.02 – 1.14) per category increase in time driving a vehicle. No interactions between the exposure factors included in model 1 were detected. The adjusted ORs for wet clothes, previous job as a driver, heavy lifting, and cold were attenuated in model 2, but all four remained associated. Of the vehicle types (model 2), driving TORO 400 (OR=2.61 [95% CI:

1.83 – 3.72]) and the K10 and K14 trains (OR=1.69 [95% CI: 1.29 – 2.22]) were most strongly associated with LBP.

Table 2. 12 month LBP in 3530 mine workers with each exposure compared to the non-exposed, with crude and adjusted odds ratios (OR)

	Crude		Adjusted [A]		Adjusted [B]	
Exposure factor (number exposed)	OR	95% C.I.[C]	OR	95% C.I.[C]	OR	95% C.I.[C]
Lifting heavy (2025) (lifting >15kg >9 times per day)	2.01	1.76–2.30	1.54	1.31–1.80	1.54	1.31–1.81
Wet work clothes at least 5 hours/week (1169)	2.38	2.06–2.75	1.82	1.55–2.15	1.81	1.54–2.14
Cold working conditions (<10˚C) [D] (1668)	1.88	1.64–2.15	1.52	1.30–1.78	1.30	1.10–1.53
Previous job as a driver (760)	1.88	1.60–2.22	1.79	1.49–2.14	1.80	1.50–2.16
Whole body vibration (driving time/week)	1.14	1.08–1.21	1.08	1.02–1.14		
TORO 400 E/D LHD vehicle (217)	3.63	2.62–5.04			2.61	1.83–3.72
TORO 40 truck (93)	1.54	1.01–3.35			1.28	0.80–2.03
K10 or K14 train (309)	1.98	1.55–2.53			1.69	1.29–2.22
Caterpillar 700 or Belaz truck (250)	0.68	0.52–0.88			0.83	0.62–1.11
Bus or lorry (98)	0.68	0.46–1.03			0.90	0.58–1.39
Car (48)	1.05	0.60–1.85			1.21	0.66–2.20

[A] Model 1. Adjusted for physical exercise, stress, sex, body mass index, duration of present occupation. Hosmer-Lemeshow test: p=0.58. Nagelkerke R^2=0.14. [B] Model 2. Adjusted for physical exercise, stress, sex, body mass index, duration of present occupation, and other vehicle. Hosmer-Lemeshow test: p=0.17. Nagelkerke R^2=0.15. [C]Confidence interval. [D]≥20 hours/week. In both models, 78 (2.2%) observations fell out of the analyses due to missing values for one or more factors and/or confounders.

5. Discussion:

The proportion of workers (51%) who reported LBP in this population is higher than that reported in mine workers in Kirovsk (KRLOH 2009) and cold storage room workers (Piedrahita *et al.* 2008, Dovrat and Katz-Leurer 2007), but closer to that reported in other studies (Porter and Gyi 2002, Bovenzi and Hulshof 1999, Robb and Mansfield 2007, Inaba and Mirbod 2010). Working with wet work clothes, lifting heavy, previous job as a driver, and working in cold conditions were associated with LBP during the last 12 months. In our study, the strongest adjusted association was found for wet clothes (OR=1.82). Wet clothes and cold working conditions were independently associated with LBP and we found no interaction between the two factors. A recent, large study in Sweden showed an increasing OR for LBP by decreasing working temperature (Burstrom *et al.* 2012), and wet work clothes was associated with LBP in a study of concrete workers (Goldsheyder *et al.* 2004). Our findings support these results. Cold exposure reduces tissue temperature and increase muscle tension and exhaustion, (Oksa 2002) which may lead to a sensation of pain. Wet clothes close to the skin has a cooling effect on thermoregulatory responses and thermal comfort (Bakkevig and Nielsen 1994). Heat loss attributed to evaporation at 10˚ C has been reported as higher than from evaporation at 34˚ C. This has been attributed to condensation within the clothing and to increased conductivity of the layers of wet clothing (Richards et al. 2008). Wet clothes can aggravate cold exposure through convection (Makinen and Hassi 2009). Our study suggests that wet clothes is an independent risk factor.

Other studies have also shown associations between heavy lifting and LBP, with a contribution greater than that from WBV (Palmer *et al.* 2003, Robb and Mansfield 2007, Kaila-Kangas *et al.* 2011). Lifting heavy loads, defined as more than 15kg more than 10 times per day, may also include lifting over 30 kg and 50 kg since the weight categories in the questionnaire were not mutually exclusive.

Some 13% of the workers had previously been employed as a driver, and an elevated proportion of this group reported LBP during the last 12 months (OR= 1.79). Since WBV exposure was defined as driving time per week, the adjusted OR for LBP per category increase in time was 1.08, which suggests that driving time is a weak risk factor, also when adjusted for the duration of the present occupation. Measurements of WBV exposure levels, which we carried out in the mines, showed WBV as acceleration levels root-mean-square over 8 hours [A(8)rms] at 1.00 m/s^2 in Caterpillar/Belaz, with mean vibration dose value (VDV) at 10.35 $m/s^{1,75}$ (Øvrum *et al.* 2012). This is comparable to levels found in previous studies in these mines (Chachin and Askarova 2008, Karnachev, Efimova and Nikanov 2006). The WBV level in TORO 400 was A(8)rms 0.82 m/s^2 and in TORO 40 A(8)rms 1.02 m/s^2 (Øvrum 2009). These levels were above action value (0.5m/s^2) but below limit value (1.15 m/s^2) (EU Dir 2002). WBV levels for K10 and K14 trains (0.4 m/s^2) were not above action value (Øvrum and Skandfer 2007). Compared to being cold and lifting heavy, WBV seemed to not be an exposure of importance in terms of LBP. However, the revealed associations, especially with previous work as a driver, suggest that drivers were at elevated risk of LBP. The association did probably not express its magnitude among current drivers, as workers with persisting LBP likely will change work or job tasks, often termed 'healthy worker effect' (Li and Sung 1999). Some may even be required to change job dependent on the results from the annual health examinations. Healthy worker effect is always present when work populations are studied, and its magnitude generally unknown.

Substituting being a driver in the model with the 6 vehicle groups driven in current work did not substantially change the associations between LBP and previous driving, heavy lifting and wet clothing, respectively. But among the current drivers only operation of TORO 400 and K10 and K14 trains were associated with LBP. These were used in the underground mines, both operating in temperatures measured at 4.8-8.2˚C, and relative humidity at 63-91% (Øvrum and Skandfer 2007). A particular feature of these vehicles is that the drivers sit in 90˚ angle to the driving directions in open cabins, working with the torso, shoulders and neck in a twisted position. Thus, these workers have a combined exposure situation of WBV, cold working conditions and awkward postures. Since cold working conditions was included as a covariate in the model, the particular work posture in these vehicles seems the most reasonable explanation for the elevated prevalence of LBP among these drivers. The vehicle-group differences in association with LBP indicate that vehicle-type specific analyses are needed when assessing the risk of musculoskeletal problems due to occupational driving.

When we substituted being a driver (model 1) with specific vehicles (model 2), the association between wet clothes and LBP remained while the association with cold work environment decreased. The observed reduction in OR for cold working conditions (from 1.52 in model 1 to 1.30 in model 2) was probably due to the introduction of new 'cold' variables in model 2, namely the vehicles with known cold working conditions (TORO-400, K10 and K14). Since the OR for other exposure variables generally persisted from model 1 to model 2, we can conclude that being a driver as a factor in model 1 represented well the vehicle categories in model 2 for assessment of the associations between lifting, cold environment, wet clothes and previous driving and LBP. The trains in the mines operate with steel wheels on steel tracks, as opposed to rubber tyres used by the heavy trucks such as TORO 400. WBV exposure levels from trains have been shown to exceed action values (Johanning *et al.* 2006). Drivers of TORO 40 trucks, Caterpillar and Belaz trucks work in temperate cabins, without the twisted position described for TORO 400 and the trains. Other studies have shown an association between professional driving with awkward working postures and LBP (Hoy *et al.* 2005, Hoogendoorn *et al.* 1999).

The high (96%) response rate was an advantageous feature, achieved by incorporating the investigation in the framework of the annual medical examination. The validity of self-reported exposure at work has been shown to be reliable (Stock, Fernandes, and Delisle 2005). However, posture was left out in the analysis since the data indicated that the questions addressing work posture had insufficient validity. Only 4% refrained from signing the informed consent.

Some 10.1% of the participating workers had been employed for a year or less. This corresponds with numbers found in a pre-study survey, with about 10% recruitment and 10% termination of work in the mines annually. Termination may be due to change of employer, retiring, or ending work in the mine due to health problems. It has not been possible to quantify these causes. With 26.5% current drivers and 12.8 % past drivers, this may indicate some flexibility both by the work force and the employer with regard to professional tasks. Health problems may require a change of work, since the health services can relocate workers with health problems away from a workplace with known high WBV exposure levels (Skandfer *et al.* 2012). All these mechanisms may contribute to a selection of healthy workers to certain jobs over time. Thus, the worker population in a given profession can be assumed to be healthier than if the general population was similarly exposed.

The main shortcoming of the study was its cross-sectional design, which does not provide cause-effect relationships. The estimated ORs for wet clothing and exposure to cold should be interpreted with care, as the chosen cut-offs may have caused misclassification of the exposed and non-exposed. Nevertheless our study revealed associations between some work place exposures in the mines and LBP. Observations of the work on-site aided our understanding of the combined exposure. For frequently occurring outcomes, such as LBP, the revealed ORs can overestimate the magnitude of the risks. The Nagelkerke R^2 from the logistic regression analysis indicate that about 15 percent of the variance in LBP was explained by the factors and confounders included in the models, but this estimate is imprecise. All the included confounders were associated with LBP, except sex, and in the direction expected.

In future studies impact from ergonomic factors on the development of LBP should be addressed in more detail, supported by measurements. Further studies should also address the issues of wet clothing, both as an independent risk factor and by differentiating between wet inner and outer layers of clothing.

6. Conclusion:

One-half of the workers in the mines reported LBP. Despite levels of WBV above action values, wet clothing, cold working conditions, heavy lifting, and previous work as a driver were more strongly associated with LBP. Driving the TORO 400 and the K10 and K14 trains were the only vehicle specific exposures associated with LBP, which may be explained by the twisted working position combined with low temperature in the open cabins – features that are particular for these vehicles. For better prevention of LBP, we recommend that improved cabin conditions and clothing should be emphasised.

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Table 2. 12 month LBP in 3530 mine workers with each exposure compared to the non-exposed, with crude and adjusted odds ratios (OR)

	Crude		Adjusted [A]		Adjusted [B]	
Exposure factor (number exposed)	OR	95% C.I.[C]	OR	95% C.I.[C]	OR	95% C.I.[C]
Lifting heavy (2025)						
(lifting >15kg >9 times per day)	2.01	1.76–2.30	1.54	1.31–1.80	1.54	1.31–1.81
Wet work clothes at least						
5 hours/week (1169)	2.38	2.06–2.75	1.82	1.55–2.15	1.81	1.54–2.14
Cold working conditions (<10˚C) [D]						
(1668)	1.88	1.64–2.15	1.52	1.30–1.78	1.30	1.10–1.53

Previous job as a driver (760)	1.88	1.60–2.22	1.79	1.49–2.14	1.80	1.50–2.16
Whole body vibration						
(driving time/week)	1.14	1.08–1.21	1.08	1.02–1.14		
TORO 400 E/D LHD vehicle (217)	3.63	2.62–5.04			2.61	1.83–3.72
TORO 40 truck (93)	1.54	1.01–3.35			1.28	0.80–2.03
K10 or K14 train (309)	1.98	1.55–2.53			1.69	1.29–2.22
Caterpillar 700 or Belaz truck (250)	0.68	0.52–0.88			0.83	0.62–1.11
Bus or lorry (98)	0.68	0.46–1.03			0.90	0.58–1.39
Car (48)	1.05	0.60–1.85			1.21	0.66–2.20

[A] Model 1. Adjusted for physical exercise, stress, sex, body mass index, duration of present occupation. Hosmer-Lemeshow test: $p=0.58$. Nagelkerke $R^2=0.14$. [B] Model 2. Adjusted for physical exercise, stress, sex, body mass index, duration of present occupation, and other vehicle. Hosmer-Lemeshow test: $p=0.17$. Nagelkerke $R^2=0.15$. [C]Confidence interval. [D]≥20 hours/week. In both models, 78 (2.2%) observations fell out of the analyses due to missing values for one or more factors and/or confounders.

Paper IV

Low back pain symptoms in relation to self-reported physical exposures among arctic mine workers: a cross-sectional population study

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Abstract

Background: We aimed to investigate characteristics of low back pain symptoms in mine workers and how low back pain (LBP) with radiation to the leg relates to occupation and occupational exposures. Methods: Cross-sectional study on 3530 mine workers in North Russia, with data collection by questionnaire. Results: LBP with radiation was experienced by more than one-third of blasters, drill-rig operators and drivers, and was associated with exposure to wet clothes, cold work environment and having worked as a driver. LBP was not associated with current employment as a driver or driving a vehicle. Cold environment and wet clothes were common exposures. Conclusions: The study suggests that cold work environment contributes to the risk of LBP with radiation.

Keywords:

Whole body vibration, low back pain, cold, lifting, wet clothes, mine workers

Background

The mining industry is expanding as global demands for minerals increase. Despite technological improvements, working in mines is still associated with elevated risk of disease and traumatic injuries. The efforts to prevent mining disasters and fatalities are currently often supplemented by a broader occupational health and safety focus [1]. The work in mines has changed with increasing mechanization; physically demanding work has become more intermittent but long working hours still expose workers to fatigue and stress [2]. Mining is nowadays a multidisciplinary industry that employs people with numerous professions and trades. The operations include several tasks and processes (exploration, drilling, mine development and operation with extraction, hauling and transport), and the term "mine worker" can denote people with a wide range of jobs. A large proportion of mine workers are drivers of heavy vehicles. Operating vehicles such as load-haul-dump (LHD) vehicles, trucks and trains in the mines exposes the driver to whole body vibration (WBV) [3]. The WBV exposure level is magnified through poorly maintained vehicles, high speed, unfavourable seat conditions and uneven roads, and WBV may also occur as sudden shocks [4]. Action and limit values for WBV are defined in the ISO 2631-1 standard and reiterated in the European Directive [5, 6]. In some regions miners are exposed not only to WBV and heavy work loads, but also to low temperatures. In addition, working in humid locations with water leaks and water-cooled machinery may cause the workers' clothes to get wet. The ISO 15734 standard defines temperatures below +10˚C as an unfavourable condition with increased risk of negative effects on human function, which may lead to increased risk of injuries and musculoskeletal symptoms [7-15].

High prevalence of low back pain (LBP) has been reported in mine workers [16, 17]. In a Finnish register study of people hospitalised for back pain, mine workers were the second largest profession category [18]. LBP imposes a heavy burden on individuals, employers and society [19].

Most LBP has no known cause; only in 6-10 % of all cases of LBP has an underlying pathological process been determined [20, 21]. Several studies have reported an association between WBV and LBP [22-25]. A possible causal relationship between operating heavy industrial vehicles and LBP has been reported [4, 26]. Low temperatures, awkward postures, pre-disposition, lifestyle, obesity, smoking and psychosocial factors may increase the risk [27-30]. Few studies of the impact of wet clothes on LBP have been published [31].

LBP episodes may show various manifestations, durations and intensities. Some persons experience back pain only, others experience back pain with radiation to the leg, a condition often termed sciatica. Although it is considered associated with disc hernia, the risk factors for LBP with radiation are not well understood. Obesity seems to be associated, and the onset of LBP with radiation may be affected by low physical activity and smoking [32]. LBP with radiation is a common condition [33, 34]. A study on municipal workers found that radiating pain was predicted by manual labour in both sexes and by previous pain in the lower back in men, while psychosocial and physical working conditions had no predictive value [32]. We have previously reported that wet clothing, cold working conditions, heavy lifting and previous work as a driver are associated with LBP [35]. These findings warranted a more detailed study of subgroups of LBP with and without pain radiation as well as other characteristics. Our hypothesis was that working in wet clothes increase the risk of LBP with radiation. Increased understanding of the association between occupational exposures and LBP with and without pain radiation may promote better prevention strategies. This requires studies on large populations.

Methods

The study aim was twofold: to investigate characteristics of low back pain symptoms (frequency, intensity, duration and radiation) in mine workers, and how back pain with radiation relates to occupation, type of vehicle driven, past driving, heavy lifting, wet work clothes and cold work environment among workers with LBP.

Study population, enrolment, data collection

The population under study consisted of all workers (3680) employed in four mines in Kirovsk, Russia. In total, 3530 (96%) signed an informed consent to participate, of which 89.3% were males. Data were collected throughout 2010 by both observations in the mines and the questionnaire Workers health 2010, completed by the workers at their periodical medical examination, which took place at the outpatient clinic of the Kirovsk Research Laboratory of Occupational Health (KRLOH) [36]. Workplace characteristics and the types of vehicles and machinery used were observed and recorded for inclusion in the questionnaire. The professional groups were defined based on observation and information obtained from the employer about the types of jobs in the mines. The enrolment and data collection have previously been described in detail [35].

Assessment of outcomes

The presence of LBP was assessed with the following questions: *Have you felt pain or discomfort during the last 12 months in the body area shown in the figure (as depicted in the questionnaire)? (Yes/No).* Localisation was measured with the question: *If yes, where was the pain or discomfort localised?* Response options were: *back only*, *radiating in the leg only* and *back and radiating in the leg*. Pain intensity was assessed on a 10-step, visual analogue scale (VAS). The frequency and duration of the pain was assessed in predetermined time and frequency categories by the questions: *How many episodes have you had*? (5 categories from 1 to more than 10 episodes) and *How long did they typically last*? (7 categories from *hours* to *all year*).

Assessment of exposures

The workers were classified by their reported current occupation, by the question: *What is your current and past occupation?* Only one current occupation was reported for each worker. Exposure from driving a vehicle was classified by type of vehicle driven, since workers in occupations other than driver could also operate vehicles. Driving a vehicle was used as a marker of exposure, and workers responding that they drove a vehicle in a typical work week were defined as exposed to WBV. Cumulative exposure was defined as hours of driving reported per week, classified into four categories: 1to19 hours, 20 to 29 hours, 30 to 39 hours and 40 hours or more per week. Lifting was measured by the questions: *How many times in a typical working day do you lift loads greater than 15 kg and 30 kg, respectively?* with five frequency categories for each question. In addition the following question was posed: *Does your work ever involve lifting or moving loads more than 50 kg?* Cold work environment (hereafter termed 'cold') was measured by the question: *How many hours per week have you been exposed to cold environment (below +10°C) during this/last winter, indoors or underground?* and *with wet clothing?* Stress and physical activity were assessed from the questionnaire.

Data analysis

The exposure factors included the type of vehicle driven (Toro 40, Toro 400, trains and other vehicle) as exposure categories. In addition, the following occupations were included as categories in the analysis: driver, mechanic, blaster, electrician, foreman, drill-rig operator, and other occupation. LBP was classified as LBP without radiation and LBP with radiation (including pain radiating in the leg only). The associations with the different exposures and worker categories were assessed in bivariate and multiple logistic regression analyses of the workers who reported LBP. Only occupation categories that were associated with LBP with radiation in the bivariate analyses were included in the multiple regression model. Odds ratios and 95% confidence intervals (C.I.) are reported. Adjustment was made for the following factors in the multiple model: duration of employment, BMI, physical activity and stress level. We chose not to adjust for age since this was strongly correlated with the duration of employment. Heavy lifting, cold and wet clothing were dichotomised, with cut-offs set at more than 15 kg ten or more times/day for heavy lifting, over 20 hours/week for cold, and over 5 hours/week for wet clothing. Stress was included as a five level ordinal variable, and physical activity and BMI were dichotomised with more than 4 hours/week and 30 kg/m^2 as reference categories respectively. Duration of employment in years was categorised as below 2, 2 to 5, 6 to14 and above 14. IBM SPSS version 18 was used for the analysis.

Ethical considerations

The workers were provided with information in writing, and gave written informed consent for participation. The questionnaire contained no personal identifier but had a running number that linked the questionnaire to the database. The list of the names of all workers required to undergo the health examination was only used for administrative purposes by the KRLOH. The study was approved by the regional committees for medical research in North Norway and North-West Russia.

Results

The mean age of the workers was 40 years (median 39 years). Cold was the most prevalent of the exposure factors studied; 85.8% of the train drivers, 81.6% of the Toro 400 drivers and 84.8% of the blasters reported exposure to temperatures below +10˚C more than 20 hours/week. The highest mean reported number of hours of weekly exposure to cold was for the drivers of Toro 400 [30.3 hours, standard deviation (SD) 12.8], with a median of 35 hours. The figures for drivers of underground trains were only slightly lower. The mean duration of cold exposure for drivers of Toro 40 was 26.0 hours (SD 12.2) with median duration 30 hours. The mean exposure time to cold for blasters was 30.3 (SD 12.2) and median was 35 hours. Drill-rig operators (61%), blasters (63%), and drivers of Toro 40 (55%), Toro 400 (53%) and trains (48%) had the highest prevalence of working with wet clothes more than 5 hours per week in a typical work week, while the highest prevalence of lifting more than 15 kg 10 times or more on a typical workday was among drill-rig operators (88%), blasters (85%) and drivers of Toro 400 (78%). Of the blasters, 35% had worked as a driver in the past. The lowest prevalence of all study factors was found among mechanics. Additional details are presented in Table 1. There were no missing values for any of the exposure factors.

Table 1. Workers with exposure to each study factor, stress and physical activity by vehicle and occupation.

		Occupational exposures			Individual factors		
		Cold[1]	Wet clothes[2]	Heavy lifting[3]	Past driver	Stress [4]	Physical activity [5]
	n	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Occupation							
Driver	936	514 (54.9)	358 (38.2)	648 (69.2)	292 (31.2)	284 (15.2)	768 (82.1)
Mechanic	632	138 (21.8)	116 (18.4)	217 (34.3)	80 (12.7)	89 (14.1)	515 (81.5)
Blaster	184	156 (84.8)	115 (62.5)	156 (84.8)	64 (34.8)	22 (12.0)	146 (79.3)
Electrician	623	296 (47.5)	209 (33.5)	382 (61.3)	76 (12.2)	52 (8.3)	510 (81.9)
Foreman	267	148 (55.4)	73 (27.3)	113 (42.3)	83 (31.1)	34 (12.7)	223 (83.5)
Drill-rig operator	188	111 (59.0)	115 (61.2)	166 (88.3)	49 (26.1)	23 (12.3)	156 (83.0)
Other occupations	700	199 (28.4)	133 (19.0)	244 (34.9)	96 (13.7)	65 (9.28)	459 (65.5)
Total	3530	1562 (44.2)	1089 (30.8)	1926 (54.6)	740 (21.0)	569 (16.1)	2777 (76.7)
Vehicle[6]							
Toro 40	93	68 (73.1)	51 (54.8)	69 (74.2)	26 (28.0)	14 (15.1)	74 (79.6)
Toro 400	217	177 (81.6)	115 (53.0)	170 (78.3)	84 (38.7)	35 (16.1)	156 (71.9)
Train	309	265 (85.8)	149 (48.2)	237 (76.7)	74 (23.9)	37 (12.0)	248 (80.3)
Other vehicle	951	285 (30.0)	312 (32.8)	628 (66.0)	297 (31.2)	98 (10.3)	796 (83.7)
Total	1560	795 (51.0)	627 (40.2)	1104 (70.8)	481 (30.8)	184 (11.8)	1274 (81.7)

[1] Working over 20 hours per week in temperature <10°C. [2]Working in wet clothes > 5 hours per week. [3]Lifting more than 15 kg ≥10 times per day. [4]Stress above 'a little', 8 missing. [5]Exercise more than 4 hours per week. [6]Vehicles were also driven by workers in other occupations than driver. [7] Including cracker machine operator, timber man, tumbler machine operator, welder and 'other'.

Every second worker with LBP was a smoker. Other characteristics of workers with LBP are presented in Table 2. Of all the workers, 51% reported having had LBP during the last 12 months. Of those with LBP, 34.8% reported LBP with radiation. The overall prevalence of LBP without radiation (33%) was almost twice as high as that of LBP with radiation (18%). The proportion that had experienced LBP ranged from 42.1% among electricians to 65.2% among blasters (Table 3). Of drivers, 59% reported LBP. Among workers with LBP the proportion that experienced back pain with radiation of pain to the leg was highest among blasters (49%), drill rig operators (40%) and drivers (36.5%). The highest reported proportion of radiation to the leg only was among blasters (4.2%) and the lowest in drivers (1.5%). In the vehicle-specific categories, 78% of the Toro 400 drivers, 66% of the train drivers and 61% of Toro 40 drivers reported LBP, and 44% of Toro 400 drivers with LBP reported radiation to the leg (Table 3).

Table 2. Characteristics of workers with self-reported low back pain with and without radiation

	LBP without radiation	LBP with radiation
Male n (%)	1059 (90.5)	581 (92.7)
Female n (%)	111 (9.5)	46 (7.3)
Mean age, years (SD)	39.3 (11.3)	43.2 (10.1)
Mean weight, kg (SD)	81.7 (14.3)	83.7 (14.2)
Smoking n (%)	575 (49.1)	314 (50.1)
Duration of present employment, years (SD)	12.6 (10.6)	14.5 (10.3)

Table 3. Number and proportion of workers reporting low back pain by occupation and vehicle group

	LBP without radiation [1]	LBP with radiation [1,2]	LBP total (% of all workers by occupation group)
	n (%)	n (%)	n (%)
Occupation			
Driver	349 (63.5)	201(36.5)	550 (58.8)
Mechanic	208 (68.9)	94 (31.1)	302 (47.9)
Blaster	62 (51.7)	58 (48.3)	120 (65.2)
Electrician	184 (70.2)	78 (29.8)	262 (42.1)
Foreman	80 (61.5)	50 (38.5)	130 (48.7)
Drill-rig operator	70 (60.3)	46 (39.7)	116 (61.7)
Other occupations [3]	217 (68.5)	100 (31.5)	317 (45.3)
Vehicle[4]			
Toro 40	38 (66.7)	19 (33.3)	57 (61.3)
Toro 400	95 (56.2)	74 (43.8)	169 (77.9)
Train	129 (63.2)	75 (36.8)	204 (66.0)
Other vehicle	317 (66.0)	163 (34)	480 (50.6)

[1] Four removed from analysis due to inconsistent data for pain localisation
[2] Includes original category 'radiating in the leg only'
[3] Includes cracker machine operator, timber man, tumbler machine operator, welder and 'other'.
[4] Vehicles were also driven by workers in other occupations than driver.

The median number of LBP episodes was 2 to 5 and median duration of pain was 1 to 2 days for all occupation categories except for blasters, for whom median duration was 3 to 6 days. For back pain without radiation the median number of pain episodes was 2 (mean 2.8) with median duration 2 days (mean 2.3 days). The median number of episodes of back pain radiating to the leg was 4 (mean 3.6) with median duration 3 days (mean 3.5 days).The mean VAS rating of worst pain was 2.3 (median 2) among workers with back pain only during the last month, and 4.2 (median 4) for those with back pain radiating to the leg. The median number of LBP episodes was 3 to 6 days and median duration for drivers of Toro 40, Toro 400 and trains was 3 to 6 days and for drivers of other vehicles 1 to 2 days. Median VAS score for worst LBP was 4 for drivers of Toro 40 and Toro 400, 3 for drivers of trains and 2 for drivers of other vehicles. Mean VAS score for worst LBP was 3.6 for drivers of trains and the two Toro vehicles and 2.9 for drivers of other vehicles.

As outlined in Table 4, a crude risk above unity for LBP with radiation (including radiating pain to the leg only) among workers with LBP was observed for wet clothes, cold environment, heavy lifting, being past driver, driving Toro 400 and working as blaster. The adjusted association was statistically significant for wet clothes (OR=1.44), cold environment (OR=1.49) and past driving (OR=1.50).

Table 4. Crude and adjusted OR for low back pain with radiation by occupational exposure factors and occupations

Occupational exposure	Crude risk for LBP with radiation		Adjusted risk for LBP with radiation[a]	
	OR	95% C.I.	OR	95% C.I.
Wet clothes	1.70	1.40-2.07	1.44	1.15-1.81
Cold environment	1.61	1.33-1.98	1.49	1.18-1.89
Heavy lifting	1.34	1.09-1.65	1.00	0.79-1.28
Toro 40	0.93	0.53-1.64	0.81	0.43-1.55
Toro 400	1.52	1.10-2.10	1.13	0.72-1.77
Train	1.10	0.81-1.49	0.95	0.62-1.45
Other vehicles	0.94	0.76-1.17	0.89	0.64-1.22
Driver	1.11	0.90-1.36	1.05	0.76-1.46
Past driver	1.50	1.21-1.85	1.50	1.19-1.89
Blaster	1.83	1.26-2.65	1.43	0.94-2.17
Drill rig operator	1.25	0.85-1.84	1.19	0.73-1.94

[a] Adjusted for physical activity, stress, body mass index, duration of present occupation, 72 missing.

Hosmer-Lemeshow test: 0.703 Nagelkerke $R^2 = 0.086$

Discussion

This cross-sectional study aimed at studying characteristics of low back pain symptoms in miners in relation to occupation and occupational exposures. Our finding of a self-reported prevalence in drivers of 59% is close to that reported in other studies [20, 32, 37]. More than one-third of the blasters, drill rig operators, foremen and drivers, in particular the drivers of Toro 400, reported back pain with radiation in the last twelve months. The number of episodes and their duration indicate that LBP and back pain with radiation typically are recurring conditions of short duration. This coincides with the time frame for acute inflammation in the musculoskeletal system, which subside after some days.

The temperatures in the Kirovsk underground mines are 5-7 ˚C with relative humidity at 63-91% (unpublished observation). The mining is often carried out under wet conditions owing to water-cooled machinery, precipitation outdoors and ground water leaking from the walls and roof of the underground mines, as we observed during several mine visits. We have previously found that when operating Toro 400 vehicles in the underground mines, drivers are exposed to WBV at exposure levels above action value, close to levels reported in Toro 400 in a Canadian study [3, 5, 38].

Our results on how LBP with radiation relates to occupation, type of vehicle driven, past driving, heavy lifting, wet clothes and cold work showed that in the crude analysis, wet clothes, cold environment, heavy lifting, being past driver, working as a blaster, and driving Toro 400 were associated with LBP with radiation. This suggests that several factors contribute to this condition. The OR for Toro 400 is close to that in a Finnish study which reported a crude risk ratio of 1.6 for machine and vehicle operators [39]. However, only wet clothes, cold work conditions and being a past driver remained associated in the adjusted analysis. The association with being a past driver suggests that driving vehicles might be a risk factor or a marker, and that some workers may have changed profession from driver to other professions due to painful, radiating back problems. The lack of an association with heavy lifting may be due to our classification of exposure or a healthy worker selection [40]. The magnitude of such selection is hard to determine, but staff turnover through lay-off and recruitment at these mines is 10% per year. Built-in mechanisms in the procedures of the annual health examination also allow for relocation of workers who show signs of occupational disease under current exposure [36].

Cold environment was the most prevalent of the studied exposure factors in several groups of the mine workers. More than 80% of the train drivers, Toro 400 drivers and blasters reported exposure to temperatures below +10˚C. Drill-rig operators, blasters, and drivers of Toro 40, Toro 400 and trains were also those with the highest prevalence of working with wet clothing. The Toro 400, Toro 40 and K 10 and K 14 trains were all operating in the underground mines, where the open cabins of Toro 400 and trains expose the drivers to the wet and cold conditions of the underground mines. Heavy lifting was reported most commonly by drill-rig operators, blasters and drivers of Toro 400, and by the group driving ‘other vehicles’. Heavy lifting was surprisingly common for drivers but the study did not allow for a detailed description of the lifting. Driving in combination with exposure to physical work has been reported to increase the risk for physician-diagnosed LBP with radiation [21]. Driving the Toro 400 and trains may be considered a marker for awkward posture since drivers operating these bi-directional vehicles sit at a right angle to the driving direction and adopt a position where they twist and bend the torso in order to obtain a clear-line view. The drivers’ position also prevents them from getting proper support from the back rest in the Toro 400 seats [41]. The drivers’ seats of K 10 and K 14 trains do not even have any springs. Nevertheless, the results suggest that the cold and wet work environment was the main risk factor for radiating pain among the drivers of Toro 400. Several studies have reported a strong association between heavy lifting, prolonged sitting, twisting and bending and LBP [4, 24, 42]. None of these studies have considered the possible contribution from cold working conditions.

Surprisingly, the highest prevalence of LBP with radiation was found among the blasters. A post hoc analysis of blasters showed a crude OR for LBP at 1.86 (CI 1.36-2.53); the adjusted OR for radiation was 1.43 (CI: 0.94-2.17). Blasters are in charge of all procedures having to do with explosions in the mine. They work in the open and do not operate vehicles, but lift and move heavy equipment as they prepare and set off the explosions in boreholes that have been made with water-cooled drilling rigs. This exposes them to wet and cold conditions. Drill rig operators were the group that second most frequently reported LBP with radiation to the leg. They work on fixed platforms with several water-cooled drills that bore holes in the rock where explosions later take place. They stand on a rig platform, in an open hut, under a metal roof and are thus exposed both to mechanical vibration transmitted through their feet and to the low temperatures in the mine. They are also exposed to water mist from the drills. Our results suggest that these groups should be studied in greater detail.

We did not analyse for possible interaction between the factors under study, but in our previous investigation we did not find statistically significant interaction between the exposures and the risk of LBP. However, that analysis did not include possible interaction between the exposure factors and vehicles driven. The cut-offs chosen for the study factors wet, cold and lifting may have affected the outcome of the analysis. Our results show that many workers in these mines are exposed to several possible risk factors, but the study did not allow for further specification of the temporal relationship of the exposure factors and the outcomes. The main weakness of this study was the cross-sectional design, which does not allow for analysis of cause-effect relationships. Information was self-reported, and thus subjective. Still, for large population studies on clinical problems that are subjective in nature, questionnaires can be appropriate and the data reported with such methods are well in concordance with the actual situation [43]. Healthy worker selection may have led to an underestimation of the actual risk. Thus, a revealed association may be stronger than the numbers indicate. Clinical testing by trained physicians could have diagnosed low back pain in a more objective manner. The cold work conditions of these mines and the large study population allowed for studying the relationship between cold exposure and back pain.

Another advantage with this study was the high response-rate and the completeness in the questionnaire responses.

Conclusions

LBP with radiation was experienced by more than one-third of blasters, drill-rig operators and drivers, and was associated with exposure to wet clothes, cold work environment and being a past driver. LBP was not associated with current employment as a driver or driving a vehicle. Exposure to cold environment and wet clothes was common. The study suggests that cold work environment and wet clothes contribute to the risk of LBP with radiation. Prevention strategies for this health problem should include improved protective clothing.

List of abbreviations:

LBP - Low back pain
WBV - Whole body vibration
LHD - Load-haul-dump vehicles
KRLOH -Kirovsk Research Laboratory of Occupational Health
Toro 40 - Truck
Toro 400 - Load-haul-dump truck
K10 - Electrical underground mine train
K 14 - Electrical underground mine train
ISO - International Standard Organization
BMI - Body mass index
SD - Standard deviation
C.I. - Confidence interval
OR - Odds ratio
VAS - Visual analogue scale

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Appendix I

To be filled in by the staff:
Serial number: |__|__|__|__|
Today: day / month / year |__|__|__|__|__|__|

Questionnaire
Workers health 2010

Collaborating institutions:
-Department of Occupational Health, University Hospital of North Norway
-Kola Research Laboratory for Occupational Health, Russia
-Institute of Community Medicine, University of Tromsø, Norway
-Department of Occupational Health, Umeå University, Sweden

Instructions (*Different ways to answer*):

Put in a cross ☐
Fill in number |__|__|
Circle one number on a scale of 0 to10
Describe (fill in)

SECTION 1. Personal information

Age |__|__| Years Sex: 1☐ M 2☐ F

SECTION 2. Occupational history

2.1 CURRENT AND PAST OCCUPATION

2.1.1. **What is your current and past occupation?**

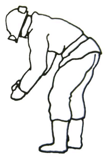
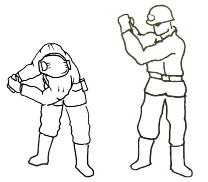
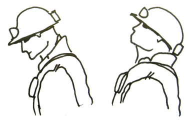
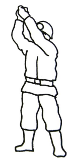
№	Occupation	**Current**	**Past**
1	TRUCK DRIVER	1☐	2☐
2	MINE LOADER DRIVER	1☐	2☐
3	MINE TRUCK DRIVER	1☐	2☐
4	MINE DRIVER	1☐	2☐
5	ELECTRIC TRAIN DRIVER	1☐	2☐
6	EXPLOSIONER	1☐	2☐
7	MINE WORKER	1☐	2☐
8	DRILLING RIG OPERATOR	1☐	2☐
9	CRACKER MACHINE OPERATOR.	1☐	2☐
10	ELECTROFITTER (FITTER), ELECTRICIAN	1☐	2☐
11	FOREMAN	1☐	2☐
12	TIMBERMAN	1☐	2☐
13	TUMBLER MACHINE OPERATOR	1☐	2☐
14	WELDER	1☐	2☐
15	OTHER	1☐	2☐

2.1.2. **When did you start this job?** |__|__|__|__| *year*

2.2 ACTIVITIES IN YOUR WORK.

Postures (*Only one answer to each posture*).

2.2.1 **How long during an average working day do you work in posture as shown below:**

Posture	 Hands placed under knee-level.	 Twisting (only twisted or twisted and bent at the same time)?	 Neck is bent forward or backwards?	 Neck is twisted (only twisted or twisted and bent/extended at the same time)?	 Arms raised and your hand held above shoulder height?
0-30 мin.	1☐	1☐	1☐	1☐	1☐
30-60 мin.	2☐	2☐	2☐	2☐	2☐
1 -3 hours.	3☐	3☐	3☐	3☐	3☐
More than 3 hours	4☐	4☐	4☐	4☐	4☐

Lifting

2.2.2. **How many times in a typical working day do you lift loads greater than 15 kg?**

Never	0 - 9 times	10 -19 times	20 - 40 times	More than 40 times
1☐	2☐	3☐	4☐	5☐

2.2.3. **How many times in a typical working day do you lift loads greater than 30 kg?**

Never	0 - 9 times	10 -19 times	20 - 40 times	More than 40 times
1☐	2☐	3☐	4☐	5☐

2.2.4. **Does your work ever involve lifting or moving loads more than 50 kg?** 1☐ No 2☐ Yes

2.3 VEHICLES USED IN CURRENT WORK

2.3.1. **How many hours in a typical week do you normally drive the following vehicles in your current work?**

№	***Vehicle***	**Approximately how many hours per week**
1	TORO 400 E/D load haul dump vehicle	☐☐ *Hours*
2	TORO 40 truck	☐☐ *Hours*
3	K10, K 14 train.	☐☐ *Hours*
4	Simba drill platform.	☐☐ *Hours*
5	Caterpillar, Belaz truck.	☐☐ *Hours*
6	Lorry or bus (as a driver, **not** a passenger).	☐☐ *Hours*
7	Car (do **not** include journeys to and from work).	☐☐ *Hours*
8	Other vehicle *type/model, please specify.*	☐☐ *Hours*
9	Other vehicle *type/model, please specify:*	☐☐ *Hours*

2.3.2. Do you experience discomfort by mechanical vibration shocks while driving?
1☐ Not at all 2☐ A little bit 3☐ Moderate 4☐ Quite a bit 5☐ Extreme

2.4 VEHICLES IN PAST WORK

Complete this section only if you have held other occupations in the past. Otherwise go to 2.5

2.4.1. **Did your previous work tasks involve:**

1a). prolonged sitting?	1☐ No	2☐ Yes
1b). Physical demands exceeding your capacity?	1☐ No	2☐ Yes

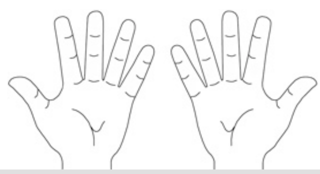
2.4.2. We are interested in your previous work that involved professional driving. **Please fill in the table below to show all of the vehicles you have used.**

№	***Vehicle***	**Approximately how many *years/***	**Approximately how many hours per week**
1	TORO 400 E/D load haul dump vehicle.	☐☐ *Years*	☐☐ *Hours*
2	TORO 40 truck	☐☐ *Years*	☐☐ *Hours*
3	K10, K 14 train.	☐☐ *Years*	☐☐ *Hours*
4	Simba type drill platform.	☐☐ *Years*	☐☐ *Hours*
5	Caterpillar, Belaz truck.	☐☐ *Years*	☐☐ *Hours*
6	Lorry or bus (as a driver, **not** a passenger)	☐☐ *Years*	☐☐ *Hours*
7	Car (do **not** include journeys to and from work)	☐☐ *Years*	☐☐ *Hours*
8	Other vehicle *type/model, please specify:*	☐☐ *Years*	☐☐ *Hours*
9	Other vehicle *type/model, please specify:*	☐☐ *Years*	☐☐ *Hours*

2.5 WORK IN A COLD ENVIRONMENT

2.5.1. How long have you been exposed to cold environment (below +10 °C) during this/last winter?

№	At work:	**Approximately how many hours per week/**
1	with wet clothing.	☐☐ *Hours*
2	indoors /underground below +10 °C	☐☐ *Hours.*
3	touching cold objects.	☐☐ *Hours*

2.5.2	**Does cold cause your fingers turn white, episodically?**	1☐no 2☐ yes
2.5.3	*We are interested in whether you have experienced frostbite. By frostbite (обморожение) we mean the medical condition where localized damage is caused to skin and other tissues due to extreme cold.* **During the last year, have you experienced a mild frostbite which has caused hardening and whitening of the skin, but no blister formation? If frostbite in hands, please indicate the location of the injury by shading the parts affected.**	1☐ No 2☐ Yes 
2.5.4	**During the last year, have you experienced a frostbite which involves the formation of blisters, or is associated with ulcers or tissue necrosis?**	1☐ No 2☐ Yes
2.5.5	**Have you ever during your lifetime experienced a frostbite which involves the formation of blisters, or is associated with wound formation or dead tissue?**	1☐No 2☐ Yes

2.5.6 **How much trouble do you get in your hands when you are exposed to cold?** *Rate on a 0 -10 scale (where 0 is 'no problem' and 10 is 'worst possible problems')*
*(please **circle** one number)*

no problem										Worst possible problems
0	1	2	3	4	5	6	7	8	9	10

SECTION 3: Your health during last 12 months.

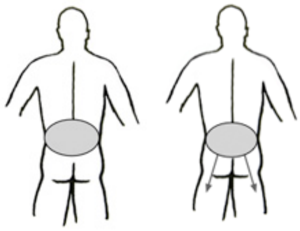
This section concerns pain or discomfort you may have had in different parts of the body and at different times, during the last 12 months.

3.1 LOW BACK PAIN, INCLUDING PAIN RADIATING IN THE LEG, DURING LAST 12 MONTHS

3.1.1 **Have you felt pain or discomfort in the area shown in the diagram?**

$_{1}$☐ No $_{2}$☐ Yes

If No, ignore this part of the section and proceed to 3.2



3.1.2 **If yes, where was the pain or discomfort localized?**

$_{1}$☐ back only $_{2}$☐ radiating in the leg only $_{3}$☐ back and radiating in the leg

3.1.3 **How many episodes have you had?**

$_{1}$☐ 1 $_{2}$☐ 2–3 $_{3}$☐ 4-5 $_{4}$☐ 6-10 $_{5}$☐ more than 10

3.1.4 **How long did they typically last?**

$_{1}$☐ hours $_{2}$☐ 1-2 days $_{3}$☐ 3-6 days $_{4}$☐ 7-14 days $_{5}$☐ 15-29 days $_{6}$☐ 1-6 months $_{7}$☐ all year

3.1.5 **How much time did you have to be on sick leave due to the back pain?**

$_{1}$☐ None $_{2}$☐ 1-6 days $_{3}$☐ 7-14 days $_{4}$☐15-29 days $_{5}$☐1-6 months $_{6}$☐ more than 6 months

3.1.6 **What year did you first experience an episode of low back pain?**

|__|__|__|__| *year* |__|__| *month*

3.1.7 **How did your low back pain start?**

$_{1}$☐ suddenly at work $_{2}$☐ suddenly outside work $_{3}$☐ gradually at work $_{4}$☐ gradually outside work

3.1.8 **If suddenly, what were you doing at the time?**

Describe:

3.1.9. **Rate your present back pain (during the last week) on a 0-10 scale** *(please **encircle** one number)*

No pain *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

3.1.10. **Rate your worst back pain (during the last month) on a 0-10 scale** (please **encircle** one number)

No pain *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

3.1.11. **Rate your back pain on average (during the last month) on a 0-10 scale** (please **encircle** one number)

No pain *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

3.1.12 **Have you ever experienced an accident followed by low back pain?** $_{1}$☐No $_{2}$☐ Yes *If No, please go to 3.2*

3.1.13 **What kind of accident?** *Describe:*

3.1.14 **When did it happen?** |__|__|__|__| *year*

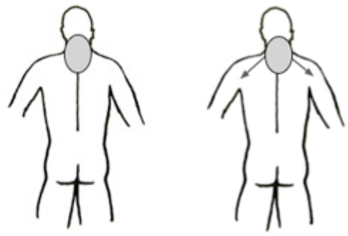
3.1.15 **Did the accident happen at work?** $_{1}$☐ No $_{2}$☐ Yes

3.2 NECK PAIN , INCLUDING PAIN RADIATING IN THE ARM, DURING LAST 12 MONTHS

3.2.1 **Have you felt pain or discomfort in the area shown in the diagram?**

1☐ No 2☐ Yes

If No, ignore this part of the section and proceed to 3.3



3.2.2	**If yes, where was the pain or discomfort localized?**
	1☐ neck pain only 2☐ radiating arm pain only 3☐ neck and radiating arm pain
3.2.3	**How many episodes have you had?**
	1☐ 1 2☐ 2–3 3☐ 4-5 4☐ 6-10 5☐ more than 10
3.2.4	**How long did they typically last?**
	1☐ hours 2☐ 1-2 days 3☐ 3-6 days 4☐ 7-14 days 5☐ 15-29 days 6☐ 1-6 months 7☐ all year
3.2.5	**How much time did you have to take off work due to the neck pain?**
	1☐ None 2☐ 1-6 days 3☐ 7-14 days 4☐15-29 days 5☐1-6 months 6☐ more than 6 months
3.2.6	**What year did you first experience an episode of neck pain?**
	|__|__|__|__| *year*
3.2.7	**How did your neck pain start?**
	1☐ suddenly at work 2☐ suddenly outside work 3☐ gradually at work 4☐ gradually outside work
3.2.8	**If suddenly, what were you doing at the time?**
	Describe:

3.2.9. **Rate your present neck pain (during the last week) on a 0-10 scale** *(please **circle** one number)*

No pain ... *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

3.2.10. **Rate your worst neck pain (during the last month) on a 0-10 scale** (please **circle** one number)

No pain ... *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

3.2.11. **Rate your neck pain on average (during the last month) on a 0-10 scale** (please **circle** one number)

No pain ... *Pain as bad as it could be*

0 1 2 3 4 5 6 7 8 9 10

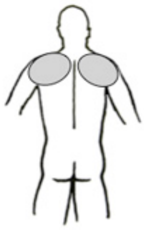
3.2.12	**Have you ever experienced an accident followed by neck pain?**	1☐ No 2☐ Yes *If No, please go to 3.3*
3.2.13	**What kind of accident?** *Describe:*	
3.2.14	**When did it happen?**	|__|__|__|__| *year*
3.2.15	**Did the accident happen at work?**	1☐ No 2☐ Yes

3.3 SHOULDER PAIN, DURING LAST 12 MONTHS

3.3.1 **Have you felt pain or discomfort in the area shown in the diagram?**

1☐ No 2☐ Yes

If No, ignore this part of the section and proceed to section 4



3.3.2 **If yes, where was the pain or discomfort localized?**

1☐ shoulder only 2☐ arm/hand only 3☐ shoulder and arm/hand

3.3.3 **How many episodes have you had?**

1☐ 1 2☐ 2–3 3☐ 4-5 4☐ 6-10 5☐ more than 10

3.3.4 **How long did they typically last?**

1☐ hours 2☐ 1-2 days 3☐ 3-6 days 4☐ 7-14 days 5☐ 15-29 days 6☐ 1-6 months 7☐ all year

3.3.5 **How much time did you have to take off work due to the shoulder pain?**

1☐ None 2☐ 1-6 days 3☐ 7-14 days 4☐15-29 days 5☐1-6 months 6☐ more than 6 months

3.2.6 **What year did you first experience an episode of shoulder pain?**

|__|__|__|__| *year*

3.2.7 **How did your shoulder pain start?**

1☐ suddenly at work 2☐ suddenly outside work 3☐ gradually at work 4☐ gradually outside work

3.2.8 **If suddenly, what were you doing at the time?**

Describe:

3.3.9. Rate **your present shoulder pain (during the last week) on a 0-10** *(please **circle** one number)*

No pain										*Pain as bad as it could be*
0	1	2	3	4	5	6	7	8	9	10

3.3.10. **Rate your worst shoulder (during the last month) on a 0-10 scale** *(please **circle** one number)*

No pain										*Pain as bad as it could be*
0	1	2	3	4	5	6	7	8	9	10

3.3.11. **Rate your shoulder pain on average (during the last month) on a 0-10 scale** *(please **circle** one number)*

No pain										*Pain as bad as it could be*
0	1	2	3	4	5	6	7	8	9	10

3.3.12 **Have you ever had an accident followed by shoulder pain?** 1☐ No 2☐ Yes *If No, please go to section 4*

3.3.13 **What kind of accident?**

3.3.14 **When did it happen?** |__|__|__|__| *year*

3.3.15 **Did the accident happen at work?** 1☐ No 2☐ Yes

SECTION 4: Supplementary information

5.1	**Place of birth** (*city and region*):	
5.2	**Raised** (until 18 years. *City and region*):	
5.3	**Height:** |__|__|__| cm *to be filled in by staff*	
5.4	**Weight:** |__|__|__| kg *to be filled in by staff*	
5.5	**What is your completed educational level?**	1☐ Primary school 2☐ Secondary school 3☐ Vocational school, College 4☐ Higher education
5.6	Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. **Do you feel this kind of stress these days?**	1☐ not at all 2☐ only a little 3☐ somewhat 4☐ rather much 5☐ very much
5.7	**Please estimate your level of physical activity in leisure time.** *If the activity varies (for example in summer and winter) then give an average for the last year.*	
	-Reading, watching TV (mostly sitting activity)	1☐ No 2☐ Yes
	-Walking, bicycling or other forms of exercise at least 4 hours pr week (including walking to place of work, Sunday walking)	1☐ No 2☐ Yes
	-Participation in recreational sports, gardening (at least 4 hours per week)	1☐ No 2☐ Yes
	-Training regularly several times a week, participation in sports activities	1☐ No 2☐ Yes
5.8	**Do you smoke or have you ever smoked?**	1☐ No 2☐ Yes
5.9	**If yes, how many years have you smoked?**	|__|__| *years*
5.10	**At what age did you start smoking regularly?**	|__|__| *years*
5.11	**How much did/do you smoke?**	Cigarettes per day: |__|__|
5.12	**Do you still smoke daily?**	1☐ No 2☐ Yes
5.13	**If no, when did you give up smoking?**	|__|__|__|__| *year*

We thank you for answering the questions. Please look over your answers to see if you have left anything out. You may also ask the staff for assistance.

.

Appendix II

Заполняется медперсоналом

Номер анкеты: |__|__|__|__|

Дата: день/месяц/год |__|__|__|__|__|__|

Анкета
Здоровье человека 2010 года

Сотрудничающие организации:
Отделение профессиональной и экологической медицины, университетская больница Северной Норвегии
Научно-исследовательская лаборатория ФГУН «Северо-Западный научный центр гигиены и общественного здоровья»
Институт общественной медицины, Университет г. Тромсё, Норвегия
Отделение профессиональной медицины, Университет г. Умео, Швеция

Инструкция для заполняющих анкету

Вписать X в рамку ☐
Вписать цифры в соответствующие клетки |__|__|
Обвести кружком необходимую цифру в шкале от 0 до 10
Другие варианты ответа (вписать в соответствующую графу)

РАЗДЕЛ 1. Персональные данные

Возраст |__|__| Лет Пол: 1☐ М 2☐ Ж

РАЗДЕЛ 2. Профессиональный маршрут

2.1 РАБОТА В НАСТОЯЩЕЕ ВРЕМЯ И В ПРОШЛОМ

2.1.1. **Ваша основная профессия в настоящее время и в прошлом?**

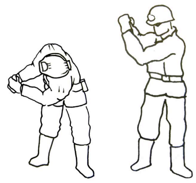
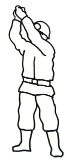
№	Профессия	Настоящая	В прошлом
1	Водитель наземной грузовой машины	1☐	2☐
2	Машинист погрузочно-доставочной машины (типа ТОРО)	1☐	2☐
3	Машинист подземных самоходных машин (типа Скаймек, Спреймек, Трансмиттер)	1☐	2☐
4	Проходчик	1☐	2☐
5	Машинист электровоза	1☐	2☐
6	Взрывник	1☐	2☐
7	Горнорабочий	1☐	2☐
8	Машинист буровой установки	1☐	2☐
9	Дробильщик	1☐	2☐
10	Электрослесарь (слесарь), Электромонтер	1☐	2☐
11	Мастер	1☐	2☐
12	Крепильщик	1☐	2☐
13	Опрокидчик	1☐	2☐
14	Сварщик	1☐	2☐
15	Прочие	1☐	2☐

2.1.2. **С какого времени Вы работаете в настоящей профессии** |__|__|__|__| *год*

2.2 ХАРАКТЕРИСТИКА ПРОФЕССИИ

Рабочая поза (Т*олько один ответ для каждой рабочей позы):*

2.2.1 **Сколько времени в обычный рабочий день Вы работаете в позах, показанных на рисунках ниже?**

Рабочая поза	 Кисти рук расположены ниже уровня коленей.	 Повороты туловища (только повороты туловища или повороты в сочетании с наклонами туловища одновременно)?	 Наклон шеи вперед или назад?	 Повороты шеи (только повороты или повороты с наклоном и вытягиванием шеи одновременно)?	 Подъем рук с кистями выше уровня плеч?
0-30 мин.	1☐	1☐	1☐	1☐	1☐
30-60 мин.	2☐	2☐	2☐	2☐	2☐
1 -3 час.	3☐	3☐	3☐	3☐	3☐
Более 3 час.	4☐	4☐	4☐	4☐	4☐

Подъем тяжестей:

2.2.2. **Сколько раз в течение смены Вам приходится поднимать грузы массой более 15 кг ?**

Не приходится	0 - 9 раз	10 -19 раз	20 - 40 раз	Более 40 раз
1☐	2☐	3☐	4☐	5☐

2.2.3. **Сколько раз в течение смены Вам приходится поднимать грузы массой более 30 кг ?**

Не приходится	0 - 9 раз	10 -19 раз	20 - 40 раз	Более 40 раз
1☐	2☐	3☐	4☐	5☐

2.2.4 **Приходиться ли Вам на работе поднимать грузы массой более 50 кг?** 1☐ Нет 2☐ Да

2.3 ТРАНСПОРТНЫЕ СРЕДСТВА, ИСПОЛЬЗУЕМЫЕ В НАСТОЯЩЕЕ ВРЕМЯ

2.3.1. **Сколько часов Вы управляете следующими видами транспорта в течение обычного рабочего дня?**

№	*Транспортное средство*	Приблизительно сколько часов в неделю
1	Погрузочно-доставочная машина (TORO 400 E/D и др.)	☐☐ *Час.*
2	Подземная самоходная машина (TORO 40 и др.)	☐☐ *Час.*
3	Электровоз (К 10, К 14)	☐☐ *Час.*
4	Буровая установка (Simba, НКР-100 и др.)	☐☐ *Час.*
5	Большегрузный автомобиль (Caterpillar, Белаз и др.)	☐☐ *Час.*
6	Грузовой автомобиль или автобус (в качестве водителя, а не пассажира)	☐☐ *Час.*
7	легковой автомобиль (не включать поездки до места работы и обратно)	☐☐ *Час.*
8	*Другие виды транспорта (пожалуйста, уточните тип и модель)*	☐☐ *Час.*
9	*Другие виды транспорта (пожалуйста, уточните тип и модель).*	☐☐ *Час.*

2.3.2. Испытываете ли Вы неудобство при управлении транспортом из-за механической вибрации и тряски?

1☐Никогда 2☐ Незначительное 3☐ Умеренное 4☐ Достаточно выраженное 5☐ Резко выраженное

2.4 ТРАНСПОРТНЫЕ СРЕДСТВА, ИСПОЛЬЗОВАВШИЕСЯ В ПРОШЛОМ

Заполните эту часть анкеты, если Вы работали в прошлом в других профессиях. Если Нет, переходите к 2.5.

2.4.1. **Приходилось ли Вам на прежней работе:**

1а) долго сидеть ? 1☐ Не 2☐ Да

1б) Испытывать физические нагрузки, превышающие возможности Вашего организма? 1☐ Нет 2☐ Да

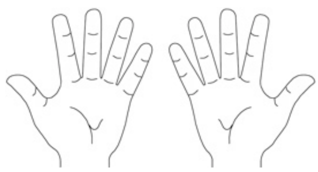
2.4.2. Мы хотим получить сведения о Вашей предыдущей работе, связанной с профессиональным вождением. **Пожалуйста, отметьте в таблице все виды транспортных средств, которые Вы ранее использовали.**

№	*Транспортное средство*	***Приблизительно в течение какого числа лет***	***Приблизительно сколько часов в неделю***
1	Погрузочно-доставочная машина (TORO 400 E/D и др.)	☐☐ *Лет*	☐☐ *Час.*
2	Подземная самоходная машина (TORO 40 и др.)	☐☐ *Лет*	☐☐ *Час.*
3	Электровоз К14, К 10	☐☐ *Лет*	☐☐ *Час.*
4	Буровая установка (Simba, HKP-10 и др.)	☐☐ *Лет*	☐☐ *Час.*
5	Большегрузный автомобиль (Caterpillar, Белаз и др.)	☐☐ *Лет*	☐☐ *Час.*
6	Грузовой автомобиль или автобус (в качестве водителя, а не пассажира)	☐☐ *Лет*	☐☐ *Час.*
7	легковой автомобиль (не включать поездки до места работы и обратно)	☐☐ *Лет*	☐☐ *Час.*
8	*Другие виды транспорта (пожалуйста, уточните тип и модель).*	☐☐ *Лет*	☐☐ *Час.*
9	*Другие виды транспорта (пожалуйста, уточните тип и модель).*	☐☐ *Лет*	☐☐ *Час.*

2.5 РАБОТА В УСЛОВИЯХ ВОЗДЕЙСТВИЯ ХОЛОДА

2.5.1. **Сколько времени Вы подвергались воздействию низких температур (ниже +10 °C) в течение этой/последней зимы?**

	На работе	***Приблизительно сколько часов в неделю***
1	При использовании мокрой одежды	☐☐ *Час.*
2	Внутри помещения или под землей при температуре ниже +10 °C	☐☐ *Час.*
3	При контакте с холодными предметами	☐☐ *Час.*

2.5.2	**Вызывает ли охлаждение побеление пальцев, периодически?**	1☐ Нет 2☐ Да
2.5.3	*Мы хотели бы знать, бывали ли у Вас обморожения. Под обморожением мы понимаем болезненное состояние, проявляющееся местным повреждением кожи и других тканей в результате воздействия холода.* **В течение последнего года были ли у Вас легкие обморожения, проявляющиеся затвердением и побелением кожи, но без образования волдырей? Если были обморожены кисти рук, пожалуйста, укажите место поражения (заштриховать соответствующий участок кисти на рисунке).**	1☐ Нет 2☐ Да 
2.5.4	**В течение последнего года были ли у Вас обморожения, проявлявшиеся образования волдырей, изъязвлением кожи, омертвлением тканей?**	1☐ Нет 2☐ Да
2.5.5	**В течение всей жизни бывали ли у Вас обморожения, проявлявшиеся образования волдырей, ран или омертвлением тканей?**	1☐Нет 2☐ Да

2.5.6 **В какой степени Вас беспокоят кисти рук, если они подвергаются воздействию холодом?**
Оцените по 10-балльной шкале, где 0 означает отсутствие жалоб, а 10 – их наибольшую степень выраженности). Пожалуйста, обозначьте кружком нужную цифру).

нет жалоб — Наиболее выраженные жалобы

0 1 2 3 4 5 6 7 8 9 10

РАЗДЕЛ 3. Состояние Вашего здоровья в течение последних 12 месяцев.

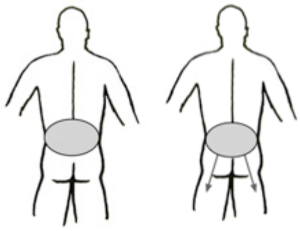
В этом разделе рассматриваются вопросы, связанные с болью и неприятными ощущениями в различных частях тела и различное время за последние 12 месяцев.

3.1 БОЛЬ В ПОЯСНИЦЕ, ВКЛЮЧАЯ БОЛИ С ИРРАДИАЦИЕЙ В НИЖНИЕ КОНЕЧНОСТИ, ЗА ПОСЛЕДНИЕ 12 МЕСЯЦЕВ

3.1.1 **Вы испытывали боли или неприятные ощущения в областях тела, указанных на рисунке?**

1☐Нет 2☐ Да

Если Нет, пропустите эту часть раздела и переходите к 3.2



3.1.2	**Если Да, где были локализованы боль и неприятные ощущения?**
	1☐ только в области спины 2☐ только распространяющиеся в ноги 3☐ в области спины с распространением в ноги
3.1.3	**Сколько было случаев подобных болей?**
	1☐ 1 2☐ 2–3 3☐ 4-5 4☐ 6-10 5☐ более 10
3.1.4	**Как долго обычно продолжаются боли?**
	1☐ часы 2☐ 1-2 дня 3☐ 3-6 дней 4☐ 7-14 дней 5☐ 15-29 дней 6☐ 1-6 месяцев 7☐ в течение года
3.1.5	**Какая была продолжительность больничного листа из-за болей в области поясницы?**
	1☐ не было 2☐ 1-6 дней 3☐ 7-14 дней 4☐15-29 дней 5☐1-6 месяцев 6☐ более 6 месяцев
3.1.6	**В каком году Вы впервые почувствовали периодические боли в области поясницы?**
	|__|__|__|__| год |__|__| месяц
3.1.7	**Как начинались боли в области поясницы?**
	1☐ внезапно на работе 2☐ внезапно вне работы 3☐ постепенно на работе 4☐ постепенно вне работы
3.1.8	**Если внезапно, что Вы делали в момент возникновения болей?**
	Опишите:

3.1.9. **Оцените выраженность болей в области поясницы в течение последней недели по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.1.10. **Оцените наиболее выраженную боль в области поясницы (за последний месяц) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.1.11. **Оцените среднюю выраженность болей в области поясницы (за последний месяц) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

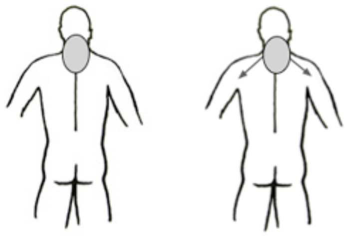
Нет болей *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.1.12	**Предшествовала ли какая-либо травма появлению болей в области поясницы**	1☐Нет 2☐ Да Если Нет, пожалуйста, переходите к *3.2*
3.1.13	**Что произошло с Вами? *Опишите:***	
3.1.14	**Когда это произошло?**	|__|__|__|__| год
3.1.15	**Это произошло на работе?**	1☐ Нет 2☐ Да

3.2 БОЛИ В ОБЛАСТИ ШЕИ С ИРРАДИАЦИЕЙ В РУКИ (ЗА ПОСЛЕДНИЕ 12 МЕСЯЦЕВ)

3.2.1 **Вы испытывали боль или неприятные ощущения в областях тела, указанных на рисунке?**



₁☐ Нет ₂☐ Да

Если Нет, пропустите эту часть раздела и переходите к 3.3

3.2.2	**Если Да, где были локализованы боль и неприятные ощущения?**
	1☐ только в области шеи 2☐ только боли, иррадиирущие в руку 3☐ боли в области шеи с иррадиацией в руку
3.2.3	**Сколько было случаев подобных болей?**
	1☐ 1 2☐ 2–3 3☐ 4-5 4☐ 6-10 5☐ более 10
3.2.4	**Как долго обычно продолжаются боли?**
	1☐ часы 2☐ 1-2 дня 3☐ 3-6 дней 4☐ 7-14 дней 5☐ 15-29 дней 6☐ 1-6 месяцев 7☐ в течение года
3.2.5	**Какая была продолжительность больничного листа из-за болей в области шеи?**
	1☐ не было 2☐ 1-6 дней 3☐ 7-14 дней 4☐15-29 дней 5☐1-6 месяцев 6☐ более 6 месяцев
3.2.6	**В каком году Вы впервые почувствовали периодические боли в области шеи?**
	|__|__|__|__| год |__|__| месяц
3.2.7	**Как начинались боли в области шеи?**
	1☐ внезапно на работе 2☐ внезапно вне работы 3☐ постепенно на работе 4☐ постепенно вне работы
3.2.8	**Если внезапно, что Вы делали в момент возникновения болей?**
	Опишите:

3.2.9. **Оцените выраженность болей в области шеи за последнюю неделю по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей — *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.2.10. **Оцените наиболее выраженные боли в области шеи (за последний месяц) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей — *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.2.11. **Оцените среднюю выраженность болей в области шеи (за последний месяц) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей — *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

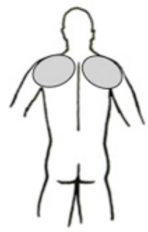
3.2.12	**Предшествовала ли какая-либо травма появлению болей в области поясницы**	1☐ Нет 2☐ Да Если Нет, пожалуйста, переходите к *3.2*
3.2.13	**Что произошло с Вами?** *Опишите:*	
3.2.14	**Когда это произошло?**	|__|__|__|__| год
3.2.15	**Это произошло на работе?**	1☐ Нет 2☐ Да

3.3 БОЛИ В ПЛЕЧЕВОМ ПОЯСЕ (ЗА ПОСЛЕДНИЕ 12 МЕСЯЦЕВ)

3.3.1 **Вы испытывали боль или неприятные ощущения в областях тела, указанных на рисунке?**

1☐ Нет 2☐ Да

Если Нет, пропустите эту часть раздела и переходите к разделу 4.



3.3.2	**Если Да, где были локализованы боль и неприятные ощущения?**	
	1☐ только плечи 2☐ только кисть и рука 3☐ плечи, кисть и рука	
3.3.3	**Сколько было случаев подобных болей?**	
	1☐ 1 2☐ 2–3 3☐ 4-5 4☐ 6-10 5☐ более 10	
3.3.4	**Как долго обычно продолжаются боли?**	
	1☐ часы 2☐ 1-2 дня 3☐ 3-6 дней 4☐ 7-14 дней 5☐ 15-29 дней 6☐ 1-6 месяцев 7☐ в течение года	
3.3.5	**Какая была продолжительность больничного листа из-за болей в области плечей?**	
	1☐ не было 2☐ 1-6 дней 3☐ 7-14 дней 4☐15-29 дней 5☐1-6 месяцев 6☐ более 6 месяцев	
3.3.6	**В каком году Вы впервые почувствовали периодические боли в плечевом поясе?**	
	|__|__|__|__| год |__|__| месяц	
3.3.7	**Как начинались боли в плечевом поясе ?**	
	1☐ внезапно на работе 2☐ внезапно вне работы 3☐ постепенно на работе 4☐ постепенно вне работы	
3.3.8	**Если внезапно, что Вы делали в момент возникновения болей?**	
	Опишите:	

3.3.9. **Оцените выраженность болей в плечевом поясе за последнюю неделю по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей ... *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.3.10. **Оцените наиболее выраженную боль в плечевом поясе (за последнюю неделю) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей ... *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.3.11. **Оцените среднюю выраженность болей в плечевом поясе (за последний месяц) по 10-балльной шкале** (пожалуйста, **обведите** только одну нужную цифру)

Нет болей ... *Наиболее выраженные боли*

0 1 2 3 4 5 6 7 8 9 10

3.3.12	**Предшествовала ли какая-либо травма появлению болей в плечевом поясе?**	1☐ Нет 2☐ Да Если Нет, пожалуйста, переходите к разделу *4*	
3.3.13	**Что произошло с Вами?** *Опишите:*		
3.3.14	**Когда это произошло?**	|__|__|__|__| год	
3.3.15	**Это произошло на работе?**	1☐ Нет 2☐ Да	

SECTION 4: Дополнительная информация

4.1	**Место рождения** (город и область):	
4.2	**Рос и воспитывался до 18 лет** (город и область):	
4.3	***Рост:*** |__|__|__| см (заполняется медперсоналом)	
4.4	**Вес*:*** |__|__|__| кг (заполняется медперсоналом)	
4.5	**Ваш уровень образования?**	1☐ Начальная школа 2☐ Средняя школа 3☐ ПТУ 4☐ Среднее специальное образование 5☐ Высшее образование
4.6	Под стрессом понимается ситуация, когда человек испытывает беспокойство, нервное возбуждение или тревогу, нарушения ночного сна из-за постоянного нервного напряжения. Вы испытываете такое состояние в настоящее время?	1☐ Нет 2☐ Незначительные проявления 3☐ В определенной степени 4☐ Значительные проявления 5☐ Очень выраженные проявления
4.7	**Пожалуйста, оцените степень Вашей физической активности в свободное от работы время?** *Если физическая активность существенно изменяется в зимнее и летнее время, дайте среднюю оценку за последний год.*	
	-Читаю, смотрю телевизионные передачи (главным образом сидячий образ жизни).	1☐ Нет 2☐ Да
	-Ходьба, езда на велосипеде и другие формы физической активности не менее 4 часов в неделю (включая ходьбу до места работы и прогулки выходного дня).	1☐ Нет 2☐ Да
	-Участие в оздоровительных спортивных мероприятиях, работа на садовом участке не менее 4 часов в неделю.	1☐ Нет 2☐ Да
	-Регулярные тренировки несколько раз в неделю, участие в спортивных соревнованиях.	1☐ Нет 2☐ Да
4.8	**Вы курите или курили раньше?**	1☐ Нет 2☐ Да
4.9	**Если Да, сколько лет Вы курите (курили)?**	|__|__| лет
4.10	**В каком возрасте Вы стали регулярно курить?**	|__|__| лет
4.11	**Сколько сигарет Вы выкуриваете ежедневно?**	|__|__| сигарет
4.12	**Вы продолжаете курить ежедневно?**	1☐ Нет 2☐ Да
4.13	**Если Нет, когда Вы прекратили курить?**	|__|__|__|__| год

Благодарим Вас за то, что Вы согласились заполнить данную анкету. Пожалуйста, просмотрите еще раз заполненные страницы, так как, возможно, какие-то пункты остались без ответа.

Если у Вас есть вопросы, пожалуйста, обратитесь за помощью к нашим сотрудникам, которым нужно передайте заполненную анкету. Мы с благодарностью учтем Ваши замечания и пожелания, касающиеся содержания анкеты.

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Appendix III

INFORMATION CONCERNING PARTICIPATION IN A SCIENTIFIC STUDY:

Project title: Health problems in miners exposed to vibration in cold climate
Vibrating tools and vehicles can cause health problems in workers. Reduced blood circulation and nerve function, as well as problems in the musculoskeletal system are associated with vibration in the work place. More knowledge is required on the relationship between the exposure to vibration (type, intensity and effect), cold climate and health problems. This can provide better basis for preventive measures. We want to conduct a joint Norwegian-Russian project in Kirovsk. You are asked to participate in the study. The Norwegian partner must comply with Norwegian standards for medical research. In order to use individual medical information for scientific purpose, we need your informed consent. This means: if you agree that data (made anonymous) from your examination is used in the project described, please sign this paper.
The participating partners and coordinators are:

- Kola Research Laboratory for Occupational Health in Kirovsk (dr L Talykova)
- Dept of Occupational and Environmental Medicine, University Hospital North Norway (dr M Skandfer +47 77 62 65 55)

In the first half of 2007 workers exposed from vibration will be routinely examined (general health and examination including sensory and circulatory function in fingers) at the Research Lab in Kirovsk, which has selected the group to be included in the study and will also distribute and collect the letters of informed consent. Data for the study will be collected from the medical records, and data from corresponding temperature and vibration exposure situations at the work places will also be collected. The project is intended to last five years, ending in 2012. The examination itself is harmless, painless and without discomfort. Data will be stored in archives in Kola Research Laboratory for Occupational Health in Kirovsk. Personal medical data will be identified by numbers. Such data may also be computed abroad, but will be archived there beyond 2017, when they only will be archived in Kirovsk. The results will be published in scientific papers. The researchers are working under full medical confidentiality. Only your doctor in Kirovsk can link the code to your person.
Participation in the project is voluntary. You may withdraw your registrated data from the study until the data have been processed in 2009. Data can not be removed from the clinic medical records. Reserving yourself from participation will not have any negative consequences regarding your routine medical examination, treatment or employment. Only the Norwegian and Kirovsk project coordinators will know your response to this letter, treating it with confidentiality. Clinical results will be communicated to each participant, with the purpose of improving the health of each participant. The participants will be informed on the results of the study.

The plans have been approved by the Regional Committee for Medical Research Ethics, North Norway and are funded by the Barents Secretariat, Troms Fylke/Oblast, and The Norwegian Science Board. If you accept to be included in the study, please sign below, and return the paper to the Kola Research Laboratory for Occupational Health in Kirovsk as soon as possible. You can also get more information there.

…………………………………………………………………………………………………..

Declaration of consent:
I have received and read the information on the project. On this basis, I allow the researchers to include data from my medical records and corresponding vibration measurements in the project.

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Place	Date	Name	Signature

Appendix VI

Информационное письмо-приглашение к участию в научном исследовании

Название проекта: *Проблемы здоровья у шахтеров, возникающие в связи с вибрациями в условиях холода*

Специальные инструменты и приспособления в горнодобывающей промышленности могут явиться причиной профессиональных заболеваний шахтеров.

Проблемы сердечно-сосудистой и нервной системы, так же как функций опорно-двигательного аппарата, ассоциируются с вибрационным воздействием в условиях горнодобывающей отрасли. Необходимо более глубокое понимание о взаимосвязи между вибрационным взаимодействием, холодным климатом и возможными проблемами со здоровьем. Все это поспособствует созданию комплекса профилактических мер с целью предупреждения развития вероятных осложнений вышеуказанных профессиональных вредностей.

Мы предлагаем провести совместный норвежско-российский проект в городе Кировск, и приглашаем Вас принять участие в этом исследовании.

Действия по проведению исследования со стороны норвежских специалистов должны соответствовать норвежским стандартам. Чтобы использовать индивидуальные медицинские данные в научных целях, нам необходимо Ваше согласие на получение информации. Это значит: если Вы согласны, чтобы данные Вашего обследования (взятые анонимно) были использованы в описанном проекте, пожалуйста, подпишите этот документ.

Участники проекта:

- Кола лаборатория исследования профессионального здоровья в г. Кировск (Др. Л.Талыкова)
- Кафедра профессионального и экологического здоровья при университетской больнице Северной Норвегии (Др. М.Скандфер, +47 77 62 65 55).

В первой половине 2007 года рабочие, подверженные вибрационному воздействию, будут обследованы в клинике в обычном порядке (оценка общего состояния здоровья, включающая оценку ангио-неврологического статуса) в исследовательской лаборатории г. Кировска, которая отобрала группу людей для исследования, а так же будет распространять и собирать подтвержденные информационные листы.

Данные будут собраны из медицинских карт, а так же будет собрана информация о температурных условиях, факторах риска и вибрационном воздействии на организм человека в условиях рабочей среды. Проект будет проводиться в течение 5 лет, заканчиваясь в 2012 году. *Само обследование является безопасным, безболезненным и не причиняющим дискомфорт.*

Данные будут храниться в архивах в Кола лаборатории исследования профессионального здоровья в Кировске. Данные обследования будут обрабатываться и храниться до 2017 года в Кировске, и после 2017 г. в г. Тромсе (Норвегия). Результаты будут опубликованы в международных научных изданиях. Исследователи будут работать конфиденциально. Только врач будет располагать информацией о Ваших личных данных.

Участие в проекте является добровольным. Вы имеете право отказаться от исследования, прежде чем данные будут обработаны в 2009 году. Отказ от участия не будет иметь никаких негативных последствий, касающихся Вашего планового обследования, лечения и трудоустройства. Ваш ответ на данное письмо будут знать лишь норвежский и кировский координаторы проекта, и они обязуются держать его в строжайшем секрете. Результаты обследования будут обсуждаться индивидуально с каждым участником с целью улучшения его здоровья.

Проект был одобрен Региональным Этическим Комитетом в Северной Норвегии, основанным Баренцевым Секретариатом (область Тромс Фюльке), и Норвежским Научным Советом. Если Вы согласны участвовать в исследовании, пожалуйста, подпишитесь внизу и верните это подтверждение о согласии в Кола лабораторию исследования профессионального здоровья как можно быстрее. Там же Вы можете получить больше информации.

Подтверждение согласия:
Я получил(а) и прочитал(а) информацию о проекте. На основе этого, я даю разрешение исследователям включить в проект данные из моей медицинской карты и соответствующие измерения вибрационного воздействия.

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Город Дата Ф И О

Подпись

Figures and tables