

MUSCULOSKELETAL DISORDERS IN THE SOUTH AFRICAN MINING INDUSTRY

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A thesis submitted to the Faculty of Health Sciences, University of the
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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy in the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg. The work contained in this thesis has not been submitted for any degree or examination in this University or any other University.

(Belinda Dias)

Signed on the _____ day _____ 2014

I certify that the studies contained in this thesis have been approved by the Committee for Research in Human Subjects of the University of the Witwatersrand, Johannesburg. The ethics approval number is M01-05-57.

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Signed on the _____ day of _____ 2014.

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In loving memory of my mother and grandmother

Maria Salomé Dias

1947 – 1988

Monica Bressan

1927 - 2007

ABSTRACT

INTRODUCTION

Musculoskeletal disorders (MSD) are common in industries worldwide and are a major cause of sick leave, disability and reduced productivity while at work. Many mining-related tasks in South African mines may be associated with MSDs and therefore work-related musculoskeletal disorders are likely to occur in the mining industry. Musculoskeletal disease had hitherto not been researched in the South Africa mining industry and the importance especially as an occupational disease of relevance to the mining industry needed to be considered. Discussion was held within the research tripartite structures; and based on the evidence that musculoskeletal diseases are common in labour-intensive industries worldwide and the South African miners are an ageing population, the need for determining the incidence and associated risk factors was recognized. The Mine Health and Safety Council commissioned this study because there were no studies on musculoskeletal disorders in the South African mining industry.

OBJECTIVES

The objectives of the study were:

- To determine the incidence of musculoskeletal disorders at a South African coal, gold, and platinum mine.
- To describe the anatomical sites of MSDs disorders reported by the mineworkers, the occupations and physical activities of these mineworkers and the sick leave and disability associated with the MSD at a South African coal, gold and platinum mine.
- To examine associations between MSDs reported by the mineworkers and mental disorders – as measured by the Self Reporting Questionnaire-20 (SRQ-20)-, significant life events (health, assault, fright and financial problems) and social functioning (personal and work relationships and ability to relax).
- To examine the association between MSDs reported by mineworkers and their home language.
- To examine the association between MSDs reported by the mineworkers and usual and recent physical activities at work.

METHOD

The study had a mixed design i.e. an incidence study to identify mineworkers presenting to the mines' primary care clinic with a musculoskeletal disorder and a nested case-control study involving consenting cases to investigate associations between musculoskeletal disorders and risk factors. At three South African mines (a coal mine, a gold mine and a platinum mine), mineworkers presenting to a mine clinic with a musculoskeletal disorder were recorded over a six month period. Complaints arising from acute traumatic injury (e.g. crush injuries, fractures, bruises, dislocations or amputations) were excluded. Mineworkers presenting with a medical condition not related to a musculoskeletal disorder or symptom were selected as controls. A standardized Nordic questionnaire was used to analyse musculoskeletal symptoms. The Southampton Examination Schedule was used to examine mineworkers presenting with neck and upper limb pain. The Self-Reporting Questionnaire was used to establish a possible mental disorder. Questions adapted from the Life Events and Difficulties Schedule and a rating scale for Social Functioning were used to determine psychosocial factors. Home language spoken by mineworkers was also recorded. Trained research nurses administered questionnaires to participating subjects in their preferred language.

RESULTS

Six hundred and ninety one cases identified at the three primary care clinics at the coal (70 cases), gold (329 cases) and platinum mine (292 cases) were included in this study. Seven hundred and one controls were identified: 81 at the coal mine, 345 at the gold mine and 275 at the platinum mine. The percentages of mineworkers employed on the mine presenting to the mine clinic with a musculoskeletal disorder over the six months of the study were 7.0% at the coal mine, 5.4% at the gold mine and 8.1% at the platinum mine. A more conservative estimate was obtained using only mineworkers who presented during office hours and who had the musculoskeletal disorder confirmed by a research nurse (termed MSD cases). The percentage of MSD cases over the six months of the study was 6.5% at the coal mine, 1.9% at the gold mine and 4.1% at the platinum mine and these data suggest an annual incidence of 130/1000, 38/1000 and 82/1000 for the coal, gold and platinum mines respectively. Lower limb pain was the most common musculoskeletal presentation at the platinum mine and at the coal and gold mine it was lower back

pain. At the platinum mine, almost all the cases (96.2%) had disabling symptoms; at the gold mine and coal mine it was 65.3% and 47.1% respectively.

Experience of an extremely frightening event increased the odds ratio for a musculoskeletal disorder of the upper limb, lower back and lower limb in the univariate, multivariate analyses and final models at the gold and platinum mine. A possible mental disorder (i.e. high Self-Reporting Questionnaire score) was consistently found to be negatively associated with upper limb pain, lower back pain and lower limb pain. No consistent associations were found between home language (a surrogate for ethnicity) and musculoskeletal disorders except for the upper limb. Kneeling was the only physical activity significantly associated with lower limb pain.

Upper limb

A recent medical diagnosis (OR = 2.6; 95% CI 1.2-5.7), speaking Southern Sotho (OR = 2.5; 95% CI 1.1-5.7) or Other Language (OR = 2.0; 95% CI 1.6-2.4) – i.e. Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga or Mpondo - and working on the surface (OR = 2.6; 95% CI 1.1-6.0) were associated with upper limb pain. The work activity that involved barring (OR = 0.6; 95% CI 0.4-0.9), working both on the surface and underground (OR = 0.7; 95% CI 0.5-0.8) and having a possible mental disorder (OR = 0.4; 95% CI 0.2-0.5) were negatively associated with musculoskeletal disorders of the upper limb.

Lower back pain

The risk factors identified were increased age and working on the surface (OR = 2.3; 95% CI 1.9-2.7). Having a possible mental disorder (OR = 0.4; 95% CI 0.4-0.5) and work activity that involved pushing (OR = 0.7; 95% CI 0.5-0.9) were negatively associated.

Lower limb pain

The risk factors identified were: working at a platinum mine (OR = 2.5; 95% CI 2.1-2.9), increasing age i.e. 45 years and older (OR = 3.5; 95% CI 1.0-12.4), working on the surface (OR = 2.4; 95% CI 1.02-5.6) and the physical activity of kneeling (OR = 2.9; 95% CI 1.6-5.1). Having a possible mental disorder was the only factor that was negatively associated with lower limb pain.

A percentage of controls selected had had a diagnosis of musculoskeletal disorders in the past year or longer and this may have diluted associations found (i.e. 29.3% of controls had a history upper limb pain, 49.7% of controls had a history of back pain and 22% of controls had a history of lower limb pain). Therefore, the final model for each anatomical region was adjusted by including an adjustment factor (i.e. history of musculoskeletal disorder) to determine the effect a past MSD would have on the ORs. When the additional models were compared with the final model with all the controls, there were small non-significant differences for a few of the ORs while most ORs were very similar to the model including all controls without the adjustment.

DISCUSSION

This is the first study to determine the incidence of musculoskeletal disorders in mining in South Africa, and one of few globally in the industry. The research considered risk factors for presenting with a musculoskeletal disorder in three body regions (upper limb, lower back and lower limb). Its strengths included the large range of explanatory variables considered, which included work-related and individual characteristics. Uniquely, report of a frightening event was strongly associated with musculoskeletal disorders (at the gold and platinum mine) and a possible mental disorder was not.

The estimated incidence of musculoskeletal disorders was considered high at all three mines with 6.2% of employed mineworkers presenting with a new episode of musculoskeletal pain during the study period. The United States' Mine Health and Safety Administration database found that the incidence before technological advancements (1983-1984) was 5% and after technological advancements were implemented (2003-2004) had decreased to 4%. The highest percentage of musculoskeletal disorders at the coal and gold mine was from lower back pain. However, at the platinum mine, lower limb pain was the most common musculoskeletal disorder presentation.

Surprisingly, no physical activity was found to increase the odds of presenting with upper limb or lower back pain. The reasons for this could be the large percentage of controls who had previously had upper limb or lower back pain; cases and controls performing similar tasks; or causative exposures had been modified or workers were

transferred to 'light duty' due to a previous MSD. However, kneeling increased the mineworkers' odds of presenting with a lower limb disorder. This finding has been reported previously where restrictive work areas due to low ceiling height (in stope panels, for example) cause workers to perform tasks in the kneeling position, resulting in excessive pressure on the knees from body weight.

Nearly 10% of cases had a possible mental disorder compared to 15.3% of controls (according to the Self-Reporting Questionnaire). Having a possible mental disorder was found to be consistently negatively associated with upper limb, lower back and lower limb pain. The reasons for this finding are unclear, further research is needed. The controls' clinical conditions may have been associated with a possible mental disorder (for example HIV and other chronic medical conditions) or the Self-Reporting Questionnaire may not be reliable or sensitive enough for the study population.

Experiencing an extremely frightening event and a recent diagnosis of a mental condition were two life events from the Life Events and Difficulties Schedule that were found to increase the odds of presenting with musculoskeletal disorders in this study. The reason or source of the fright could not be determined nor whether the fright was recurrent, prolonged or a single extreme episode which is a limitation of this finding. Working underground can be potentially frightening. Frequent earth tremors, the real threat of rock falls and consistently looking for fault lines, and activities required to secure the roof above the mineworker are part of the job, especially at the gold and platinum mine.

Language is likely to be a weak surrogate for ethnicity and in this study was used in an exploratory sense. Industrialisation, urbanization, migration, and electronic media and social affiliations throughout South Africa are in a state of rapid transformation, internalising one another's values and beliefs which make defining an ethnic group difficult.

IMPLICATION FOR POLICY AND PRACTICE

There is a growing understanding that mechanical overload may not be the leading cause of regional musculoskeletal pain. Therefore, both work and non-work related

factors need to be considered in order to develop multifaceted interventions and programmes. The aim would be to reduce the incidence and disability of musculoskeletal disorders. Important considerations for future research in the mining industry are also discussed. Limitations of and gaps identified in this study are addressed in future research to further our understanding of a very important and potentially manageable condition.

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GLOSSARY AND ABBREVIATIONS

Acculturation	Acculturation is the process that explains the cultural and psychological changes that occur when different cultures meet.
Barring	Is an underground mine activity which involves removing loose rock from the walls and rock face of underground mines to make the ground safe.
Cases	Mineworkers presenting to the mine clinic with a MSD confirmed by a research nurse and consenting to be interviewed.
Cellulitis	Inflammation of the skin and subcutaneous layers of the skin.
Controls	The very next mineworker after the case presenting to the mine clinic without a MSD.
Disabling MSD	Symptoms identified as disabling according to the Nordic Questionnaire.
Geothermal gradient	The rate at which the temperature goes up with depth, is low in South Africa i.e. often as low as 9 °C per kilometre depth compared with a world average of about 25 °C/km.
Lobola	A tradition in South Africa whereby the man pays the family of his fiancée for her hand in marriage.
LBP	Lower back pain.
MSD	Musculoskeletal disorder due to either exposure at work or other aetiology.
MSDs	Musculoskeletal disorders.
Mine clinic	Primary care clinic at the mine.
Mine nurse	Nurse at the primary care clinic at the mine.
Mine occupational clinic	Clinic at the mine that conducts periodical examination to assess fitness for work, pre-employment and exit medicals.

Mine Health and Safety Council	The Mine Health and Safety Council is a national public entity comprising a tripartite board represented by State, Employer, and Labour members chaired by the Chief Inspector of Mines. It is established in terms of the Mine Health and Safety Act (Act 29 of 1996) to advise the Minister of Mineral Resources on occupational health and safety legislation and research outcomes.
Mineworker	Permanently employed surface or underground employee at a mine.
OA	Osteoarthritis.
Nguni languages	Xhosa, Zulu, Swazi, Hlubi, Phuthi and Ndebele.
OHS services	Occupational health and safety services.
OMP	Occupational medicine practitioner.
Other Language	Other languages not including Zulu, Southern Sotho, Xhosa or Shangaan, i.e. English, Afrikaans. Portuguese, Pedi, Tswana etc.
Research nurse	Trained nurse deployed at each mine clinic to assess cases and controls, and examine cases with upper limb pain.
SIMRAC	Safety in Mines Research Advisory Committee was established in terms of Section 29 (9) (a) of the Minerals Act, (Act 50 of 1991) with the principal objective of advising the Mine Health and Safety Council on the determination of the safety risk on mines, and the need for research into safety on mines based on the safety risk.
Somatisation	Somatisation is the presentation of physical symptoms in response to social, cultural or psychological triggers and may be one mechanism proposed for the relation between MSD and psychosocial issues
SRQ	Self-reporting questionnaire.
Ukuthwasa	A culture-bound condition in South Africa among the Nguni which is sent by the ancestors and presents with the following somatic symptoms: numbness, aches and pains which restrict movement and performance of usual roles.

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CHAPTER 1 INTRODUCTION

1.1 Background

Musculoskeletal disorders (MSDs) are painful conditions which affect muscles, joints, nerves, vessels and supporting structures. Both work-related and non-work exposures have been linked to MSDs, namely the physical, organizational and social aspects of work, and economic incentives in the workplace; and physical and social aspects of life outside the workplace that include physical activities, cultural values and the physical and psychological characteristics of the individual (Bernard, 1997; Bongers et al., 2002). In addition, the above-mentioned factors interact with each other, and may vary over time and in different occupational situations (Bongers et al., 2002). Also, MSDs have multiple risk factors and may be affected by systemic diseases (such as rheumatoid arthritis, gout and diabetes), culture and socio-economic status (Punnett and Wegman, 2004a). Controversy exists regarding the contribution of work exposures to MSDs, particularly in relation to the contribution of non-work exposures (Coggon, 2005). Inconsistencies regarding the definition of work and non-work exposure and MSD outcomes may partly explain this controversy (Coggon, 2005).

Musculoskeletal disorders are very common and are a major cause of sick leave, disability and reduced productivity while at work (Palmer et al., 2005; Ryall et al., 2007; Palmer et al., 2008). The leading users of disability pensions, sick leave and compensation claims are people with musculoskeletal pain (Linton, 1990; Aptel et al., 2002). Earlier studies have shown that approximately a quarter of all sick leave applications are related to a MSD (Linton, 1990). In France, work-related MSDs of the upper limb account for two-thirds of all occupational disorders (Aptel et al., 2002). Long term sick leave increased in Sweden during the 1990s with forty percent of all sick leave related to MSDs (Nordlund and Ekberg, 2004).

Direct and indirect costs related to MSDs vary across countries because of the different health care services, for example, administration costs, service intensity and the wages of physicians and other health care providers (Baldwin, 2004). Also, the true burden of work-related MSDs may be underestimated because only a small percentage of

workers with a MSD file for compensation (Baldwin, 2004). The burden of MSD and associated costs have not been established in South Africa (Parker and Jelsma, 2010).

1.2 Literature review

The existing literature on MSD is extensive. Consequently, the literature reviewed in this chapter focuses on what is relevant to this particular study, mainly covering MSDs in mining (excluding studies looking at traumatic injuries), the mining context in South Africa and MSDs in South African studies, the extent of upper limb, lower back and lower limb pain, physical and psychosocial risk factors for MSDs and the role of culture and MSDs.

The literature review was conducted by searching MEDLINE, PUBMED and Science Direct dated from 1952 until July 2013. First, database searches were conducted using combinations of the general terms, e.g. “musculoskeletal disorder(s)/disorders(s)”, and for example the general terms “psychosocial/psychological” to cover all potential psychosocial stressors and “work/occupation” and MSD symptoms links. In a second step, a search using combinations of specific psychosocial stressors (e.g., anxiety, fright) and specific localizations (e.g., lower back pain, neck or knee pain) and occupation that involved heavy physical activity (e.g. mining, construction) was done.

1.2.1 Musculoskeletal disorders in the mining industry

There are many factors in the mining industry that contribute to MSD (Mine Safety Advisory Council, 2009). The roads and workplace area are often uneven, muddy and wet with limited access around equipment and poor visibility. Especially underground, mineworkers work in awkward positions because of restricted ceiling heights; therefore, mineworkers often cannot work standing upright and have limited space to change position. Risk factors and hazards in the mining workplace include equipment and vehicle design; work organisation (high job demands, time pressures, lack of job rotation and long working hours without opportunity for rest and recovery); access; duration of task; overtime; and maintenance/breakdowns (Mine Safety Advisory Council, 2009).

In mining, mineworkers are often required to adopt postures such as kneeling, stooping, squatting or lying down for significant periods which results in the musculoskeletal

system enduring substantial performance limitations (Gallagher, 2005). When they are standing, they cannot reposition their feet to avoid twisting the trunk to pick up a load that may be in front of them. If the same mineworkers are kneeling in a confined space, they may not be able to avoid twisting the trunk resulting in a sizeable axial torque on the spine (Gallagher, 2005; Bhattacharjee et al., 2007; Gallagher, 2008).

Another concern is that mineworkers may not be able to shift part of the load from fatigued muscles to another muscle group due to restricted working height; for example, mineworkers may not be able to shift from a kneeling position to standing position. This would result in fatigue, decreased performance and increased risk of tissue injury in restricted postures (Gallagher, 2005; Gallagher, 2008).

The literature indicates that occupational groups with physically demanding jobs including mineworkers have a higher prevalence of knee pain than those with less physically demanding jobs (O'Reilly et al., 2000). In terms of ergonomic hazards, mining is among the most hazardous of occupations (Winn et al., 1996). Winn and colleagues (1996) estimated the extent to which mineworkers in the American mining industry were exposed to ergonomic hazards in different commodities (Table 1.1). Limitations in their study were the small samples for each commodity and hazard, and lack of ergonomic expertise among the observers, which may have resulted in possible unreliability of the observations.

Table 1.1 Percentage of workforce in each American mining commodity exposed to ergonomic hazards (Winn, 1996)ⁱ

Commodity	Total workforce ⁱⁱ	Percentage of workforce (%) ⁱⁱⁱ											
		Al ^{iv}	Hi ^v	F&h ^{vi}	Wm ^{vii}	Fa&s ^{viii}	N/B ^{ix}	Lim ^x	Sit ^{xi}	Std ^{xii}	P/S ^{xiii}	Di ^{xiv}	
Aluminium Ore	3801.4	19	35	62	24	56	60						
Asbestos	444		17	22	24		43	24					
Baron Minerals	1344	19		27	15	63	61	35					
Gemstones	80		46	82		62	71				24		
Gilsonite	142.5												30
Gold-Lobe/Placer	4289.7	20	32	45	40	54	63	16	21				35
Gypsum	1170.2			20	20	21	32		24				20
Leonardite	52		50	58		71	77		35		17		25
Mercury	59			15									
Nonmetallic Mineral (NEC)	2545.6	17	20	36	17	32	43	19					
Perlite	243.7			22	18	28	24	17					
Potash	1712		21	30		16	37	32					34
Rare Earths	218	23	28	36	16	66	54	41					
Salt-evaporated	330	17	24	48	36	37	33			21			
Salt-rock	1768.3		23	41	22	36	42						37
Sandstone-crushed/broken	2278.4		14	20		28	31						
Silver Ore	2738.8	23			15	25	28						23
Sodium compounds	2256	27	35	43	24	41	44	21					
Trona	749		48	66	30	41	63	34					46
Vermiculite	275		17	33		34	39						

ⁱ Presented with permission from the publisher, Elsevier.

ⁱⁱ Estimated total (national) employment for each commodity.

ⁱⁱⁱ The number of miners exposed (nationally) was determined by multiplying the estimated exposure percentage by the estimated workforce.

^{iv} Awkward lifting: lifting an object above head level; lifting an object while twisting the body; or, reaching an extended distance while lifting an object.

^v Heavy lifting: lifting unaided an object heavier than 50 lbs.

^{vi} Fingers and hands and wrist movement: using forceful finger actions on an object without using the whole hand to grasp the object

^{vii} Wrist movement: forceful movements or finger manipulations with wrist bent, repeated wrist motions; or, twisting motions with the hands.

^{viii} Forearms, arms and forearms shoulder: elbows were unsupported and/or abducted, hyperextended, resting on sharp edges; or, hands were at shoulder level or higher while working.

^{ix} Neck and/or back: bending forward, bending to the side, hyperextended or twisting the neck or back .

^x Lower limb movement: kneeling or crawling on hands and knees; squatting.

^{xi} Sitting: in a cramped position; with the knees lower than the hips; with feet dangling; without lower back support; seat tilted forward or to one side.

^{xii} Standing: standing without movement for four or more minutes; operating foot pedals while standing; or, standing in a restricted space for two hours or more without sitting or leaning.

^{xiii} Prone or supine: assuming a position in which less than half of the body weight was supported by the buttocks i.e. lying flat on back, lying on abdomen or lying on side supported by the hip and shoulder or elbow.

^{xiv} Diminished light: the workspace had inadequate illumination.

Early studies described an increased incapacity from back-hip-sciatica, and neck, shoulder and knee complaints among mineworkers compared with non-mineworkers at the Manchester coal fields (Lawrence and Aitken-Swan, 1952). In another study it was found that coal mineworkers aged 41-50 years of age were more likely to suffer from osteoarthritis (OA) than either manual or office workers of the same age (Kellgren and Lawrence, 1952). Kellgren and Lawrence (1952) did not show any association between lack of emotional stability and joint pain except for a few miners with pains of undetermined nature in multiple sites.

From the 1950s to the early 1970s, kneeling and squatting remained the common work positions for a significant proportion of coalminers in the UK (Liddell, 1973). When the knee is in the flexed position (i.e. kneeling), there is laxity of the knee joint which increases the susceptibility of the joint to rotatory injuries resulting in damage of the menisci. It has been shown that coal mineworkers had more meniscectomies than the general population (Sharrard and Liddill, 1962).

In 1962 in Great Britain, 1.2% of all coal mineworkers had 'beat knee', which was often caused from kneeling due to low coal seams, and where standing work was difficult or impossible. Beat knee refers broadly to occupational bursitis (from long periods of kneeling and resultant pressure over the bursa) and cellulitis of the skin over the knee. The skin responds to chronic pressure and friction by thickening (hyperkeratosis). High temperatures and humidity in deep seams result in maceration of the thickened skin, which becomes more prone to infective changes. The reduction of beat knee was attributed to the introduction of mechanisation at the mines, improved preventive measures and early treatment (Rogan, 1972).

A cross-sectional study was conducted at a Scottish colliery to compare the prevalence of back pain with type of job among mineworkers and administrative staff (Lloyd et al., 1986). Greater than two thirds of mineworkers and more than one half of the office workers reported pain at some time in their life. No relationship to present job and back pain was found for mineworkers except for a suggestion that recent lower back pain was more common among mineworkers working at the face or among underground transport mineworkers. It should be noted that this study was cross-sectional and mineworkers with lower back pain were more likely to be off work than office workers with lower back pain due to the nature of mineworkers' work which could have biased

the results. Another limitation of this Scottish study was the poor participation rate in the study possibly resulting in symptomatic subjects being more likely to have taken part.

Friis and colleagues (1998) evaluated the health of 79 miners (cases) in a Swedish iron ore mine with 226 age-matched controls from the general population over one year after the closure of the mine. Negative effects on self-reported health attributable to unemployment were not found. However, neuropsychiatric symptoms were common among the unemployed miners and pain in the upper extremities (RR 2.27; 95% CI = 1.44-3.59), back pain (RR = 1.84; 95% CI = 1.23-2.75) and vasospastic disease of the fingers (RR = 2.05 95% CI = 1.18-3.57) were more prevalent among mineworkers. Limitations of this study included poor participation rate in the study and loss to follow-up among miners and controls.

A cross-sectional study of 280 male underground gold miners in a mine in Ghana found the twelve-month prevalence of lower back pain among miners was 67% (comparable with data obtained from other studies in Africa and Europe) (Bio et al., 2007). The mean age of the workers was 40 years (SD \pm 5.6, ranging from 27 to 53 years). Increasing age was associated with lower back pain (OR 2.1; 95% CI 1.0-4.3) after adjustment for smoking and occupation. Prevalence of lower back pain was highest among workers performing engineering (82%); blasting (77%) and supervisory (72%) work. Heavy physical work was the prominent risk factor for causing lower back pain. Mineworkers with a Body Mass Index (BMI) of over 23 had a higher prevalence lower back pain. Over-reporting to gain sympathy was identified in the study as a potential source of bias.

Fifty underground workers (Group I) and 38 age-matched surface workers (Group II) were included in a study to investigate the relationship between angles of the lumbar spine and lower back pain in coal miners (Sarıkaya et al., 2007). The prevalence of lower back pain among these Turkish coal miners was 78.0% compared to 32.4% among age-matched surface workers. There was no difference in the measure of functional disability between Group I and Group II but Group I reported more severe lower back pain. The low number of controls due to insufficient number of surface workers in this study may potentially bias the results.

Very few studies have evaluated the association between occupational factors and lower back pain in mining. Xu and colleagues (2012) conducted a cross-sectional survey of 1573 coal miners in northern China addressing this association specifically. The prevalence of lower back pain over a 12-month period was 64.9%. The following was associated with lower back pain: a high degree of repetitiveness (OR 1.3, 95%CI 1.0-1.6), high level of physical demand (OR 1.4, 95% CI 1.1-1.8), posture requiring extreme bending (OR 1.6, 95% CI 1.2-1.7) and insufficient recovery time (OR 1.4, 95% CI 1.0-1.8). The study was cross-sectional and therefore cause-effect relationships regarding the observed associations could not be established. The study population included retired coal miners who may have taken early retirement due to lower back pain, as well as participants with lower back pain who were more likely to participate in the study. Participants with lower back pain might recall exposure to work-related factors more accurately than respondents without complaints (recall bias) and therefore an overestimation of associations and prevalence is likely.

Despite the size of the mining industry globally, there is a relative paucity of research on the extent and nature of MSD in the industry, especially on psychosocial and ethnic factors. Many physical risk factors have been identified and lower back pain and knee pain have been reported frequently. Many of the studies conducted in the mining industry determining MSDs included injuries (Moore et al., 2008) or often injury was not an exclusion criteria for lower back pain because lower back pain presenting after an activity may be considered an injury. Few of the studies thoroughly examined non-physical risk factors and many of the studies included injuries and accidents as MSD outcomes.

1.2.1.1 The mining context in South Africa

The Republic of South Africa is one of the world's leading mining and mineral-processing countries (Yager, 2010). In 2003, there were about 920 mines and quarries, which included 116 diamond, 59 coal, 42 gold and 21 platinum mines (United States Geological Survey, 2003). The number of mineworkers employed in the mining industry was 418,294 in 2000 compared with 498,141 in 2010 (Yager, 2010). In 2000, gold mining accounted for 52% of the mining industry's employment followed by platinum mining (23%) and coal mining (12%). In 2010, platinum mining accounted for a large proportion of the mining industry's employment (36.5%) followed by gold (31.5%) and

coal mining (14.8%). Forty nine percent of coal mines are open pit mines (Mbendi, 2013).

Gold was discovered on the Witwatersrand in 1886, which resulted in expansion of the gold-mining industry and other industries. A number of government commissions (1902, 1903, 1907, and 1911) were established in the early 1900s because of the very high rates of tuberculosis and silicosis in gold miners. These were followed by the Miners' Phthisis Act and the Mines and Works Act in 1911 which addressed the concerns of the high prevalence of silicosis and provided compensation for affected miners (Zwi et al., 1988). From 1910 the Chamber of Mines, which represented most mining companies, also looked at issues such as ergonomics, dietary needs and methods of increasing productivity (Zwi et al., 1988).

In 1941, the Workmen's Compensation Act (WCA) was passed to compensate workers with injuries and diseases (MSDs were not included). The Act removed from workers the right to sue employers for not providing a safe and healthy work place (Zwi et al., 1988). Unfortunately, as in most developing countries, incomplete submission of eligible compensation cases and failure to submit cases have been common (Kielkowski et al., 2004). There are many reasons for this: for example, limited access to health services for the poor and especially migrant workers who go back to their homes in rural areas; under-reporting to avoid legal liability (Kielkowski et al., 2004); and the long latent period of many occupational diseases before presentation. Therefore, compensation statistics are of limited value in terms of determining the burden of disease.

In 1974, the Erasmus Commission of Enquiry into Occupational Health was established to assess the state of occupational health in South Africa. Among its findings were the following (Zwi et al., 1988): occupational hazards and diseases were widespread; inadequate research, statistics and notification of occupational diseases and injuries; South African standards for occupational health and safety (OHS) were lower than for other countries; employers had done little to promote OHS in the workplace; and there was an inadequate number of trained OHS practitioners.

In 1995, the Leon Commission of Enquiry into Occupational Health in the South African Mining Industry found that the focus of occupational health activity on the mines had been on regulating the compensation for occupational diseases rather than the

prevention thereof. The Minerals Act focused predominantly on safety issues in the mining industry with no emphasis on promoting occupational health of workers.

As a result of the Commission's findings it recommended the drafting of a new Mine Health and Safety Act to provide a comprehensive legal framework for creating a healthy and safe working environment; promulgation of regulations and protective measures to protect the health of workers including occupational hygiene and medical surveillance programmes; restructuring research institutions and health information systems; and ensuring appropriate training and certification of all workers in the industry.

Consequent to the Leon Commission's recommendations, the Mine Health and Safety Act (Act 29 of 1996) making specific reference to ergonomics was promulgated. Section 21(1)(c) of the Act states that: any person who designs, manufactures, erects or installs any article for use at a mine must ensure, as far as reasonably practicable, that ergonomic principles are considered and implemented during design, manufacture, erection or installation. Furthermore, the Compensation for Occupational Injuries and Diseases (COID) Act (Act 130 of 1993) Schedule 3 lists hand-arm vibration syndrome and any disease due to overstraining of muscular tendonous insertion as a compensable disease. However due to lack of epidemiological data on occupational diseases, with the partial exception of pulmonary disease, it was difficult to assess the incidence and prevalence of musculoskeletal disorders in mineworkers in the South African context (Leger, 1992). Moreover, before 1975, most black mineworkers spent relatively short periods of their working lives on the mine (Leger, 1992). Since then, the average length of service and age of the mineworker has increased and therefore the resultant prolonged exposure to risk factors, which may contribute to MSD, is probable.

SIMRAC is a tripartite committee of the Mine Health and Safety Council, (established in terms of the Mine Health and Safety Act (29/1996)). SIMRAC reviews OHS risks and establishes the need for OHS research projects to promote health and safety in the South African mining industry. An industry-wide risk assessment conducted in 1997 demonstrated that poor ergonomic design and the lack of a strategy for introducing ergonomics into the South African mining industry were major contributing factors to the development of work-related injury and disease (Schutte, 2005). A lack of ergonomics research in the local mining industry prior to the 21st century was also found to be a

major shortcoming as well as a contributing factor (Schutte, 2005). In 2003, amendments to Schedule 3 of the COID Act changed 'hand-arm vibration syndrome and any disease due to overstraining of muscular tendonous insertion' to musculoskeletal diseases caused by specific work activities or work environments where particular risk factors are present. Examples given were: rapid or repetitive motion, forceful exertion, excessive mechanical force concentration and vibration. The mining industry in South Africa has undergone significant changes in the past 20 years due to increased mechanisation and new technologies and equipment, which have often neglected the human-centred design principal. However, despite these changes, mining is labour intensive, physically demanding and repetitive (Van Tonder and Schutte, 2001).

Only one MSD, namely hand-arm vibration syndrome, has been studied in South African mining. Prior to this research, Van Niekerk and colleagues (1998) identified mining equipment with hazardous levels of vibration. Pneumatic rock drills had the highest average vibration level of 24 m/s², followed by hydraulic rock drills, pavement breakers and jackhammers. Therefore, a study was conducted to determine if mineworkers exposed to equipment with significant levels of vibration had hand-arm vibration syndrome (HAVS), a syndrome not previously recorded in African mineworkers. At a gold mine, 156 mineworkers exposed to vibration were interviewed and examined; 15% were diagnosed with HAVS which is a low prevalence compared to other countries like the UK where the percentage of rock drillers with HAVS reached 80% (Nyantumbu et al., 2002). The warmer climate and underground temperatures in South Africa were postulated as possible reasons for the low percentage of HAVS (Nyantumbu et al., 2002). Despite HAVS being a compensable occupational disease, very little awareness of the condition and how it presents in South Africa may have played a role in the observed low prevalence of HAVS, because mineworkers may not present to the clinic with HAVS if they felt the symptoms were related to age or climate. The study took place at the mine clinic and under-reporting of symptoms by mineworkers in order to protect their jobs may also have occurred. In addition, chronic non-occupational disease e.g. HIV/AIDS, hypertension and diabetes as well as chronic occupational diseases (e.g. silicosis and TB) affect the overall labour force due to mortality, change in skill composition and increased labour turnover (Haupt et al., 2005).

Mining activities in South Africa probably expose a large proportion of mineworkers to risk factors for MSD. However, with the exception of HAVS, no research has been conducted in the country either on the extent or nature of MSD in the industry or on the risk factors associated with MSD. One explanation for the lack of research is the historical focus on traumatic accidents and occupational lung diseases.

1.2.1.2 Studies on musculoskeletal disorders in South Africa

Musculoskeletal disorders account for approximately 4.3% of disability adjusted life years (years living with disability) in the developed world, and were reported to contribute approximately 1% in the developing world (Louw et al.; 2007). The difference was thought to be due to genetic diversity and social and economic differences between the developing and developed nations. However, Louw and colleagues (2007) demonstrated in a systematic review that there was no difference in the prevalence of MSDs between developed and developing nations. The one-year lower back pain prevalence among Africans ranged from 14% to 72% (Louw et al.; 2007). The one-year lower back pain prevalence among developed countries is reported to be between 20% and 62% (Walker, 2000). Similarly, lifetime prevalence estimates for Africans in South African workplaces ranged from 28% to 74%, whilst those for developed countries, ranged from 30% to 80% (Van Vuuren et al.; 2005a; Van Vuuren et al.; 2005b; Louw et al.; 2007).

In 1988, it was reported that, on average, approximately 300,000 work-related accidents were reported annually in South Africa, with 2000 fatalities occurring in industry and agriculture and a further 500 in the mines (Zwi et al., 1988). The number of workers with occupational disease was largely unknown due to the lack of available statistics (Zwi et al., 1988, Loewenson, 1999). Hence in 1998, two large household surveys – the South African Demographic and Health Survey 1998 (Department of Health and Medical Research Council, 2002) and the October Household Survey 1998 (Statistics South Africa, 2000) - were conducted in South Africa and questions on occupational diseases and injuries were included (Kielkowski et al., 2004). Due to methodological limitations in both studies, the burden of work related morbidity in South Africa could not be reliably estimated (Kielkowski et al., 2004). Nevertheless, the key results from the two surveys were that musculoskeletal and respiratory disorders were approximately equally prevalent and absenteeism from work-related morbidity was reported to be between

8.7% and 8.9% of respondents. Importantly, a large number of the study participants thought that their health had been affected by work.

There is a paucity of published data on the prevalence of MSDs in South Africa. Parker and Jelsma (2010) interviewed 1005 patients attending clinics in two resource poor communities in Cape Town and found that 36% of the patients reported MSDs which were not related to injury or trauma in the past three months. The prevalence is considerably greater than those reported in community based studies in the USA (24%), Mexico (17%) and the Philippines (16%) (Parker and Jelsma, 2010). The study was cross-sectional, the response rate was 79.2% and participants were not selected randomly i.e. a convenience sample. However, the percentage of patients who attended the clinic for a MSD only was 6.9% (Parker and Jelsma, 2010).

South African studies to determine the prevalence and/or risk factors of MSD in settings likely to produce moderate to heavy exposure to physical activities will be discussed next within two main settings: factories and heavy industry, and construction. Four studies have been conducted in factories and heavy industry: the steel industry (Van Vuuren et al., 2005a; Van Vuuren et al., 2006a), a brick making factory (Ndivhudzannyi, 2003), a manganese factory (Vuuren et al., 2005b; Vuuren et al., 2006b; Vuuren et al., 2007) and one study in manufacturing that included eleven factories from seven sectors of this industry (Schierhout et al., 1993; Schierhout et al., 1994; Schierhout et al., 1995; Schierhout and Myers, 1996). One study has been conducted in the construction industry (Deacon et al., 2005), but two reviews have been published (Deacon et al., 2005; Haupt et al., 2005).

a) Factories and heavy industries

A cross-sectional study of 366 steel plant workers was conducted to determine the percentage of workers with lower back pain complaints and disability, using the Functional Rating Index (FRI) (Van Vuuren et al., 2005a; Van Vuuren et al., 2006b). The study showed that the lifetime, annual and point prevalences of lower back problems were 63.9%, 55.7% and 35.8% respectively. Perceived dysfunction and disability (assessed with FRI) was 15.3%. In the multivariate analysis (including all lower back complaints), twisting and bending (OR 2.8; 95% CI 1.0-7.7), carrying 5-15 kg objects (OR 7.2; 95% CI 1.6-32.4) and sitting (OR 2.3; 95% CI 1.0-5.4) were significantly

associated with lower back problems. Bulky manual handling (OR 5.6; 95% CI 1.2-27.7), kneeling and squatting (OR 4.6, 95% CI 1.3-16.6) and working on uneven and slippery surfaces (OR 3.6; 95% CI 1.2-10.9) were found to be significantly associated with disabling lower back pain. A significant association was found between lower back problems and/or disability with fear-avoidance beliefs and pain coping mechanisms, especially in the group with lower back pain associated with disability. However, the study design does not permit causal inferences to be made. The average age of study participants (31 years; SD 7.8 years) and service history (6.7 years; SD 5.5 years) suggested a younger workforce when compared with the construction and mining industries. Most of the study participants were male (97%), and had educational levels of at least a secondary educational certificate (matric). The average work exposure was 6.7 years and there were no data presented on how long the steel plant had been in operation.

Ndivhudzannyi's thesis on work-related MSDs amongst workers in a brick making factory (Ndivhudzannyi, 2003) involved a small convenience sample of 19 workers who were observed in the workplace and interviewed to obtain information on symptoms of pain by anatomical regions and psychosocial characteristics. Fifteen of the 19 workers (79.0%) indicated that lower back pain prevented them from doing normal activities. Material handling and bending and twisting at the waist were observed frequently. Workers complained that the excessive work load required that they work at 'high pace' and it was a source of stress for them.

Van Vuuren and colleagues (2005b; 2006b; 2007) conducted a cross-sectional study in a manganese plant. All 109 study participants were male. The objectives of the study were to determine the prevalence of manganese plant workers who had lower back pain and/or disability and to determine the association of lower back pain, in this type of setting, with physical exposure as well as work-related psychosocial factors, fear avoidance and coping mechanisms. The study showed that the lifetime, annual and point prevalences of lower back problems were 71.0%, 69.8% and 37.6% respectively. Perceived dysfunction and disability was 29.6%. The company had only eight official reports of lower back pain for the manganese workers from April 1996 - April 2003, which suggests a high degree of underreporting of lower back pain. The reasons suggested were a cultural ethos not to complain about work organisational and support systems due to fear of losing their job, or that their task demands led to work hardening

and the ability to work harder. There were no significant associations found with perceived lower back pain and psychosocial factors, coping mechanisms and work-related organisation except for work-related fear-avoidance beliefs (RR 2.35; 95% CI 1.39–3.95). The study design and self-reports of disability were potential limitations. The response rate was not given.

Schierhout (Schierhout et al., 1995) conducted a cross-sectional study in eleven factories from seven sectors of the manufacturing industry in South Africa. The aim of the study was to develop and use an instrument to measure ergonomic risk factors, for example repetition, posture and force across numerous jobs in different factories and to measure the association with musculoskeletal pain (Schierhout et al., 1993; Schierhout et al., 1994). The prevalence of neck pain complaints was 14%. Mainly workers in the motor assembly, fruit packing and clothing industries were affected. The model demonstrated that repetitive work, seated rather than standing work, and short stature were significantly associated with pain of the neck and shoulder. The prevalence of lower back pain was 20%, among the fruit packing and canning industry. The model showed no significant ergonomic factors associated with pain of the lower back: only being female was shown to increase risk significantly. The prevalence of pain in the forearm, wrist and hands was 2% for acute pain, and 4% for chronic pain, among the fruit packing and canning industries. Being male and a summed score of dynamic postures of the wrist were significantly associated with pain in the forearm, wrist and hands. This was a cross-sectional study and, therefore, prone to the healthy worker effect. Indeed, the low prevalence of reported wrist and hand pain, when many workers indicated it was a serious problem, suggests that the healthy worker effect existed.

b) Construction

Deacon (Deacon et al., 2005) conducted a cross-sectional study of 142 construction workers from the Western Cape comprising carpenters, roofers, bricklayers, painters and general labourers. The physical risk factors are comparable with mining (for example heavy work, vibration exposure, frequent use of hand held tools, repetitive work and awkward positions). Thirty one percent of the construction workers complained of back problems, which increased with age: 38% in the 51 to 55 year group reported back pain compared to 83% in the 61 to 65 years age group. The limitations of the study were the study design (i.e. healthy worker effect bias with cross-sectional

studies), a possible selection bias (older construction workers were selected on a voluntary basis) and weight not BMI or fat percentage was reported.

Although small in number and cross-sectional, South African studies have shown high prevalences of MSDs in a range of non-mining workplace settings. Lower back problems were particularly common. Generalising the results to the workforce as a whole should be done with caution, given the mainly relatively small sample sizes in selected industries and study design limitations.

1.2.2 Extent of musculoskeletal disorders by anatomical region

The literature shows convincingly that people in certain jobs have an increased risk of presenting with certain MSDs compared with other population groups or groups not exposed to these risk factors (Bernard, 1997). The number of symptoms and the severity of the symptoms (e.g. as measured by sick leave and disability) increase with the intensity and duration of the work exposure (Bernard, 1997). The expression of these symptoms appears to be somewhat associated with complex work organisation, psychosocial and personal mediating factors which will be discussed in more detail in section 1.2.3.

1.2.2.1 Upper limb, neck and upper back pain

The population prevalence of upper limb MSD (shoulder, neck, hand, arm and upper back) varies widely between studies because case definitions and study methods differ and therefore comparison of the proportions affected is not straight forward (Nordlund and Ekberg, 2004). Nevertheless, many studies in different groups of manual workers have found upper limb MSDs to be common. In a recent study, the prevalence of neck and shoulder pain among Brazilian and Italian nurses was similar (40.4% versus 46.4%) but shoulder pain was more prevalent among Brazilian nurses (41.5%) compared to Italian nurses (33.2%) (Carugno et al., 2012). Novices from 12 occupational groups where high rates of MSDs were anticipated revealed after 12 months of exposure, 20% developed shoulder pain and 9% wrist pain which showed that mechanical factors in the short term are associated with shoulder and wrist pain (Nahit et al., 2001). In the automobile industry in Portugal, the prevalence of shoulder pain was 21-24% and for elbow and wrist pain the prevalence was 17-24% and 24-28%, respectively (Carnide et

al., 2006). In the Netherlands, 28% of the working population reported neck/shoulder or elbow/wrist/hand symptoms in the 12 months prior to the study (Bongers et al., 2006).

Pain in the neck and shoulders is frequently the cause of disability and time lost from work (Leclerc et al., 2004). A UK Labour Force Survey found a self-reported annual incidence of 91 per 1000 adults for work-related illnesses of the upper limb and neck, with an estimated loss of 4.1 million working days per year (Punnett and Wegman, 2004a). In France, 50% of all reported occupational diseases were upper limb MSDs which had increased six fold between 1985 and 1994 (Cassou et al., 2002). Among male workers in the following industries the prevalence of shoulder pain was: clothing (36%), slaughtering and food processing (39%), fish processing, repetitive assembly line work (33%), and among female supermarkets cashiers (69%) (Leclerc et al., 2004).

In the working population shoulder pain may present with generalised pain around the shoulder or as specific disorders like rotator cuff syndrome or shoulder tendonitis. Shoulder and neck disorders are not always distinguishable, although their risk factors may differ. A prospective longitudinal study done in seven regions in France conducted by occupation physicians found the incidence of chronic neck and shoulder pain was 7.3%, for men and 12.5% for women for the period 1990–95 (Cassou et al., 2002). In Denmark, a four year prospective cohort study of workers from industrial and service companies found the average annual incidence rate of neck/shoulder pain was 14% with 1.7% having clinical symptoms (muscle tenderness) on examination (Andersen et al., 2003).

A literature review of 21 selected articles indicated that the prevalence of carpal tunnel syndrome (CTS) varied between 0.6% (slaughterhouse workers) and 61% (grinders) (Hagberg et al., 1992). The high prevalence of CTS was found also among butchers, grocery store workers, frozen food factory workers and platters (Hagberg et al., 1992); the impact of occupation was shown to be substantial.

1.2.3.2 Lower back pain

There are many conditions of the lower back which may cause pain, including muscular or ligamentous strain, facet joint arthritis, or disc pressure on the annulus fibrosis, vertebral end-plate or nerve roots. In most patients, the anatomical cause of lower back pain, regardless of its relation to work exposures, cannot be determined with any

degree of clinical certainty. Sciatica may occur in one quarter of those experiencing back problems (Andersson, 1981) whereas the most common form of back disorder has “non-specific symptoms”, which often cannot be diagnosed.

Lower back pain is the most prevalent musculoskeletal condition and the most common cause of disability in developed nations (Woolf and Pfleger, 2003). The lifetime prevalence of lower back pain (at least one episode of lower back pain in a lifetime) in industrialised countries is reported to be up to 85% (Walker, 2000) and the symptoms are often persistent or recurrent (Waddell and Burton, 2001). It has been estimated that 8% of the working-age population will experience disabling lower back pain in any given year (Baldwin, 2004).

Studies of workers’ compensation data have suggested that lower back pain represents a significant portion of morbidity in working populations and the single most costly injury in terms of compensation cost (Baldwin, 2004). Compensation claims for back pain in 1992 represented 24% of US workers’ compensation claims and 31% of compensation costs (Baldwin, 2004). The rates of back disorders vary substantially by industry, occupation and by job within given industries and facilities (Bigos et al., 1986; Skovron et al., 1994). Novices from 12 occupational groups where high rates of MSDs were anticipated revealed that after 12 months of exposure, 24% developed lower back pain which showed that mechanical factors in the short term are associated with lower back pain (Nahit et al., 2001). Among construction workers, the 12-month prevalence of lower back pain was highest in painters (57%), concrete builders and bricklayers (41%) and carpenters and unskilled workers (38%) (Stumer et al., 1997).

1.2.3.3 Lower limb pain

Across Europe, one out of three men and one out of two women experienced some pain in the lower limb over a 12 month period (Dreinho et al., 2007). An age-dependent increase in the incidence of lower limb pain is evident which suggests that a large number of reported cases may be caused by underlying degenerative joint disease (Dreinho et al., 2007). The prevalence of hip osteoarthritis was higher in farmers who had farmed for over 10 years compared to controls from mainly sedentary jobs (Croft et al., 1992a).

The prevalence of knee pain varies from 10%-60%, depending on age, occupation and the definition of knee pain (Miranda et al., 2002a). Data from the third National Health and Nutrition Examination Survey III conducted from 1988-1994 showed that 18.1% of men and 23.5% of women aged 60 years or older in the United States suffered from significant knee pain (Andersen et al., 1999). During the same period, a study estimated that the 1-year prevalence of persistent knee pain in England was 25% among those aged 55 years and older (Peat et al., 2001).

Causes of knee pain include bursitis, tendonitis, chondromalacia and meniscal disorders. Thickening of the prepatellar or superficial infrapatellar bursa i.e. bursitis, on ultrasonography examination, was found in 49% of 96 carpet and floor layers, compared with 7% of 72 house painters examined (Kivimaki et al., 1992). The epidemiology of bursitis in the general population is unknown and the pathogenesis is not completely understood. Friction and mechanical compression due to kneeling may cause mechanical trauma and may lead to local inflammation of the synovial membrane of the bursa, resulting in thickening of the membrane. Meniscal disorders and chondromalacia patellae have been described in coal mineworkers working in low seams (Sharrard and Liddell, 1962) and floor-layers (Spector et al., 2011). In the novices from 12 occupational groups 21% developed knee pain which showed that mechanical factors in the short term may also be associated with knee pain (Nahit et al., 2001).

Osteoarthritis of the knee, an important cause of pain, was present in 15% of elderly people in Britain, and was responsible for pain and disability in a third of those affected (Cooper et al., 1994). Convincing evidence suggests that there is a relationship between occupational activity and osteoarthritis (OA) of the knee and hip (Vignon et al., 2006). Osteoarthritis (OA) is also highly age-related with high prevalences in those aged 75 and older and often no longer working (Miranda et al., 2002a). Universally, the prevalence of symptomatic hip OA in population-based cohorts of 45 years and over is 2-10% (Fransen et al., 2011). In the United States, the prevalence of hip OA in those 60-76 years old was between 2.0% and 4.5% among men and women respectively; in Swedish male office workers (mean age 64 years) 3.1%; and 5.1% in a consecutive series of 1315 x-rays (for intravenous urograms) in men (60-76 years) from England (Croft et al., 1992b).

Persons at risk of hip and/or knee MSD are farm workers (Croft et al., 1992a; Manninen, et al., 2002; Rossignol et al., 2003; Jensen, 2008) and mineworkers (Coggon et al., 2000; Walker-Bone et al., 2002a; McMillan and Nichols, 2005). Men working in building and construction for 11-30 years had a 3.7 times increased risk of knee arthritis (95% CI 1.2-11.3) (Holmberg et al., 2004). However, in another study farm work was not related to increased risk for men (Holmberg et al., 2004). An excess prevalence of OA was found in men who were truck drivers (observed/expected ratio 6.7) or unskilled male workers (observed/expected ratio 10.3) (Rossignol et al., 2003). Persons at risk of knee MSD are flooring installation workers, plumbers, moulders, core makers, construction workers, truck drivers and fire-fighters (Coggon et al., 2000; Vignon et al., 2006).

1.2.3 Risk factors for musculoskeletal disorders

A large number of risk factors for MSDs has been identified in a number of epidemiological studies, population surveys and clinical studies. Evidence suggests that there are causal relationships between MSDs and a number of physical risk factors (both occupational and non-work-related), including frequent repetitiveness, high force, awkward posture and vibration, (Bernard, 1997; Andersen et al. , 2007; Macfarlane et al., 2009; da Costa and Vieira, 2010), particularly when risk factors are combined with individual characteristics. The latter may include age, sex, cigarette smoking, physical fitness, anthropometric measures, lumbar mobility, strength, psychosocial factors, medical history and structural abnormalities (Garg and Moore, 1992).

The individual characteristics of a person may influence the biological, clinical and disability responses to a MSD, which are in turn dependent on the physical, psychological and social features of the individual. Research has suggested that the person's culture may play a significant role through societal beliefs and expectations about causation and prognosis and may influence their chronicity and associated disability (Coggon, 2005). Coggon proposes that MSDs present as a psychologically mediated response to an external trigger and that the response is moderated by individual characteristics and cultural circumstances (Coggon, 2005).

The literature shows that people in certain jobs are exposed to physical work-related factors which are associated with a significant risk of contracting a work-related MSD compared with other population groups or groups not exposed to these risk factors

(Ayoub and Wittels, 1989; Stock, 1991; Bernard, 1997). It is assumed that repeated movements and awkward postures, static work, continuous loading of the tissue structures or lack of recovery time trigger or cause a pathological process that then manifests as a work-related MSD.

Furthermore, there is growing evidence that psychosocial variables (both individual and organisational) increase the likelihood of adverse health effects related to MSD (Bongers et al., 2002). Initially, these factors were seen as confounders but now are seen as independent risk factors (Bernard, 1997; Feuerstein et al., 2004). The difficulty in establishing associations between psychosocial and organisational factors and MSD is due to the numerous factors of which some are difficult to qualify and to quantitate. In addition, there may be interactions among these factors which make it difficult to establish an independent role in the presentation of MSD (Aptel et al., 2002).

Psychosocial factors studied in the occupational health field mainly fall within three separate domains: factors associated with the job and work environment; factors associated with extra-work environment; and those characteristic of the individual worker. Work organisational factors include job content (workload, repetitiveness, job control, mental demands, job clarity), organisational characteristics (hierarchy versus flat organisational structures, communications issues), interpersonal relationships at work and temporal aspects of the work and task (cycle time and shift work), financial and economic aspects (pay, benefit and equity issues), and community aspects (occupational prestige and status). Extra-work environment parameters include factors associated with a parent, spouse or children. Individual factors comprise genetic factors (e.g. sex), acquired aspects (social class, culture and educational status) and personality factors (personality traits, characteristics and attitudes such as life and job satisfaction) (Bernard, 1997; Aptel et al., 2002; Bongers et al., 2002).

1.2.3.1 Physical and psychosocial risk factors by anatomical region

This following section focuses on physical and psychosocial factors associated with MSD. However, a number of studies consider physical and psychosocial factors along with other determinants of MSD. These studies are included in this section and reference is made to the other determinants if appropriate. The main findings from the review are summarised in Tables 1.2 to 1.4 at the end of the literature review.

a) Upper limb disorders including neck and upper back

The following physical exposures have been related to neck and shoulder pain: repetitive movements requiring precision and or within time constraints; lifting; carrying; awkward working positions; working above shoulder level; and long-term exposure to vibrating tools (Ekberg et al., 1994; Cassou et al., 2002; Fredriksson et al., 2002; Leclerc et al., 2004). Psychosocial and work-organisational factors include: low level of job control (Fredriksson et al., 2002; Leclerc et al., 2004; Punnett et al., 2004b); rushed work pace and irregular working hours (Fredriksson et al., 2002); and depressive symptoms (Leclerc et al., 2004). When stress symptoms were adjusted for in one study, the risk of high job demand decreased and therefore stress may play an intermediate role (Van den Heuwel et al., 2005). A job change closely preceding the evaluation was also shown to increase the risk of upper limb pain which was not explained by changes in exposure (Punnett et al., 2004b). Workers with a high BMI showed increased risk in some studies (Punnett et al., 2004b) but not in another (Kerr et al., 2001). Similarly for smoking status, some studies found an increase in risk (Ekberg et al., 1994; Cassou et al., 2002), while others did not (Fredriksson et al., 2002).

Limitations found in some case-control studies were the high percentage of controls who had a previous history of a MSD (Ekberg et al., 1994) and response bias (study participants with a MSD or previous MSD may have been more willing to take part in the study and recall certain exposures more readily) (Ekberg et al., 1994). Fewer cases were selected in another study than anticipated because of an economic crisis in Sweden resulting in fewer people on the sick list and a reduction in the number of people seeking care for MSD complaints which highlighted that care seeking was also dependent on a number of factors; including affordability (time and resources) and whether or not cases were able to work despite neck and/or shoulder pain which would vary from job to job (Fredriksson et al., 2002).

In cohort studies; loss to follow-up is an issue particularly if MSDs became progressively worse and study participants are not able to continue working (Leclerc et al., 2004). In one study the largest loss to follow up was in the group where MSDs were anticipated which confirmed the above concern (Leclerc et al., 2004).

Occupational exposure assessment in one study was limited because the 18 different companies in various sectors may have had different methods of exposure measurement, and the researchers relied on self-assessment of biomechanical constraints, which prevented precise evaluation (Leclerc et al., 2004). Limitations of another study were that the physical risk factors were only assessed at baseline and the personal characteristics (i.e. coping styles and negative affectivity) were only assessed at the three-year follow up (van den Heuvel et al., 2005).

Table 1.2 summarises the main findings from the studies described above.

Table 1.2 Summary of results from literature review on physical and psychosocial risk factors and neck and upper limb pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Ekberg et al., 1994)	Case-control study	In southern Sweden, 109 cases presenting with neck and shoulder pain and 637 controls.	Work conditions and background factors.	Nordic questionnaire for neck and shoulder pain and clinical examination	The most common diagnosis was tension neck syndrome (47%), followed by cervical syndrome (18%) and humeral tendinitis (27%)	Repetitive movements requiring precision Light lifting Uncomfortable sitting Rushed work pace Exercising rarely Immigrant background Current smoker Uncertainty in managing job demands High demands on attention	7.5 (2.4-23) 13.6 (4.8-39) 3.6 (1.4-9.3) 3.5 (1.3-9.4) 0.3 (0.1-1.0) 4.9 (1.8-14) 3.7 (1.8-7.5) 16.5 (6.0-46) 3.8 (1.4-11)
(Cassou et al., 2002)	Cohort study	In France, 21 378 working subjects were interviewed in 1990 and 87% were interviewed again in 1995	Questions on different kinds of physical activities at work and the psychosocial work environment	Questionnaire on chronic neck and shoulder pain and medical examination	Prevalence of chronic neck and shoulder pain was 7.8% for men in 1990 and the incidence was 7.3% for men for the five-year follow up	In men, incidence of neck and shoulder pain was associated with: Repetitive work under time constraints before 1990 Awkward work in 1990 High job demand in 1990 Depressive symptoms in 1990 MSD in the past Smoking before 1990	1.3 (1.0-1.7) 1.3 (1.1-1.7) 1.2 (1.0-1.4) 1.3 (1.0-1.8) 1.5 (1.3-1.8) 1.2 (1.0-1.4)
(Fredriksson, 2002)	Case-control study	Norrtälje in Sweden, 310 cases consulting caregivers and 1277 working controls	Physical and psychosocial conditions in the work environment	Self-administered questionnaire on neck and shoulder pain and an examination.	Among the male cases, 17% had tension neck syndrome, 31% had cervical and 10% had cervical rhizopathy. The mean age was 43.1 among men.	<u>For men: sitting >75% of the working day</u>	3.4 (1.5-7.6)
(Leclerc et al., 2004)	Cohort study	In France, 598 workers experiencing shoulder pain (SP) and 337 workers without pain	Occupations and exposures to repetitive work	Self-administered questionnaire on shoulder pain	Six-month prevalence of SP 37% and, incident SP was 29% for men and risk of shoulder pain was high among workers with <1 year experience at baseline	<u>For men in the bivariate analysis:</u> Depressive symptoms Low level of job control Repetitive use of a tool	2.6 (0.9-7.7) 3.7 (1.4-9.4) 4.3 (1.58-11.9)

Table 1.2 (Cont) Summary of results from the literature review on physical and psychosocial risk factors and neck and upper limb pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Punnett et al., 2004b)	Cohort study	1324 workers from automotive plant in the USA	Ratings of the physical features of subjects' usual job and psychosocial work environment	Interviews and examinations for workers with upper limb disorders	The cumulative incidence of new disorders was 14% (symptoms) and 12% (physical examination).	Physical job exposures Workers with a change in job on follow up	1.5 (1.1 - 2.2) 4.8 (1.5 – 15.4)
(Van Den Heuvel et al., 2005)	Cohort study	34 participating companies in the Netherlands: employees with >1 year experience	Questionnaires on exposure as well as video observation	Adapted version of the Nordic questionnaire	3-year cumulative incidence rate of neck/upper limb symptoms (32%), neck/shoulder symptoms (24%) and elbow/wrist/hand symptom (15%)	<u>High job demands</u> Neck/shoulder symptoms Elbow/wrist/hand symptom <u>Low social support of co-workers</u> Elbow/wrist/hand symptom	2.1 (1.2-3.6) 1.9 (1.0-3.7) 2.2 (1.0-4.9)

b) Lower back pain

Heavy lifting and forceful exertion have been positively associated with lower back pain (Walsh, 1989; Linton, 1990; Thorbjornsson et al., 2000; Kerr et al., 2001; Cole et al., 2001; Jansen et al., 2004; Linton, 2005). The following work-related physical factors have also been associated with lower back pain: driving (Walsh et al., 1989); whole-body vibration (WBV) (Linton, 1990; Bernard, 1997); twisting of the trunk (Miranda et al., 2002b; Jansen et al., 2004); and sedentary and monotonous work (Bigos et al., 1990; Thorbjornsson et al., 2000)

Poor psychosocial working environment has been shown to be associated with lower back pain (Miranda et al., 2002b; Magora, 1973; Kerr et al., 2001; Bigos et al., 1990). Factors included high demand and low control over work, low supervisor and co-workers support (Kerr et al., 2001; Kaila-Kangas et al., 2004; Jansen et al., 2004), working overtime and fatigue (Thorbjornsson et al., 2000; Magora, 1973) and high job insecurity (Cole et al., 2001).

Depression, anxiety and stress have also been associated with lower back pain (Miranda et al., 2002b; Magora, 1973; Kerr et al., 2001; Bigos et al., 1990; Linton, 2005; Kaila-Kangas et al., 2004), as well as poor social relations (Cole et al., 2001), catastrophising (Linton, 2005) and somatising (Solidaki et al., 2010).

Other factors associated with lower back pain include: greater age (Miranda et al., 2002b; Jansen et al., 2004); smoking (Miranda et al., 2002b; Jansen et al., 2004); immigration (Linton, 2005); low BMI and prior MSD (Kerr et al., 2001).

Limitations in assessing temporality would need to be considered in cross-sectional studies (Magora, 1973; Walsh et al., 1989; Linton, 1990; Cole et al., 2001; Linton, 2005) and exposure misclassification due to difficulty in recalling the onset of exposure (start of job) and onset of lower back pain may have been present in some studies. Other limitations suggested were small sample size (Walsh et al., 1989); poor response rate (Bigos et al., 1990; Kerr et al., 2001); and selection bias (volunteer basis) (Bigos et al., 1990; Stürmer et al., 1997). Recall bias may have occurred when information on physical, psychosocial and working conditions was collected retrospectively resulting in

overestimated associations (Thorbjornsson et al., 2000). Table 1.3 summarises the main findings from the studies described above.

Table 1.3 Summary of results from the literature review on physical and psychosocial risk factors and lower back pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Magora, 1973)	Cross-sectional study	3316 subjects interviewed	Occupation and psychosocial work-related factors	Symptom of LBP	12.9% were found to suffer, or to have suffered in the previous year from a LBP disorder		
(Walsh et al., 1989)	Cross-sectional study	Postal questionnaire to 535 subjects from a small town in England	Multiple physical exposures	A history of back pain for more than a day and character of the pain	64% of men had reported having had back pain and 10% with sciatica.	<u>For men:</u> Driving a car for more than 4 hours per day Lifting or moving weights of 25 kg or more	1.7 (1.0-2.9) 2.0 (1.3-3.1)
(Linton et al., 1990)	Cross-sectional	22180 workers in Sweden	Exposure at work and lifestyle factors	Questionnaire to assess symptoms	Prevalence of neck and back pain over one year period was 31% and 39% respectively	Lifting Monotonous work tasks Vibration Uncomfortable work postures	1.89 (1.6 - 2.2) 1.94 (1.6-2.3) 1.82 (1.5-2.3) 2.4 (2.1-2.8)
(Bigos et al., 1990)	Cohort study	3020 aircraft workers in Western Washington	Work perceptions and certain psychosocial responses	Back problems identified through company doctor, compensation or sick note from private GP	Not enjoying job and previous history of back treatment were positively associated with reports of back pain		
(Stürmer et al., 1997)	Cohort study	571 construction workers	Current job categorised, complete job history and service history	LBP was based on clinical signs	12-month prevalence of LBP was 57% for painters, 41% in concrete builders and bricklayers and 38% in carpenters and unskilled workers	Working longer than 10 years as a bricklayer	2.3 (1.2-4.5)

Table 1.3 (cont) Summary of results from the literature review on physical and psychosocial risk factors and lower back pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Thorbjornsson et al., 2000)	A nested retrospective case-control study	484 subjects drawn from the general population was examined in 1969 and 1993,	Physical and psychosocial working conditions	LBP during the period 1970 to 1993	24-year period, 46% of the subjects became patients with LBP	<u>Among men excess risk for LBP:</u> Heavy physical workload, Sedentary work High perceived load outside work Combination of poor social relations and overtime.	1.5 (0.9-2.3) 1.7 (0.9-3.11) 1.7 (1.0-2.9) 3.1 (1.3-7.2)
(Cole et al., 2001)	Cross-sectional	Sample from Canadian 1994 National Population Health Survey	Job category	Self-reported health measures and activity restriction	Prevalence of chronic back pain was 14.5% among men	<u>LBP in men</u> High physical exertion among men <u>Restricted activity due to MSD:</u> High job insecurity	1.39 (1.09 - 1.77) 1.5. (1.0-2.2)
(Kerr et al., 2001)	Case-control study	137 cases presented with a new episode of LBP (244 controls) from a n automobile manufacturing complex in Canada	Direct workshop measurements of subjects at their usual job and psychosocial and self-report questionnaire of physical loading at work	New episode of LBP	There were few statistical differences between cases and controls including the mental health score.	Peak lumbar shear force Cumulative lumbar disc compression Low body mass index Prior LBP compensation claims A poor workplace social environment Inconsistency between job and education level Better job satisfaction Better co-worker support Higher perceived exertion at work	1.7 (1.0-2.9) 2.0 (1.2-3.6) 2.0 (1.2-3.6) 2.2 (1.1-4.4) 2.6 (1.3-5.4) 2.2 (1.1-4.9) 1.7 (1.2-2.5) 1.6 (1.1-2.3) 3.0 (1.8-5.4)
(Miranda et al., 2002b)	Cohort study	2077 Finnish forest industry workers without sciatic pain and 327 with severe sciatic pain	Potential predictors of sciatic pain: individual factors, work-related factors and physical exercise	Modified version of the Nordic Questionnaire	9% experienced new onset sciatic pain during 1-year follow-up and 53% with sciatic pain at baseline still had symptoms	<u>For persistent severe sciatic pain:</u> Greater age Mental stress Former smokers Poor job satisfaction <u>The risk of incidental sciatic pain:</u> A greater age Mental stress Smoking of long duration Work-related twisting of the trunk	1.9 0 (6–6.7) 3.1 (1.3–6.9) 2.0 (1.1–3.4) 2.6 (1.2–5.8) 3.3 (1.4-7.6) 3.0 (1.5-5.9) 2.3 (1.3-3.9) 1.9 (1.1-3.2)

Table 1.3 (cont) Summary of results from the literature review physical and psychosocial risk factors and lower back pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Jansen et al., 2004)	Cohort study	523 subjects working in nursing homes	Job history and service history and an observational multimoment method for sample of workers	LBP in the past 12 months	Risk of LBP without disability was not associated with physical factors	<u>LBP with disability:</u> Trunk flexion over 45° Age	3.1 (1.1-9) 1.68 (0.6-4.9)
(Kaila-Kangas et al., 2004)	Cohort study	902 metal industry employees	Job strain, psychosocial factors at work, and history of physical work	Hospital admissions for back disorders	8% of study participants admitted for back disorders.	Low job control Low supervisor support No association between psychosocial factors at work and hospitalisation for intervertebral disc disorders	2.93 (1.22-7.1) 2.86 (1.4-6.0)
(Linton et al., 2005)	Cross-sectional study	1914 subjects postal survey in Sweden in the 35-45 year age group.	Physical exposure, psychosocial, fear-avoidance and catastrophising	Symptoms of back pain as well as intensity and frequency	17% reported being absent for back pain (average of 1.5 days)	Psychological distress Poor back physical function Psychological distress Catastrophising Workload	13.2 (7.6-22.9) 6.4 (3.3-12.5) 2.2 (1.0-5.3) 3.0 (1.1-8.4) 2.3 (1.0-5.5)-
(Seidler, 2009)	case-control study	German patients with disc herniation (286 males, 278 females) or symptomatic lumbar disc narrowing (145 males, 206 females)	Self-reported occupational history	Orthopaedic surgeons identified cases and CT, MRI or x-ray were reviewed by radiologist		<u>Lumbar disc herniation group:</u> Cumulative lumbar load (highest category) <u>Lumbar disc narrowing:</u> Cumulative lumbar load (highest category)	3.4 (2.2-5.0) 2.3 (1.5-3.6)

c) Lower limb disorders

The following body positions or body movements at work were found to be associated with lower limb MSD: repeated stair climbing; jumping; exposure to vibration; squatting; kneeling (Cooper et al., 1994); and repeated heavy lifting (Jensen, 2008). At least five studies found a dose dependent relation between the onset of a lower limb MSD and the duration of exposure to an occupational activity (Croft et al., 1992a; Heliovaara et al., 1993; Roach et al., 1994; Manninen et al., 2002; Walker-Bone et al., 2002b).

Vigorous hip flexion and extension have been identified as possible causes of iliopsoas bursitis (Toohey et al., 1990). However, this proposed association between physical exposure and iliopsoas bursitis is based on case descriptions. Farm work may cause mechanical stress on the hip joint from heavy lifting or frequent walking over rough ground and exposure to vibration from driving agricultural machinery (Coggon et al., 1998). For hip OA, heavy lifting in excess of 10 kg for a long period (greater than 10 years) showed moderate to strong evidence (Coggon et al., 1998; Jensen, 2008).

For the knee, kneeling and squatting were associated with OA of the knee (Cooper et al., 1994; Coggon et al., 2000; Baker et al., 2003; Vignon et al., 2006) as well as walking more than two miles (3.2 km) per day and or lifting heavy weights of more than 25 kg in the course of work (Croft et al., 1992a; Coggon et al., 2000). Two studies also suggested climbing stairs as a risk factor for presenting with hip and knee MSD (Cooper et al., 1994; Coggon et al., 1998). Manninen and colleagues (2002) found no association with lifting and OA of the knee.

In some studies (Miranda et al., 2002a; Manninen et al., 2002) general physical exercise and sports were not shown to influence the risk of knee pain. An increased risk of knee pain was found with age, a BMI of 26 kg/m² or more (Coggon et al., 2000; Manninen et al., 2002; Holmberg et al., 2004), among women and among ex- and current smokers (Miranda et al., 2002a). However, in other studies, no relation to smoking was shown (Holmberg et al., 2004). Olsen and colleagues (1994) have estimated that the risk of OA of the hip and knee due to work-related risk factors were similar to those for obesity. In contrast, Vignon and colleagues (2006) estimated that the contribution of occupation compared to the contribution of obesity to the development of

OA, was nearly double. Therefore, the contribution of occupation to the development of OA may not be trivial (Vignon et al., 2006).

The use of weak diagnostic criteria and non-specific pain descriptors or different diagnostic criteria with little clinical and/or radiographic confirmation may have inflated pain prevalence estimates (Baker et al., 2003), especially for the controls in case-control studies. The limitations in the aforementioned studies included: poor response rate (Baker et al., 2003; Holmberg et al., 2004); and selecting patients for hip/knee surgery may have inadvertently selected patients doing strenuous work (Coggon et al., 1998; Coggon et al., 2000). Many of the studies included OA with radiological changes, which is seen in the older age group (often no longer working) (Croft et al., 1992a; Croft et al., 1992b; Coggon et al., 1998; Coggon et al., 2000). Occupational exposure was poorly described and often determined by tasks, body positions or movements considered risky, and the duration was often estimated over a typical work day (Jensen, 2008). The above methods introduce potential bias if cases tended to overestimate their exposures as compared to controls. In small sample sized studies, recall bias, especially for exposure history, in cases with hip/knee pain may have shown spurious association, especially for subjects classified as severely disabled (Coggon et al., 1998; Coggon et al., 2000; Miranda et al., 2002a). Most were cross-sectional studies (Croft et al., 1992b; Baker et al., 2003; Rossignol et al., 2003; Chen et al., 2004; Messing et al., 2008) with one cohort study (Miranda et al., 2002a). Table 1.4 summarises the main findings from the studies described above.

Table 1.4 Summary of results on the literature review of physical and psychosocial risk factors and lower limb pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Croft et al., 1992a)	Cross-sectional study	Cases: 167 male farmers (83 controls) from Staffordshire and Cheshire	Interviewed and examined farmers and controls with sedentary occupations	Hip replacements for OA (x-ray evidence)	Prevalence of hip OA was higher among farmers (16.8%) than controls (2.4%)	Farming ≥10 years	9.3 (1.9 to 44- 5)
(Croft et al., 1992b)	Case-control study	245 cases with hip OA and 294 controls at North Staffordshire and Shrewsbury hospitals	Blinded interview. Occupational history, history of sports and hobbies, weight and height measured	Case had hip joint space narrowing of <2.5mm Severe cases: (<1.5mm) controls: Hip joint space ≥3.5mm		Climbing ladders (severe cases): 1-19 years ≥ 20 years Climbing >30 stairs" >1 year versus < 1 year Farmers and agricultural workers who had been in the job for more than 10 years	0.8(0.3-1.8) 1.6(0.7-3.8) 1.2(0.6-2.5) 2.0 (0.9-4.4)
(Cooper et al., 1994)	Case-control study matched for age and sex	109 cases and 218 controls from a practice in Bristol, England	Occupational history and specified activities	Radiographic evidence of OA of the knee	The mean age of onset of pain was 59.9 years.	<u>Main job entailed more than 30 minutes per day of the following physical activity:</u> Squatting Kneeling Climbing >10 flights of stairs	6.9 (1.8-26.4) 3.4 (1 3-9 1) 2.7 (1.2-6.1)
(Coggon et al., 1998)	Case-control study matched for age and sex	611 cases waiting for total hip replacement from two English districts: Portsmouth and North Staffordshire	Occupation history (>1 year) and specified physical activities	On waiting list for total hip replacement	The mean age of 70 years	Men regularly lifting weights ≥50 kg for 10 years or longer	3.2 (1.6 -6.5).
(Lau et al., 2000)	Case-control study	138 cases hospitalised with OA of the hip and 658 cases with OA of knee and controls from general practice in Hong Kong	Occupational history (main job was job held longest before onset of pain), sports activities, smoking history and measured height and weight	Primary OA of the hip or knee with a grade 3 or 4 OA	Body weight (in the highest quartile) was associated with hip OA only in women	<u>For hip OA:</u> Climbing ≥15 flights of stairs Male Female <u>For knee OA:</u> Climbing ≥15 flights of stairs Male Female Lifting weight (10-50 kg) for ≥10 times Male Female	8.7 (1.8-42.7) 2.5 (1.0, 5.9) 4.1 (2.1-8.2) 6.1 (3.5-10.8) 7.1 (3.1-16.2) 9, 95 (1.9- 4.5)

Table 1.4 (cont) Summary of results on the literature review of physical and psychosocial risk factors and lower limb pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Coggon et al., 2000)	Case-control study matched for age and sex	518 patient awaiting knee surgery at Portsmouth, Southampton and Stoke-on-Trent (England)	Occupational history and specified activities	Patients identified by orthopaedic surgeon (clinical records and x-rays reviewed)	The median age was 71.5 years	Kneeling or squatting Walking >2 miles/day (Regularly lifting weights of at least 25 kg BMI of >30 kg/m ² and prolonged kneeling or squatting	1.9 (1.3–2.8) 1.9; (1.4–2.8) 1.7 (1.2–2.6) 14.7 (7.2–30.2)
(Manninen et al., 2002)	Case-control study matched for age and sex	281 cases (80% women) in the Kuopio University Hospital	Occupational history (up to the age of 49years) and specified activities	Patients who had their first knee surgery for knee OA	The trades with highest risk of knee OA were agriculture, forestry, fishing, transportation, and traffic, the mean age of male cases was 67.5 years.	High physical load Men Women Climbing for men Kneeling and squatting	1.53 (0.42–5.56) 2.03 (1.03–3.99) 3.06 (1.25–7.46) 1.73 (1.13-2.66)
(Miranda et al., 2002a)	Prospective study	Finnish forestry workers: 2122 workers free of knee pain and 333 workers with severe knee pain	Physical exposure, mental stress and job satisfaction	Knee pain	10% of workers developed knee pain during follow up (mean age 45.3 years)	<u>Predictors of knee pain:</u> Age (≥55yrs) BMI (≥29.0 kg/m ²) Ex-smoker Previous knee injury <u>Persistence of knee symptoms:</u> Age (45-54yrs) Job dissatisfaction	2.3 (1.4-3.9) 1.8 (1.1-3.1) 1.6 (1.1-2.2) 2.4 (1.7-3.5) 3.7 (1.4-9.8) 2.8 (1.0-7.8)
(Baker et al., 2003)	Cross-sectional study	2806 men aged 20–59 years in Southern England	Lifetime occupational and sporting activities	Knee symptoms lasting >24 hours)	Prevalence of knee pain 54%		
(Rossignol et al., 2003)	Cross-sectional study	10 412 patients in France	Occupations: agriculture, white collar workers, blue collar workers, “mixed” collar workers	Symptomatic OA and functional and work limitation	One third of patients had OA of the knee, 16% of the hip, and 12% of the hand; a third had multiple joint OA		

Table 1.4 (cont) Summary of results on the literature review of physical and psychosocial risk factors and lower limb pain

Study	Study design	Study population	Exposure measured by	Diagnostic criteria	Results	Comparison	Results Effect estimate (95% CI)
(Chen et al., 2004)	Cross-sectional study	1242 taxi drivers	Self-administered questionnaire	Self-reports of knee pain using the Nordic questionnaire	Prevalence of knee pain in the last 12 months was 19% and the mean age of 44.5±8.7 years	Driving >6 hours compared to ≤6 hours	2.52 (1.36- 4.65)
(Thelin et al., 2004)	Case-control study matched for age	427 farmer and controls in Sweden	Exposure data for the years before the symptoms started, height and weight	Personnel at the local service units were asked to identify farmers who had hip symptoms	Mean age of cases was 61.8 years	Milking more than 40 cows daily Working (>5hrs/day) in animal barns Having a large farm area (>100 ha)	4.5 (1.9–11.0) 13.3 (1.2–145.0) 0.14 (0.05–0.43)
(Holmberg et al., 2004)	Case-control study	778 subjects and 695 matched controls (by age, gender and country) in the Southern part of Sweden	Occupations, sporting activity, smoking and stress	X-ray verified OA in the femorotibial joint	High BMI and a previous knee pathology were risk factors but smoking was protective, the mean age of participants was 62.6±5.2 years	Men working 10-30 years in the building and construction industry	3.7 (1.2–11.3)
(Jinks et al., 2007)	A multi-method approach: cross-sectional (n=5784). and qualitative study	A population survey of adults aged 50 years and older at 3 general practices in Northern Staffordshire	Self-administered questionnaire		The 12-month prevalence of knee pain was 49.5%.		
(Messing et al., 2008)	Cross-sectional study	20773 completed self-administered questionnaire from the 1998 Quebec Health and Social Survey (Canada)	General work postures and work-related psychological factors	Pain in lower legs/calves or ankles/feet during the previous 12 months	9.4% reported significant ankle/foot pain, and 6.4% had lower-leg/ calf pain both strongly associated with prolong standing		

1.2.3.2 Cultural/ethnicity risk factors

Ethnicity refers to a community which shares a common ancestral origin, language, belief and traditional background (Rahim-Williams et al., 2007). The terms race, ethnicity and culture have no generally agreed upon definition. Ethnicity and culture may be difficult to disentangle or may have been imprecisely described in studies. This literature review, therefore, uses the terms as reported in the particular study or where no term is specified, simply reports the descriptor used in the study.

Various patterns of belief and behaviour are associated with the human response to illness, injury and premature death (Kennedy, 1973). Ethnicity has been shown to be a powerful predictor of health-related outcomes, beliefs and behaviours (Lipton and Marbach, 1984). Furthermore, recent evidence suggests that a person's beliefs and expectations play an important role in predicting the outcome in people suffering from back and arm pain (Boersma and Linton, 2006; Ryall et al., 2007). In contrast, several studies have demonstrated no difference in the pain threshold of patients of different ethnic backgrounds, but rather that different expressions of pain may occur due to the circumstances associated with the pain. For example, the different expressions of pain for African black, Irish, Italian, Jewish and Puerto Rican were not due to ethnicity but medical acculturation, social assimilation, duration of pain and the level of psychological distress (Ortega et al., 1999).

A population based cross-sectional survey of South Asian and European populations in the UK showed that the age and gender-adjusted pain prevalence in South Asians was almost four-fold that in Europeans (Palmer et al., 2007). There was marked variation in the reporting of widespread pain and general practitioner (GP) consultations between groups of South Asians formed along linguistic, religious and geographical lines. If the degree of acculturation (the extent to which immigrants take on the culture of their host population) among the South Asian population was low, the prevalence of pain was found to be high. The association between culture and widespread pain may be influenced by psychological distress, work-related psychosocial factors and attitudes to health and illness behaviour which were not mentioned in the study. There was also a poor response rate (51%) and participants were largely recruited from poor socio-economic areas. The results of the study may therefore not be generalizable (Palmer et al., 2007).

A survey was conducted on six groups of workers defined by combinations of job content (regular use of computer keyboards in offices or repetitive manual tasks with the hands and arms) and ethnicity (Indian or UK of Indian sub-continental origin or UK white) (Madan et al., 2008). Absence due to sickness in the past year was higher in the UK white than in the Indian group. Poor mental health was more common in white UK manual workers and those of Indian sub-continental origin (46% and 51% respectively) than in the Indian manual workers (14%). Most study participants believed that their work could cause musculoskeletal pain. However, knowledge of work-related MSDs ranged from 1% among the manual workers in India and 16% in office workers in India to 86% in UK white manual workers and 95% in UK white office workers. Most striking, however, were the much lower rates of symptoms at all anatomical sites among manual workers in India. By design, physical exposure in the three ethnic groups was similar for the three groups of manual workers and three groups of office workers. The prevalence of lower back pain in the last month was 15% for Indian manual workers which was only about half of that in the UK white manual group (37%) and UK of Indian sub-continental origin manual workers (33%). The survey showed major differences in the prevalence of musculoskeletal symptoms and associated disability between workers in India and the UK. The authors concluded that the differences could not be explained by differences in established physical risk factors or mental health (Madan et al., 2008) with ethnicity being the possible reason for the differences among UK workers and Indian workers. That workers from India had less knowledge about work-related MSDs may partly explain the differences in pain prevalences. Societal belief about illness and its causation has been shown to play an important role in its occurrence (Madan et al., 2008). Furthermore, economic factors such as the amount of paid sick leave and financial compensation for occupational injuries may differ in the UK and in India and have influenced the results of the study.

1.2.3.3 Conclusion

For upper limb pain, physical risk factors include working with arms above shoulder level and other awkward postures (for example, with trunk flexed forward), hand-arm vibration, repetitive movements, pushing and pulling, and carrying loads supported by the shoulder (Bjelle, 1989; Bernard, 1997; Devereux et al., 2002; Bongers et al., 2006). Many of the studies on upper limb focused on the neck and shoulder. Macfarlane and colleagues (2000) found that upper limb pain and neck pain was often associated with other regional pain (back, lower limb or other part of the upper limb). This finding is

particularly important in establishing physical exposure as pain in other sites may influence how patients perform their work-related activities. Most studies of the upper limb have not examined physical exposure exclusively and often presented significant findings in terms of work-related and individual characteristics and psychosocial factors. These included sex, high job demand with low control, intensified work load, time pressure; monotonous work; low support from co-workers and management; and high BMI and smoking (Devereux et al., 2002).

Despite a large number of studies, the aetiology and risk factors of work-related back disorders are not well understood (Van Vuuren et al., 2005a). However, it has been shown in the literature that back disorders are multifactorial in origin and associated with occupational and non-occupational risk factors, work-related psychosocial and non-work related factors and characteristics (Bernard, 1997). The physical risk factors associated with lower back pain are work-related lifting and forceful movements, work-related awkward posture (twisting and lateral bending), static work posture and WBV (Lötters et al., 2003). The literature provides evidence suggesting that whole body vibration (WBV) may act in combination with other work-related factors, such as prolonged sitting, lifting and awkward postures, to cause increased risk of back disorder. For lower back pain, it appears that socio-cultural factors, personal mental health (low mood), somatising tendency and health beliefs are important influences on the development and persistence of pain (Dionne et al., 1997; Thomas et al., 1999; Oleske et al., 2000; Linton, 2000; Kopec et al., 2004; Pincus et al., 2002; Solidaki et al., 2010; Matsudaira et al., 2011). Widespread pain and persistent pain may be predicted by somatisation and poor mental health, illness behaviour and poor self-report of health (SRH) (Gureje et al., 2001; McBeth et al., 2001; Mäntyselkä et al., 2003; Eriksen et al., 2004).

For the lower limb, most of the recent studies focused on knee and hip pathology. Risk factors identified for knee pain were kneeling and squatting, walking more than two miles (3.2 km) per day, lifting heavy weights of more than 25 kg in the course of their work and climbing stairs. Risk factors for presenting with hip pain were obesity, previous injury or hip deformity, generalised susceptibility to OA in multiple joints, heavy lifting or frequent walking over rough ground and exposure to vibration from driving, for example agricultural machinery.

Psychosocial factors and personal mental health have been shown to be important influences on the development and persistence of lower back pain (Dionne et al., 1997; Thomas et al., 1999; Oleske et al., 2000; Kopec et al., 2004). However, such factors have been less commonly considered in relation to arm pain. Many cross-sectional studies reported associations with psychosocial risk factors, but the results are inconsistent across studies (Leclerc et al., 2004). Pain can often result in anxiety and depression which may also influence the worker's current job situation (avoid high risk exposure jobs or be placed in less demanding jobs i.e. healthy worker' effect bias) (Eriksen et al., 1999). No study reviewed examined the role that psychosocial factors played in the presentation of lower limb pain.

Ethnicity refers to a community who shares a common ancestral origin, language, belief and traditional background and has been shown to be a powerful predictor of health-related outcomes, beliefs and behaviours (Rahim-Williams et al., 2007). Ethnicity has been shown to play an important role in predicting the outcome in people suffering from back and arm pain but has not been investigated in the mining industry and for lower limb pain.

1.3 Study justification, aims and objectives

1.3.1 Introduction

A large number of risk factors for MSDs have been identified in a number of epidemiological studies, work population surveys and clinical studies. Convincing evidence suggests that there are causal relationships between many physical risk factors particularly when these risk factors were combined with certain individual characteristics. The individual characteristics of a person may influence the biological, clinical and disability responses to a MSD, which are in turn dependent on the physical, psychological and social features of the individual. How the development and persistence of MSDs and resultant disability is influenced by physical activities, mental health and possibly culturally determined health beliefs, have important practical implications especially for strategies aimed at preventing work-related MSDs (Coggon et al., 2012).

1.3.2 Justification for studying MSD in mining in South Africa

Despite the size of the mining industry, globally there is a relative paucity of research on the extent and nature of MSDs in the industry, especially on psychosocial and ethnic factors. Many risk factors have been identified and lower back pain and knee pain have been reported frequently. Few of the studies thoroughly examined non-physical risk factors and many of the studies included injuries and accidents as MSD outcomes.

Although small in number and cross-sectional, South African studies have found high prevalences of MSD in a range of non-mining workplace settings. Lower back problems were particularly common. Generalising the findings to the workforce as a whole should be done with caution given the relatively small samples in selected industries and study design limitations.

Relatively little is known about the incidence of MSDs and the risk factors associated with MSD in the South African mining industry. No research has been done to determine the risk factors associated with MSDs in South African mineworkers for the different mining commodities (coal, gold and platinum) comprising the vast majority of the workforce. The lack of information on the incidence and risk factors for MSDs in the South African mining industry is a significant shortcoming, particularly as it has been

predicted that the greatest increases in MSDs will be in developing nations and the cost of MSDs has been shown to be substantial in England, USA and Europe. Understanding determinants of MSDs in the mining industry in South Africa may also assist in understanding the global causes of MSDs.

The Mine Health and Safety Council commissioned this study because there were no studies on MSDs in the South African Mining Industry.

1.3.3 Study aims

The primary aims of this study were to determine the incidence of musculoskeletal disorders at three South African mines from the three commodities that represent the vast majority of mineworkers; and to examine associations between selected risk factors (i.e. physical, psychosocial and language) and MSD. The study did not limit subjects to only those with work-related MSDs and included all major anatomical sites, namely upper limb, lower back and lower limb.

1.3.4 Study objectives

- To determine the incidence of musculoskeletal disorders at a South African coal, gold, and platinum mine.
- To describe the anatomical sites of MSDs disorders reported by the mineworkers, the occupations and physical activities of these mineworkers and the sick leave and disability associated with the MSD at a South African coal, gold and platinum mine.
- To examine associations between MSDs reported by the mineworkers and mental disorders – as measured by the Self Reporting Questionnaire-20 (SRQ-20)-, significant life events (health, assault, fright and financial problems) and social functioning (personal and work relationships and ability to relax).
- To examine the association between MSDs reported by mineworkers and their home language.
- To examine the association between MSDs reported by the mineworkers and usual and recent physical activities at work.

CHAPTER 2 MATERIALS AND METHODS

2.1 Introduction

In this chapter, a description of the study setting and the study population will be provided. Furthermore, the tools used to assess musculoskeletal disorders (MSDs) and the risk factors for MSDs, quality control methods employed and data management and analyses will be presented.

2.2 Study design

In order to determine the incidence of MSDs at the three mines (coal, gold and platinum), mineworkers presenting to the three mine primary care services with a MSD were recorded over a full six month period. A nested case-control study to investigate possible risk factors or predictors for mineworkers presenting with MSDs (cases) to the mine clinic was done using mineworkers with other medical conditions presenting to the same mine clinic as controls.

The study had a mixed design i.e. an incidence study to identify all mineworkers presenting to the mine clinic with a MSD and a nested case-control study involving consenting cases and controls to investigate associations and risk factors. The strength of the case-control design is that many risk factors can be studied at the same time and in the study there were many explanatory variables (over 21 explanatory variables were used in the analysis). Case-control studies are relatively simple and economical to carry out and are increasingly used in studies to investigate accidents and injuries (Paul, 2009). The reason for using a case-control study as opposed to a cohort study was that in the South African mining industry there is a high turnover of mineworkers and many of the mineworkers' homes are in other provinces or countries which would have made follow up very difficult. Loss to follow-up was therefore a major consideration. Even for mineworkers who may still have been employed, over 80% work underground and do variable shifts and would not have been readily available to be interviewed so following-up a large cohort of mineworkers with limited resources would not have been feasible. Matching was considered unnecessary because it was anticipated that large numbers of mineworkers with MSD would be recruited into the study thus providing sufficient data to adjust for confounding in the analysis. Additionally, sex was not an issue because all

mineworkers were men; and the method used to take account for age (or age band) was adjustment rather than matching.

2.3 Study plan and mine selection

As part of the planning phase of the study, a workshop was held with international and local experts on work-related MSDs. The objectives of the workshop, attended by industry representatives, academics and the researchers involved, were to discuss the MSDs in a mining context and to discuss practical aspects of the design of the study, diagnostic criteria for classifying cases, selecting suitable controls and non-occupational risk factors likely to be important in the industry (psychological and cultural influences). Active involvement of labour, management and the primary care staff was achieved from the planning to the implementation of the study. The PhD research protocol was written by Dr Dias (primary investigator) based on literature, the workshop discussions and input from supervisors.

One mine was selected from each of the three major commodities (i.e. coal, gold and platinum) which employ the vast majority of mineworkers in South Africa. The study was limited to three mines due to available resources and therefore formal sample calculations could not be considered. Convenience sampling, on an invitation-response basis, was used to select the three mines for participation in the study. Convenience sampling was chosen because unwilling mines recruited by random sampling would have hindered access and data collection. They were all underground mines, all gold and platinum mines are similar whereas coal mines are highly mechanised (Ross M, personal communication, 2013). The three mines were selected from three different leading mining companies that all provided in-house medical services to workers and at which there was support from both employers and labour for the research. Labour support in unionised mines is essential for research conducted on the mines in South Africa.

2.4 Study setting

2.4.1 The Coal Mine

The coal mine was located in Mpumalanga, about 20 km west of Kriel. The colliery lay on the western portion of the Witbank coalfield. Production at the coal mine was

achieved by means of board-and-pillar methods with continuous mechanised miners and wall mining in the coal seams. The mining infrastructure included three vertical shafts capable of producing 14-million metric tonnes of coal a year. Coal from the mine was transferred from underground conveyors onto surface conveyors. The conveyors fed the silos. Coal was transferred from the silos through line conveyors to feed the screening plant. The plant capacity was rated at 1 200 tonnes per hour through the crushing circuit.

All 1 073 mineworkers at the coal mine had medical aid and had to select a primary service provider of their choice, either the practitioners at the mine clinic or a general practitioner in the community. All mineworkers who consulted the mine clinic or a general practitioner in the community of their choice, had to report to the mine clinic before returning to work in order to assess their fitness for work. Therefore, mineworkers presenting with a MSD to service providers outside of the mine, still needed to report to the mine clinic, and would be identified for recruitment into the study.

2.4.2 The Gold Mine

The gold mine was located in South Africa's West Wits Line goldfield, about 60km south west of Johannesburg. The gold mine is part of the Witwatersrand Basin. Gold mineralisation occurs at depths between 1,000m and 4,000m below surface and the gold is hosted within two major orebodies: the Carbon Leader Reef (CLR) and the Ventersdorp Contact Reef (VCR). A third body, the Middelvlei Reef (MR), is a minor contributor to the resource base.

The gold mine had limited opportunities for increasing workplace mechanisation. It comprised eight operating shaft systems, which access the VCR and CLR. The mine was a large, well-established deep to ultra-deep-level gold mine. The gold mining group produced 4.3 million ounces (121 900 700 g) of gold in the study year of this research project. The mine used in the study belonged to a mining group and in the company annual report for the mining group there was extensive seismic activity and underground fires reported. However, information on similar events for the study mine during or just before the study period was not available.

The mine clinic offered primary and secondary medical services, 24 hours a day, seven days a week to all employees of the mine. Five primary care nurses examined approximately 200 mineworkers per day. Mineworkers who attended the mine clinic lost a day of work by default (because the mine lift transports mineworkers only at the beginning and end of the shift). Therefore, the nurse either signed them off for that day (with or without prescribing medication), or referred them to the doctor for further medical assessment. An adjacent mine occupational clinic offered occupational health services to all 17 571 mineworkers for periodical medical examinations.

2.4.3 The Platinum mine

The platinum mine belonged to a mining group producing over 900,000 ounces (25 514 100g) of platinum. Their operations were located near Rustenberg, in the North West Province of South Africa. Underground mining predominated, although open cast mining has been undertaken at all three of the operational units included in the study.

The mine clinic and adjacent hospital offered primary and secondary medical care to approximately 7 090 of the mineworkers (24-hours per day, seven days a week).

2.5 Study population

The study population included all mineworkers employed at each mine during the study period who were eligible to attend the mine clinics during the study period. Mineworkers were defined as employees working underground, on the surface or both. Mineworkers' dependants, contractors, administrative staff and mine professionals (for example mine engineers, mine managers and mine medical staff) were excluded from the study. The number of mineworkers fulfilling the criteria set for the study on the gold mine and was 17 571. The corresponding numbers for the coal and platinum mine participating in the study were 1 073 and 7 090 respectively. The number for the study population was obtained from the Human Resources (HR) department at each mine.

2.6 Study participant selection

For each mine, a trained nurse practitioner – hereafter the research nurse - was appointed (who was not employed by the mine) and who was based in the coal, gold and platinum mine clinics during the study period. All mineworkers who presented with MSDs first consulted the clinic for initial assessment by the mine clinic nurse. The

nurses and doctors at all three mines were requested to refer all mineworkers presenting with a MSD to the designated research nurse (who formed part of the project team) for a structured interview and medical examination once written consent was obtained. The research nurse would then refer study participants back to the clinic nurse to be referred to a doctor or hospital if further assessment or treatment was required. For each interviewed case, the next mineworker consulting the same clinic nurse for a condition not related to a MSD was referred to the research nurse as a control, provided the mineworker agreed to participate in the study (see Section 2.9).

The primary investigator and research nurses were trained at a workshop held at each mine with Prof Keith Palmer and colleagues from the Medical Research Council (MRC) at the University of Southampton, UK. Each research nurse was also trained by the primary investigator to use the questionnaire. The three month period before the start of the study (October – December) was used as a trial period to ensure the research nurses were properly trained and quality control measures were in place.

All nurses at the mine primary care clinic received training on the presenting signs and complaints of patients with MSD. If the primary care nurse was uncertain about the diagnosis of patients presenting with possible MSD, the doctors at each medical clinic assessed such a subject before referring the patient to the research nurse. Figure 2.1 is a schematic representation of the study design.

2.6.1 Diagnostic criteria for cases

The research nurses assessed cases during normal working hours for the six month study period. Cases were mineworkers presenting to the clinic nurse or doctor with a MSD (Figure 2.1). Complaints arising from acute traumatic injury (e.g. crush injuries, fractures, bruises, dislocations or amputations) and skin conditions (e.g. herpes zoster or fungal infections) were specifically excluded. Mineworkers presenting with a specific injury resulting in lower back pain were included. However, if an external force was responsible for the lower back pain e.g. object hit the lower back or the mineworker fell on his back/buttock, the mineworker was excluded as a case.

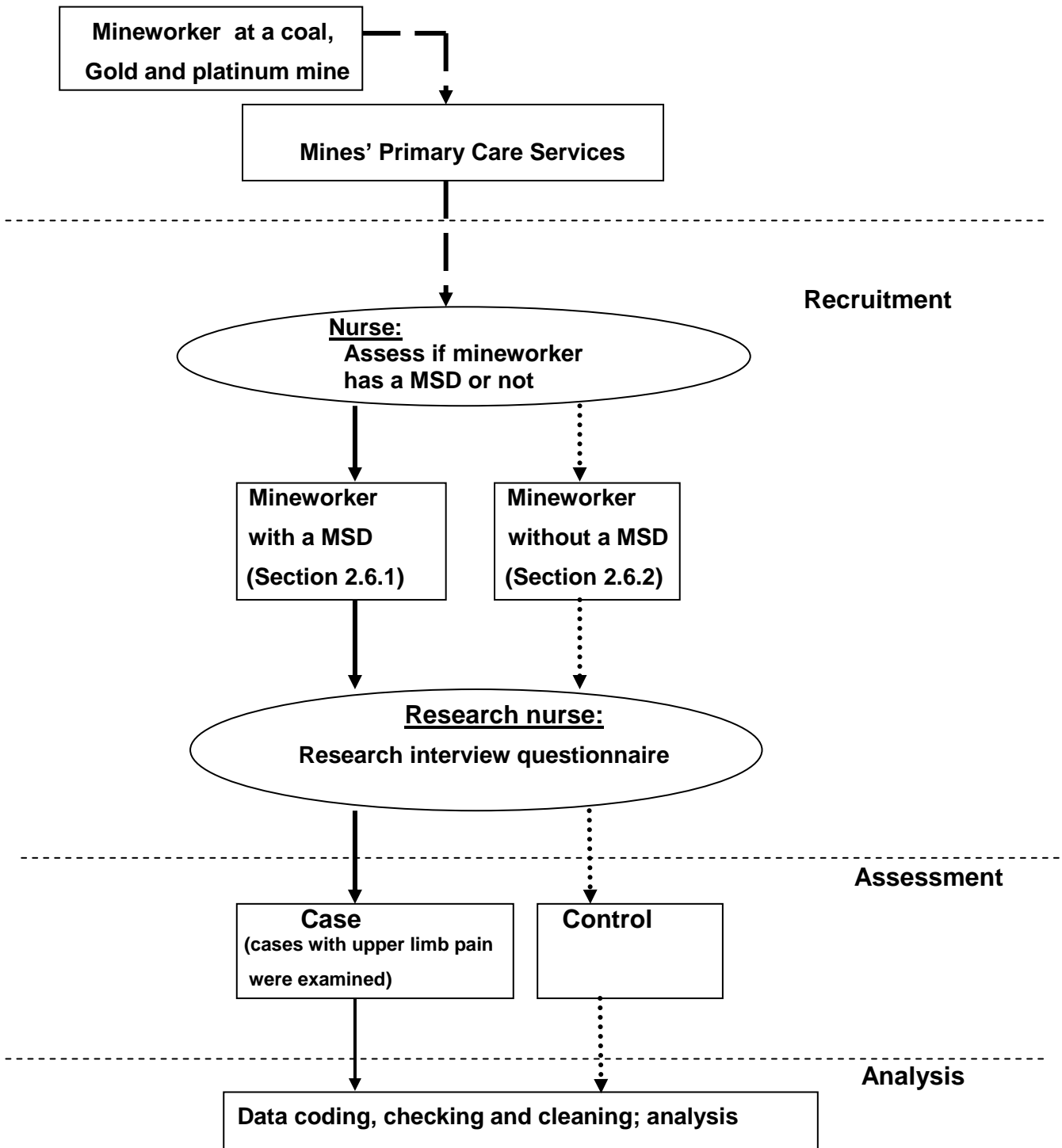


Figure 2.1 Schematic diagram of study design

Note:

— — — — —> Mineworkers from the coal, gold and platinum mines presenting to the primary care services.

—————> Mineworkers with a musculoskeletal disorder.

.....> Mineworkers with a diagnosis not related to a musculoskeletal disorder.

Injuries or complaints due to sports activity were not specifically asked in the questionnaire but research nurses would ask about accidents/injuries related to work and leisure (including motor vehicle accidents).

2.6.2 Selection of controls

For each interviewed case, the next mineworker consulting the same clinic nurse for a condition not related to a MSD was referred to the research nurse as a control, provided the mineworker agreed to participate in the study. As with cases, subjects attending by reason of an accident were not considered except for laceration (cuts by sharp objects).

If the patients declined to participate as a control, the next available patient fulfilling the defined criteria was used. If a suitable control was not found directly after the case or if the research nurse was not able to interview a control because she had cases to interview and examine, the research nurse asked the clinic nurse to refer a mineworker without a MSD the following day more or less at the same time she had obtained the case. Control subjects were not examined.

2.6.3 Response rate

Mineworkers presenting with a MSD were asked to take part in the study. The number of cases who did not give consent to be interviewed and examined was five at the coal mine, 121 at the gold mine and 23 at the platinum mine. The response rate was 92.9% at the coal mine, 87.2% at the gold mine and 96% at the platinum mine. There are an unequal number of cases (n=691) and controls (n=701) because repeat attendees were excluded during the data management stage. Each study participant was only recorded once during the study period. Therefore, if the study participant was a case and presented later with another MSD or was referred as a control he would not be included for a second or more times in the analysis. Similarly for controls, even if the same participant presented with a MSD later during the study period, he was not analysed as a case (there were nine controls who later presented with a MSD).

2.7 Outline of data collection

The main data collection tool was a questionnaire administered by the research nurse for cases (Appendix A) and controls (Appendix B). Physical risk factors, occupation, service record in current job and a profile of typical activities associated with mining

tasks were recorded. Level of education, questions to determine if mineworkers had a possible mental disorder (SRQ), life events and social functioning were recorded in order to determine psychosocial risk factors. Home language was used as a surrogate for ethnicity. The questionnaire was based on a modified Nordic questionnaire used by the Health and Safety Executive in the United Kingdom which was developed to identify the extent of musculoskeletal problems in the UK workplace (Dickinson et al., 1992). Cases were referred to a schematic outline of different body regions (Appendix C) to show the research nurse which areas were affected so that the correct body regions were identified. Cases presenting with an upper limb pain were examined using the Southampton Examination Schedule (Appendix D). For every case assessed, the research nurse would follow up when the mineworker was back at work. The length of sick leave taken by each case was recorded (Appendix E).

2.8 Questionnaire and examination

2.8.1 Measurement tools for psychosocial determinants

A questionnaire developed by the Medical Research Council in the UK formed the basis for the data collection tool. After site visits to the primary care clinics of the project mines, and consultations with the occupational medicine practitioners at these clinics, it became evident that minor changes to the questionnaire were needed to suit South African conditions. The part of the questionnaire used by the Health and Safety Executive in the United Kingdom to assess psychosocial factors was the GHQ (General Health Questionnaire) (Winston and Smith, 2000), which is the most widely used instrument in the UK. At the time of the study, the GHQ was not validated for the South African population whereas the SRQ has been used in many studies in South Africa and other developing countries.

Standardised questionnaires (i.e. Nordic questionnaire) have become an important part of epidemiological research because they are often simple and easy to use (Winston and Smith, 2000). There is a concern that they may be culture sensitive and therefore may not be applicable in different settings (Winston and Smith, 2000). The two most commonly used trans-cultural research instruments to assess psychosocial risk or the study participants' mood in MSD studies are the Self-Reporting Questionnaire (SRQ) and the GHQ (General Health Questionnaire) (Harding et al., 1980). The GHQ is the

most widely used instrument in the UK. The GHQ consists of common psychiatric symptoms and has been validated in the UK and in the USA and validated against other psychiatric instruments e.g. the Present State Examination (PSE) and the Clinical Interview Schedule (Winston and Smith, 2000). The SRQ was developed by the World Health Organization as a case-finding instrument to be used in developing countries. The questionnaire was compiled by a group of experts from items extracted from four established instruments (i.e. PSE, GHQ, the Patient Self-report Symptom Form (PASSR) and the PGI Health Questionnaire N2) (Harding et al., 1980). Although the GHQ and SRQ have been used in a variety of developing country settings, they were always foreign or external to the cultural setting i.e. not derived from within the culture (Winston and Smith, 2000).

In a Welsh primary care setting, the SRQ and GHQ were evaluated against two other case finding instruments, i.e. Mental Health Index and Shona Symptom Questionnaire, all four questionnaires performed adequately within a primary care setting. It was highlighted that these screening instruments do not identify a disorder directly but identify the individuals at greater or lesser risk of displaying a mental disorder (Winston and Smith, 2000).

After consultation with Dr T Burmeister, Consultant Psychiatrist at the University of the Witwatersrand and principal investigator of a study to assess the prevalence of mental disorders in a rural Black population in Limpopo Province and the (former) Cape Province, it was decided to include (in addition to the SRQ), life events and social functioning questions for the cases (Appendix A) and controls (Appendix B) based on the following sources:

- Questions adapted from the Life Events and Difficulties Schedule (Brown and Harris, 1989).
- Questions adapted from a rating scale for Social Functioning developed for use with patients with schizophrenia (Stevens, 1972).

2.8.2 Measurement tools for musculoskeletal disorders

The exact nature of MSDs is difficult to determine because the term covers a heterogeneous group of clinical disorders and non-specific regional pain syndromes (Palmer et al., 1998). Investigations have been hampered by the lack of an accepted

measuring instrument for use in the screening and diagnosis of MSDs (Palmer et al., 1999). Nevertheless, subjective symptoms of MSD are useful in population-based surveys because these symptoms can be used across groups of workers from different industries, are easy to measure and have been validated in epidemiological studies (Punnett and Wegman, 2004a). Subjective symptoms are also important because they are the reason for health seeking behaviour and resultant sick leave and productivity loss (Punnett and Wegman, 2004a). A tool commonly used in occupational settings to determine the presence of MSD symptoms is the standardized Nordic questionnaire (Kuorinka and Forcier, 1995). Some aspects of the questionnaire can be self-administered or used in interviews, and it is well suited for studying the history of musculoskeletal symptoms and disability. The reliability of the questionnaire has been found to be acceptable (Kuorinka and Forcier, 1995), but may be subject to poor recall by subjects, because questions include musculoskeletal symptoms and problems experienced during the previous 12 months. The standardised Nordic questionnaire was used in this study.

2.8.3 Languages used to administer the questionnaires

The SRQ questionnaires for cases (Appendix A) and controls (Appendix B) were translated into Zulu, Xhosa and Tswana and then independently back-translated into English. The English, Zulu, Xhosa and Tswana versions were piloted in a sample of mineworkers, different from those used in the main study. The SRQ questionnaire had two questions which were shown during the pilot study to be understood by mineworkers as being the same question. Therefore, only one of the questions was included to eliminate confusion. The questionnaire was administered in the preferred language of the study subject.

2.8.4 Format of the questionnaire for cases

The questionnaire (Appendix A) had six sections, the details of which are given below:

Section 1 Musculoskeletal complaint

This section determined which region of the body was affected. Questions to exclude injuries due to accidents (except for back pain) and dermatological conditions affecting the region were included.

Section 2 Demographics

In this section information regarding age, level of education, ethnicity and handedness of the subjects was obtained. In addition, information on marital status, number of children, and how many people were financially dependent on the study participant, was elucidated in order to assess potential social stresses.

Section 3 Occupational exposure

This section of the questionnaire aimed at determining the occupation/job description of the study participant. Details of the service record in the current job were also requested. A profile of typical physical activities associated with mining tasks was selected and included the following:

- Overhead reaching for loads, tools, or mining equipment
- Bending at the waist to handle loads, tools or mining equipment
- Twisting at the waist to handle loads, tools or mining equipment
- Repeatedly carrying, lifting or lowering loads of more than 25 kg
- Climbing up or down stairs or a ladder with loads, tools or mining equipment
- Pushing loads, tools or mining equipment
- Pulling loads, tools or mining equipment
- Working with the hands above shoulder height
- Operating equipment or tools above shoulder height
- Shovelling
- Barring
- Working in tunnels where it is not possible to stand upright
- Kneeling or squatting
- Repeated bending and straightening of the elbow
- Using a vibratory tool

The above activities were based on the National Institute for Occupational Safety and Health (NIOSH) ergonomics checklist and each task was accompanied by a photograph of a miner engaged in the activity. Study participants were asked to indicate the usual frequency of their involvement in these tasks for the last week. The focus of this study was not to measure physical exposure objectively.

Section 4 Psychosocial issues

The objective of this section of the questionnaire (which was in the questionnaires for cases (Appendix A) and controls (Appendix B)) was to assess if the study participant had a possible mental disorder, experienced a significant life event or had problems with social functioning. The number of positive responses to the questions from the SRQ was added and a score of eight or more suggested the mineworker may have a possible mental disorder. This cut-off has been used in studies conducted in South Africa using the SRQ (Tomlinson et al., 2007).

There are life events which may influence the reporting of MSDs. The following questions were used from the Life Events and Difficulties Schedule:

- Have you had a problem with your health or nerves?
- Have you been assaulted or beaten up in the last couple of weeks?
- Have you been in a situation that was extremely frightening or horrifying?
- Have you had any difficulties relating to finance?

Questions on relationships (roommates, wife and/or family), at work (time management and relationship with supervisors and colleagues) and ability to relax were asked to determine social functioning.

Section 5 History of symptoms and disability

Following section 1, detailed questions on site of pain (including neck, shoulder, elbow, wrist/forearm/hand, upper back, lower back, hip, knee, foot/ankle and numbness/tingling), based on the Nordic questionnaire (Kuorinka and Forcier, 1995) were included in this section. The Nordic questionnaire was modified to include upper limb neurological symptoms (numbness and tingling), finger blanching and the need for treatment with steroid injection (Palmer et al., 1999). A picture of the human form with nine body areas defined and shaded was shown to each study participant to ensure that the correct body region was being referred to (Appendix C). Furthermore, information with respect to history of similar symptoms, treatment received in the past and the duration of symptoms and the interference with work and leisure activities was recorded. If the MSD restricted or prevented normal function, for example, if the mineworker with shoulder pain indicated that pain in the shoulder made it difficult or impossible to sleep, get dressed, get tools down from the high shelves or/and wash his

hair, then his MSD would be considered disabling. For each region, similar questions were asked on how the pain affected their ability to work and do basic functions appropriate for that region.

Section 6 Alcohol and smoking consumption

The amount of alcohol consumed during the week and each day of the weekend was requested. This included, beer, wine and spirits. The amount was recorded as grams of alcohol per week. Regarding smoking, the number of cigarettes smoked and for the duration (number of years) was requested for current and ex-smokers.

2.8.5 Format of questionnaire for controls

The questionnaire for controls (Appendix B) was the same as the questionnaire for cases, except for the first section and the fifth section. The first section recorded the main complaint and was followed by questions to ensure that the control did not have a musculoskeletal injury or musculoskeletal disorder. The sections on demographics, occupational exposure and psychosocial issues were identical to the corresponding sections of the cases' questionnaire. The questions in the fifth section aimed at establishing whether the control had presented with a musculoskeletal disorder within the previous year or before, and to indicate which region of the body had been affected. The questions in the last section i.e. alcohol and smoking consumption were identical to those posed to the cases.

2.8.6 The Southampton Examination Schedule

Cases with upper limb or neck pain had a standardised examination done by the research nurse (Appendix D). These regions were selected for physical examination because there is an existing examination schedule which has been validated (Palmer et al., 2000; Palmer, 2007). The examination entailed recording the location of pain at the shoulder, elbow, wrist and hand; eliciting signs of tenderness and pain on resisted movement at these sites; conducting three standard clinical provocation tests (Finkelstein's test, Phalen's test and Tinel's test); and searching for tender spots, as described in the American College of Rheumatology criteria for the diagnosis of fibromyalgia (Wolfe et al., 1990). The range of shoulder movement and neck movement was measured using a plane inclinometer (pleurimeter) and a goniometer for external rotation of the shoulder, as previously described (Norkin and White, 1985). Individual

physical findings were combined to yield diagnoses using the consensus criteria of the Birmingham workshop (Walker-Bone et al., 2002a).

2.8.7 Training of research nurses

The medical and nursing personnel participating in the data collection at the respective mine clinics were well briefed on MSDs and procedures pertaining to the study. The research nurses participating in the study underwent intensive training by a trainer from the Medical Research Council, University of Southampton, United Kingdom and/or the primary investigator on the project team. These intensive training sessions were aimed at standardising assessment procedures and minimising inter- and intra-observer variation. Three individuals were taken to all three research nurses and examined within one week. The examination results for the three individuals were found to be in agreement for all three research nurses but the sample size is too small to make definitive conclusions about inter-observer agreement.

2.9 Quality control

The primary investigator was responsible for the quality assurance of data collection during the structured interview and examination by the research nurse, as well as the implementation of measures to ensure, as far as practicable, that no potential MSD cases were missed during the study period. In general, research nurses were visited by the primary investigator at weekly intervals and mentored on an on-going basis during the study period.

Initially, the primary investigator was present during consultations at the weekly visits and checked that all questionnaires were completed correctly, after which the primary investigator performed random quality control checks. Similar checks made for cases were made for controls and steps were taken to ensure that no participant in the control group had a MSD and that each case referred to the research nurse had a corresponding control.

2.10 Musculoskeletal disorder cases and records

MSD cases were mineworkers presenting to the clinic with a MSD, who were referred to the research nurse by the primary health nurse and who provided consent to be interviewed (and if required, examined). **MSD records** were records of mineworkers

who presented to the mine clinic with a MSD but were not seen by the research nurse. The reasons for not being seen by the research nurse were: not providing consent to take part in the study, presenting to the clinic after-hours or “missed cases” (i.e. referred by the mine sister to the research nurse but even after giving consent did not go through to the research nurse for a variety of reasons). As each of the mine clinics was managed differently, it was necessary to implement site-specific quality control measures to ensure that no cases were missed. These are described for each mine.

2.10.1 Musculoskeletal disorder cases and records at the coal mine

The clinic nurses at the coal mine were required to fill in a form stating the mineworker’s company number and diagnosis for all patients seen at the clinic. These included mineworkers seen by GPs in the community. This list was made available to the mine’s primary investigator to determine whether any MSD cases had been missed. The medical clinic at the coal mine operated only during office hours (7:00am-16:30pm). There was a doctor and mine clinic nurse available after hours and over weekends for emergencies only e.g. injuries. Therefore, mineworkers presenting with MSDs would be seen only during office hours when the research nurse was present.

2.10.2 Musculoskeletal disorder cases and records at the gold mine

A screening form was issued to every mineworker who presented to the gold mine clinic. The date, the mineworker’s company number and indication if the mineworker had an MSD or not was recorded on the screening form. The clinic nurse completed this form after seeing every mineworker during office hours as well as after hours. The primary investigator collected these forms at the end of each week to determine clinic attendance and number of mineworkers presenting with a MSD. The primary care nurse left all the medical files of mineworkers presenting with MSD after hours for the research nurse because those presenting during the day would have been referred to the research nurse. The following morning the research nurse would go through the medical files and complete MSD records. The MSD records contained three questions to determine that the subjects’ main complaint was musculoskeletal in nature and not related to an injury, recent accident or skin condition.

2.10.3 Musculoskeletal disorder cases and records at the platinum mine

The clerks at the platinum mine clinic kept a register of all the mineworkers presenting to a primary care nurse. In order to determine the number of MSD patients seen at the clinic after hours and over weekends, every medical file of patients complaining of a possible MSD (as suggested by the recorded complaint in the register) was reviewed by the primary investigator to assess whether the mineworker did present with MSD or not. Musculoskeletal disorder records were completed from the medical files reviewed for patients presenting after hours with MSDs.

2.11 Data management and analysis

The data from the questionnaires were entered into the database twice, by two independent individuals. The two datasets were compared to correct for any anomalies with data entry. Basic editing of the data involved checking each variable for impossible or unusual values. The data cleaning and clinical findings from the Southampton Examination Schedule were done by the Medical Research Council at the University of Southampton. Questionnaires with insufficient information and all duplicate entries (i.e. cases or controls presenting twice or more times to the clinic) were excluded. The entire distribution of each variable was examined to exclude errors, for example with programming using cross-tabulations. The statistical data analysis was performed using Stata Release 9, Stata Press, Stata Corporation, College Station, Texas.

Table 2.1 Number of study subjects at the time of data entry and after cleaning the data

	Coal mine	Gold mine	Platinum mine	Total
Cases after data entry	86	355	311	752
Duplicates	6	23	13	42
Entries with poor info	0	0	0	0
Cases with no presentation site depicted in questionnaire	10	3	6	19
Final number of cases	70	329	292	691
Controls after data entry	85	355	304	744
Duplicates	4	10	16	30
Entries with poor information	0	0	3	3
Controls with no diagnosis	0	0	10	10
Final number of controls	81	345	275	701

2.11.1 Incidence of musculoskeletal disorders

In order to determine the incidence of MSDs at the three mines, mineworkers presenting to the three primary care services with MSD were recorded. During office hours the clinic nurses referred mineworkers with MSD to the research nurse (cases). Mineworkers who presented after-hours were not seen by the research nurse but if they had features of a MSD they were recorded as a MSD record once the research nurse and/or primary investigator reviewed the mineworkers medical file (only to determine the incidence of MSDs and not for further analysis). The study populations at the coal, gold and platinum mine were 1 073, 17 571 and 7 090 respectively.

In the Results Chapter (Chapter 3), the incidence of MSDs is given as two values. The lower incidence estimate includes only the mineworkers interviewed by the research nurse. The higher incidence estimate includes the MSD records. The lower estimate is thus an underestimate because it does not include the mineworkers with MSD presenting after hours.

The percentage of clinical attendees presenting with a MSD was calculated using the number of mineworkers presenting with a MSD i.e. cases and MSD records as the numerator and the total number of attendances to the clinic (with acute and chronic conditions) during the study period as the denominator.

2.11.2 Descriptive statistics of cases

Means, ranges, standard deviations, percentages and/or frequency distributions with their 95% confidence intervals were used to report on descriptive statistics. The following were presented: upper limb pain, back pain and lower back pain for each mine; disability; duration of symptoms; sick leave; and physical and psychosocial risk factors and language spoken.

2.11.2.1 Grouping pain sites into anatomical regions

Pain at specific sites was grouped into anatomical regions for descriptive and case-control analyses. The anatomical regions were: (1) upper limb (which included wrist, elbow, shoulder, neck and upper back); (2) lower back; and (3) lower limb (which included hip, knee and ankle) pain. Each anatomical region was analysed separately because it is likely to have different determinants associated with the outcome,

especially with respect to physical exposure as has been shown in the literature. Cases complaining of pain at more than one site, as described in Chapter 3 (Table 3.2) were not analysed separately but were included in the analysis for the regional pain with which they presented.

2.11.2.2 Variables used for a mental disorder, life events and social functioning

An SRQ score was used as an indication that the mineworker may have a possible mental disorder. Each life event (financial difficulties, a recent medical/mental diagnosis, experiencing an extreme fright and/or assault) was included separately in the analysis. Social functioning was determined by answers to a number of questions to determine if the mineworker was having difficulties within personal relationships, at work, or with being able to relax. If the mineworker responded positively to one or more of the questions under each area (i.e. personal relationships, issues at work and/or inability to relax) it was considered separately in the analyses as positive for possible social dysfunction.

2.11.2.3 Variables used for physical risk factors and other determinants of MSD

Physical exposures which were shown in the literature to cause anatomical region pain, were included in analyses for the region. Therefore, the upper limb analysis included: carrying, lifting and lowering loads; working with hands above shoulder height; barring; operating equipment above shoulder height and working in tunnels (i.e. restricted height and awkward body positions). For the lower back analysis, physical factors included in the analysis were: bending and twisting at the waist; carrying and lifting heavy loads; pushing; using vibratory tools and working in tunnels (i.e. restricted height and awkward body positions). For the lower limb analysis, physical activities included kneeling, squatting and working in tunnels.

2.11.3. Case-control analysis

Controls may have presented with possible psychosomatic symptoms (for example, headache, malaise or gastrointestinal complaints from Table 4.7). A sensitivity analysis was conducted by comparing the odds ratio (OR) in the univariate analysis with all the controls and then with controls that did not present with possible psychosomatic symptoms (Table 4.7). Since no difference was found, the total number of controls was used in the analysis.

2.11.3.1. Univariate analysis

The univariate analysis calculated the OR for each risk factor for back, lower limb or upper limb pain without the influence of other risk factors.

2.11.3.2 Multivariate analysis with all variables (full model)

Multivariate analysis was used to determine the association between regional MSD (i.e. back, upper and lower limb pain) and all measured risk factors namely: language, SRQ score evaluation indicating a possible mental disorder, life events, social functioning, season, age, service history, area of work (i.e. surface, underground or both), educational status, alcohol consumption and smoking, mine and physical exposure. In the multivariate analysis, the reference value used for each ordinal variable (e.g. extent of alcohol consumption, age, level of education) was the lowest level of the variable (e.g. 0 g/week alcohol consumption, age 19-34 years, no education). For non-ordinal variables, (e.g. language, season), the lowest ORs calculated in the univariate analysis for each level of the variable were used as the reference level. For mine, the gold mine was the reference mine for all three body regions (i.e. upper limb, lower back and lower limb). Service history was included in the model as a continuous variable.

The variable fright (i.e. fright=1, if the mineworker had experienced an extremely frightening event) had a high OR in the univariate analysis with the potential to distort the model and a significant interaction was found between fright and study mines (a potential effect modifier). Consequently, a sensitivity analysis was conducted by repeating the multivariate analysis with only those mineworkers who had not experienced a frightening event (i.e. fright=0).

2.11.3.3 Final models (with significant determinants)

Backward hierarchical stepwise regression analysis was with the variables considered for the model having good epidemiological evidence that they were appropriate (Vittinghoff et al., 2012). Hence, all variables were initially included irrespective of the p-value in the univariate or multivariate analysis (Kleinbaum, 2002). Including language was exploratory, and backward stepwise regression appears to be the preferred method of exploratory analysis (Menard, 1995). Therefore, at the beginning of the analysis all explanatory variables were used in the model and variables were removed one at a

time. A goodness of fit (LR test) was conducted after each variable was removed to ensure that the model still fitted the data adequately. If the p-value was >0.05 the risk factor was eliminated. If the p-value was ≤ 0.05 then the risk factor remained in the model. When no more variables could be eliminated from the model, the analysis was considered complete.

An interaction effect was noted between the study mine and fright and thus three interaction variables namely, frightXmine1, frightXmine2 and frightXmine3 were included in regression analysis. The adjusted OR was estimated by using STATA LINCOM command. Again, a sensitivity analysis was performed by repeating the model but only with mineworkers who had not experienced a frightening experience (i.e. fright=0).

The Hosmer-Lemshow goodness of fit test was used because the number of covariate groups was large relative to the sample size, resulting in more than 10% of the expected cell values to be less than 5 (Hosmer and Lemeshow, 1989). For the upper limb and lower limb models, robust estimates were used to produce estimators that are not unduly affected by small departures from model assumptions. Mineworkers were not randomly selected with respect to a specific mine and mineworkers belonging to one mine, may have been similar compared to mineworkers from the other mine. Thus, using the robust estimate provided a conservative estimate which considers this possible effect on the model.

A percentage of controls selected had had a diagnosis of musculoskeletal disorders in the past year or longer and, therefore, this may have diluted associations found. Therefore, the final model was repeated with an adjustment factor (i.e. history of a MSD).

2.12 Ethics

The protocol was approved by the Human Research Ethics Committee, University of the Witwatersrand Ethics Committee (M01-05-57) (Appendix F). The aims of the investigation were communicated as clearly as possible to the subjects in a language that they understood. All participants provided written informed consent to be interviewed and, if required, examined.

Subjects participated in the study on the basis of informed consent, and on the understanding that they could refuse to participate and withdraw from the study at any time. Consent was also sought to inspect medical records during follow-up. Care was taken to maintain confidentiality so that subjects were not identifiable to persons not involved in the research. Personal identifying data (name and ID number) were not recorded on data sheets.

The results of the study were presented at conferences, workshops at each mine and to SIMRAC.

CHAPTER 3 INCIDENCE OF MUSCULOSKELETAL DISORDERS AND DESCRIPTION OF CASES

3.1 Introduction

This chapter describes the incidence of MSD at three South African mines. The different clinical and anatomical presentations of cases will be shown including the severity of the presenting symptoms. Psychosocial and other characteristics of the 691 cases that were identified at the three primary care clinics at the coal (70 cases), gold (329 cases) and platinum mine (292 cases) are also presented.

3.2 Incidence of musculoskeletal disorders at three mines

The incidence of MSDs at the three study mines was estimated by determining the number of mineworkers referred to the research nurse during normal office hours (cases) and then including mineworkers who presented after hours i.e. MSD records (see Section 2.10) at the three primary care clinics during the study period (Figure 3.1). Consequently, the estimated incidence of mineworkers presenting with a MSD is presented based on cases only (lower estimate) and a higher estimate which included mineworkers presenting after hours plus the number of mineworkers not giving consent to be interviewed by the research nurse (MSD records). The estimated six-month incidence of mineworkers with a MSD was 7.0% at the coal mine, 5.4% at the gold mine and 8.1% at the platinum mine (Table 3.1). Unlike the gold and platinum mine clinic, the coal mine clinic was only open during office hours. Therefore, the estimates based on cases and MSD records are similar because MSD records added only a small number of mineworkers who did not give consent to take part in the study or were “missed”. However, at the gold mine, 64% of mineworkers with MSD presented after hours or refused to participate resulting in a bigger difference. At the platinum mine, nearly half the mineworkers with a MSD presented after hours. For all mines combined, the estimated incidence was 6.2% (Figure 3.1) over six months suggesting an annual incidence of 24/1000. The incidence based on MSD cases only was 2.7%; an annual incidence of 54/1000 if extrapolated over the full year.

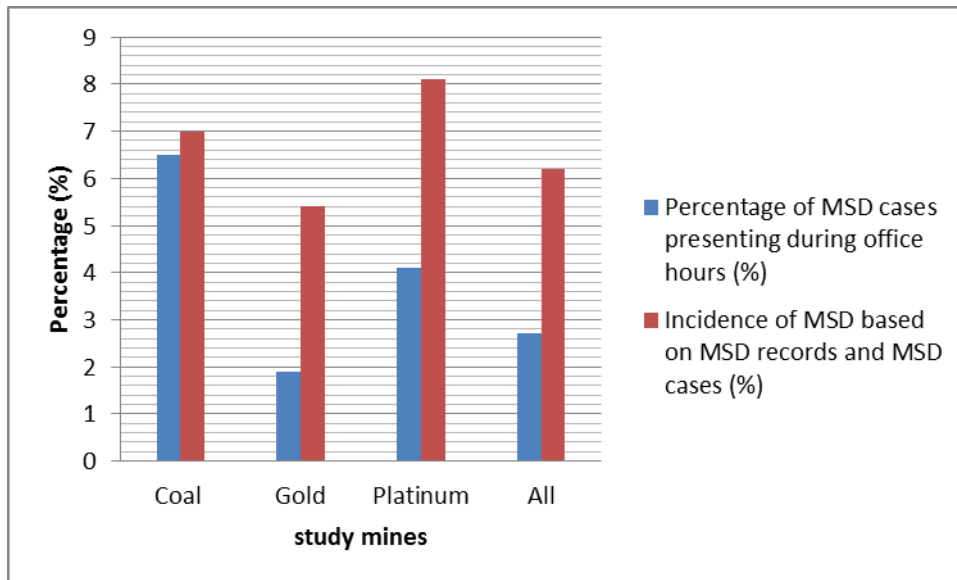


Figure 3.1 Estimated incidence of MSD at the coal, gold and platinum mine

Table 3.1 gives a breakdown of MSD presentations, study population and clinic attendances for the coal, gold and platinum mine. The study population is the number of mineworkers at the coal, gold and platinum mine who had access to the mine clinic. The percentage of MSD cases is the number of mineworkers presenting with a MSD during office hours and consenting to be interviewed by the research nurse. The number of mineworkers presenting during the day (MSD cases) plus after hours and non-consenting mineworkers with a MSD (MSD records) is the most useful measure of incidence because it takes into account non-consenting cases and the potential cases presenting after hours at the gold and platinum mine. The number of clinic attendances is the number of consultations over the six month study period and some mineworkers consulted the clinic more than once, hence attendances are larger than the study population.

Table 3.1 Incidence of musculoskeletal disorders in mineworkers at the coal, gold and platinum mine during the study period

	Coal mine	Gold mine	Platinum mine	All mines
Casesⁱ (n)	70	329	292	691
Mineworkers with a MSD after hoursⁱⁱ (n)	0	497	259	756
Non-consenting casesⁱⁱⁱ (n)	5	121	23	149
Total MSD presentations^{iv} (n)	75	947	574	1 596
Study population^v (N)	1 073	17 571	7 090	25 734
Incidence of MSD cases^{vi} (%)	6.5	1.9	4.1	2.7
Estimated incidence of total MSD^{vii} (%)	7.0	5.4	8.1	6.2
Number of clinic attendances (n)	963	18 641	25 704	44 345
Percentage of clinical attendances due to MSD^{viii} (%)	7.8	5.1	2.2	3.6

ⁱ Mineworkers presenting to the primary care clinic with a MSD who were interviewed by the research nurse.

ⁱⁱ Mineworkers presenting to the primary care clinic with a MSD but not interviewed by the research nurse because they presented to the clinic after hours (i.e. MSD record).

ⁱⁱⁱ Mineworkers presenting to the primary care clinic with a MSD but not giving consent to be interviewed by the research nurse (MSD record).

^{iv} Total MSD presentations includes cases and MSD records (i.e. mineworkers with a MSD presenting after-hours and mineworkers with a MSD not giving consent to be interviewed).

^v Number of mineworkers who had access too or who would utilize the primary care clinic.

^{vi} Percentage of MSD using the number of cases interviewed by the research nurses only.

^{vii} Incidence of MSD presentation to the clinic i.e. cases and MSD records.

^{viii} Percentage calculated using total MSD presentations as numerator.

3.3 Description of musculoskeletal disorders at the three mines

The description of MSD presentations at the three mines is based on the MSD cases i.e. those mineworkers with a MSD interviewed by the research nurse.

From these interviews it is clear that lower back pain was the most common MSD presentation at the coal and gold mines (Figure 3.2). The proportion of MSD cases with lower back pain differed by mine: gold the highest (65.6%), followed by coal (59.7%) and then platinum (35.7%). The difference was statistically significant (Chi-square = 15.3; $p = <0.0001$). Lower limb pain was the most common MSD presentation at the platinum mine. The proportion of MSD cases with lower limb pain differed by mine with the platinum mine the highest (41.0%); followed by the gold mine (12.7%); and then the

coal mine (11.1%). The difference was statistically significant (Chi-square = 53.6; $p < 0.0001$). The percentage of cases presenting with upper limb pain was similar for the three mines: coal mine 30%; platinum mine 23.9% and gold mine 23.4%. These differences were not statistically significant (Chi-square = 1.4; $p = 0.50$).

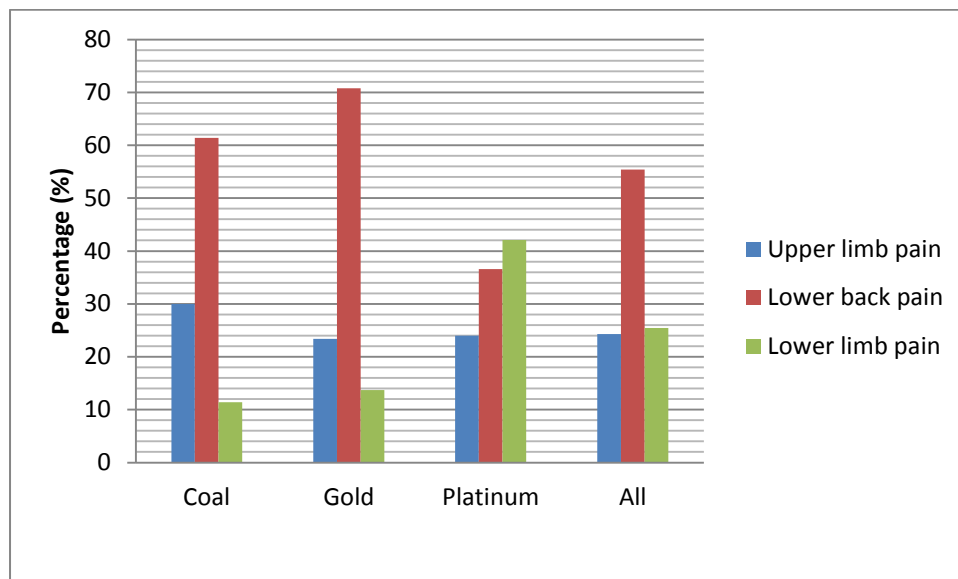


Figure 3.2 Percentage of mineworkers presenting to the coal, gold and platinum mine with MSD by anatomical region

The percentage of cases reporting a previous musculoskeletal disorder at the same site as the current presentation was 11.8% for neck, 2.6% for shoulder, 7.6% for wrist, 11.1% for upper back, 11.5% for lower back, 8.1% for hip, 13.9% for knee and 14.5% for foot pain. None of the cases who presented with an elbow pain had a history of prior elbow pain.

Sixty five mineworkers presented with musculoskeletal symptoms at more than one anatomical site (Table 3.2) at the three mines. Common sites were the upper and lower back (18), and neck and shoulder (16). Not shown in Table 3.2, 19 cases presented with upper limb pain and lower back pain, 15 cases presented with lower limb pain and lower back pain and two cases presented with upper limb pain and lower limb pain.

Table 3.2 Mineworkers presenting with musculoskeletal symptoms at more than one anatomical site at a coal, gold and platinum mine (n=65)

Number of cases:	Neck	Shoulder	Elbow	Wrist	Upper back	Lower back	Hip	Knee	Foot
18					x	x			
16	x	x							
9						x	x		
3								x	x
2						x	x	x	x
2						x		x	
2						x			x
2							x	x	
2			x	x					
2		x	x						
1	x	x	x						
1	x	x			x				
1	x			x					
1		x	x	x					
1	x					x			
1		x					x		
1				x					x

3.3.1 Clinical diagnosis of cases presenting with an upper limb pain

The Southampton Examination Schedule (discussed in Chapter 2 Methodology) was conducted on cases presenting with an upper limb disorder to make a clinical diagnosis. In a proportion of cases a diagnosis could not be reached because the clinical features were not sufficiently specific. (Note: cases presenting with back or lower limb pain cannot be classified using the Southampton Examination Schedule.)

Of the 39 cases presenting to the primary care clinic with shoulder pain, nine cases were not examined and six could not be classified using the Southampton Examination Schedule. Table 3.3 shows the number, site and diagnosis for the remaining 24 mineworkers who presented with shoulder pain. Although over 97% of the cases were right-handed, shoulder conditions were diagnosed in both left and right shoulders almost equally; only one case presented with shoulder conditions in both shoulders. Only five cases had one shoulder diagnosis, the majority had more than 1 diagnosis.

Table 3.3 The diagnosis of the shoulder pain using the Southampton Examination Schedule for mineworkers presenting at the coal, gold and platinum mine (n=24)

	Right	Left	Both
Shoulder capsulitis	0	4	0
Rotator cuff tendonitis	1	0	0
Shoulder capsulitis and rotator cuff tendonitis	2	1	1
Shoulder capsulitis, rotator cuff tendonitis, and biceptal tendonitis	7	1	0
Shoulder capsulitis, rotator cuff tendonitis, biceptal tendonitis and acromio-clavicular joint disorder	1	0	0
Shoulder capsulitis, rotator cuff tendonitis, and acromio-clavicular joint disorder	1	2	0
Shoulder capsulitis, rotator cuff tendonitis, biceptal tendonitis, acromio-clavicular joint disorder and sub-acromial bursitis	1	2	0

Of the 10 cases presenting with elbow pain, one was not examined and five could not be classified into a diagnosis using the Southampton Examination Schedule. Two cases had lateral epicondylitis (one left-sided and the other right-sided), one had left-sided olecranon bursitis and one had left-sided lateral epicondylitis, medial epicondylitis and olecranon bursitis.

Of the 13 cases presenting with wrist pain, two were not examined and three could not be classified as to a diagnosis using the Southampton Examination Schedule. Two cases had tenosynovitis (both right-sided) and one had thumb base OA (left-sided). Three cases had both tenosynovitis and thumb base OA (all left-sided), one case had both de Quervain's disease and tenosynovitis (left-sided) and one case had thumb base OA, de Quervain's disease and tenosynovitis (left-sided).

3.3.2 The severity of musculoskeletal disorders

The severity of the MSD was determined by the duration of symptoms, symptoms of disability and/or the amount of sick leave resulting from the MSD. Pain duration varied substantially as shown in Table 3.4. The majority of cases (63.9%) complained of pain for 1-7 days. However, 21.3% of cases had pain for more than a week and 13.3%

complained of pain for that day only. Over 40% of cases complaining of wrist and knee pain, had pain for over a week before presenting to the clinic.

Interestingly, a large percentage of cases at the coal mine (64.3%) reported to the primary care clinic on the first day of experiencing pain associated with a MSD, compared to the gold (1.9%) and platinum mines (13.7%) (Chi-square = 322.9; $p < 0.001$). At the gold and platinum mine, the majority of cases presented to the primary care clinic with pain for 1-7 days (291 cases for the gold mine and 122 cases for the platinum mine). Thirty eight percent of the platinum mineworkers had symptoms for eight days or more compared to the coal mine (12.9%) and gold mine (8.0%) (Chi-square = 322.9; $p < 0.001$).

Table 3.4 Musculoskeletal symptom duration (frequency, %) for mineworkers presenting at the coal, gold and platinum mine

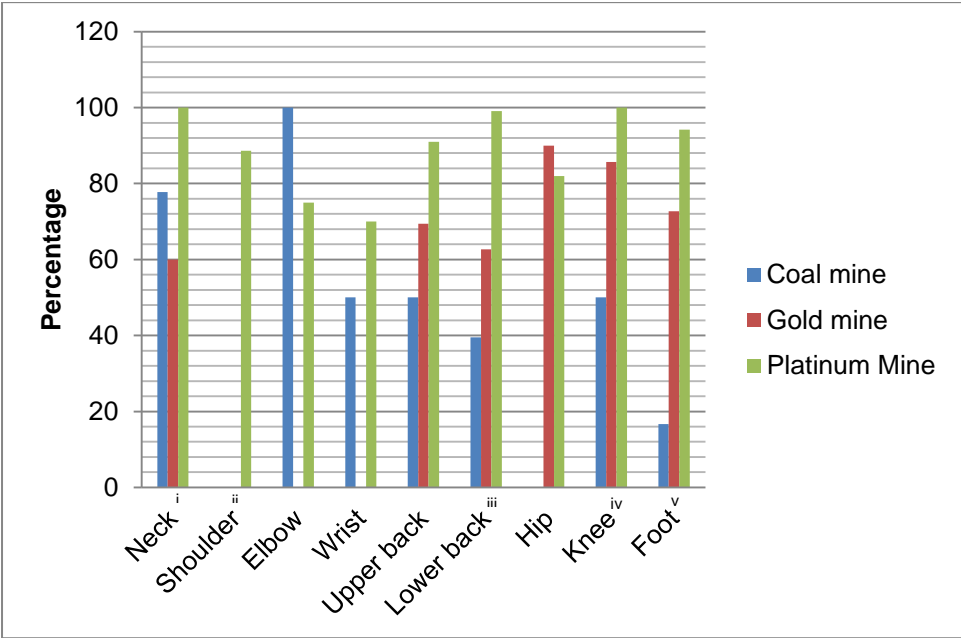
	Coal mine		Gold mine		Platinum mine		All mines	
	n	(%)	n	(%)	n	(%)	N	(%)
Just today	45	(64.3)	6	(1.9)	38	(13.7)	89	(13.3)
1-7 days	16	(22.9)	291	(90.1)	122	(43.9)	429	(63.9)
>= 8 days	9	(12.9)	26	(8.0)	108	(38.8)	143	(21.3)
Unknown	0	(0.0)	0	(0.0)	10	(3.6)	10	(1.5)
Total	70	(100.0)	323	(100.0)	278	(100.0)	671	(100.0)

Furthermore, a large percentage of the cases (76.6%) reported symptoms suggestive of disability using the Nordic questionnaire (discussed in Chapter 2 Methodology) at the different mines (Table 3.5). Most of the cases from the platinum mine (96.2%) had symptoms of disability, followed by cases at the gold mine (65.3%) and the cases at the coal mine (47.1%).

Table 3.5 Musculoskeletal symptoms indicating disability (frequency, %) for mineworkers presenting at the coal, gold and platinum mine

	Coal mine		Gold mine		Platinum mine		All mines	
	n	(%)	n	(%)	n	(%)	N	(%)
Disability present	33	(47.1)	215	(65.3)	281	(96.2)	529	(76.6)
No disability	37	(52.9)	114	(34.7)	11	(3.8)	162	(23.4)
Total	70	(100.0)	329	(100.0)	292	(100.0)	691	(100.0)

Figure 3.3 shows how the symptoms of disability varied for the different anatomical sites across the different mines. Ninety seven percent of cases presenting with knee pain had disabling symptoms, followed by cases presenting with neck, hip and foot pain (88.0%, 86.5% and 82.9% respectively). At the gold mine, cases presenting with shoulder, elbow and wrist pain did not have disabling symptoms. At the coal mine there were no cases who presented with shoulder pain.



ⁱSignificant difference among mines for symptoms of disability for neck pain (Chi-square = 12.9; p = 0.02).
ⁱⁱSignificant difference among mines for symptoms of disability for shoulder pain (Chi-square = 17.3; p = <0.01).
ⁱⁱⁱSignificant difference among mines for symptoms of disability for lower back pain (Chi-square = 68.3; p = <0.01).
^{iv}Significant difference among mines for symptoms of disability for knee pain (Chi-square = 21.7; p = <0.01).
^vSignificant difference among mines for symptoms of disability for foot pain (Chi-square = 24.7; p = <0.01).

Figure 3.3 Percentage of mineworkers with disability presenting at the coal, gold and platinum mine clinic with a MSD

Days of sick leave by mine are shown in Table 3.6. One or two days sick leave for a MSD was most common at the coal and platinum mine, whereas at the platinum mine no sick leave was given (58.9%). At the coal mine the mean number of sick days given for a MSD was 3.1 days (±6.1 days) and most cases from the coal mine received 3 – 7 days sick leave (42.2%). At the gold mine the mean number of sick days given for a MSD was 1.1 days (±0.6 days) and the majority of cases at the gold mine (92.1%) received 1-2 days of sick leave. At the platinum mine the mean number of sick days given for a MSD was 2.5 days (±12.9 days) and, notably, the majority of cases (58.9%) did not receive sick leave.

Table 3.6 Days of sick leave for mineworkers presenting with a musculoskeletal disorder at the three primary care clinics at a coal, gold and platinum mine

	Coal mine ⁱ		Gold mine ⁱⁱ		Platinum mine ⁱⁱⁱ		All mines	
	n	(%)	n	(%)	n	(%)	N	(%)
Just today	7	(10.9)	11	(3.4)	155	(58.9)	173	(26.4)
1-2 days	26	(40.6)	302	(92.1)	75	(28.5)	403	(61.5)
3-7 days	27	(42.2)	14	(4.3)	23	(8.7)	65	(9.9)
>= 8 days	4	(6.2)	1	(0.6)	10	(3.8)	143	(2.2)
Total	64	(100.0)	328	(100.0)	263	(100.0)	655	(100.0)

ⁱ 6 missing.

ⁱⁱ 1 missing.

ⁱⁱⁱ 29 missing.

No sick leave was given for large proportions of cases presenting with elbow (60%), knee (54%), wrist (50%) and shoulder (45%) pain. One day of sick leave was given to most cases presenting with lower back (64%) and upper limb pain (54.3%) but for mineworkers with lower limb pain 40.5% were not granted sick leave and 38.1% were given one day's sick leave. About a third of cases presenting with neck pain (38%) were given 3 – 7 days' sick leave.

3.5 Psychosocial factors

The SRQ questionnaire was used to determine if the cases had symptoms of a possible mental disorder (for example anxiety or depression). Among the 691 cases, 66 (9.6%) had a SRQ score greater than or equal to 8, suggesting that they had a mental disorder. Per mine, the proportions of these symptoms were 1.4%, 0% and 22.2% for the coal, gold and platinum mines respectively. (These differences were statistically significant Chi-square test = 94.7; $p = <0.001$) (See Table 3.7)

Experiencing certain life events may be associated with a negative affect. Eighty percent of all the MSD cases at the coal, gold and platinum mine had financial problems, 8% percent had a recent medical diagnosis; 56.4% had experienced a frightening event and 1.3% had been physically assaulted.

Table 3.7 indicates that most of the cases at the gold and platinum mine had financial problems. The coal mine had the largest proportion of cases with a recent medical

diagnosis. The majority of cases experiencing a fright were from the gold mine. The percentages of cases reported being assaulted over the past 12 months were similar for the coal, gold and platinum mine.

To assess social functioning, cases were questioned on how well they managed in their relationships at home and at work, and about their ability to relax. Fifty-two cases (7.5%) at the coal, gold and platinum mine had problems related to work, 10.1% had problems with relationships and 2.9% had a problem with relaxing.

Table 3.7 The number (and percentage) of cases with a possible mental disorder, experience of significant life event or had social dysfunction

	Coal mine (N=70)	Gold mine (N=329)	Platinum mine (N=292)	Chi- square
	n (%)	n (%)	n (%)	p value
Possible mental disorder (SRQ¹ ≥8)	1 (1.4)	0 (0)	65 (22.2)	0.00
Life events				
Financial problems	25 (35.7)	322 (97.9)	210 (71.9)	0.00
Recent medical diagnosis	21 (30)	6 (1.8)	28 (9.6)	0.00
Experienced a fright	9 (12.9)	263 (80.0)	118 (40.4)	0.00
Assaulted in last year	1 (1.4)	2 (0.6)	6 (2.1)	0.28
Social functioning				
Difficulties at work	8 (11.4)	0 (0)	44 (15.1)	0.00
Difficulty relaxing	4 (5.7)	10 (3.0)	6 (2.1)	0.25
Relationship problem	2 (2.9)	0 (0)	68 (23.3)	0.00

¹SRQ = Self-reporting questionnaire.

3.6 Languages

The home languages of the cases were divided into five groups, as shown in Table 3.8. Approximately one third of cases spoke Xhosa.

Table 3.8 The number and percentage of cases by home a language for all the mines and then for the coal, gold and platinum mine

	All		Coal mine		Gold mine		Platinum mine	
	N	(%)	n	(%)	n	(%)	n	(%)
Zulu	77	(11.3)	6	(8.6)	56	(17.0)	15	(5.3)
Xhosa	236	(34.7)	16	(22.9)	108	(32.8)	112	(39.7)
Shangaan	106	(16.6)	12	(17.1)	36	(10.9)	58	(20.6)
Southern Sotho	128	(18.8)	1	(1.4)	76	(23.1)	51	(18.1)
Other ⁱ	134	(19.7)	35	(49.2)	53	(16.1)	46	(16.3)

ⁱ Other languages included: Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

3.8 Summary of findings

- Close to four percent of all patients who attended the mine health care services did so for a MSD.
- The estimated six-month incidence of MSDs (using MSD records) was 6.2% for coal, gold and platinum mines combined.
- The majority of cases (63.9%) complained of pain for 1-7 days.
- Over 75% of mineworkers presenting with a MSD at the coal, gold and platinum mines had disabling symptoms.
- The platinum mine's cases had significantly more disability for most anatomical sites than cases at the coal and gold mine.
- Lower back pain was the most common MSD presentation at the coal and gold mines. Lower limb pain was the most common presentation at the platinum mine.
- The coal mine had the highest percentage of upper limb cases.
- Less than 10% of the cases had a possible mental disorder (using the SRQ).
- A large percentage of cases (56.4%) had experienced a frightening experience.
- The majority of cases (80.6%) had financial problems.
- Ten percent or less of cases had been diagnosed recently with a medical diagnosis, had problems in their relationships and had issues at work.
- A small percentage of mineworkers had been assaulted (1.3%) or had difficulty relaxing (2.9%).
- A third of cases spoke Xhosa followed by Southern Sotho, Shangaan, and Zulu.

CHAPTER 4 CASE – CONTROL STUDY

4.1. Introduction

In this chapter the controls are described and compared with cases. Univariate odds ratios for variables which may be potential risk factors for MSD involving the back, upper limb or lower limb are also shown. Multivariate analyses complete the present chapter to derive adjusted odds ratios for significant independent predictor variables.

4.2 Reason for controls presenting to the clinic

The medical complaints of the controls presenting to the primary care clinic are listed in Table 4.1. The main reason for controls presenting to the primary care clinic was for pulmonary complaints, followed by gastrointestinal disease, especially diarrhoea, influenza and skin disorders.

Table 4.1 The medical conditions of mineworkers presenting to the primary care clinic at a coal, gold and platinum mine with no symptoms of a musculoskeletal disorder

Presentations of Controls	Number	(Percent)
Pulmonary complaints incl. coughs	136	(19.4)
Gastrointestinal complaints	126	(18.0)
Influenza	123	(17.5)
Skin disorder	80	(11.4)
Ear, nose & throat	63	(9.0)
General body pains	36	(5.1)
Genital/urinary tract disorders	32	(4.6)
Chronic illness (asthma, hypertension etc.)	31	(4.4)
Headaches & dizziness	26	(3.7)
Lacerations	17	(2.4)
Eye pathology	12	(1.7)
Endocrinology (diabetes, hypothyroidism etc.)	7	(1.0)
Infectious	7	(1.0)
Allergy	3	(0.4)
Dental	2	(0.3)
Total	701	(100)

4.3. Characteristics of cases and controls

Seven hundred and one controls were included in the analysis: 81 at the coal mine, 345 at the gold mine and 275 at the platinum mine. There are an unequal number of cases (n=691) and controls (n=701) because repeat attendees were excluded (see Chapter 2 Methodology).

The characteristics of the cases and controls and all study participants are shown in Table 4.2. The largest group of cases and controls was from the gold mine because the study population and clinic attendance were greater for this mine (Table 3.1). The largest group of cases and controls was between 35 – 44 years old. The mean age of cases in the study was 40.2 ± 7.9 years and for all the controls, the mean age was 38 ± 7.9 years. The mean age of cases from the coal mine was 41.3 ± 7.9 years and for controls at the coal mine it was 38.6 ± 7.9 years. At the gold mine the mean age was 39.1 ± 7.4 years and for controls at the gold mine it was 37.9 ± 7.4 years. At the platinum mine, the mean age for cases was 41.1 ± 9.4 years and for the controls from the platinum mine it was 38.1 ± 8.6 . Slightly more cases (48.8%) only went as far as primary school than did controls (44.1%). Whereas more controls (34.1%) had secondary or higher education than cases (32.6%), but the difference was small.

In the main cases and controls were very similar with respect to characteristics shown in Table 4.2 except for the SRQ-20 score where 15.3% of controls compared to 9.6% of cases had a possible mental disorder. Another difference noted was that a frightening event was experienced by more cases (56.4%) than controls (2.7%).

The largest proportion of the cases and controls had a service history of greater than 12 years at the coal, gold or platinum mine i.e. 33.3%, 28% and 35% respectively for cases and for controls 28.8%, 27.9% and 30.4% respectively. Around 80% of cases and controls worked underground at the gold and platinum mine and the percentages of cases and controls working on the surface or both underground and on the surface were similar. At the coal mine more cases compared to controls worked on the surface.

Table 4.2 Characteristics of mineworkers who presented with a musculoskeletal disorder (MSD) at a coal, gold and platinum mine and controls without MSD

		Cases		Controls	
		n=691(%)	Missing	n=701(%)	Missing
Mine			0		0
	Coal	70 (10.1)		81 (11.6)	
	Gold	329 (47.6)		345 (49.2)	
	Platinum	292 (42.3)		275 (39.2)	
Age			8		12
	19-34	178 (26.1)		236 (34.3)	
	35-44	296 (43.3)		304 (44.1)	
	45 or more	209 (30.6)		149 (21.6)	
Season			0		0
	Summer (Jan-Feb)	229 (33.1)		230 (32.8)	
	Autumn (Mar-May)	310 (44.9)		321 (45.8)	
	Winter (June)	152 (22.0)		150 (21.4)	
Handedness			3		4
	Right	671 (97.5)		656 (94.1)	
	Left	12 (1.7)		34 (4.9)	
	Ambidextrous	4 (0.6)		6 (0.9)	
Education			9		3
	No education	148 (21.7)		152 (21.8)	
	Primary school	312 (45.8)		308 (44.1)	
	Secondary or more	222 (32.6)		238 (34.1)	
Smoking			0		0
	Non smoker	394 (57.0)		397 (56.6)	
	Ex-smoker	21 (3.0)		33 (4.7)	
	Current smoker	276 (39.9)		271 (38.7)	
Alcohol consumption			0		0
	(grams/week)				
	None	394 (57.6)		404 (57.0)	
	1-56 grams	75 (10.9)		69 (9.8)	
	57-112 grams	164 (23.7)		154 (22.0)	
	113 and more	58 (8.4)		74 (10.6)	
Service history			29		17
	Less than 4 years	136 (20.5)		162 (23.7)	
	4-6 years	133 (20.1)		159 (23.3)	
	7-9 years	94 (14.2)		86 (12.6)	
	10-12 years	75 (11.3)		79 (11.6)	
	More than 12 years	224 (33.8)		198 (29.0)	

Table 4.2 Characteristics of mineworkers who presented with a musculoskeletal disorder (MSD) at a coal, gold and platinum mine and controls without MSD (cont)

	Cases			Controls		
	n=691	(%)	Missing	n=701	(%)	Missing
Physical activities						
overhead reaching	433	(62.7)	0	464	(66.7)	5
bending at the waist	174	(25.2)	0	187	(26.8)	4
twisting at the waist	523	(75.7)	0	522	(74.8)	4
carrying, lifting or lowering loads	487	(70.6)	0	492	(70.8)	3
climbing up or down	436	(63.1)	1	444	(63.7)	4
pushing	339	(49.3)	0	349	(50.3)	7
pulling	35	(48.6)	3	329	(47.3)	5
hands above shoulder height	394	(57.0)	1	412	(59.3)	6
operating equipment	320	(46.3)	0	329	(47.3)	6
shoveling	320	(46.5)	0	334	(48.1)	6
barring	391	(56.9)	3	413	(59.6)	8
working in tunnels	222	(32.3)	4	216	(31.1)	7
kneeling or squatting	369	(53.6)	2	357	(51.3)	5
repeated bending and straightening of your elbow	600	(87.1)	2	591	(84.8)	4
using vibratory tools	237	(34.4)	1	256	(36.8)	5
Work area on the mine						
			5			9
Surface	48	(7.0)		30	(4.3)	
Surface and underground	59	(8.6)		64	(9.3)	
Underground	579	(84.4)		598	(86.4)	
Home language						
			10			6
Zulu	77	(11.3)		78	(11.4)	
Xhosa	236	(34.6)		225	(32.8)	
Shangaan	106	(15.5)		132	(19.2)	
Southern Sotho	128	(18.7)		134	(19.5)	
Other	134	(19.6)		116	(16.9)	
Possible mental disorder (SRQ score >= 8)						
	66	(9.6)	0	107	(15.3)	0
Life events						
			0			0
Recent medical diagnosis	55	(8.0)		36	(5.1)	
Assaulted	9	(1.3)		2	(0.3)	
Frightening experience	390	(56.4)		17	(2.4)	
Financial problem	557	(80.6)		562	(80.3)	
Social functioning						
			0			0
Relationships	70	(10.1)		76	(10.8)	
Work	52	(7.5)		43	(6.1)	
Time management	20	(3.0)		21	(3.0)	

4.3.1 Previous history of a musculoskeletal disorder among controls compared to incident cases

All controls were asked if they had previously presented to the primary care clinic with a musculoskeletal disorder (Table 4.3). If controls had previously presented with a MSD, they were asked which region of the body had been affected. Table 4.3 demonstrates that a large percentage of controls had had a past history of lower back, upper back, shoulder and neck pain at the gold mine. Just over a third of controls had a previous history of attending a clinic for upper limb pain, just less than half of the controls had previous history of lower back pain requiring a clinic visit and around ten percent of controls had attended the clinic in the past for lower limb pain.

4.3.2 Physical risk factors

Figure 4.1 illustrates the most common occupational groups at the coal, gold and platinum mine and the distribution of cases and controls in each occupational group. For surface jobs, there were more cases who were drivers and general workers compared to controls. For occupations done both underground and on the surface, there were more cases who were artisans, onsetters and environmental technicians compared to controls. For underground occupations, more controls were represented except for winch drivers, team leaders and belt operators.

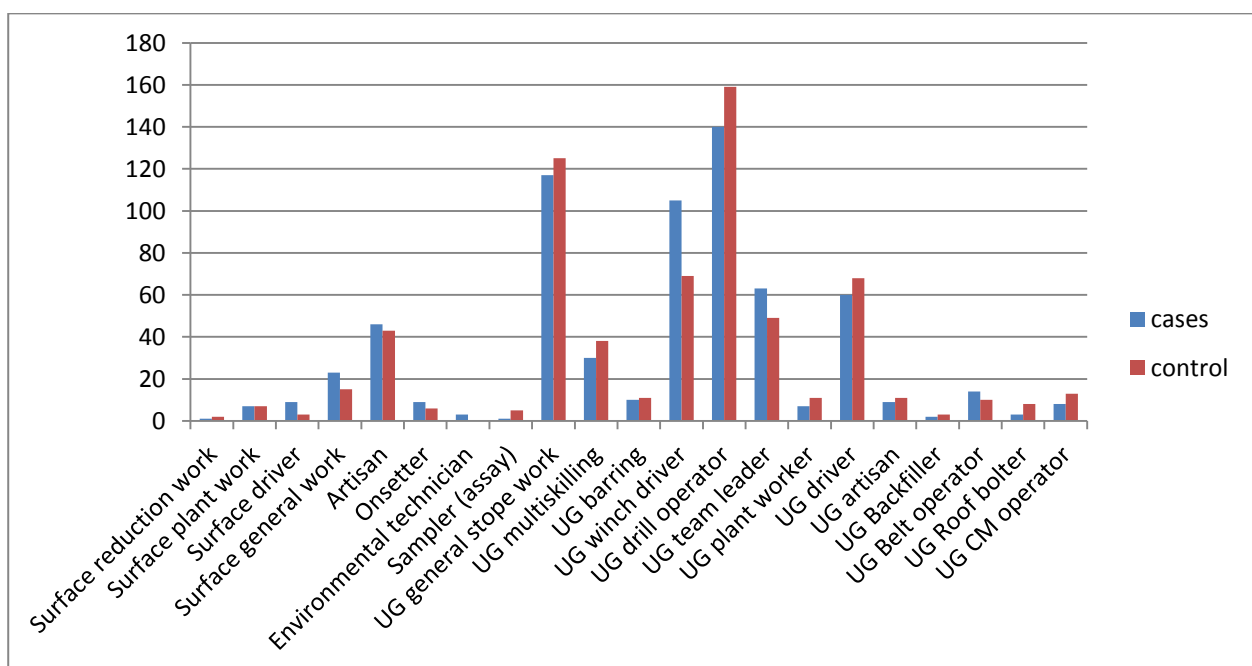


Figure 4.1 Occupations of cases and controls at the coal, gold and platinum mine

Table 4.3 Numberⁱ and percentage of cases presenting with incident MSD and controls with previous history of MSD for each anatomical site at a coal, gold and platinum mine

	Coal		Gold		Platinum							
	Cases (N=70)		Cases (N=329)		Cases (N=292)							
	N	(%)	N	(%)	N	(%)						
Neck	9	(12.9)	8	(9.9)	10	(2.9)	105	(30.6)	32	(11.0)	9	(3.3)
Shoulder	0	(0.0)	7	(8.6)	4	(1.2)	102	(29.7)	35	(12.0)	9	(3.3)
Elbow	2	(2.9)	3	(3.7)	0	(0.0)	6	(1.7)	8	(2.7)	3	(1.1)
Wrist	2	(2.9)	3	(3.7)	1	(0.3)	6	(1.7)	10	(3.4)	3	(1.1)
Upper back	8	(11.4)	4	(4.9)	62	(18.1)	214	(62.4)	11	(3.8)	6	(2.2)
Lower back	43	(61.4)	14	(17.3)	233	(67.9)	283	(82.5)	107	(36.6)	9	(3.3)
Hip	0	(0.0)	2	(2.5)	20	(5.8)	6	(1.7)	17	(5.8)	6	(2.2)
Knee	2	(2.9)	6	(7.4)	7	(2.0)	51	(14.9)	63	(21.6)	7	(2.5)
Foot	6	(8.6)	4	(4.9)	18	(5.2)	9	(2.6)	52	(17.8)	4	(1.5)

ⁱ Note cases and controls may have presented with pain in more than one site.

4.4 Case-control analyses: univariate and multivariate and final models

4.4.1 Univariate analysis

4.4.1.1 Physical risk factors

Table 4.4 lists the univariate ORs for cases and controls involved “almost always” in physical activities that may be associated with upper limb MSD. In the first analysis, all controls were used with cases that presented with upper limb pain. In the second analysis, cases who presented with upper limb pain are compared with controls who had no history of an upper limb pain. Carrying, reaching, pushing, pulling, working with hands above shoulder or with equipment and shovelling were all significantly negatively associated with upper limb pain if controls with a previous history of upper limb disorder were excluded. When all the controls were used in the univariate analysis, the ORs spanned one except for working with vibrating equipment, which was no longer negatively associated when controls with a past history of upper limb were excluded. Excluding controls with a past history of MSD resulted in a narrower confidence interval and increased precision. A similar finding was found for the lower back (Table 4.5).

Table 4.4 Odds ratios for activities that may result in upper limb pain using all controls and only controls with no history of upper limb pain

	All controls			Controls with history of upper limb pain excluded		
	Case/Control (n=168 / 701)	OR	(95% CI)	Case/Control (n= 168 / 405)	OR	(95% CI)
Carrying	(168/695)	0.8	(0.5-1.1)	(168/403)	0.6	(0.4-0.9)
Reaching	(168/696)	0.8	(0.6-1.1)	(168/403)	0.5	(0.4-0.8)
Pushing	(168/694)	1.1	(0.8-1.5)	(168/403)	0.6	(0.4-0.9)
Pulling	(168/696)	1.0	(0.7-1.4)	(168/403)	0.5	(0.3-0.7)
Work with hands above shoulder	(168/695)	0.8	(0.6-1.1)	(168/402)	0.4	(0.3-0.6)
Work with equipment above shoulder	(168/695)	0.7	(0.5-1.0)	(168/401)	0.4	(0.3-0.6)
Shoveling	(167/695)	0.7	(0.5-1.0)	(167/402)	0.4	(0.3-0.6)
Barring	(167/693)	0.7	(0.5-1.0)	(167/399)	0.7	(0.5-1.1)
Repeated elbow bending	(167/697)	0.9	(0.6-1.4)	(167/403)	0.9	(0.5-1.4)
Working with vibrating equipment	(168/696)	0.7	(0.5-0.97)	(168/402)	0.9	(0.6-1.4)

For physical activities associated with lower back pain (Table 4.5), the ORs for reaching, pushing and pulling were negatively associated when all controls were used in the univariate analysis opposed to when controls with no history of lower back pain were used. In addition, bending, twisting, shovelling were significantly negatively associated with lower back pain if controls with history of lower back were excluded. Working with vibratory tools increased the odds of presenting with lower back pain which was significant if controls with a history of lower back pain were excluded.

Table 4.5 Odds ratio for activities that may result in lower back pain using all controls and only controls with no history of lower back pain

	All controls			Controls with history of lower back pain excluded		
	Case\Control (n=383/701)	OR	95% CI	Case\Control (n=383/387)	OR	95% CI
Reaching	(383/696)	0.7	(0.5-0.9)	(383/385)	0.4	(0.3-0.5)
Bending	(383/697)	1.0	(0.8-1.3)	(383/387)	0.6	(0.4-0.9)
Twisting	(383/698)	0.9	(0.7-1.3)	(383/387)	0.6	(0.5-0.9)
Carrying	(382/695)	0.9	(0.7-1.2)	(382/384)	0.7	(0.5-1.0)
Pushing	(381/694)	0.7	(0.6-0.96)	(381/385)	0.4	(0.3-0.6)
Pulling	(383/696)	0.7	(0.6-0.9)	(383/385)	0.3	(0.2-0.4)
Shoveling	(383/695)	0.8	(0.6-1.0)	(383/384)	0.5	(0.4-0.6)
Working in a tunnel	(382/694)	1.0	(0.8-1.3)	(382/383)	1.1	(0.8-1.5)
Working with vibrating tools	(382/696)	1.2	(0.9-1.5)	(382/385)	1.7	(1.3-2.3)

For lower limb pain (Table 4.6), the following activities were found to increase the odds of presenting with a MSD: bending, climbing, pulling, shovelling and kneeling when using all controls. When controls with a history of lower limb pain were excluded, then bending and climbing were no longer convincing risks (lower 95% CI=1.0). This could be because the sample size has been reduced resulting in wider 95% CI. Working with vibratory tools was negatively associated with lower limb pain.

Table 4.6 Odds ratio for activities that may result in lower limb pain using all controls and only controls with no history of lower limb pain

	All controls			Controls with history of lower limb pain excluded		
	Case\Control (n=176/701)	OR	95% CI	Case\Control (n=176/615)	OR	95% CI
Bending	(176/697)	1.5	(1.02-2.3)	(176/614)	1.5	(1.0-2.2)
Carrying	(176/695)	1.4	(1.0-2.1)	(176/611)	1.3	(0.9-1.9)
Climbing	(176/697)	1.6	(1.1-2.3)	(176/613)	1.4	(1.0-2.1)
Pushing	(175/694)	1.5	(1.1-2.1)	(175/610)	1.4	(1.0-1.9)
Pulling	(175/696)	2.3	(1.6-3.2)	(175/612)	2.1	(1.5-3.0)
Shoveling	(174/695)	1.6	(1.1-2.2)	(174/611)	1.5	(1.05-2.1)
Working in tunnels	(175/694)	1.2	(0.9-1.7)	(175/610)	1.2	(0.8-1.7)
Kneeling	(175/696)	2.1	(1.5-3.0)	(175/612)	2.1	(1.4-3.0)
Working with vibrating equipment	(176/696)	0.6	(0.4-0.9)	(176/612)	0.6	(0.4-0.9)

4.4.1.2 Psychosocial factors

The psychosocial factors listed in Table 4.7 include questions to determine if the study participants had a possible mental disorder (SRQ score), if study participants had experienced a negative life event and questions on social functioning. The univariate OR was analysed with all controls and then with controls who presented to the primary care clinic with possible somatic symptoms (i.e. headache, insomnia, poor appetite, and digestion problems) excluded.

Table 4.7 shows that the SRQ score indicated that more controls had a possible mental disorder than cases. The association of a possible mental disorder was found to be negatively associated with MSD even when controls with possible somatic complaints were excluded.

Social functioning (i.e. problems with finances, work and personal relationships) was similar for cases and controls and no variables were found to be significantly associated with MSDs. However, more cases than controls had negative life events except for financial problems which were similar for cases and controls (with no significant association).

A recent medical diagnosis, assault and fright were found to increase the odds of presenting with a MSD. When controls who presented with a possible somatic complaint were excluded, assault was no longer significantly associated.

Table 4.7 The association (odds ratio) of having a MSD and psychosocial factors using all controls and then excluding controls with somatic symptoms

	Cases (N=691)		Controls (N=701)		Univariate OR with all controls (N=1392)		Cases (N=691)		Modified Controls ⁱ (N=525)		Univariate OR with modified ⁱ number of controls (N= 1216)	
	N	(%)	N	(%)	OR	95% CI	N	(%)	OR	95% CI		
Mental disorderⁱⁱ	66	(9.6)	107	(15.3)	0.6	(0.4-0.8)	66	(9.6)	74	(14.1)	0.6	(0.5-0.9)
Life events-mild												
A recent medical diagnosis	55	(8.0)	36	(5.1)	1.6	(1.0-2.5)	55	(8.0)	27	(5.1)	1.6	(1.0-2.6)
Assaulted	9	(1.3)	2	(0.3)	4.6	(1.0-21.4)	9	(1.3)	1	(0.2)	6.9	(0.9-54.8)
Frightening experience	390	(56.4)	17	(2.4)	52.1	(31.5-86.3)	390	(56.4)	14	(2.7)	47.3	(27.2-82.1)
Financial problem	557	(80.6)	562	(80.3)	1.0	(0.8-1.3)	557	(80.6)	419	(80.0)	1.0	(0.8-1.4)
Social functioning												
Relationships	70	(10.1)	76	(10.8)	0.9	(0.7-1.3)	70	(10.1)	54	(10.3)	1.0	(0.7-1.4)
Work	52	(7.5)	43	(6.1)	1.2	(0.8-1.9)	52	(7.5)	36	(6.9)	1.1	(0.7-1.7)
Problem with relaxing	20	(3.0)	21	(3.0)	1.0	(0.5-1.9)	20	(3.0)	15	(2.9)	1.1	(0.5-2.2)

ⁱ Controls who had somatic symptoms were excluded i.e. 176 controls.

ⁱⁱ SRQ score ≥ 8 .

Table 4.8 shows the number and percentage of cases and controls who experienced a frightening or horrifying event by the different commodities. A large percentage of cases from the gold and platinum mine had had a frightening experience compared to the controls at the gold and platinum mine. At the coal mine, the percentage of cases who had experienced a frightening experience was higher compared to controls but not significantly. The ORs were high for the gold and platinum mine but not significant for the coal mine

Table 4.8 The association (odds ratio) of having a MSD and an extreme fright using all controls.

	Cases		Controls		Univariate analysis	
	n	(%)	n	(%)	OR	(95% CI)
Coal mine	9	(12.9)	9	(14.3)	1.0	(0.4 – 2.7)
Gold mine	263	(79.9)	2	(0.8)	454.3	(141.2 – 1460.9)
Platinum mine	118	(40.4)	3	(1.5)	46.0	(16.7 – 126.7)
Total	390	(56.4)	14	(2.7)	52	(31.5 - 86.3)

4.4.1.3 Languages spoken

The largest group of study participants was Xhosa speaking (33.7%). There were no significant associations found in home language and MSDs (Table 4.9), although speaking Shangaan was borderline negatively associated.

Table 4.9 The association (odds ratio) of having a MSD and home language spoken using all controls

	Cases n=683(%)		Controls n=686(%)		OR	(95% CI)
Zulu	77	(11.3)	78	(11.4)	1.0	(0.7-1.4)
Xhosa	236	(34.6)	225	(32.8)	1.1	(0.9-1.4)
Shangaan	106	(15.5)	132	(19.2)	0.8	(0.6-1.0)
Southern Sotho	128	(18.7)	134	(19.5)	1.0	(0.7-1.3)
Other languageⁱ	134	(19.6)	116	(16.9)	1.2	(0.9-1.6)

ⁱ Other language = Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

4.4.2 Multivariate analysis

In this section for each region, the univariate and adjusted ORs are presented for upper limb pain, lower back pain, and lower limb pain. The adjusted ORs for the full model include all the mineworkers. A second set of adjusted ORs (Full model excluding fright) excludes mineworkers who experienced a fright. The aim of this analysis was to account for the unbalanced nature of the fright variable data (see Table 4.8) which may distort or bias the non-fright OR estimates (i.e. a sensitivity analysis).

There are two final models for upper limb, lower back and lower limb pain. The first model (final model with fright) includes all the mineworkers whereas the second model (final model excluding fright) excludes mineworkers who had experienced a fright (for the same reason as explained above). The modelling approach used in the final model for each region is described in 2.11.3.3. Interaction was examined for a large number of variables as described in 2.11.3.3. Only the mine and fright interaction term was significant and hence retained in the models.

4.4.2.1 Analyses for upper limb pain

Table 4.10 shows the univariate analysis (OR) for the explanatory variables (not adjusted) which demonstrated that a possible mental disorder and speaking Xhosa were negatively associated with upper limb pain. However, a recent medical diagnosis, working on the surface, a frightening experience and mineworkers whose home language was Other language, i.e. did not include Zulu, Xhosa, Shangaan or South Sotho, were found to increase the odds of presenting with upper limb pain.

Table 4.10 Univariate and adjusted odds ratio for presenting with an upper limb pain at a coal, gold or platinum mine

	Cases/Controls (n= 168/701)	Univariate OR		Full model with fright (Adjusted OR) ⁱ (n=826) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=722) ^v	
		Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)
Mines							
Gold mine	(77/345)	1.1	(0.7 1.8)	Reference		Reference	
Coal mine	(21/81)	0.9	(0.6 1.2)	2.8	(0.9 9.1)	2.5	(0.8 8.6)
Platinum mine	(70/275)	1.1	(0.8 1.6)	3.9	(1.7 9.3)	4.0	(1.6 9.7)
Age (years)							
19-34	(47/236)	0.8	(0.5 1.1)	Reference		Reference	
35-44	(73/304)	1.0	(0.7 1.4)	1.2	(0.7 2.3)	1.6	(0.8 3.2)
45-older	(44/149)	1.3	(0.9 1.9)	1.2	(0.5 2.7)	1.7	(0.7 4.2)
Service history (years)	(160/684)	1.0	(1.0 1.0)	1.0	(0.9 1.0)	0.97	(0.9 1.01)
Season							
Winter	(34/150)	1.0	(0.7 1.4)	1.3	(0.6 2.9)	1.2	(0.5 1.4)
Summer	(57/230)	0.9	(0.6 1.4)	1.0	(0.5 2.0)	0.7	(0.3 2.6)
Autumn	(77/321)	1.1	(0.7 1.5)	Reference		Reference	
Education							
No education	(31/152)	0.8	(0.5 1.3)	Reference		Reference	
Primary school	(65/308)	0.8	(0.6 1.1)	0.6	(0.3 1.2)	0.7	(0.3 1.4)
Secondary and higher	(67/238)	1.3	(0.9 1.8)	0.7	(0.4 1.5)	1.0	(0.5 2.1)
Smoker	(168/701)	1.2	(0.8 1.7)	1.2	(0.7 2.1)	1.2	(0.7 2.3)
Alcohol consumption							
0	(94/404)	0.9	(0.7 1.3)	Reference		Reference	
1-56 grams/week	(19/69)	1.2	(0.7 2.0)	1.0	(0.4 2.13)	1.2	(0.5 3.0)
57-112 grams/week	(38/154)	1.0	(0.7 1.6)	0.5	(0.2 1.2)	0.6	(0.2 1.3)
113 grams/week and more	(17/74)	1.0	(0.5 1.7)	0.6	(0.3 1.5)	0.9	(0.4 2.3)

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 43 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 78 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 40 missing and 90 cases and 17 controls excluded from the analysis.

Table 4.10 Univariate and adjusted odds ratio for presenting with an upper limb pain at a coal, gold or platinum mine (cont.)

	Cases/ Controls (N=168/701)	Univariate OR		Full model with fright (Adjusted OR) ⁱ (n=826) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=722) ^v	
		Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)
Physical activity							
Barring	(167/693)	0.7	(0.5 1.04)	0.7	(0.4 1.3)	0.7	(0.4 1.4)
Carrying, lifting or lowering loads	(168/695)	0.8	(0.5 1.1)	0.8	(0.4 1.6)	0.5	(0.4 1.7)
Hands above shoulder	(168/695)	0.8	(0.6 1.1)	0.5	(0.2 1.1)	0.5	(0.2 1.2)
Equipment above shoulder	(168/695)	0.7	(0.5 1.04)	1.3	(0.6 2.9)	1.2	(0.5 3.0)
Working in tunnels	(166/694)	1.0	(0.7 1.5)	1.3	(0.7 2.4)	1.3	(0.6 2.5)
Location of work							
Surface	(139/598)	2.0	(1.1 3.9)	2.4	(0.97 6.0)	2.0	(0.8 5.2)
Both	(14/64)	0.9	(0.5 1.7)	0.6	(0.2 1.6)	0.8	(0.3 2.1)
Underground	(14/30)	0.8	(0.5 1.3)	Reference		Reference	
Mental disorder	(168/701)	0.5	(0.3 0.96)	0.3	(0.1 0.7)	0.3	(0.1 0.8)
Life events							
Recent medical diagnosis	(168/701)	2.8	(1.6 4.9)	2.0	(0.8 4.9)	2.5	(0.99 6.3)
Frightening experience	(168/701)	46.4	(26.3 82.0)	92.6	(45.5 188.3)		
Financial problems	(168/701)	0.8	(0.6 1.3)	0.6	(0.3 1.3)	0.6	(0.3 1.3)
Social functioning							
Relationship difficulties	(168/701)	0.9	(0.5 1.6)	0.8	(0.3 1.8)	0.9	(0.3 2.2)
Difficulties at work	(168/701)	1.5	(0.8 2.8)	1.9	(0.8 4.6)	1.7	(0.7 4.4)
Difficulty relaxing	(168/701)	0.8	(0.3 2.3)	1.2	(0.3 4.8)	0.7	(0.1 3.4)
Language							
Shangaan	(17/78)	0.9	(0.5 1.6)	2.1	(0.7 6.2)	1.5	(0.5 4.8)
Zulu	(53/225)	1.0	(0.7 1.4)	2.2	(0.9 5.4)	1.8	(0.7 4.5)
Xhosa	(16/132)	0.5	(0.3 0.8)	Reference		Reference	
South Sotho	(40/134)	1.3	(0.9 2.0)	4.2	(1.6 10.9)	3.5	(1.3 9.4)
Other language^{vi}	(39/116)	1.5	(1.01 2.3)	3.4	(1.3 8.9)	2.5	(0.9 6.6)

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 43 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 78 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 40 missing and 90 cases and 17 controls excluded from the analysis.

^{vi} Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

In Table 4.10, the adjusted odds ratios for all the explanatory variables (**Full model with fright** which includes the mineworkers who had experienced a fright), showed a possible mental disorder to still be negatively associated with upper limb pain. Whereas working at a platinum mine, a recent medical diagnosis and a frightening experience were associated with increased odds of presenting with upper limb pain.

The adjusted odds ratios for all the explanatory variables (**Full model excluding fright** which excluded the mineworkers who had experienced a fright) showed a possible mental disorder was still negatively associated with upper limb pain and working at a platinum mine increased the odds of presenting with upper limb pain.

Table 4.11 shows the final models with and without subjects who reported “fright”. The following factors were found to decrease the odds of presenting with upper limb pain: barring almost all the time; working on the surface or underground; and a possible mental disorder. A recent medical diagnosis, working on the surface, if the mineworkers home language was Southern Sotho or Other language (i.e. did not include Zulu, Xhosa or Shangaan) were found to increase the odds of presenting with an upper limb pain.

There was an interaction between fright and mine. Therefore, in the first model (**Final model with fright**) fright was found to increase the odds of presenting with an upper limb pain only at the gold and platinum mine. The coal mine was associated with increased odds of presenting with an upper limb pain whether the mineworker experienced a fright or not. However at the platinum mine, only mineworkers who had not experienced a frightening event were found to have increased odds of presenting with an upper limb pain.

In the second model (**Final model excluding fright**), where mineworkers who experienced a frightening event were excluded, working at the coal mine and platinum mine, if the mineworkers home language was not Zulu, Xhosa, South Sotho or Shangaan, and a recent medical diagnosis, increased the odds of presenting with upper limb pain. Factors that were negatively associated with upper limb pain were summer, barring or working with hands above the shoulder most of the time and a possible mental disorder. The Hosmer and Lemeshow Goodness of Fit test for both models was not significant.

Table 4.11 Multivariate analysis (final model) of variables as possible risk factors for presenting with upper limb pain in mineworkers at a coal, gold and platinum mine

Variable	Cases/Controls (n=168/701)	Final model with fright ⁱ (n=860) ⁱⁱ		Cases/Controls (n=78/684)	Final model excluding fright ⁱⁱⁱ (n=751) ^{iv}	
		Adjusted OR			Adjusted OR	(Robust 95% CI)
Gold mine^v	(77/345)	Reference		(19/342)	Reference	
Coal mine	(21/81)			(19/71)	4.4 (1.8 10.5)	
		Fright	2.3 (1.1 2.5)			
		No fright	2.6 (2.3 2.8)			
Platinum mine	(70/275)			(40/271)	5.1 (2.5 10.3)	
		Fright	1.1 (0.4 3.5)			
		No fright	3.6 (3.1 4.2)			
Fright^v	(168/701)					
		Gold mine	3.7 (3.2 4.2)			
		Coal mine^{vi}	<0.05 (<0.05 <0.05)			
		Platinum mine	2.8 (2.4 3.1)			
Autumn				(27/317)	Reference	
Summer				(34/223)	0.6 (0.3 0.9)	
Working with hands above shoulders				(78/678)	0.5 (0.3 0.9)	
Barring	(167/693)	0.6 (0.4 0.9)		(77/676)	0.6 (0.3 1.01) ^{vii}	
Location						
		Working underground	Reference			
		Working on the surface	2.6 (1.1 6.0)			
		Working on the surface and underground	0.7 (0.5 0.8)			
Mental disorder	(168/701)	0.4 (0.2 0.5)		(78/684)	0.4 (0.2 0.96)	
Recent medical diagnosis	(168/701)	2.6 (1.2 5.7)		(78/684)	2.8 (1.3 4.5)	
Language						
		Shangaan	Reference	(7/77)		
		Southern Sotho	2.5 (1.1 5.7)	(20/133)		
		Other language^{viii}	2.0 (1.6 2.4)	(22/108)	2.5 (1.3 4.5)	

ⁱ ROC area: 0.87; Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.67); 10 percentile group (0.72); 8 percentile group (0.53).

ⁱⁱ 9 missing.

ⁱⁱⁱ ROC area: 0.74 Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.27); 10 percentile group (0.39); 8 percentile group (0.72).

^{iv} 11 missing.

^v In the model an interaction term was used because there was an association between mine and fright.

^{vi} There were only 2 cases who presented with upper limb pain and fright at the coal mine.

^{vii} LRTEST was significant, therefore kept in model.

^{viii} Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

4.4.2.2 Analyses for lower back pain

In Table 4.12 shows the univariate analysis for all the explanatory variables (not adjusted) which demonstrates that a possible mental disorder, young mineworkers (ages 19-35 years) and working at a platinum mine were negatively associated with lower back pain. However, working at a coal mine and having a fright increased the odds of presenting with lower back pain.

The adjusted odds ratios for all the explanatory variables (**Full model including fright** which included the mineworkers who had experienced a fright) showed a possible mental disorder and difficulties at work were negatively associated with lower back pain. Whereas working at a coal or platinum mine, experiencing a fright, working on the surface and increasing age (i.e. thirty five years and older) increased the odds of presenting with back pain.

The adjusted odds ratios in Table 4.12 which excluded mineworkers who had experienced a fright (**Final model excluding fright**) showed that activities involving pushing almost always during the shift and summer were negatively associated with lower back pain and having a mental disorder was not significant. The following variables were found to be associated with increased odds of presenting with back pain: working in the coal mine or platinum mine and increasing age (i.e. thirty five years and older).

The first final model (Table 4.13) with all mineworkers (**Final model with fright**) found pushing and a possible mental disorder decreased the odds of presenting with lower back pain. Age of thirty five years and older and working on the surface were shown to increase the odds of presenting with lower back pain. There was an interaction for fright and mine. Therefore, having a fright at a gold and platinum mine was associated with increased odds for lower back pain, whereas at the coal mine it was negatively associated. In the second model (**Final model excluding fright**), a possible mental disorder or pushing almost all the time was found to be negatively associated with lower back pain. However, working at the coal mine or platinum mine, thirty-five years old and older and the season increased the odds of presenting with back pain. The Hosmer and Lemeshow Goodness of Fit test for both models was not significant.

Table 4.12 Univariate and adjusted odds ratio for presenting with a lower back pain at a coal, gold or platinum mine

		Cases/Controls (n=383/701)	univariate OR		Full model with fright (Adjusted OR) ⁱ (n=1038) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=802) ^v	
			Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)
Mines								
	Gold mine	(233/345)	1.0	(0.7 1.4)	Reference		Reference	
	Coal mine	(43/81)	1.6	(1.2 2.1)	5.3	(2.5 11.2)	6.5	(2.9 14.4)
	Platinum mine	(107/275)	0.6	(0.5 0.8)	4.8	(2.6 8.6)	5.3	(2.8 9.8)
Age (years)								
	19-34	(98/236)	0.7	(0.5 0.9)	Reference		Reference	
	35-44	(186/304)	1.2	(0.96 1.6)	1.8	(1.1 2.9)	1.9	(1.1 3.2)
	45-older	(97/149)	1.3	(0.9 1.7)	2.0	(1.1 3.8)	2.4	(1.3 4.6)
Service history (years)		(372/684)	1.012	(0.995 1.030)	1.002	(0.98 1.01)	1.00	(0.97 1.03)
Season								
	Autumn	(176/321)	1.0	(0.8 1.3)	0.8	(0.4 1.1)	0.9	(0.5 1.6)
	Winter	(83/150)	1.0	(0.8 1.4)	Reference		Reference	
	Summer	(124/230)	1.0	(0.8 1.3)	0.7	(0.5 1.4)	0.6	(0.4 0.9)
Education								
	No education	(79/152)	0.9	(0.7 1.3)	Reference			
	Primary school	(183/308)	1.2	(0.9 1.5)	1.1	(0.7 1.8)	1.2	(0.7 2.0)
	Secondary and higher	(119/238)	0.9	(0.7 1.1)	0.8	(0.5 1.4)	0.8	(0.5 1.5)
Smoker (yes)		(383/701)	1.1	(0.9 1.5)	0.8	(0.5 1.2)	0.7	(0.5 1.2)
Alcohol consumption (grams/week)								
	0	(209/404)	0.9	(0.7 1.1)	Reference		Reference	
	1-56	(49/69)	1.3	(0.9 2.0)	1.5	(0.8 2.7)	1.8	(0.9 3.5)
	57-112	(93/154)	1.1	(0.8 1.5)	1.1	(0.7 1.9)	1.3	(0.7 2.2)
	113 and greater	(32/74)	0.8	(0.5 1.2)	1.1	(0.5 2.0)	1.6	(0.8 3.2)

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 46 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 155 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 37 missing and 228 cases and 17 controls excluded from the analysis.

Table 4.12 Univariate and adjusted odds ratio for presenting with a lower back pain at a coal, gold or platinum mine (cont.)

	Cases/Controls (n=383/701)	Univariate OR		Full model with fright (Adjusted OR) ⁱ (n=1038) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=802) ^v	
		Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)
Physical activity:							
Pushing	(381/694)	0.7	(0.6 0.96)	0.7	(0.4 1.1)	0.6	(0.4 0.96)
Bending at the waist	(383/697)	1.0	(0.8 1.3)	1.2	(0.7 2.1)	1.2	(0.7 2.0)
Carrying, lifting or lowering loads	(382/695)	0.9	(0.7 1.2)	0.8	(0.5 1.3)	0.8	(0.4 1.3)
Working in tunnels	(382/694)	1.0	(0.8 1.3)	1.4	(0.9 2.1)	1.4	(0.9 2.3)
Using vibratory tools	(382/696)	1.2	(0.9 1.5)	1.0	(0.7 1.6)	1.0	(0.6 1.6)
Location of work							
Surface	(25/30)	1.6	(0.9 2.7)	2.6	(1.2 5.4)	2.1	(0.96 4.6)
Both	(35/64)	1.0	(0.6 1.5)	1.4	(0.7 2.6)	1.3	(0.6 2.6)
Underground	(321/598)	0.9	(0.6 1.3)	Reference		Reference	
Mental disorder	(383/701)	0.4	(0.3 0.6)	0.5	(0.2 0.9)	0.6	(0.3 1.1)
Life events							
Recent medical diagnosis	(383/701)	1.1	(0.6 1.9)	0.7	(0.3 1.6)	0.7	(0.3 1.6)
Assaulted	(383/701)	4.6	(0.9 23.9)	2.0	(0.2 25.6.8)	9.2	(0.6 135.6)
Frightening experience	(383/701)	59.2	(35.1 99.8)	102.9	(56.7 186.7)		
Financial problems	(383/700)	1.3	(0.97 1.9)	1.2	(0.7 2.0)	1.4	(0.8 2.4)
Social functioning							
Relationship difficulties	(383/701)	0.6	(0.4 0.9)	0.8	(0.4 1.4)	1.0	(0.5 1.9)
Difficulties at work	(383/701)	0.7	(0.4 1.3)	0.5	(0.2 1.2)	0.5	(0.2 1.2)
Inability to relax	(383/701)	1.1	(0.6 2.3)	1.5	(0.5 3.9)	1.3	(0.5 3.5)
Language							
Shangaan	(55/78)	1.3	(0.9 1.9)	1.7	(0.8 3.5)	1.6	(0.7 3.4)
Zulu	(130/225)	1.1	(0.8 1.4)	1.5	(0.9 2.5)	1.5	(0.8 2.6)
Xhosa	(56/132)	0.7	(0.5 1.04)	Reference		Reference	
South Sotho	(65/134)	0.9	(0.6 1.2)	1.3	(0.7 2.5)	1.3	(0.6 2.5)
Other ^{vi}	(72/116)	1.2	(0.8 1.6)	1.3	(0.7 2.5)	1.3	(0.7 2.4)

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 46 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 155 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 37 missing and 228 cases and 17 controls excluded from the analysis.

^{vi} Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

Table 4.13 Multivariate analysis (final model) of variables as possible risk factors for presenting with lower back pain in mineworkers at a coal, gold and platinum mine

Variable	Cases/Controls (n=383/701)	Final model with Fright ⁱ (n=1075) ⁱⁱ		Cases/Controls (n=155/684)	Final model excluding Fright ⁱⁱⁱ (n=832) ^{iv}	
		Adjusted OR	(Robust 95% CI)		Adjusted OR	(Robust 95% CI)
Gold mine^v	(233/345)	Reference		(43/342)	Reference	
Coal mine	(43/81)			(36/71)	4.0	(3.9 4.1)
No Fright Fright^{vi}		3.9	(2.3 6.6)			
		<0.01	(0.0 0.1)			
Platinum mine	(107/275)			(76/271)	3.6	(3.0 4.4)
No Fright Fright		3.7	(2.3 6.1)			
		0.3	(0.0 3.5)			
Fright^v	(383/701)					
Gold mine		3.5	(2.9 4.3)			
Coal mine		0.01	(0.01 0.01)			
Platinum mine		3.9	(3.9 4.0)			
Age						
19-34years	(98/236)	Reference		(28/231)	Reference	
35-44 years	(186/304)	2.1	(1.5 2.7)	(80/297)	2.2	(1.7 2.9)
≥ 45 years	(97/149)	2.2	(2.1 2.3)	(45/144)	2.6	(1.9 3.5)
Autumn				(52/317)	1.3	(1.1 1.6)
Pushing	(381/694)	0.7	(0.5 0.9)	(69/344)	0.5	(0.4 0.8)
Location						
Working underground	(321/598)	Reference		(123/587)		
Working on the surface	(25/30)	2.3	(1.9 2.7)	(15/30)		
Mental disorder	(383/701)	0.4	(0.4 0.5)	(17/102)	0.5	(0.5 0.6)

ⁱ ROC area: 0.70; Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.65); 10 percentile group

ⁱⁱ 9 missing.

ⁱⁱⁱ ROC area: 0.70; Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.48); 10 percentile group (

^{iv} 7 missing.

^v In the model an interaction term was used because there was an association between mine and fright.

^{vi} There were only 7 coal cases who experienced a fright.

4.4.2.3 Analyses for lower limb pain

Table 4.14 shows the univariate analysis (OR) for the explanatory variables (not adjusted) demonstrating that mineworkers who were older than 44 years, had a long service history, who work while kneeling, experienced a fright, had issues at work and/or had problems with close relationships, increased the odds of presenting with a lower limb pain. Mineworkers from the gold mine and young mineworkers (35-44 years) were found to be negatively associated with lower limb pain.

The adjusted odds ratios (Table 4.14) for all the explanatory variables (**Full model including fright** which included the mineworkers who had experienced a fright) showed possible mental disorder to be negatively associated with lower limb pain. Whereas, working at a platinum mine, mineworkers older than 44 years, working on the surface, kneeling and/or experiencing a fright increased the odds ratio of presenting with lower limb pain.

The adjusted odds ratios in Table 4.14 which excluded mineworkers who had experienced a fright (**Final model excluding fright**) showed that working at the platinum mine, being older than forty four years, autumn and winter, primary school education and/or kneeling or squatting increased the odds of presenting with a lower limb pain. A possible mental disorder remained a negatively associated factor.

The coal mine was excluded from the final model because of the small number of mineworkers presenting with lower limb pain from the coal mine (i.e. eight). The first final model (Table 4.15) with all mineworkers (**Final model with fright**) demonstrated that a possible mental disorder was negatively associated. The following factors were found to increase the odds of presenting with lower limb pain: increasing age i.e. forty-five years or older, working at the platinum mine (with or without experiencing a fright), working on the surface, experiencing a fright (at the gold and platinum mine) and kneeling most of the time during the shift. In the second model (**Final model excluding fright**), working at the platinum mine, mineworkers forty-five years or older, winter and kneeling, increased the odds of presenting with lower limb pain. A possible mental disorder was consistently shown to be negatively associated. The Hosmer and Lemeshow Goodness of Fit test for both models was not significant.

Table 4.14 Summary of univariate and adjusted odds ratio for presenting with a lower limb pain at a coal, gold or platinum mine

Cases/Controls (n=176/701)			Univariate OR		Full model with fright (Adjusted OR) ⁱ (n=840) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=731) ^v		
			Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	
Mine	Coal mine	(8/81)	0.4	(0.2 0.8)	6.2	(1.6 23.6)	6.9	(1.7 27.3)	
	Gold mine	(45/345)	0.4	(0.2 0.5)	Reference		Reference		
	Platinum mine	(123/275)	3.6	(2.5 5.1)	11.6	(4.6 28.8)	11.5	(4.5 29.4)	
Age (years)									
	19-34	(46/236)	0.7	(0.5 1.01)	1.7	(0.8 3.4)	1.5	(0.7 3.2)	
	35-44	(55/304)	0.6	(0.4 0.8)	Reference		Reference		
	45-older	(73/149)	2.6	(1.8 3.7)	3.4	(1.7 6.8)	4.0	(1.9 8.4)	
Service history (years)			(164/684)	1.04	(1.02 1.06)	1.03	(0.99 1.06)	1.02	(0.98 1.07)
Season									
	Autumn	(71/321)	0.8	(0.6 1.1)	2.1	(0.96 4.2)	3.6	(1.7 7.6)	
	Winter	(44/150)	1.2	(0.8 1.8)	1.9	(0.9 3.7)	2.5	(1.2 5.4)	
	Summer	(61/230)	1.1	(0.8 1.5)	Reference		Reference		
Education									
	No education	(44/152)	1.2	(0.8 1.8)	Reference		Reference		
	Primary school	(82/308)	1.1	(0.8 1.6)	1.3	(0.7 2.6)	1.7	(0.8 3.5)	
	Secondary and higher	(47/238)	0.7	(0.5 1.02)	0.5	(0.2 1.2)	0.6	(0.3 1.5)	
Smoking (yes)			(176/701)	0.8	(0.6 1.2)	0.9	(0.5 1.6)	0.9	(0.4 1.7)
Alcohol consumption (grams/week)									
	0	(110/404)	1.2	(0.9 1.7)	Reference		Reference		
	1-56	(14/69)	0.8	(0.4 1.4)	1.1	(0.4 3.3)	1.3	(0.4 4.3)	
	57-112	(39/154)	1.0	(0.7 1.5)	0.9	(0.4 1.9)	1.1	(0.5 2.3)	
	113 and greater	(13/74)	0.7	(0.4 1.2)	0.8	(0.3 2.2)	1.5	(0.5 4.2)	

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 37 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 76 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 29 missing and 100 cases and 17 controls excluded from the analysis.

Table 4.14 Univariate and adjusted odds ratio for presenting with a lower limb pain at coal, gold or platinum mine (cont.)

	Cases/Controls (n=176/701)	Univariate OR		Full model with fright (Adjusted OR) ⁱ (n=840) ⁱⁱ		Full model excluding fright ⁱⁱⁱ (Adjusted OR) ^{iv} (n=731) ^v	
		Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)	Odds Ratio	(Robust 95% CI)
Physical activity:							
Kneeling or squatting	(175/696)	2.1	(1.5 3.0)	2.5	(1.3 5.1)	2.3	(1.1 4.8)
Working in tunnels	(172/674)	1.2	(0.9 1.7)	1.4	(0.7 2.5)	1.3	(0.7 2.5)
Location of work							
Surface	(12/30)	1.6	(0.8 3.3)	2.8	(0.6 13.8)	2.0	(0.4 10.3)
Both	(12/64)	0.7	(0.4 1.4)	Reference		Reference	
Underground	(150/598)	1.0	(0.6 1.6)	1.1	(0.4 2.4)	0.7	(0.2 2.1)
Mental disorder	(176/701)	1.0	(0.6 1.5)	0.3	(0.2 0.7)	0.4	(0.2 0.9)
Life events							
Diagnosis of disease	(176/701)	1.5	(0.8 2.8)	1.3	(0.4 3.8)	1.6	(0.5 4.9)
Frightening experience	(176/701)	52.9	(30.1 93.3)	132.2	(60.6 288.5)		
Financial problems	(176/701)	0.9	(0.6 1.3)	0.9	(0.5 1.9)	1.2	(0.5 2.5)
Social functioning							
Relationship difficulties	(176/701)	1.6	(1.02 2.6)	0.8	(0.4 1.7)	1.0	(0.5 2.4)
Difficulties at work	(176/701)	2.1	(1.2 3.6)	0.7	(0.3 1.7)	0.5	(0.2 1.5)
Loss of interest	(176/701)	0.8	(0.3 2.2)	1.8	(0.4 8.1)	2.0	(0.5 8.9)
Language							
Zulu	(11/78)	0.5	(0.3 1.0)	Reference		Reference	
Xhosa	(65/225)	1.2	(0.9 1.7)	0.7	(0.3 1.8)	0.7	(0.2 2.0)
Shangaan	(37/132)	1.1	(0.8 1.7)	0.5	(0.2 1.6)	0.7	(0.2 2.2)
South Sotho	(31/134)	0.9	(0.6 1.4)	0.8	(0.3 2.4)	0.8	(0.2 2.4)
Other ^{vi}	(30/116)	1.0	(0.7 1.6)	0.9	(0.3 2.7)	0.8	(0.2 2.5)

ⁱ Adjusted = all variables shown in the first column included in the model.

ⁱⁱ 37 missing.

ⁱⁱⁱ Mineworkers not reporting fright in the analysis i.e. cases = 76 and controls = 684.

^{iv} Adjusted = all variables shown in the first column included in the model except for fright.

^v 29 missing and 100 cases and 17 controls excluded from the analysis.

^{vi} Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

Table 4.15 Multivariate analysis (final model) of variables as possible risk factors for presenting with lower limb pain in mineworkers at a gold and platinum mineⁱ

Variable	Cases/Controls (n=168/620)	Final model with fright ⁱⁱ (n=782) ⁱⁱⁱ		Cases/Controls (n=68/613)	Final model excluding fright ^{iv} (n=675) ^v	
		Adjusted OR	(Robust 95% CI)		Adjusted OR	(Robust 95% CI)
Gold mine^{vi}	(45/345)	Reference		(8/342)	Reference	
Platinum mine	(123/275)			(60/271)	8.5	(8.1 8.8)
Fright^{vi}	(176/701)					
no fright		9.2	(8.7 9.8)			
fright		2.5	(2.1 2.9)			
Gold mine		85.9	(72.6 101.8)			
Platinum mine		9.3	(8.5 10.1)			
Mental disorder	(176/701)	0.3	(0.3 0.4)	(76/684)	0.5	(0.4 0.5)
Age: 19-34yrs	(46/236)	Reference		(18/231)	Reference	
≥ 45 yrs	(73/149)	3.5	(1.0 12.4)	(35/144)	4.2	(1.6 10.7)
Summer					Reference	
Winter				(31/144)	2.1	(2.0 2.3)
Working on surface and underground	(12/64)	Reference				
Working on the surface	(12/30)	2.4	(1.0 5.6)			
Kneeling	(175/696)	2.9	(1.6 5.1)	(75/679)	2.2	(1.3 3.6)

ⁱ Coal mine was excluded from the model due to small number of cases with lower limb pain.

ⁱⁱ ROC area: 0.92; Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.56); 10 percentile group (0.72); 8 percentile group (0.53).

ⁱⁱⁱ 6 missing.

^{iv} ROC area: 0.82; Hosmer and Lemeshow Goodness of Fit test P-value results: 12 percentile group (0.60); 10 percentile group (0.46); 8 percentile group (0.47).

^v 6 missing.

^{vi} In the model an interaction term was used because there was an association between mine and fright.

4.5 Adjustment analyses for controls with a history of musculoskeletal disorders

The associations between physical activities and psychosocial factors with upper limb, lower back and lower limb pain were unexpected findings and the possibility of selection bias or disease misclassification regarding the controls needed to be considered, especially since a large percentage of controls had a history of MSD. In order to consider the effect this may have had on the findings, the analyses were repeated for each region including an adjustment factor (i.e. a binary variable for history of MSD) in the logistic regression. The results were compared with the final models obtained in section 4.3 and are presented in Tables 4.16 (upper limb pain), 4.17 (lower back pain) and 4.18 (lower limb pain). The two models for upper limb, lower back and lower limb are not the same but very similar, there are some big differences for some ORs while others are very similar. The associations do not change much. Mine and fright become non-significant in the additional models for the upper limb and lower back.

Table 4.16 Final models for upper limb pain at a coal, gold and platinum mine using all controls then including past MSD in the final model (with all controls)

		Final model ⁱ (N= 860) ⁱⁱ		Final model with binary variable for previous MSD included ⁱⁱⁱ (N= 860) ^{iv}	
		OR	(Robust 95% CI)	OR	(Robust 95% CI)
Gold mine^v		Reference		Reference	
Coal Mine	Fright	2.3	(1.1 2.5)	4.0	(0.2 8.0)
	No fright	2.6	(2.3 2.8)	1.3	(0.5 3.8)
Platinum mine	Fright	1.1	(0.4 3.5)	1.4	(0.5 3.9)
	No fright	3.6	(3.1 4.2)	1.6	(0.5 5.4)
Fright^v					
	Gold mine	3.7	(3.2 4.2)	1.7	(0.5 6.6)
	Coal mine	<0.05	(<0.05 <0.05)	0.006	(0.004 0.008)
	Platinum mine	2.8	(2.4 3.1)	1.5	(0.6 4.1)
Mental disorder		0.4	(0.2 0.5)	0.4	(0.3 0.6)
Recent medical diagnosis		2.6	(1.2 5.7)	3.0	(1.7 5.2)
Barring		0.6	(0.4 0.9)	0.6	(0.4 0.9)
Languages	Shangaan	Reference		Reference	
	Southern Sotho	2.5	(1.1 5.7)	2.6	(1.3 5.3)
	Other language^{vi}	2.0	(1.6 2.4)	2.2	(1.3 4.0)
Location	Underground	Reference		Reference	
	Working on the surface	2.6	(1.1 6.0)	2.3	(0.7 6.8)
	Working surface & underground	0.7	(0.5 0.8)	0.7	(0.6 0.8)
Previous MSD				0.3	(0.02 3.9)

ⁱ Final model results for upper limb MSD with fright (Table 4.13).

ⁱⁱ 168 cases: 701 controls: 9 missing.

ⁱⁱⁱ An adjustment factor (binary variable) was included in the logistic regression for cases and controls who previously presented to the clinic with a MSD (i.e. 1) and 0 if they did not.

^{iv} 168 cases: 701 controls: 9 missing.

^v In the model an interaction term was used because there was an association between mine and fright.

^{vi} Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo.

Table 4.17 Final models for lower back pain at a coal, gold and platinum mine using all controls then including past MSD in the final model (with all controls)

		Final model ⁱ (N=1075) ⁱⁱ		Final model with binary variable for previous MSD included ⁱⁱⁱ (N= 1075) ^{iv}	
		OR	(Robust 95% CI)	OR	(Robust 95% CI)
Gold mine^v		Reference		Reference	
Coal Mine	Fright	<0.01	(0.0 0.1)	<0.01	(<0.01 0.01)
	No fright	3.9	(2.3 6.6)	2.2	(0.5 9.5)
Platinum mine	Fright	0.3	(0.0 3.5)	1.9	(0.5 8.0)
	No fright	3.7	(2.3 6.1)	1.6	(0.2 11.0)
Fright^v					
	Gold mine	3.5	(2.9 4.3)	1.6	(0.2 10.7)
	Coal mine	0.01	(0.01 0.01)	0.01	(0.01 0.02)
	Platinum mine	3.9	(3.9 4.0)	2.2	(0.5 9.7)
Mental disorder		0.4	(0.4 0.5)	0.5	(0.4 0.6)
Age		Reference		Reference	
	35-44 years	2.1	(1.5 2.6)	2.2	(1.6 3.0)
	≥ 45 years	2.2	(2.0 2.4)	2.4	(1.6 3.5)
Pushing		0.7	(0.5 0.9)	0.7	(0.5 0.99)
Working on the surface		2.3	(1.9 2.7)	2.1	(1.4 3.2)
History of MSD				0.3	(<0.01 11.8)

ⁱ Final model results for lower back MSD with fright (Table 4.14).

ⁱⁱ 383 cases: 701 controls: 46 missing.

ⁱⁱⁱ An adjustment factor (binary variable) was included in the logistic regression for cases and controls who previously presented to the clinic with a MSD (i.e. 1) and 0 if they did not.

^{iv} 383 cases: 701 controls: 46 missing.

^v In the model an interaction term was used because there was an association between mine and fright.

Table 4.18 Final models for presenting with a lower limb pain at a gold and platinum mine using all controls and then then including past MSD in the final model (with all controls)ⁱ

	Final model ⁱⁱ (N= 782) ⁱⁱⁱ		Final model with binary variable for previous MSD included ^{iv} (N= 782) ^v	
	OR	(Robust 95% CI)	OR	(Robust 95% CI)
Gold mine^{vi}	Reference		Reference	
Platinum mine				
Fright	2.5	(2.1 2.9)	2.5	(2.2 2.8)
No Fright	9.2	(8.7 9.8)	9.5	(9.3 9.7)
Fright^{vi}				
Gold mine	85.9	(72.6 101.8)	93.1	(83.4 104)
Platinum mine	9.3	(8.5 10.1)	9.7	(9.1 10.2)
Age				
19-34 years	Reference		Reference	
35-44 years	3.5	(0.96 12.4) ^{vii}	3.4	(1.02 11.0)
Mental disorder	0.3	(0.3 0.4)	0.3	(0.3 0.4)
Kneeling	2.9	(1.6 5.1)	2.9	(1.6 5.3)
Working on the surface	2.4	(1.02 5.6)	2.5	(1.1 5.3)
History of MSD			1.3	(0.6 3.1)

ⁱ Coal mine was excluded from the model due to small number of cases with lower limb pain.

ⁱⁱ Final model results for lower limb MSD with fright (Table 4.15).

ⁱⁱⁱ 168 cases: 620 controls: 6 missing.

^{iv} An adjustment factor (binary variable) was included in the logistic regression for cases and controls who previously presented to the clinic with a MSD.

^v 168 cases: 620 controls: 6 missing.

^{vi} In the model an interaction term was used because there was an association between mine and fright.

^{vii} LRTEST significant therefore kept in model.

4.6 Summary of findings

The numbers of controls who had never presented with an upper limb, lower back, and lower limb pain were 404 (57.8%), 386 (55.2%) and 618 (87.9%) respectively.

A possible mental disorder (SRQ) was found in 15.3% of controls compared to 9.6% of cases. Social functioning was similar for cases and controls. However, more cases compared to controls had negative life events. The home language spoken by cases and controls were similar.

For upper limb pain the risk factors identified were the type of mine (working at the coal and platinum mine if mineworkers who had experienced a fright were excluded), a recent medical diagnosis, language (not speaking Zulu, Xhosa, Southern Sotho or Shangaan if fright was excluded from the model), season (summer if fright was excluded from the model) and fright. Having a possible mental disorder, summer, working on the surface, barring and working with hands above shoulders most of the time, was negatively associated.

For back pain the risk factors identified were age (greater than thirty four years), mine (working at the coal and platinum mine if mineworkers who had a fright were excluded), season (autumn if mineworker who had a fright were excluded), working on the surface (if all mineworkers used in the analysis) and fright. Activities involving pushing and having a possible mental disorder were negatively associated. Working with vibratory tools increased the odds of presenting with lower back pain which was significant when controls with a history of lower back pain were excluded.

For lower limb, the following activities were found to increase the odds of presenting with a MSD: bending; climbing; pulling; shovelling and kneeling when compared with all controls.

The risk factors identified for a lower limb pain presentation were age (forty five years and older), kneeling, season (winter if mineworkers who had experienced a frightful event were excluded from the model and in the multivariate analysis – without fright - autumn as well), platinum mine (coal mine was excluded from the model because of the small number of cases with lower limb pain), working on the

surface and fright. Having a possible mental disorder was negatively associated. It is notable that language was not significantly associated with presenting with back pain or lower limb pain in any of the analyses.

When controls with a history of a MSD were excluded, fright was no longer significantly associated with upper limb and lower back pain.

CHAPTER 5

DISCUSSION

5.1 Introduction

The aims of this research were to determine the incidence of MSD at three South African mines, and to determine if physical exposure, psychosocial factors and language spoken were associated with presenting to a coal, gold and platinum mine clinic with a MSD. The estimated incidence of MSD (using case records) for the six-month study period was 6.2% for the three mines combined, suggesting an annual incidence of 124/1000 if the six-month finding is extrapolated over a whole year. Using more restrictive criteria for MSDs (i.e. only cases evaluated by the research nurses) incidence was 2.7%, suggesting an annual incidence of 54/1000 which was considered high for all three mines.

Lower back pain was the most common MSD presentation at the coal and gold mines. Lower limb pain was the most common presentation at the platinum mine. The coal mine had the highest percentage of upper limb cases. The large majority of these mineworkers presenting with a MSD had disabling symptoms. One day's sick leave was most commonly given for most MSD presentations to the mine clinic. A large percentage of cases reported a frightening experience. The largest group of study participants was Xhosa speaking.

A possible mental disorder was consistently found to be a negative association for the presentation of upper limb pain, lower back pain and lower limb pain. Experiencing a fright was consistently found to increase the odds of presenting with upper limb, lower back and lower limb pain. Both findings are unusual. It is notable that language was not consistently associated with presenting with lower back pain or lower limb pain in any of the analyses, but that upper limb pain was associated with Other languages (i.e. Swazi, Afrikaans, Ndebele, Tswana, Portuguese, English, Tsonga and Mpondo). Working on the surface was found to increase the odds of presenting with an upper limb, lower back and lower limb pain. The only physical

activities associated with MSD in this study was kneeling associated with increased risk of lower limb pain and barring which was a negative association for upper limb pain. Age was found to increase the odds of presenting with a MSD. For lower back being 35 years and older and for lower limb pain being 45 years and older increased the odds ratios. Interestingly, summer was found to be a negative association for upper limb pain. However, autumn was associated with increased odds of presenting with lower back pain and winter with lower limb pain.

5.2 Incidence of musculoskeletal disorders

The percentage of mineworkers employed on the mine presenting to the mine clinic with a musculoskeletal disorder over the six months of the study was 7.0% at the coal mine, 5.4% at the gold mine and 8.1% at the platinum mine (upper estimate because it includes mineworkers presenting with a musculoskeletal disorder during and after office hours). The percentage of cases (mineworkers employed on the mine presenting with a musculoskeletal disorder during office hours - lower estimate) over the six months of the study was 6.5% at the coal mine, 1.9% at the gold mine and 4.1% at the platinum mine and these data suggest an annual incidence of 130/1000, 38/1000 and 82/1000 for the coal, gold and platinum mines respectively. Moore and colleagues (2008) identified cumulative injuries (due to awkward postures, repetitive motions, jarring and jolting and vibration) in coal mines using the USA Mine Health and Safety Administration (MSHA) database for two data sets i.e. 1983-1984 and 2003-2004. The latter was after technological advancements (i.e. machinery design, control and operations) were implemented. The annual incidence rate before technological advancements was 5% and had decreased to 4% after technological advancements. The annual incidence rates found in this study are comparable if only cases are used (i.e. lower estimate - estimated incidence of MSD cases for the six-month study period at the gold mine was 1.9% suggesting an annual incidence of 3.8% if the six-month finding is extrapolated over a whole year).

It is difficult to compare the findings of this study with other studies conducted in the mining industry or in similar industries in South Africa because of the different study methodologies used i.e. cross-section studies (Lloyd et al., 1986; Bio et al., 2007; {Van Vuuren et al., 2007; Xu et al., 2012) and case-control studies (Friis et al., 1998;

Sarikaya et al., 2007). Therefore comparing the extent of MSDs is complicated. Most of the studies done in the mining industry and in South Africa provide prevalence data. In the studies conducted in the mining industry, the prevalence of lower back pain was found to be approximately two-thirds of the mineworkers (Lloyd and Soutar, 1986; Bio et al., 2007; Xu et al., 2012). In factory workers in South Africa, the prevalence of lower back pain, neck and shoulder pain and forearm pain was 26%, 14% and 1% respectively (Schierhout et al., 1993). The lifetime, annual and point prevalence of lower back pain among 366 workers in a South African stainless steel industry was 63.9%, 55.7% and 35.8% respectively (Van Vuuren et al., 2006a). The lifetime, annual and point prevalence of lower back pain among 109 men working in a Manganese factory in South Africa was 71.6, 69.8% and 37.6% respectively (Van Vuuren et al., 2007).

Difficulties in determining work-relatedness of MSD complaints include; mineworkers not presenting to the mine clinic with a MSD (for example seeking treatment from a service provider not associated with the mine) or mineworkers with MSD not associating their condition with work but possibly with aging (Linton et al., 1990) and, therefore, not seeking medical treatment. Schierhout and colleagues (1995) reported a prevalence of 1% for MSD of forearms, wrists and hands of factory workers in the manufacturing industry of South Africa, which was lower than expected. The incidence may have been underestimated due to the healthy worker effect, and because patients with MSDs may not consult the company clinic since they either choose not to or because they have another preferred health care provider. Linton and colleagues (1990) demonstrated that around 50% of patients with severe MSD did not seek medical treatment. Of the 31% of study participants complaining of neck pain, 16% consulted a doctor for the pain. Similarly, for back pain, 39% reported symptoms but only 16% of the participants consulted a medical professional during the year (Linton et al., 1990).

The upper estimate (i.e. MSD cases and MSD records) of MSDs at the coal, gold and platinum mine is more likely to be closer to the real incidence because a large number of mineworkers with MSDs presented after hours. These mineworkers complaints could not be confirmed by a research nurse, however, not every mineworker with a MSD presented to the clinic. Relying on the MSD cases only

would be an underestimation, therefore the real incidence of MSDs is closer to 6.2% which was comparable to the percentage of patients attending a community health clinic in South Africa (Cape Town) for a MSD i.e. 7% (Parker and Jelsma, 2010). A reason for the lower proportion may be the high prevalence of other medical conditions presenting to the mine clinic (for example HIV and TB). Linton found that people with severe MSD did not seek medical care because there was a lack of association with work; the belief that the pain and disability was part of an aging process, belief that there was very little that doctors could do and fear of drug dependency (Linton, 1990).

5.3 Anatomical location

High percentages of MSDs at the gold and coal mine were lower back pain (65.6% and 59.7% respectively). Furthermore, 30% of MSD cases at the coal mine presented with upper limb pain, which included the neck. These results are somewhat in agreement with previous research, which has demonstrated that exposure to ergonomic hazards found in the American mining industry resulted in pain in the neck, back, and upper limbs (Winn et al., 1996). An analysis of the USA Mine Safety and Health Administration database for 1996-2005 revealed that the back was the most predominant part of the body affected in coal mining cumulative injuries (31%), with the knee the second most frequently reported body part (17%) (Gallagher, 2008). Interestingly in this study, 41% of MSD cases at the platinum mine presented with lower limb pain which is not unexpected since underground seams are very narrow (Ross M, personal communication, 2013).

Anatomical locations of MSDs appear to be influenced by the industrial sector in which workers are employed. Of work-related MSDs reported from 1992-2003 among workers in the Norwegian offshore petroleum industry, upper limb MSDs accounted for 53% , back disorders for 20% and lower limb MSD for 16% (with knee disorders accounting for 12% of all cases) (Morken and Moen, 2007). Andersen and colleagues (2007) studied a cohort of workers from the service sector and other industrial settings. The prevalence of neck/shoulder pain at baseline interview was high among the cleaning and kitchen workers (49%). Lower back pain ranged from

15% among administrative workers in industry to 33% among cleaning and kitchen workers and 30% among nurse assistants. Lower limb pain was highest among cleaning and technical staff in the service sector (35%).

In this study, 65 cases (9.4%) reported signs and symptoms at multiple sites: 2.7% of cases presented with upper limb and lower back pain, 2.1% of cases presented with lower limb and lower back pain and two cases presented with upper limb and lower limb pain. A possible mental disorder was a negative association for MSD and experiencing a fight (at the gold and platinum mine) was associated with MSD of the upper limb, lower back or lower limb. Increasing age was associated with lower back and lower limb pain, and if controls experiencing a fright were excluded, cooler seasons were associated with MSD.

5.4 Southampton Examination Schedule

The use of the Southampton Examination Schedule in this study demonstrated that cases presenting with upper limb pain could be categorised into a specific clinical diagnosis (Palmer et al., 2000; Palmer, 2007). A high proportion of cases that could be categorised, however, had more than one clinical diagnosis i.e. 75% of cases with shoulder pain, 38.5% with elbow pain and 20% with wrist pain. This finding of multiple diagnoses is in agreement with two other studies. One study showed 24% of subjects with a specific disorder had more than one clinical diagnosis (Walker-Bone et al., 2006). Shoulder capsulitis, rotator cuff tendonitis and painful OA of the thumb base or distal finger joints were the most common disorders (Walker-Bone, 2006). In another study physiotherapists and physicians, who followed a different distinct diagnostic protocol, (Waris et al., 1979) found the diagnosis of neck or shoulder pain was accompanied by a concurrent disorder (Ekberg, 1994).

The limitation of the Southampton Examination Schedule is that it requires extensive training and on-going periodical checks of examiners (Walker-Bone et al., 2002a). In this study a high proportion of cases could not be examined, for example 15% of cases with shoulder pain could not be classified using the Southampton Examination Schedule, but these cases would be classified as non-specific shoulder MSD. About

20% cases with upper limb pain was not examined because mineworkers did not give consent due to time constraints or did not come back for examination as requested. The Southampton Examination Schedule relies on symptoms and physical examination findings without imaging or ultrasound and has been shown to be fairly reliably in diagnosing upper limb MSDs (Palmer et al., 2000; Palmer, 2007). However, in this study, the clinical presentations were not always specific enough for a clinical diagnosis. The other limitation is that the Southampton Examination Schedule is only for upper limb pain. The examination is lengthy and in a busy clinic attending to 200 mineworkers a day it may not be feasible to use routinely in the clinic setting.

A multitude of studies has been conducted on upper limb disorders. However, case definitions vary in the studies thus making it difficult to compare them. There is no evidence that specific MSDs have the same cause and management as non-specific pain of the same anatomical region (Walker-Bone et al., 2006). Another concern is the non-specific nature of MSD symptoms. If a specific MSD (for example carpal tunnel syndrome) and non-specific MSD (for example shoulder and elbow pain) do not have the same cause and management, then it is important to differentiate, as management will be different and different risk factors in the work place need to be identified.

5.5 Severity of musculoskeletal disorders

Assessment of MSD severity with the Nordic questionnaire showed that the majority of cases at the gold mine (90.1%) and a high percentage at the platinum mine (43.9%) complained of pain for 1-7 days. However, at the coal mine the majority of cases (64.3 %) presented to the mine clinic with pain that had started on the day. Accessibility and confidence in treatment at the clinics are important factors that could influence the above finding, but were not investigated in this study.

A large percentage of the cases reported symptoms suggestive of disability. At the platinum mine, almost all the cases (96.2%) had symptoms of disability, at the gold mine it was over half the cases (65.3%) and at the coal mine it was just less than half (47.1%). The response to the Nordic questionnaire to assess symptom duration and

associated disability is subjective, but validated (Dickinson et al., 1992; Palmer et al., 1999). In South Africa, 15.3% of the workers at a steel industry and 37.6% of the workers at a manganese factory complained of lower back pain which limited their daily activity (using the Functional Rating Index) (Van Vuuren et al., 2006b; Van Vuuren et al., 2007). Both studies were cross-sectional and conducted at the workplace whereas in this study, mineworkers presented to the mine clinic with a MSD and thus one may expect more severe disease. Symptoms of the MSD were sufficiently severe to result in the mineworker presenting to the mine clinic for treatment, and therefore the percentages with disability are likely to be higher than in surveys of workforces. Interestingly, although 96.2% of platinum mineworkers had symptoms of disability, the majority (58.9%) were not given sick leave.

The main cause of sick leave in Dutch agricultural workers was MSDs (Hartman et al., 2006). Hartman and colleagues (2006) found that 30% of the claims for sick leave were for upper limb disorders and back disorders (Hartman et al., 2006). In this study, sick leave for one day was given to the greater proportion of cases presenting with lower back (64%) and lower limb pain except for the knee (42%). A large percentage of cases presenting with neck pain (38%) were given 3 – 7 days sick leave. Hartman and colleagues (2006) also demonstrated how sick leave varied greatly between the agricultural sectors and suggested that this was due to the different exposure to risk factors in different types of farming (Hartman et al., 2003).

The method of assessment of severity used in this study was subjective. Cases reported their symptoms, duration of symptoms and disability and no objective methods (e.g. x-rays or subsequent tests or examinations) were used. Sick leave is influenced by sick leave policy of the mine and accessibility to the shaft. At the coal mine, mineworkers had easy access to the shaft during the shift, whereas at the gold and platinum mines, the mineshafts usually only transported mineworkers at the beginning and end of the shift. Therefore, the variability of estimates of severity at the different mines may be due to sick leave policy and practices and not a true reflection of extent of severity. Regardless, mineworkers with a MSD are potentially less productive due to sick leave or pain causing the mineworker to work more slowly or avoid certain activities which will cause more pain. In production, mineworkers work in teams; if a mineworker with a MSD is off sick or disabled due to

a MSD, the rest of the team will have to work harder to compensate for the affected mineworker and as a result may be at greater risk of developing a MSD. If the MSD becomes chronic and severe, the mineworker will no longer be found to be fit to work on the mine. In this case, some costs are directed to disability insurances or the State in the form of workers' compensation or disability grants, but often the burden of disease falls on the community to which he returns, which often has limited resources to assist him medically or socially (Trapido, 1999). In other studies it has been shown that many workers continue to work in spite of their back pain although their working capacity is reduced. This "loss of man power" was estimated to be greater than one third of the manpower losses due to sick leave caused by back pain (Lloyd et al., 1986). Therefore, MSD presenting to the mine clinic may grossly underestimate the true impact of MSDs on the industry.

5.6 Physical risk factors

For upper limb pain, barring and working with hands above shoulders most of the time, were shown to be a significant negative association in both the univariate analysis and multivariate analysis. If mineworkers who had experienced a fright were removed from the multivariate analysis, mine (coal and platinum mine), and season (summer) were significantly associated with an upper limb MSD. A number of job activities have been associated with upper limb pain: repetitive work (Ekberg et al., 1994; Fredriksson et al., 2001; Leclerc et al., 2004); work in extreme and static postures (Fredriksson et al., 2001) and forceful arm and hand movement (Fredriksson et al., 2001); working with arms above shoulder level and other awkward postures (for example, with trunk flexed forward); hand-arm vibrations; pushing and pulling; and carrying loads supported by the shoulder (Leclerc et al., 2004). Although age has been shown in the literature to be associated with neck and shoulder pain (Devereux et al., 2002), this was not shown for mineworkers presenting with upper limb pain in this study. More than a third of the controls had previously presented to the mine clinic with an upper limb pain, and when history of a MSD was included in the multivariate analysis, there was very little change in the ORs. In fact the negative association increased. The reason for the negative association with an activity may be due to restricted activity as a result of the MSD. The Canadian 1994 national population health survey (NPHS) sampled over 8000

working men and women and found that the prevalence of restricted activities due to musculoskeletal disorders was 6.6% among men and 5.3% for women (Cole et al., 2001). Lastly, traditional exposures that have been associated with potential MSDs may have changed. For example, barring was expected to cause upper limb MSDs because mineworkers would work above the shoulders, but the re-design of pinch bars for operation at waist level has reduced the potential exposure and may explain why it was found to be negatively associated in this study (Schutte P, personal communication, 2013).

For lower back pain, pushing during a shift for almost all the time was found to be significantly negatively associated. In the multivariate analysis, age (greater than thirty four years) was significantly associated with back pain and, if mineworkers who had experienced a fright were excluded from the model, mine (working at the coal and platinum mine) was significantly associated with back pain. The use of vibratory tools was found to increase the odds of presenting with lower back pain but not significantly. Low back disorders have been associated with heavy lifting and forceful movements (Fredriksson et al., 2001), whole body vibration (Linton, 1990; Bernard, 1997) and forward bent position (Fredriksson et al., 2001) but these factors were not associated with lower back pain in this study. Surprisingly, no physical activity was found to increase the odds of presenting with and lower back pain. The reason for this could have been the large percentage of controls who had previously had lower back pain. However, when a history of a MSD was included in the final model, ORs remained similar but no longer significant for mine and fright. Pushing was found to be negatively associated with lower back pain. This unexpected finding may be because the pain that cases experienced prevented them from pushing as much as controls.

Cases presenting with lower limb pain performed most of the physical activities listed more often than cases who presented with upper limb or back pain. Not surprisingly, in the univariate analysis, kneeling and squatting were found to be significantly associated with lower limb pain. In the multivariate analysis kneeling, age (forty five years and older), and mine (platinum mine) were significantly associated with lower limb MSD. Lower limb pain has been associated with the following activities; kneeling and squatting (Cooper et al., 1994; Coggon et al., 2000; Baker et al., 2003;

Vignon et al., 2006), walking more than two miles per day, climbing stairs (Cooper et al., 1994, Coggon et al., 1998), exposure to vibration from driving agricultural machinery (Coggon et al., 1998) and lifting heavy weights of more than 25 kg in the course of work (Croft et al., 1992a; Coggon et al., 2000; Croft et al., 2003). In this study, only kneeling was shown to be significantly associated with lower limb pain in the final model. This may be because in the gold and platinum mines restrictive work areas due to low ceiling height (in stope panels, for example) cause mineworkers to perform tasks in the kneeling position, resulting in excessive body weight pressure on the knees. Other activities shown to be associated with lower limb pain (for example walking over rough ground and/or for over 3.2 km per day (Croft et al., 1992a; Coggon et al., 1998; Coggon et al., 2000)) was not asked and the majority of mineworkers walk more than 2 km to get to underground locations in the gold mining industry (Ross M, personal communication, 2013).

Physical risk factors were not a prominent or consistent determinant of MSD in the study mines; a finding somewhat in conflict with the literature on MSD. Many of the cases at the gold and platinum mines were general workers (or general stope workers if they worked underground). General workers multi-tasked and were trained and rotated through different job activities to ensure continuity of production should a mineworker become ill or injured. In the gold and platinum mines, the underground working environment was very warm and mineworkers were encouraged to self-pace to prevent heat exhaustion (Donoghue et al., 2000; Schutte, 2009). Multi-tasking and self-pacing provide rest for the musculoskeletal system and may be a negatively associated factor. A similar conclusion was made when underground mineworkers were compared with administration staff at a Scottish coal mine and no obvious relationship between the current job of the mineworker and the presentation of lower back pain was established (Lloyd et al., 1986). Since the tasks performed by mineworkers were common to all job categories and, in addition, movement of men between jobs occurred an association between pain and certain jobs/tasks was said to be obscured (Lloyd et al, 1986). Another study (Vargas-Prada et al., 2013) suggested that workers with lower back pain may be more likely to modify their postures or activities to protect the back and reduce their pain. Vargas-Prada and colleagues (2013) also found no association with physical exposure and attributed it

to crude measures used with limited heterogeneity of the exposure within the two occupational groups studied.

A number of methodological and workplace issues may explain the general lack of association between physical activity and MSDs in this study. The usual physical exposure for the present job was recorded and not for previous exposures/occupations. Placement to a less strenuous job due to injury or poor performance was not investigated. Research to determine the association between physical exposure at work and MSDs is complex because a worker with chronic or recurrent pain may not be placed in specific high-exposure jobs, or if in one, may change to a lower exposure job or deliberately not perform activities that cause pain (Fredriksson et al., 2002; Punnett and Wegman, 2004a). In this study, mineworkers were asked about usual physical activities and physical activities performed over the past seven days. There was no significant difference between the physical activities performed usually and physical activities performed in the past seven days. Therefore, it is unlikely that the current MSD had been affected by a recent change in physical exposure. However, MSD may be recurrent or chronic and mineworkers may have adapted or avoided certain physical activities due to their MSD and that may be why certain physical activities appear to be negatively associated with certain MSD when in the literature they have been shown to increase the risk of MSD.

Placement to a less strenuous job due to a MSD was not established. A previous MSD may have either caused a change in job activities or in physical exposure for cases, which were similar to controls. The Statistics Sweden Survey of Living Conditions interviewed 5 436 men and 5 486 women aged 25 to 74 and found an increase in prevalence of MSDs in occupations with low physical demand because of workers from labour intensive work had been recently moved into physically light occupations (Ostlin, 1988). The study also showed that there was a high turnover among men who worked in labour intensive work, and of those who stopped working in labour intensive areas, many still complained of MSDs (Ostlin, 1988). Similarly, coal mineworkers in Nottingham, who required surgical treatment for knee pain, often did not return to their work at the rock-face; even though they could kneel, they were unable to crawl or squat for long periods and therefore continued to work in the pits, taking on standing-up jobs like maintaining belts or button pushing (Want,

1978). Since mineworkers' usual physical exposure for the present job was recorded and not for previous exposures/occupations, it is possible that mineworkers may have been relocated from their usual workplace to the surface. This may partly explain why working on the surface was found to be significantly associated with presenting to the clinic with a MSD for upper limb, lower back and lower limb pain. It is common practice to relocate temporarily disabled mineworkers to surface jobs, if these are available, during a rehabilitation process. However, the number of surface jobs in the South African mining industry is limited. Study participants were asked about physical exposure during their ordinary working day and physical exposures in the past 7 days in order to determine if physical exposure had differed as a result of the incident MSD but this was not found in this study.

Increased age was found to be significantly associated with lower back and lower limb MSDs in this study. Similar findings have been found for lower back pain (Miranda et al., 2002) and lower limb pain especially for the knee (Miranda et al., 2002; Croft et al., 1992b). In a study consisting of 85,191 males from the Swedish construction industry, prevalence of MSD was shown to increase with age and was higher for construction workers compared to foreman and office workers (Holmström and Engholm, 2003). For construction workers, lower back pain had the highest prevalence for ages below 45 years whereas hip disorders initially increased slowly in the younger age-groups but increased more sharply from the age of 45 year (Holmström and Engholm, 2003). Similar finding was shown for lower back pain and lower limb pain in this study.

Season was only found to be significant in the final model if mineworkers who had experienced a fright were removed from the model. For back pain and lower limb pain, there were increased odds of presenting with these MSDs during winter. In population studies, musculoskeletal pain was most commonly (27-30%) reported during winter at a temperature of 10°C or below (Mäkinen and Hassi, 2009). Due to methodological limitations in many epidemiological studies, a causal relationship between season and MSD has not been established. In this study, the reason for summer being negatively associated with the presentation of upper limb disorders is not clear. However, during summer most mineworkers return from vacation, and the rest from heavy physical work may have allowed for healing or possibly upper limb

pain presents later from physical exposure than do back and lower limb pain, but this could not be established in this study.

5.7 Psychosocial risk factors

Nearly 10% of cases had a possible mental disorder compared to 15.3% of controls (according to the SRQ). Interestingly, the highest proportion of study participants (cases and controls) with a possible mental disorder using the SRQ score were from the platinum mine (29.3%) compared to the coal and gold mine (2.7% and 0.5% respectively). The prevalence of mental disorders in patients attending primary care clinics in four developing countries was between 10.6%-17.7% (Harding et al., 1980). In Harding's study, the SRQ was also used and a research psychiatrist confirmed the diagnosis (Harding et al., 1980). The prevalence of possible mental disorders was comparable with that found in this study for the platinum mine. Furthermore, the prevalence of mental disorder in a primary care clinic in Soweto was found to be 14.4% and the SRQ was also one of the tools used in that study (Thom et al., 1993). The reason for the relatively low percentage of cases with symptoms suggestive of a mental disorder, may be due to the healthy worker effect but this does not explain why the percentage of controls with a possible mental disorder was consistently higher at all three mines, even when controls who presented with possible psychosomatic conditions (i.e. headache, malaise, abdominal pain and gastroenteritis) were removed. The reason for this finding is unclear, but controls may have presented to the clinic with a complication or flare up of a chronic condition associated with a possible mental disorder, for example HIV and other chronic medical conditions.

In this study, there was no increased risk of mineworkers presenting with a MSD if study subjects had a possible mental disorder. This finding was consistent for upper limb, lower back and lower limb pain (with and without fright). Several cross-sectional studies and prospective studies have shown an association between psychological stress and musculoskeletal pain (Eriksen et al., 1999; Cole et al., 2001; Cassou et al., 2002; Leclerc et al., 2004; Linton et al 2005; Palmer et al., 2008, Vargas-Prada et al., 2013) while, other studies have not (Jansen et al., 2004; Kaila-Kangas et al.,

2004). The SRQ might not have been reliable or sensitive enough for this study population.

In a previous study of mineworkers, there was evidence that somatising tendency, as opposed to a mental disorder may be responsible for mineworkers presenting with multiple sites of musculoskeletal pain (Kellgren and Lawrence, 1952). The important role of somatising tendency has been confirmed in recent studies (Carugno et al., 2012; Solidaki et al., 2013). However, when somatic symptoms were accounted for in this study, a greater proportion of controls (7.9%) than cases (5.5%) still had symptoms consistent with a possible mental disorder. The presentation of musculoskeletal pain may be a somatising symptom. However, the controls were also symptomatic and may have presented with a somatising symptom, which made determining the importance of presenting with somatisation difficult. In addition, only 9.4% of cases presented with a MSD at more than one site in this study; this is almost half of that reported in workers in Crete, Greek Island i.e. 17% among new cases (Solidaki et al., 2013) and the percentage of Brazilian and Italian nurses with three or more painful anatomical sites of pain in the past month was 42% and 30% respectively.

Social functioning was similar for cases and controls. The highest proportion of cases with problems in their personal relationships was from the platinum mine (23.3%) and the coal mine (2.9%). Interestingly, none of the cases and controls at the gold mine reported issues at work or with close relationships. However, at the coal and platinum mine the percentage of cases who indicated they had problems with work-related issues was 11.4% and 15.1% respectively. No consistent associations were found between social functioning and MSDs in the univariate or multivariate analysis. In the final models for upper limb, lower back and lower limb pain no association was found with social functioning.

Interactive effects between physical, psychosocial work environmental factors and outside work psychosocial factors have been associated with MSD (Bernard, 1997; Hammig et al., 2011). Psychosocial factors are often assessed subjectively, as objective measures are difficult to develop. In the literature, psychosocial variables (both individual and organisational) have been reported as prominent risk factors for

MSD and associated outcomes. Initially, these factors were seen as confounders but now are seen as independent risk factors (Feuerstein et al., 2004). Socio-cultural factors, personal mental health and health beliefs are important influences on the development and persistence of MSD (Dionne et al., 1997; Thomas et al., 1999; Oleske et al., 2000; Kopec et al., 2004; Vargas-Prada et al., 2013). Many cross-sectional studies report associations with psychosocial risk factors, but inconsistencies across studies have also been found (Leclerc et al., 2004; Carugno et al., 2012). Kellegran and associates (1952) found lack of emotional or mental stability did not result in a greater percentage of either knee or back pain.

Experiencing an extremely frightening event and a recent medical diagnosis were two life events from the Life Events and Difficulties Schedule (LEDS) that were found to increase the odds of presenting with a MSD in this study. The Life Events and Difficulties Schedule is used to examine the onset of a range of disorders, in the hope of illustrating the importance of contextual meaning in rating life stress (Brown and Harris, 1989). More cases than controls had life events (a recent diagnosis medical diagnosis and/or a frightening event) that could influence reporting of MSDs. A recent medical diagnosis increased the odds of presenting with upper limb pain.

The majority of cases from the gold mine (79.9%) had a frightening event compared to 0.9% of controls. Similarly, at the platinum mine, more cases (40.4%) than controls (1.5%) had a frightening experience. At the coal mine, slightly more cases (12.9%) had experienced a frightening experience compared to controls (12.7%). Surprisingly, fright was associated significantly with MSD presentation at the gold and platinum mine. The reason or extent of the fright was not known nor whether the fright was recurrent, prolonged or a single extreme episode. Working underground can be potentially frightening. Frequent earth tremors, the real threat of rock falls and consistently looking for fault lines and activities required to secure the roof above the mineworker is part of the job especially at the gold and platinum mines. Unfortunately, information on the nature of these events were not available because the mines declined to provide any information on any mine accidents, fires or seismic events that may have occurred prior to or during the study period. Mineworkers who had experienced an extremely frightening event were excluded in the sensitivity analysis. ORs for possible mental disorder remained negatively associated

(significantly) as did the other significant findings. However, in addition, season and mine became significant.

The only studies found in the literature that related musculoskeletal disorders with fright were among musicians (stage fright) and ambulance drivers (inherently stressful nature of their work) (Hansen et al., 2012). Professional musicians usually make use of their hands and arms and other parts of the body (when playing certain larger instruments). Specific MSDs (for example rotator cuff syndrome, epicondylitis or tenosynovitis) have been reported in musicians. However, in a large proportion of instrumentalists symptoms are 'non-specific forearm pain' (MacIver et al., 2007). In a cohort study, the prevalence of poor self-rated health among the ambulance personnel and fire fighters was 5% compared to 10% of the core workforce in Denmark and levels of mental health were the same for both groups (Hansen et al., 2012). However, a higher proportion of ambulance personnel reported musculoskeletal pain compared to the core workforce in Denmark.

An important association with MSDs that was not explored in this study was work-life conflict. Work-life conflict has recently been shown to be a risk factor for mental health or a predictor of psychological distress which can result in substance abuse, somatising symptoms and mental disorders (Hammig et al., 2011), which were associations not explored in this study. Many mineworkers are migrants and live in hostels far from family, suggesting that work-life conflict may be an issue and should be considered in future research of mineworkers and MSDs

North and colleagues (1996) found a low correlation between "objective" and self-reported information on the psychosocial work environment including control at work. Pain-ridden people are probably more likely than other persons to perceive aspects of their work as strenuous (Eriksen, 1999). Quantitative studies may limit the ability to assess psychosocial factors such as the effect of retrenchments, industrial relations between unions and management as well as cultural issues; all of which may play significant roles in moderating risk of presenting with a MSD. Jinks and colleagues (2007) conducted a multi-method approach to determine the health care needs for knee pain by conducting a survey in the form of a questionnaire (quantitative study) and then doing in-depth interviews (qualitative study) with those

that had “severe” pain and disability. The qualitative part of the study established the reason for 53% of participants with severe knee pain and disability not seeking medical care i.e. participants mentioned knee pain was part of aging with no effective treatment and expressed concerns about side effects of treatment and dependency.

Qualitative studies may be required to explain findings in quantitative studies and assist in developing recommendations and interventions. Qualitative studies are useful because they allow for greater exploration of factors than quantitative studies that rely on simple answers to questions i.e. meanings can be explored. The findings in one occupational setting based on explanatory variables for psychosocial factors (both at individual and work related levels) may not be generalizable to other occupational groups even though the same explanatory variables are used, because of other factors not measured or included in the study which affect the interpretation of the findings. Qualitative studies, because of factors that may be specific to that study population, may be important to conduct in the mining industry to better understand the relation between psychosocial factors and MSDs. In particular, the association between fright and MSDs in the study may lend itself to further qualitative investigations.

5.8 Language

Language was examined in this study as a possible determinant of MSD. Using language was exploratory, as it is recognized that this variable is a proxy measure of ethnicity, itself a complex social construct. Nevertheless, had an association been found with language, it would have identified an important area for future research. Approximately one third of cases spoke Xhosa at the gold and platinum mine. At the coal mine, 49.2% of cases spoke other languages besides Zulu, Xhosa, Shangaan or Southern Sotho. No consistent associations were found between language and MSD in the univariate or multivariate analyses. If a mineworker spoke Southern Sotho or Other language (i.e. did not speak Zulu, Xhosa, or Shangaan) there was an increased risk of presenting with upper limb pain. This finding was only present in the final model when mineworkers who experienced an extreme fright were removed and for “Other languages” if all mineworkers were included. The reason for this could

be chance (due to multiple comparisons). For back pain and lower limb pain, no increased odds ratios were found with language spoken.

Researchers have shown that a person's ethnic background is a strong determinant of how the person communicates and expresses pain (Donovan, 1984). Ethnicity is something that is learned, through socialisation, usually through the medium of a specific language. Language is one of the factors used as a basis for ethnic classification (Braun and Hammond, 2008). In 1967, a complete Ethnographic atlas, which contained a summary of 239 African societies organized into 85 clusters, was published by Murdock (Braun and Hammond, 2008). Murdock felt that language was particularly informative of ancestral relationships and used language, ethnic identity and geographical location to distinguish societies.

Language is a weak surrogate for ethnicity and in this study was used in an exploratory sense. History shows that populations are produced which form groups that appear and disappear and reappear, depending on local and global socio-political factors (Braun and Hammond, 2008). The ideology in South Africa which emphasises ethnic differences may not be relevant (Seedat and Nell, 1990) because of endogenous mechanisms and exogenous demands. For instance industrialisation, urbanization, migration, and electronic media and social affiliations throughout South Africa are in a state of rapid transformation, internalising one another's values and beliefs (Seedat and Nell, 1990). Given this complexity, the definition of ethnicity is very important. Often investigators use the word "race", language or place of origin e.g. Irish, Italian and even religious affiliation e.g. Jewish. The above categories may be important features of ethnicity but are not measuring ethnicity and often result in lumping distinct ethnicities together (Todd, 1996). A precise definition of ethnicity that is practical within a study is required; attempts to determine ancestral origin may reveal a wide variety of ethnicities in what was considered a single entity (Todd, 1996). Tsonga, Manganika and Nguni are examples of identities assigned to and embraced by a diverse group of people in specific historical backgrounds; these identities do not conform to unified biological units and are, therefore, too broad to be used as a proxy for ethnicity (Braun and Hammond, 2008). Although the home language spoken by the study participant was requested, the effect of acculturation could not be ascertained. When investigating ethnicity in a multicultural society, the

degree of acculturation needs to be determined and this was not considered in this study.

In South Africa, a culture-bound disorder called 'ukuthwasa' among the Nguni, is an illness that is said to be sent by the ancestors and presents with numbness, aches and pains which restrict movement and performance of usual roles. Its treatment consists of either animal sacrifices within the family or that the individual becomes a diviner (Mogale, 1999). The cultural viewpoint is that the disorder is not a Western illness and therefore cannot be cured by "Western" methods. The above example demonstrates how an ethnic group may have a belief about pain as not being a 'Western illness'; consequently, they may not present to the clinic or consider that work may be a cause, resulting in underestimation of MSDs.

Currently there is an international multi-centre study –'Cross-cultural Study of Musculoskeletal and Other Somatic Symptoms and Associated Disability'– to determine if work-related MSD and resultant disability are influenced by cultural beliefs as well as by physical exposure and mental health (Coggon et al., 2012; Madan et al., 2008). Twenty two countries are taking part in the study and the Cultural and Psychosocial Influences on Disability (CUPID) questionnaire is in two parts: cross sectional surveys and a follow-up questionnaire to assess course and impact of symptoms at later follow-up (Ferrari et al., 2010). The CUPID instrument offers responses of a qualitative perspective which is innovative. Matsudaira and colleagues (2011) recently published their findings of the cross-sectional survey completed in Japan as part of the CUPID study. The prevalence of regional pain and the extent of sickness absence in Japan was lower than that for the UK. The strongest and most consistent risk factor for regional pain was somatising but not for sickness absence which was related to absence from work for other health problems. Somatisation was not shown to play a role in this study of mineworkers. However, future research is required to determine if the predominant effect of somatisation in our study population is symptoms of MSD which would possibly explain the association that fright has with the presentation of MSD and not with other symptoms of somatisation that was shown in the CUPID study in Japan (Matsudaira, 2011).

Conclusions and recommendations from the CUPID study were that there was a marked difference in MSD symptoms, disability and sickness absence between countries and that interventions to reduce the persistence of multi-site pain should focus on modifying workers belief in the role that work plays in causing MSD symptoms and not to overemphasis the risk of physical activities resulting in MSDs but rather making work more pleasant and efficient and to consider the important role of somatising tendency (Matsudaira et al, 2011; Carugno et al, 2012; Warnakulasuriya et al, 2012; Solidaki et al, 2013).

5.9 Strengths of the study

The study was conducted over six months at three mines of the mining industry in South Africa. Good quality control measures were used in an effort to include most mineworkers presenting to all three mine clinics with a MSD. Employers and Trade Unions were informed of the study at numerous workshops and this resulted in a good response from mineworkers and willingness of staff at the clinic to assist. The interviews were conducted face to face by trained research nurses.

The study had a mixed design i.e. an incidence study to identify mineworkers presenting to the clinic with a MSD and a nested case-control study involving consenting cases to investigate associations and risk factors. The strength of the case-control design is that many risk factors can be studied at the same time and in the study there were many explanatory variables (over 21 explanatory variables were used in the analysis). Case-control studies are relatively simple and economical to carry out and have been used in studies to investigate MSDs (Punnett and Wegman, 2004a; Paul, 2009; Driscoll, 2011). The main reason for not choosing a cohort study was the potential for high dropout that may occur in the mining industry as there is a high turnover of mineworkers and many of the mineworkers' homes are in other provinces/countries, which would have made follow up very difficult. Furthermore, even for mineworkers who may still be employed, over 80% of the study participants worked underground and would not have been available to be interviewed and they work different shifts during the course of the year, thus following up a large cohort of mineworkers with limited resources would not have been feasible.

Lastly, in order to determine if the Southampton Examination Schedule could be used in the mining industry to assist in the diagnosis of upper limb pain diagnosis, mineworkers with current shoulder pain needed to be examined at the time of presentation with symptoms, which was another reason why the case-control study design was chosen.

5.10 Limitations of the study

5.10.1 Incidence of musculoskeletal disorders

One mine from each of the three major commodities (i.e. gold, platinum and coal) was selected. Convenience sampling, on an invitation-response basis, was used to select the mines from the mining industry for participation in the study. Convenience sampling was chosen because unwilling mines recruited by random sampling would have hindered access and data collection. The mines selected were however typical of other underground coal, gold and platinum mines in South Africa with respect to mining techniques and size of the mines. Nevertheless, the use of a convenience sample of mines may limit the generalisability of the findings across the coal, gold and platinum industries.

The cases were identified when they presented to the mines' primary care clinic and therefore excluded mineworkers with MSD who did not present to the mine clinic. In addition, cases were currently employed and excluded an unknown number of mineworkers who were found unfit to work at their annual periodical examination or mineworkers on disability. Several studies have shown that workers who develop MSD in ergonomically stressful jobs may have left employment or have been transferred to an ergonomically less stressful occupation (Punnett and Wegman, 2004a). Selection of only employed mineworkers who presented to a mine clinic may have resulted in an underestimation of the incidence of all MSDs at the three mines, but is likely to have included severe MSDs.

The incidence of MSD at the mines is based on two sources. The higher incidence (MSD records) may be an overestimate, as the research nurse could not confirm the

diagnosis of MSD for mineworkers presenting after hours or declining further examination. The lower incidence (MSD cases) is an underestimation as it did not include mineworkers who presented after hours and over weekends. Malingering mineworkers or mineworkers who intentionally fake symptoms, illness or disability for psychological reasons or to get a day off as sick leave may also affect the incidence of MSD. However, quality control measures in the study were in place and primary care nurses adhered to study protocol and procedures. In a recent study, 8% of four hundred consecutive new patients referred to the UK's National Health Service occupational medicine clinic presented with behaviour in keeping with malingering or factitious behaviour (Poole, 2010). However, the clinic was a referral centre and errors of case attribution could not be excluded.

The study only consisted of male mineworkers. However, recent targets have been set for the increased employment of female mineworkers. Due to lower physical work capacity and strength, physiological strain experienced by female mineworkers may present as a MSD (Schutte, 2011) and the incidence of MSDs may be higher in female mineworkers.

The clinical attendance at the three mine clinics differed. At the coal mine, mineworkers who had access to the mine clinic attended on average 0.9 times during the study period. All coal mineworkers were on medical aid and had the option to either attend the mine clinic at the mine or a general practitioner of their choice. If the mineworker consulted a general practitioner not at the mine and was given sick leave for a day or longer, the mineworker had to report to the mine clinic with the sick note. However, if the mineworker with a MSD was not given sick leave, then the mineworker was not required to present to the mine clinic. This would result in an underestimation of the incidence of MSD at the coal mine. At the gold mine, mineworkers who had access to the mine clinic attended on average 1.1 times during the study period and at the platinum mine 3.6 times. The gold mine was situated close to a town and the mine hospital. Mineworkers at the gold mine could have consulted a GP at the nearby town. At the platinum mine, the mine clinic was attached to the mine hospital and the mine was remote compared to the other two mines studied. Therefore, the high mine clinic attendance at the platinum mine could have been due to restricted access to other health care providers. Therefore,

comparison of the incidence of MSDs among the three mines is complicated by differing clinic usage patterns.

5.10.2 Case-control study

The appropriateness of the controls is a consideration in case-control studies. In this study, the high percentage of controls who had previously presented to the clinic with a MSD in the past (i.e. 39.8% with upper limb pain, and 43.8% with lower back pain compared to 9.6% with lower limb pain) may have resulted in weaker associations between risk factors and MSD. In this study, underestimation of risk especially for the upper limb and lower back risk factors may have occurred. Nonetheless, Anderson and colleagues (2007) found it hard to find a population that was pain-free and argued that if there were such a group, its characteristics would be so special and the numbers so small that it would hamper its use as a reference group in epidemiological studies. For example, Ekberg and colleagues (1994) found that among their controls only 21% had never had a MSD complaint (1994). In underground mines, selecting from currently working underground mineworkers is difficult because of their shifts and accessibility to the mine clinic. Inclusion of currently employed workers in mining implies that research is 'subject to the vagaries of the workplaces. These include retrenchments, shutdowns, strikes, personnel changes, section or shaft closures etc. (Naidoo et al, 2002). Selecting surface workers or administration staff is a possible solution but may result in a small control group as these employees are usually much fewer than mineworkers underground. This was the case in Lloyds study (567 miners and 255 admin staff) (Lloyd et al., 1986) and Sarikaya's study (50 underground mineworkers age-matched with 38 surface workers) (Sarikaya et al., 2007). Additionally, administrative staff are likely to differ from mineworkers in important characteristics such as education, socio-economic status and psychological risk factors. Also injured underground mineworkers may be temporarily relocated to surface work. In this study the cases and controls were very similar with respect to level of education, smoking and alcohol consumption.

An aim of this study was to identify risk factors for incident cases presenting to the clinic with a MSD. The questionnaire was designed and the primary care nurses and

research nurses were trained to ensure that controls were selected who had not presented with a MSD in the past seven days and who were attending the clinic for a non-MSD related complaint. Regional pain is common in the general population and correlated with pain in another anatomical region and with pain status in subsequent years (Andersen et al., 2007). Therefore, a past history of MSD was found for both cases and controls but was not found to alter the ORs in the final model for upper limb, lower back and lower limb pain. Therefore, a past history of MSD was not found to alter significantly the associations found in this study for incident cases of MSD presenting to the mine clinic.

5.10.2.1 Misclassification

a) Exposure

Another potential limitation in this study is information bias. In case-control studies, the recalled exposure may not be the same for cases and controls (Delgado-Rodriguez and Llorca, 2004), and may be a possible explanation for the significant association MSDs have with fright if cases recalled fright more readily than controls.

The choice of an assessment technique for exposure to work factors in musculoskeletal epidemiology depends on its feasibility in a large sample. Information is typically gathered from workers' response to questions in self-administered questionnaires or interview as was done in this study (Leclerc et al., 2004). But self-reports yield information that may be subject to systematic bias and lack of precision. Few studies have adequately characterised ergonomic exposure. Often just a job title is used or not enough information on the work ergonomic exposure is included (Stock, 1991; Schierhout et al., 1995). Some studies that have shown an exposure-effect relationship used self-reported exposures which resulted in over reporting and artificially inflated associations (Schierhout et al., 1995). Schierhout used observation to characterise a broad ergonomic spectrum of exposures in an effort to reduce bias and misclassification. In this study, it was not possible to observe every study participant's ergonomic exposure, due to capacity and cost-effectiveness, thus exposure was assessed subjectively. Pain and a mental disorder (for example a low mood) may influence workers' observation and memory and therefore have an influence on the reports of job characteristics and result in

spurious association (Eriksen et al., 1999). One study found that the correlation between the questionnaire and observation ratings of physical work characteristics was reduced when the subjects were bothered by lower back pain (Viikari-Juntura et al., 1996).

Non-differential misclassification of physical activities may have occurred, which would have decreased associations towards the null. The questions on physical activities were not detailed enough. For example, asking if mineworkers were involved in pushing loads, tools, or mining equipment most of the time, did not specify weights and shape of the item involved. Neither did the question ask which part of his body was used in the activity. With height restrictions in some mine passages, assumptions that certain body regions are associated with certain tasks may not be true. Study participants, both cases and controls, were questioned about exposure in exactly the same way, and similar frequencies of physical exposures for cases and controls were found. Consequently, very few significant associations with physical exposures were found because many of the tasks performed by mineworkers were similar for the different job categories or due to multiskilling, job rotation or self-pacing (especially in the warmers gold and platinum mine).

Another possible limitation was that mineworkers were not asked about change in routine work due to maintenance, break down of machinery or increased workload due to absent mineworkers. These sporadic exposures do not produce work hardening and workers exposed to them are vulnerable to MSD (Van Vuuren et al., 2005a; Van Vuuren et al., 2005b). If mineworkers with MSDs were transferred to another job due to a previous MSD, the association with the exposure would also be underestimated (Punnett and Wegman, 2004a) In this study, mineworkers were asked what their usual physical exposure was and then again what their physical exposure had been in the prior seven days. Since there was no difference between the responses to usual physical exposure and in the prior seven days, the effect of a recent job change as described above, probably did not affect the associations found.

Language spoken was probably a poor surrogate for ethnicity. Non-differential misclassification may have occurred by grouping broad groups of people (based on the language they speak) who may not share similar health belief or awareness,

confidence in “western” medicine, and/or access to healthcare, which are influenced by ethnicity and may play an important role in the presentation of MSDs.

The SRQ has a high sensitivity but the positive predictive value of the SRQ is poor at low cut offs (Alsuwaida, 2006). The cut-off was pre-determined by using a cut-off value used in other studies conducted in South Africa (Tomlinson et al., 2007), but may have been too high for this study population. A study has shown that a high rate of somatic symptoms in non-depressed populations also limited the positive predictive value of the SRQ (Alsuwaida, 2006) which is a concern since recent studies show that somatising tendency was strongly related to the number of painful musculoskeletal sites (Solidaki et al., 2010; Matsudaira et al., 2011; Carugno et al., 2012; Warnakulasuriya et al., 2012). The SRQ is also subjective and the questionnaire was administered to mineworkers by female research nurses, which may have caused some mineworkers to not respond to questions honestly due to fear of being viewed as weak.

In this study, the mine clinic nurses at each mine clinic were also not aware of the detailed objectives of the study (to avoid interviewer bias). Cases were referred to the research nurse based on the diagnosis of a MSD which was verified by the research nurse. Cases and controls were not aware of the detailed objectives of the study. Nevertheless, answers about work activity may be exaggerated because they do not want to be seen as lazy or underperforming (obsequiousness bias). Underreporting bias is common with socially adverse conduct like alcohol consumption, thoughts of suicide etc. (Delgado-Rodriguez and Llorca, 2004).

Gold mining is associated with frequent earth tremors and accident rates are high. The overall fatalities and fatality frequency rate (FFR) in 2006 for the mining industry was 0.2 per 1000 per annum. However, for the gold mines the FFR was 0.35 per 1000 per annum for the same year (Chamber of Mines, 2006). Therefore, it is not inconceivable that fright was common among cases at the gold mine (i.e.79.9% of cases and 0.9% of controls) compared to all the mines combined i.e. 56.4% of cases and 2.4% of controls. However, the source of the fright could not be determined nor whether it occurred during the study period which is a limitation of this finding. Another limitation may have been in the translation of the word fright which may

have resulted in an unintended meaning which could have been related to MSD. The non-reporting of relationships and work problems by gold mines is surprising but the questionnaires were checked and non-reporting did occur. The reason is unknown.

b) Outcome

Closed-ended questions were used to determine if mineworkers had a MSD (case) or not (control). Subjective reports of musculoskeletal pain were considered in this research and others (Schierhout et al., 1995) to be an appropriate measure of outcome in assessing the burden of MSD. The Nordic questionnaire has been found to have high test-retest reliability and the majority of subjects reporting musculoskeletal pain using the Nordic questionnaire were given a diagnosis of a MSD during a clinical interview (Eriksen et al., 1999; Palmer et al., 1999). Self-report of pain has a high generalisation, is easy to use and has been proven to be valid (Schierhout and Myers., 1996). A simple outcome measure is arguably less prone to misclassification than complex clinical diagnostic entities which often require a few discreet symptoms, which if not present would result in an underestimation of a disorder (Schierhout et al., 1995). In addition, mineworkers were only included in the study as a case if the primary reason for attending the clinic was for a MSD only (i.e. no other conditions or complaints (not associated with MSD) were considered).

5.10.2.2 Misrepresentation

In this study, three forms of misrepresentation may be choice of controls (see Section 5.10.2), healthcare access bias and healthy worker effect (Delgado-Rodriguez and Llorca, 2004). Healthcare access bias occurs when mineworkers attending the mine clinic do not represent the cases originating in the workplace. Healthy worker effect occurs because mineworkers who remain employed tend to be healthier than those who leave employment.

Varied health-seeking behaviour is found most frequently in a multicultural environment (Germond and Cochrane, 2010) and thus one would expect such behaviour in this study population. In South Africa, new developments seek to place African traditional healers and allopathic doctors on the same level (Germond and Cochrane, 2010). At the coal and gold mine, secondary care hospitals and GPs in

private independent practices were easily accessible to the study population. Importantly, the option to consult traditional healers instead of presenting to the mine clinic may have occurred at all three mines. It is not known to what extent, if any, exclusive consultation with traditional healers occurred in this study, or if those who consulted other health care providers (including traditional healers) differed from those who did not. It is feasible, though, that cultural and psychosocial factors would influence the choice of health care provider. Hence, this factor should be considered in future research of risk factors and MSD.

The healthy worker effect is observed in workers in high physical exposure activities or jobs because workers found with symptoms of MSD in certain anatomical regions, are placed either on disability, seek alternate employment or are placed in another job with less exposure (Punnett and Wegman, 2004a). At the coal, gold and platinum mine, mineworkers undergo an annual periodical medical examination. Many of the MSDs cannot be diagnosed by objective tests, therefore, unless a mineworker complains or mentions symptoms of a MSD, the mineworker will most likely be found fit to work. In South Africa, since unemployment is high and there is a poor social security network, mineworkers are probably more likely not to mention symptoms of a MSD or conditions affecting fitness until the symptoms become disabling or result in not coping at work. Thus, the potential for misrepresentation exists, but the impact on effect estimates is probably small, except for the most severe MSDs.

5.10.2.3 Analysis

In this study, a potential limitation is the large number of risk factors under investigation, which may have led to chance associations between risk factors and MSD (i.e. multiple comparisons). Given the many risk factors and MSD outcomes (i.e. upper limb, lower back and lower limb pain), chance association is a real possibility. One method of dealing with this issue is to adjust the significance level in accepting an association (i.e. reduce the p value), for example using the Bonferroni correction approach (Bender and Lange, 2001). This approach has, however, been criticised for being too conservative (Bender and Lange, 2001). Although chance association should be considered when interpreting the findings of this study, the

results were consistent across the three MSD regions for many risk factors, which strengthens the likelihood that these are not chance associations.

An objective in this study was to assess psychosocial and physical factors and language. Mineworkers are exposed to numerous physical factors, for example bending at the waist, twisting, lifting and carrying. Often these physical factors are strongly inter-correlated (Jansen et al., 2004). The conventional approach for analysing such correlated exposures may invoke problems of multiple colinearity (Jansen et al., 2004) and thus stepwise hierarchical logistic regression was used.

Anatomical regions were combined to preserve the power in order to detect associations, but may have resulted in a bias of the odds ratio towards the null if the physical risk factors were associated with only one or some of the disorders that were grouped together.

The analysis to take account of the past history of MSDs in controls may have only partially adjusted for this factor.

5.10.2.4 Confounding factors

Many chronic pain syndromes can be classed as one subgroup of so-called functional somatic syndromes which include chronic fatigue, fibromyalgia and irritable bowel syndrome which are diagnosed more by symptoms and distress than demonstrable tissue abnormalities (Croft et al., 2003). Palmer and colleagues (2005) argue that somatisation may be an important confounder/effect modifier. In this study a sensitivity analysis was conducted (comparing univariate OR with all controls and then with controls without symptoms suggestive of psychosomatic conditions). However, there was no difference in the ORs.

In mineworkers, BMI may be a measure of muscle mass and not predominately fat content due to work hardening which is negatively associated with MSD. Body mass index has been shown in some studies not to be significantly associated with MSD (Manninen et al., 1996; Bernard, 1997; Hartman et al., 2006) but BMI has been shown in other studies to influence MSD risk and associated disability and sickness

absence, and thus was potentially an important variable to include. In one study, workers with a high BMI (greater than twenty-seven) compared to workers with a BMI of less than twenty-five was an independent risk factor for disability in general (Hartman et al., 2006). However, co-morbidities associated with obesity e.g. hypertension, elevated cholesterol, joint and mobility problems and diabetes may play a role, which was not considered. The role of BMI in MSD in mineworkers could not be established in this study. However, more research is required to establish the relationship between BMI and MSD, to determine if it is not the high fat content that is associated with MSD risk as opposed to mass *per se*.

Silica dust exposure may be associated with a wide range of autoimmune diseases including rheumatoid arthritis, which may present as a MSD. Silica has an adjuvant effect on antibody production by non-specifically enhancing or potentiating an immune response to an antigen and thus may play a role in the inflammatory response (Parks et al., 1999). One hundred and fifty seven South African gold mineworkers with rheumatoid arthritis (RA) were matched by year of birth with mineworkers with no evidence of RA and the odds ratio of presenting with silicosis was 2.84 (95% CI: 1.36-4.32) (Sluis-Cremer et al., 1986). In this study, mineworkers at the gold mine would have been exposed to silica; however, there was a lower prevalence of MSD in the gold mine compared to the coal and platinum mine. Therefore, silica exposure was unlikely to have been a possible confounder. HIV may also be a possible confounder as there are musculoskeletal manifestations reported in infected individuals (e.g. HIV associated arthritis, infectious arthritis and spondyloarthropathies (Casado et al., 2001). However, HIV may also present with many of the conditions the controls had; for example, chest infections and gastroenteritis and there is no reason to suppose that the prevalence of HIV infection was different between cases and controls. Therefore, the effect of HIV in this study would probably be negligible in the case-control component of this study even though there is a high prevalence of HIV in the mining industry.

5.11 Contribution to existing knowledge

This is the first study to investigate MSDs in the South African mining industry which is one of the largest mining industries in the world. The incidence rate was 6.2% over

a six-month period; an important finding for the industry as the extent of the problem overall and specific patterns for different mining commodities were not previously known. The incidence rate is comparable with incidence rates found in the mining industry but as discussed may be an underestimation because only mineworkers with MSD presenting to the clinic were included in this study. In addition, in the same study population, indicators of severity, i.e. sick leave and symptoms of disability, were presented for the different mines, which has not been done before in other studies in the mining industry and the impact of MSDs is considerable since more than 75% of cases presented with symptoms of disability.

The study is also unique in the industry of mining in that it considers three body regions (i.e. upper limb, back and lower limb); and lower back pain was found to be the most common anatomical site of pain at the coal and gold mine but that lower limb pain was the most common presentation at the platinum mine. Lower limb pain was strongly associated with the activity of kneeling.

A possible mental disorder was found to be negatively associated with MSD and experiencing a fright was associated with MSD which has not been described before in the literature.

Season, especially the change of season (autumn) and colder weather (winter) was associated with MSD which has not been shown before. The importance of considering recent/not so recent job placement due to a MSD and past history of MSD was highlighted as potential sources of bias and is an important consideration for future studies.

No consistent associations were found between home language and MSDs.

5.12 Summary of findings

The six-month incidence of MSDs (using MSD records) was found to be substantial at the three mines: 7%, 5.4% and 8.1% at the coal, gold and platinum mines respectively. This may be underestimations because only mineworkers presenting to the mine clinic and currently employed were selected in this study. The healthy

worker effect may have lowered the incidence because mineworkers with MSD and disability may have chosen not to return to work or may have been on disability absence.

No increased risks of MSDs were found for physical activities except for kneeling with lower limb pain and this may be due to past history of MSD in controls, cases and controls performing similar tasks, and because self-pacing and job rotation were common practices and may be protective factors for MSD (Donoghue et al., 2000). Working on the surface was found to be significantly associated with presenting with a MSD. Mineworkers may have been transferred to “light duty” due to a MSD and therefore not exposed to the physical activity that resulted in the MSD. Studies have also suggested the fear avoidance of certain activities believed to cause MSD may play a role and this could not be excluded in this study.

A possible mental disorder (i.e. a high SRQ score) was found to be negatively associated with the presentation of a MSD for all three anatomical regions. Interestingly, low mood has also been shown not to be significantly associated with MSDs in a recent study (Carugno et al., 2012). Even after consideration of somatic complaints or excluding medical conditions among controls that may have been somatic, a higher percentage of controls still had a possible mental disorder. Possible explanations were that mineworkers without a mental disorder work harder and are therefore more prone to present with a MSD or controls presented with chronic medical conditions associated with depression or anxiety.

A novel finding which was consistent for all three anatomical regions was the positive association of fright with MSD. When mineworkers who had experienced a frightening event were removed from the final model, season was found to be significantly associated with the presentation of a MSD. The ORs for fright may have overestimated the strength of the association because the prevalence was very high among cases at the gold and platinum mine.

In this study, language was a weak and inconsistent determinant of MSD. Language was found to be associated with upper limb pain only. However, ethnicity may still be an important factor in the presentation of MSD, as language is likely to be an

unsatisfactory surrogate for ethnicity. A more appropriate measure of ethnicity is needed to study its effect on MSD. Two important issues need to be addressed: first, how to measure ethnicity; and second, if ethnicity has been established as an important determinant of MSD, how to use this information to decrease the incidence of MSD. A measure to determine the grouping of society has to be in real time and subject to change and circumstances, but simple enough to be an independent variable in future studies on MSD. Simply looking at language, race, religion or country of origin may no longer be valid or informative. The other issue to discern would be whether ethnicity is a true determinant of MSD or an expression of health belief and/or access to health care which may be easier to measure, and provide information that is more useful for policy formulation and interventions to reduce MSD in the workplace.

CHAPTER 6 IMPLICATIONS FOR POLICY AND PRACTICE

6.1 Influence of research outcomes on practice

The main contribution made by this study was estimating the incidence and characterisation of MSDs in mines of commodities employing the vast majority of miners in the South African industry. The research results also highlighted that mechanical overload may not be the only important cause of regional musculoskeletal pain; aging, work organisation and non-work related factors are important in the development of a multifaceted and multidisciplinary intervention aimed at reducing the incidence and disability of MSD in the mining industry.

Following the completion of the study, the Mine Health and Safety Council sponsored 'launches' where the results were presented at workshops in the three different provinces of South Africa where the research had been conducted for the coal, gold and platinum mining industries. These sessions were attended by a range of medical, government, labour and management representatives from the wider industry, not just the three participating mines, so that the results were disseminated and discussed widely. In addition, clinical presentations were made at meetings of the professional societies with which the occupational health professions are registered. Subsequently, individual mines and mining houses have sought assistance with diagnostic training, ergonomic risk assessments, MSD guidelines and procedures to monitor MSDs and assessment of disability; these developments have mostly been secondary to the awareness of MSDs being raised in the occupational health fraternity. As a result, some interventions, based on the findings of this study, have already been implemented and extended beyond the mining industry. Following the study, training material on ergonomics and fatigue management programmes were developed and funded by SIMRAC. Many mines now have work-hardening programmes.

In addition, there has recently been consensus acceptance to include a Functional Ability Assessment in the Guidance for the Mandatory Code of Practice on Fitness for Work that each mine is legally obliged to prepare and implement (Ross M, personal communication, 2013). However, there are other implications for policy, practice and further research arising from the findings of this study.

6.2 Cost of musculoskeletal disorders in the mining industry

The potential cost of MSDs in terms of loss of productivity has not been determined for the South African mining industry. This study indicated a 6-month incidence of 6.2% that may well be an underestimate because it included only the mineworkers who chose to attend the mine clinic. Another concern is the high percentage of mineworkers who presented with symptoms of disability. Consequently, the mining industry has a large cohort of mineworkers who are potentially either not working optimally because of a MSD, or not returning to work because of disability. The cost of MSDs to the industry and to mineworkers may be high and more attention to MSDs is warranted.

Preventive interventions, proper assessment and management to minimise disability may help to reduce costs. These interventions should be evaluated to identify those which improve prognosis and reduce the incidence and severity of MSDs and possible changes to the workplace activities associated with disability.

6.3 Establishing the true magnitude of musculoskeletal disorders in the mining industry, and reducing exposure/s

Operational research in occupational medical surveillance programmes could contribute to an understanding of MSDs, including on surface mines and commodities other than gold, platinum and coal. In order to establish the true extent of MSD on a mine, mineworkers who present for their annual periodical medicals could be screened by questionnaire and appropriate examination. Mineworkers are not permitted to work unless they have successfully completed a periodical examination which is conducted at the mine occupational health clinic. A cohort could be followed up annually and comparisons made between different groups of workers, although high labour turnover is a potential concern.

The high percentage of lower back and lower limb pain in the mining industry as compared to other industries was an interesting finding in this study, which may be related to the type of mining investigated (low seam and mostly underground mining). Ergonomic risk assessments in the workplace need to take account of risks that affect the lower back and lower limb. However, ergonomic interventions may be limited by restricted work-space beyond the control of engineering solutions. Therefore, job rotation, mechanization and even robotics are potential feasible solutions. Importantly, as seen in the coal mine, mechanization may assist with heavy physical labour or awkward postures, but is often replaced with small repetitive movements or

static posture especially of the upper limb and neck, which need to be considered when designing and purchasing equipment and machinery.

6.4 Interventions by mine health services

Mineworkers should routinely be asked about current and past MSDs and injuries since the previous examination as well as details of current tasks, changes in tasks and non-work factors that may impact on MSDs. Health service providers can then identify and assist in establishing relevant programmes to monitor and manage problems identified. For example, one mining house in South Africa is measuring psychosocial indicators of well-being in the workforce by monitoring usage of Employee Assistance Programmes and the institution of garnishee orders, and it has also established 'Biggest loser' weight-loss programmes where obesity is problematic in terms of increased risk of injury and MSDs (Ross M, personal communication, 2013).

Those over 35 or in jobs resulting in increased risk of back pain should be specifically asked about lower back pain during their periodical medical examination. Mineworkers in physically demanding jobs, particularly older workers, and any miner complaining of an MSD should be assessed by a health professional trained in Functional Ability Assessment and, depending on the findings, appropriate 'work hardening' or preventive interventions should be introduced.

Early identification of potential pathology would result in treating the condition early with a better prognosis and potentially preventing disability. Thus, in order to institute secondary prevention early in the course of the condition to reduce disability and impairment, mineworkers should be encouraged to present to the mine clinic at early onset of symptoms and not when their symptoms become disabling. This would provide an opportunity to educate mineworkers about MSD and address their concerns, fears or health beliefs about MSD.

Mineworkers presenting with two or more sick notes from the mine clinic or from a service provider not affiliated to the mine for more than one day sick leave for a MSD-related condition, should be referred to the occupational medicine practitioner or a physiotherapist to confirm the MSD diagnosis, adequate treatment and fitness to work in the current job.

6.5 Southampton Examination Schedule

The Southampton Examination Schedule is useful as a research tool and potentially as a tool in occupational medical practice to diagnose shoulder conditions. As this examination schedule

does not require x-ray or ultrasound, it is cost-effective for the mining industry especially for mines far from hospitals. However, extensive training and follow-up over a six to 12 month period is required because nurses often do not recognise pathology due to lack of experience (Walker-Bone et al., 2002) and may become ineffective if there is high nursing staff turnover and no transfer of skills. The schedule could be considered as a screening tool by mine health services to identify mineworkers requiring more sophisticated evaluation i.e. x-ray, ultrasound examination or MRI scans. The effectiveness of the schedule as a screening tool in the mine setting would require formal evaluation.

6.6 Research implications around ethnicity

Language is likely to be a weak surrogate for ethnicity and in this study was used in an exploratory sense. It is important to note that industrialisation, urbanization, migration, and electronic media and social affiliations throughout South Africa are in a state of rapid transformation, leading to internalising one another's values and beliefs (Seedat and Nell, 1990) which makes defining an ethnic group difficult.

If groups used for comparison are not defined clearly to ensure that each group shares common cultural values and norms, health beliefs and expectations, then the possibility for misclassification is high and associations may be overestimated or underestimated or of no value. Acculturation needs to be considered within the work place, for example in the mining industry which historically employed culturally diverse group of people.

Further study of ethnic variations and beliefs may be warranted, although using education as a tool to bridge difference and come to a common understanding despite the different cultures represented in the mining industry may be a more pragmatic approach.

6.7 Considerations for future research

From this study, except for kneeling, no physical risk factor was associated with the presentation of a MSD and no psychosocial factor related to work or the individual was shown to be positively associated with a MSD presentation at the clinic (except for fright at the gold and platinum mine). Many of the traditional exposures that have been associated with potential MSDs have changed. For example, barring was previously associated with upper limb MSDs from working above the shoulders, but the re-design of pinch bars for operation at waist level has reduced the potential exposure (P Schutte, personal communication). Work-relatedness of the MSDs needs

to be addressed in future studies to assist with the reporting and compensation of mineworkers with MSDs and these may best be addressed by ongoing operational research supported by independent verification as mechanization and other workplace changes occur continuously.

Occupational health services with collaboration between the medical and occupational hygiene personnel with line management in the mining industry provide a setting for continued research on MSDs because legislation requires that all hazards, including ergonomic hazards, be defined, measured and controlled. Improvement in assessment questionnaires to define ethnicity, psychosocial issues (including somatisation, health beliefs, work-life conflict and expectations of workers), detailed work history (including transfer due to previous MSD), BMI and fat content should be considered in such future research.

In this study, mineworkers who had experienced an extremely frightening event (at the gold and platinum mine) were more likely to present with a MSD and a possible mental disorder appeared to be negatively associated. Qualitative studies may be more appropriate to determine the context of psychological symptoms including their relation to work and possibly to determine the role fright had in the presentation of MSDs. This was an unexpected finding, which needs to be studied further.

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APPENDIX A : Survey of musculoskeletal disorders questionnaire: cases

1. Study number _____

2. Company number _____

3. Mine _____

4. Nurse name. _____

5. Date completed _____ / _____ / 20____ Time started ____h____
 DD MM YY

SECTION 1: CHECK OF ELIGIBILITY (MSD must be MAIN reason for consultation!)

Please circle the response given by the patient

BACK PAIN?

6. Has the patient come to the clinic with **back pain**? **No / Yes**
If No, go straight to question 10. If Yes, continue
7. Has patient attended for same problem in the last 7 days? **No / Yes**
If Yes, go straight to question 10. If No, continue
8. Has the patient been referred to the doctor today because of back pain?
No / Yes
9. Does the patient's company number end in a 1, 3, or 9? **No / Yes**

ANOTHER MUSCULOSKELETAL DISORDER?

10. Has the patient come to the clinic with *any other* musculoskeletal disorder (muscle and/or joint pain) **No / Yes**

If No, follow the instructions at the bottom of the page. If Yes, record the site(s) of the pain, aching or discomfort (tick as many boxes as apply)

- | | | | |
|---|--------------------------|---------------------|--------------------------|
| Neck? | <input type="checkbox"/> | Hip(s)? | <input type="checkbox"/> |
| Shoulder(s)? | <input type="checkbox"/> | Knee(s)? | <input type="checkbox"/> |
| Elbow(s)? | <input type="checkbox"/> | Ankle(s)? | <input type="checkbox"/> |
| Wrist(s)/hand(s)? | <input type="checkbox"/> | Foot (feet)/toe(s)? | <input type="checkbox"/> |
| Other parts of upper limb?(e.g. forearm) | <input type="checkbox"/> | Other part of legs? | <input type="checkbox"/> |
| Numbness and tingling in hand or fingers? | | | <input type="checkbox"/> |
| OR NONE OF THESE | | | <input type="checkbox"/> |

14. Has patient been interviewed as a MSD case for the same problem in the last 7 days? **No / Yes**

If Yes, stop the questionnaire. If No, continue

15. Was the pain due to an accident? **No / Yes**

WHAT TO DO NEXT

If there are circles around any of the shaded “yes” or “no” eg. No / **Yes**
CONTINUE.

Otherwise, stop now.

SECTION 2: ABOUT YOURSELF

16. What is your date of birth ____/____/ 19____ **or** approximate age ____ (years)

17. Highest level of education? _____

18. What is your home language? Zulu1
Xhosa2
Tswana.....3
Pedi.....4
Shangaan.....5
N Sotho.....6
S Sotho.....7
Other.....8 describe _____

19. Current marital status: Married.....1
Divorced.....2
Widowed.....3
Never married.....4
Separated.....5
Partner.....6

20 Do you have children? **No / Yes** If yes how many? _____

21. How many people do you share your accommodation with currently? _____

22. How many people are financially dependent on you? _____

23. Which hand is your dominant hand? Right 1
Left2
Able to use both hands equally3

SECTION 3: ABOUT YOUR JOB

24. What is your job title? _____

25. How long have you been in this job? _____ months or
_____ years

26. What activity do you do most of the time? _____

27. Does an **ordinary** working day in your job **usually** involve a lot of the following?

[show pictures or demonstrate each activity each question will have a laminated photograph]

	Almost Never	Sometimes	Almost Always
a) overhead reaching for loads, tools, or mining equipment (several times/hour)	1	2	3
b) bending at the waist to handle loads, tools, or mining equipment (several times/hour)	1	2	3
c) twisting at the waist to handle loads, tools or mining equipment (several times/hour)	1	2	3
d) carrying, lifting or lowering loads of more than 25 kg repeatedly (several times/hour)	1	2	3
e) climbing up or down stairs or a ladder with loads, tools, or mining equipment (several times/day)	1	2	3
f) pushing loads, tools, or mining equipment (several times/hour)	1	2	3
g) pulling loads, tools, or mining equipment (several times/hour)	1	2	3
h) working with the hands above shoulder height (for longer than 1 hr in total)	1	2	3
i) operating equipment or tools above shoulder height (for longer than 1 hr in total)	1	2	3
j) shovelling	1	2	3
k) barring	1	2	3
l) working in tunnels where you cannot stand up straight (for longer than 1 hr in total)	1	2	3
m) kneeling or squatting (for longer than 1 hr in total)	1	2	3
n) repeated bending and straightening of your elbow (for longer than 1 hr in total)	1	2	3
o) using vibratory tools such as rock drills	1	2	3

28. In the **past 7 days** has the job involved any of these activities ?

	Almost Never	Sometimes	Almost Always
a) Overhead reaching for loads, tools, or mining equipment (several times/hour)	1	2	3
b) bending at the waist to handle loads, tools, or mining equipment (several times/hour)	1	2	3
c) twisting at the waist to handle loads, tools or mining equipment (several times/hour)	1	2	3
d) carrying, lifting or lowering loads of more than 25 kg repeatedly (several times/hour)	1	2	3
e) climbing up or down stairs or a ladder with loads, tools, or mining equipment (several times/day)	1	2	3
f) pushing loads, tools, or mining equipment (several times/hour)	1	2	3

g) pulling loads, tools, or mining equipment (several times/hour)	1	2	3
h) working with the hands above shoulder height (for longer than 1 hr in total)	1	2	3
i) operating equipment or tools above shoulder height (for longer than 1 hr in total)	1	2	3
j) shovelling	1	2	3
k) barring	1	2	3
l) working in tunnels where you cannot stand up straight (for longer than 1 hr in total)	1	2	3
m) kneeling or squatting (for longer than 1 hr in total)	1	2	3
n) repeated bending and straightening of your elbow (for longer than 1 hr in total)	1	2	3
o) using vibratory tools such as rock drills	1	2	3

SECTION 4: ABOUT YOUR FEELINGS

The questions in this section are about how you feel. For each question tick the one item which comes closest to how you have been feeling in the past 14 days. (Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought out response)

29. Have you often had headaches? **No / Yes**
30. Has your appetite been poor? **No / Yes**
31. Have you slept badly? **No / Yes**
32. Have you been easily frightened? **No / Yes**
33. Have your hands shaken? **No / Yes**
34. Have you felt nervous tense or worried? **No / Yes**
35. Has your digestion been poor? **No / Yes**
36. Have you had trouble thinking clearly? **No / Yes**
37. Have you felt unhappy? **No / Yes**
38. Have you cried more than usual? **No / Yes**
39. Have you found it difficult to enjoy your daily activities? **No / Yes**
40. Have you found it difficult to make decisions? **No / Yes**
41. Has your daily work suffered? **No / Yes**

- | | |
|---|-----------------|
| 42. Have you been unable to play a useful part in life? | No / Yes |
| 43. Have you lost interest in things? | No / Yes |
| 44. Have you felt that you are a worthless person? | No / Yes |
| 45. Has the thought of ending your life been on your mind? | No / Yes |
| 46. Do you feel self conscious with others? | No / Yes |
| 47. Have you had uncomfortable feelings in your stomach? | No / Yes |
| 48. Have you been easily tired? | No / Yes |
| 49. Are your feelings easily hurt? | No / Yes |
| 50. Do you feel inferior to others? | No / Yes |
| 51. Do you get the feeling that people are unfriendly or dislike you? | No / Yes |

Now we'd like to get an idea of some things that have happened to you in the past 12 months? *

- 0=No problem
- 1=mild problem
- 2=major problem

- | | |
|---|------------------|
| 52. Have you had a problem with your health or nerves? | 0 / 1 / 2 |
| 53. Have you been assaulted or beaten up in the last couple of weeks? | 0 / 1 / 2 |
| 54. In the past, have you been in any situation that was extremely frightening or horrifying? | 0 / 1 / 2 |
| 55. Have you had any difficulties relating to finance? | 0 / 1 / 2 |
| -loss of finance | |
| -inadequate income | |

In the past, have any problems affected your relationship with Room mates, wife or family members

- | | |
|---|------------------|
| 56. Do you have a problem discussing interests or conflicts? | 0 / 1 / 2 |
| 57. Do you have a problem sharing household tasks? | 0 / 1 / 2 |
| 58. Do you get tense or irritable, or get into fights with him/her? | 0 / 1 / 2 |

Have any of these problems affected your ability to work?

59. Do you have a problem getting to work in the morning? 0 / 1 / 2
60. Do you have a problem completing a full day's work, most days? 0 / 1 / 2
61. Do you have a problem working a full week, most weeks? 0 / 1 / 2
62. Do you have a problem getting along with supervisors and colleagues? 0 / 1 / 2

Have any of these problems affected your leisure time activity?

63. Do you have a problem enjoying things such as TV, Radio, Magazines? 0 / 1 / 2
64. Do you have a problem spending your time usefully? 0 / 1 / 2

**SECTION 5: ABOUT YOUR SYMPTOMS (Show pictures of the affected area to the patient)
Refer only to the section that is causing the patient pain.**

5.1 NECK PAIN

[complete this section IF the patient has neck pain; otherwise go to 5.2]

65. Does the pain or aching in your NECK affect the area shown in the diagram?
No / Yes

Show picture. If No, go to 5.2. If Yes:

66. For how long in total have you had these neck symptoms during the past 4 weeks?
Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

67. Have you found it difficult or impossible to do any of the following activities during this episode because of neck pain?

a) Sleeping **No / Yes**

b) Looking backwards over your shoulder? **No / Yes**

68. a) Have you EVER had neck pain like this, bad enough to take time off your work?
No / Yes

b) If yes, how long ago? ___Weeks ___months ___years

69. a) Have you EVER had surgery for neck pain or an injection in the neck area?
No / Yes

b) If yes, how long ago? ___Weeks ___months ___years

5.2. SHOULDER PAIN

[Complete this section IF the patient has SHOULDER pain; otherwise go to 5.3]

70. a) Does the pain or aching in your SHOULDER affect the area shown in the diagram?
No / Yes Show picture. If **No**, go to 5.3

b). If **Yes**: which shoulder is affected: Right..... 1
Left2
Both3

71. For how long in total have you had these shoulder symptoms during the past 4 weeks?
Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

72. Have you found it difficult or impossible to do any of the following activities during this episode because of shoulder pain?

- | | |
|--|-----------------|
| (a) Sleeping | No / Yes |
| (b) Getting dressed | No / Yes |
| (c) Getting tools down from high shelves | No / Yes |
| (d) Washing your hair | No / Yes |

73. a) Have you EVER had shoulder pain like this, bad enough to take time off your work?
No / Yes

b) If yes, how long ago ? ___weeks ___months ___years

74. a) Have you EVER had surgery for shoulder pain or an injection in the shoulder joint?
No / Yes

b) If yes, how long ago ? ___weeks ___months ___years

5.3. ELBOW PAIN

[complete this section IF the patient has ELBOW pain; otherwise go to 5.4]

75.a) Does the pain or aching in your ELBOW affect the area shown in the diagram?
No / Yes (Show picture. If **No**, go to 5.4.)

b) If **Yes**: which elbow is affected? Right..... 1
Left2
Both3

76. For how long in total have you had these ELBOW symptoms during the past 4 weeks?
Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

77. Have you found it difficult or impossible to do any of the following activities during this episode because of ELBOW pain?

- | | |
|--|-----------------|
| (a) Getting tools down from high shelves | No / Yes |
| (b) Fastening your clothing | No / Yes |

- (c) Undoing lids on bottles and jars **No / Yes**
- (d) Heavy jobs at work **No / Yes**

78. a) Have you EVER had elbow pain like this, bad enough to take time off your work?
No / Yes

b) If yes, how long ago? ___weeks ___months ___years

79. a) Have you EVER had surgery for elbow pain or an injection in the elbow area?
No / Yes

b) If yes, how long ago? ___weeks ___months ___years

5.4. WRIST/FOREARM/HAND PAIN

[complete this section IF the patient has WRIST, FOREARM, OR HAND pain; otherwise go to 5.5]

80. a) Does the pain or aching in your *WRIST, FOREARM, OR HAND* affect the area shown in the diagram? **No / Yes** (Show picture. If **No**, go to 5.5).

b) If **Yes**: which wrist/forearm/hand is affected? Right..... 1
Left2
Both3

81. For how long in total have you had these *WRIST, FOREARM, OR HAND* symptoms during the past 4 weeks?

Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

82. Have you found it difficult or impossible to do any of the following activities during this episode because *WRIST, FOREARM, OR HAND* pain?

- (a) Fastening your clothing **No / Yes**
- (b) Undoing lids on bottles and jars **No / Yes**
- (c) Carrying a glass **No / Yes**

83. a) Have you EVER had wrist, forearm, or hand pain like this, bad enough to take time off your work? **No / Yes**

b) If yes, how long ago? ___weeks ___months ___years

84. a) Have you EVER had surgery for this pain or an injection in the wrist area?
No / Yes

103. a) Have you EVER had surgery for this type of pain?

No / Yes

b) If yes, how long ago ? ___weeks ___months ___years

5.8. KNEE PAIN

[complete this section IF the patient has KNEE pain; otherwise go to 5.9]

104. a) Does the KNEE pain or aching affect the area shown in the diagram? **No / Yes**

(Show picture. If **No**, go to 5.9.)

b) If **Yes**: which knee is affected?

Right..... 1
Left2
Both3

105. For how long in total have you had *KNEE pain* during the past 4 weeks?

Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

106. Has your KNEE pain been associated with any of the following, over the past 4 weeks?

A) Stiffness **No / Yes**

B) Swelling **No / Yes**

C) Locking (Knee is fixed in flexion and unable to extend the knee) **No / Yes**

D) Giving way **No / Yes**

E) Grating (crepitus sound with flexion and extension of the knee) **No / Yes**

107. Have you found it difficult or impossible to do any of the following activities during this episode because of *KNEE pain*?

(a) Squatting or kneeling **No / Yes**

(b) Walking up stairs **No / Yes**

(c) Walking down stairs **No / Yes**

(d) Climbing **No / Yes**

(e) Crawling **No / Yes**

108.a) Have you EVER had knee pain like this, bad enough to take time off your work?

No / Yes

b) If yes, how long ago? ___weeks ___months ___years

108.a) Have you EVER had surgery for neck pain or an injection into the knee?

No / Yes

b) If yes, how long ago? ___weeks ___months ___years

5.9. FOOT/ANKLE PAIN

[complete this section IF the patient has FOOT OR ANKLE pain; otherwise go to 6.0]

109.a) Does the FOOT/ANKLE pain or aching affect the area shown in the diagram?
No / Yes (Check if in foot or ankle If **Not**, go to 6.0)

b) If **Yes**, which foot/ankle is affected? _____

110. For how long in total have you had FOOT OR ANKLE pain during the past 4 weeks?
just today 1- 7 days 7 - 13 days 14 - 28 days don't know

111. Have you found it difficult or impossible to do any of the following activities during this episode because of FOOT OR ANKLE pain?

- | | |
|--|-----------------|
| (a) Standing up for more than 1 hour | No / Yes |
| (b) Walking | No / Yes |
| (c) Climbing stairs | No / Yes |
| (d) Pressing or bearing weight on heels first thing in the morning | No / Yes |

112. a) Have you EVER had foot or ankle pain like this, bad enough to take time off your work? **No / Yes**

b) If yes, how long ago ? ___weeks ___months ___years

113. a) Have you EVER had surgery for foot or ankle pain or an injection in the foot or ankle?
No / Yes

b) If yes, how long ago ? ___weeks ___months ___years

5.10 NUMBNESS OR TINGLING IN THE HANDS OR FINGERS

[complete this section IF the patient has NUMBNESS OR TINGLING in the HANDS OR FINGERS; otherwise go to Section 6]

114. For how long in total have you had NUMBNESS OR TINGLING in the HANDS OR FINGERS

during the past 4 weeks?

Just today 1- 7 days 7 - 13 days 14 - 28 days don't know

115. Have you found it difficult or impossible to do any of the following activities during this episode

because of NUMBESS OR TINGLING in the HANDS OR FINGERS?

- | | |
|-----------------------|-----------------|
| (a) Sleeping | No / Yes |
| (b) Fastening clothes | No / Yes |

SECTION 6: RAYNAUDS PHENOMENON

116. Have you EVER had attacks in which any or all of your fingers suddenly became cold and numb

and at the same time turned white or pale? **No / Yes**

(If **No**, go to Q57. If **Yes**.)

117. [Show picture] Do you mean like this?

No / Yes / Not sure

If **No**, go to Q57.

118. About how old were you when you first had one of these attacks?

____(years)

SECTION 7: YOUR VIEWS ABOUT YOUR SYMPTOMS

119. Based on your own views and what the doctor or others may have told you about back pain and aches and pains in the muscles and joints, how strongly do you agree with the following statements? (Tick one box on each line).

- (a) Physical activity might make such conditions worse. **No / Yes / Not sure**
- (b) Normally these problems get better within three months. **No / Yes / Not sure**
- (c) Symptoms of this sort need to be rested to get better. **No / Yes / Not sure**

SECTION 8: ALCOHOL AND SMOKING HISTORY

120. Do you drink alcohol? **No / Yes**

121. If yes, how much do you drink? seldom everyday every week

122. How much do you drink in an average week,?

	BEER/DUMPIES	GLASSES OF WINE	TOTS OF SPIRITS
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

123. Do you smoke? **No / Yes**

if yes

a) If yes, how many cigarettes do you smoke a day? _____

b) For how many years? _____

If no, did you smoke before?

c) If yes, when did you stop? ____/____/____ and

d) How much were you smoking? _____

124. Do you smoke dagga? **No / Yes**

YOU HAVE FINISHED THE QUESTIONNAIRE!

FOR THOSE WITH PAIN IN THE NECK OR UPPER LIMB

"I WOULD NOW LIKE TO EXAMINE YOUR NECK, SHOULDERS, ARMS AND HANDS."

FOR THOSE WITH PAIN IN THE KNEE

"I WOULD LIKE TO EXAMINE YOUR KNEE"

FOR ALL OTHERS, THANK THEM AND REFER ON TO DOCTOR OR HOSPITAL AFTER NOTING DOWN THE MAIN FINDINGS FROM YOUR INTERVIEW AND EXAMINATION THAT MIGHT ASSIST THE DOCTOR

APPENDIX B: survey of musculoskeletal disorders questionnaire: controls

1. Study number _____
2. Company number _____
3. Mine _____
4. Nurse no. _____
5. Date completed _____ / _____ / 20____ Time started ____ h ____
DD MM YY

SECTION 1: CIRCUMSTANCES OF CONSULTATION: CHECK WHETHER THE PATIENT IS ELIGIBLE! (MSD must NOT BE reason for consultation)

6. Has the patient come to the clinic with **back pain**?
No / Yes
*If **Yes**, USE THE RECORDING FORM FOR CASES!*
7. Has the patient come to the clinic with *another* musculoskeletal disorder (muscle and/or joint pain), and if so, which one(s)?
No / Yes
*If **Yes**, USE THE RECORDING FORM FOR CASES!*
*If **No** continue with question 8*
8. What was the main reason for attendance? _____

WHAT TO DO NEXT

Continue with the questions on the next page!

SECTION 2: ABOUT YOURSELF

9. What is your date of birth ____/____/ 19____ or approximate age ____ (years)

10. Highest level of education? _____

11. What is your home language?

Zulu1
Xhosa2
Tswana.....3
Pedi.....4
Shangaan.....5
N Sotho.....6
S sotho.....7
Other.....8 describe _____

12. Current marital status:

Married.....1
Divorced.....2
Widowed.....3
Never married.....4
Separated.....5
Partner.....6

13 Do you have children? **No / Yes** If yes, how many? _____

14. How many people do you share your accommodation with currently? _____

15. How many people are financially dependant on you? _____

16. Which hand is your dominant hand? Right 1
Left2
Able to use both hands equally3

SECTION 3: ABOUT YOUR JOB

17. What is your job title? _____

18. How long have you been in this job? _____ months or
_____ years

19. What activity do you do most of the time? _____

20. Does an **ordinary** working day in your job **usually** involve a lot of the following?

[show pictures or demonstrate each activity each question will have a laminated photograph]

	Almost Never	Sometimes	Almost Always
p) overhead reaching for loads, tools, or mining equipment (several times/hour)	1	2	3
q) bending at the waist to handle loads, tools, or mining equipment (several times/hour)	1	2	3
r) twisting at the waist to handle loads, tools or mining equipment (several times/hour)	1	2	3
s) carrying, lifting or lowering loads of more than 25 kg repeatedly (several times/hour)	1	2	3
t) climbing up or down stairs or a ladder with loads, tools, or mining equipment (several times/day)	1	2	3
u) pushing loads, tools, or mining equipment (several times/hour)	1	2	3
v) pulling loads, tools, or mining equipment (several times/hour)	1	2	3
w) working with the hands above shoulder height (for longer than 1 hr in total)	1	2	3
x) operating equipment or tools above shoulder height (for longer than 1 hr in total)	1	2	3
y) shovelling	1	2	3
z) barring	1	2	3
aa) working in tunnels where you cannot stand up straight (for longer than 1 hr in total)	1	2	3
bb) kneeling or squatting (for longer than 1 hr in total)	1	2	3
cc) repeated bending and straightening of your elbow (for longer than 1 hr in total)	1	2	3
dd) using vibratory tools such as rock drills	1	2	3

21. In the **past 7 days** has the job involved any of these activities ?

	Almost Never	Sometimes	Almost Always
p) overhead reaching for loads, tools, or mining equipment (several times/hour)	1	2	3
q) bending at the waist to handle loads, tools, or mining equipment (several times/hour)	1	2	3
r) twisting at the waist to handle loads, tools or mining equipment (several times/hour)	1	2	3
s) carrying, lifting or lowering loads of more than 25 kg repeatedly (several times/hour)	1	2	3
t) climbing up or down stairs or a ladder with loads, tools, or mining equipment (several times/day)	1	2	3
u) pushing loads, tools, or mining equipment (several times/hour)	1	2	3

v) pulling loads, tools, or mining equipment (several times/hour)	1	2	3
w) working with the hands above shoulder height (for longer than 1 hr in total)	1	2	3
x) operating equipment or tools above shoulder height (for longer than 1 hr in total)	1	2	3
y) shovelling	1	2	3
z) barring	1	2	3
aa) working in tunnels where you cannot stand up straight (for longer than 1 hr in total)	1	2	3
bb) kneeling or squatting (for longer than 1 hr in total)	1	2	3
cc) repeated bending and straightening of your elbow (for longer than 1 hr in total)	1	2	3
dd) using vibratory tools such as rock drills	1	2	3

SECTION 4: ABOUT YOUR FEELINGS

The questions in this section are about how you feel. For each question tick the one item which comes closest to how you have been feeling in the past 14 DAY. (Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought out response)

- | | |
|---|-----------------|
| 22. Have you often had headaches? | No / Yes |
| 23. Has your appetite been poor? | No / Yes |
| 24. Have you slept badly? | No / Yes |
| 25. Have you been easily frightened? | No / Yes |
| 26. Have your hands shaken? | No / Yes |
| 27. Have you felt nervous tense or worried? | No / Yes |
| 28. Has your digestion been poor? | No / Yes |
| 29. Have you had trouble thinking clearly? | No / Yes |
| 30. Have you felt unhappy? | No / Yes |
| 31. Have you cried more than usual? | No / Yes |
| 32. Have you found it difficult to enjoy your daily activities? | No / Yes |
| 33. Have you found it difficult to make decisions? | No / Yes |
| 34. Has your daily work suffered? | No / Yes |

35. Have you been unable to play a useful part in life? **No / Yes**
36. Have you lost interest in things? **No / Yes**
37. Have you felt that you are a worthless person? **No / Yes**
38. Has the thought of ending your life been on your mind? **No / Yes**
39. Do you feel self-conscious with others? **No / Yes**
40. Have you had uncomfortable feelings in your stomach? **No / Yes**
41. Have you been easily tired? **No / Yes**
42. Are your feelings easily hurt? **No / Yes**
43. Do you feel inferior to others? **No / Yes**
44. Do you get the feeling that people are unfriendly or dislike you? **No / Yes**

Now we'd like to get an idea of some things that have happened to you in the past 12 months? *

0=No problem

1=mild problem

2=major problem

45. Have you had a problem with your health or nerves? **0 / 1 / 2**
46. Have you been assaulted or beaten up in the last couple of weeks? **0 / 1 / 2**
47. In the past, have you been in any situation that was extremely frightening or horrifying? **0 / 1 / 2**
48. Have you had any difficulties relating to finance? **0 / 1 / 2**
 -loss of finance
 -inadequate income

In the past, have any problems affected your relationship with Roommates, wife or family members

49. Do you have a problem discussing interests or conflicts? **0 / 1 / 2**
50. Do you have a problem sharing household tasks? **0 / 1 / 2**
51. Do you get tense or irritable, or get into fights with him/her? **0 / 1 / 2**

Have any of these problems affected your ability to work?

52. Do you have a problem getting to work in the morning? **0 / 1 / 2**
53. Do you have a problem completing a full day's work, most days? **0 / 1 / 2**
54. Do you have a problem working a full week, most weeks? **0 / 1 / 2**
55. Do you have a problem getting along with supervisors and colleagues? **0 / 1 / 2**

Have any of these problems affected your leisure time activity?

56. Do you have a problem enjoying things such as TV, Radio, Magazines? **0 / 1 / 2**

SECTION 5: ABOUT YOUR SYMPTOMS (Show pictures of the affected area to the patient)

Have you EVER attended the occupational health department because of pain, aching or discomfort in the muscles or joints of the following body parts?

(Circle the number corresponding to the patient's response)

	Never	Yes within past year	Yes, more than a year ago
58. neck pain?	1	2	3
59. pain in the shoulder(s)?	1	2	3
60. pain in the elbow(s)?	1	2	3
61. pain in the wrists/hands?	1	2	3
62. pain in the forearm(s)?	1	2	3
63. pain in the upper back?	1	2	3
64. pain in the lower back?	1	2	3
65. pain in the groin (on first getting out of a chair)?	1	2	3
66. pain in the knee(s)?	1	2	3
67. pain in the ankle(s) or foot/feet?	1	2	3
68. numbness or tingling in the arm hand or fingers?	1	2	3

SECTION 6: RAYNAUDS PHENOMENON

69. Have you EVER had attacks in which any or all of your fingers suddenly became cold and numb and at the same time turned white or pale? **No / Yes**

If No, go to Q57. If Yes:

70. [Show picture] Do you mean like this? **No / Yes / Not sure**

If No, go to Q57.

71. About how old were you when you first had one of these attacks? ____ (years)

SECTION 7: YOUR VIEWS ABOUT YOUR SYMPTOM

72. Based on your own views and what the doctor or others may have told you about back pain and aches and pains in the muscles and joints, how strongly do you agree with the following statements? (Tick one box on each line).

- (a) Physical activity might make such conditions worse. **No / Yes / Not sure**

- (b) Normally these problems get better within three months. **No / Yes / Not sure**
- (c) Symptoms of this sort need to be rested to get better. **No / Yes / Not sure**

SECTION 8: ALCOHOL AND SMOKING HISTORY

73. Do you drink alcohol? **No / Yes**

74. If yes, how much do you drink? seldom everyday every week

75. How much do you drink in an average week,?

	BEER/DUMPIES	GLASSES OF WINE	TOTS OF SPIRITS
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

76. Do you smoke? **No / Yes**

If yes

e) If yes, how many cigarettes do you smoke a day? _____

f) For how many years? _____

If no, did you smoke before?

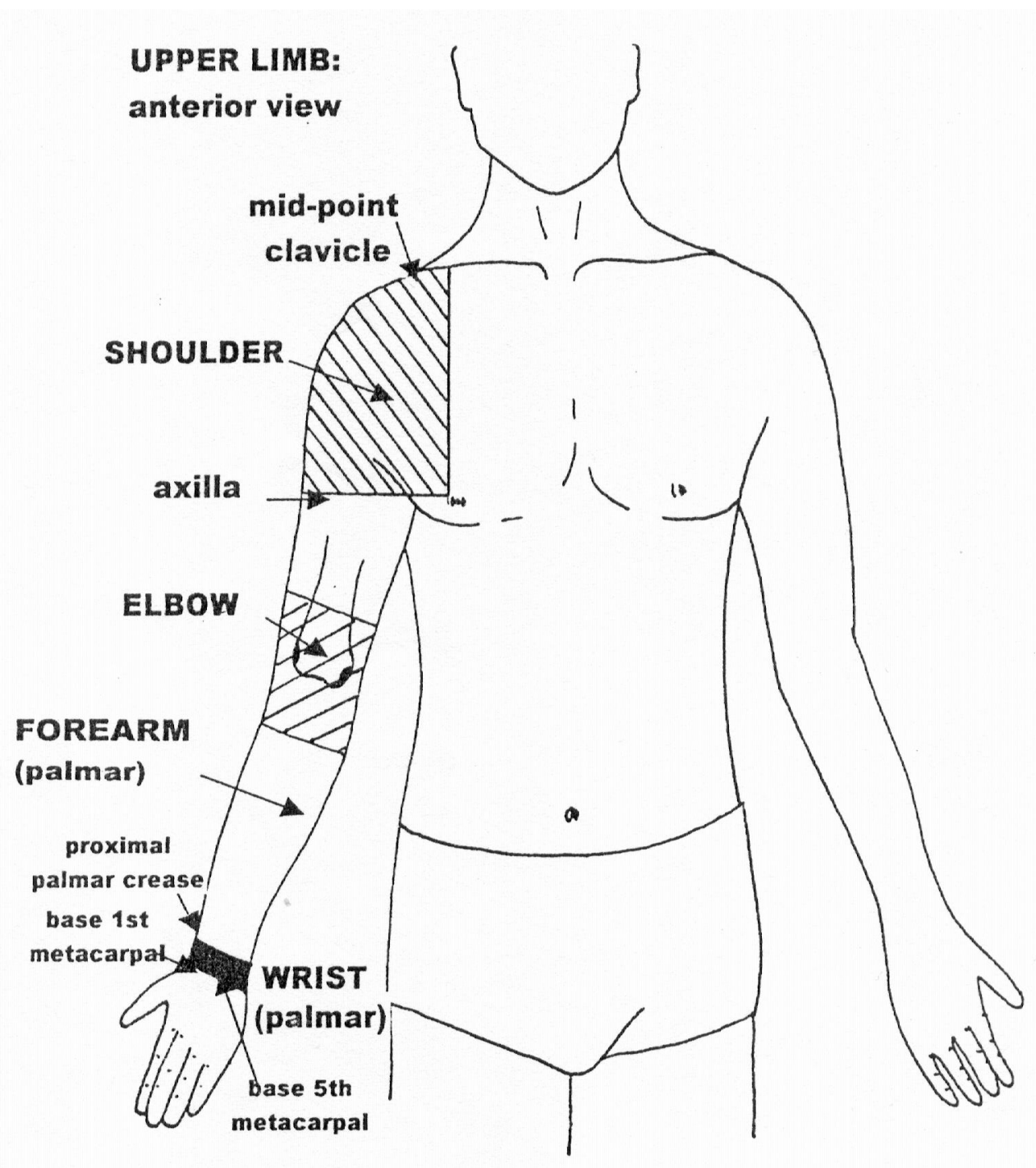
g) If yes, when did you stop? ____/____/____ and

h) How much were you smoking? _____

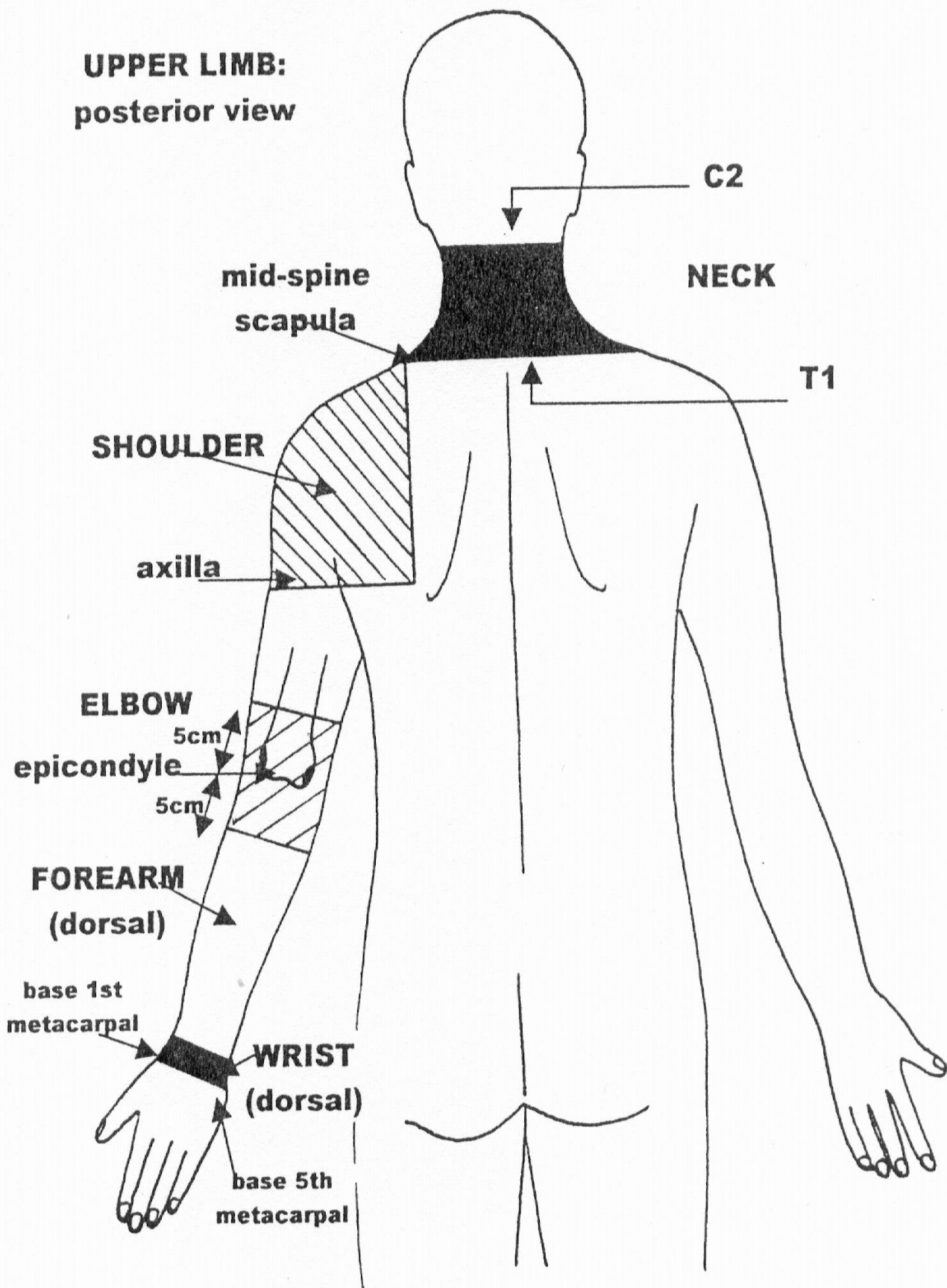
77. Do you smoke dagga? **No / Yes**

YOU HAVE FINISHED THE QUESTIONNAIRE !

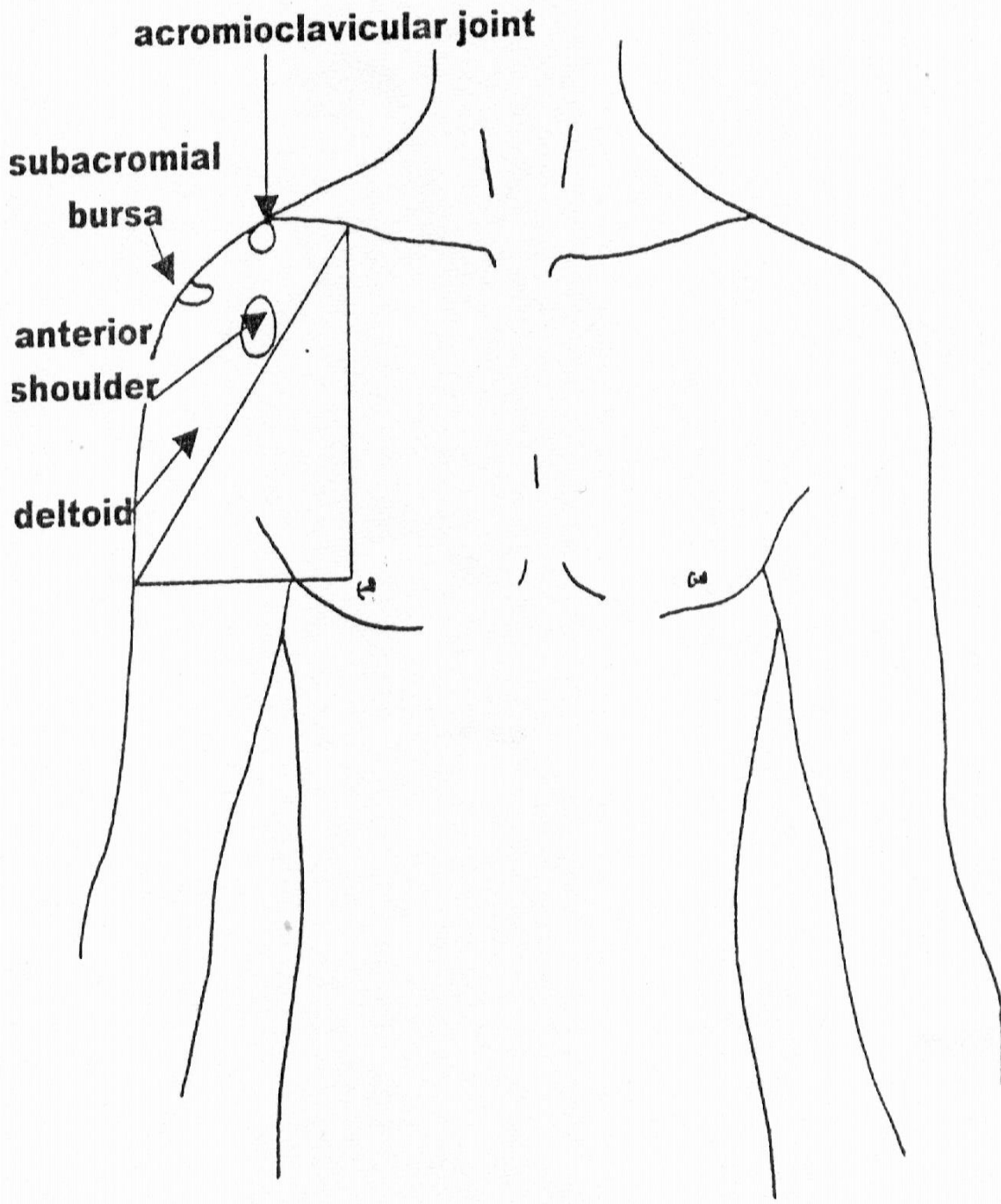
APPENDIX C: Body regions



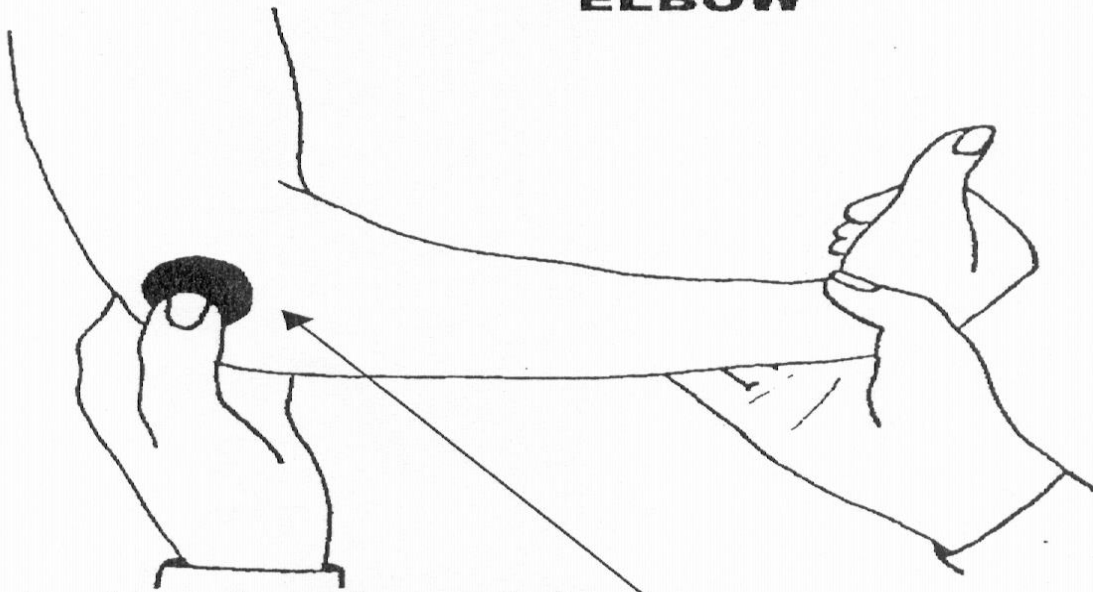
**UPPER LIMB:
posterior view**



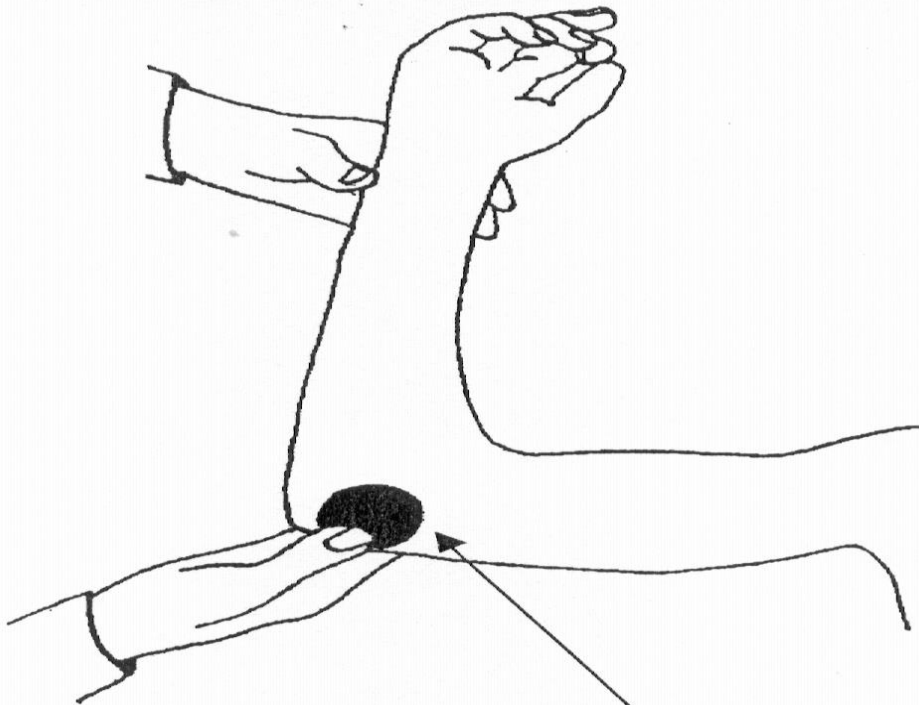
SHOULDER: anterior view



ELBOW



Lateral epicondyle
(radius=2cm around epicondyle)

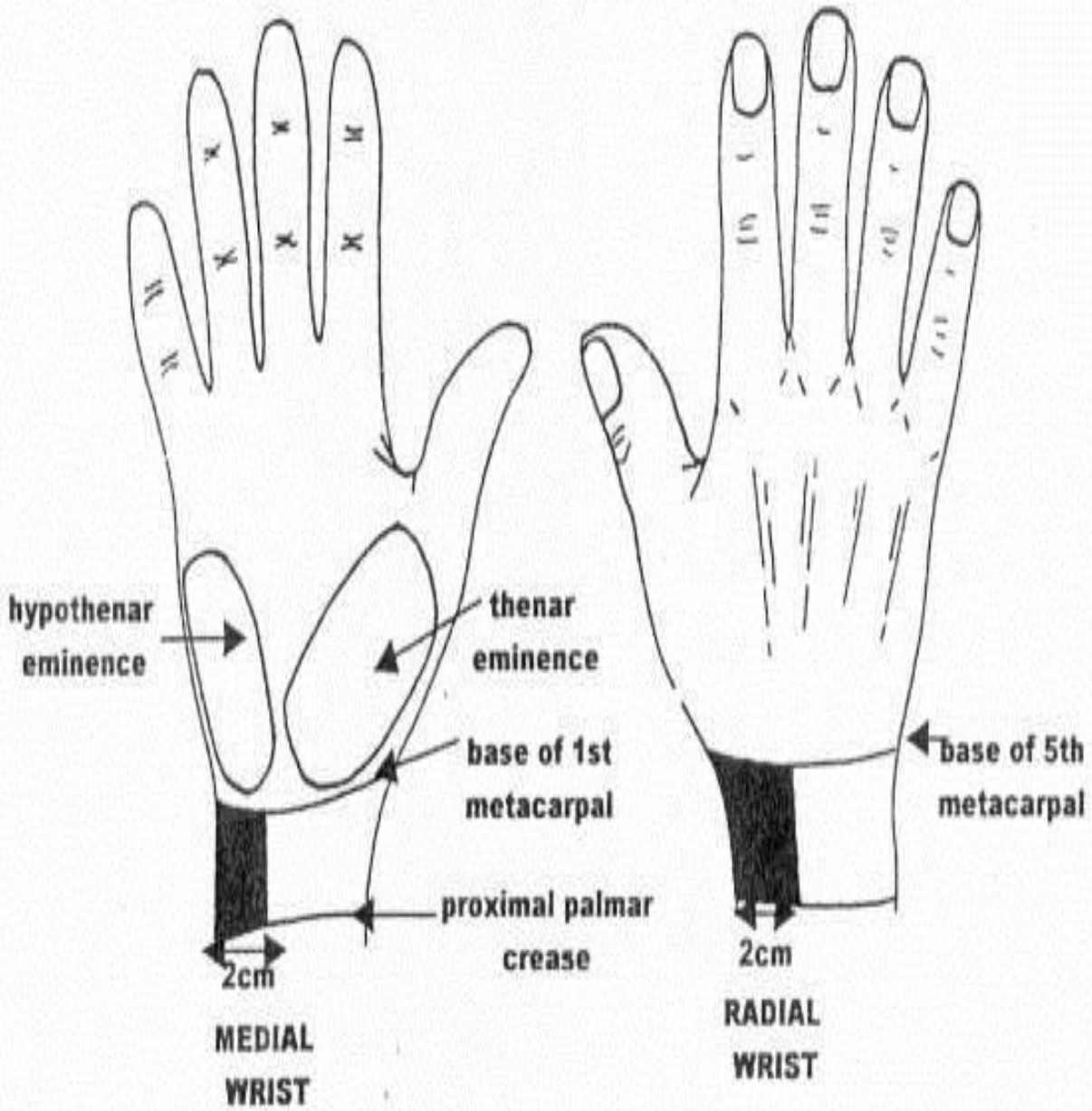


Medial epicondyle
(radius=2cm around epicondyle)

HAND AND WRIST

posterior view

anterior view



APPENDIX D : Examination proforma

Interviewer:

Day

month

year

Height

cms

Weight

kg

NECK

Range of movement (°)?

Active Movement

Rotation

right side

Left side

Flexion

Extension

Lateral flexion

right side

left side

SHOULDERS

Left Side

1 History: Where is the pain located?

2 Palpation: Where is it maximally tender?

	Yes
No pain	<input type="checkbox"/>
Deltoid area	<input type="checkbox"/>
Anterior shoulder	<input type="checkbox"/>
Acrocioclavicular joint	<input type="checkbox"/>
Subacromial bursa	<input type="checkbox"/>
Diffuse	<input type="checkbox"/>
Elsewhere?	<input type="checkbox"/>

	Yes
No tenderness	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

(describe) _____

(describe) _____

3 Pain on resisted movement

	No	Yes
Elbow flexion	<input type="checkbox"/>	<input type="checkbox"/>
Forearm supination	<input type="checkbox"/>	<input type="checkbox"/>
External rotation	<input type="checkbox"/>	<input type="checkbox"/>
Internal rotation	<input type="checkbox"/>	<input type="checkbox"/>
Abduction	<input type="checkbox"/>	<input type="checkbox"/>

Painful are?	<input type="checkbox"/>	<input type="checkbox"/>
--------------	--------------------------	--------------------------

Range of movement(°)?

<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
(started)	(stopped)

4 Stress test, acromioclavicular joint

	No	Yes
Acromioclavicular joint pain on adduction?	<input type="checkbox"/>	<input type="checkbox"/>

5 Range of movement (°)?

	Active Movement	Passive Movement
Abduction	<input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/>
Forward flexion	<input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/>
Extension	<input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/>
External rotation	<input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/>
Internal rotation	<input type="text"/> <input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/> <input type="text"/>

SHOULDERS

Right Side

1 History: Where is the pain located?

	Yes
No pain	<input type="checkbox"/>
Deltoid area	<input type="checkbox"/>
Anterior shoulder	<input type="checkbox"/>
Acrocioclavicular joint	<input type="checkbox"/>
Subacromial bursa	<input type="checkbox"/>
Diffuse	<input type="checkbox"/>
Elsewhere?	<input type="checkbox"/>

(describe) _____

2 Palpation: Where is it maximally tender?

	Yes
No tenderness	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

(describe) _____

3 Pain on resisted movement

	No	Yes
Elbow flexion	<input type="checkbox"/>	<input type="checkbox"/>
Forearm supination	<input type="checkbox"/>	<input type="checkbox"/>
External rotation	<input type="checkbox"/>	<input type="checkbox"/>
Internal rotation	<input type="checkbox"/>	<input type="checkbox"/>
Abduction	<input type="checkbox"/>	<input type="checkbox"/>

No Yes

Range of movement(°)?

Painful are?

(started) (stopped)

4 Stress test, acromioclavicular joint

No Yes

Acromioclavicular joint pain on adduction?

5 Range of movement (°)?

Active Movement

Passive Movement

Abduction	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Forward flexion	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Extension	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
External rotation	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Internal rotation	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

ELBOWS

Left Side

1 History: Where is the pain located?

2 Palpation: Where is it maximally tender

	Yes		Yes
No pain	<input type="checkbox"/>	No tenderness	<input type="checkbox"/>
Lateral elbow	<input type="checkbox"/>		<input type="checkbox"/>
Medial elbow	<input type="checkbox"/>		<input type="checkbox"/>
Posterior elbow	<input type="checkbox"/>		<input type="checkbox"/>
Other	<input type="checkbox"/>		<input type="checkbox"/>

(describe) _____

(describe) _____

ELBOWS

Right Side

1 History: Where is the pain located?

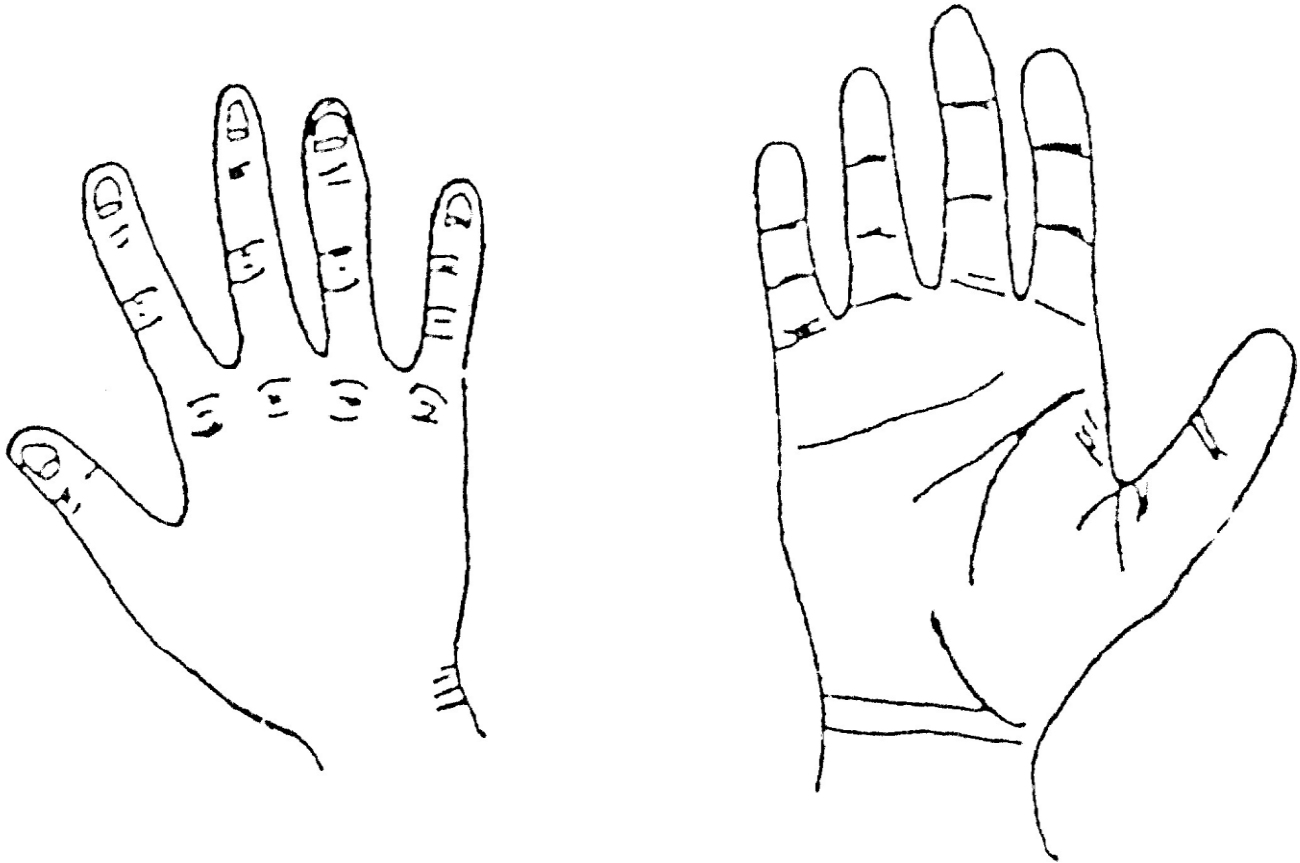
2 Palpation: Where is it maximally tender

	Yes		Yes
No pain	<input type="checkbox"/>	No tenderness	<input type="checkbox"/>
Lateral elbow	<input type="checkbox"/>		<input type="checkbox"/>
Medial elbow	<input type="checkbox"/>		<input type="checkbox"/>
Posterior elbow	<input type="checkbox"/>		<input type="checkbox"/>
Other	<input type="checkbox"/>		<input type="checkbox"/>
(describe) _____		(describe) _____	
_____		_____	

KATZ HAND DIAGRAM

Right Side

If the subject has indicated tingling or numbness in the hand(s)/arm(s) in the past 7 days (question 30) indicate where it (they) occurred by shading the affected parts on the diagram below.

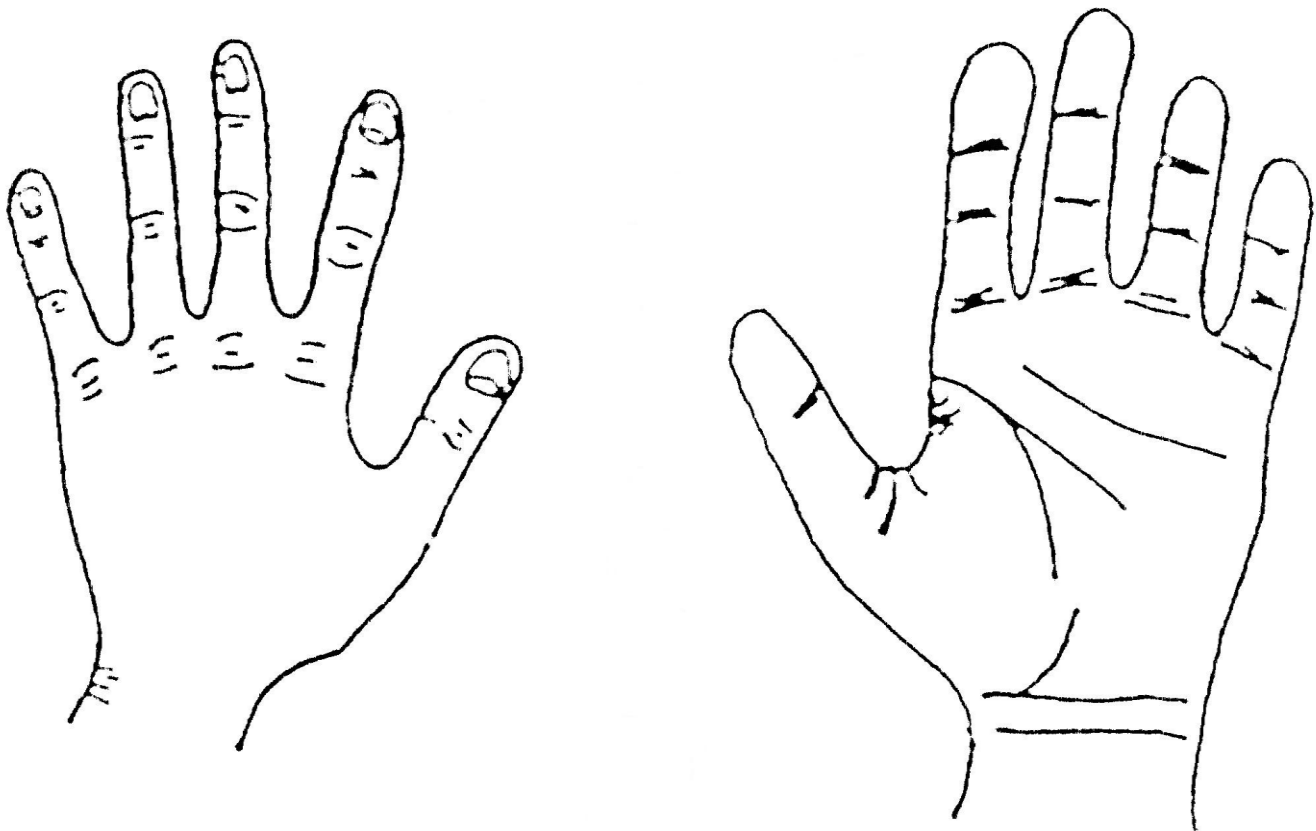


Diagnosis classical probable possible unlikely

KATZ HAND DIAGRAM

Left Side

If the subject has indicated tingling or numbness in the hand(s)/arm(s) in the past 7 days (question 30) indicate where it (they) occurred by shading the affected parts on the diagram below.



Diagnosis classical probable possible unlikely

FOREARMS AND HANDS

Left Side

1 History: location of pain (on movement)	Palpation: maximum tenderness?		Swelling?
	Yes	Yes	Yes
dorsal forearm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
palmar forearm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dorsal wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Palmar wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Radial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2 Pain on resisted movement

	Pain on resisted movement		Crepitus?
	No	Yes	Yes
Radial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finger extension	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finger flexion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3 Hand examination

	No	Yes		No	Yes
muscle wasting	<input type="checkbox"/>	<input type="checkbox"/>	Hypothenar eminence	<input type="checkbox"/>	<input type="checkbox"/>
Thenar eminence	<input type="checkbox"/>	<input type="checkbox"/>			
Dupuytren's contracture	<input type="checkbox"/>	<input type="checkbox"/>			
Herberden's nodes	<input type="checkbox"/>	<input type="checkbox"/>			

Light touch:

Thumb base:

	Normal	Abnormal		No	Yes
Thumb	<input type="checkbox"/>	<input type="checkbox"/>	Pain?	<input type="checkbox"/>	<input type="checkbox"/>
index finger	<input type="checkbox"/>	<input type="checkbox"/>		Tenderness?	<input type="checkbox"/>
little finger	<input type="checkbox"/>	<input type="checkbox"/>			

	No	Yes		
Positive Phalen's test?	<input type="checkbox"/>	<input type="checkbox"/>		
Positive Tinel's test?	<input type="checkbox"/>	<input type="checkbox"/>		
Weakness of thumb abduction	<input type="checkbox"/>	<input type="checkbox"/>	Thumb opposition	<input type="checkbox"/>
Pain on resisted left thumb extension?	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
Positive Finkelstein test?	<input type="checkbox"/>	<input type="checkbox"/>		

FOREARMS AND HANDS

Right Side

1 History: location of pain (on movement)		Palpation: maximum tenderness?	Swelling?
	Yes	Yes	Yes
dorsal forearm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
palmar forearm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dorsal wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Palmar wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Radial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2 Pain on resisted movement

	No	Yes	Crepitus? Yes
Radial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Medial wrist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finger extension	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finger flexion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3 Hand examination

	No	Yes		No	Yes
muscle wasting	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
Thenar eminence	<input type="checkbox"/>	<input type="checkbox"/>	Hypothenar eminence	<input type="checkbox"/>	<input type="checkbox"/>
Dupuytren's contracture	<input type="checkbox"/>	<input type="checkbox"/>			
Herberden's nodes	<input type="checkbox"/>	<input type="checkbox"/>			

Thumb base:

Light touch:

	Normal	Abnormal		No	Yes
Thumb	<input type="checkbox"/>	<input type="checkbox"/>	Pain?	<input type="checkbox"/>	<input type="checkbox"/>
index finger	<input type="checkbox"/>	<input type="checkbox"/>	Tenderness?	<input type="checkbox"/>	<input type="checkbox"/>
little finger	<input type="checkbox"/>	<input type="checkbox"/>			

	No	Yes		No	Yes
Positive Phalen's test?	<input type="checkbox"/>	<input type="checkbox"/>			
Positive Tinel's test?	<input type="checkbox"/>	<input type="checkbox"/>			
Weakness of thumb abduction	<input type="checkbox"/>	<input type="checkbox"/>	Thumb opposition	<input type="checkbox"/>	<input type="checkbox"/>
Pain on resisted left thumb extension?	<input type="checkbox"/>	<input type="checkbox"/>			
Positive Finkelstein test?	<input type="checkbox"/>	<input type="checkbox"/>			

APPENDIX E: Record review Following musculoskeletal disorders episode

Company Number

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Study Number

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1. Data on which sickness absence began (dd) (mm) (yy)

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2. Date of return to work (dd) (mm) (yy)

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3. Diagnosis _____

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4. Treatment or treatments given: (tick as many as apply)

NSAID or another analgesia?
 No / Yes

NSAID or another analgesia?
 No / Yes

Injection in joint?
 No / Yes

NSAID or another analgesia?
 No / Yes

NSAID or another analgesia?
 No / Yes

NSAID or another analgesia?
 No / Yes

NSAID or another analgesia?
 No / Yes

Diagnosis and treatment according to the coding sheet

APPENDIX F: Ethics form