

Safety in Mines Research Advisory Committee

Report

**A prospective study to assess the
prevalence and work-related risk
factors in the development of
musculoskeletal disorders in the
South African mining industry**

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Executive summary

The objective of the present study was to assess the prevalence of work-related musculoskeletal disorders (WMSD) in the South African mining industry and to identify work-related factors that may pose a risk of WMSD developing. Aspects covered in the report include the findings of a literature review dealing with WMSD; the results of a retrospective record review of WMSD; the results of a prospective study to determine the prevalence of WMSD; the identification of work categories and tasks that pose a risk of WMSD; and, finally, recommendations for controlling or reducing the risk of WMSD.

From the literature, it is evident that there is a link between physical work factors and WMSD. The results of epidemiological studies of working populations provide sufficient evidence of causal relationships between a number of risk factors (which include awkward postures, repetitive motions, high force and vibration) and the gradual onset of musculoskeletal disorders. The evidence is strong, particularly when risk factors are combined. WMSD are multifactorial and currently, there is more information available on physical risk factors than on psychosocial risk factors. Generally speaking, studies have demonstrated associations between WMSD and psychosocial factors related to job and task demands (especially heavy workload, time and work pressure, limited job control, and monotonous work).

Retrospective record reviews were conducted at three mines (one from the gold mining sector, one from the platinum mining sector, and one from the coal mining sector). The objective of the record reviews was to get a “snap shot” of the situation regarding WMSD in the South African mining industry, in terms of both prevalence and high-risk occupations. This information was used in the design of the prospective study to estimate the extent of WMSD in the South African mining industry and in the ergonomics assessments of occupations.

At the gold mine, 16.2% of the 1 235 records reviewed were WMSD-related. Of these musculoskeletal disorders, 15% were associated with the upper limbs, 16% with the lower limbs and 69% with the back region. In the case of the platinum mine, 41.3% of

the 75 records dealt with WMSD and 62% of the 31 records were associated with the upper limbs, 8% with the lower limbs and 30% with the back region. At the coal mine, a total of 226 medical records dealing specifically with WMSD were reviewed. Analysis revealed that 37% of the musculoskeletal disorders were associated with the upper limbs, 13% with the lower limbs and 50% with the back region.

As far as work categories and the development of WMSD on the gold mine are concerned, 43% of the WMSD cases recorded were rock drill operators, 14% general stope team workers, and 12% mechanical loader operators. Occupations at the platinum mine were rock drill operators (18% of the total WMSD recorded), scraper winch drivers, mechanical loader drivers and general stope team workers (5% of the total WMSD recorded was associated with each of these work categories). At the colliery occupations were continuous miner operators (12% of the total WMSD recorded), shuttle car drivers (8% of the total WMSD recorded) and fitters (7% of the total WMSD recorded).

In the prospective study, incident cases of musculoskeletal disorders (MSD) presenting to the medical services at three mines were identified, recruited, classified, and assessed in terms of potential risk factors. This information was compared to that obtained from subjects presenting to the same services with other disorders. Three mines were used as project mines: one gold mine, one platinum mine and a colliery.

In terms of MSD, the outcomes of interest were upper limb disorders, pain or stiffness in the neck (with or without radiating neurological symptoms), lower back pain (with or without sciatica), and lower limb disorders (including knee cartilage injuries, pre-patellar bursitis, Achilles tendinitis, and hip and knee pain). Cases were subjects in each of these categories who had consulted a medical service and had been absent from work due to one or more of these conditions. For each interviewed case, a control was chosen who was the next consenting patient in turn seen by the primary health care nursing officer - provided that the reason for consultation was not a MSD. As with cases, subjects attending by reason of an accident were not considered. A purpose-designed questionnaire was used during structured interviews to obtain relevant information and when cases with an upper limb or neck pain were identified, a standardised examination

was conducted. Complaints arising from acute trauma (e.g. crush injuries, lacerations, fractures, bruises, dislocations or amputations) were specifically excluded.

A total of 695 cases and 693 controls were investigated. In the cases group, 337 were from the gold mine, 271 from the platinum mine and 85 from the colliery. The corresponding numbers for control groups were 336, 271 and 87, respectively. The ages of the study participants ranged from 19 to 73 years old and the average service period of all the cases was 10,1 years, with a service range of one month to 41 years.

At the gold mine, a total of 18 641 mine employees attended the medical centre during the six-month study period and 1,8%-4,5% of them presented with MSD. A total of 21 825 mine employees attended the medical centre at the platinum mine during the study period and the percentage of patients presenting with MSD was 1,2%-5,9%. For the colliery the percentage of patients presenting to the clinic with MSD was 8,9%-9,5% of the 963 employees attending the medical centre. The mineworkers presenting after-hours with a MSD were not seen by the research sister. The research sister reviewed their medical files the following day. Hence, a range has been given for the number of presentations for the 3 mines' clinics.

From the results obtained in the study, there is evidence of different musculoskeletal presentations at the different mines. At the gold mine, backache is by far the most common presenting musculoskeletal complaint (82,1%). At the platinum mine and the colliery, the corresponding figures were 37,8 0% and 66,2% respectively. Back complaints at the gold mine were followed by complaints of pain in the hip region (5,5%) and the foot region (4,6%). At the platinum mine the second most common complaint was knee pain (17%), followed by ankle pain (9%) and neck pain (9,1%). At the colliery neck pain (13,5%) and foot pain (8,1%) were also common presentations.

At the gold mine, the majority of cases presenting with backache were rock drill operators (28,1%) and winch operators (22,3%). At the platinum mine, backache most frequently occurred in rock drill operators (17,7%) and workers falling in the 'general team' category (39,2%). For the colliery, the majority of people presenting with backache were shuttle car drivers (18,4%), belt operators (18,4%) and artisans (18,3%).

In order to calculate the prevalence of MSD, the number of mineworkers presenting with MSD for the first time during the study period at each mine was divided by the number of employees in the study population. The study population is the number employees at each mine that would be at risk of developing MSD and might present to the primary health care centre. The platinum mine had the highest prevalence rate (3.4-18.2%), followed by the colliery (7.4-8.4%) and then the gold mine (2.1-5.2%). The above result was surprising since the working conditions at the gold mine and the platinum mine are very similar. The exact reason for this result is not clear. The prevalence is given as a range; the lower range is the number of patients with a MSD interviewed and examined by the research sister. The upper range includes patients seen after hours presenting with a MSD according to their medical file. Two-thirds of the MSD patients presented after hours and at weekends. The research sister did not see these patients as she was only at the clinic during the day. These patients were not interviewed and information from their record card was limited. This could have resulted in patients presenting with old injuries or with symptoms similar to a MSD being included. For example, patients with a sexually transmitted disease presenting with backache could have been included. Age distribution of ages and service history imply an increased prevalence of MSD with age and service history. However, the mean age and mean service years cases and controls for were similar.

The ergonomics assessments focused on the identification of work-related risk factors in the development of WMSD. Typically, musculoskeletal injury risk factors are associated with exertions that are forceful, are repeated frequently, are sustained, are performed in a deviated (awkward) posture, involve vibration, or produce high contact stresses. Due to the large number of occupations on the three mines at which the investigations were carried out in the project, it was decided to study the tasks of the high-risk occupations identified in the record review and the prospective study. Those occupations that were identified by mine personnel as potentially high-risk occupations in their opinion were also studied.

The results of the ergonomics assessments conducted indicated that many of the known risk factors for musculoskeletal disorders, usually in combination, are associated with typical mining tasks. Risks factors identified included awkward body posture, manual material handling, repetitive motions, force and vibration. Of these, working in an

awkward posture and manual material handling are considered to be the major risk factors.

From an ergonomics viewpoint, there are three strategies available to control or reduce the risk of MSD: engineering controls, work practice controls and administrative controls.

Engineering controls such as properly designed workstations and the substitution of manual material handling with appropriate mechanical handling equipment could be implemented relatively easily in work areas on surface. The underground environment, however, provides unique challenges. Restrictive work areas due to low ceiling height (in stope panels, for example) cause workers to perform tasks in postures that are not desirable. Due to practical, geological and economic constraints, it is highly unlikely that this situation will change but practical solutions are available. An example of a possible solution to the large number of knee problems in platinum and gold miners (most likely the result of excessive pressure on the knees from body weight when the miners are working in a kneeling position in areas with low ceiling heights) is the introduction of a kneepad seat developed by NIOSH. The kneepad seat allows workers to rest the body weight on the seat, thus removing some weight from the knees and ankles.

In view of the importance of the identification and treatment of WMSD, it is recommended that a series of workshops be organised (under the auspices of SIMRAC or any suitable institution) to assist occupational health personnel on mines to build capacity and expertise in WMSD diagnosis, treatment, rehabilitation and return to work.

There is no universally accepted classification for WMSD that could be used for surveillance. The Southampton examination schedule for the diagnosis of MSD of the upper limb used in the present study is repeatable and gives acceptable diagnostic accuracy in a hospital setting. If the planned further analyses of results obtained in this study show a similar finding, it is recommended that this examination schedule be considered for use in an industrial setting such as mining. It could become an important tool to assist primary health care nurses, as well as occupational health care nurses, to diagnose upper limb MSD.

The implementation of ergonomically sound interventions in the workplace has the potential to reduce the risk of WMSD. Since each mine presents a unique workplace, generic solutions will not necessarily fully address ergonomics-related risks at all mines. It is therefore recommended that mine-specific ergonomics programmes be considered as a method for the introduction and implementation of ergonomics programmes in the workplace at mines. These programmes should be based on participatory principles to ensure successful implementation by and participation of workers at all levels at the mine. Existing health and safety structures, resources and procedures should be considered for this purpose. Information dealing with the important aspects of an ergonomics programme and its implementation is contained in SIMRAC Report GEN 603.

Good design of workplaces and tasks is one of the strategies for preventing musculoskeletal injuries. However, in view of the large variation in the mine worker population's body dimensions and mechanical work capacity, as well as technical and physical constraints in the mining environment, it is not always possible to accommodate all individuals, especially when manual material handling is involved. It is therefore recommended that a criterion for worker selection and placement be functional biomechanical strength capabilities, along with appropriate worker training within a comprehensive plan for preventing musculoskeletal injuries.

Current information on the physical dimensions of South African mine workers is dated, and very little information is available on their mechanical work capacity. In view of the importance of this information in the design of mining equipment, workstations and mining tasks, it is recommended that studies be carried out to determine the functional anthropometry (i.e. those body dimensions that are essential for the design of workstations) and the functional biomechanical strength capabilities of South African mine workers (both female and male).

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GLOSSARY

Achilles tendonitis

Inflammation of the Achilles tendon

Amputations

The act of amputating; esp. the operation of cutting off a limb or projecting part of the body

Bruises

To injure, as by a blow or collision, without laceration; to contuse; as, to bruise one's finger with a hammer

Bursitis

Inflammation of a bursa. Bursa is any sac or saclike cavity; especially, one of the synovial sacs, or small spaces, often lined with synovial membrane, interposed between tendons and bony prominences

Carpal tunnel syndrome

A condition where there is disturbance of the median nerve function at the wrist as the nerve passes through the carpal tunnel

Control

The next patient seen after the MSD case that did not present with a MSD or injury

Diagnostic criteria

The signs or symptoms by which one disease is known or distinguished from others

Dislocation

The act of dislocating, or putting out of joint

Disorders

To disturb or interrupt the regular and natural functions of (either body or mind); to produce sickness

Epicondylitis

A strain of the lateral forearm muscles (extensors of the digits and wrist) or their tendinous attachments near their origin on the lateral epicondyle of the humerus (i.e. at the elbow)

Epidemiological

Pertaining to the study of the distribution and determinants of disease in populations and the application of this study to control health problems

Fractures

The breaking of a bone

Hand-arm vibration syndrome

A condition affecting peripheral nerves, blood vessels and musculoskeletal system of workers exposed to hand arm vibration

Heterogeneous

Differing in kind; having unlike qualities; possessing of different characteristics; dissimilar

Incidence

Incidence is a measure of the frequency with which an event, such as a new case of illness, occurs in a population over a specified period in time

Laceration

A breach or wound made by lacerating

Lower limb

From the hip to the toes

MSD

Musculoskeletal disorders are disorders of the muscles, bones and cartilages of the body collectively

MSD case

MSD cases were identified through the participating primary health care sister and referred to the designated, trained research sister appointed at each primary health care centre for a structured interview

MSD record

When the research sister was not available, i.e. after hours or over the weekends, the primary health care sister would set aside the medical records of the patients presenting with a MSD. The following day or on the Monday, the research sister would then make a MSD record of the consultation

Multifactorial

Involving or depending on several factors or causes

Musculoskeletal system

All the muscles, bones and joints of the body collectively

Neurological system

The entire integrated system of nerve tissue in the body

Numbness

Inability to feel anything

Period prevalence

Refers to the number of cases in a population who have a particular disease over a specified period of time.

Point prevalence

Refers to the number of cases in a population who have a particular disease at a specified point in time

Private G.P.

Private General Practitioners are the practitioners who coal miners choose to be their medical provider

Psychosocial factors

The term "psychosocial" is commonly used in the occupational health arena as a catchall term to describe a very large number of factors that fall into three separate domains: (1) factors associated with the job and work environment, (2) factors associated with the extra-work environment, and (3) characteristics of the individual worker

Raynaud's disease

Cold induced intermittent vasospasm causing pallor in the fingers; it can be idiopathic or secondary i.e. due to vibration

Raynaud's phenomenon

Paroxysmal spasm of the digital arteries causing pallor of the fingers and toes, usually on exposure to cold

Rehabilitation

Training of the mentally or physically disabled in work skills so they may be returned to regular employment utilizing these skills

Research sister

Designated trained sister (employed by the study) to recruit MSD cases and controls for the study

Rotator cuff tendonitis

Tearing and inflammation of the tendons of the shoulder

Sciatica

Neuralgia of the sciatic nerve, an affection characterized by paroxysmal attacks of pain in the buttock, back of the thigh, or in the leg or foot, following the course of the branches of the sciatic nerve

Study period

Time taken to collect prospective study data: in this study, the study period was 6 months

Study population

The number of employees at each mine who are at risk of developing a MSD and had accessed the primary health care centre during the study period

Tendonitis

Inflammation of the tendons

Tenosynovitis

Inflammation of the synovial sheath of a tendon

Upper limb

From the shoulder girdle to the fingers

WMSD

Work-related musculoskeletal disorders (WMSD's) is a term given to a group of disorders involving the muscles, joints, nerves and vascular compartments of the body where certain jobs or work-related factors have been shown to be associated with an increased risk of developing these disorders

1. Introduction

Musculoskeletal disorders are a group of conditions that involve the nerves, tendons, muscles and supporting structures needed for locomotion. These disorders can result in anything from mild periodic symptoms to severe chronic and debilitating conditions. The specific term “work-related musculoskeletal disorders” (WMSD) refers to musculoskeletal disorders to which the work environment and the performance of work contribute significantly, or musculoskeletal disorders that are made worse or longer-lasting by the work environment.

WMSD have been observed worldwide, in developed, and developing countries. They also occur in many different industries and jobs; indeed they can be found wherever there are work risk factors thought to be associated with the development or aggravation of these disorders. Examples of risk factors are tasks requiring repetitive, forceful or prolonged exertion of the hands, frequent heavy lifting, pushing, pulling or carrying of heavy objects, and prolonged awkward body postures (NIOSH, 1997).

Many mining tasks performed by an aging workforce on South African mines are associated with strenuous physical activities and also feature many of the known risk factors identified above. In many instances, these tasks are performed in awkward body postures as a result of the restricted roof heights and angles of the workplace. Exposure to vibration can also aggravate the situation. In view of the above, the development of WMSD as a result of mining tasks is not unexpected. The extent of this problem, if present, has not been estimated and there was thus a need to assess the prevalence of WMSD in the South African mining industry.

2. Objective of study

The objective of this present study was to assess the prevalence of WMSD in different commodities in the South African mining industry and to identify work-related factors that may pose a risk for the development of WMSD.

The primary outputs of the study are: a retrospective record review of WMSD; a data collection tool for relevant WMSD information; a prospective study to determine the prevalence of WMSD; and, finally, the identification of work categories and tasks that pose a risk of WMSD.

3. Literature review

A literature review was conducted focusing primarily on the type and nature of disorders in the workplace that could be classified as WMSD in the mining industry, the prevalence of these disorders and the epidemiological evidence regarding work-related risk factors. The complete literature review is attached as Appendix 1. A number of the important issues identified during the literature review are discussed in this section of the report.

Musculoskeletal disorders (MSD) are disorders of the muscles, joints, nerves, vessels and supporting structures that are involved in locomotion. They are usually manifested by pain, numbness, tingling, swelling or loss of function, and are usually located in the upper limb, back and, to a lesser extent, the lower limbs. The term “MSD” is not a diagnosis but a category of specific and non-specific diagnoses related to the above tissues that have some common features (Silverstein, 2001).

WMSD particularly those of the upper limb are known by a variety of terms across the world. In the United States of America, “cumulative trauma disorders” (CTD) is sometimes used to refer to this group of disorders. In Japan, they have been known as “occupational cervicobrachial disorders” (OCD), in Canada and Australia as “repetitive strain injuries” (RSI), and more recently in Australia as “occupational overuse syndrome” (OOS). Lately, WMSD has gained popularity worldwide as the preferred designation for this group of disorders (Forcier and Kuorinka, 2001).

From the literature it is evident that there is a link between physical work factors and WMSD. The results of epidemiological studies of working populations provide sufficient evidence for causal relationships between a number of risk factors including awkward postures, repetitiveness, high force and vibration, and the gradual onset of MSD (Bernard *et al.*, 1997; NIOSH, 1997; Viikari-Juntura, 1998). The evidence was strong, particularly when risk factors were combined. The latter two publications contain no systematic examination of the work-relatedness of disorders of the lower limbs. However, Kuorinka and Forcier (1995) did review knee bursitis and found that there was evidence for a relationship between posture (kneeling) and the disorder.

WMSD are multifactorial and currently there is more information available on physical risk factors than on psychosocial risk factors. Generally speaking, studies have demonstrated the associations between WMSD and psychosocial factors related to job and task demands

(especially heavy workload, time and work pressure, limited job control, and monotonous work (Hales and Bernard, 1996; NIOSH, 1997). Mechanisms postulated to explain such associations are based on the possibility of a direct relationship (i.e. these factors increase stress, which in turn increases muscle strain and subsequently the response to physical risk factors) and/or an indirect relationship (i.e. these factors mediate the employees' perception and response to the physical risk factors).

Some personal factors (e.g. gender, age, body mass and some anatomical differences) have also been linked with the development of WMSD. An interesting observation made in an Australian study (Gun, 1990) was that women have a higher rate of WMSD than men.

4. Record review

Retrospective record reviews were conducted at three mines (one from the gold mining sector, one from the platinum mining sector, and one from the coal mining sector). The objective of the record reviews was to get an indication of the current situation regarding MSD in the South African mining industry, in terms of both prevalence and high-risk occupations. This information was used in the design of the prospective study to determine the prevalence of WMSD in the South African mining industry and in the ergonomics assessments of occupations.

4.1 Results of record review

Data on musculoskeletal disorders from primary care consultations and injuries recorded at the project mines were analysed.

4.1.1 Gold mine

At the gold mine, a consecutive sample of 1 235 medical records was reviewed. Of these records 200, (16,2%) were MSD-related. A total of 228 musculoskeletal disorders fitting the definition of WMSD were identified in the 200 medical records. Of these musculoskeletal disorders, 15% were associated with the upper limbs, 16% with the lower limbs and 69% with the back region.

As far as work categories and the development of MSD are concerned, 43% of the MSD cases recorded were in rock drill operators, 14% in general stope team workers, and 12% mechanical loader operators. The remaining occupations that presented with MSD were a small percentage for each.

4.1.2 Platinum mine

In the case of the platinum mine, a random sample of 75 medical records was drawn and 31 (41,3%) of these records dealt with MSD. Fewer records were selected because the mine was relatively smaller than the gold and coal mine. Thirty-seven musculoskeletal disorders fitting the definition of WMSD were identified in the 31 medical records. Of these musculoskeletal disorders, 62% were associated with the upper limbs, 8% with the lower limbs and 30% with the back region.

The main occupations affected were rock drill operators (18% of the total MSD recorded), scraper winch drivers, mechanical loader drivers and general stope workers (5% of the total MSD recorded associated with each of these work categories). The remaining occupations that presented with MSD were a small percentage for each.

4.1.3 Coal mine

At the coal mine, 226 new cases of MSD presenting to the primary health care center over a year were reviewed. Analysis revealed that 37% of the musculoskeletal disorders were associated with the upper limbs, 13% with the lower limbs and 50% with the back region.

The main occupations affected were continuous miner operators (12% of the total MSD recorded), shuttle car drivers (8% of the total MSD recorded) and fitters (7% of the total MSD recorded).

Table 4.1.3: Summary of record review at the 3 project mines

	Gold Mine		Platinum mine		Coal Mine	
	No.	%	No.	%	No.	%
Back	138	69	9	30	113	50
Upper limb	30	15	20	62	84	37
Lower limb	32	16	2	8	29	13
MSD records/Total records reviewed	200/1235		31/75		226/2825	

4.1.4 Age profiles

The age profiles of the individuals presenting with MSD at the respective mines are given in Figure 4.1.4.

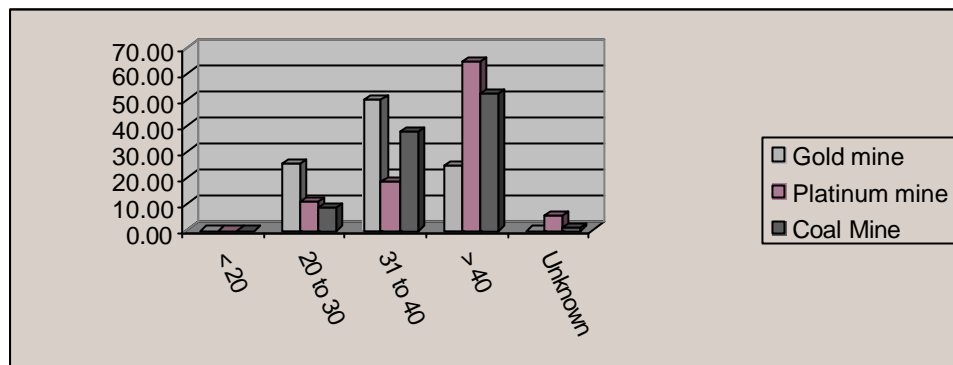


Figure 4.1.4: Age profiles of MSD cases

From Figure 4.1.4 most of the MSD cases at the gold mine (50,0%) fell into the age category between 31 and 40 years. In the case of the platinum mine and coal mine, most of the MSD cases were older than 40 years, 64,9% and 52,6%, respectively. The average age of mineworkers in the gold mine was 39.1years and at the coal mine was 46 years.

5 Prospective study

A prospective study was carried out at three mines (a gold mine, a platinum mine and a coal mine) to identify, recruit and measure the prevalence of MSD cases and identify the possible risk factors for WMSD. The study design included a nested case-control component in which the cases of MSD presenting to medical services were compared with cases of other disorders presenting to the same medical services

As part of the planning phase of the study, a workshop was held with international and local experts on WMSD. The objective of the workshop, attended by industry representatives, academics and the researchers involved, was to identify the type of WMSD to be considered in a mining context and to design the prospective study, taking into account factors such as diagnostic criteria for classifying cases, suitably selected controls and information on non-occupational risk factors (psychological and cultural influences). The workshop also provided an opportunity to transfer technology and increase local expertise in the field of WMSD.

5.1 Study population

The study population comprised all workers who attend the medical centres during the study period.

The study period was initially set for a year. A sister at each clinic was identified to conduct the questionnaire and examination when required. At the initial platinum mine no sister was available to do the study. The prospective study was therefore transferred to another platinum mine.

Numerous data acquisition problems due to insufficient time available to the sister to be involved in the study was noted after 4 months into the study period. It was decided to employ a research sister (not employed by the mine) at each primary health clinic. The research sisters assessed all MSD patients and controls presenting to the primary health care centre during the day for the remaining 6 months.

The number of employees fulfilling the criteria set for the study population on the gold mine participating in the study was 15 932. The corresponding numbers for the platinum mine and colliery participating in the study were 7 090 and 1 073 respectively.

5.2 Case definition

The health effects of interest in the study included one or more of the following:

- ? Upper limb disorders (including carpal tunnel syndrome, tenosynovitis, epicondylitis, rotator cuff tendonitis, hand-arm vibration syndrome, and non-specific upper limb pain).
- ? Pain or stiffness in the neck (with or without radiating neurological symptoms).
- ? Lower back pain¹ (with or without sciatica).
- ? Lower limb disorders (including knee cartilage injuries, pre-patellar bursitis, achilles tendonitis, and hip and knee pain).
- ? Less specific MSD, which led to consultation (e.g. non-specific pains and tingling or numbness).

¹ For this report, upper and lower back complaints are referred to as back pain. In a subsequent report backache will be reported on for lower- and upper-back pain respectively.

5.3 Identification of cases and controls

Cases were identified through the participating primary care medical centres. All employees who presented with MSDs first consulted the centre for initial assessment by the primary health care sisters, who sometimes referred them to a doctor or hospital for further treatment. The primary health care sisters and doctors at all three mines were requested to refer all patients presenting with an MSD to a designated, trained research sister (who formed part of the project team) appointed at each primary health care centre for a structured interview and medical examination. (Details of the questionnaires and examination schedules used by the research sister are given in Section 5.4). Patients not giving consent to take part in the study were included as MSD records.

For each interviewed case, the next patient in turn seen by the primary health care sister was used as a control, provided that the reason for the consultation was neither MSD nor injury, and that the patient agreed to participate in the study. If the patients declined to participate as a control, the next available patient fulfilling the defined criteria was used.

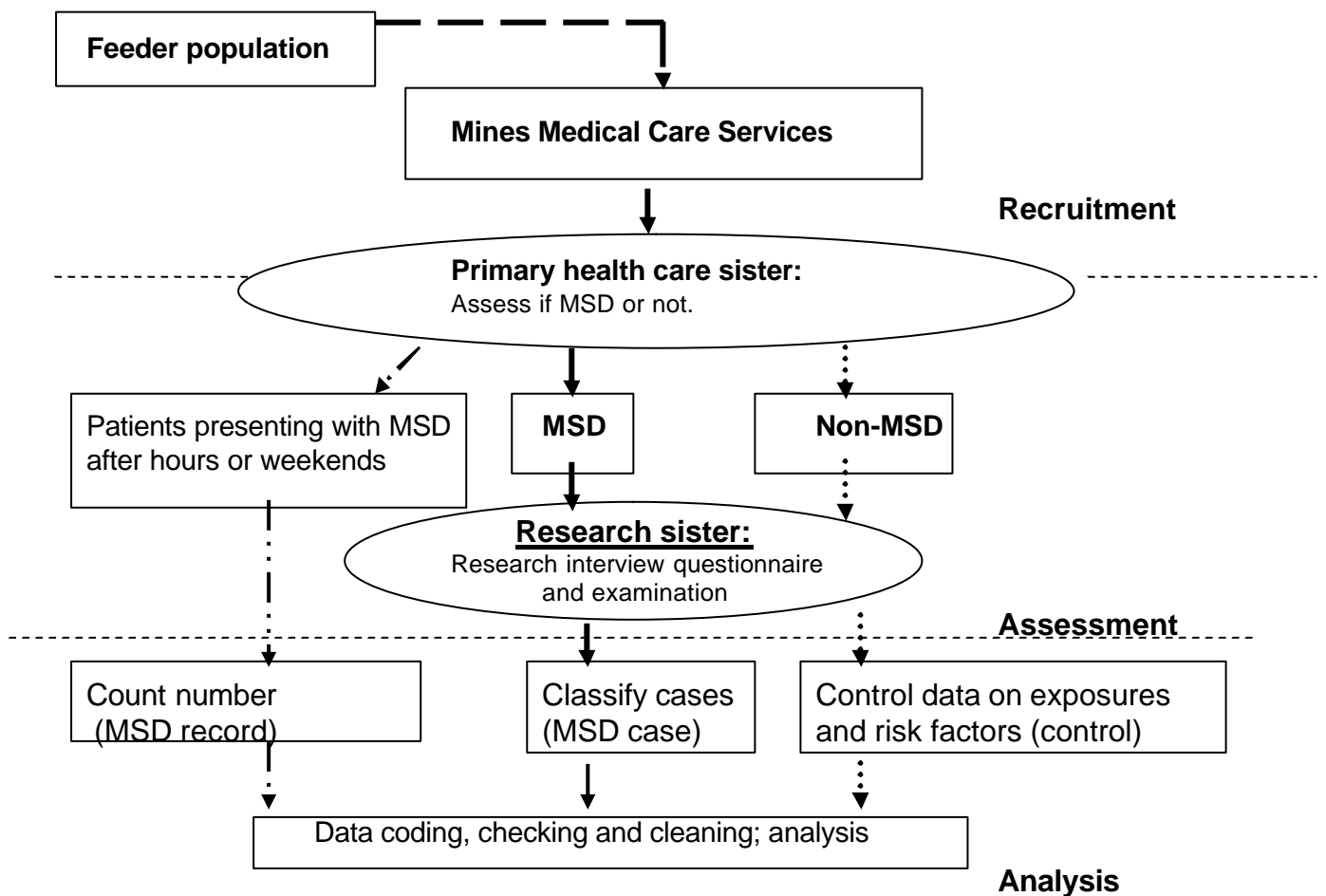


Figure 5.3: Schematic diagram of study design

Employees with complaints arising from acute trauma (e.g. crush injuries, lacerations, fractures, bruises, dislocations or amputations) were excluded from the study. Primary health care sisters were requested to set aside medical files of patients presenting with MSD after hours (i.e. from 16:00 to 8:00 on weekdays, and on Saturdays and Sundays). The following morning the research sister would go through the medical files and complete an MSD record review, which included the patient's work force number, site of symptoms, presumptive diagnosis, and occupation. MSD records were not included as cases and therefore no control was selected. MSD records were included in the estimation of the prevalence rate and percentage of patients presenting to the clinic.

5.4 Data acquisition

The exact nature of MSD 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 MSD (Palmer *et al.*, 1999).

It was necessary to develop an instrument to facilitate the determination of the frequency of MSD at the three project mines. The specific requirements for the data collection instrument were that it must have a scientifically sound basis, be applicable to the local mining population and mining conditions, and be user-friendly, taking into account the background and experience of the occupational health personnel destined to use it.

5.4.1 Development of data collection tool

The data collection tool used in the present study was developed with the assistance of Professor DNM Coggon and Dr KT Palmer of the Medical Research Council, University of Southampton, United Kingdom, who are international experts in the field of MSD and consultants to the project, and Professor M Ross, Programme Manager, SIMPROSS.

A questionnaire and an examination schedule developed by the Medical Research Council in the UK formed the basis for the data collection tool. After site visits by Dr KT Palmer to the occupational health centres of the project mines, and consultations with the occupational medicine practitioners at these centres, it became evident that minor changes to the questionnaire were needed to suit South African conditions. The data collection tool did not include the examination of the back as there was no scientifically sound technique that would add value to the study and be suitable for the occupational health personnel destined to use

it. A local Orthopaedic surgeon with extensive mine experience was consulted and he suggested that only the upper limb and knee should be examined as part of the study.

The data collection tool developed and used in the study for cases (i.e. patients identified by the primary health care sister as presenting with MSD and referred to the research sister) consisted of three parts. The first part was a questionnaire (Appendix 3), the second part made provision for details of a purpose-designed medical examination for cases presenting with a neck or upper limb disorder (Appendix 4), and the third part was a record of sick leave and treatment received (Appendix 5).

A separate questionnaire was developed for the controls, i.e. patients identified by the primary health care sister as not presenting with MSD or injury and referred to the research sister (Appendix 6). It was basically of a similar format, and the differences from the one used for MSD cases are highlighted in Section 5.4.3.

5.4.2 Format of questionnaire for cases

The questionnaire had six sections:

Section 1: Musculoskeletal complaint

This section was aimed at determining 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. Injuries or complaints due to sports activity were not specifically excluded.

Section 2: Demographics

In this section information on age, level of education, ethnicity and handedness of the cases was obtained. There were also questions on marital status, number of children, and how many were financially dependent on the study participant, in an effort to assess social stresses.

Section 3: Occupational exposure

This section was 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:

1. Overhead reaching for loads, tools, or mining equipment
2. Bending at the waist to handle loads, tools or mining equipment
3. Twisting at the waist to handle loads, tools or mining equipment
4. Repeatedly carrying, lifting or lowering loads of more than 25 kg
5. Climbing up or down stairs or a ladder with loads, tools or mining equipment
6. Pushing loads, tools or mining equipment
7. Pulling loads, tools or mining equipment
8. Working with the hands above shoulder height
9. Operating equipment or tools above shoulder height
10. Shovelling
11. Barring
12. Working in tunnels where it is not possible to stand upright
13. Kneeling or squatting
14. Repeated bending and straightening of the elbow
15. Using a vibratory tool

The above activities were very similar to those on the NIOSH ergonomics checklist and each task was accompanied by a photograph of a miner engaged in the activity (Appendix 7). Study participants were asked to indicate the frequency of their involvement in these tasks over various time periods. This would then provide information on activities/occupations for the ergonomics assessment that forms part of the study.

Section 4: Psychosocial issues

The initial intention was to assess the psychosocial risk factors using the Short Form 36 (SF-36) developed by Stewart and his co-workers in 1989, supplemented with questions from a survey of British civil servants (Stansfeld *et al.*, 1992; Bosma *et al.*, 1997), and questions on disability (including items from the DASH questionnaire [Hudak *et al.*, 1996]).

However, it became evident early in the study that a locally developed questionnaire would be more appropriate. After consultation with Dr T Burmeister, Consultant Psychiatrist at the University of the Witwatersrand, a decision was made to use questions from a local study aimed at assessing levels of anxiety and depression in a rural Black population in Limpopo Province and the (former) Cape Province. The "SANPAD" questionnaire used in the local study was based on the Self-reporting Questionnaire-20 (SRQ-20) developed by the World Health Organisation (Brown *et al.*, 1989). Some questions in the SANPAD questionnaire were also adapted from the Life Events and Difficulties Schedule (Harding *et al.*, 1980), and

from a rating scale for Social Functioning developed for use with patients with schizophrenia (Stevens *et al.*, 1972).

The questionnaire was translated into Zulu, Xhosa and Tswana and back translated to English to facilitate the information gathering process.

Section 5: History of symptoms and disability

Questions on regional pain (including head, shoulder, elbow, wrist/forearm/hand, upper back, lower back, hip, knee, foot/ankle and numbness/tingling), based on the Nordic questionnaire (Kuorinka *et al.*, 1987) were asked 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 8).

The Health and Safety Executive in the United Kingdom uses the modified Nordic questionnaire as its standardised questionnaire tool for identifying the extent of musculoskeletal problems in the workplace (Dickinson *et al.*, 1992).

Information on the period of prevalence of symptoms and their interference with work and leisure activities was also assessed in Section 5.

Section 6: Raynaud's Phenomenon

This section used the modified Nordic questionnaire discussed above. Every MSD case and control in the study was questioned to assess the prevalence of Raynaud's phenomenon. It should be noted that most study participants responded that they did not have the condition or symptoms. This was consistent with the findings in SIMRAC health 703 (Nyamtambu *et al.*, 2002)

Section 7: Health beliefs

Questions in this section were aimed at establishing whether the individual understood the relationship between task activities and the symptoms of MSD, and the management of MSD.

Section 8: Smoking and alcohol consumption

This section was aimed at assessing alcohol consumption and smoking habits in an attempt to determine whether there is a correlation with the information obtained in Section 4, and possibly with MSD.

5.4.3 Format of questionnaire for controls

The questionnaire for controls (Appendix 6) was similar to that for cases, except that Section 1 documented the presenting complaint while the rest of the section ensured that the control did not present with an injury or musculoskeletal disorder.

Sections 2, 3 and 4 were identical to the corresponding sections of the 'cases' questionnaire, while the questions in Section 5 were aimed at establishing whether the control had presented with a musculoskeletal disorder within the previous year or further back, and also to indicate which region of the body was affected. The questions in Sections 6, 7 and 8 were identical to those posed to the cases.

5.5 Examination schedule

When a case was identified with an upper limb or neck pain, a standardised examination was conducted. In distinguishing between discrete disorders of the upper limb, use was made of the validated schedule (Palmer et al., 2000) which classifies such conditions according to the international consensus criteria (Harrington et al., 1998).

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.

The range of shoulder movement and neck movement was measured in accordance with the methods described by Norkin and White, using a plane inclinometer (pleurimeter) and a goniometer for external rotation of the shoulder.

The knee was examined to determine the location of the pain; anterior, lateral or posterior pain and to determine if pain occurred on downward pressure the extended knee joint.

5.6 Training of research nurses

The medical and nursing personnel participating in the data collection at the respective medical centres were well briefed on the objective and procedures pertaining to the study. The research sisters used in the study had undergone intensive training by a trainer from the Medical Research Council, University of Southampton, United Kingdom and/or the Occupational Medicine Practitioner on the project team. These intensive training sessions were aimed at standardising assessment procedures and minimising inter- and intra-observer variation.

5.7 Quality control measures

The Occupational Medicine Practitioner on the project team was responsible for the quality assurance aspects of data collection during the structured interview and examination by the research sister, 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 view of the fact that each of the primary health care medical centres is managed differently, it was necessary to implement site-specific quality control measures.

Research sisters were visited at weekly intervals and mentored on an ongoing basis during the study period. Site-specific procedures were followed to ensure that all potential MSD cases were identified. These were additional to routine organisational arrangements.

5.7.1 Gold mine

5.7.1.1 ROUTINE HEALTH SERVICE ORGANISATION

All patients attending the primary health care centre are first seen by a clerk. The patient's complaint is recorded, and then his medical file is given to him. An enrolled nurse then takes the patient's vital signs (body temperature, blood pressure, etc.) records them in the medical file. The patient is then directed to a primary health care sister to be assessed and treated.

5.7.1.2 STUDY ORGANISATION

Information on the number of patients seen every week, their company numbers, the day of the week seen, as well as the diagnosis was obtained on a weekly basis. Unfortunately the diagnosis given was often the complaint recorded by the clerk, and was therefore not accurate. In order to compensate for this shortcoming, a second form was issued to every

patient attending the clinic during the study period. The form collected the date, the patient's company number and indicated if the patient had an MSD or not. The primary health care sister completed this form after seeing every patient during office hours and after hours. The research sister collected these forms at the end of every day.

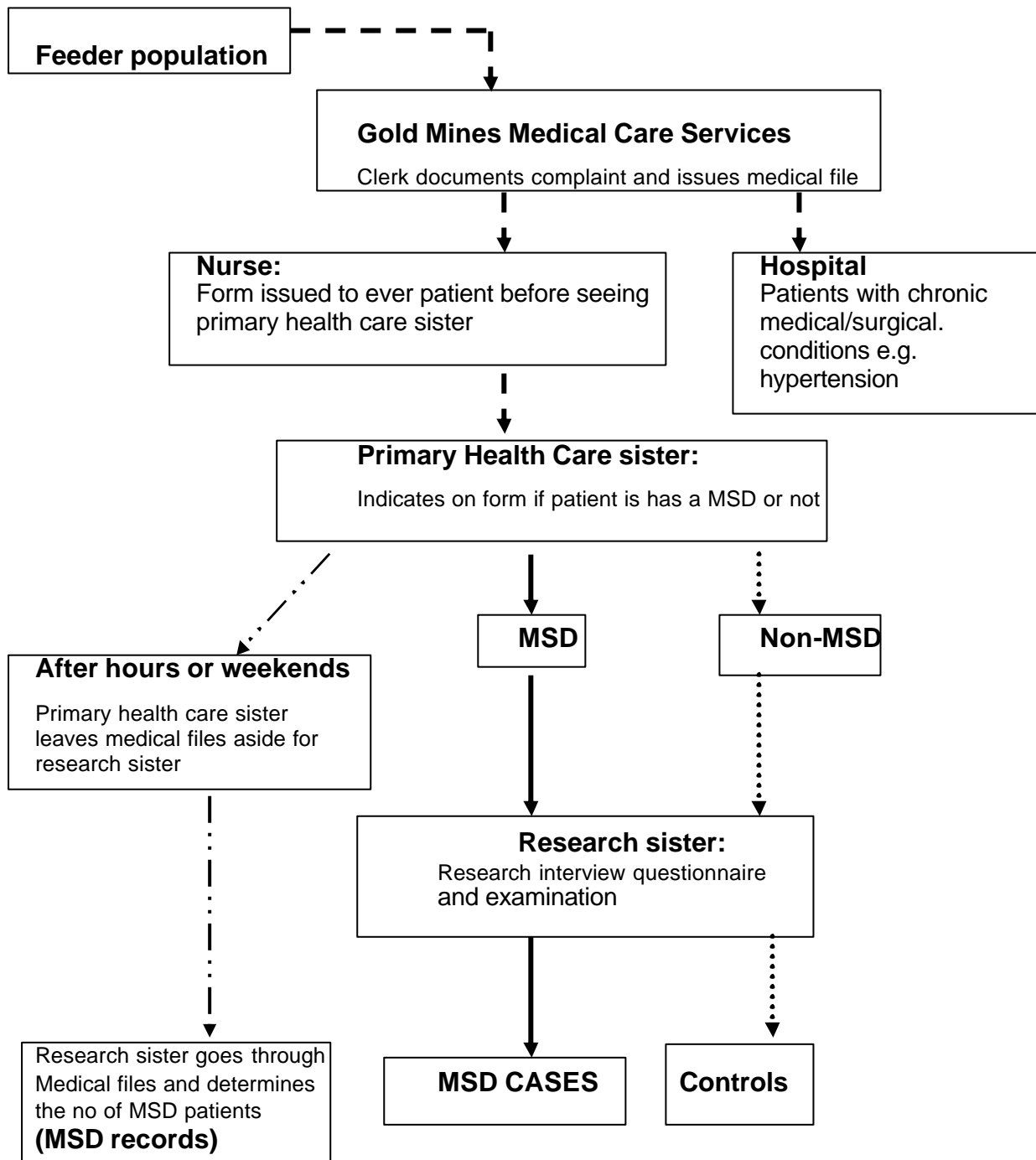


Figure 5.7.1: Schematic diagram of study design at Gold mine's clinic

During office hours all MSD patients seen by the primary health care sister was referred to the research sister. The very next patient seen by the research sister was also referred to the

research sister as a control. After hours the health care sister left all the medical files of patients the diagnosed with a MSD for the research sister. The following morning the research sister would go through the medical files and complete a MSD record.

5.7.2 Platinum mine

5.7.2.1 ROUTINE HEALTH SERVICE ORGANISATION

At the platinum mine, all patients attending the primary health medical centre are first seen by a clerk. The complaint is recorded in a register and the patient's medical file is then given to the patient. An enrolled nurse then takes the patient's vital signs, and records them in his medical file. The patient is then directed to a primary health care sister to be assessed and treated. A sick note is issued to the patient with the diagnosis. There was no system in place to determine the diagnosis made by the primary health care sister. The clerk's register containing the main complaint served as the only reference of patient's complaints seen at the clinic. Presently this system is being updated.

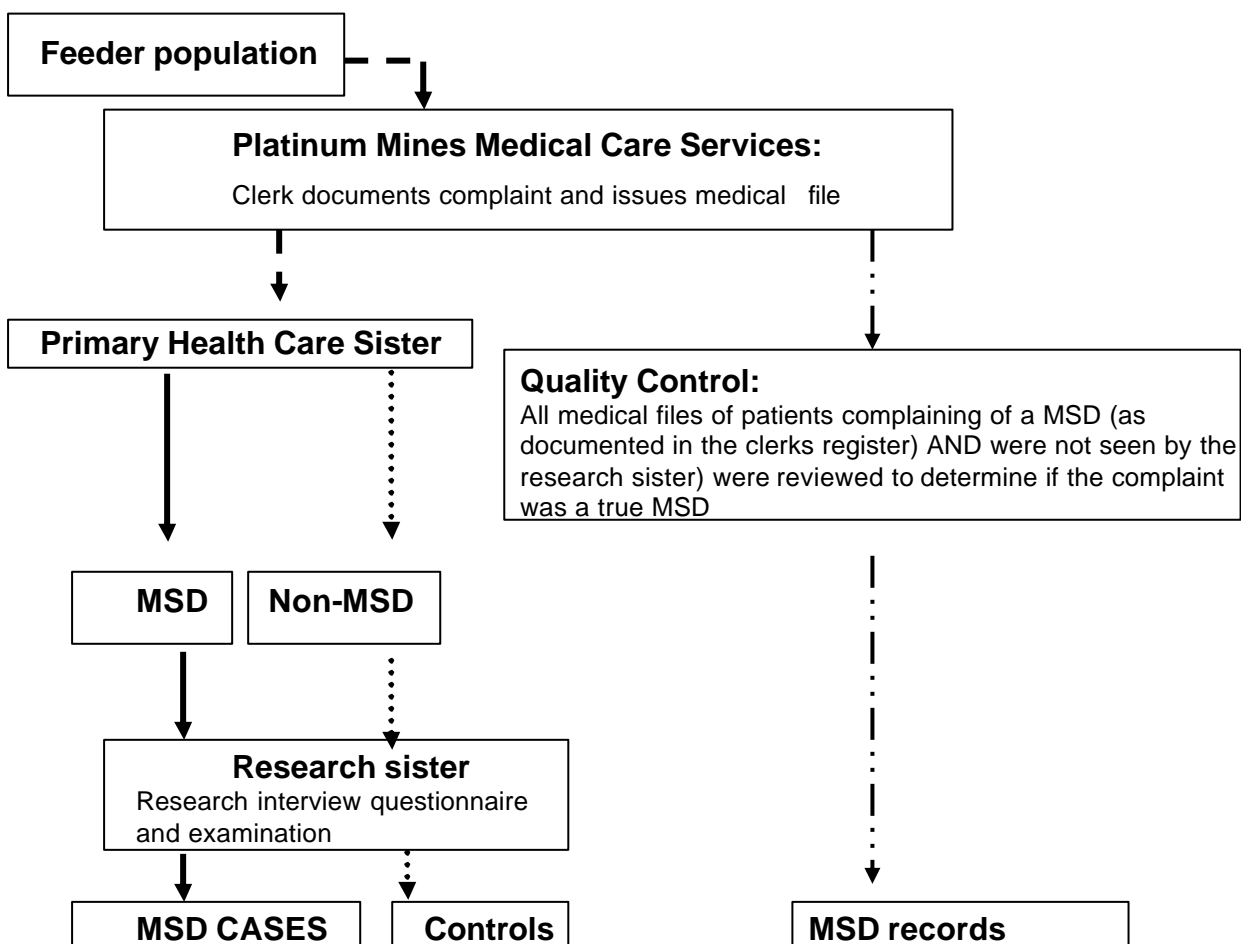


Figure 5.7.2: Schematic diagram of study design at platinum mine's clinic

5.7.2.2 STUDY ORGANISATION

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 in the register) was reviewed to assess whether the patient did complain of a MSD. An MSD record of all medical files reviewed that suggested the patient had a MSD was completed for patients presenting after hours.

5.7.3 Coal mine

5.7.3.1 Routine Health Service Organisation

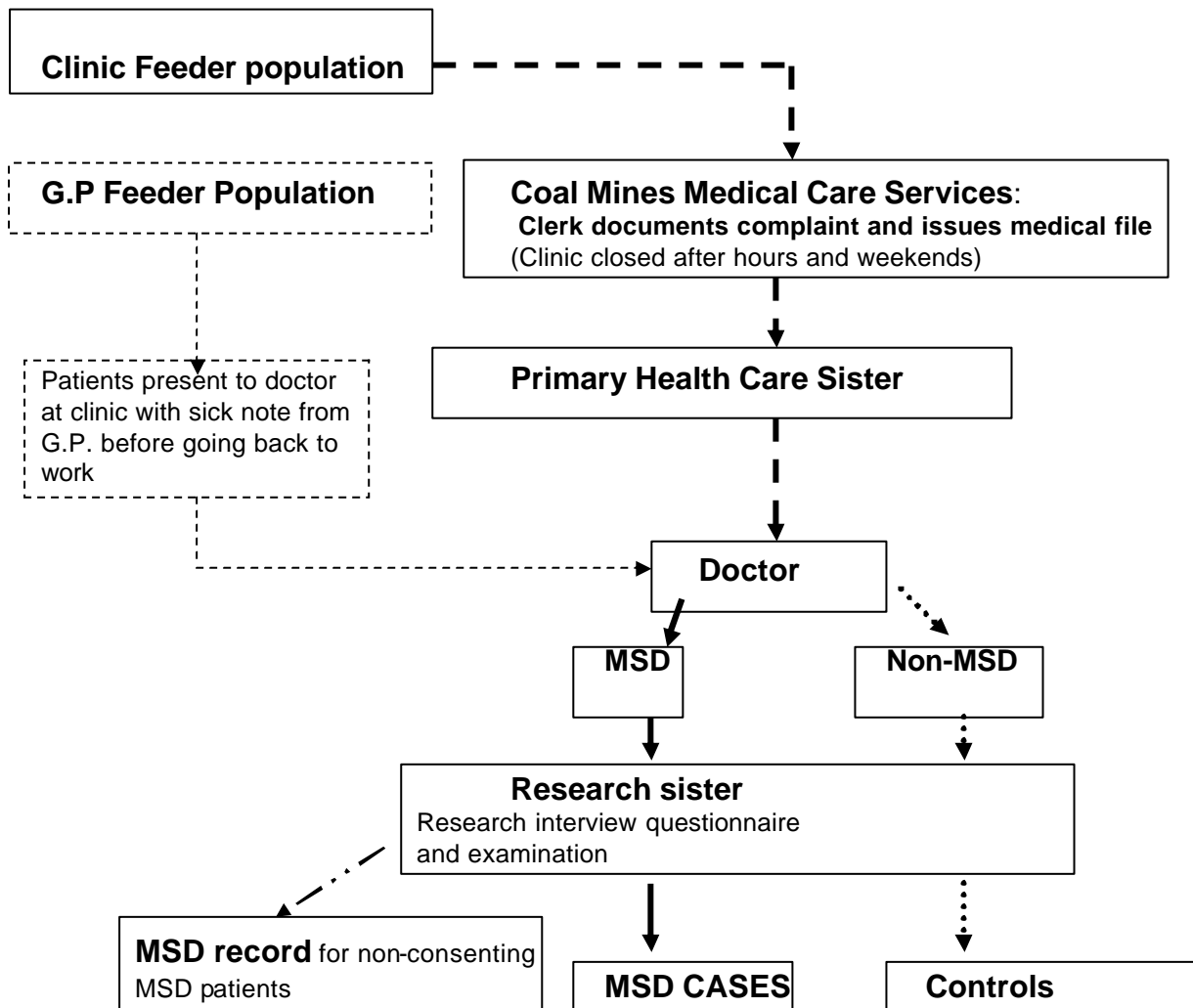


Figure 5.7.3 Schematic diagram of the study design at the Coal mine's clinic

Unlike at the other two project mines, all the mineworkers at the coal mine belong to a medical aid scheme and have the choice of consulting either the mine's medical practitioner or private general practitioners. They are, however, required to present their sick notes from the general practitioners to the mine's medical centre before returning to work and hence any miner booked off work for any reason has to report to the clinic.

However in terms of the study, this arrangement resulted in two problems: firstly, the patients diagnosed with MSD by a general practitioner were seen by the research sister after the diagnosis had been made, introducing potential recall bias. Secondly, if the patient required an examination for the study, many of the signs and symptoms may have subsided after the delay. For these reasons the data collected for the colliery had to be divided into cases presenting to the mine's Occupational Medicine Practitioner and cases diagnosed by private general practitioners. The private G.P. feeder population was made up of over 20 private general practitioners with different recording systems. For logistic reasons they could not be contacted for details of MSD presentations.

5.7.3.2 STUDY ORGANISATION

At the colliery participating in the study, far fewer patients were seen at the medical centre than at the other two clinics. Moreover, the medical centre was open only during the day when the research sister was there and, therefore, the chances of missing potential MSD cases were minimal. The mine's Occupational Medicine Practitioner, who works at the medical centre on a full-time basis, assessed the vast majority of MSD cases seen by the research sister. Over and above this, the primary health care sisters were required to fill in a form stating the patient's company number and diagnosis for all patients seen. This list was made available to the project team's Occupational Medicine Practitioner to determine whether any MSD cases had been missed.

5.8 Analysis

The statistical software employed is SAS V8.2, (SAS Institute Inc., SAS Campus Drive, Cary, NC 27513, USA). Results were considered to be statistically significant when the p-value is less than or equal to 0.05. Simple Frequency procedures on appropriate variables to yield counts, cumulative counts, percentage contributions and cumulative percentage contributions made by values of variables in the data. Means determinations of selected variables to yield Mean value, Std dev, Std Error of the Mean value, Min value, Max value and Variance for each of the variables tested. t-Test Procedures with a CLASSIFICATION

variable on appropriate variables by MINE. Where appropriate one-sample, two-sample and paired observation t-Tests were performed.

5.9 Limitations

This study was a pilot study to estimate the problem and risk factors for MSD and has been done despite considerable limitations.

The current report focuses on part of the project, which looked at the risk factors for developing a MSD. For this report: age, service history, occupation and task activity are discussed. In a subsequent report the following will be covered:

- ? Psychosocial factors
- ? The history and nature of the MSD complaint
- ? The accuracy and repeatability of the examination schedule developed by the MRC (UK)
- ? The impact of MSD to the industry in terms of sick leave.

The following factors could have influenced our findings:

- ? Patients presenting with backache may have a sexually transmitted disease or another condition that presents with backache
- ? Not all patients with a MSD will present to the mine health medical centre. As seen in the Coal mine, a significant number choose to go to their private G.P.s
- ? Complaint of a MSD may be used as an excuse to take time off work. At one of the clinics, the health care sister was issuing “backache” sick notes for a payment to mineworkers who wanted the day off
- ? Patients presenting after hours were not interviewed
- ? Patient with chronic MSD may no longer consult with the clinic because earlier consultations did not help them
- ? At the gold mine, MSD records were used to determine the number of patients presenting after hours. Clerks could have collected medical files from the primary health care sister during the course of the night or weekend. Therefore the number of MSD records completed by the research sister the following morning could have been underestimated
- ? At the platinum mine, all patients presenting with a symptom suggestive of a MSD had their medical records reviewed. If the symptoms and signs were suggestive of a MSD, they were included as a MSD records if the research sister did not interview

them. Since they were not examined, and the medical files did not exclude old injuries or differential diagnosis (for example STD) the number of MSD records could have been overestimated.

5.10 Results and discussion

The results obtained during the prospective study are presented and discussed.

5.10.1 Study participants

A total of 1 388 miners (693 controls and 695 MSD cases) participated in the study. Of this total, 673 were from the gold mine, 172 were from the coal mine, and 543 were from the platinum mine. The numbers of cases and controls at the respective project mines are given in Table 5.10.1.

Table 5.10.1: The number of cases and controls at the project mines

Project mines	Cases	Controls
Gold mine	337	336
Coal mine	85	87
Platinum mine	271	272
Total	693	695

5.10.2 Age profile of participants

The ages of the study participants ranged from 19 to 73 years. Figure 5.10.2 contains the age distribution of the cases and controls at the respective project mines. The mean age of the cases at the gold mine was 38,9 (± 7.3) years, which was not significantly higher than the mean age of 37,8 (± 7.4) years of the control group. At the colliery the mean age for the cases was 40,3 (± 7.9) years, which was not statistically significantly different from the mean age (38,0 (± 7.9) years) of the controls. In the case of the platinum mine, the mean age of the cases 39,3 (± 9.27 years) was statistically significantly higher ($p < 0,0001$) than the mean age of 34,5 (± 8.6) of the control group.

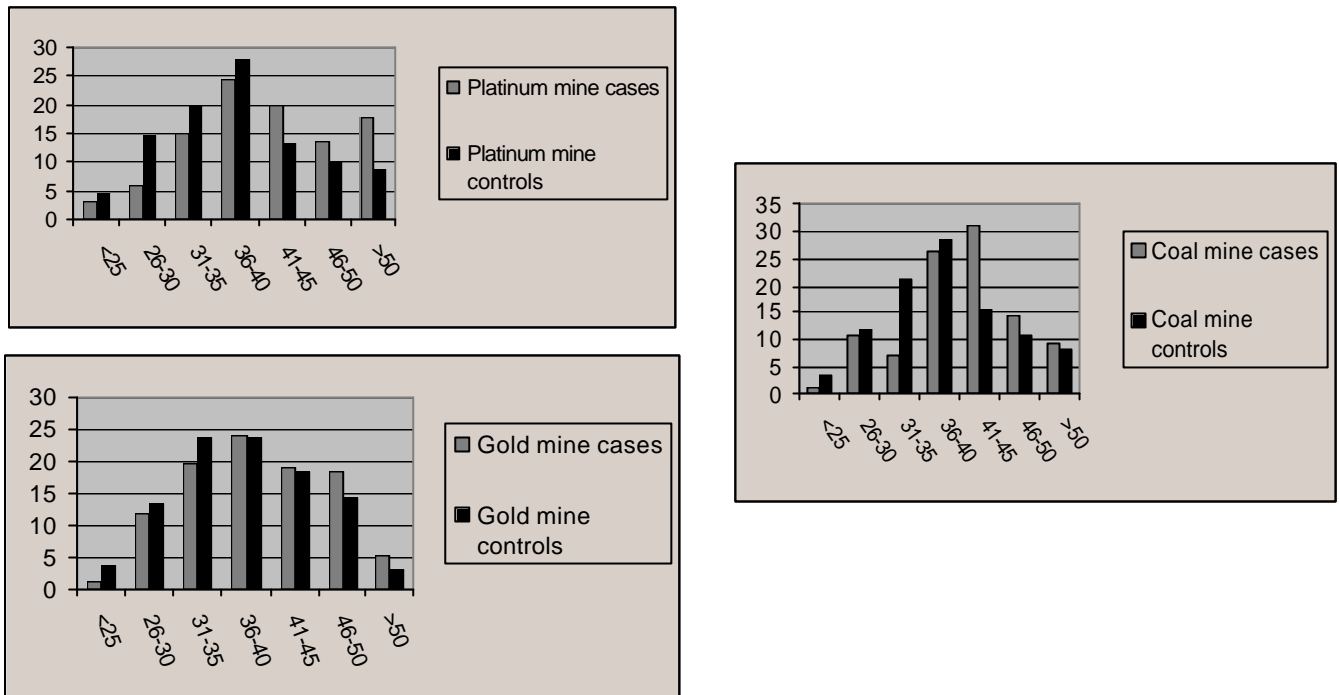


Figure 5.10.2: Distribution of cases and controls by age and mine

5.10.3 Service profile of participants

The years of service for all the cases participating in the study ranged between one month and 41 years, with an average of 10,1 years. The corresponding values for all the controls were one month to 38 years, and 9,1 years respectively. There was a statistically significant difference between the years worked by the cases and the controls ($p=0.0337$) (service comprised the time worked only at the gold, coal or platinum mine and did not include time worked previously at other mines or industries). The distribution of service years for the study participants is given in Figure 5.10.3.

The cases had been working for a mean of 9,8 ($\pm 7,3$) years at the gold mine, 11,04 years at the coal mine and 9,4 years at the platinum mine. At the gold mine and the coal mine, the years of service distribution was similar for the cases and the controls but at the platinum mine, the years of service of the cases were statistically significantly higher ($p = 0,0294$) than the years of service of the controls. Twenty-one per cent of the cases compared to 12% of the controls at the platinum mine had worked 15 years or longer. At the gold mine, approximately 6% of the cases and 7% of the controls had less than one year's service at the mine compared to the corresponding figures of approximately 1% for cases and

approximately 8% for controls at the colliery. At the platinum mine approximately 18% of the cases and approximately 15% of the controls had less than one year's service.

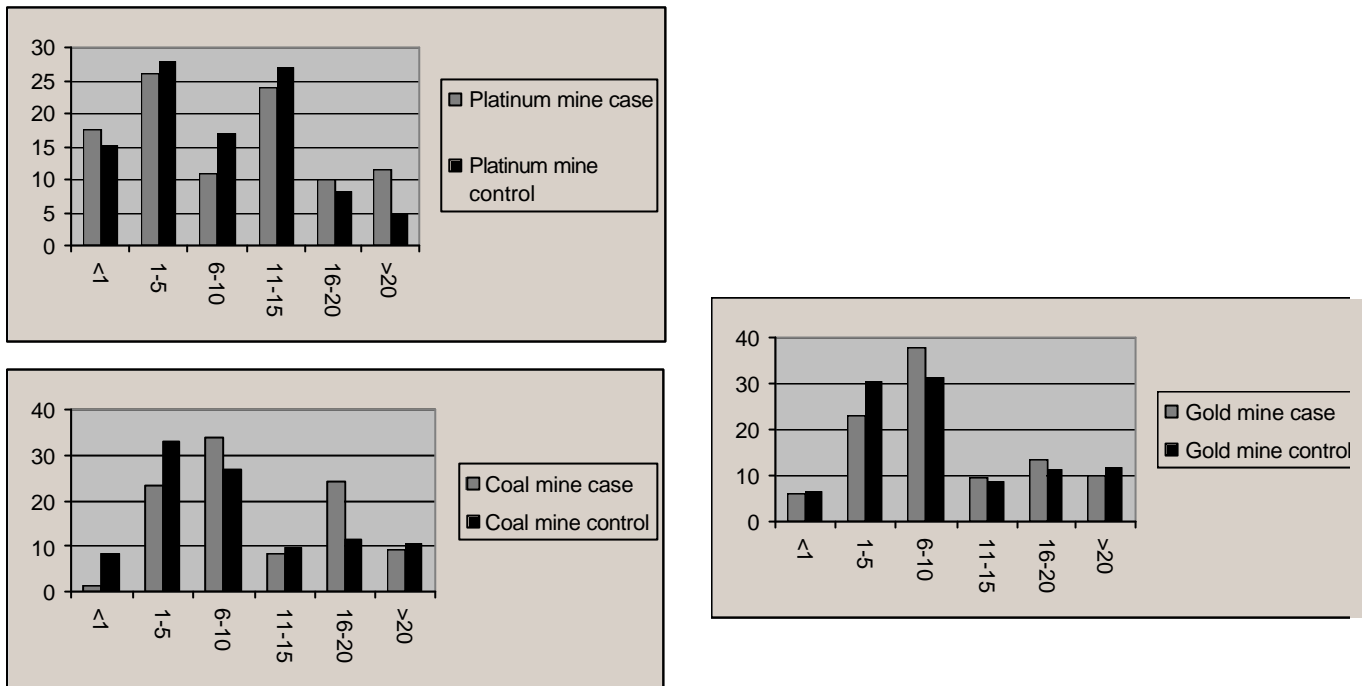


Figure 5.10.3: Distribution of cases and controls by years of service at the different mines

5.10.4 Other

For the study participants as a whole, there was no statistically significant difference between cases and controls in terms of level of education ($p = 0,4092$) and ethnicity ($p = 0,0988$). One point nine percent of cases were left handed compared to 5,1% of controls who were left handed (statistically significant difference: $p = 0,0049$).

The psychosocial information obtained in the study will be analysed in detail and a further report submitted on completion

5.10.5 Percentage of MSD at the medical centre

MSD cases² were identified by the participating primary health care sister and referred to the designated, trained research sister appointed at each primary health care centre for a structured interview. When the research sister was not available i.e. after hours or over the weekends, the primary health care sister would set aside the medical records of the patients presenting with a MSD. The following day or on the Monday, the research sister would then make a **MSD record**² of the consultation. The **total attendance at each clinic**² (new cases) was obtained from clinic records. The number did not include patients presenting to the clinic for reviews or follow-up.

The number of patients presenting with MSD during the study period at the project mines are given in Tables 5.10.5.1 and 5.10.5.2. These tables also contain the medical centre attendance figures for the study period. At the gold mine a total of 18 641 mine employees attended the clinic during the study period and between 1,8 – 4,5% presented with MSD. At the platinum mine a total of 21825 mine employees attended the medical centre during the study period. The percentage of patients presenting with MSD was between 1,2 - 5,9%.

Table 5.10.5.1: Number of MSD cases and MSD records at the gold and platinum mine medical centres

	MSD cases	MSD records	TOTAL MSD	Total attendance at the clinic	Percentage of patients presenting with MSD³
Gold Mine	336	497	833	18 461	1,8 - 4,5
Platinum Mine	271	1 016	1 287	21 825	1,2 -5,9

At the colliery, 963 mine workers presented to the clinic either with a complaint or a sick note. As mentioned, mine employees at the colliery have the option of consulting either the medical practitioner at the mine's medical centre or a private medical practitioner. In Table 5.10.6 the number of MSD cases is divided into those seen by private general practitioners (GPs) and those seen by the Occupational Medicine Practitioner at the mine's medical

² Bold terms used in table 4

³ Refer to appendix 11 for calculations

centre. It is interesting to note that the percentage of MSD patients seen by private GPs (13,1%) is substantially higher than the corresponding percentage (4,9%) presenting at the mine's medical centre. The estimated percentage of patients presenting with MSD at the coal mine was therefore between 4,9% - 13,3%.

Table 5.10.5.2: Number of MSD cases seen at the Coal mine’s primary health care clinic and from private general practitioners

	Private GP's	Matla medical primary health care sisters
Total MSD	62	24
Total number of patients seen by	472	491
Percentage of patients presenting with MSD ⁴	13.1%	4.9%

5.10.6 Prevalence of MSD

Period prevalence refers to the number of mineworkers in the study population who have a MSD over a specified period of time.

$$P = \frac{\text{Number of existing cases of diseases and number of new cases}^5}{\text{Total population at risk}}$$

In order to calculate the prevalence of MSD, the number of patients presenting to the clinic (i.e. MSD cases and MSD records) with a MSD for the first time during the study period for each mine was divided by the number of employees who were at risk at each of the mines

⁴ Refer to appendix 11 for calculations

⁵ In this study the numerator is equivalent to new cases since there was no way of distinguishing when their first presentation was. Thus new cases includes prevalent and incident cases

(i.e. the study population). The study population comprised all workers employed at the three project mines who were eligible to attend the medical centres of these mines for their primary care services.

At the gold mine, between 15.2-26.9% of the MSD cases seen at the clinic were repeat visits⁶. At the platinum mine, 19.7-40.7% of the MSD consultations were repeat visits⁶. Of the 91 cases presenting with MSD at the colliery, between 6.6 and 12.1% were repeat consultations⁶.

The prevalence rates of MSD at the mines used during the study are given in Table 5.10.6⁷.

Table 5.10.6: Estimated prevalence of MSD at the different mines

	Prevalence (%)
Gold Mine	2,1 – 5,2
Platinum Mine	3,7-18,2
Coal Mine	7,4-8,4

From Table 5.10.6 it is evident that the platinum mine has the highest estimated prevalence rate, followed by the colliery and then the gold mine.

The above result is surprising since the working conditions for the gold mine and the platinum mine are very similar. If there are indeed differences between commodities, the reasons are not clear.

A possible explanation for any differences in prevalence could be subject related. The psychosocial information obtained in the study will be analysed in detail as part of a postgraduate continuation of Health 702.

It was noted that workers at the platinum mine seem to have a lower threshold to present to the clinic compared to gold miners⁸. In the case of the colliery, the percentage of patients

⁶ Refer to Appendix 12 for calculations

⁷ Refer to Appendix 13 for prevalence calculation

⁸ The platinum mine population is 7090. Within the study period, there were 21825 consultations. This implies that each mineworker could have presented to the clinic 3 times within the study period. This compares with 1.2 times at the Gold mine and 0.9 times at the coal mine.

with MSD diagnosed by private general practitioners is higher than the percentage diagnosed by the mine's occupational medical practitioner, which could suggest observer bias or different motives for visiting site services.

Backache was a common presentation at all mines but has been associated with conditions other than MSDs. For example, it could be a symptom of an STI (sexually transmitted infection). In addition, since there is no clinical diagnosis to exclude backache, it may be used as a means to get off work.

5.10.7 MSD and body regions

The distribution of musculoskeletal complaints for the back region and upper and lower limb disorders are summarised in Figure 5.10.7.

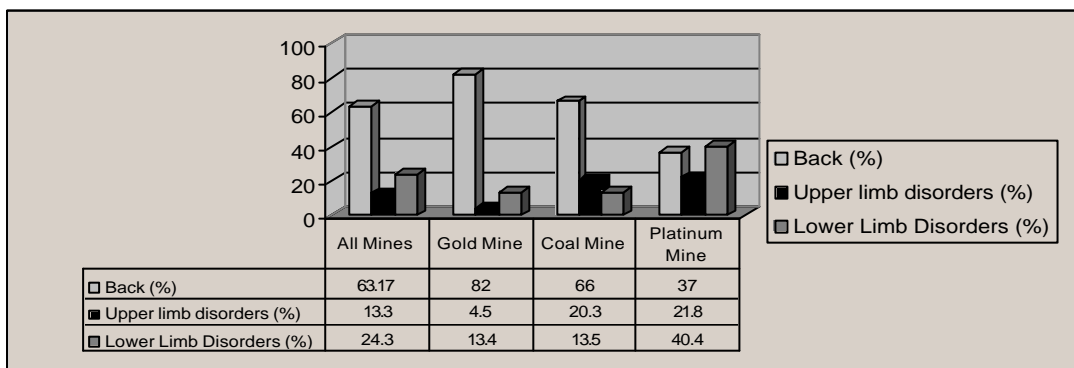


Figure 5.10.7: Musculoskeletal complaints presenting at the gold, coal and platinum mines

From Figure 5.10.7 it is evident that backache is by far the most common presenting musculoskeletal complaint. For the combined group, backache presented 63,2% of the total MSDs. At the gold mine, backache comprised 82,1% of MSDs compared to 66,2% at the colliery and 37,8% at the platinum mine.

At the gold mine, lower limb disorders (13,4%) are more common than upper limb disorders (4,5%). The same trend is observed at the platinum mine where lower limb disorders accounted for 40,4% of MSDs, compared to 21,8% for the upper limbs. On the contrary at the colliery, upper limb disorders (20,3%) are more prevalent than lower limb disorders (13,5%).

Table 5.10.7: Table of odds ratio for the different complaints

COMPLAINT	MINE BEING COMPARED WITH THE OTHER TWO PROJECT MINES	ODDS RATIO	P-VALUE
Back	Gold	1.8	<0.05
Neck	Coal	2.33	0.012
Shoulder	Platinum	6.96	<0.05
Knee	Platinum	7.18	<0.05
Ankle	Platinum	9.55	<0.05
Leg	Platinum	8.81	0.0004

Based on the statistics obtained, mineworkers at the gold mine are 1,9 times more likely to present with backache compared with their counterparts on the other mines used in the study. Coal mine workers are 2.3 times more likely to present with neck pain than at the other two mines. At the platinum mine, mineworkers are 7,2 times more likely to present with knee pain, 7 times more likely to present with shoulder pain, 9.6 times more likely to present with ankle pain and 8.8 times more likely to present with leg pain than mineworkers at the other mines.

5.10.8 MSD and occupations

In order to establish the possible work-relatedness of MSD in the mining industry, information on the occupations of the study participants was analysed. One of the major shortcomings in this regard was that many of the cases and controls did not know what their 'official' designation was. This is, however, not surprising given the large number of post descriptions used in the South African mining industry and the move towards multiskilling. The problem was further complicated as very small numbers, in some cases only an individual, represented a given work category. In an attempt to overcome the above problem, generic titles were used as far as was practicable, and cases where synonyms were used to describe a certain occupation were pooled under a generic title⁹.

⁹ Refer to Appendix 14 for explanation of generic titles

5.10.8.1 Occupations at gold mine

The occupations of the cases and controls at the gold mine are given in Figure 5.10.8.1. At the gold mine, 27,6% of the cases presenting with MSD were rock drill operators, 23,6% were winch drivers, and 17,7% were general stope workers. These are the three occupations with the highest number of MSD.

From the cases presenting with backache 28,1% were rock drill operators, 22,3% were winch drivers, 8,8% were team leaders, and 5,5% were timber shaft workers. Winch operators were 2,2 times more likely to present to the clinic with backache than any other symptom. Team leaders and shaft timber workers showed an increased presentation of backache, but this was not significant when compared with controls.

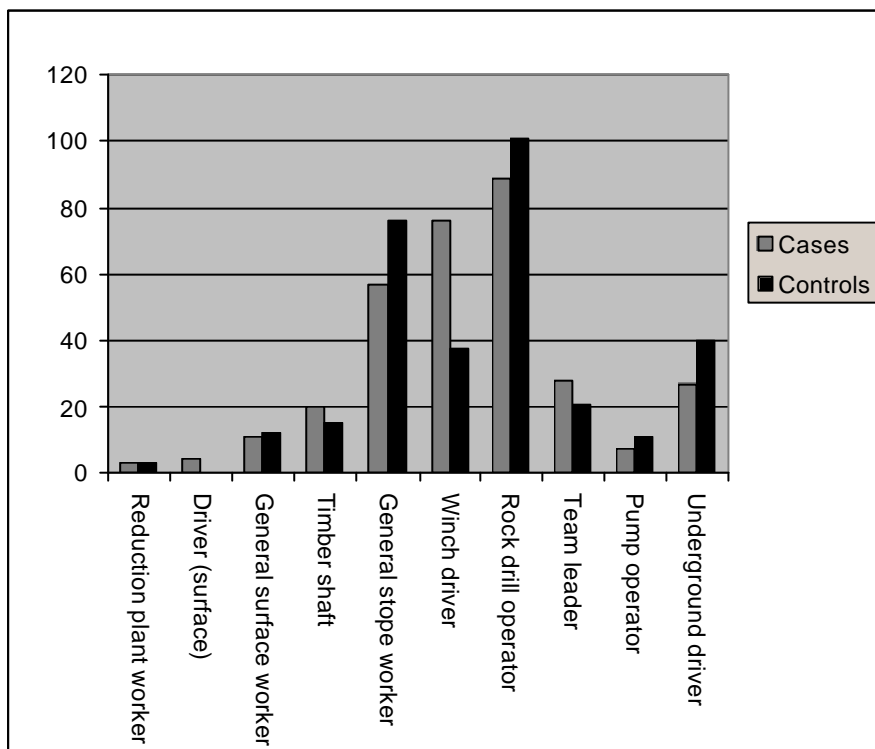


Figure 5.10.8.1: Occupations of cases and controls at gold mine

Work categories presenting with neck pain were plant attendants, clerks, winch drivers and pump operators, but due to the small number presenting (n=10), no statistically significant difference compared to controls could be determined. Occupations presenting with shoulder pain were timber shaft workers, machine operators and locomotive drivers. Wrist pain was associated with clerks and general stope workers. Occupations presenting with hip pain included rock drill operators, winch drivers, timber shaft workers, general stope workers, and drivers.

Knee pain was associated with the following occupations: timber shaft workers, general stope workers (especially those involved in barring), rock drill operators and team leaders. Work categories presenting with foot/ankle pain were winch drivers, team leaders and timber shaft workers.

5.10.8.2 Occupations at colliery

The occupations of the cases and controls at the colliery are given in Figure 5.10.8.2. At the colliery mine the three occupations presenting with the highest number of MSD were artisans (27,6%), belt operators, (15,8%), and drivers of underground mining vehicles (1,8%).

Workers in the following categories presented with backache: drivers (surface), clerks, cage drivers, shuttle car drivers and belt operators. Mine workers presenting with neck pain were drivers of surface vehicles, clerks, shuttle car drivers, fitters and belt operators. Belt operators, fitters, clerks and general workers presented with upper limb disorders, while lower limb disorders were presented by drivers of surface vehicles, clerks, general workers, shuttle car drivers, fitters, belt operators and roof bolt operators.

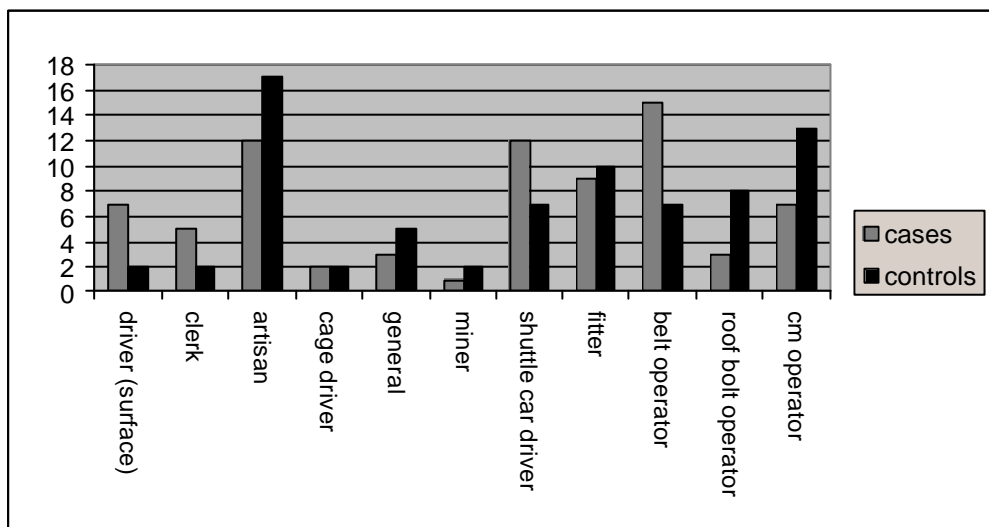


Figure 5.10.8.2: Occupations of cases and controls at the colliery

5.10.8.3 Occupations at platinum mine

The occupations of the cases and controls at the platinum are given in Figure 5.10.8.3.

At the platinum mine the following occupations presented with MSD: general stope team workers (37,5%), rock drill operators (19,0%) and supervisors (12,8%).

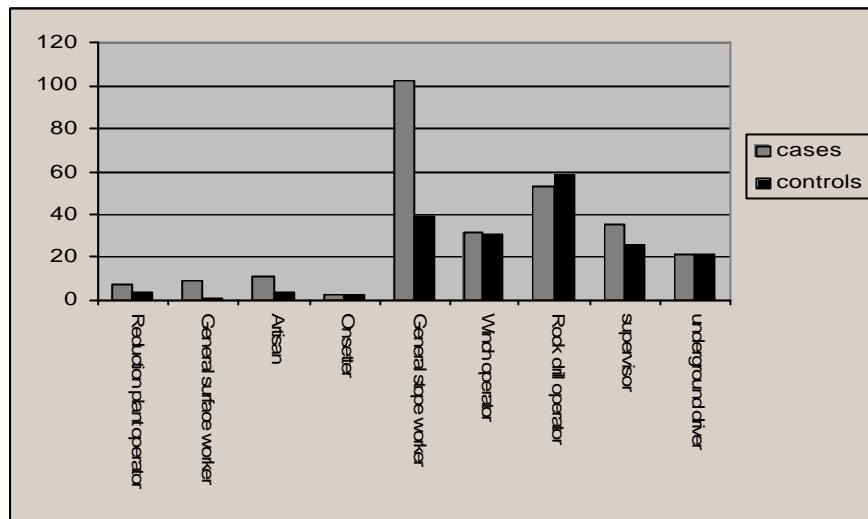


Figure 5.10.8.3: Occupations of cases and controls at platinum mine

Mine workers presenting with neck and upper limb disorders included general stope team workers, winch operators, rock drill operators and supervisors. In the case of lower limb disorders the work categories were: plant operators, artisans, onsetters, general stope team workers, winch operators, rock drill operators, supervisors and drivers of underground vehicles.

5.10.9 MSD and task activity

As part of the structured interview (Section 3, Appendix) all the study participants were asked certain questions to determine whether they had been exposed to any activities that could be related to the development of MSD.

The participants were asked how often over an hour the activity was done by responding 'hardly', 'occasionally' or 'frequently'. In retrospect, the research sisters admitted that the participants answered the question looking at an average day. The answers obtained during the interview could, therefore, be somewhat biased. Since the tasks are fairly common to most occupations in the mines participating in the study, there was a high response to 'frequently' for most of the activities. Based on the responses of the 'study participants' associations between task activities usually performed and MSD observed are given below.

Table 5.10.9: Associations between task activities and MSD observed

BODY REGION ¹⁰	BACK		NECK		HIP		KNEE		ANKLE		LEG	
ACTIVITY		P-Value		P-Value		P-Value		P-Value		P-Value		P-Value
Bending at the waist	v	0,03 ¹¹					v	0,003			v	0,03
Twisting at the waist	v	0,02 ¹¹					v	0,03				
Using vibrating tools			v	0,003 ¹²					v	0.03		
Pulling					v	0,04 ¹¹	v	0.001	v	0.02	v	0.006
Pushing							v	0.02			v	0,054
Kneeling and squatting							v	0.002				
Carrying, lifting or lowering loads							v	0,005				
Shovelling											v	0,02

There was no significant difference between activities done by the cases presenting with backache compared to the controls for the coal and platinum mine. Similarly for neck pain among cases and controls in the Gold and platinum mine. For other upper limb disorders there were no significant associations with any task performed. This may be because of the small numbers. However, there was a significant association with knee pain, ankle pain and leg pain for all the mines as shown in Table 5.10.9.

Tasks usually performed were compared with the task performed seven days prior to presentation at the medical centre. For the combined group of study participants, as well for the cases and controls at the individual mines, there was no significant difference between the tasks usually performed and those performed seven days before presenting at the mine medical centre¹³.

The results given in Section 5.10.6 will be subjected to further analysis in the postgraduate extension to Health 702.

¹⁰ No activity was significantly associated with shoulder pain

¹¹ Only significant at the Gold Mine

¹² Only significant at the Coal mine

¹³ Refer to Appendix 15 for the correlation for each task for cases and controls

6. Ergonomics assessments

This phase of the project focused on the identification of work-related risk factors in the development of MSD. Typically, musculoskeletal injury risk factors are associated with exertions that are forceful, are repeated frequently, are sustained, are performed in a deviated (awkward) posture, involve vibration, or produce high contact stresses (Chaffin, 1999). Due to the large number of occupations on the three mines at which the investigations were carried out in the project, it was decided to comprehensively study the tasks of the high-risk occupations identified in the record review (Section 4) and the prospective study (Section 5). Those occupations that were identified by mine personnel as potentially high-risk occupations in their opinion, were also studied.

6.1 Methods

The screening for risk factors for WMSD involved the following:

- ? Walk-through observational surveys of the work facilities to observe obvious risk factors. An ergonomics risk checklist (Appendix 9) was used.
- ? Interviews with workers and supervisors to obtain information and other data not so apparent during walk-through observations.
- ? Task analysis and measurements in the workplace.

The task analysis included the following:

- ? Taking workstation measurements (e.g. working surface heights, reach distances, ceiling heights).
- ? Observing the workers performing tasks, with the focus on body postures and the nature of the tasks.
- ? Videotaping of certain tasks and taking still photos of working postures, workstation layouts, and tools to illustrate the tasks. A computer-aided programme, Ovako Working Posture Analysing System (OWAS™) (Karhu *et al.*, 1981) was used to analyse postural load during the tasks.
- ? Measuring of environmental factors such as temperature, noise and illumination levels.
- ? Determination of physical energy demands. This aspect had to be terminated soon after the task analyses commenced due to worker resistance to wearing heart rate monitors. Apart from the workers' resistance, the subjects' wet skins and interference from electrical power sources affected the accuracy of heart rate recordings and in many cases rendered them useless.

- ? Evaluation of manual material-handling tasks. The NIOSH Work Practice Guide to Manual Lifting (Waters *et al.*, 1994) was used to determine recommended weight limits.
- ? Assessment of perceived exertion using a modified (culturally calibrated) Borg Scale (Scott, 1994).
- ? Assessment of body part discomfort using a body map and five-point scale developed by Wilson and Corlett (1992).

6.2 Results and discussion

The results obtained from the ergonomics assessments are discussed below.

6.2.1 Walk-through survey

The main objective of the walk-through surveys, which included interviews with supervisors in the work areas surveyed, was to identify potential ergonomics-related risk factors in the work areas of those occupations associated with a high presentation of MSD. The walk-through surveys involved a quick ergonomics assessment of the workplaces identified, based on observations of the job and physical environment, but without specialised measurements. Information obtained during the walk-through surveys was also used to confirm the occupations for which more detailed task assessments would be needed.

Ergonomics risk factors relating to MSD observed during the walk-through surveys of a number of underground and surface work areas included the following:

- ? Confined and restrictive work spaces
- ? Poorly designed workstations
- ? Carrying and lifting of heavy objects
- ? Incorrect work postures
- ? Working with vibrating hand tools and equipment
- ? Exposure to whole-body vibration.

6.2.2 Task and postural analysis

The environmental conditions of the underground work areas where task assessments were conducted were typical of those associated with the South African mining industry. Thermal conditions in the gold and platinum mines participating in the study were hot and humid, with wet-bulb temperatures ranging between 27,0 °C and 32,5 °C, and a difference of approximately 2,5 °C between the wet-bulb and dry-bulb temperatures. In the coal mine the ambient temperatures ranged between 18,0 °C and 27,0 °C. In the mock-ups of the surface training centres used in the study the wet-bulb temperatures ranged between 20 °C and

26°C. Dry-bulb temperatures ranged between 25,0 °C and 30,0 °C. Most of the working areas were demarcated as 'noise zones' (i.e. noise levels above 85 dBA), and workplace illumination levels ranged between 1000 lux in surface workshops to less than 5 lux in stopes.

The results of the task analysis are described in detail in Appendix 10. The main findings regarding ergonomics-related risk factors are summarised in Table 6.2. From Table 6.2 it is evident that many of the known musculoskeletal injury risk factors, usually in combination, are associated with the tasks of the occupations studied.

Vibration is also recognised as a risk factor for MSD. Rock drill operators are exposed to hand-arm vibration while operating rock drills, boilermakers use hand-held vibrating tools (e.g. grinders), while drivers of trackless mining equipment (e.g. shuttle cars) are exposed to whole-body vibration, which could potentially contribute to lower back disorders (Wilder and Pope, 1996).

Nearly all activities require some degree of force to stabilise the body, resist gravity, and move loads. In the present context force is defined as a "push or pull produced by the action of one body against another" or "the mechanical effort to accomplish a specific movement or exertion" (Sanders, 1997). Force was associated with work-related activities such as lifting, pushing, pulling, grasping or handling objects, activities prevalent in the majority of occupations assessed.

Force has been implicated as a factor in WMSD, especially when combined with other risk factors. In the confined and poorly designed work areas observed in this study, the influence of posture on force is important. Posture greatly affects the ability of muscles to generate power. Overall, muscles generate optimal forces for the desired movement when the extremity is positioned in neutral – that is, roughly halfway between the beginning and ending ranges of movement of an extremity (Chaffin and Anderson, 1984). In this position, the moment arm about the joint is longest and the muscle is at the position for the best biomechanical advantage. When muscles generate forces in a deviated position, they must generate higher internal forces to accomplish the same task. An example of this concept is the relationship of grip strength to hand posture: when the wrist flexes 45 degrees from the neutral position, the grip strength is reduced by 40% (Rodgers, 1987).

Table 6.2: MSD risk factors identified during ergonomics assessments

Occupation	Posture	Manual materials handling	Vibration	Repetition	Force
Roof bolter operator	v	v	v	v	v
Shuttle car driver	v		v	v	v
Shearer operator				v	
Fitter (machine)	v				v
Fitter (underground)	v				v
Boilermaker	v		v		v
Cable repairer	v	v		v	v
Electrician (panel)	v				v
Electrician (motor)	v	v		v	
Scraper winch operator (mechanical)	v	v		v	v
Scraper winch operator (pneumatic)	v	v		v	v
Tugger winch driver	v			v	v
Monorope winch members	v	v			v
Pneumatic rock drill operator	v	v	v	v	v
Mechanical loader operator	v			v	v
General stope team installing:					
Timber packs	v	v		v	v
Pencil sticks	v	v		v	v
Camlock jacks	v	v		v	v
Blasting barricades	v	v		v	v
General stope team:					
Lashing	v	v		v	v
Barring	v	v			v

7. Ergonomics interventions

Ergonomics can be briefly defined as a systematic and rational means of designing tasks, jobs and workstations to be compatible with the needs, abilities and limitations of people.

Ergonomics is an approach or solution to dealing with a number of problems – among them is WMSD.

From an ergonomics viewpoint, there are three control strategies available: engineering controls, work practice controls and administrative controls. The Occupational Health and Safety Administration (OSHA) in the USA defines engineering controls as “controls that physically change the job in a way that controls or reduces MSD hazards”. Work practice controls involve procedures and methods for working safely, whereas administrative controls are “work practices and policies implemented by the employer that are designed to reduce the magnitude, duration, and/or frequency of employee risk factors by changing the way work is assigned or scheduled” (Federal Register, 2001). Engineering controls include workstation modifications and changes to equipment and tools, while work practice controls include the use of neutral positions or posture and team lifting, for example. Administrative controls include employee rotation and job enlargement.

As part of the current project, a number of meetings were held with ergonomists and mining personnel to identify possible ergonomics interventions for controlling or reducing the MSD hazards associated with the tasks of the occupations surveyed. The aforementioned OSHA control strategies were used as the basis for the discussions. Suggested interventions emanating from these meetings are presented in this section.

7.1 Control strategies

There was general consensus that, given the choice, engineering controls are to be preferred since they have the ability to reduce the causative factor at the source instead of reducing levels of exposure or relying on individual operators to monitor the ergonomics of their activities. This is not to say that work practice and administrative controls do not have their place – in some instances these may be the only reasonable/feasible solution.

At the mines involved in the study, mine workers are exposed to many of the recognised occupational risk factors for MSD: awkward posture, manual material handling, repetitive work cycles and the application of force. Force in many cases becomes a risk factor as a result of the effort needed to handle materials while adopting an awkward posture.

Of the factors mentioned, working in an awkward posture and manual material handling are considered to be the major risk factors and the following ergonomics interventions have the potential to reduce these risks. These interventions are not the full range of possible

ergonomics solutions, but they are relatively low-cost and easy to implement and should, therefore, be considered as a starting point.

7.2 Workstation design

In the surface workshops surveyed, awkward posture was in the majority of cases the result of poorly designed workstations (see Figures 14, 16 and 17 in Appendix 10). This is a problem that can be addressed quite easily compared with the causal factors associated with awkward posture in the underground work situation, especially on the gold mines and platinum mines.

At these mines the underground environment provides unique challenges. Restrictive work areas due to low ceiling height (in stope panels, for example) cause workers to perform tasks in postures that are not desirable. Due to practical, geological and economical constraints, it is highly unlikely that this situation will change. The only recommendation in this regard, from an engineering control viewpoint, is that mine standards dealing with the dimensions of workplaces and housekeeping practices should be strictly adhered to. Ceiling heights lower than the required standard and loose rocks and other unnecessary material in stope panels will aggravate the situation in an already restricted work area.

Knee pain was identified in the prospective study as one of the major complaints on the platinum mine and, to a lesser extent, on the gold mine. The knee pain is very likely the result of excessive pressure on the knees from body weight when the miners are working in a kneeling position in areas with low ceiling heights. A possible solution is the use of the kneepad seat developed by NIOSH (Figure 7.2). The kneepad seat allows workers to rest the body weight on the seat, thus removing some weight from the knees and ankles. It should be noted that the workplace should be analysed to ensure that the kneepad seats do not get caught in moving machinery.

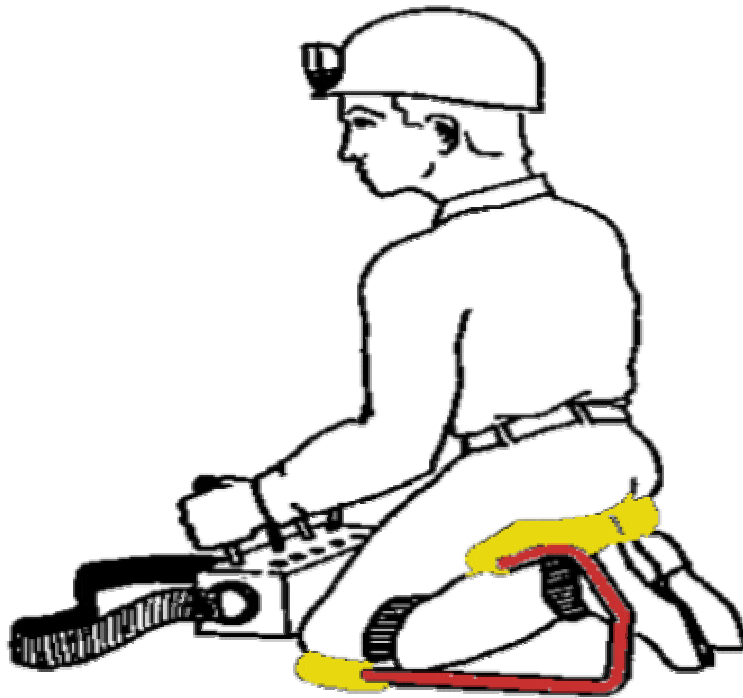


Figure 7.2: Kneepad seat developed by NIOSH

For the physical design of industrial workstations, the three essential design dimensions are work height, normal and maximum reaches, and lateral clearance. Lateral clearance is not a problem in most of the mining tasks observed.

7.2.1 Work heights (workshops)

The height above the ground at which a standing person performs manual activities is a major determinant of that person's posture. If the working level is too high, the shoulder and upper limbs will be raised, leading to fatigue and strain in the muscles of the shoulder region. If any downward force is required in the task, the upper limbs will be in a position of poor mechanical advantage for providing it. This situation can be avoided by lowering the working level, or by using a platform or stepladder to bring the operator closer to the task. When the work height is too low, a person not only leans forward to adopt a forward stooped posture, but may also lower and rotate the shoulders forward, causing pain and fatigue in the shoulder region. This situation can be avoided by lifting the working level to an acceptable height.

The height of the working surface should maintain a definite relationship with the operator's elbow height, depending on the type of work. Ideally, the elbow should be flexed to about 90 degrees, the shoulders abducted or flexed less than 20 degrees, and the neck slightly flexed.

The following recommendations concerning working heights for standing work are widely quoted (Kroemer and Grandjean, 1997):

- ? For manipulative tasks involving a moderate degree of both force and precision: 50 - 100 mm below elbow height
- ? For delicate manipulative tasks (including writing): 50 - 100 mm above elbow height
- ? For heavy manipulative tasks (particularly if they involve downward pressure on the workpiece): 100 - 250 mm below elbow height
- ? For lifting and handling tasks: between knuckle height and elbow height
- ? For hand-operated controls (e.g. switches and levers): between elbow height and shoulder height.

Ergonomically speaking, a work bench with a facility to adjust the working height to suit the individual is desirable. If fully adjustable benches cannot be provided, then in principle working heights should be set to suit the tallest operators: smaller people can be accommodated by giving them platforms to stand on (Kroemer and Grandjean, 1997).

Hard floor surfaces (such as concrete) should be cushioned with anti-fatigue mats or rubber matting to decrease stress on the legs and lower back while standing. Footrests are necessary to relieve stress on the lower back and to provide a change of position for the legs.

7.2.2 Reach envelope (workspace)

The posture that a person adopts when performing a particular task is determined by the relationship between the dimensions of the person's body and the dimensions of the various items in his or her workspace. The placing of controls, tools and accessories within the 'workspace envelope', i.e. the zone in which an object may be reached conveniently, is important.

The reach requirements of a task should not exceed the maximum reach limit, to avoid leaning forward and bad posture. An example of poor workspace envelopes observed in the present study is the placing of the control levers on a scraper winch, where the operator has to lean forward from the waist to reach them. When the arm is close to its reach limit (when the elbow is straight or locked in extension), push and pull forces directed through the shoulder can become very high, being limited only by torso strength and balance.

The grasp or reach envelope is determined by the sweep radius of the arms, with the hands in a grasping or reaching attitude. For each arm, the working space becomes a nearly semi-circular shell, with the shells overlapping in front of the body. Decisive factors are the location of the person's shoulder joint and the distance from this joint to the hand. In this case, the fifth percentile measurements need to be used in order to accommodate individuals with short arms. An occasional stretch to reach beyond this range is permissible since the momentary effect on the trunk and shoulders is transient – in fact, it might be desirable to change the body posture.

7.3 Manual materials handling

In the present context, the term 'manual handling' includes lifting, putting down, pushing, pulling, carrying, holding and restraining.

Generally, the primary approach to the prevention of WMSD due to manual handling is the ergonomic redesign of work in order to optimise the workload and make it compatible with the physical capacity of the worker. Work organisational and task design modifications that could be considered are the following:

- ? Provide appropriate handling equipment and substitute manual material handling with mechanical devices where possible. (Chain blocks and monorope systems are examples of such mechanical devices.)
- ? Spread the burden of carrying loads among a group of workers for a limited period of time, instead of having a single worker involved all day in that task.
- ? Package materials on surface in a form suitable for handling.
- ? Use self-adjusting pallet lifters to eliminate the need for stooping and bending.
- ? Provide good visibility (e.g. eliminate blind corners, mark obstructions and danger points, and provide appropriate illumination in closed workplaces and confined spaces).
- ? Supply workers with appropriate personal equipment for handling tasks.
- ? Provide handles or other holding points on the object to be handled to help with gripping.

7.4 Reduction of vibration exposure

Reducing exposure to harmful vibration cannot be accomplished only through limiting exposure time as this is impractical in many situations where vibration levels are high. A number of ways to reduce vibration are listed below.

7.4.1 Whole body vibration (vehicle drivers)

- ? Install effective vehicle suspension and use appropriate tyres and tyre pressures.
- ? Install seats with effective suspensions and train drivers to deal with the importance of seat adjustment – this is essential.
- ? Ensure that the road and work surfaces used by trackless vehicles are smooth.
- ? Provide adequate lighting of roadways, either by headlights and/or road lights as this can help to reduce the risk of hitting potholes or encountering other unexpected rough road conditions.
- ? Develop appropriate vehicle maintenance systems, including suspension and seat maintenance, and replace seats timeously.
- ? Train operators to raise awareness of what constitutes harmful vibration and of its effects.
- ? Improve drivers' competencies and skills for when they are working in rough conditions in a way that will not unnecessarily increase vibration exposure.
- ? Ensure that workers take regular breaks out of the seat (a minimum of 5 minutes each hour, preferably 10 minutes in each hour where 12-hour shifts are worked).

7.4.2 Hand-arm vibration

The following suggestions for decreasing vibration exposure when working with powered hand tools and machines have been gleaned from Sanders (1997).

- ? Keep machines well maintained as imbalanced tools or fittings may increase vibration.
- ? Reduce vibration load to the lowest level possible for the efficient performance of the task.
- ? Provide counterbalances to reduce the forces needed to hold and manipulate vibrating tools.
- ? Use damping materials on handgrips to reduce the transmission of vibration to the body.
- ? Reduce the grip force necessary to operate powered tools.
- ? Alternate work tasks to reduce vibration exposure.

7.5 Worker selection and training

The preceding sections have emphasised the application of ergonomics principles when designing workstations and tasks as a means of minimising WMSD for most of the workers using the workstations or attempting to perform those tasks. However, there is a large

variation in the mining population's body dimensions and mechanical work capacity. Thus, designing a job to accommodate the weakest workers who may be interested in performing a task may not be the most desirable approach from a technical and cost-benefit perspective. An alternative strategy may be to select the workers who are most capable for the tasks.

Furthermore, even if a job is ergonomically well designed, if a worker fails to be aware of the inherent biomechanical risks when he or she is either moving or handling objects while in an awkward posture or during the performance of certain motions that are controlled by the worker (as opposed to the job), then musculoskeletal injuries may still occur (Chaffin *et al.*, 1999). Hence, worker training becomes a necessary part of a comprehensive plan for preventing musculoskeletal injuries.

Information, instruction and training are needed for all employees involved in activities that could contribute to the development of WMSD. Topics to be covered should be:

- ? The identification of hazardous situations and how they will affect the body
- ? Factors that will increase the risk of MSD
- ? How MSD can be prevented
- ? Appropriate manual handling techniques
- ? The use of ergonomics-related risk controls, such as mechanical aids.

7.6 Anthropometry, occupational biomechanics and the design of workstations

Ergonomic design based on anthropometry and occupational biomechanics can play a major role in the design of workstations and manual handling practices with the aim of reducing WMSD risk factors. Current information on the body dimensions of South African mine workers is rather dated (Schoeman, J.J. *et al.*, 1981) and very little information at all is available on their mechanical work capacity (strength). In view of the importance of this information in the design of mining equipment, workstations and mining tasks, a study to determine at least the functional anthropometry (i.e. those body dimensions that are essential for the design of workstations) and functional biomechanical strength capabilities of South African mining personnel (both females and males) is urgently required.

8 Conclusions

The results of this study show that work-related musculoskeletal disorders occur amongst South African gold, platinum and coal miners. The overall prevalence of 6,2% is relatively low

compared to the figures quoted in the literature for other industries. The reason for the lower prevalence is not apparent. A possible explanation is that the assumption was made in the present study that all workers in the study population would present to the primary care medical centres at project mines if they had MSD. From the results of the coal mine it is evident that this is not necessarily the case, and if a similar situation existed on the other project mines, the number of workers presenting with MSD could have been underestimated.

In the present study the diagnosis of MSD was restricted to the identification of the body region affected. There is, however, no doubt about the importance of making a proper diagnosis of MSD. The suitability of techniques used in the study to achieve this objective in the South African mining industry will be determined during the postgraduate project with the Medical Research Council at the University of Southampton.

Determining the cause and type of MSD is important for the following reasons:

- ? It allows the most effective treatment to be selected.
- ? The cause of MSD must be identified so that the stressful activity can be avoided or modified to reduce or eliminate trauma to the body.
- ? The patient must be informed about the course of MSD, as most are known, so that he knows what to expect.
- ? The work-relatedness of the condition must be established (work-related upper limb disorder movements have been included in the Third Schedule of the Compensation for Occupational Injuries and Diseases Act, 1993).

Once a worker is diagnosed, he becomes an index case by which to assess other workers doing a similar job/activity. In this way, the condition can be identified at an early stage or its development prevented by implementing ergonomics interventions. Diagnosis also allows the identification of other MSD risk factors such as inadequate functional biomechanical strength capabilities or poor training.

Many of the known musculoskeletal injury risk factors, usually in combination, are associated with typical mining tasks. A number of ergonomically based strategies are available to control or reduce the identified risks of MSD. Although ergonomics interventions can be implemented fairly easily in work areas on surface, the underground environment provides unique challenges. In the majority of cases awkward posture, one of the most frequently cited risk factors for WMSD, is the result of restrictive work areas due to low roof height, for example in stopes. This forces workers to assume undesirable postures to perform their tasks. However, it is not possible to change the geometry of the underground workspace as

the reef occurs in thin layers, and this determines the height of the excavations. It would not be economically feasible to increase the height of the stopes.

9 Recommendations

In view of the importance of the identification and treatment of WMSD, it is recommended that a series of workshops be organised (under the auspices of SIMRAC or any suitable institution) to assist occupational health personnel on mines to build expertise in WMSD diagnosis, treatment, rehabilitation and return to work.

There is no universally agreed classification for WMSD that could be used for surveillance. The Southampton examination schedule for the diagnosis of MSD of the upper limb used in the present study is repeatable and gives acceptable diagnostic accuracy in a hospital setting. If the planned further analyses of results obtained in this study show a similar finding, it is recommended that this examination schedule be considered for use in an industrial setting such as mining. It could become an important tool to assist primary health care nurses, as well as occupational health care nurses, to make a diagnosis of MSD.

The implementation of ergonomically sound interventions in the workplace has the potential to reduce the risk of WMSD. Due to the uniqueness of the workplace on mines, generic solutions will not necessarily fully address ergonomics-related risks at all mines. It is therefore recommended that mine-specific ergonomics programmes be considered as a method for the introduction and implementation of ergonomics programmes in the workplace at mines. These programmes should be based on participatory principles to ensure successful implementation by and participation of workers at all levels at the mine. Existing health and safety structures, resources and procedures should be considered for this purpose. Information dealing with the important aspects of an ergonomics programme and its implementation is contained in SIMRAC Report GEN 603 (De Koker and Schutte, 1999).

Good design of workplaces and tasks is one of the strategies for preventing musculoskeletal injuries. However, in view of the large variation in the mine worker population's body dimensions and mechanical work capacity, as well as technical and physical constraints in the mining environment, it is not always possible to accommodate all individuals, especially when manual material handling is involved. It is therefore recommended that the selection of workers on the basis of functional biomechanical strength capabilities, as well as appropriate worker training, be considered as components of a comprehensive plan for preventing musculoskeletal injuries.

Current information on the physical dimensions of South African mine workers is rather dated, and very little information is available on their mechanical work capacity. In view of the importance of this information in the design of mining equipment, workstations and mining tasks, it is recommended that studies be carried out to determine the functional anthropometry (i.e. those body dimensions that are essential for the design of workstations) and the functional biomechanical strength capabilities of South African mine workers (both female and male).

The latest South African anthropometric data are based on a representative sample of males and females from a SANDF survey. It is recommended that a small sample representative of the mine worker population be measured for critical anthropometric variables used in work design and specification, in order to verify if indeed the military data are applicable to the mining community and if current data differ from mining data obtained in the 1980s.

It is recommended that occupational health centres follow up patients presenting to the primary health care centres with a musculoskeletal condition. Ideally all patients presenting with a MSD requiring more than one day sick leave, or those presenting more than twice for the same condition within a specified time, should be referred to the occupational health centre. If this is not feasible, a mechanism (in the form of a database) should be considered to identify all mineworkers presenting often with MSD. These individuals could then be assessed during their annual medical examination for a possible WMSD.

As part of the above information on job descriptions and work activities should be obtained in order to identify high-risk occupations or activities, and to consider further screening of workers in these categories or workplaces to identify early pathology. Medical and ergonomic interventions would be most effective at this stage. As for those with pathology, which has progressed, and with little opportunity to change the workplace, relocation and compensation could be inevitable consequences. Another advantage of the monitoring these patients would be to assess malingering and abuse of sick leave both, by the patients and the medical staff.

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Appendices