Mine Health and Safety Council

MHSC

CENTRE OF EXCELLENCE PROJECTS

The impact of over-exertion on women's health and safety in the South African mining industry

Milestone Report:

Milestone 9 – Final Report

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LIST OF ABBREVIATIONS

API	:	Application Programming Interface
ASM	:	Artisanal and Small-Scale Mining
AMV	:	African Mining Vision
ARV	:	Antiretorviral
AWIM	:	Association of Women in Mining
AZWIM	:	Association of Zambian Women in Mining
BBBEE	:	Broad-Based Black Economic Empowerment
BCEA	:	Basic Conditions of Employment Act
BMI	:	Body Mass Index
CCOHS	:	Canadian Centre for Occupational Health and Safety
COP	:	Code of Practice
CSIR	:	Council for Scientific and Industrial Research
CTAC	:	Culture Transformation Advisory Committee
CVD	:	Cardiovascular Disease
DMPR	:	Department of Mineral and Petroleum Resources
DOHSH	:	Directorate of Occupational Safety and Health Services
EAP	:	Employee Assistance Programme
EMAN	:	Emerging Mining Association of Namibia
EWP	:	Employee Wellness Programme
FWC	:	Functional Work Capacity
GASI	:	General Authority for Specialised Inspection
GBV	:	Gender-Based Violence
HTS	:	Heat Tolerance Screening
HR	:	Human Resources
ICMM	:	International Council on Mining and Metals
ILO	:	International Labour Organisation
KPI	:	Key Performance Indicator
MEMD	:	Ministry of Energy and Mineral Development
MHSA	:	Mine Health and Safety Act
MHSC	:	Mine Health and Safety Council
MPRDA	:	Mineral and Petroleum Resources Development Act
MSD	:	Musculoskeletal Disorder
NIOH	:	National Institute for Occupational Health
NIOSH	:	National Institute for Occupational Safety and Health

NSAID	:	Nonsteroidal Anti-inflammatory Drugs
NUM	:	National Union of Mineworkers
OEM	:	Original Equipment Manufacturer
OHS	:	Occupational Health and Safety
OMP	:	Occupational Medical Practitioner
OREP	:	Occupational Risk Exposure Profile
PDTC	:	Programme Delivery Technical Committee
POPIA	:	Protection of Personal Information Act
PPE	:	Personal Protective Equipment
PTB	:	Pulmonary Tuberculosis
PWC	:	Physical Work Capacity
REC	:	Research Ethics Committee
RFA	:	Rehabilitation and Functional Assessment
RPE	:	Rating of Perceived Exertion
RSI	:	Repetitive Stress Injury
RTF	:	Regional Tripartite Forums
SADC	:	Southern African Development Community
SAMI	:	South African Mining Industry
SATCAP	:	Successful Application of Technologies Around People
SDG	:	Sustainable Development Goal
SHE	:	Safety, Health and Environment
SIMRAC	:	Safety in Mines Research Advisory Committee
SSRI	:	Selective Serotonin Reuptake Inhibitors
TWE	:	The Work Expert
UDM	:	United Democratic Movement
WHS	:	Work Health and Safety
WIM	:	Women in Mining
WIMA	:	Women in Mining Association
WIMAC	:	Women in Mining Advisory Committee
WIMSA	:	Women in Mining South Africa

EXECUTIVE SUMMARY

Introduction

The South African mining industry (SAMI) is historically male dominated, but increasing numbers of females are entering the workforce. However, there are challenges that still need to be addressed, including those related to the occupational health and safety (OHS) of women in mining (WIM). As a result, there is a need for further research to assess factors that impact the health and safety of WIM. The aim of this project is to assess the impact of over-exertion on women's health and safety in the SAMI. There were ten project milestones, as follows:

- Milestone 1: Project initiation;
- Milestone 2: Comprehensive literature review report;
- Milestone 3: Assessment tool;
- Milestone 4: Assessment report;
- Milestone 5: Report on channels for women's OHS concerns;
- Milestone 6: Report on additions to the existing channels of OHS reporting for WIM;
- Milestone 7: Report on workshop;
- Milestone 8: Draft final report;
- Milestone 9: Final report with recommendations and webpage summary; and
- Milestone 10: Publishable article and final technical handover/presentation.

Literature review

The activities undertaken for Milestone 2: Comprehensive literature review included scoping of the literature review, sourcing of relevant local and international literature, and drafting and review of the report. The milestone objective was to ascertain whether the inclusion of WIM exposes them to increased risk, and the impact of over-exertion on women's health and safety.

Identified risks associated with the inclusion of women in the mining industry included those associated with a lack of ergonomic fit of equipment, personal protective equipment (PPE), work tools and tasks to the workers' physiques, and can result in injuries and impaired productivity. Few gender-appropriate modifications have been made for various aspects of the work environment, including mining equipment and facilities. It is evident that the SAMI is still labour intensive, especially for commodities such as gold, where conventional mining methods are still used for extraction. Due to differences in body composition and physical work capacity, women generally cannot perform laborious activities to the same extent as men, and may get fatigued faster as they work closer to their aerobic capacities. In addition, thermoregulation is less efficient in women than in men in hot work environments. Additionally, as women can fall pregnant, risk factors for the mother and baby need to be considered, such as exposure to chemical substances, and physical, ergonomic, and biological hazards. Further challenges and risks that increase women's exposures include the "double jeopardy" of domestic responsibilities following work, inflexible working hours, sexual harassment and bullying, wage gaps, unfair treatment and dismissals of pregnant women, and vulnerability when travelling to work during late or early hours.

Activities such as lifting, carrying, pushing, pulling, and moving objects, as well as engaging in strenuous or repetitive tasks and maintaining awkward or prolonged postures, can lead to over-exertion in the mining industry. Further contributors to over-exertion include long travelling times, confined workplaces, exposure to vibration, heat, noise, dust, and gases.

Over-exertion in the mining industry can have significant and multifaceted impacts on women, affecting their physical health, mental well-being, job performance, and long-term career prospects. More specifically, over-exertion can lead to fatigue, injuries, musculoskeletal disorders, occupational disease, decreased productivity, impaired reproductive health, lack of concentration, and psychological stress. Addressing the impacts of over-exertion on women in mining requires a holistic approach, including ergonomic interventions, work schedule adjustments, health monitoring, access to appropriate PPE, and support systems to ensure a safe and inclusive working environment.

Assessment tool

The objective of Milestone 3: Assessment tool was to develop an assessment tool to assess the impact of over-exertion of women at identified mines. The associated activities for this milestone included discussions with stakeholders, design of the assessment tool, and review and iteration of the tool.

For this assessment, over-exertion was defined as when the demands placed on a person exceeded their capacity or capability; this may result in fatigue, discomfort, impaired concentration and mood, and an increased probability of accidents or incidents. The assessment questions were developed based on insights gained from the literature review. Examples of aspects that relate to job demands included environmental exposures, shifts worked, PPE, and facilities. Capacity-related questions included those relating to fitness, health, sleep, and household responsibilities.

The assessment survey (tool) was developed as a web-based application that communicates with an Application Programming Interface to enable linkages with fitness and anthropometric data. The survey is also available on MS Forms. Most of the questions were quantitative and required a selection of responses from available options. A few open-ended questions were also included. Both subjective and objective data were gathered during the primary research phase. Feedback on the assessment tool was received and incorporated into updated versions.

Assessment report

During Milestone 4, a survey was conducted using the assessment tool developed in Milestone 3. In so doing, the efficacy of the assessment tool for providing insights into over-exertion was ascertained. The associated activities included gaining ethics approval, requesting and securing permission from mines to conduct the study at their sites, conducting the survey (online and on-site), and collating and analysing the data.

Data were gathered from June to September 2025. Permission to conduct the study was received from nine companies, including those in the gold, platinum, coal, chrome, iron ore, manganese, and aggregates/construction materials sectors. A total of 549 usable surveys were completed by women from these mines. The findings were grouped for respondents from surface offices (32%), those from other surface workplaces (including plants, workshops, and surface areas with environmental exposures) (30%), and underground workplaces (including workshops, and cool, hot, restricted, and unrestricted workplaces) (38%). The findings are detailed for over 50 questions, including aspects relating to the work environment and exposures, personal factors, and health, safety, and wellness. Statistical analyses are provided, including Chi-square and logistic regression.

It is evident that there are various factors affecting women in mining. Notably, those in underground workplaces and other surface workplaces indicated the highest rates of physical exposures, including those of noise (81-88%), dust (77-83%), and frequent thirst (35-41% of the sample). Underground workers reported the highest incidences of heat stress symptoms (61%). Adequate access to toilets and access to drinking water on sites remained a challenge, as 14% of the sample indicated not having access to adequate toilet facilities, and 18% did not have drinking stations available near their workplaces. Harassment was a concern, with

8% reporting to have experienced this in the workplace. In addition to shift work and overtime, household responsibilities and commuting times could impact the amount of time the women had for rest and recovery, with 71% usually spending over 2 hours on household chores each day, and 12% spending over an hour to travel to or home from work. A total of 29% reported usually getting less than 6 hours of sleep when working. The respondents experienced higher rates of fatigue after (50%) than before their shifts (5%). There is a high prevalence of obesity in the sample (63%, according to BMI), which could have health and safety implications. Over a third of the sample (37%) experienced musculoskeletal pain and discomfort, primarily in their backs.

The statistical analysis provided insight into factors associated with outcome variables that were identified to represent different facets of over-exertion, including musculoskeletal pain or discomfort, tiredness (fatigue), and high ratings of perceived exertion. These outcomes were experienced by 37%, 52%, and 21% of the respondents, respectively. Factors associated with all of these outcomes included exposure to dust, thirst, energy drinks consumed, shift duration, frequency of being out of breath during work, sleep quality, and number of heat stress symptoms. Meanwhile, when looking at each outcome variable separately, most of the variables included in the assessment survey were shown to have an influence on over-exertion outcomes.

The tool was seen to be useable on both hard-copy and online formats. It was evident that the assessment tool was effective in providing inputs into numerous variables that can contribute to, or result from, over-exertion of women in the SAMI. An assessment of these factors is useful towards the identification of interventions to improve health, safety, and productivity in the sector, and the inclusivity of women in mining.

Reporting channel assessment

Chapter 5 summarises activities conducted in Milestone 5: Reporting channel evaluation. This milestone aimed to evaluate the existence and effectiveness of reporting channels for women's OHS concerns, with a focus on over-exertion. A non-systematic desktop study of publicly available literature was conducted, and insights were obtained from focus group discussions. Both local and international sources were consulted to understand the current landscape of OHS reporting mechanisms and their gender responsiveness among women. The focus group discussions focused on challenges facing women in mining, available reporting channels, and recommendations regarding these. Ten focus groups were held with 94 participants from mines of a range of commodities, as well as an industry organisation. The participants included those from management positions to women from a range of manual or semi-skilled positions.

Findings from academic sources, grey literature, and webpages revealed that several reporting platforms exist, such as internal OHS committees, whistleblower hotlines, regulatory bodies, unions, and WIM associations. However, many are not tailored to women's specific OHS needs. Over-exertion is recognised as a risk but appears to be often underreported due to cultural stigmas and a lack of gender-sensitive protocols. In Africa, especially in artisanal and small-scale mining, regulatory enforcement is weak, and women lack safe platforms for raising concerns. In South Africa, various channels exist through legislation and institutional structures, but the gender responsiveness of these systems remain limited.

The effectiveness of the various channels is not entirely clear; however, several authors suggest that effectiveness depends on factors such as trust, anonymity, accessibility, feedback mechanisms, and integration into the company culture. Improvements in gender-sensitive reporting channels and stronger enforcement are essential to support the health and safety of women in hazardous work environments.

There was alignment between the findings from the desktop review and focus group discussions. Focus group participants noted that reporting channels for women regarding OHS challenges at work included health and safety departments, supervisors, foremen, WIM committees, and anonymous hotlines.

Meanwhile, challenges related to the reporting channels included fear of victimisation, lack of trust in the anonymity or confidentiality of the platforms, inaction, and lack of feedback. Related recommendations for improving the OHS reporting channels included cultural transformation, the implementation of suggestion boxes, support for WIM platforms, and conducting surveys, along with increased awareness and the enhancement of employee wellness programmes. In addition, the focus group discussions provided further insight into challenges facing women in mining relating to over-exertion, and related suggestions for improvements. The reporting channels should take consideration of the identified challenges relating to over-exertion, including with respect to the job demands, work environment, workplace culture, equipment and facilities, and work-life balance.

Better reporting and response would intend to address the impacts of over-exertion of women in mining, including that of fatigue, injury, and mental or physical strain.

Reporting channel evaluation

Milestone 6: Reporting channel evaluation entailed recommendations towards improving or adding to reporting channels for women's OHS concerns. These recommendations were based on findings from the focus group discussions and qualitative data obtained from the assessment survey conducted. The report includes an assessment of factors that can lead to, or result from, over-exertion. Reporting channels need to be specific to the concerns of WIM; therefore, recommendations for improving the health, safety, and wellness of WIM were detailed.

Evident causes of over-exertion that were reported included job demands, workplace exposures, the culture in mining, a lack of development, and household responsibilities. Consequences included fatigue, stress, anxiety, a lack of motivation, and injuries. Recommendations that the participants made included ergonomic assessments, improved PPE, improved access to emergency sanitary facilities, training and development, and increased respect in the mining industry. Wellness programmes, health and safety awareness campaigns, as well as counselling or support for WIM, were recommended. The reporting channels could entail anonymous suggestion boxes, WhatsApp reporting, and online OHS management systems, and should involve WIM committees, along with health and safety departments. There is a need for safe and reliable reporting systems in the mining industry, which allow women to speak up without fear. It is also important to train women on over-exertion, and on how to report it and other OHS concerns and exposures safely. Improved collaboration, trust, and culture change in the mining industry are needed for the success of reporting systems.

Workshop

The objective of Milestone 7 was to host a stakeholder engagement workshop to present findings and solicit industry inputs on the project. The workshop was conducted in a hybrid format, with in-person attendance taking place at the CSIR International Convention Centre in Pretoria, Gauteng, and virtual attendance taking place on MS Teams. The workshop was held on 3 October 2025. The comments and queries made by the participating stakeholders following the presentation of the project findings were recorded and summarised. Furthermore, a Mentimeter survey was conducted during the workshop to gain insights from the stakeholders into the project and potential recommendations. Key recommendations arising from the discussion included:

- Improved risk assessments;
- Ergonomics interventions and the application of new technologies;
- Improvements to change houses, PPE, and availability of emergency sanitary pads;
- Updates to Codes of Practice relating to fitness to perform work and medical surveillance;
- Better policies at mines relating to bullying and harassment;
- Strengthened culture transformation efforts;
- Enhanced training and awareness;
- Improved development of WIM;
- Continued collaboration between state, unions, and mines;
- Anonymous and accessible reporting systems, including periodic surveys; and
- Updates and streamlining of the assessment tool developed in the project.

Conclusion and recommendations

It can be concluded that over-exertion is complex and multi-faceted. Numerous factors contribute to over-exertion of WIM in the SAMI, including those relating to the physical work environment, job demands, workplace culture, and difficult work-life balance.

Findings from the literature reviewed, assessment survey, and focus group discussions were consolidated to provide an in-depth understanding of over-exertion on its impacts on women's health and safety in the SAMI. Impacts of over-exertion include those of fatigue, physical and mental strain, injury, occupational disease, and reproductive health outcomes. Channels available for WIM to report OHS challenges relating to over-exertion include health and safety departments, anonymous whistleblower hotlines, human resources, medical centres, unions and WIM committees. Interventions may be made to address concerns relating to reporting channels, including lack of trust in the anonymity and confidentiality of reports, fear of victimisation, lack of feedback and inaction.

Updates to codes of practice and guidelines are recommended based on the findings of the study, such as those relating to fitness for work and medical surveillance, including the improved application of occupational risk exposure profiles (OREPs).Continuous monitoring and support is recommended, including participatory risk assessments, and the incorporation of elements of over-exertion into medical surveillance. Improvements in access to hygienic change houses, toilets, emergency sanitary pads, and drinking water underground are required. Continued improvements to PPE quality, design and availability, are recommended, along with darker colour overalls for WIM in underground workplaces. Training and awareness campaigns are recommended on a range of topics, including relating to over-exertion, reporting channels available, and gender inclusivity, for women, men and leadership. Increased development and promotion opportunities are important.

The assessment tool developed in the project was able to measure various aspects that contribute to and result from over-exertion, and could be used for periodic assessment of over-exertion in the industry. The assessment tool should be updated and implemented to provide anonymous insights into areas where interventions can be implemented and where improvements are evident.

1. INTRODUCTION

1.1 Background

The mining industry is historically male-dominated, and women were legally prohibited from being employed in underground operations in South Africa until the 1990s (Benya, 2016; van Aardt *et al.*, 2008; Zungu, 2012). There have been several legislation and policy frameworks implemented in South Africa to redress past inequalities, including the Mineral and Petroleum Resources Development Act (MPRDA) 28 of 2002, the Employment Equity Act 55 of 1998, the Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000, and the Mining Charter and its revisions. The 2002 Mining Charter required a baseline of 10% of women participation in the South African mining industry (SAMI) by 2009. Increasing numbers of women are entering the industry, and in 2019 women comprised approximately 12% of the SAMI's workforce (Minerals Council South Africa, 2020). At this time, women made up 17% of top management, 17% of senior management, 24% of professionally qualified, and 18% of skilled technical positions (Minerals Council South Africa, 2020).

The health, safety, and performance of women in mining may be compromised if their needs are not accommodated, due to physiological and anatomical differences between males and females (Zungu, 2012). Females generally have lower physical work capacity, strength, and potentially lower heat tolerance than males (Van Aardt *et al.*, 2008). The mining industry often requires physically demanding work in demanding environments (Blacker *et al.*, 2012; Hofmann and Kielblock, 2007). Therefore, females would have to work closer to their physical work capacity than men to maintain the same levels of productivity, which in turn can lead to greater levels of fatigue and an increased possibility of accidents and injury (Dlamini, 2016). Additionally, there are differences in the anthropometry and body composition between females and males (Van Aardt *et al.*, 2008). Moreover, higher rates of obesity are evident in females than in males in South Africa (Department of Health, 2004). The design of mining equipment (including personal protective equipment (PPE)) and tools is generally based on anthropometric data of males from other countries, which may contribute to the risk of accidents and musculoskeletal disorders in women (AngloAmerican, 2012; Hodgskiss *et al.*, 2017; Van Aardt *et al.*, 2008; Zungu, 2012). Provisional occupational health and safety (OHS) statistics for women in mining (WIM), as per the Department of Mineral and Petroleum Resources (DMPR) weekly report on 24 July 2023, are shown in Figures 1 and 2. It is evident that safety is a concern for WIM, and as both injuries and fatalities have taken place.

Classifications of injuries include, “general” causes (68%), transportation and mining (16%), conveyance accidents (5%), machinery (4%), and falls of ground (4%), amongst others.

As a result of the identified concerns, it is important that factors such as the impact of over-exertion on women’s health and safety be investigated so that these potential challenges may be addressed for a safer working environment for women in the SAMI.

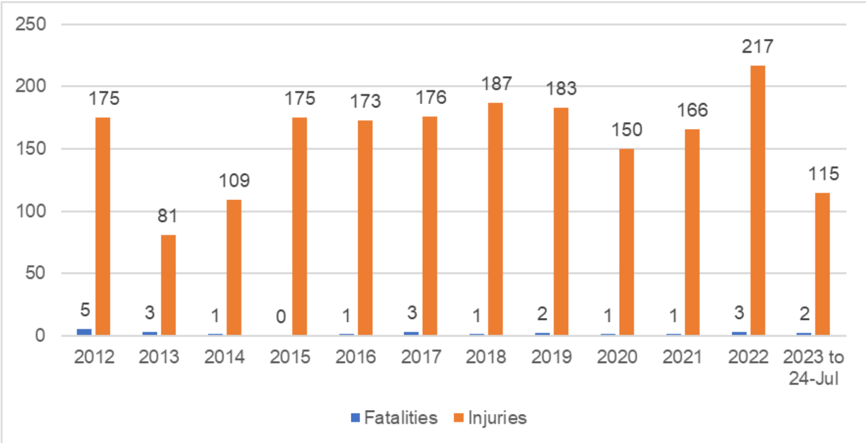


Figure 1: WIM fatalities and injuries from January 2012 to July 2023

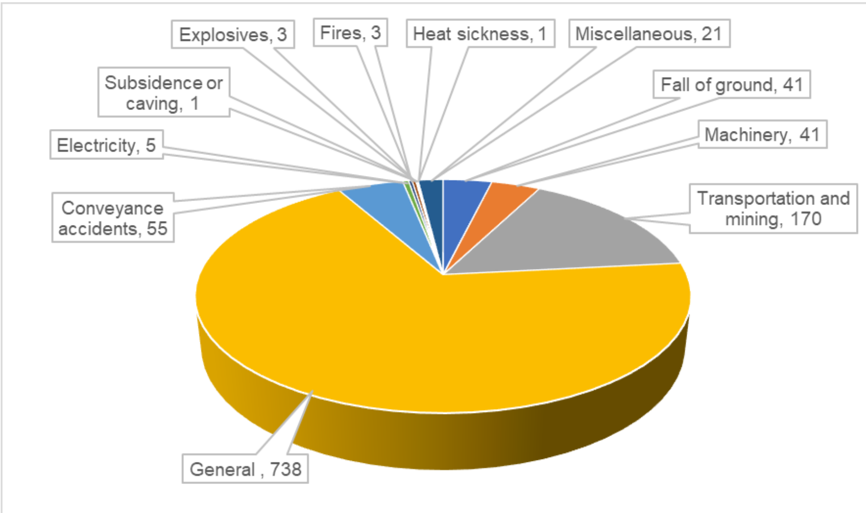


Figure 2: WIM injuries per classification from 2017 until 2022

Further challenges faced by WIM, as listed by Minerals Council South Africa (2023), include those relating to physical facilities, safety and security, childcare facilities, a gender pay gap, male-dominated culture and gender stereotypes, and impeded career progression. Despite the progress in employing women in mining, both conscious and unconscious gender bias is still rife in the mining industry (International Labour Organization, 2021). Leadership positions remain largely male-dominated. Additional barriers to women leadership, as outlined by the

International Labour Organization (2021), include the roles assigned by society to men and women; women have fewer role models; men are not encouraged to take leave for family responsibility; lack of flexible working models; and lack of retention strategies for skilled women. In addressing these challenges, there is potential for the mining industry to contribute to the Sustainable Development Goals (SDGs), particularly SDG 5 (to achieve gender equality and empower all women and girls).

1.2 Project aim and objectives

The aim of this project is to assess the impact of over-exertion on women's health and safety in the SAMI. The study will be achieved by completing the following objectives namely:

- To conduct a comprehensive literature review, nationally and internationally, to ascertain whether the inclusion of women in the mining industry exposes them to increased risk, and the impact of over-exertion on women's health and safety.
- To develop an assessment tool to assess over-exertion of women and the impact thereof in the identified mines. Related considerations include:
    - The tool must motivate or act as a go-to instrument to assess and mediate over-exertion for women who work in the hazardous environments of the SAMI;
    - The different occupations and environmental conditions that women work in, in relation to hazardous environments in the SAMI;
    - Body Mass Index (BMI) and fitness to perform work, and if this has an impact in the hazardous areas of the mining environment;
    - Determination of the relationship between the hazardous working environment in the SAMI and the well-being of women, emotionally and physically; and
    - The OHS impact on women as a result of over-exertion.
- To determine the efficacy of the approved assessment tool to measure the over-exertion rates of women at the identified mines.
- To determine the existence of reporting channels for OHS concerns and exposure and the effectiveness of these – including determining whether sufficient aspects of over-exertion are well incorporated.
- To determine any additions to the existing channels of OHS reporting for women (working in hazardous environments) and how these relate to, or can be incorporated in relation to legal, technical, and social evolution.
- To conduct and host one workshop, with relevant stakeholders, to present the findings and solicit further input.

The project milestones and associated activities are shown in Table 1. The report chapters are associated with these deliverables. It is envisaged that the outcomes of the study will ultimately lead to the promotion of OHS in the SAMI. Study findings and recommendations will be disseminated by means of a workshop, technical presentation, and publishable paper, in addition to a webpage summary and the study report.

Table 1: Project milestones and activities

No.	Milestone	Supporting initiatives per milestone
1.	Project initiation	• Start-up presentation • Project kick-off meeting • Planning and administration
2.	Literature review	• Scoping review of literature • Source local and international literature relating to the impact of over-exertion of women in mining • Draft and review report
3.	Assessment tool	• Discussion(s) with stakeholders • Design/develop assessment tool • Develop adoption strategy • Review and iterate assessment tool
4.	Assessment report	• Permissions from mines • Ethics approval • Fieldwork (data collection using developed tool at mines) • Collate and analyse data • Draft and review report
5.	Reporting channel evaluation	• Desktop research • Focus group discussion(s) with stakeholders • Draft and review report
6.	Reporting channel recommendations	• Focus group discussion(s) with stakeholders • Draft and review
7.	Workshop	• Invite relevant stakeholders • Prepare workshop presentations and agenda • Host workshop
8.	Draft final report	• Compile study findings • Draft and review report
9.	Final report	• Incorporate feedback received into report • Close-out activities
10.	Information dissemination	• Draft publishable paper • Compile technical handover/presentation

1.3 Methods

The project utilised a mixed-methods research approach, and both qualitative and quantitative data were gathered. Data were collected during focus group discussions with stakeholders and using the assessment tool developed during the project. Desktop research and stakeholder engagements were conducted to inform the design and content of the assessment tool and qualitative question guides. Secondary data may also be used to evaluate the relationship between over-exertion and the health and safety of WIM. Ethical clearance was obtained from the CSIR Research Ethics Committee (REC) prior to engagement with study participants.

The assessment tool developed was envisaged as a web-based mobile application for females to indicate physical over-exertion or discomfort levels and emotional well-being at work as a "go-to instrument", along with components for capturing information of the wearer and context of use. Further details relating to the specific platform or tool used was assessed and decided upon based on assessments conducted during the study. The development of an adoption strategy for the tool was also planned.

Table 2: Study sample

Mines	Women mine workers	Women miners	Women supervisors	Women in management
Underground				
2 x Gold	25	15	8	4
2 x Platinum	25	15	8	4
1 x Coal	25	15	8	4
2 x Other	25	15	8	4
Surface				
1 x Iron ore	12	7	4	3
2 x Coal	12	7	4	3
2 x Other	12	7	4	3

As per the scope of works for the project, it was envisaged that data would be collected using the assessment tool at 12 mines, with approximately 500 participants. The expected study sample is shown in Table 2. WIM from different occupational levels, commodities and those affected by varying environmental factors were invited to participate. The initial mines that were approached to participate in the study were those with Rehabilitation and Functional Assessment (RFA) centres. However, the participating mines were not limited to those with associated RFA centres, to enable broader participation, such as the inclusion of smaller operations, representatives from junior and emerging miners, and a variety of activities. These needs were identified following presentation of the study overview to tripartite stakeholders. Physical and functional work capacity assessments are conducted at RFA centres. Data gathered at RFA centres could be linked to the data collected using the assessment tool that is developed, or for secondary analysis, to gain a better understanding of aspects associated with over-exertion of WIM. The project team collaborated with RFA centre partners to assist with the participation of the associated mines, and the MHSC and its tripartite structures further assisted in securing buy-in and participation from further relevant mines.

Further stakeholders that were engaged with in the project included relevant industry bodies or working groups relating to WIM, such as at Minerals Council South Africa, the WIM Advisory Committee (WIMAC) of the MHSC, and tripartite forums. The stakeholders included academia, consultants, organised labour (unions), government (mainly the Department of Minerals and Petroleum Resources), safety professionals, occupational hygiene professionals, occupational health professionals, human resources management professionals, and those working in mining companies.

Furthermore, the research findings will be disseminated to stakeholders in the SAMI for implementation. The research outcomes include mechanisms for organisational use or uptake of the research outputs. These recommendations will enable those in industry to best implement interventions based on the study findings. As part of the study, a workshop was held with relevant individuals to share information on the study findings, as well as to gain inputs and feedback from the participants. The outcomes of the study intend to ultimately lead to the promotion of zero harm initiatives in the SAMI.

1.4 Project risk and mitigation measures

The potential project risks and associated mitigation measures are shown in Table 3.

Table 3: Project risk and mitigation measures

Potential risks	Mitigation measures
Delays in obtaining ethics approval	Early submission of ethics application
Dependency of tool development on literature review	Start development prior to all the information and questions being ready
Lack of access to champion mines and participants	Use of networks (collaboration and MHSC)
Lack of buy-in from stakeholders	Draft adoption plan Early engagement and good communication
Large sample size (e.g. number of participating mines and WIM from the indicated categories)	Potential need to reduce number of mines/ participants (and/or use of secondary data)
Time constraints for conducting fieldwork	Good project management and planning
Procurement delays	Internal development of assessment tool

1.5 Milestone conclusion

This study aims to assess the OHS impacts of over-exertion of women in the SAMI, as a result of the risks and challenges facing WIM. The project entailed a review of literature, development of an assessment tool, an assessment survey, reporting channel evaluation and recommendations, and workshop, to achieve the study objectives. A mixed methods research approach was taken and qualitative and quantitative data were gathered from over 500 participants from mining companies from a range of commodities and occupations. The project procedures and findings are detailed further in this report.

1.6 Next milestone

The following chapter entails a review of literature as completed in Milestone 2 of the project. Both national and international literature relating to the project topic was sourced and reviewed. The literature review topics included, but were not limited to, ascertaining whether WIM are exposed to increased risk, and the impact of over-exertion on women's OHS.

2. LITERATURE REVIEW

2.1 Introduction

The purpose of this milestone was to gather literature that gives a brief background on the inclusivity of women in the mining industry, highlights whether the inclusion of women in the mining industry exposes them to increased risk and notes the impact of over-exertion of women in the mining industry.

A desktop study targeted at scoping the literature was conducted. The review was structured to provide context within which to structure a background for the development of a survey tool for the assessment of over-exertion of women in the SAMI. Data was collated from publicly available literature such as journal articles, books, scientific reports and articles. The study included literature from local and international authors to understand the various impacts of over-exertion on women in local and international mining operations.

The review focused on women in the mining industry, both locally and internationally (Sections 2.2 and 2.3); the risks facing women in mining (Section 2.4); and causes and impacts of over-exertion on women's health and safety (Sections 2.5 and 2.6).

2.2 International context

In South Africa, other developing countries, and globally, women in mining have been marginalised over the years due to various issues such as the lack of appropriate policies , as well as due to superstitions such as that women in mining work environments bring bad luck. This subsection and the next will unpack the inclusion of women in the mining industry internationally.

The mining sector in Australia ranked second in the economy for the lowest female proportion of total employment (IGF, 2022). In 2021, the Australian mining sector employed 253 000 persons full-time and only 16% were women, whilst of the 9 800 persons employed on a part-time basis, 67% constituted women (IGF, 2022). Most women historically held positions such as clerical, administration and community and personal services. However, there has been an increase of female machinery operators, technicians, trade workers, drivers and professionals, and those owning and managing mine-related enterprises (IGF, 2022).

Female workers are found in major operations and artisanal (small scale) mining operations. Artisanal is defined as a single unit mining operation with an annual production of unprocessed material of 50,000 tons or less. It is usually characterised as informal, illegal and unregulated by government, undercapitalised, utilising simple tools and lacking in technology, and hazardous under labour-intensive conditions (Lu, 2012). However, countries such as the Philippines have acts and regulations that support artisanal mining (Lu, 2012). On the other hand, major mining industries are regulated and unionised. While unions are supposed to be non-sexist and democratic, it is noted that the unions by nature are male dominated, where women, especially in workplaces that are dominated by men, continue to be marginalised and relegated to second-class workers (Benya, 2013). These situations can lead to mental fatigue – linked to discrimination and the need to balance work with family responsibilities, ultimately exacerbating physical over-exertion (Benya, 2013).

Various developing countries such as Kenya, Zimbabwe, Mali, the Philippines, Papua New Guinea, Bolivia, Colombia, and Indonesia have extensive artisanal (small-scale) mining activities (Lu, 2012). Most research conducted has primarily focused on mainstream mining and the involvement of male workers. However, Mwendwa (2023) highlights that several authors have pointed out the gap in studies regarding the participation of women in artisanal gold mining. Furthermore, he notes that the exclusion of women in artisanal mining has been due to the cultural barriers and beliefs that women in the vicinity of a mine bring "bad luck". Regardless, in countries such as Kenya, where artisanal and small-scale mining continues to rise, the workforce constitutes approximately 30% women (Mwendwa, 2023). The global consensus around artisanal mining is generally associated with high unemployment rates and poverty.

The mining process in artisanal mining is tedious and labour-intensive due to its conventional approach to activities, an example being hand-sorting (Lu, 2012). In Kenya's artisanal gold mining, women are involved directly in activities such as sieving, water and ore hauling, crushing, washing, panning, separating, and sorting. Women also hold positions such as dealers, mine operators, concession owners, buying agent and equipment owners (Mwendwa, 2023). Mwenda (2023) notes that African countries should formulate and implement policies that reduce the health risks (associated with dust, noise and mercury) that women experience in artisanal gold mining.

2.3 Local (South African) context

The South African mining industry (SAMI) has always been male dominated, which can be attributed to the lack of an inclusive policy, mining operations' hazardous working environments, and the physical strength required to carry out core mining roles or activities. While there have been numerous improvements, the SAMI is still very much labour intensive, especially in commodities such as gold where conventional mining methods are used for extraction. For decades, aspects of the work environment have offered little or no gender-appropriate modifications (MHSC, 2015).

Historically, most of the jobs of women on mines and heavy industries related to either administrative or menial lower rank activities such as sweepers, cleaners, or attendants in the administration offices (Badenhorst, 2009). The 2018 Mining Charter was intentional with including women, and therefore states the following (DMR, 2018):

- *For new mining rights*, *"A minimum of 20% effective ownership in the form of shares to a BEE Entrepreneur, 5% of which must preferably be for women";*
- For the Board, *"A minimum of 50% Historically Disadvantaged Persons with exercisable voting rights, proportionally represented in terms of provincial or national demographics, 20% of which must be women";*
- *For executive management, "A minimum of 50% Historically Disadvantaged Persons at the executive director level as a percentage of all executive directors proportionally represented in terms of provincial or national demographics, 20% of which must be women";*
- *For middle management, "A minimum of 60% of Historically Disadvantaged Persons in Middle Management proportionally represented in terms of provincial or national demographics, 25% of which must be women"; and*
- *For junior management, "A minimum of 70% Historically Disadvantaged Persons in Junior Management proportionally represented in terms of provincial or national demographics, 30% of which must be women".*

2.4 Risk associated with the inclusion of women in the mining industry

The inclusion of women in core mining roles and activities means that they are required to carry out whatever men would have done in that same role (MHSC, 2015). This can involve roles in surface and underground mining operations, in fields such as metallurgy, mining, engineering, and geology. These roles expose both men and women to operational mining environments with potential occupational health and safety (OHS) risks. However, the impact of these risks on women differs from men due to biological differences. Mining equipment, such as drills and front-end loaders, were originally designed with men in mind and therefore have become a significant factor in injury risk for women (Badenhorst, 2009).

When mines began recruiting women, the facilities remained tailored to male workers, as adjustments could not be implemented quickly enough. Consequently, both men and women had to share this equipment. It is important that the human resources employed to carry out activities within the operation are suitably qualified and physically able to carry out said activities. Emphasis should be placed on worker selection, paying attention to the ergonomic fit of equipment, work tools and tasks to the worker's physique (Van Aardt, 2014).

It is imperative to ensure that the mine work environment accommodates women in the sense of reasonable hygienic facilities and PPE. Specific attention to the health and safety of women working in mines is necessary. Women have specific unique requirements in terms of the PPE with which they are provided, as ill-fitting PPE can affect the extent to which women are protected and the manner in which they are able to perform their duties (Botha & Cronjé, 2015).

Many women, due to their body composition and physical work capacity are unable to undertake laborious activities within the mining industry with the same rigor as their male counterparts (Badenhorst, 2009). According to Schutte (2014), the aerobatic capacity (physical work capacity) of women is 15-30% below the values of their male counterparts. This is attributed thereto that women being different from men physically and biologically, and pertinently in the ability to fall pregnant, which leaves two people, the mother and the baby, with very specific risk factors to consider (Badenhorst, 2009). There is considerable concern within the industry regarding the potential impact of occupational exposure to chemical substances, as well as physical, ergonomic, and biological hazards, on reproductive health. In addition to the evident physical and ergonomic risks associated with underground work and heavy industry jobs, many chemical substances that are known to affect reproduction and development are commonly used, posing potential exposure risks to workers (Badenhorst, 2009).

Women who work in artisanal mining in Bolivia are mostly employed as hand pickers and gravel scratchers, work long hours without efficient PPE (such as masks, goggles, shoes and helmets), and are sometimes exposed to contaminated water. This reduced the life expectancy of most of these women, which is rarely more than 40 years (Lu, 2012).

In South African mines, work environments with a wet-bulb temperature of 27.4°C are considered hot and necessitate the introduction of safeguarding processes to prevent heat stress. According to Ashworth (2020), all workers who are susceptible to heat stroke should be subjected to a screening test procedure for gross or permanent heat tolerance. Heat tolerance is a measure of the individual's ability to endure high temperatures while undertaking physically demanding work. The aim of the heat tolerance test procedure is to protect individuals against the consequences of heat exposure, such as heat strokes and heat-related diseases (Benya, 2013). Van Aardt (2014) believes that thermoregulation in women is less efficient than in men under high ambient temperature conditions. High occupational heat loads can lead to impaired work capacity, errors in judgement that impact safety, lethargy and fatigue, and heat stress that may lead to potentially fatal heat strokes (Van Aardt, 2014).

In Ghana, mines such as the Akoon Mining Cooperative avoid women's participation underground, but rather include them in activities such as carrying gold ore and water, ore pounding, cooking, security, bookkeeping, and care of children brought by other women (Mwendwa, 2023). The women involved in the purification process are exposed to mercury, which may damage the lungs, kidneys and brain, cause detrimental effects on pregnancy, and lead to birth defects and intellectual disability of the unborn child (Mwendwa, 2023). Those involved in the crushing process, which produces dust, are susceptible to skin and respiratory ailments. The lifting of heavy materials results in muscular disorders, and the noise from the crushing machines results in hearing complications (Mwendwa, 2023). A great challenge with artisanal mining is the lack of compliance with occupational health and safety standards, which results in women being exposed to poor working environments, contributing to over-exhaustion (Lu, 2012).

Women working in Congo's artisanal mining sector experience poor hygiene and malnutrition. Furthermore, the injury-related accidents and stress associated with the mining environment have resulted in various miscarriages (Lu, 2012). In Uganda, prolonged standing in concentrated saltwater in artisanal salt mines results in women suffering from genital corrosion, which affects fertility rates (Skillings Mining Review, 2024). Furthermore, it also results in mercury poisoning and silicosis.

The Canadian mining industry had 16% female workers versus 84% male workers in 2006, 17% versus 83% in 2011, and 16% versus 84% in 2016 (IGF, 2022). Very little change in the ratio of female workers was seen between 2006 and 2022. To date, the representation of women in mining is three times lower than the average across all sectors in Canada (Scales, 2024). Quarry mining in the United Kingdom is seen as dangerous and has high injuries rates when compared to the construction industry. It is important to note that there are limited publications on the impact of female workers in mining operations outside of Africa. Most research emphasises the significance of integrating occupational health and safety with gender diversity in the mining sector. Additionally, many mining operations outside Africa are modernised, mechanised, or automated, which means that female workers are likely less exposed to harsh environmental conditions and, consequently, less vulnerable to negative OHS impacts.

As indicated in the previous paragraphs, the introduction of women into the core business of mining has posed new health and safety challenges to the industry. Furthermore, it has increased women’s exposure to the following risks and challenges (Botha, 2017):

- Women's workplace health problems, which are frequently compounded by getting more of the same at home - the "double jeopardy" of domestic work, which can mean a second shift of lifting, responsibility and chemicals on top of those experienced all day at work (Badenhorst, 2009);
- Discriminatory practices and structures of major, mid-tier, junior and artisanal mining that hinder the advancement and recruitment of women (IGF, 2022);
- Sexual harassment and bullying;
- Working hours and shifts that are not flexible, which create challenges of taking care of their children and household;
- Physical constraints associated with the work;
- Inadequately fitting PPE which poses health and safety risks;
- Wage gap (there is a large difference in the average wage earned by women versus men);
- Unfair treatment and dismissals of pregnant women, which causes financial strain on their families (Stockholm Precision Tools, 2022);
- The male-dominated nature of the mining industry, which can lead to marital challenges for some women, as their husbands may struggle to accept this environment. As a result, women often face the dual pressures of managing the demands of their work while also attempting to meet their husbands' expectations (Botha, 2017); and

- Vulnerability to crime due to shift work that often requires them to travel during late or early hours (Botha, 2017).

2.5 Causes of over-exertion in open cast and underground mines

Over-exertion occurs when a person pushes themselves beyond their physical or mental limits. It varies based on factors such as age, medical history, environment, and the specific task at hand. Since each person has unique limits, the point of over-exertion differs from person to person. Over-exertion is linked to fatigue, which is defined as a condition characterised by reduced mental and physical performance and decreased alertness. Fatigue results from a combination of intense physical and mental effort, health and psychological factors, or insufficient restorative sleep (Pelders & Nelson, 2018). Higher levels of fatigue result in decreased alertness, coordination, judgment, and motivation, as well as negatively affecting mood and job satisfaction. These higher levels could result in over-exertion.

Over-exertion can be dangerous, potentially causing injuries such as strains, sprains, and fractures, and may impact the ability to perform activities in the future. Typically, over-exertion is linked to activities such as lifting, carrying, pushing, pulling, and moving objects, as well as engaging in strenuous or repetitive tasks and maintaining awkward or prolonged postures. In the mining industry, over-exertion is frequently caused by using manual hand tools, handling and transporting materials, working in confined spaces, frequently getting on and off equipment, exposure to vibrations, and performing maintenance tasks (Jones, et al., 2019). This is somewhat similar to the military, where over-exertion is caused by running, marching, hiking, and team sports.

Eiter *et al.* (2023) note that both anthropometric and physiological data have been used to establish thresholds for environmental factors in the workplace. These thresholds are vital for managing environmental hazards such as heat, especially as underground mines delve deeper and become hotter and more humid, while surface mines face rising heat indices. Engineering controls, such as enhancing air circulation in the mine, along with work practices such as limiting time spent in high-temperature areas, can help prevent heat-related illnesses among miners.

Although these strategies are essential for mitigating heat hazards, they often adopt a one-size-fits-all approach. Recent research reveals that there are sex differences in extreme heat exposure—such as women having a lower sweat rate than men. Further studies are needed to capture the variability within the mining population to better understand the overall impact and identify individual differences in exposure to environmental factors such as heat (Eiter, et al., 2023).

Open-cast surface mining operations involve the removal of overburden, dumping, and backfilling in excavated areas. Minerals are extracted from an open pit in the ground that increases in depth over time. The open cast mining environment requires the ability to work outside in the sun, cold, and sometimes rain for extended periods of time (Botha & Cronjé, 2015). Underground mining involves the extraction of minerals and metal from below the earth's surface. The environments on both are extremely different, even though the extraction of minerals and metals is the focus of both contexts. Many jobs in these operations require physical strength, endurance, and mental strength (Botha & Cronjé, 2015). This can be a challenge for women, as their physical work capacity and muscle and physical strength is less than that of men. The lifting strength for women is 60 – 70% that of men, and their aerobic capacity is 15 – 30% lower; hence, women get fatigued quicker because they work closer to their aerobic capacity (Ashworth, et al., 2004). The aerobic capacity refers to maximal oxygen uptake that provides a quantitative measure of a person's ability to sustain high-intensity physical work for longer than five minutes. Women's genetic predisposition, the equipment and machinery design, and their lifestyle often disadvantage them (Botha & Cronjé, 2015). It is important for women to apply a different technique to men. However, there are hopes that modernisation and mechanisation will improve this; in the interim, mining tasks remain labour-orientated.

The underground mining environment is different from open cast. Occupational health hazards that women are faced with in underground operations include exposure to intense heat, poor ventilation, vibration, dust, fumes, repetitive stress injury (RSI), intense noise, and biological hazards (Lu, 2012). The poor ventilation causes extreme heat, leading to heat stress and dehydration, which can quickly lead to exhaustion. Underground mines often have confined and dark spaces, mostly influenced by the mining method, which adds to physical and mental strain, thus increasing the risk of fatigue and over-exhaustion. Some of these spaces also do not have sufficient lighting, requiring the use of lamps attached to hard hats. As mining depth increases, so does the temperature, which in turn exacerbates the heat to levels higher than the accepted wet-bulb temperature of 27.4 °C and increases ventilation requirements (Botha & Cronjé, 2015).

Some of the causes of over-exertion include (Badenhorst, 2009; Ngwaku, et al., 2022; Ping & Guang, 2017):

- Unhygienic sanitary facilities underground have necessitated women to develop coping mechanisms such as suppression of the urge to use the toilets and avoidance of drinking fluids (Zungu, 2012). If women do not drink enough fluids, they can experience dehydration, which may result over-exertion and the potential for serious conditions such as heat strokes;
- Women are faced with increasingly higher heat indices. Research has shown that women's sweat rate is lower than that of men (Eiter, et al., 2023). This makes them prone to over-exertion;
- The physically demanding activities, found in both open cast and underground mines, causes fatigue and sometimes physical trauma in women (Lu, 2012);
- In mining operations, PPE such as goggles, overalls, and boots are typically designed for men. This means that the dimensions of the PPE often do not fit women properly, leading to issues with comfort and protection (Badenhorst, 2009). Poorly fitting PPE can negatively impact women's productivity and job performance, increasing the risk of slips, trips, falls, and breathing difficulties due to ill-fitting face masks. Additionally, the lack of proper fit can cause women to expend more energy on tasks, leading to greater fatigue and reduced efficiency (Eiter, et al., 2023). In 2023, the Mine Health and Safety Council (MHSC) issued the Guideline for a Mandatory Code of Practice for the Selection and Provision of Personal Protective Equipment for Women in the South African Mining industry. However, it is currently unclear whether mining operations have been adhering to this guideline;
- Pregnancy intensifies the challenges faced by women in mining environments. According to Rutkowski (2024), pregnant women are more susceptible to fatigue and edema, and they are more at of injury due to more flexible tendons and ligaments. The expanding uterus contributes to back strain and reduced blood flow to the sciatic nerve (Rutkowski, 2024). Additionally, PPE often becomes more uncomfortable for pregnant women. While major mining companies typically reassign pregnant employees to different roles to acknowledge their needs, this approach tends to increase their stress levels. On the other hand, many small, mid-tier, and artisanal mining companies do not follow this practice, leaving pregnant women vulnerable to exposure to harmful chemicals;
- The continuous use of conventional machinery and equipment such as hand-held drills causes vibration and mechanical shocks over time;
- The nature of mining operations and the activities undertaken causes the release of dust, which needs to be watered down. Although there is PPE, Botha (2017) notes that long-term exposure to dust eventually affects women's ears, eyes, and lungs. This

exposure can drain their energy as aspects such as seeing and hearing becomes blurred and slow down their productivity;

- The underground environment is supplied with ventilation; however, there are working areas that may be poorly ventilated, causing women to experience extreme heat. Engineering controls, such as increasing air velocity in the mine, and altered work practices, such as limiting time in hot areas of the mine, can be used to prevent heat-related illness for mine workers;
- Mine workers (women and men) often must work with equipment and machinery that produce a considerable amount of noise. The most common sources of hazardous noise in mining are pneumatic and percussion tools, ventilation fans, compressors, crushers, and grinding mills. Working in environments with hazardous noise levels can result in occupational deafness and hearing loss. The South African occupational noise exposure limit is set at 85 dBA (Moroe, et al., 2022). The country follows a 3-dB exchange rate, unlike the US and Brazil, which implement a 5-dB exchange rate rule;
- Female mine workers also engage in physically demanding tasks that require the repetitive use of large and bulky tools and equipment. This can intensify their exhaustion levels. In underground mines, the time it takes to travel to and from change houses has significantly increased, particularly as mineshafts continue to deepen. Some employees now spend around three hours each day only getting to and departing from their workstations. Additionally, the long hours spent standing in open-pit mines contribute to considerable exhaustion;
- Diesel accounts for 46% of operational costs in open cast mines. It is used in equipment and machinery dump trucks, excavators, front end loaders, bulldozers, graders, and water trucks. Underground diesel-powered equipment includes drill rigs, loaders, and dump trucks. The diesel-powered equipment releases exhaust gases such as carbon monoxide, to which short- and long-term exposure may cause acute irritation, asthma, coughing, light-headedness and lung cancer;
- Confined spaces in underground mines, particularly in narrow-reef mines, require bending that may affect the back depending on the length and frequency of bending. Repetitive bending can exhaust the body;
- Both men and women generally experience higher rates of mental health conditions due to the work environment and culture, which can make the body feel tired (Eiter, et al., 2023). Furthermore, psychological stress often results in self-medication or substance misuse to cope; and
- A study examining the effects of the mining industry on women in Zambia revealed that copper mining contributes to environmental pollution, including air and water

contamination from emissions such as sulphur dioxide from smelter stacks. Working in such environments can significantly deplete women's energy levels (Business & Human Rights Resource Centre, 2015).

2.6 Impacts of over-exertion on women's health and safety

Over-exertion in the mining industry can have significant and multifaceted impacts on women, affecting their physical health, mental well-being, job performance, and long-term career prospects. A study investigating the causes of injury in mining in Australia highlighted that most injuries are caused by over-exertion (Jones, et al., 2019). Furthermore, older employees were more prone to over-exertion due to their reduced strength and mobility. This was applicable to both men and women.

Pregnant women who are not removed from harmful mining working environments become more tired than those who are not pregnant. Furthermore, their exposure to metals such as cadmium, aluminium, manganese, zinc, lead, mercury, and arsenic lead to foetal growth delays, adverse birth outcomes, and child behavioural and cognitive issues, including cerebral palsy and autism (Eiter, et al., 2023). This implies that these metals do not only affect the pregnant woman and her foetus, but also have impact on the child once born.

The following impacts result from over-exertion:

- Inadequate ventilation can lead to dehydration, which may cause respiratory failure, potentially resulting in brain dysfunction or even death (Lu, 2012);
- Excessive exposure to heat causes impaired work capacity, errors of judgement while working, dehydration, and complications such as heat stress, heat stroke, fatality (even though it is not common);
- Long hours of activities that require physical strength harm the female reproductive system and result in the development of musculoskeletal disorders (MSDs) (Eiter, et al., 2023). Furthermore, women have a higher risk of developing work-related MSDs than men (73% versus 54.3%) due to work design aspects such as the human-machine interface and interaction, the bulky size and shape of the tools and equipment and the repetitive nature of the task(s) being performed (Eiter, et al., 2023). Furthermore, the long working hours could result in muscle strain, sprains, and tears;
- Heavy physical labour may affect menstrual health and exacerbate conditions such as endometriosis or dysmenorrhea;

- Psychological factors such as stress and anxiety can cause disorders in the menstruation cycle (Eiter, et al., 2023);
- The exposure to sulphur dioxide from smelter stacks, which drains energy, can cause lead and cadmium poisoning (Business & Human Rights Resource Centre, 2015);
- Over-exertion, coupled with exposure to hazardous substances, can negatively impact reproductive health. It may increase the risk of miscarriages, pre-term labour, and other pregnancy-related complications. Pregnant women in mining can be exposed to Teratogens, which lead to a problem in setting occupational health standards (Badenhorst, 2009). An embryo of a few weeks or a foetus of a few months should be given consideration and should not be exposed to a toxic environment. Even after birth, some chemicals can be passed to the baby during breast feeding and could possibly impair the health and development of the child;
- The mining environment, work stress, and the need to balance work and life cause chronic and mental fatigue that results in substance abuse as a coping mechanism;
- Exhaustion decreases the level of concentration and safety consciousness, resulting in injuries such as slips, trips, and falls. These injuries lead to pain and having to constantly purchase medicine to address medical or physical pain resulting from over-exertion; this, in turn, contributes to financial strain;
- Prolonged over-exertion can lead to chronic health conditions that may limit a woman's ability to work in the mining industry. Decreased productivity at the workplace results in a negative attitude; and
- Women may be unable to fulfil some family and marital responsibilities due to the impacts of over-exertion (Botha, 2017).

Addressing the impacts of over-exertion on women in mining requires a holistic approach, including ergonomic interventions, work schedule adjustments, health monitoring, access to appropriate PPE, and support systems to ensure a safe and inclusive working environment.

2.7 Milestone conclusion

This literature review provided a background to women in the mining industry, both locally and internationally, identified risks facing women in mining, and discussed causes and impacts of over-exertion on women’s health and safety. Some of the identified risks and factors that could potentially result in over-exertion of women in mining include marginalisation of women; lack of gender-appropriate modifications of procedures, tools, equipment and facilities; reproductive considerations; inadequate PPE; physically demanding work; hot work environments; exposure to dust, toxic gases, noise, and vibration; long and inflexible working hours; the “double-jeopardy” of domestic work; and sexual harassment and bullying. Identified impacts of over-exertion include fatigue, musculoskeletal disorders, injury, impaired job performance, stress and anxiety, reproductive problems, and relationship issues. These findings informed the variables to be included in the development of a survey tool for the assessment of over-exertion of women in the SAMI. The findings from the survey will assist with gaining specific insight into these factors for women in the SAMI, and to assist with prioritising interventions to address the identified concerns.

2.8 Next milestone

The following chapter details the development of an assessment tool that was used to assess over-exertion of women within the mining industry. The segregation of roles was incorporated into the tool, where an evaluation of the potential propensity to over-exertion was evaluated and highlighted through analytics. The literature review informed the development of the survey tool, and has highlighted causes of over-exertion of women within the mining industry. The focus was on challenges that specifically affect women, over and above the inherent risks associated with the core business of mining that also affect their male counterparts. Following the use of the tool by women in mining in the SAMI during the project, further opportunities for optimisation will be incorporated into the work to enable a more objective assessment of causes of over-exertion.

3. ASSESSMENT TOOL

3.1 Introduction

The objective of Milestone 3 was to develop an assessment tool to assess over-exertion of women at identified mines in the South African mining industry (SAMI) and its impacts on health and safety. As per the scope of work provided for the project, related considerations include the following:

- The tool must motivate or act as a go-to instrument to assess and mediate over-exertion for women who work in the hazardous environments of the SAMI;
- The different occupations and environmental conditions that women work in, in relation to hazardous environments in the SAMI;
- Body Mass Index (BMI) and fitness to perform work, and if this has an impact in the hazardous areas of the mining environment;
- Determination of the relationship between the hazardous working environment in the SAMI and the well-being of women, emotionally and physically; and
- The occupational health and safety (OHS) impact on women because of over-exertion.

Over-exertion occurs when a person pushes themselves beyond their physical or mental limits. As such, over-exertion may be defined as when the demands placed on a person exceed their capability. This over-exertion may result in strain, such as fatigue, discomfort, pain, and an increased possibility of accidents or injury. A basic model for this project is shown in Figure 3. Ideally, there should be a good balance between the demands placed on an individual and their capability or capacity. The assessment tool developed considers variables related to both the demands and capability of women in mining (WIM), along with the impacts of a potential imbalance between these aspects.

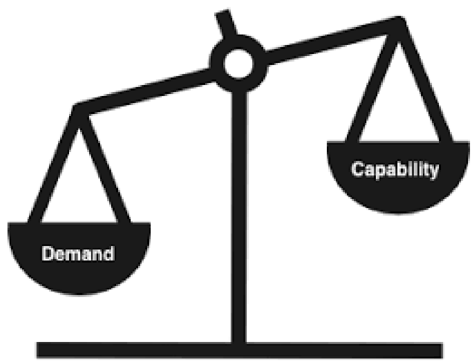


Figure 3: Demand versus capability scale (image taken from Lilja, 2013)

The rationale for focusing on over-exertion particularly for WIM, is because of the increased participation of women in the industry, along with the differences between men and women. As females generally have lower physical work capacity, strength, and potentially lower heat tolerance than males, they would have to work closer to their physical work capacity than men to maintain the same levels of productivity, which could lead to over-exertion (Dlamini, 2016; Van Aardt *et al.*, 2008). Additionally, there are differences in the anthropometry and body composition between females and males (Van Aardt *et al.*, 2008). As tools and equipment have predominantly been designed based on a male data, this could contribute to the risk of accidents and musculoskeletal disorders in women (AngloAmerican, 2012; Hodgskiss *et al.*, 2017; Van Aardt *et al.*, 2008; Zungu, 2012). The health, safety and performance of WIM may be compromised if their needs are not accommodated (Zungu, 2012).

3.2 Development of the assessment tool

The findings of the literature review informed the development of the assessment tool. Main findings pertaining to causes and impacts of over-exertion of women in the SAMI were key inputs into the development. These aspects were included as survey questions in the tool. Inputs into the tool were further received from the project team, the MHSC, and its stakeholders.

3.2.1 Basic architecture

The assessment survey was presented as a web application form that the respondents could complete or select options or drop-down menu inputs. The assessment tool communicates with an Application Programming Interface (API) to enable the integration with Rehabilitation and Functional Assessment (RFA) database information. For participants who have completed an RFA assessment, the web application/portal was accessed by study participants by supplying their ID or passport numbers. This enabled data collected to be linked to RFA data. The data was, however, anonymised prior to analysis.

The tool was also available on MS Forms, in cases where a link to the RFA system was not possible. The MS Forms data was anonymous, as data such as name, employee or ID numbers were not required.

Table 4 and Figure 4 show a summary of the basic system architecture.

Table 4: Basic system architecture

System Component	Description	System Owner
Cloud service	The assessment tool is hosted on the Google Firebase cloud platform.	CSIR Mining Cluster
External API and Database	External API accessed to retrieve test participants' data.	The Work Expert (TWE)
Platform development	The front-end of the application is developed in Angular, the back-end implements Firebase SDK as well as issues HTTP requests to external API.	CSIR Mining Cluster
Authentication	Participant data is requested with a dedicated API key to retrieve the data related to this research project.	CSIR Mining Cluster / TWE

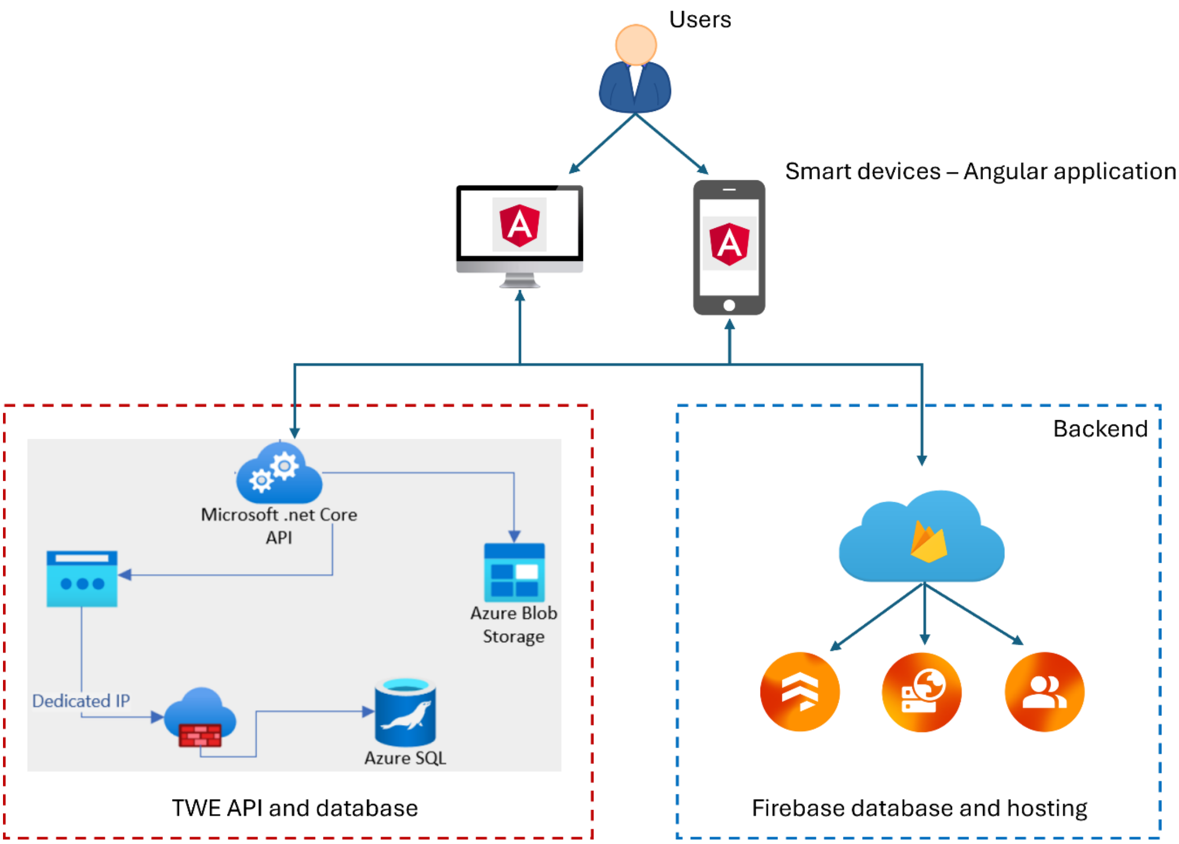


Figure 4: System architecture

3.2.2 Assessment parameters

Over-exertion in the mining industry can have significant and multi-faceted impacts on women, affecting their physical and mental health, well-being, job performance, and long-term career prospects. Indicators of over-exertion include fatigue, impaired mood and concentration, injuries, and accidents.

Assessment parameters included in the over-exertion assessment tool were derived from literature in the Milestone 2 project report. The study variables were related to the demands, capacity, and health, safety and wellness impacts of over-exertion. A summary of these parameters is shown in Figure 5.

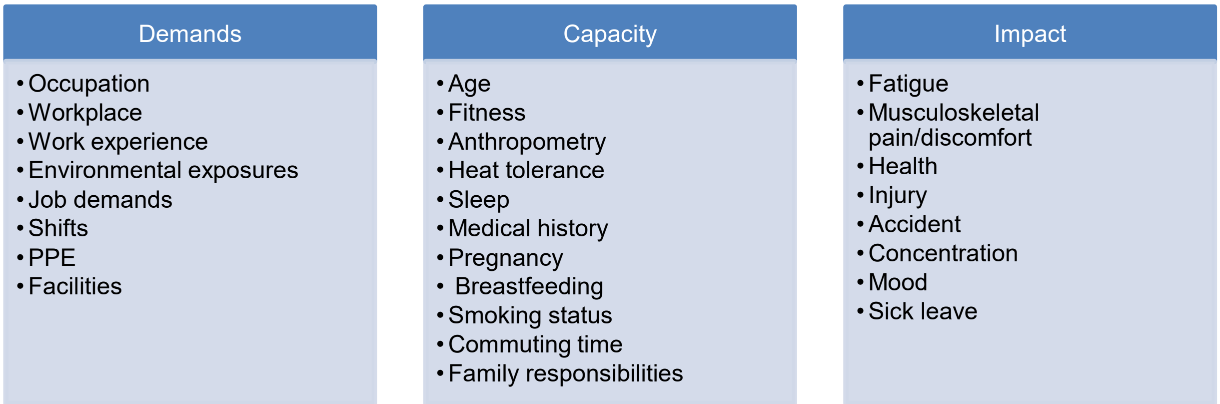


Figure 5: Summary of assessment tool variables

In the assessment tool, the questions were grouped in the following sections:

- Work environment;
- Personal factors;
- Health, safety and wellness;
- Anthropometry (body measurements); and
- Fitness/work capacity.

Most of the questions were quantitative and entailed the selection of a response. However, qualitative data was sought to gain more detailed data in terms of PPE, medical conditions, and medication taken by the participants. In addition, open-ended questions were added at the end of the survey for any further comments from the participants. Both subjective and objective data were gathered.

The anthropometric data included that of stature, body weight, waist girth and hip girth. Stature and body mass can further be used to calculate the individuals' BMIs. Waist and hip girths (circumferences) can be used to calculate waist-to-hip ratios. The BMIs, waist girth, and waist-to-hip-ratio values can be used as an indication of the women's fitness and health status. This data could be measured directly from the participants or taken from the RFA tool.

RFA data relating to fitness and work capacity were only available if the participants had completed this assessment previously, as part of work requirements. Some of the mines where data collection took place did not have RFA centres, and as such the analysis of RFA data only took place when this information was available, to enhance the project findings. As such, statistics for these variables involved a smaller sample size than for other variables.

Table 5 includes a list of the variables gathered in the assessment tool. The full list of survey questions and response options are included in Appendix A.

Table 5: Assessment tool variables

Work environment	Personal factors	Health, safety and wellness	Anthropo-metry	RFA data
• Occupation/job category • Workplace • Commodity • Work experience • Heat • Dust • Noise • Lighting • Humidity • Chemicals • Confined workspaces • Hand-arm vibration • Whole-body vibration • Lifting/lowering of loads • Repetitive motions • Cognitive demands • Long walking distances • PPE • Access to toilets • Access to water • Thirst • Water consumed • Energy drinks consumed • Shift roster • Shift length • Shift breaks • Overtime • Breathlessness • Harassment	• Age • Recreational exercise • Intensity of exercise • Commuting time • Family responsibilities • Hours of sleep – workdays • Hours of sleep – off days • Sleep latency • Sleep quality • Sleep medications • Medical conditions • Medication • Heat tolerance • Smoking status • Pregnancy • Breastfeeding • Menstrual cycle	• Muscle pain • Tiredness before shift • Tiredness during shift • Tiredness after shift • Anxiety/sadness • Concentration • Mood • Quality of life • Health status • Incident at work • Sick leave	• Body weight • Body height • Waist girth • Hip girth	• Physical and functional work capacity • Cardiorespiratory fitness data • Load handling capabilities • Physical intensity and functional requirements of occupations where females are employed • Current pathology and treatment

3.2.3 *Stakeholder engagement*

An engagement session was held with the project team members to present and engage on the development of the assessment tool. Table 6 lists the expertise and relevance of those who participated in the session.

Table 6: Stakeholder list

Stakeholder function / expertise	Organisation	Contribution / relevance
Occupational Therapist	TWE	Focus on occupational aspects affecting different levels of employment. Supported development of assessment tool through the provision of an API and access to database.
Statistician	CSIR	Data collation and analytics to support assessment tool optimisation.
Operations Researcher	CSIR	Systemic interpretation, modelling.
Human Factors (x2)	CSIR	Focus on human factors affecting over-exertion.
Occupational Medical Practitioner	Mishumo	Focus on medical and anthropometric aspects affecting over-exertion.

The purpose of the engagement session was to:

- Present the findings of the literature review;
- Demonstrate the first iteration (beta-version) of the assessment tool; and
- Solicit inputs on potential improvements to be implemented.

Following the demonstration of the tool, the following recommendations were made:

- Include an informed consent notice on the landing page indicating that the participants understand the purpose, risks, and benefits of the study before participating in the assessment;
- Hormonal aspects could affect work ability and contribute to over-exertion; it was recommended by the group to include hormonal aspects, which may include the following: menstrual cycle, menopause, perimenopause;
- Review the current questions in the tool and focus attention on only those that affect over-exertion. For example, the use of chemicals may affect a pregnant mother and the unborn child; however, it may not directly over-exert the mother;
- Consider including a question that assesses whether the participant has chronic conditions, as some conditions may contribute to over-exertion; and

- Consider including a scale that gives an indication of mood (analogue scale), which may affect the mental alertness of the participants.

Further recommendations included the following:

- Continue to develop and update the assessment tool to ensure that all effects are considered;
- Revise the language used in the assessment tool questionnaire into simple English to ensure all respondents understand the questions fully;
- Include a risk calculation rating based on a Rating of Perceived Exertion (RPE) scale, fatigue and musculoskeletal effects to determine the level of over-exertion; and
- Consider including updates such as a weighted rating scale to ensure that the tool gives a visual indication of the potential for over-exertion.

The tool was updated based on the recommendations that were made. For example, a consent form, including Protection of Personal Information Act (POPIA) considerations, was included on the landing page of the tool. Questions relating to hormonal cycles, medical conditions, and mood were included in the tool. Furthermore, the questions in the tool were streamlined to focus on the most applicable aspects. Development continued to ensure important aspects relating to over-exertion were included, such as fatigue, RPE and musculoskeletal strain. The language was reviewed to ensure it was easy to understand by the study sample. While considered, it was not feasible to provide a scoring system and immediate feedback to each participant for this phase of the project. The study findings will assist to refine potential weightings and priorities of certain variables in relation to over-exertion.

In addition, feedback on suggested improvements was provided from the MHSC, and the inputs were used towards revisions of the tool. These inputs included additional work-related factors to consider in the questionnaire, including environmental, ergonomic, and shift work variables.

As such, the recommendations that were made during the engagements were considered and, where feasible, incorporated into the updated version of the assessment tool.

3.3 Data collection procedures

To enable data collection using the assessment tool, a user adoption strategy was developed. This strategy involves the identification of relevant stakeholders in line with the planned sample (indicated in Milestone 1). Permission for participation was sought from the mining industry in the form of letters. The participating mines were identified and on-boarded. The purpose and impact of the study was presented and input solicited from the stakeholders around the implementation plan, including access to operations, timelines, templates, and other logistical matters. Where necessary, the team conducted a demonstration of the assessment tool to create awareness of the questionnaire and how the assessment tool works.

Figure 6: Flow diagram illustrating data gathering processes in the project

The basic project flow, incorporating planned data collection, is illustrated in Figure 6. Project initiation (Milestone 1) took place to ensure alignment of the project team and the MHSC on the project aims and plans, and for necessary administrative process to be completed. In Milestone 2, a literature review was conducted to inform the questions to be included in the assessment tool (Milestone 3). Milestone 4 involved data collection with the use of the assessment tool at participating mines. In parallel with Milestone 4, desktop research, interviews, and focus group discussions were used to assess OHS reporting channels available for WIM (Milestone 5). These discussions were planned to take place at the participating mines and with broader industry stakeholders. This research further informs recommendations for potential additions to existing reporting channels (Milestone 6). The findings from the data gathered were consolidated and then presented and discussed in a workshop session with stakeholders for their information and to gain their inputs (Milestone 7). This input was incorporated into the draft final report of the project. The final report was submitted once inputs from the MHSC were received and incorporated. Furthermore, information dissemination will take place to share the findings of the research more broadly.

3.4 Interviews and focus group discussions

In addition to data collection using the developed tool, focus group discussions were held with various stakeholders, primarily relating to the reporting channel assessments and evaluations, as required in Milestones 5 and 6 of the project. The focus group discussions were directed by open-ended questions, and follow-up questions were also posed. In cases where WIM in mining participated directly in the focus group discussions, considerations of gender or sexual identity were made. The basic question guide is included in Appendix B.

3.5 Data analysis

Statistical analysis was undertaken on the data collected *via* fieldwork with the assessment tool. The statistical analysis involved summarising data patterns, as well as applying regression analysis to assess relationships between capacity, demand and impact assessment variables within the collected data, and the results were reported in an assessment report. The qualitative data, primarily from the interviews and focus group discussions, were captured electronically, and assessed using thematic analysis. The results were integrated (methodological triangulation), and conclusions and recommendations were drafted based on the findings.

3.6 Limitations

There are evident limitations with the use of survey tools, such as the assessment tool developed in this project, including the reliance on self-reported data. Self-reported data limitations include social desirability bias, response bias, and inaccurate recall. While the responses are highly dependent on respondents' experiences, many of the questions require objective information (e.g. workplace, shift cycles, medical conditions etc.). Furthermore, the linkage to the RFA database, enables the provision of objective physical performance data. The length of the survey was a potential concern; however, this was balanced with the need to be comprehensive. The data gathered in the project could be used to streamline the content, based on identification of the variables with the strongest associations with over-exertion.

3.7 Milestone conclusions

A beta-version of the assessment tool was developed. The assessment tool was demonstrated to and evaluated by stakeholders with relevant expertise to identify and recommend appropriate questions to be included in the survey. The recommendations were considered and included in the assessment tool, which can now be implemented.

3.8 Next milestone

The following milestone involved data gathering using the assessment tool to assess causes and impacts of over-exertion of women in the mining industry. The project plan, including the identification of relevant stakeholders and contact points at mines, was established and implemented. Permission for research and access to mine staff was sought from relevant stakeholders and mining company management. Ethics approval was finalised to ensure compliance with good governance standards. Following the acceptance of the tool and ethics clearance, the team conducted data collection using the assessment tool at mines. Once sufficient data was collected, these were analysed.

4. ASSESSMENT REPORT

4.1 Introduction

The objective of this milestone was to determine the efficacy of the approved assessment tool to measure the over-exertion rates of women at identified mines. The associated activities included obtaining ethics approval, permission for participation from mines, data collection, data cleaning and analysis, and reporting.

4.2 Methods

4.2.1 Overview

The project utilised a mixed-methods research approach, and both qualitative and quantitative data were gathered. For this milestone, data were collected using the assessment tool developed during the project (Milestone 3). The questions included in the assessment tool are attached (Appendix A). For this assessment, over-exertion was defined as when the demands placed on a person exceeded their capacity or capability; this may result in fatigue, discomfort, impaired concentration and mood, and an increased probability of accidents or incidents. This definition was based on the work system model and Balance Theory, as shown in Figure 7 (Carayon, 2009).

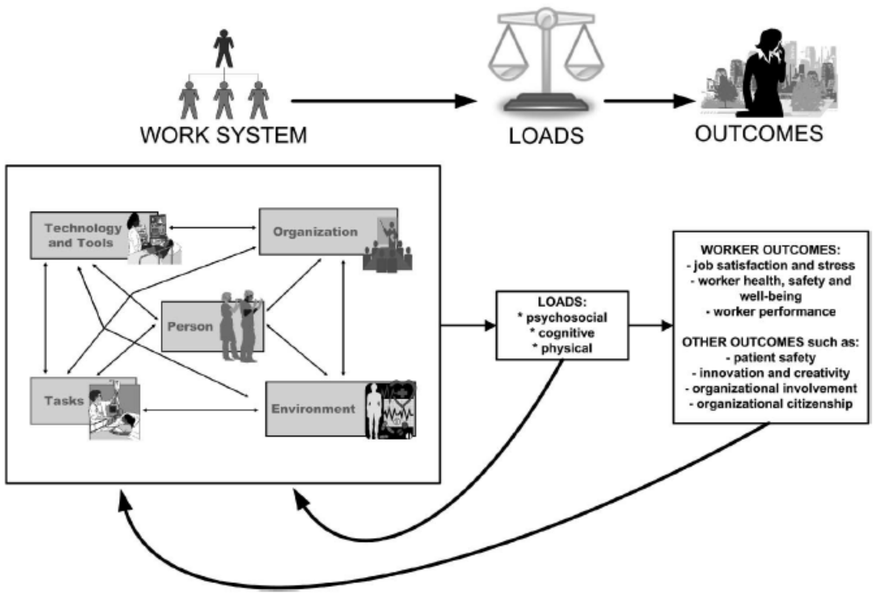


Figure 7: Impact of the work system on psychosocial, cognitive and physical loads and outcomes (Carayon, 2009)

It should be noted that currently there is no single, comprehensive definition or measurement of over-exertion available in industry, and this has presented a challenge for this project. The data collection had to take into account that over-exertion can be seen as purely physical, mostly mental, or a combination of the two. It was therefore not possible to use only one measure of over-exertion, and therefore a decision was taken to measure a range of facets that may contribute to over-exertion.

The assessment questions were developed based on insights gained from the literature review (Milestone 2). Examples of aspects that relate to job demands included environmental exposures, shifts worked, PPE and facilities. Capacity-related questions included those relating to fitness, health, sleep, and household responsibilities. The assessment survey was developed as a web-based application that communicates with an Application Programming Interface to enable linkages with fitness and anthropometric data. The survey was also available on MS Forms and hardcopy formats. Most of the questions required a selection of responses from available options. A few open-ended questions were also included, for which the findings were categorised into themes and are included in the Milestone 6 report (Chapter 6). Further detail of the project methods and assessment tool are included in the Milestone 1 and 3 reports (Chapters 1 and 3).

Data were collected from participating women from the participating mines, via the survey links or using hardcopy versions, where preferred. The participants took approximately 20 minutes to complete the questionnaire. The surveys that were completed on hardcopy versions were subsequently captured electronically. The mining companies facilitated the distribution of the surveys to potential participants, with in-person facilitation available, where the usefulness of this was identified. The data from the tools were consolidated into Excel workbooks for further analysis. Data cleaning took place prior to analysis.

4.2.2 Analysis plan

The analysis of the survey data consists of a summary of the data collected via descriptive statistics such as summary tables and charts, as well as a more in-depth analysis of patterns contributing to measures of over-exertion. As noted in section 4.2.1, a number of different aspects contributing to over-exertion were measured, since no single measure currently exists. Therefore, the in-depth statistical analysis consisted of the definition of various "outcomes" variables to help represent over-exertion. Survey questions that asked respondents to rate their musculoskeletal strain, fatigue, perceived exertion, health, overall feelings and quality of life, to say how often they feel anxious or feel that they cannot concentrate, and to indicate how many days of sick leave they required, were all considered "outcomes" representing facets of over-exertion and were therefore analysed further.

The statistical analysis of the "outcomes" variables consisted of compiling cross-tables (also called contingency tables) comparing the counts per category of the "outcomes" measures with those of other factors measured in the survey questions (as detailed in Chapter 3), both as related to the workplace and person-related, such as smoking and exercise. The strength of associations between each "outcome" variable and each underlying "factor" variable was tested with Chi-squared tests applied to the contingency table values. In addition, step-wise Logistic regression, with the "outcome" variables as dependent variables, was applied to determine which (if any) of the "factors", used as independent variables, contribute to lower levels of health or wellness as measured by the "outcome" variables. The statistical analysis included all data obtained from the quantitative survey, except for the answers to open questions. Most of the analysed data were answered in terms of the selection of an option from a pre-coded list, thereby providing categorical data elements – the statistical analysis therefore mainly used categorical analysis methods. Some of the data, such as weights and heights, were supplied as continuous (not categorised) data, and so some correlation analysis could be done on those variables. Where necessary, levels of "outcomes" variables were first grouped into high/low/middle categories before analysis, to ensure that the analysis could be carried out on ordered variables with only two or three levels.

Summary statistics for each of the measures recorded in the quantitative survey, also indicating the categories used in answers, are provided in subsection 4.3, below, while details on the "outcomes" variables and the statistical analysis results are provided in subsection 4.4.

4.2.3 Research ethics clearance

Research ethics clearance is required for research involving human participants. Research ethics is important to confirm that the research is conducted responsibly to minimise potential harm and maximise the benefits, while ensuring adherence to aspects such as anonymity, confidentiality and voluntary informed consent of participants. An initial ethics application and supporting documentation were compiled and submitted to the CSIR's Research Ethics Committee (REC) in June 2024. Review and modifications of the documents were required, and ethics approval was finally granted on 2 May 2025, on the condition that signed permission letters from participating mines be submitted. These permission letters were subsequently submitted to the REC. A copy of the research ethics clearance certificate is provided in Appendix C (Ref: 478/2024).

4.2.4 Permissions from mines

A stakeholder map and plan were drafted during project initiation. The initial list of mines that were identified for participation (nine mines) included those that had an associated RFA centre, so that the related data could be linked with data collected using the assessment tool. A contact list for identified mines was drafted. Invitation emails were sent to the mine contacts from March 2025 to request participation in the study. Telephonic and/or electronic follow-ups were made following this time. Of these mines, five provided approval to participate within the project timeframe. In addition, the project was presented to the MHSC WIM Committee, with an invitation for participation. It was further suggested that the selected mines include small, junior, and emerging miners to enhance representation. The list of participating mines was expanded based on interest received, with four additional companies participating in the project. Meetings were held with interested mines and organisations to discuss participation and what the study would involve. Those agreeing to participate were requested to sign permission letters before data could be collected. Where necessary, supporting documentation was submitted to enable this permission to be granted from the relevant personnel at the mines. A copy of the permission letter is included in Appendix D.

4.3 Results

4.3.1 Overview

Data collection commenced on 2 June 2025 and concluded on 5 September 2025. A total of 554 questionnaires were completed, but 5 participants indicated that they were not willing to be included in the survey, and therefore, 549 questionnaires could be used in the analysis. This report provides an overview of the results of the questions, along with the statistical analysis of the findings. In the assessment tool, the questions were grouped in the following sections:

- Work environment;
- Personal factors;
- Health, safety and wellness;
- Anthropometry (body measurements); and
- Fitness/work capacity.

4.3.2 Study sample obtained

Permission to conduct the study was obtained from nine mining companies, with three of these incorporating both surface and underground operations. Participation from most of the organisations took place from multiple mining sites. The planned versus current study sample per commodity is shown in Table 7. The planned study sample was stipulated in the scope of work for the project provided by the MHSC, and indicated in Chapter 1. While the total number of participants is beyond the planned amount, there is some variation in terms of numbers per mine and commodity group. Both contract and permanent employees were included.

Table 7: Final study survey numbers

Commodity	Number of participants	Planned number of participants
Gold (underground)	55	104
Platinum (underground)	65	104
Coal (surface and underground)	217	104
Iron Ore (surface)	97	26
Chrome (underground)	65	Other (underground): 104 Other (surface): 52
Manganese (surface and underground)	30	
Aggregates/construction materials (surface)	20	
Total	***549***	***494***

4.3.3 Work environment

Figure 8 illustrates the workplaces of the survey respondents. It is evident that a relatively large proportion of the respondents were office workers. The primary intended data collection method was the use of online rather than hardcopy surveys, and it is likely that office workers had easier access and time to complete the survey using their computers or smartphones, hence accounting for the higher response rate in this group. In the end, around half of the surveys were completed using hard copy versions, which were subsequently captured online. As a result of differences between groupings, the findings have been grouped into the following categories:

- Surface office [n=174] (32%);
- Surface workers ("surface plants"; "surface with environmental exposure"; "surface workshop"; [n=166] (30%); and
- Underground workers ("underground cool", "underground hot – unrestricted/development"; "underground – restricted/stopes"; "underground workshops") [n=208] (38%).

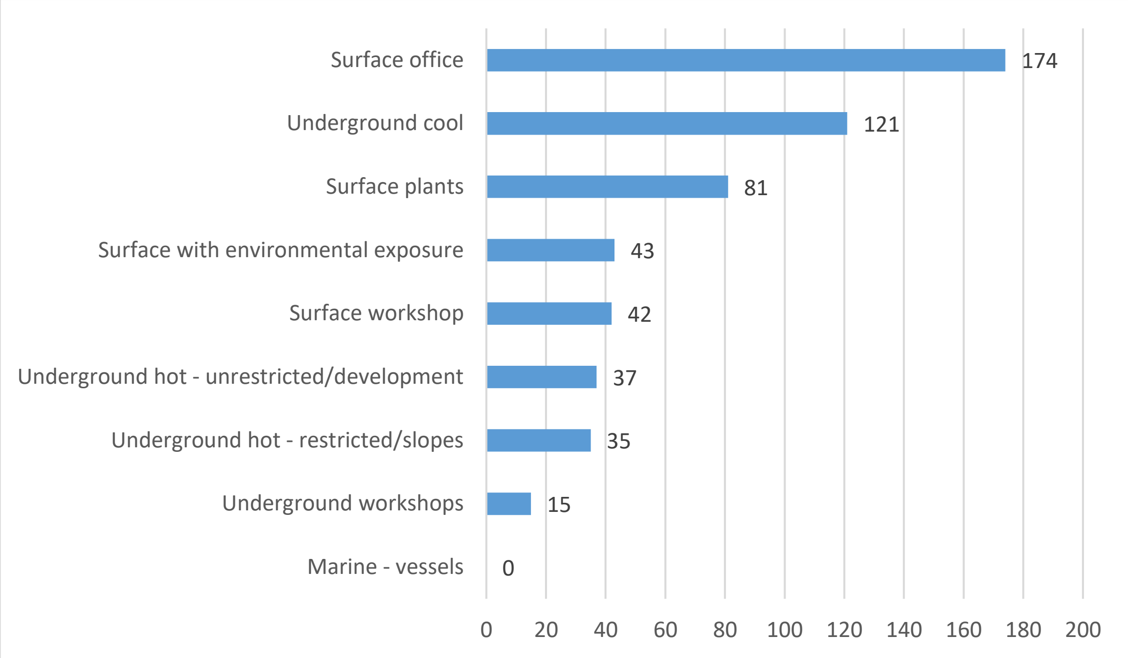


Figure 8: Workplace

The respective commodity groups for respondents in each of these categories is shown in Table 8.

Table 8: Respondent commodity groups

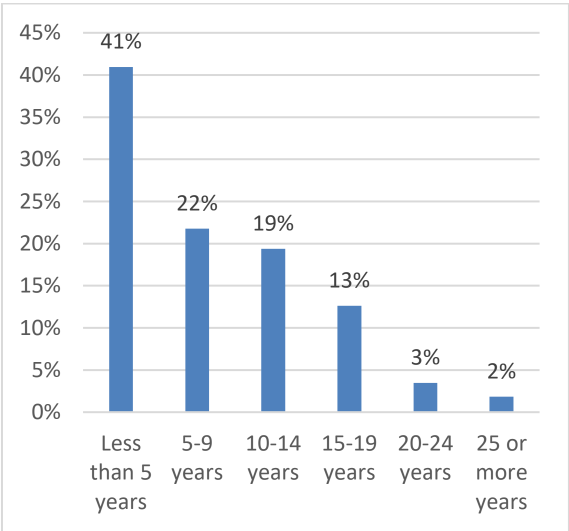
Respondent group	Commodity	Sample size n(%)
Surface office workers	Aggregates/construction materials	10 (2%)
	Chrome	22 (4%)
	Coal	77 (14%)
	Gold	8 (1%)
	Iron ore	36 (7%)
	Manganese	13 (2%)
	Platinum	8 (1%)
Surface workers	Aggregates/construction materials	10 (2%)
	Chrome	14 (3%)
	Coal	58 (11%)
	Gold	3 (1%)
	Iron ore	61 (11%)
	Manganese	10 (2%)
	Platinum	9 (2%)
Underground workers	Chrome	29 (5%)
	Coal	81 (15%)
	Gold	44 (8%)
	Manganese	7 (1%)
	Platinum	46 (8%)

Table 9: Occupations of respondents and workplace grouping

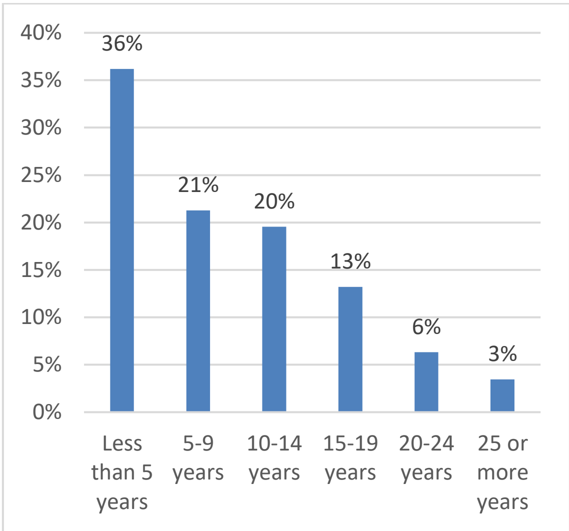
Workplace	Physical intensity of work	Occupation	Sample size n(%)
Surface office workers	Roaming	Manager	10 (2%)
	Sedentary	Office worker	101 (19%)
	Light	Cleaner	21 (4%)
		General surface worker	14 (3%)
		Professional (e.g. geologist, engineer, hygienist, heat and safety officer, metallurgist etc.)	11 (2%)
		Health worker (e.g. nurse, doctor, therapist, radiographer, first aider, full-time safety rep. etc.)	3 (1%)
		Supervisor	1 (0.2%)
	Moderate	Artisan	13 (2%)
	Heavy	Artisan assistant	1 (0.2%)
Surface workers	Roaming	Manager	5 (1%)
	Sedentary	Office worker	5 (1%)
	Light	Supervisor	27 (5%)
		Driver (e.g. dump truck, forklift, light vehicle etc.)	13 (2%)
		Operator (e.g. plant, chairlift etc.)	9 (2%)
		Cleaner	8 (1%)
		Professional (e.g. geologist, engineer, hygienist, heat and safety officer, metallurgist etc.)	7 (1%)
		Health worker (e.g. nurse, doctor, therapist, radiographer, first aider, full-time safety rep. etc.)	2 (0.4%)
	Moderate	General surface worker	24 (4%)
		Artisan	21 (4%)
		Plant operator	10 (2%)
		Belt attendant	5 (1%)
		Mining team (e.g. drill rig operators, drill rig assistants etc.)	3 (1%)
		Shaft assistant	1 (0.2%)
	Heavy	Artisan assistant	18 (3%)
Underground workers	Light	Supervisor	21 (4%)
		Operator (e.g. plant, chairlift etc.)	15 (3%)
		Professional (e.g. geologist, engineer, hygienist, heat and safety officer, metallurgist etc.)	5 (1%)
		Driver (e.g. dump truck, forklift, light vehicle etc.)	5 (1%)
		Health worker (e.g. nurse, doctor, therapist, radiographer, first aider, full-time safety rep. etc.)	2 (0.4%)
		Banksman / onsetter	1 (0.2%)
	Moderate	General miner	33 (6%)
		Belt attendant	28 (5%)
		Artisan	19 (4%)
		Loco operator	6 (1%)
		Shaft assistant	5 (1%)
		Cleaner	2 (0.4%)
	Heavy	Mining team (e.g. rock drill operator, scraper winch, water jet, cheesa, etc.)	33 (6%)
		Construction worker (pipes, tracks, ventilation etc.)	18 (3%)
		Development and construction worker	8 (1%)
		Artisan assistant	4 (1%)

A breakdown of the participating occupations, as indicated by the respondents, is provided in Table 9, along with the reported workplace group. Around a third of the participants' occupations fall in the "strenuous" work category. Strenuous work can be defined as that with a work rate exceeding 160Watts/m^2, and includes moderate to heavy work, according to the Department of Mineral and Petroleum Resources (DMPR) fitness to work guidelines (DMPR, 2013). Most (85%) of the underground occupations fall into the strenuous work category.

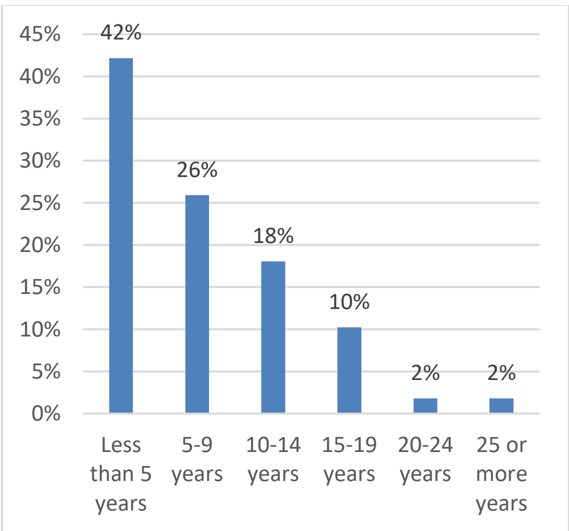
Figure 9 illustrates the number of years that the respondents had been working in mining. The majority (41%) had been working in mining for less than 5 years. Around 37% had been working in mining for 10 or more years.



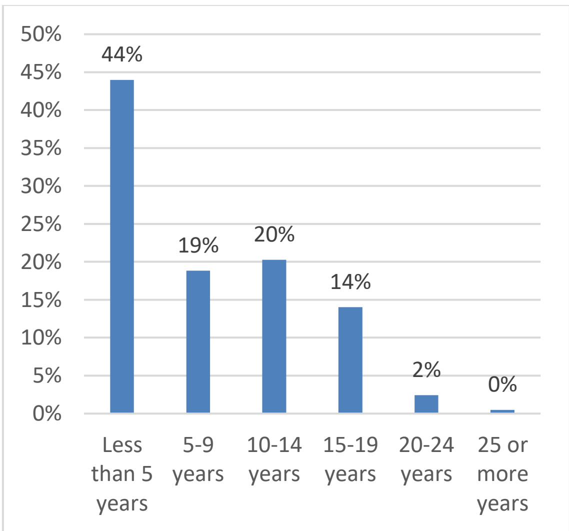
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 9: Length of service

Table 10 details the occupational exposures that the respondents reported. In the study sample, the most commonly reported workplace exposures were thinking and planning (i.e. mental demands) (68%), noise (66% of the sample), and dust (65%). However, it was evident that these exposures differed according to workplace. The primary exposure for surface office workers was thinking and planning (mental demands) (72%). For other surface workers, the main exposures were noise (81%), dust (77%), and thinking and planning (70%). Underground workers appeared to face the highest number of exposures, with over half noting exposures to noise (88%), dust (83%), long walking distances (67%), lifting and lowering (63%) and thinking and planning (62%). All of these occupational exposures could be linked with mental or physical over-exertion (e.g. as indicated in Botha, 2017; Mwendwa, 2023; Jones *et al.*, 2019; Stanton *et al.*, 2007).

Table 10: Occupational exposures

Group	Exposure	Total sample	Office workers	Surface workers	Underground workers
Mental demands	Thinking and planning	68%	72%	70%	62%
Physical demands	Long walking distances	44%	16%	43%	67%
	Lifting and lowering	43%	10%	51%	63%
	Repetitive motions	42%	29%	48%	47%
	Confined spaces	21%	7%	20%	33%
Environmental exposures	Noise	66%	24%	81%	88%
	Dust	65%	31%	77%	83%
	Cold	30%	11%	45%	35%
	Hand-arm vibration	28%	6%	41%	35%
	Humidity	26%	11%	23%	41%
	Heat	26%	10%	32%	34%
	Hazardous chemicals	23%	12%	26%	29%
	Poor lighting	19%	4%	19%	32%
	Whole-body vibration	16%	2%	28%	18%

Participants were asked whether their PPE fitted properly. While this did not apply to a number of office workers, the majority indicated that their PPE did fit properly (Table 11). Poor PPE fit can affect comfort, protection, job performance, and increases the risk of accidents (Badenhorst, 2009; Botha and Cronjé, 2015; Eiter *et al.*, 2023). An open-ended question was posed in which participants were asked “What adjustments do you believe will help to improve your PPE?” Responses were received by around half of the participants. These findings have been detailed in the Milestone 6 report (Chapter 6).

Table 11: PPE fit

	Total sample	Office workers	Surface workers	Underground workers
PPE fits properly	82%	63%	87%	94%
PPE does not fit properly	6%	3%	10%	4%
N/A	12%	34%	3%	2%

Respondents were asked whether they had adequate access to toilets in the workplace (Table 12). While the majority indicated that they did (86%), a number did not have adequate access to toilets. The proportion without adequate access was lowest in office workers, and highest in underground workplaces. Adequate access to toilets is important in relation to health and hygiene. Furthermore, in relation to over-exertion, women might not drink sufficient water to avoid potential use of toilets, which could result in dehydration and associated OHS and over-exertion-related impacts (Zungu, 2012). If the distance to the toilet facilities is far, this could contribute to physical workloads.

Table 12: Adequate access to toilets

	Total sample	Office workers	Surface workers	Underground workers
Yes	86%	95%	83%	82%
No	14%	5%	17%	18%

The next question related to sources of clean drinking water in the workplace (Table 13). While the majority indicated that they did have access to drinking stations, 10% did not, while a further 8% indicated that although they did have access to water, the drinking stations were not spaced frequently. As expected, access was highest in surface offices, and lowest underground. Drinking water availability is important to ensure adequate hydration.

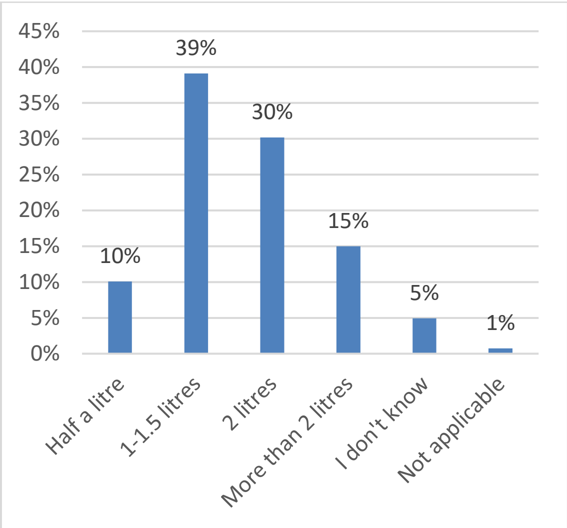
Table 13: Drinking station availability

	Total sample	Office workers	Surface workers	Underground workers
Yes, drinking stations are available nearby	82%	93%	82%	72%
Yes, but drinking stations are not spaced frequently	8%	2%	13%	9%
No, there aren't drinking stations available in my workplace	10%	5%	5%	19%

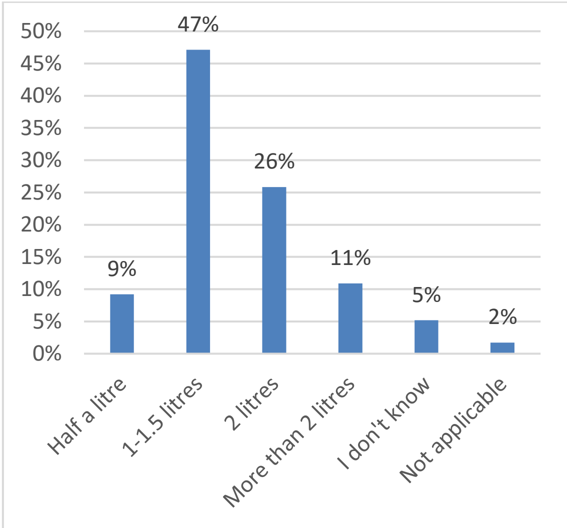
Approximately a third of the sample often experienced extreme thirst during their shifts, 39% sometimes, 16% rarely, and 9% never experienced extreme thirst at work (Table 14). While this question was less applicable to office workers, it was more of a concern for those in other surface positions and in underground workplaces.

Table 14: Extreme thirst during shift

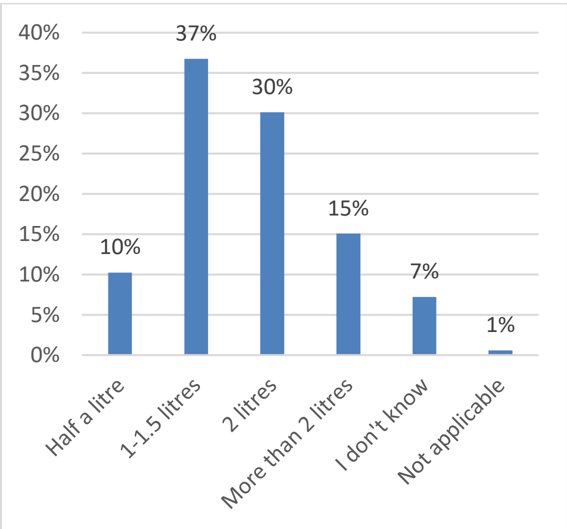
	Total sample	Office workers	Surface workers	Underground workers
Often	32%	19%	35%	41%
Sometimes	39%	39%	38%	40%
Rarely	16%	18%	16%	14%
Never	9%	14%	11%	4%
Not applicable	4%	10%	0%	1%



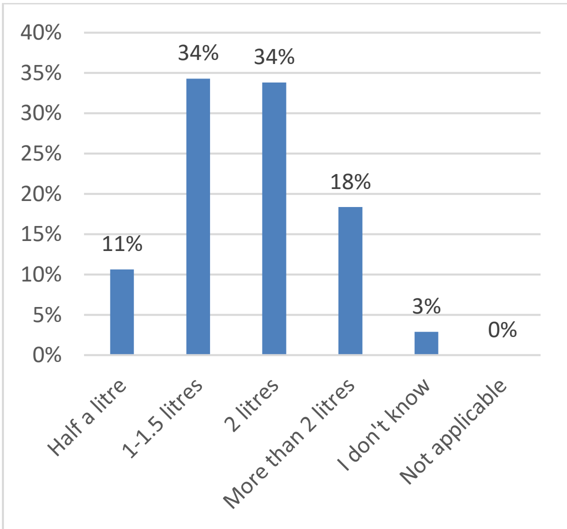
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 10: Average water intake during shift

The majority of respondents usually drank between 1 and 2 litres of water during a shift; however, the quantities were greater in underground workers (Figure 10). The amount of water consumed during a shift should be assessed in relation to the shift length and physical work demands. Insufficient water intake can contribute to dehydration, along with the development of heat strain, heat cramps, and even heat stroke. The DMPR's Thermal Stress Guideline recommends fluid replacement regimens of 350 to 500 ml every 30 minutes for work in heat (DMPR, 2015). In this case, more than 5 litres of water should be consumed during an 8-hour shift. The findings indicate that the survey participants doing heavy physical labour are likely not having a sufficient intake of fluids.

Most of the respondents (71%) did not drink energy drinks or boosters, while 23% usually had one, and 6% had two or more (Table 15).

Table 15: Energy drinks/boosters per day

	Total sample	Office workers	Surface workers	Underground workers
0	71%	79%	66%	69%
1	23%	18%	25%	25%
2	5%	2%	7%	4%
3 or more	1%	1%	2%	2%

Most of the participants worked day shift, particularly in office positions (Table 16). Although only a few worked only night shifts, a large proportion worked "other" shifts, which included both day and night shifts or rotating shifts. In terms of shift length, over half worked 8-hour shifts, 17% worked 12-hour shifts, and 28% worked "Other" shifts (Table 17). "Other" shifts mostly accounted for those shifts between 8 and 12 hours in length. Shift work is a primary cause of fatigue, along with the associated OHS risks, and has negative effects on social and domestic activities, and long-term physical and psychophysiological health (Pelders, 2020). Some of the features of shift work that contribute to fatigue and increased accident risk include long working hours, night work, and a lack of appropriate rest breaks (Pelders, 2020). Increased overtime is also associated with fatigue, and impaired job performance and safety (Pelders, 2020).

Table 16: Shifts worked

	Total sample	Office workers	Surface workers	Underground workers
Day	68%	89%	59%	58%
Night	2%	0%	1%	4%
Other	30%	11%	40%	38%

Table 17: Shift length

	Total sample	Office workers	Surface workers	Underground workers
8 hours	55%	65%	47%	53%
12 hours	17%	6%	34%	11%
Other	28%	29%	19%	36%

Around 60% of the sample took breaks during work, 26% indicated that they sometimes did, and 15% reported that they did not (Table 18). Underground workers were least likely to take breaks during their shifts, with over a quarter indicating that they did not take breaks. Rest breaks of 30 minutes are considered to reverse accumulation of fatigue that increases gradually during a shift (Folkard *et al.*, 2007).

Table 18: Breaks during work

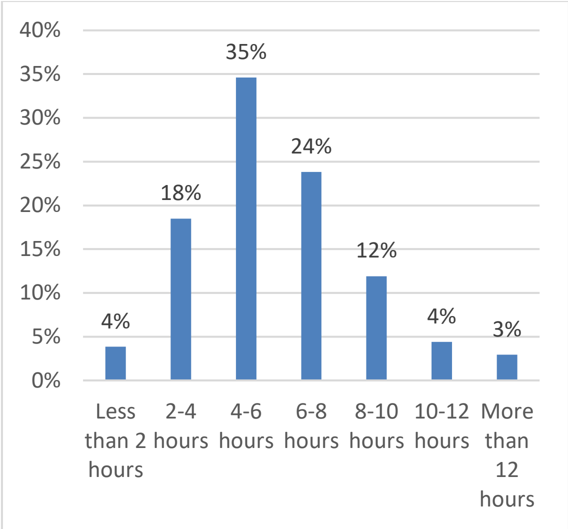
	Total sample	Office workers	Surface workers	Underground workers
Yes, 30 minutes or more	39%	44%	56%	21%
Yes, short breaks (~15 minute)	20%	21%	16%	22%
Sometimes	26%	27%	21%	29%
No	15%	8%	7%	28%

Around half of the sample sometimes worked overtime, 13% often did, and 35% rarely or never did (Table 19). Underground workers reported working overtime most frequently.

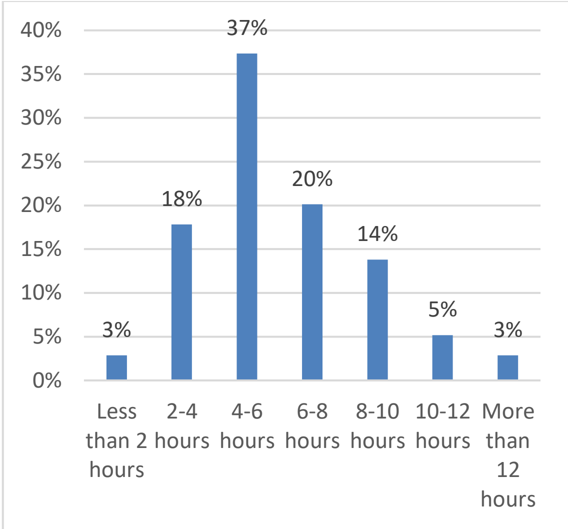
Table 19: Overtime

	Total sample	Office workers	Surface workers	Underground workers
Often	13%	7%	15%	16%
Sometimes	52%	41%	52%	62%
Rarely	14%	19%	14%	8%
Never	21%	33%	19%	14%

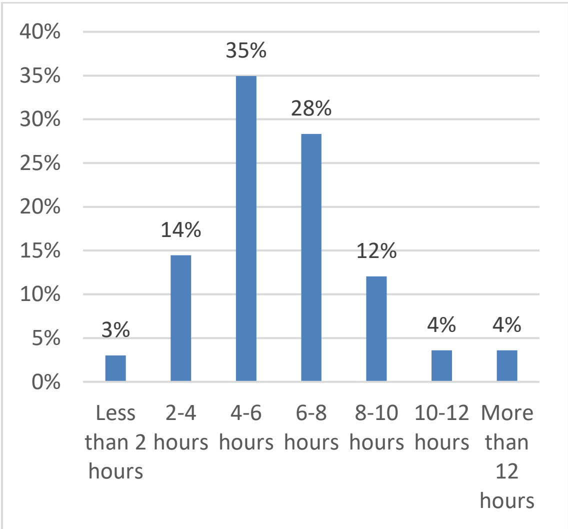
The respondents were asked how long they could work without feeling tired. The category with the highest number of responses was that of between 4 and 6 hours (Figure 11). This variable could be related to rest breaks, fitness as well as job demands.



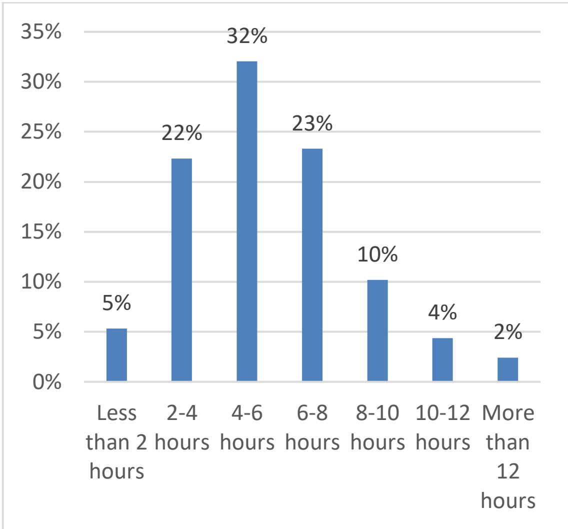
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 11: Time before tired at work

Over half of the sample never (52%) or rarely (39%) felt out of breath during work, with these values being highest in surface office workers (Table 20). Amongst underground workers, 11% indicated they were often, and 5% always out of breath during work.

Table 20: Out of breath during work

	Total sample	Office workers	Surface workers	Underground workers
Always	3%	2%	1%	5%
Often	6%	2%	4%	11%
Rarely	39%	34%	46%	39%
Never	52%	62%	49%	45%

The final question in the survey relating to the workplace was “Have you experienced any form of harassment (e.g. physical/sexual) in the workplace?”. In total, 8% of the sample reported that they had, and a similar amount indicated that they would rather not say (Table 21). The reported incidence of harassment was highest in underground workers, and lowest in office workers. Botha (2016) reported on the existence of exploitation and sexual harassment of women in mining, and further convey that gender discrimination and sexual harassment could affect psychological and physical health, including stress-related disorders. Furthermore, male colleagues were reported to often refuse to provide the necessary support to female colleagues, and regularly ignore, harass, or undermine them (Botha, 2016).

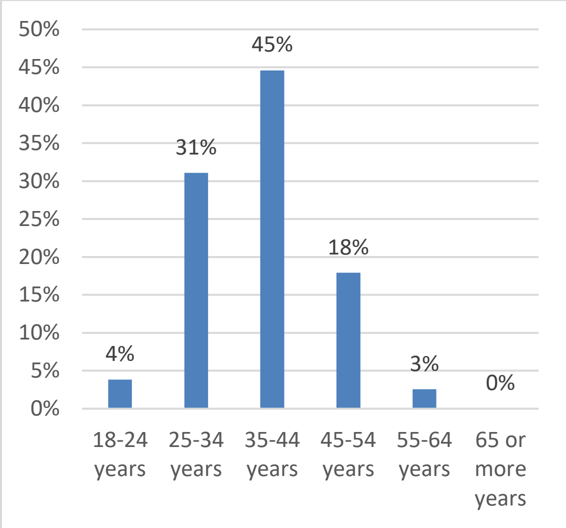
Table 21: Harassment

	Total sample	Office workers	Surface workers	Underground workers
Yes	8%	4%	7%	13%
No	83%	88%	82%	78%
I would rather not say	9%	8%	11%	9%

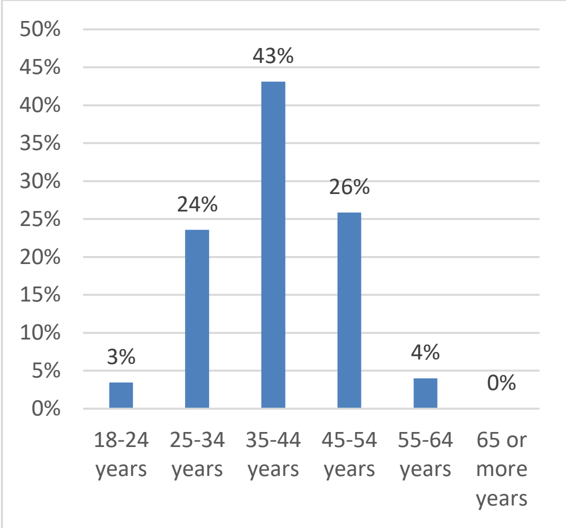
4.3.4 Personal factors

The average age of the participants was between 35 and 44 years old (Figure 12). Twenty-one percent were 45 years or older, and 35% were younger than 35 years. Older workers may be more prone to over-exertion, due to reduced strength and mobility (Jones *et al.*, 2019).

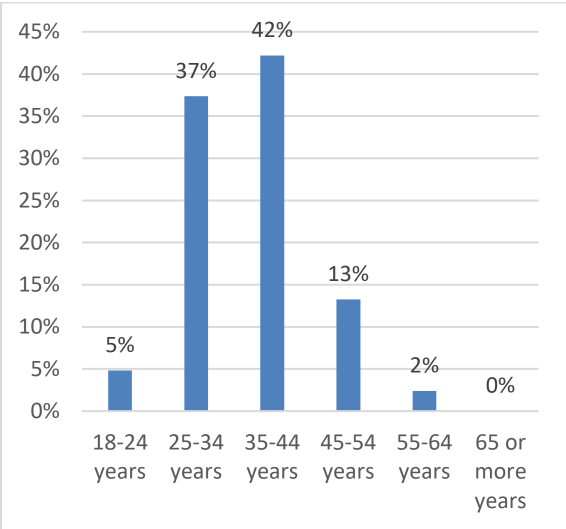
Around half of the sample never or rarely participated in recreational exercise, a quarter did around once a week, while the remainder exercised twice or more a week (Table 22). Of those who reported participating in recreational exercise, the most (62%) participated in light intensity exercise, such as walking, while 30% participated in medium intensity exercise, such as jogging, and 8% in high intensity exercise, such as weightlifting, playing soccer, or participating in competitive sports (Table 23). Recreational exercise can be related to fitness and health, and could therefore protect workers from over-exertion related injuries; however, over-training could also contribute to potential over-exertion without sufficient recovery. The World Health Organization (WHO, 2026) recommends that adults “should do at least 150 minutes of moderate-intensity physical activity throughout the week, or at least 75 minutes of vigorous-intensity physical activity, or an equivalent combination of both”.



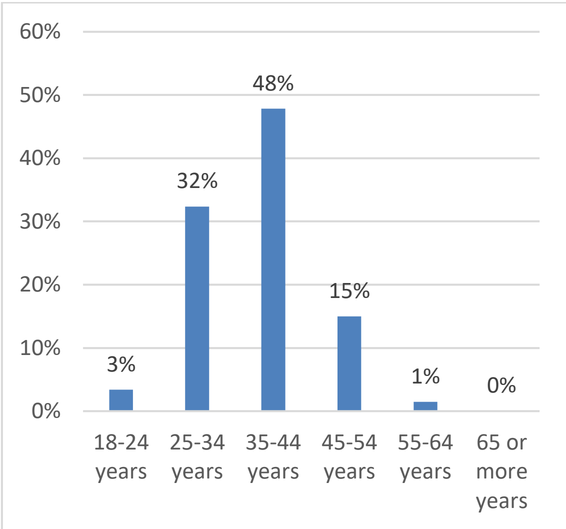
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 12: Age

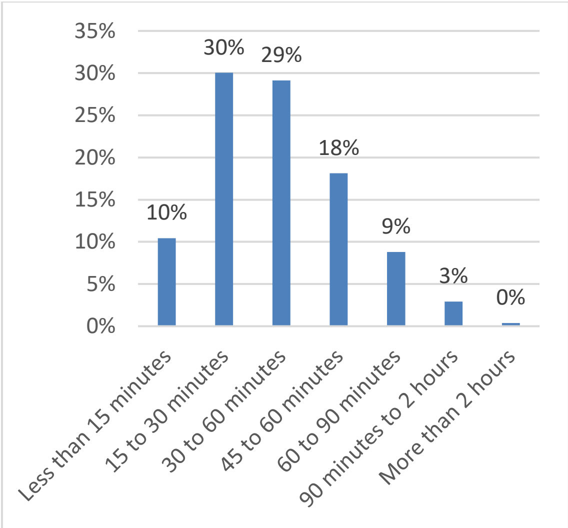
Table 22: Recreational exercise

	Total sample	Office workers	Surface workers	Underground workers
Never	24%	22%	18%	31%
Seldom	28%	31%	29%	26%
Once a week	25%	22%	28%	24%
Two to three times a week	15%	18%	17%	12%
More than three times a week	8%	7%	8%	7%

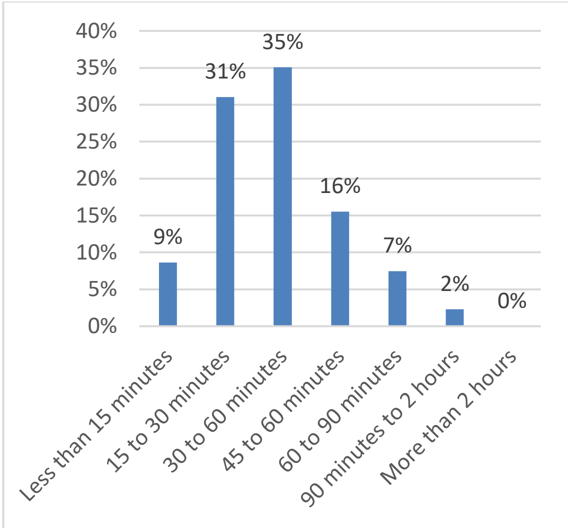
Table 23: Intensity of exercise

	Total sample	Office workers	Surface workers	Underground workers
Light	62%	61%	64%	59%
Medium	30%	29%	30%	31%
High	8%	10%	8%	10%

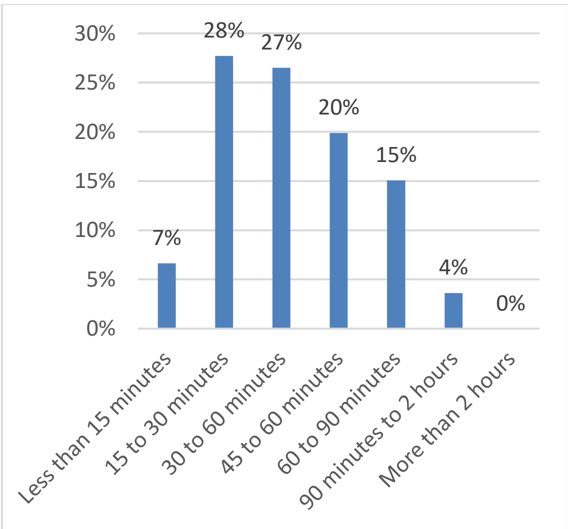
Participants were asked how long it took them to travel to work (Figure 13), for which 40% took less than 30 minutes, 47% took between 30 minutes and an hour, and 12% took over an hour.



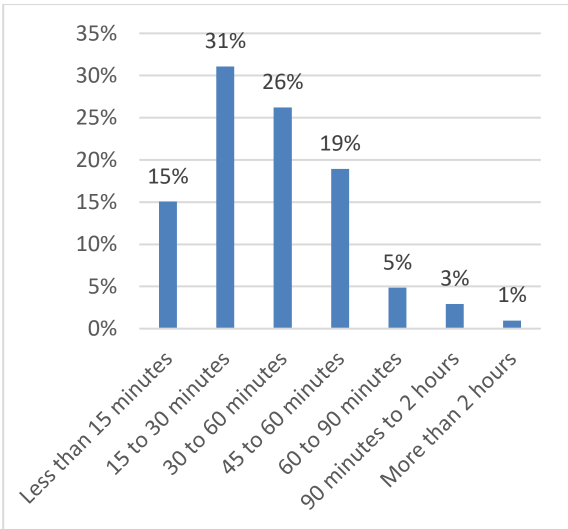
a) Total sample



b) Office workers



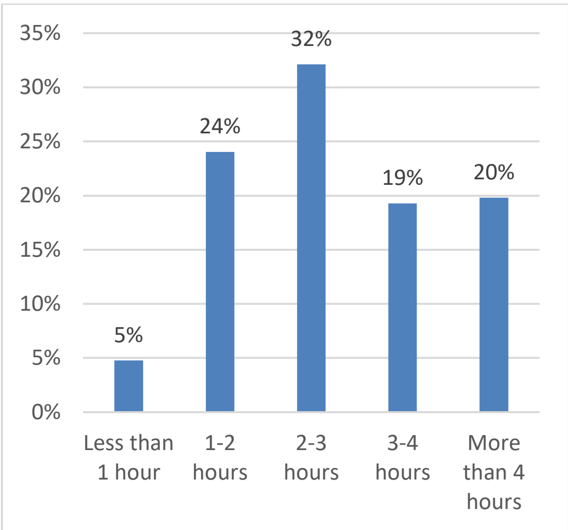
c) Surface workers



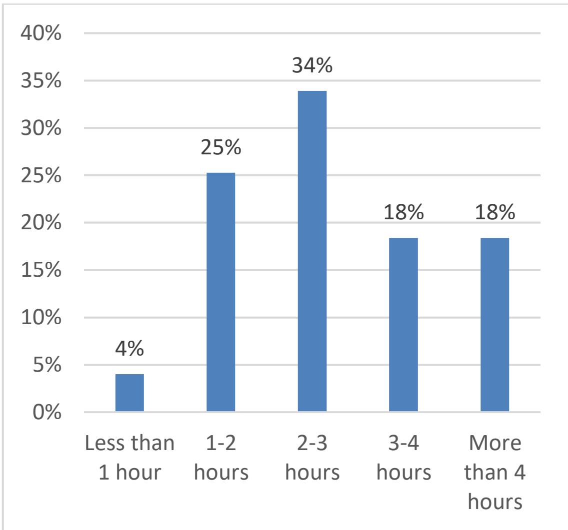
d) Underground workers

Figure 13: Commuting time

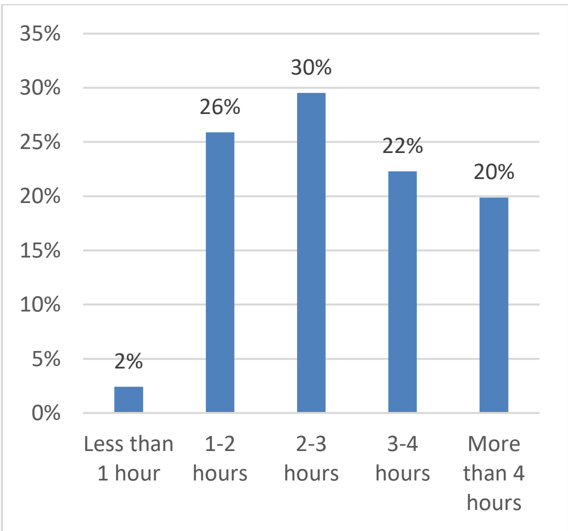
Responses to the question “How much time, on average, do you spend on household activities (e.g. washing, cooking, looking after young children) outside of work each day?” are shown in Figure 14. The average amount of time spend on household activities was 2 to 3 hours per day, while 20% reported spending more than 4 hours on household responsibilities per day. Along with shifts worked and commuting time, time spend on these duties could add to the physical and psychological demands experienced, and reduce the time available for to sleep and recover between shifts.



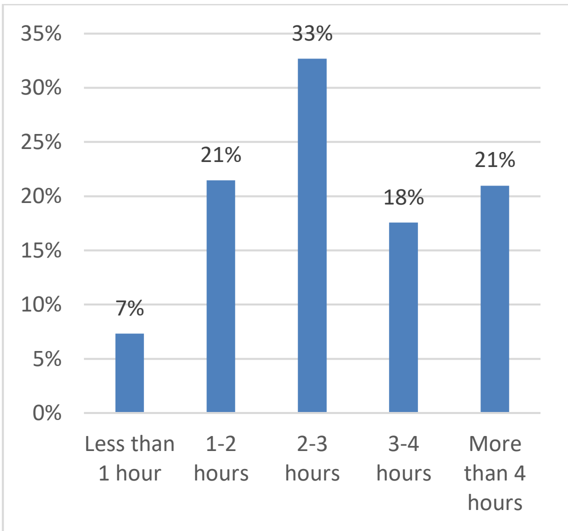
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 14: Household activities

Figures 15 to 18 show the total amount of sleep that the respondents usually get per day (24 hours) when working, and when off. It is evident that more sleep is received on off days. The majority (56%) obtained between 6 and 8 hours of sleep when working, and 52% obtained between 7 and 9 hours of sleep when not working. Approximately 30% got less than 6 hours sleep before working. It is reported that more than six hours of time in bed per night is required to maintain performance across consecutive shifts (Ferguson *et al.*, 2010; 2011).

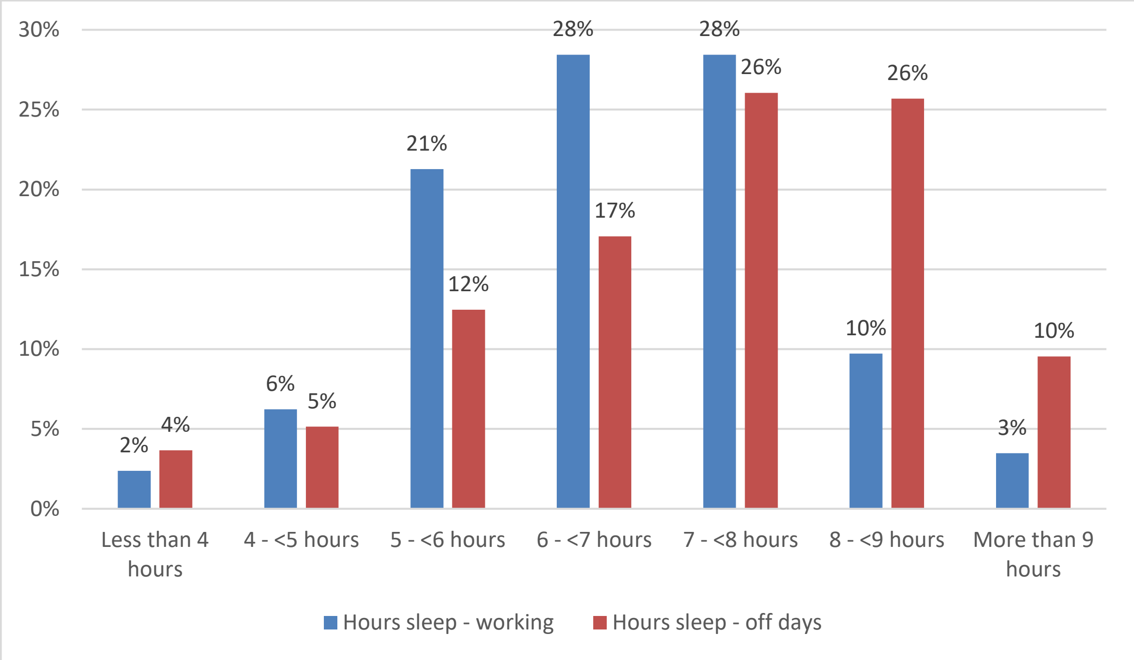


Figure 15: Hours sleep – total

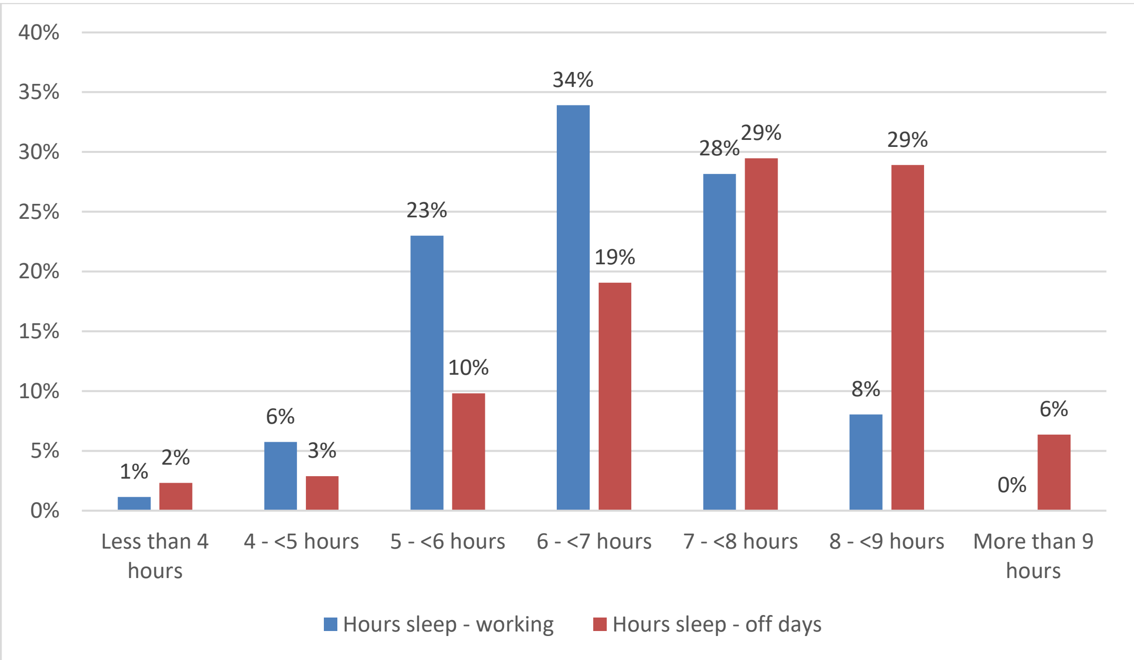


Figure 16: Hours sleep – office workers

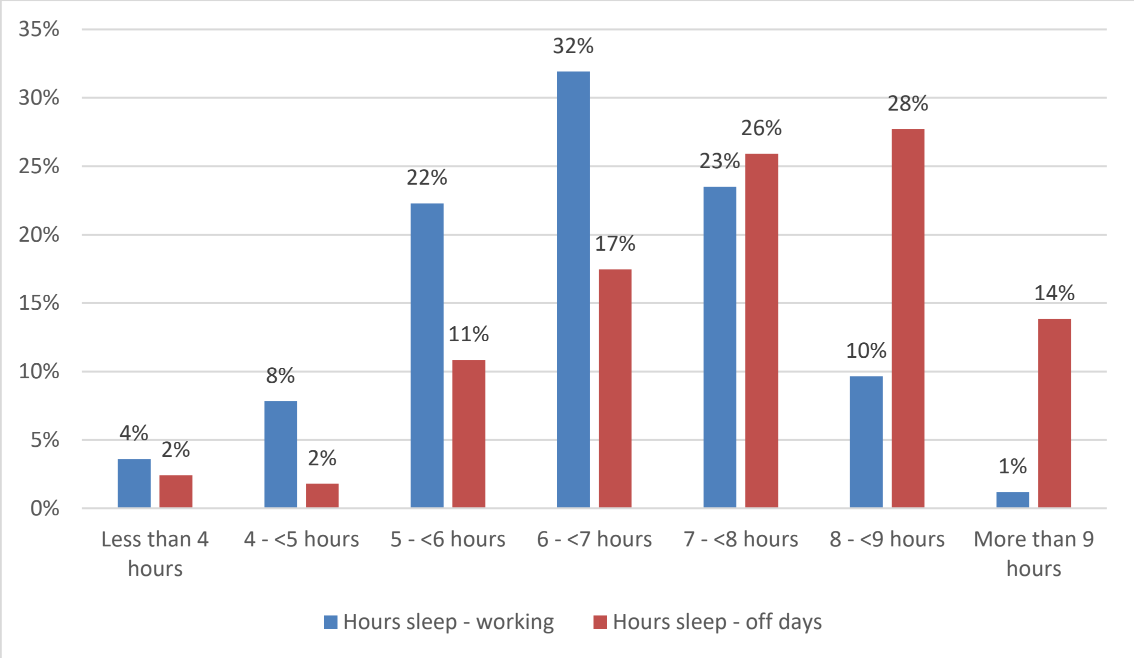


Figure 17: Hours sleep – surface workers

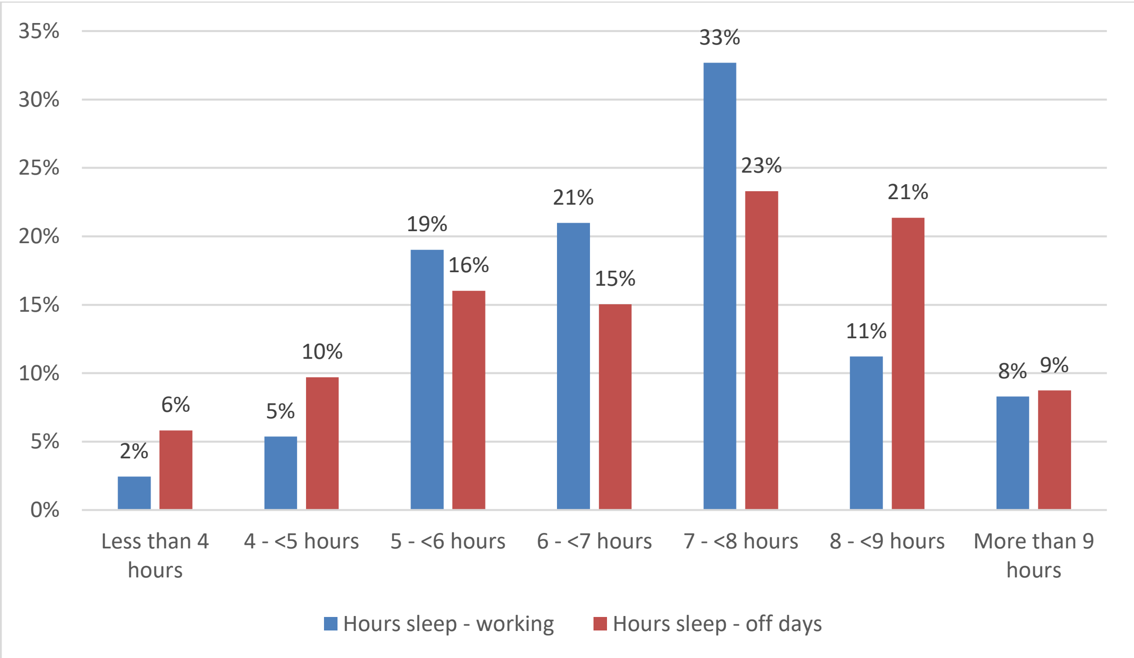
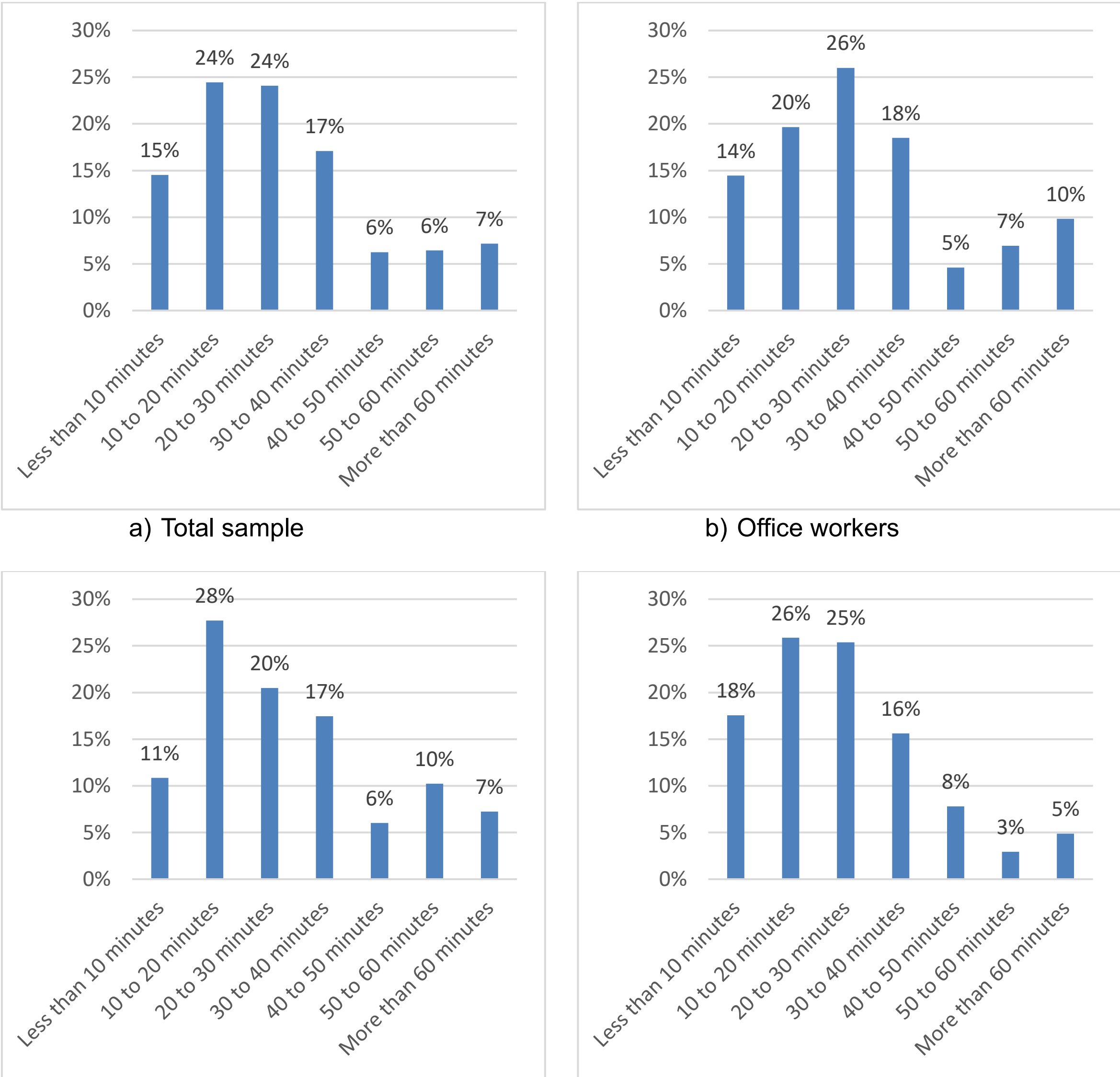


Figure 18: Hours sleep – underground workers

Figure 19 indicates the length of time it took participants to fall asleep once in bed. Most (63%) fell asleep within 30 minutes, however 29% took between 30 and 60 minutes, and 7% took more than an hour to fall asleep. This length of time appeared longer in office workers. A normal range for sleep latency in adults is between 10 and 20 minutes; meanwhile short sleep latencies (e.g. below 5 or 10 minutes) could indicate sleep deprivation, pathology, or excessive daytime sleepiness (e.g. Iksander *et al.*, 2023; Thomas and Anderson, 2023). Taking longer than 30 minutes to fall asleep could indicate insomnia, stress, or poor sleep hygiene.



a) Total sample

b) Office workers

c) Surface workers

d) Underground workers

Figure 19: Sleep latency

Half of the respondents (50%) indicated sleeping fairly or very well (Table 24). Meanwhile, 11% slept fairly or very badly. Poor sleep quality and sleep disorders are associated with fatigue, along with increased risk of workplace injuries and numerous mental and physical health problems (Pelders, 2020). Around 10% of the sample reporting using medication or beverages to help them sleep (Table 25). In a previous study conducted in the SAMI, 13% of the sample reported having a sleep disorder (Hodgskiss *et al.*, 2015).

Table 24: Sleep quality

	Total sample	Office workers	Surface workers	Underground workers
Very well	23%	20%	20%	29%
Fairly well	27%	29%	31%	22%
Moderately	39%	39%	40%	38%
Fairly badly	7%	9%	5%	6%
Very badly	4%	3%	4%	5%

Table 25: Use of medication or beverages to sleep

	Total sample	Office workers	Surface workers	Underground workers
Yes	10%	9%	11%	11%
No	90%	91%	89%	89%

Table 26: Medical condition

	Total sample	Office workers	Surface workers	Underground workers
Yes	16%	15%	14%	18%
No	84%	85%	86%	82%

Table 27: Medical conditions and medication used

Medical condition	Medication (examples)
• Cardiovascular disease, including hypertension (n=24) • HIV (n=12) • Asthma (n=11) • Diabetes (n=5) • Arthritis and back pain (n=4) • Depression (n=4) • Other (including anaemia, low blood pressure, bipolar, restless leg syndrome, sinus problems, gastrointestinal problems, gout and eye problems) (n=9)	• Amloc, Cardiloc, Spiraling, Tywinsta, Enap, Exforge, Amlodipine, Ridaque, Ziak, Accozetoma, Enalapril, Dapamol • ARVs, Actopaga • Asthma pumps e.g. Asthavent, Foxair, Montair, Sereflo • Jalamet, Diagen, Metformine, Rapid Nova, Optisil, Isoline • Pain killers, anti-inflammatories • Cilift, antidepressants • Pexola, Sinutab, eye drops, Puricos, Supplements

The respondents were asked if they had any medical condition, with the examples of arthritis, asthma or cardiovascular disease being provided. In total, 16% indicated having a medical condition (Table 26). Those who indicated having a medical condition were also asked to specify the condition they had and what medication they were taking, for further analysis. These conditions included cardiovascular disease, hypertension, diabetes, asthma, arthritis, HIV/AIDS, and depression, along with the related medication (Table 27). An assessment of the impacts of diseases and the use of certain medications in relation to over-exertion is provided further in this report. Medical conditions could be a cause or consequence of fatigue and over-exertion, meanwhile the use of medication could contribute to or mitigate the effects of over-exertion.

Participants were asked to indicate which symptoms, out of a list of ten, they experienced during work. Around half of the sample did not experience any symptoms, while the most commonly experienced symptom was headaches (37%) (Figure 20). Headaches and muscle cramps often signal dehydration. Meanwhile, headaches could also be a symptom of stress (or mental strain). Office workers experienced the lowest number of symptoms and underground workers experienced the most (Table 28).

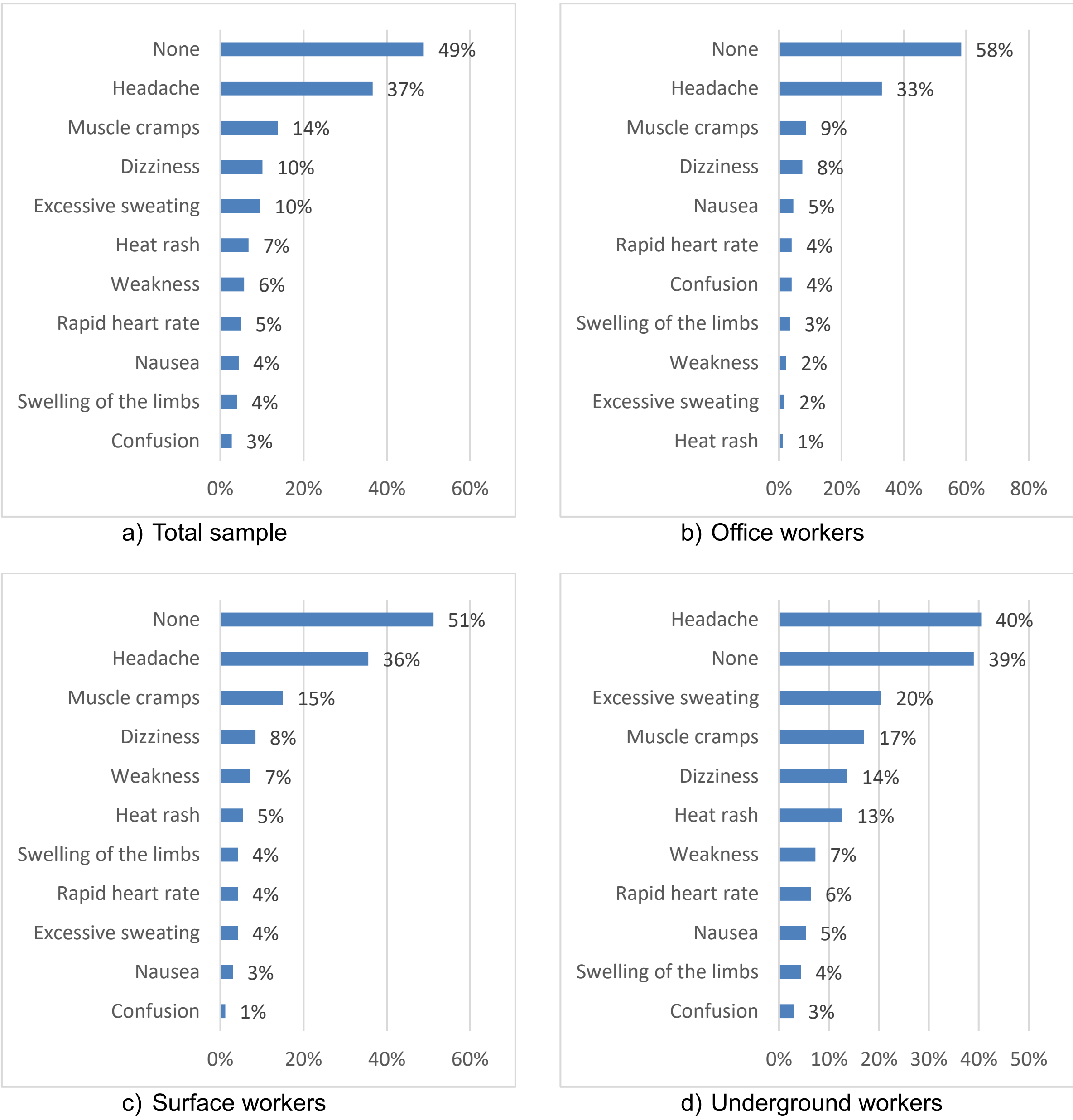


Figure 20: Heat stress symptoms

Table 28: Number of heat stress symptoms

	Total sample	Office workers	Surface workers	Underground workers
No symptoms	49%	58%	51%	39%
1 symptom	28%	27%	28%	30%
2 symptoms	10%	6%	11%	13%
3 symptoms	6%	5%	4%	8%
More than 3 symptoms	7%	3%	5%	10%

Around 6% of the sample reported being smokers, with a higher percentage (9%) amongst surface office workers (Table 29). Tobacco use is a risk factor for many debilitating health conditions (WHO, 2026). This percentage is substantially less than a previous study involving men and women in the SAMI, in which 24% reported smoking (Hodgskiss *et al.*, 2015).

Table 29: Smoke

	Total sample	Office workers	Surface workers	Underground workers
Yes	6%	9%	5%	5%
No	94%	91%	95%	95%

A few of the participants reported that they may be pregnant (3%), including amongst underground workers (Table 30). A few (2%) were currently breastfeeding (Table 31). Pregnancy could intensify the risk over-exertion of WIM, and they are additional exposure risks for pregnant and breastfeeding women; however, these women should be reassigned to roles away from harmful mining environments (Badenhorst, 2009; Eiter *et al.*, 2023; Rutkowski, 2024).

Table 30: Pregnant

	Total sample	Office workers	Surface workers	Underground workers
Yes	3%	2%	3%	4%
No	97%	98%	97%	96%

Table 31: Breastfeeding

	Total sample	Office workers	Surface workers	Underground workers
Yes	2%	3%	2%	2%
No	98%	97%	98%	98%

Participants were asked about when their last period was, to provide an indication of hormonal impacts on over-exertion (Figure 21). Some (21%) did not get periods, and this could be related to age (menopause). Over-exertion can affect menstrual health and hormonal balance. Meanwhile, risks of over-exertion can vary according to phase of the menstrual cycle (e.g.

during the luteal phase), and menopause can contribute to over-exertion (e.g. Lurati, 2017; Wen *et al.*, 2025).

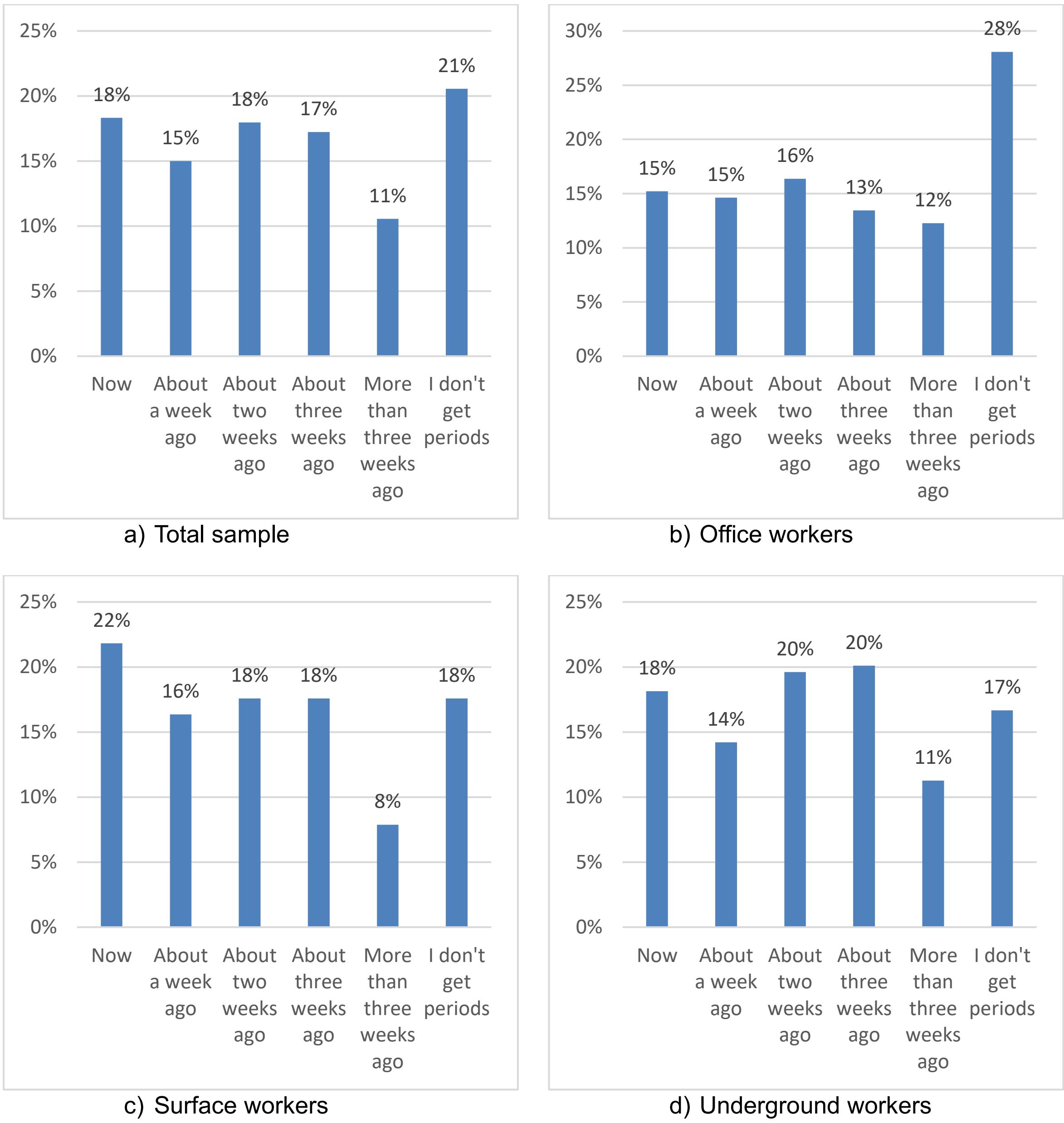


Figure 21: Last period

4.3.5 Health, safety and wellness

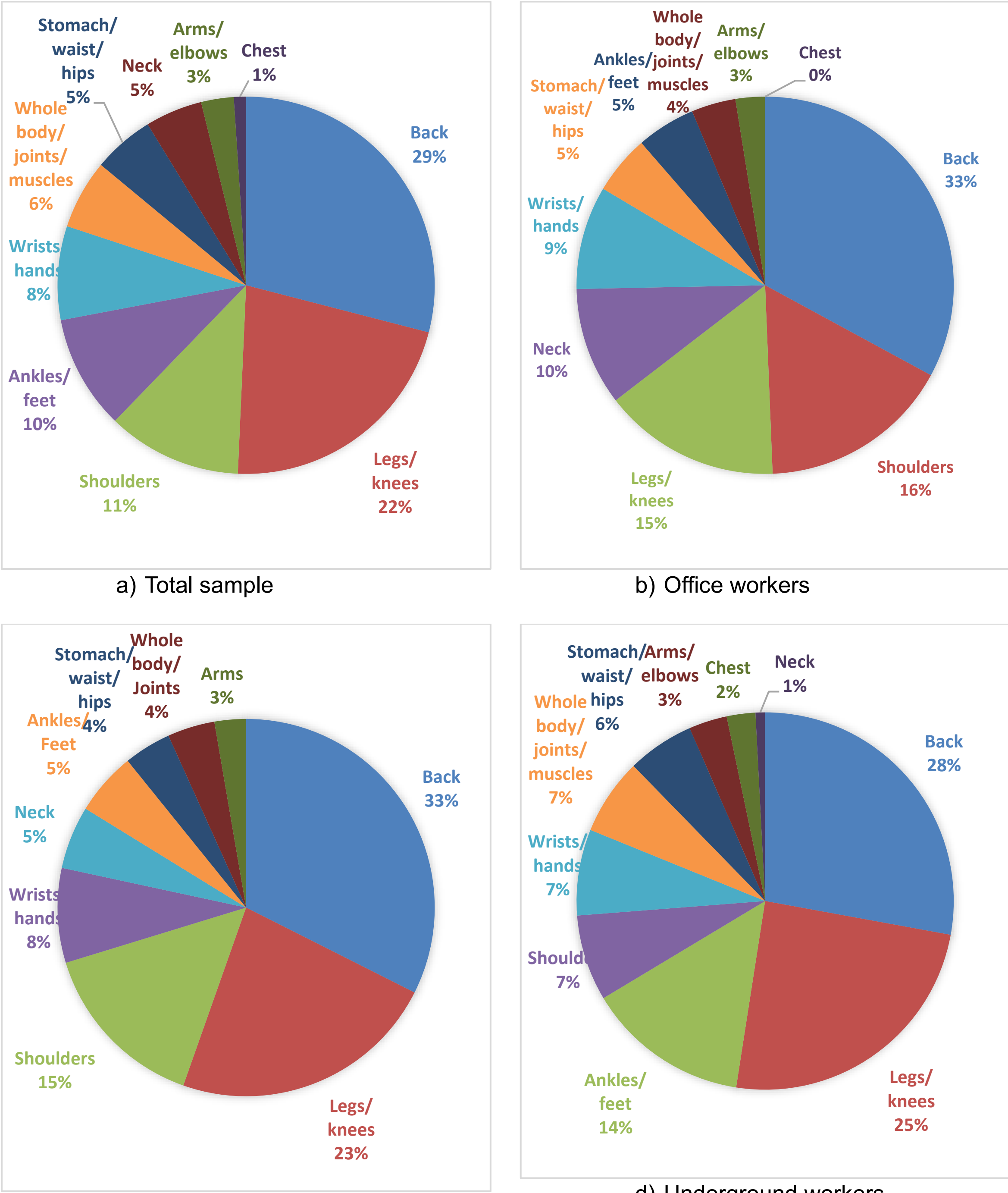
The variables in the health, safety and wellness section of the survey included those of musculoskeletal pain or discomfort, tiredness, ratings of perceived exertion, anxiety/sadness, trouble concentrating, mood, quality of life, subjective health, and sick leave taken in the previous year. These variables were included in the statistical analysis as "outcomes" of over-exertion.

Table 32 illustrates responses for whether respondents were experiencing pain or discomfort in their muscles or joints. This was reported by 37% of the sample, with a slightly higher percentage reported by underground workers (42%). Figure 22 illustrates where in the body these respondents were experiencing pain or discomfort, while Figure 23 indicates the level of the pain or discomfort on a scale of 1 (very slight discomfort) to 10 (extreme discomfort). Pain was most frequently experienced in the back (29%), followed by in the legs/knees (22%). Other body areas that were reported to have pain or discomfort included the shoulders (11%), ankles/feet (10%), and wrists/hands (8%). Office workers experienced the highest proportion of neck pain. Underground workers reported a higher proportion ankle/foot pain than the other groupings. On a scale of one to ten, five was the most commonly reported level of pain or discomfort experienced in the muscles and joints (Figure 23). In terms of questionnaire formatting, it is evident that the respondents preferred to select a number that had an associated emoji.

In a previous study assessing the prevalence of musculoskeletal disorders (MSDs) in the SAMI, Schutte *et al.* (2003) similarly reported that most of the reports were in the back region. The estimated prevalence of MSDs at the study sites ranged from 2-18%. A link was reported between physical work factors, such as awkward postures, repetitive motions, high force, vibration and psychosocial factors, and the gradual onset of MSDs (Schutte *et al.*, 2003). Musculoskeletal pain or discomfort could be considered a pre-cursor or indicator of the presence of an MSD.

Table 32: Musculoskeletal pain or discomfort

	Total sample	Office workers	Surface workers	Underground workers
Yes	37%	32%	35%	42%
No	63%	68%	65%	58%



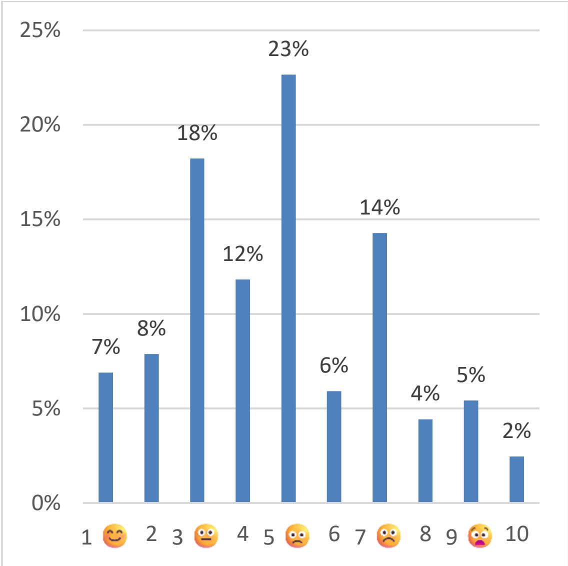
a) Total sample

b) Office workers

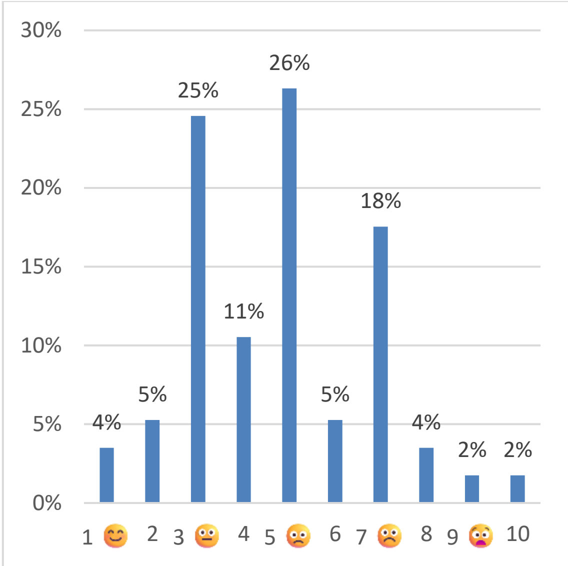
c) Surface workers

d) Underground workers

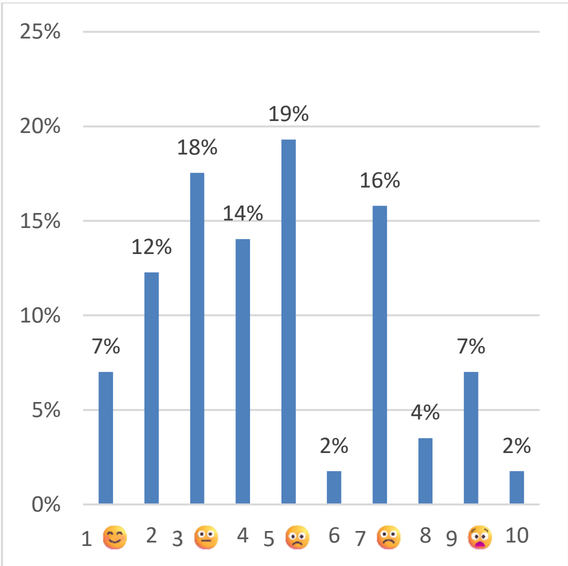
Figure 22: Body areas experiencing pain or discomfort



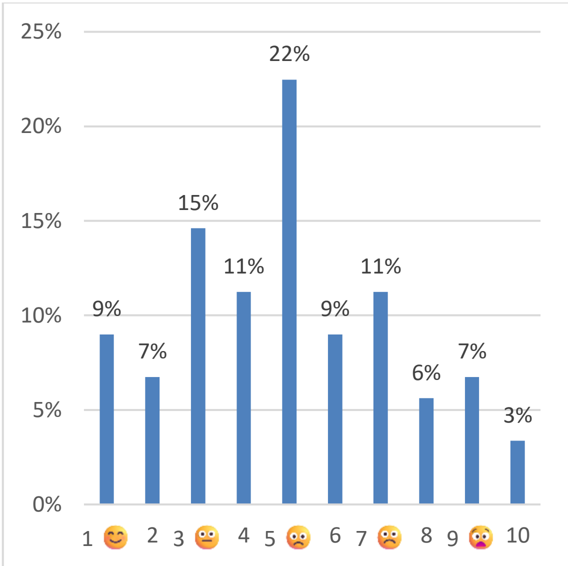
a) Total sample



b) Office workers



c) Surface workers



d) Underground workers

Figure 23: Level of pain or discomfort

Figures 24 to 27 illustrate levels of tiredness at various times throughout a work day. The majority (55%) did not feel tired before a shift, while 36% felt moderately tired halfway through a shift, and 50% felt very tired or exhausted after a shift. In a study by Pelders and Nelson (2018), 28% of the sample were classified as fatigued, and numerous factors were associated with fatigue, including those relating to work, socio-demographics, lifestyle, and wellness.

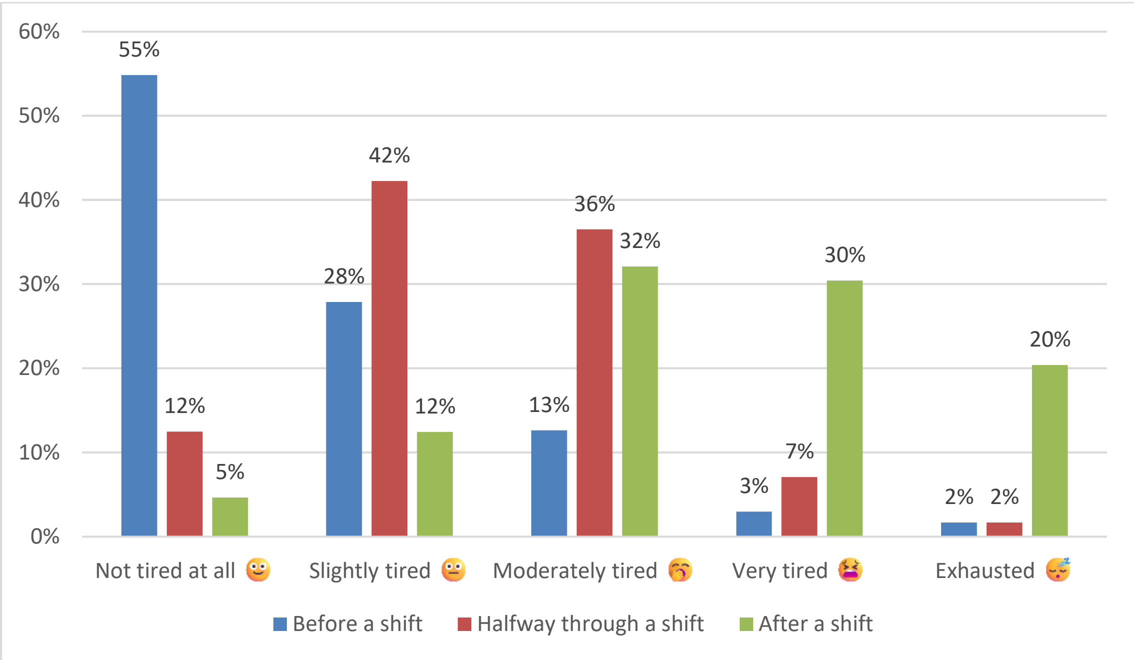


Figure 24: Tiredness at work – total

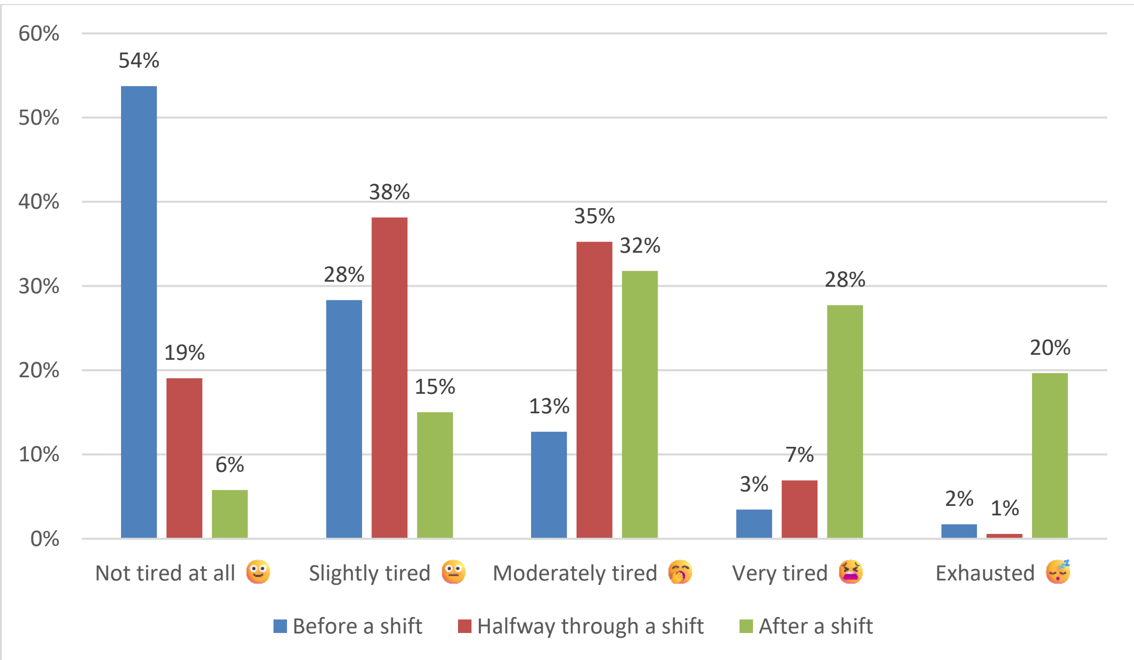


Figure 25: Tiredness at work – office workers

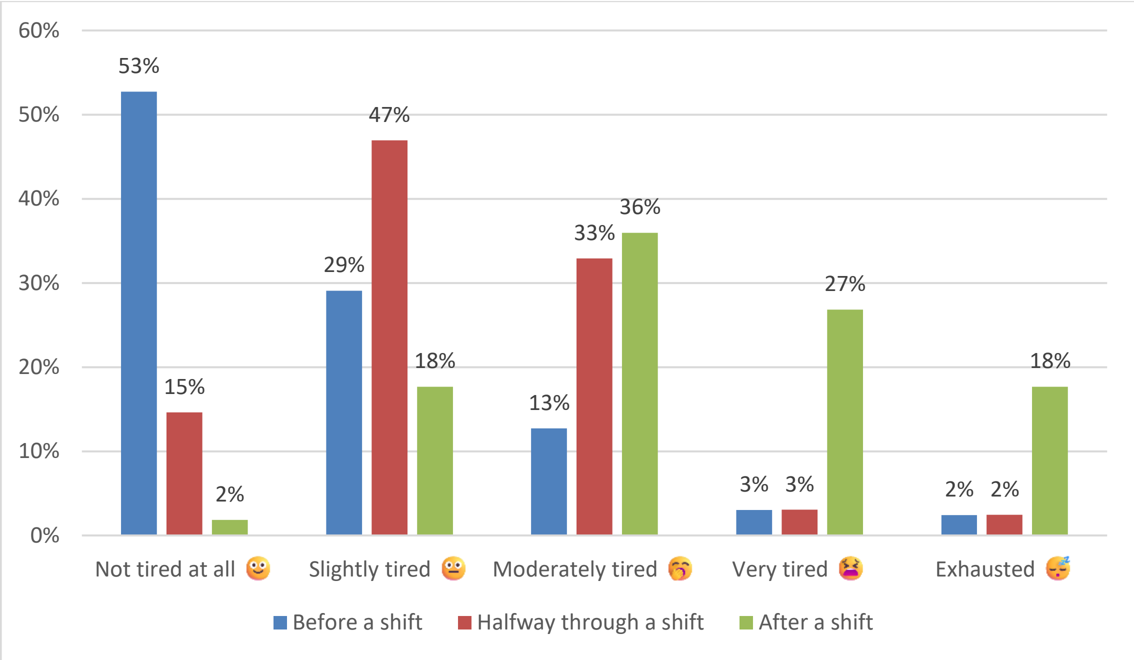


Figure 26: Tiredness at work – surface workers

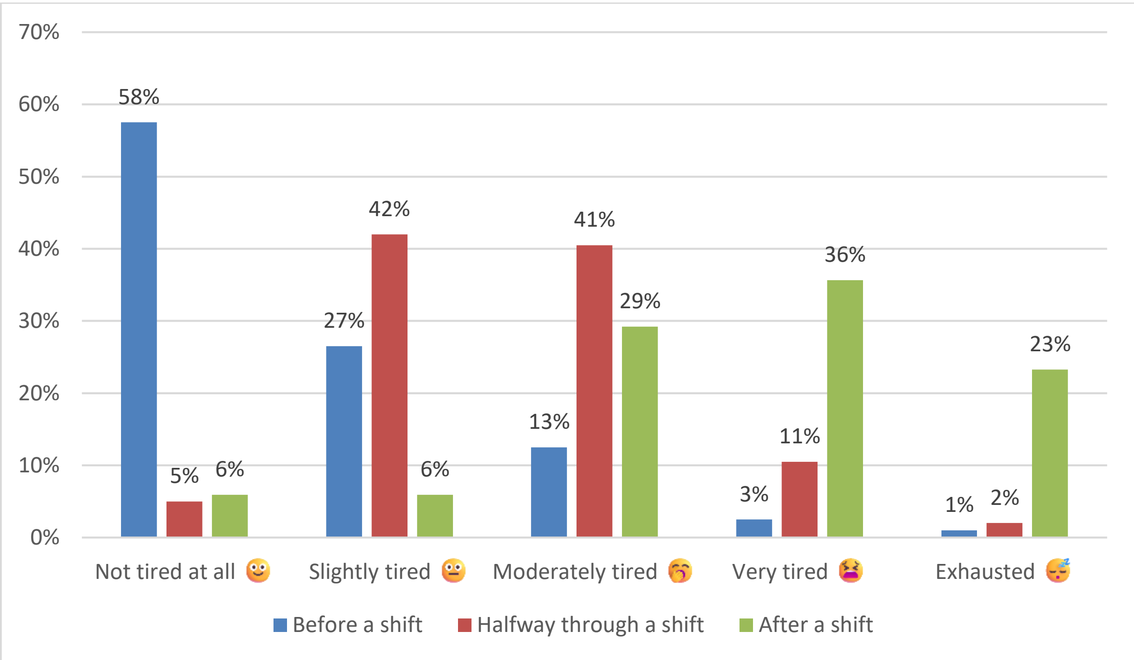


Figure 27: Tiredness at work – underground workers

Participants were asked how hard they usually felt their bodies were working during their shift, on a scale from 0 (minimum) to 10 (maximum) (Figure 28). The majority of participants (43%) felt that they worked moderately hard. Over a third (35%) considered their work to involve light activity. Meanwhile, 21% felt that their bodies were working at hard to maximal levels. Hard to maximal levels of exertion were considered as indicators of over-exertion.

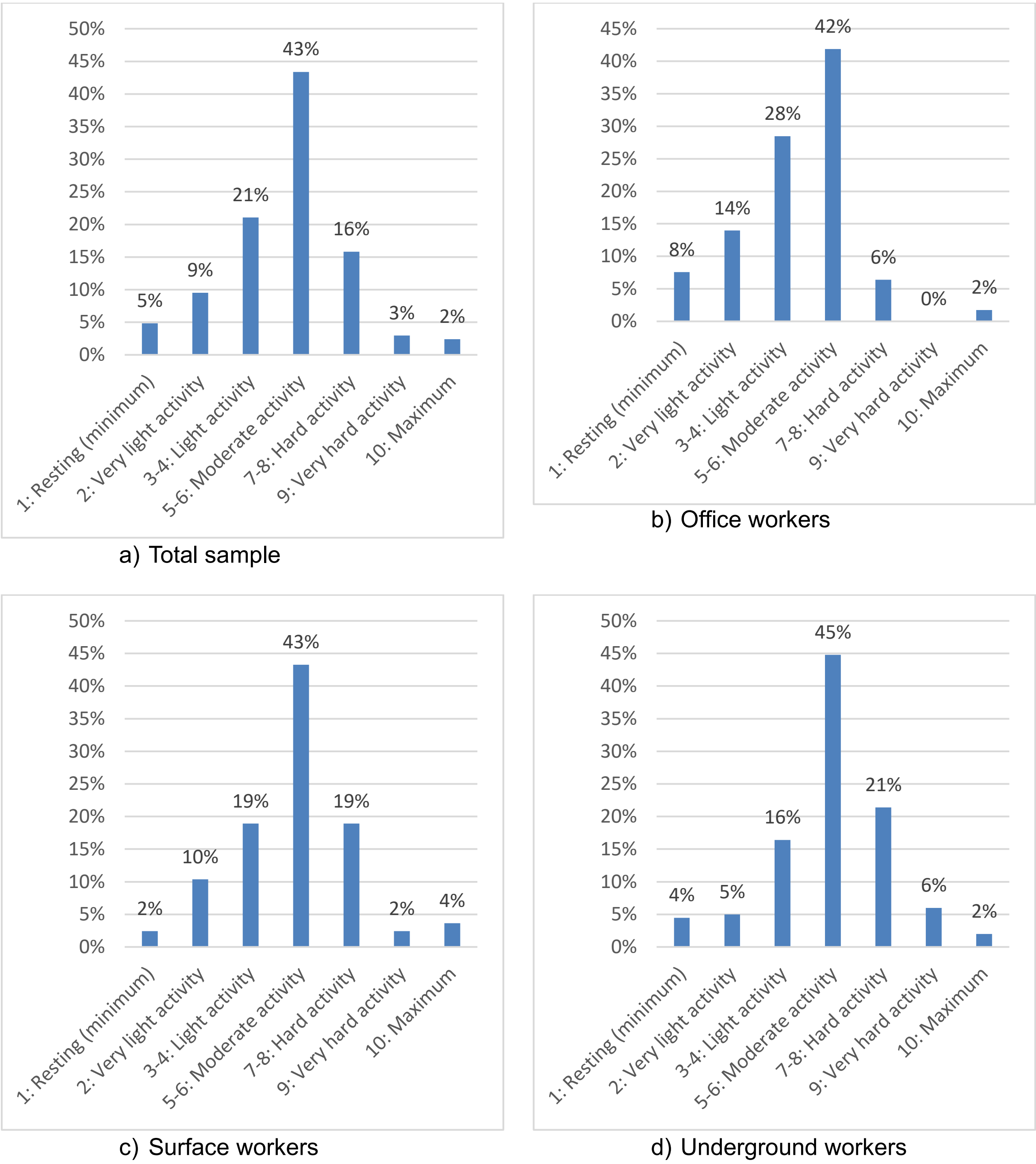


Figure 28: Modified Ratings of Perceived Exertion (RPE)

Fatigue and over-exertion-are further associated with impaired mood, anxiety, and a lack of concentration (Pelders, 2020).

Participants were asked how often they felt anxious or sad (Table 33). Most (53%) felt they were sometimes anxious or sad, 22% rarely, and 11% never sad. However, 11% said they were often, and 3% always anxious or sad.

Table 33: Anxiety or sadness

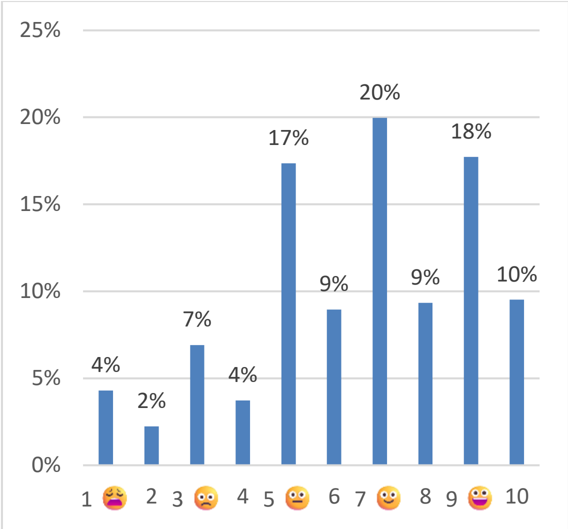
	Total sample	Office workers	Surface workers	Underground workers
Always	3%	2%	3%	4%
Often	11%	15%	8%	10%
Sometimes	53%	50%	52%	57%
Rarely	22%	22%	29%	17%
Never	11%	11%	8%	12%

Most of the participants never (29%), rarely (32%) or sometimes (33%) had trouble concentrating on their work tasks (Table 34). Meanwhile 4% often, and 2% always did.

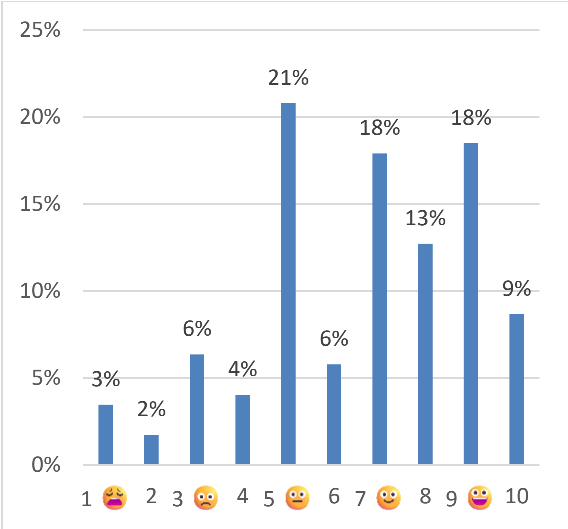
Table 34: Trouble concentrating

	Total sample	Office workers	Surface workers	Underground workers
Always	2%	3%	2%	2%
Often	4%	6%	3%	2%
Sometimes	33%	34%	27%	37%
Rarely	32%	34%	39%	25%
Never	29%	23%	29%	34%

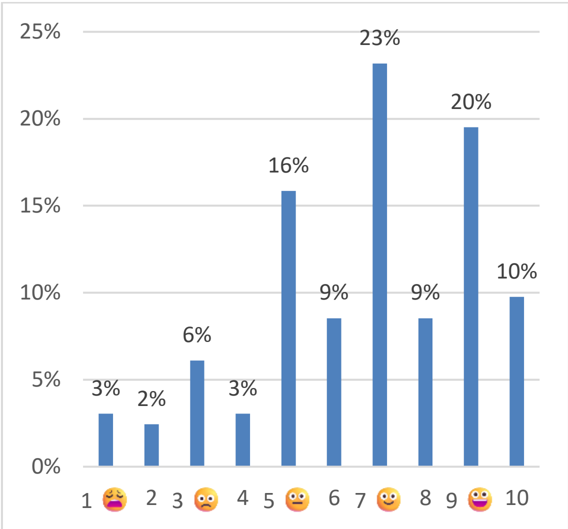
Participants were asked how they were feeling on a scale from 1 (terrible) to 10 (great). The respondents tended to report more positive emotions, with 17% reporting a score of 1 to 4 (negative), 26% reporting a score of 5 to 6 (neutral), and 57% reporting a score from 7 to 10 (positive) (Figure 29).



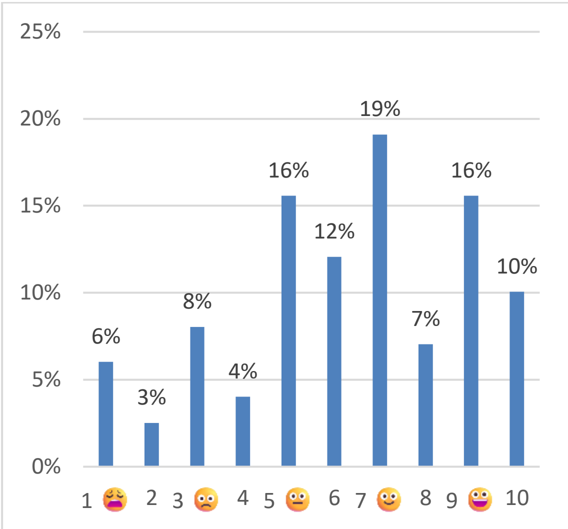
e) Total sample



f) Office workers



g) Surface workers



h) Underground workers

Figure 29: Current emotional state

Most of the participants considered their quality of life to be good (47%) (Table 35). However, some (6%) considered it to be poor or very poor. In a previous study in the SAMI, the 39% sample reported their quality of life to be good, and 12% very good (Hodgskiss *et al.*, 2015).

Table 35: Quality of life

	Total sample	Office workers	Surface workers	Underground workers
Very good	14%	13%	12%	16%
Fairly good	47%	51%	48%	43%
Neither poor nor good	33%	28%	36%	35%
Poor	4%	5%	4%	4%
Very poor	2%	3%	0%	2%

Similarly, most (53%) considered their health to be good (Table 36), while 4% rated it as bad or very bad. In a previous study conducted in the gold and platinum sector in South Africa, the majority (84%) of the sample considered their health to be good, and 16% not good (Pelders and Nelson, 2018).

Table 36: Subjective health

	Total sample	Office workers	Surface workers	Underground workers
Very good	17%	18%	16%	17%
Good	53%	52%	57%	50%
Neither poor nor good	26%	25%	22%	30%
Bad	3%	4%	4%	0%
Very bad	1%	1%	0%	2%

In terms of sick leave taken in the previous year, 22% had not taken any, 42% had taken between 1 and 4 days, 24% between 5 and 9 days, and 13% had taken 10 or more days of sick leave (Table 37). In the study by Pelders and Nelson (2018), 71% had taken less than five days of sick leave in the previous year, and 29% taking five or more days, indicating higher levels of sick leave taken in the current study.

Table 37: Sick leave in past year

	Total sample	Office workers	Surface workers	Underground workers
None	22%	27%	23%	17%
1 – 4 days	42%	48%	33%	43%
5 – 9 days	24%	18%	29%	25%
10 or more days	13%	8%	16%	14%

4.3.6 Anthropometry (body measurements)

Participants were asked to indicate their height, weight, waist girth, and hip girth. As not all of the participants were able to recall or measure these at the time of the survey, this question was not compulsory and some of the values are approximations. Data were cleaned prior to analysis. For stature, values provided of below 140 cm and above 200 cm were excluded, as these were considered unfeasible. Where data was not provided in the survey, anthropometric data from the RFA database was used to supplement these values, where available. Where feasible, this data was measured directly during the project.

Descriptive data for weight, stature, waist girth, hip girth, BMI and waist-to-hip ratios are included in Tables 38 to 41. The average body weight was 85 kg, the average body height was 160 cm, while the average waist circumference was 95 cm, and hip girth was 113 cm. BMI was calculated using stature and mass, and the average value was 33. Meanwhile, waist-to-hip ratios were calculated using waist and hip girths, and the average value was 0.85.

Table 38: Anthropometric data – total sample

	Body weight (kg) (n=480)	Stature (cm) (n=410)	BMI (kg/m^2) (n=399)	Waist girth (cm) (n=301)	Hip girth (cm) (n=275)	Waist-to-hip ratio (n=273)
Average	85	160	33	95	113	0.85
Standard deviation	17	7	6	14	15	0.10
Minimum	46	140	18	58	71	0.54
Maximum	134	191	52	140	160	1.30

Table 39: Anthropometric data – office workers

	Body weight (kg) (n=148)	Stature (cm) (n=120)	BMI (kg/m^2) (n=114)	Waist girth (cm) (n=78)	Hip girth (cm) (n=66)	Waist-to-hip ratio (n=66)
Average	85	161	33	96	116	0.85
Standard deviation	19	8	7	14	15	0.09
Minimum	46	140	18	66	71	0.54
Maximum	130	191	52	126	160	1.30

Table 40: Anthropometric data – surface workers

	Body weight (kg) (n=138)	Stature (cm) (n=117)	BMI (kg/m^2) (n=113)	Waist girth (cm) (n=69)	Hip girth (cm) (n=61)	Waist-to-hip ratio (n=60)
Average	85	160	33	94	112	0.85
Standard deviation	18	8	7	14	16	0.11
Minimum	47	143	18	58	81	0.54
Maximum	134	187	52	132	155	1.30

Table 41: Anthropometric data – underground workers

	Body weight (kg) (n=193)	Stature (cm) (n=172)	BMI (kg/m^2) (n=171)	Waist girth (cm) (n=154)	Hip girth (cm) (n=147)	Waist-to-hip ratio (n=146)
Average	85	160	33	96	113	0.85
Standard deviation	16	6	6	15	14	0.10
Minimum	51	145	18	58	84	0.53
Maximum	120	181	52	180	150	1.30

BMI data were classified into categories, and most of the sample (63%) was categorised as obese (Table 42). BMI categories are as follows: Normal weight: 18.5 – 24.9; Overweight: 25.0 – 29.9; Obesity class 1: 30.0 – 34.9; Obesity class 2: 35.0 – 39.9; and Obesity class 3 (severe obesity): 40.0 or greater. The presence of obesity in South Africa is higher in women than in men, and is both a health, ergonomic and safety challenge (The Work Expert, 2025). Similarly, waist girth was categorised as low risk (<88 cm) and high risk (≥88 cm), with 77% having a waist circumference of 88 cm and above (Table 43). Waist-to-hip ratios of over 0.85 indicates an increased risk of metabolic complications, and 48% of the sample was in this category (Table 44).

Table 42: BMI categories

	Total sample	Office workers	Surface workers	Underground workers
18.5 – 25.0 (Normal weight)	12%	12%	11%	11%
25.0 – 29.9 (Overweight)	25%	24%	26%	23%
30.0 – 34.9 (Class 1 obesity)	27%	25%	27%	26%
35.0 – 39.9 (Class 2 obesity)	21%	15%	19%	28%
≥40 (Class 3 obesity)	15%	24%	17%	12%

Table 43: Waist girth

	Total sample	Office workers	Surface workers	Underground workers
Waist <88 cm	23%	28%	33%	35%
Waist ≥88 cm	77%	72%	67%	65%

Table 44: Waist-to-hip ratios

	Total sample	Office workers	Surface workers	Underground workers
Waist-to-hip ratio ≤0.85	52%	45%	37%	36%
Waist-to-hip ratio >0.85	48%	55%	63%	64%

4.3.7 Fitness/work capacity

Rehabilitation and Functional Assessment (RFA) data relating to physical work capacities was linked to the survey data, where available. This data was available for 90 of respondents. Most of this data was available for underground workers (n=68), while some were available for office workers (n=8) and other surface workers (n=14). The outcome of two of the RFA test results were used towards the statistical analysis, namely physical work capacity, and maximum load handling. The corresponding results for the respondents are shown in Figures 30 and 31, whereby the majority (63%) met the physical requirements of the occupation, and most (90%)

were able to lift loads of 25 kg and above. A comparison of work capacity assessment outcomes for male and female employees revealed pass rates of 47% and 74% for female novices and new employees, respectively, compared to 83% and 89% for males (The Work Expert, 2025).

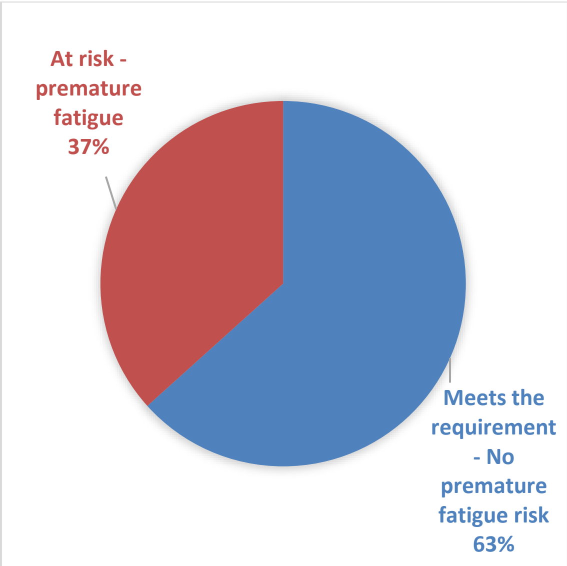


Figure 30: Physical work capacity results

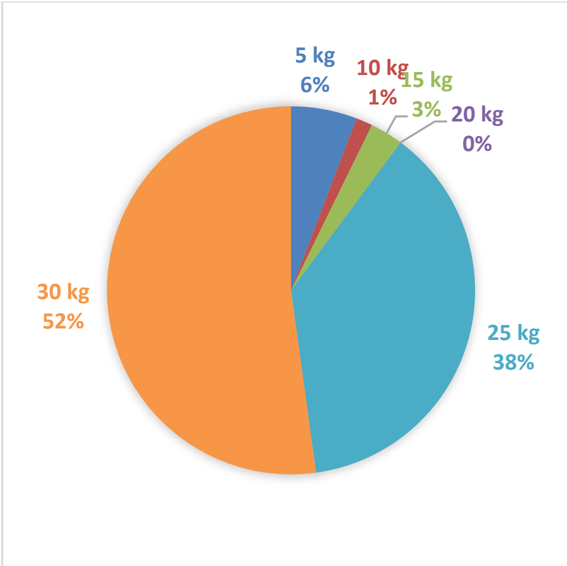


Figure 31: Maximum load handling

4.3.8 Comments

Three open-ended questions were included at the end of the questionnaire, for optional further comment, namely:

- Please list factors that you can think of that lead to, or result from, over-exertion of women in mining, that may have not been mentioned in this questionnaire;
- Please provide recommendations you can think of for improving the health, safety and wellness of women in mining; and
- Please provide any additional comments you may have.

Around half of the sample responded to each of these questions. The findings are included in the Milestone 6 report (Chapter 6).

4.4 Statistical analysis

The main objective of the statistical analysis of the quantitative survey data was to gain insight into the quantitative measurement of over-exertion, as well to determine appropriate ways to identify factors contributing to over-exertion. It should be pointed out that, due to the fact that over-exertion has not previously been explicitly measured, the development of the quantitative survey tool, and the subsequent analysis of the data collected with the survey, followed an exploratory approach.

A secondary goal was to determine whether there were any questions in the survey that did not seem to contribute meaningfully to the measurement of over-exertion, and therefore could be left out of the survey in future.

4.4.1 Over-exertedness measures used in analysis

Multiple survey questions were selected to capture various aspects of over-exertion in the analysis of the quantitative survey data, as no single measure of over-exertion was available. These are called "outcome" variables in the following discussion of analysis results, and are now briefly defined:

- The survey question related to the respondent's experience of musculoskeletal pain (answers of "Yes" on the question "Are you experiencing any pain or discomfort in your muscles and joints?") was considered indicative of physical over-exertion over some period of time. This variable was given the label (as a shortened version of the question text) of **Muscle and joints pain** in the tables provided as part of the reporting of analysis results.
- A respondent indicating that they experienced tiredness before, during, and/or after a shift, i.e., providing answers of "very tired" or "exhausted" on any of those three questions, were considered to experience high levels of fatigue and therefore physical over-exertion. This variable is labelled **Tiredness** in the discussion of analysis results.
- Respondents who indicated high levels of exertion during shifts (i.e. answering "7-8", "9", or "10" on the question "How hard do you usually feel your body is working during your shift, on a scale from 0 (minimum) to 10 (maximum)?") were also considered to be experiencing over-exertion on work shifts. This variable is labelled as **RPE** in the discussion of analysis results.

- A variable labelled **Anxiousness** was used to capture information from responses to the survey question “How often do you feel anxious or sad?” to indicate some extent of mental stress. Responses “never” and “rarely” were labelled as “Low” on Anxiousness, “sometimes” was labelled as “Medium” on Anxiousness and “often” and “always” were labelled as “High” for the Anxiousness outcome variable.
- Another aspect of mental exertion was loss of concentration, or the outcome variable labelled **Concentration**. Respondents who answered “never” or “rarely” to the question “How often do you have trouble concentrating on your work tasks?” were grouped as “low” on Concentration, those who answered “sometimes” were grouped as “medium” on Concentration, and those who responded “often” or “always” were grouped as “high” on concentration.
- The answers to the question “How are you feeling on a scale of 1 (terrible) to 10 (great!)?” were used to create the outcome measure labelled **Feelings**. Ratings of 1-4 on the question were grouped as a “low” value for Feelings, ratings of 5 and 6 were grouped as “medium” Feelings, and ratings of 7-10 as “high” value on Feelings.
- Respondents’ answers on the question “How would you rate your quality of life?” were used for the outcome measure **Quality of life**. Values of “poor” and “very poor” were grouped as “low”, “neither good nor poor” as “medium” and “good” and “very good” as a “high” value on Quality of life.
- Respondents were asked to provide their perspective on their health with the question “How is your health?” which was used for the outcome measure labelled Health. Answers of “bad” and “very bad” were translated into “low” on Health, “neither good nor bad” was translated into a “medium” value for Health and “good” and “very good” answers were grouped as “high” on Health.
- Finally, an outcome measure labelled **Sick leave** was obtained from answers to the survey question “How many days of sick leave did you take in the past year?” Answers of “None” and “1-4 days” were grouped into “low”, and “5-9 days” and “10 or more days” into “high” values for Sick leave.

These “outcome” variables formed the focus of the analysis, in which the objective was to understand underlying causes of over-exertion. Therefore, in the analysis, relationships between the “outcome” variables and all the other questions in the survey were investigated. For ease of reference in the discussion, the variables related to the survey questions on underlying factors that could potentially influence over-exertion are called “factor” measures.

4.4.2 Analysis steps carried out

The first step in the analysis was to investigate patterns within the "outcome" variables, for the total group as well as within the different workplace categories. This was done with the frequency tables below, in which a count (and the percentage the count forms of the total) is provided per answer category for each "outcome" measure.

Table 45 shows that just over a third of the respondents reported that they experienced musculoskeletal pains.

Table 45: Summary of responses on musculoskeletal pain

Muscle and joints pain	Frequency (count)	Percentage
No	344	63.24
Yes	200	36.76
Number who did not answer the question (missing data) = 5		

Slightly more than half of the respondents reported that they experience fatigue (Table 46).

Table 46: Summary of responses on tiredness outcome

Tiredness	Frequency (count)	Percentage
Yes	281	52.43
No	255	47.57
Number who did not answer the question (missing data) = 13		

Just over 20% of the respondents reported that they work at "high" levels of intensity during their work shifts.

Table 47: Summary of responses on work intensity outcome

RPE	Frequency (count)	Percentage
Low	190	35.38
Medium	233	43.39
High	114	21.23
Number who did not answer the question (missing data) = 12		

Not very many respondents experienced high levels of anxiety, as Table 48 shows, only 14%, while most respondents indicated a medium level of anxiousness.

Table 48: Summary of responses on anxiousness outcome

Anxiousness	Frequency (count)	Percentage
Medium	289	53.32
Low	177	32.66
High	76	14.02
Number who did not answer the question (missing data) = 7		

Most respondents did not experience problems with concentration, since over 60% of them were in the "low" group for the concentration outcome measure and only about 6% reported often having problems concentrating on tasks (Table 49).

Table 49: Summary of responses on concentration outcome

Concentration	Frequency (count)	Percentage
Low	331	61.41
Medium	176	32.65
High	32	5.94
Number who did not answer the question (missing data) = 10		

Generally, respondents reported that they felt good, and about 17% of respondents reported low ratings on the Feelings outcome measure (Table 50).

Table 50: Summary of responses on feelings outcome

Feelings	Frequency (count)	Percentage
High	262	48.88
Medium	182	33.96
Low	92	17.16
Number who did not answer the question (missing data) = 13		

Again, not very many respondents rated themselves low on the quality of life measure, only 5.9% measuring low on the quality of life measurement (Table 51).

Table 51: Summary of responses on quality of life outcome

Quality of life	Frequency (count)	Percentage
High	331	61.41
Medium	176	32.65
Low	32	5.94
Number who did not answer the question (missing data) = 8		

Only 3.4% of respondents rated their health as "low", and just over 70% rate it as "high" (Table 52).

Table 52: Summary of responses on health outcome

Health	Frequency (count)	Percentage
High	379	70.32
Medium	140	25.97
Low	20	3.71
Number who did not answer the question (missing data) = 10		

Most of the respondents had taken a low or medium number of sick leave days, and only 12.7% of them had a high number of sick leave days (Table 53).

Table 53: Summary of responses on sick leave outcome

Sick leave	Frequency (count)	Percentage
Low	346	63.49
Medium	130	23.85
High	69	12.66
Number who did not answer the question (missing data) = 4		

The next step was to investigate if these patterns differed between workers underground or on the surface. This was done by compiling a cross-table (also called a contingency table) that provides a count of the number of respondents indicating musculoskeletal pain, with the count broken down according to their place of work. The contingency table (Table 54) shows that a higher percentage of underground workers experienced pains – 42.2% indicated "Yes" which is higher than the percentage amongst surface workers (34.6%) or surface office workers (32.4%).

These patterns can be further analysed by applying the statistical Chi-squared test to the count data in this table. This test determines whether the differences in patterns seen (i.e., the differences in percentage values of the different workplace groups) represent a consistent, non-random pattern. The test produces a probability value (referred to as a p-value) as an analysis output. Generally, if a p-value of *lower than* 0.05 is obtained, it is taken as an indication of a non-random pattern, or a **statistically significant** pattern. For this table, the calculated p-value from the Chi-squared test is p = 0.1088. Therefore, since this p-value is above 0.05, it can be concluded that there is **not** a statistically significant association between workplace and musculoskeletal pain amongst respondents. In other words, workplace does not seem to have a strong influence on the pattern of musculoskeletal pain amongst respondents.

Table 54: Summary of responses on musculoskeletal pain grouped per workplace

Muscle and joints pain	Workplace			
	Surface office	**Surface workers**	**Underground**	**Total**
No	117 (67.6%)	108 (65.45%)	119 (57.8%)	344
Yes	56 (32.4%)	57 (34.55%)	87 (42.2%)	200
Total	173	165	206	544
Not answered = 5				

A similar analysis process of compiling a cross-table and then applying a Chi-squared test to the table data was followed on all the "outcome" measures. Table 55 indicates that a higher percentage of underground workers (59.8%) reported being tired before, during, or after a shift than surface workers (46.9%) or surface office workers (49.1%). The p-value obtained from the Chi-squared test applied to this table is p = 0.0293. This value is lower than 0.05, and therefore this pattern is considered as **statistically significant** (i.e. a consistent, non-random pattern), and it can be concluded that workplace has an influence on tiredness.

Table 55: Summary of responses on tiredness per workplace

Tiredness	Workplace			
	Surface office	**Surface workers**	**Underground**	**Total**
No	88 (50.9%)	87 (53.05%)	80 (40.2%)	255
Yes	85 (49.1%)	77 (46.95%)	119 (59.8%)	281
Total	173	164	199	536
Not answered = 13				

In terms of work intensity during the shift, surface workers and underground workers reported similar levels, and surface office workers lower levels of intensity. 29.3% of underground workers, and 25% of surface workers reported high levels of RPE, compared to only 8.1% of surface office workers (Table 56). The p-value from the Chi-squared test for the data in this table is p = 0.0001, and this is **statistically significant**, which means that workplace is considered to have a non-random and consistent influence on RPE.

Table 56: Summary of responses on work intensity per workplace

RPE	Workplace			
	Surface office	**Surface workers**	**Underground**	**Total**
Low	86 (50%)	52 (31.7%)	52 (25.9%)	190
Medium	72 (41.9%)	71 (43.3%)	90 (44.8%)	233
High	14 (8.1%)	41 (25%)	59 (29.3%)	114
Total	172	164	201	537
Not answered = 12				

On the Anxiousness outcome measure there seemed to be relatively small differences in patterns amongst the workplace groups, as seen in Table 57, and the Chis-squared test on this table resulted in a p-value of p = 0.3905, which is above 0.05. It can therefore be concluded that there is **not** a statistically significant pattern difference when comparing workplaces in terms of anxiousness.

Table 57: Summary of responses on anxiousness per workplace

Anxiousness	Workplace			
	Underground	Surface office	Surface worker	Total
Medium	117 (57.1%)	86 (50%)	86 (52.1%)	289
Low	60 (29.3%)	57 (33.1%)	60 (36.4%)	177
High	28 (13.6%)	29 (16.9%)	19 (11.5%)	76
Total	205	172	165	542
Not answered = 7				

It seems that a slightly higher percentage of surface office workers had a "high" value for the Concentration outcome, with 9.3%, compared to 4% amongst the underground group and 4.8% amongst the surface worker group (Table 58). The p-value from the Chi-squared test on this table was p = 0.0436, which is lower than 0.05, and indicates a **statistically significant** pattern difference per workplace.

Table 58: Summary of responses on concentration per workplace

Concentration	Workplace			
	Underground	Surface office	Surface worker	Total
Low	120 (59.4%)	98 (57%)	113 (68.5%)	331
Medium	74 (36.6%)	58 (33.7%)	44 (26.7%)	176
High	8 (4%)	16 (9.3%)	8 (4.8%)	32
Total	202	172	165	539
Not answered = 10				

The way respondents rated their overall feelings did not seems to differ extensively amongst the three workplace groups, even though a slightly higher proportion of underground workers indicated "low" feelings ratings (Table 59). The Chi-squared test resulted in a p-value of p = 0.3986, which is lower than 0.05 and therefore confirmed that there is **not** a statistically significant difference in Feelings patterns amongst workplace subgroups.

Table 59: Summary of responses on feelings per workplace

Feelings	Workplace			
	Underground	Surface office	Surface worker	Total
High	94 (47.2%)	81 (46.8%)	87 (53.1%)	262
Medium	64 (32.2%)	65 (37.6%)	53 (32.3%)	182
Low	41 (20.6%)	27 (15.6%)	24 (14.6%)	92
Total	199	173	164	536
Not answered = 13				

For Quality of life there also did not seem to be a consistent patten of differences amongst the three workplace groups (Table 60). The Chi-squared test confirmed this with a p-value of above 0.05, namely p = 0.3255, indicating that there is **not** a statistically significant pattern difference.

Table 60: Summary of responses on quality of life per workplace

Quality of life	Workplace			
	Underground	Surface office	Surface worker	Total
High	119 (58.3%)	111 (64.2%)	99 (60.4%)	329
Medium	72 (35.3%)	49 (28.3%)	59 (36%)	180
Low	13 (6.4%)	13 (7.5%)	6 (3.7%)	32
Total	204	173	164	541
Not answered = 8				

Small, but no distinct differences in Health outcome measure patterns were observed amongst the workplace groups, confirmed by the Chi-squared test result of p = 0.2178, which is above 0.05, indicate that there is **not** a statistically significant difference amongst workplace groups with relation to the reported health of respondents.

Table 61: Summary of responses on health per workplace

Health	Workplace			
	Underground	Surface office	Surface worker	Total
High	137 (67.8%)	121 (70%)	121 (73.7%)	379
Medium	61 (30.2%)	43 (24.8%)	36 (22%5)	140
Low	4 (2%)	9 (5.2%)	7 (4.3%)	20
Total	202	173	164	539
Not answered = 10				

The Chi-squared test on the Sick leave outcome measure indicated a **statistically significant** difference amongst workplace groups, with a p-value of p = 0.0047, well below 0.05. Table 62 shows that there seems to be similar patterns for surface workers and underground staff (as seen from similar percentage values of around 60% “low” and 15% “high”), but their pattern differs from that of surface office workers (much lower “high” percentage of almost 75% and a “low” percentage of just over 7%), as seen in Table 62 below.

Table 62: Summary of responses on sick leave per workplace

Sick leave	Workplace			
	Underground	Surface office	Surface worker	Total
Low	126 (60.6%)	129 (74.6%)	91 (55.5%)	346
Medium	52 (25%)	31 (17.9%)	47 (28.7%)	130
High	30 (14.4%)	13 (7.5%)	26 (15.8%)	69
Total	208	173	164	545
Not answered = 4				

The next step was to do further contingency tables and Chi-square tests to determine whether any of the underlying factors such as working conditions or personal habits contributed in a statistically significant way to the over-exertion “outcome” measures. Since the survey included a very large number of such underlying factors, this report does not provide all the contingency tables. Instead, a summary is provided of the p-values from the Chi-squared tests conducted on the contingency tables for each factor compared to an “outcome”. In this way, the statistically significant patterns can be identified from the p-values provided. This summary is provided, and the analysis results discussed, in the next sub-section.

The final step in the analysis was to conduct a step-wise logistic regression for each of the “outcome” variables to identify which of the underlying “factors” had the **strongest** influence on each “outcome”. Logistic regression is an appropriate method to use to analyse the “outcome” measures, since logistic regression can be applied to ordered categorical data, and “outcomes” were measured as ordered categories. Respondents answered Yes / No to some of the “outcome” questions (where “Yes” meant higher over-exertion than “No”), and on others gave a rating which could be translated into a High/Moderate/Low value with a direct ordering from “Low” to “High”. Logistic regression was therefore applied, considering each “outcome” measure in turn as the dependent variable in the model, and all the “factor” measures as independent variables. Using step-wise selection within logistic regression meant that the factors having the strongest effect on the “outcomes” could be identified, with the strongest factor selected into the model during the first step, and the next factors selected in subsequent steps, given their additional influence on the “outcome”, until no further statistically significant effects could be identified.

Since there were pattern differences between workplaces for four of the “outcome” measures, the logistic regression was repeated on those “outcomes” per workplace as well as for the total respondent group. The results of the logistic regression analysis are provided in the sub-section following the Chi-squared analysis results.

4.4.3 Testing influence of underlying factors on outcome measures

The results of the Chi-squared test for association between over-exertion “outcome” measures and potential underlying “factors” contributing to over-exertion is discussed in this sub-section. Since the quantitative survey had many questions, i.e., a large number of potential underlying factors were included in the survey, there were a very large number of contingency tables relating each “outcome” to each “factor”. To maintain clarity on the results of the statistical analysis, the contingency tables are not provided in this report. Instead, a summary containing the p-values obtained from applying the Chi-square test on each of the contingency tables is provided to show which of the “factors” had a statistically significant association with an “outcome”, and which did not.

4.4.3.1 ***Factors relating to the overall work environment***

A few survey questions related to the general work environment of the respondents, such as whether this is a great deal of dust or noise where they work, or whether heavy lifting or the use of vibrating equipment forms part of their work. In Table 63, below, the p-values obtained from the Chi-squared test are summarized, with statistically significant p-values indicated with a grey shading in the relevant table cells. Since the statistically significant values represent non-random, consistent patterns, it seems that heavy lifting, repetitive work actions, and dusty and humid conditions were associated with respondents who indicated that they experience musculoskeletal pains. Tiredness could be linked to commodity, walking long distances as part of the work environment, environments with hot temperatures, dust and poor lighting, as well as exposure to harmful chemicals. RPE patterns were affected by virtually all the measures related to work environment, except for mental demands. Mining experience and mental demands had a statistically significant relationship with Anxiousness, Concentration is related to commodity, and Sick leave to mining experience as well as a number of work environment factors. Concentration and Health do not seem to have statistically significant relationships with any of the work environment factors.

Table 63: Results of Chi-squared test for association between outcome variables and work environment factors for the total respondent group

P-values from Chi-square test: all respondents *(shaded values indicate a statistically significant p-value of < 0.05)*									
Underlying factor	**"Outcome" measure**								
	Muscle and joint pain	**Tired-ness**	**RPE**	**Anxious-ness**	**Concen-tration**	**Current feelings**	**Quality of Life**	**Health**	**Sick leave**
Commodity	0.3523	0.0225	0.0089	0.0455	0.7905	0.0183	0.1022	0.8914	0.164
Mining experience	0.6218	0.2535	0.037	0.753	0.3094	0.806	0.0063	0.577	0.0028
Lifting work	0.0027	0.1384	0.0001	0.7925	0.8468	0.3867	0.1005	0.4951	0.0841
Repetitive work	0.0087	0.7835	0.0004	0.7244	0.73	0.2302	0.2878	0.4336	0.0394
Confined spaces	0.2384	0.1213	0.0001	0.4632	0.9493	0.8591	0.719	0.3783	0.0627
Walk long distances	0.0975	0.0001	0.0001	0.1	0.8061	0.8061	0.0815	0.9281	0.4247
Temperature: hot	0.0697	0.0035	0.0003	0.7792	0.5922	0.8134	0.4251	0.9871	0.0036
Temperature: cold	0.4014	0.386	0.033	0.5611	0.4195	0.195	0.9224	0.4875	0.0888
Dusty environment	0.0125	0.0048	0.0001	0.5843	0.1391	0.2391	0.0965	0.7094	0.009
Poorly lit environment	0.0585	0.0021	0.0001	0.3498	0.2766	0.0734	0.2131	0.095	0.0157
Noisy environment	0.1291	0.0556	0.0001	0.1246	0.1076	0.4717	0.02	0.1503	0.0912
Humidity	0.0041	0.0688	0.0001	0.6113	0.5316	0.6845	0.3619	0.6911	0.4993
Vibration: body	0.9257	0.5637	0.0001	0.4134	0.168	0.0716	0.8657	0.3386	0.0511
Vibration: work	0.5703	0.0563	0.0001	0.8344	0.8279	0.7054	0.8951	0.6543	0.0001
Chemical exposure	0.1078	0.0443	0.0001	0.5285	0.5686	0.3691	0.9473	0.2386	0.0427
Mental demands	0.1211	0.4985	0.2393	0.0326	0.3967	0.6766	0.9314	0.2334	0.863

Since the test on workplace did not indicate a statistically significant effect of workplace on musculoskeletal pains, Chi-squared tests for the influence of work environment factors on outcomes for each of the workplace subgroups were only done for Tiredness, RPE, Concentration and Sick leave, as shown in the following three tables. Generally, the patterns differed for the different workplaces. It should be noted that the surface office workers and surface general workers were smaller subgroups than the underground workers, and for some of the measures there were not enough data within the subgroup to assess. For example, for surface workers there were not a large enough number of respondents for each type of commodity that the commodity factor could be reliably assessed – p-values are indicated, but the values are given in italic font to indicate that they are indicative only. An asterisk in the added “low numbers” column indicate where such problem may affect the reliability of the p-values in a particular row of a table.

Table 64: Results of Chi-squared test for association between outcome variables and work environment factors for the underground workplace subgroup

P-values from Chi-square test: Underground *(shaded values indicate statistically significant p-value of < 0.05)*				
Underlying factor	**"Outcome" measure**			
	Tiredness	**RPE**	**Concentration**	**Sick leave**
Commodity	0.1654	0.1231	0.3686	0.2843
Mining experience	0.9153	0.4079	0.693	0.5896
Lifting work	0.9172	0.1694	0.485	0.6026
Repetitive work	0.2702	0.5403	0.6202	0.5708
Confined spaces	0.0694	0.0532	0.518	0.2245
Walk long distances	0.0093	0.1598	0.5607	0.998
Temperature: hot	0.0024	0.0032	0.3917	0.1328
Temperature: cold	0.7016	0.064	0.9721	0.3426
Dusty environment	0.6549	0.2956	0.0456	0.464
Poorly lit environment	0.5926	0.072	0.7465	0.5418
Noisy environment	0.6786	0.2891	0.0004	0.6968
Humidity	0.8976	0.0015	0.4034	0.795
Vibration: body	0.8592	0.0708	0.8752	0.9464
Vibration: work	0.7762	0.0381	0.7056	0.1118
Chemical exposure	0.0633	0.0031	0.6877	0.4288
Mental demands	0.9401	0.2376	0.2542	0.3725

Table 65: Results of Chi-squared test for association between outcome variables and work environment factors for the surface workers subgroup

P-values from Chi-square test: Surface work *(shaded values indicate statistically significant p-value of < 0.05)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Commodity	*0.2475*	*0.1788*	*0.7248*	*0.269*	*
Mining experience	*0.0145*	*0.3437*	*0.0125*	*0.0085*	*
Lifting work	0.0817	0.0033	0.0726	0.1731	
Repetitive work	0.4562	0.0058	0.7668	0.235	
Confined spaces	0.3304	0.461	0.2304	0.7966	
Walk long distances	0.0039	0.3626	0.4069	0.6971	
Temperature: hot	0.479	0.9948	0.0712	0.0335	
Temperature: cold	0.6929	0.5919	0.4155	0.0063	
Dusty environment	0.0303	0.2625	0.7411	0.0514	
Poorly lit environment	0.0001	0.0058	0.4662	0.0265	
Noisy environment	0.0264	0.6485	0.6898	0.4236	
Humidity	0.0832	0.1468	0.9901	0.7987	
Vibration: body	0.7598	0.0205	0.1269	0.1806	
Vibration: work	0.0538	0.0099	0.4049	0.0462	
Chemical exposure	0.5116	0.0634	0.1269	0.1528	
Mental demands	0.7309	0.0193	0.7905	0.8225	

Table 66: Results of Chi-squared test for association between outcome variables and work environment factors for the surface office subgroup

P-values from Chi-square test: Surface office *(shaded values indicate statistically significant p-value of < 0.05)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Commodity	*0.1459*	*0.4886*	*0.818*	*0.0881*	*
Mining experience	0.7368	0.6805	0.0849	0.128	
Lifting work	0.6742	0.8779	0.843	0.1172	
Repetitive work	0.5171	0.1753	0.6168	0.7607	
Confined spaces	0.5087	0.0025	0.4854	0.4592	
Walk long distances	0.0473	0.5773	0.6404	0.6079	
Temperature: hot	0.55	0.1514	0.0735	0.3447	
Temperature: cold	0.0384	0.8779	0.1106	0.2706	
Dusty environment	0.1018	0.9169	0.089	0.4627	
Poorly lit environment	0.7346	0.3113	0.6507	0.6964	
Noisy environment	0.9588	0.864	0.1267	0.1127	
Humidity	0.4181	0.3461	0.1663	0.5883	
Vibration: body	0.2951	0.4256	0.2593	0.8096	
Vibration: work	0.2798	0.2812	0.9816	0.2167	
Chemical exposure	0.2951	0.4256	0.2593	0.8096	
Mental demands	0.2235	0.9429	0.6593	0.5064	

4.4.3.2 ***Factors relating to specific work conditions***

Amongst the factors relating to work conditions during shifts, the availability of toilets and clean water sources did not seem to influence any of the outcome measures significantly (Table 67), but this could be due to the fact that respondents mostly reported having these facilities in place – if respondents mostly had access to these then there would not be a noticeable difference between those that have access to the facilities and those who do not. Also, while the "work overtime" factor was not statistically significant for the total group, it had a significant influence on Tiredness in the underground subgroup (but not in the other subgroups). Finally, note that not all respondents may have required PPE in their work roles, so for surface workers and surface office workers we did not have sufficient numbers of respondents answering the question on how well PPE fits (as seen from the asterisk in the "low numbers" column) to assess the p-value. The information in these tables must therefore be carefully studied and interpreted.

Table 67: Results of Chi-squared test for association between outcome variables and work condition factors for the total respondent group

P-values from Chi-square test: all respondents *(shaded values indicate statistically significant p-value of < 0.05)*									
Underlying factor	**"Outcome" measure**								
	Muscle and joints pain	**Tired-ness**	**RPE**	**Anxious-ness**	**Concen-tration**	**Feelings**	**Quality of Life**	**Health**	**Sick leave**
Toilets available	0.1269	0.3386	0.4084	0.4089	0.2265	0.127	0.5817	0.0311	0.0077
Clean water source	0.6107	0.2532	0.2193	0.8588	0.7364	0.6206	0.0259	0.4629	0.893
Thirst frequency	0.0076	0.0001	0.0001	0.4148	0.3471	0.1935	0.4113	0.0269	0.0001
Liters of water	0.0322	0.065	0.0039	0.0976	0.7684	0.6954	0.2267	0.9893	0.0008
Energy drink boosters	0.0056	0.0136	0.0035	0.0761	0.0875	0.4027	0.8601	0.1604	0.0003
Work shifts	0.9546	0.1519	0.0001	0.0501	0.4632	0.7955	0.4572	0.8937	0.0001
Shift duration	0.0032	0.0068	0.0016	0.4961	0.439	0.0167	0.0077	0.0459	0.0001
Shift breaks	0.1243	0.0051	0.1317	0.8099	0.4524	0.7367	0.5346	0.1599	0.0059
Work overtime	0.0583	0.1696	0.1105	0.0585	0.2041	0.283	0.8162	0.8317	0.1297
Work duration without tiredness	0.4167	0.0573	0.1801	0.2029	0.6059	0.2013	0.5096	0.8215	0.2063
Work duration out of breath	0.0001	0.0001	0.0142	0.0001	0.0013	0.0051	0.0008	0.0038	0.0001
Harassment experience	0.0135	0.014	0.2766	0.0001	0.0007	0.009	0.0001	0.0006	0.0062
PPE fit	0.0001	0.0702	0.3765	0.0014	0.118	0.012	0.098	0.005	0.0242

Table 68: Results of Chi-squared test for association between outcome variables and work condition factors for the underground subgroup

P-values from Chi-square test: Underground *(shaded values indicate statistically significant p-value of < 0.05)*				
Underlying factor	**"Outcome" measure**			
	Tiredness	**RPE**	**Concentration**	**Sick leave**
Toilets available	0.1094	0.5221	0.8796	0.0001
Clean water source	0.6077	0.8556	0.861	0.7856
Thirst frequency	0.1261	0.0053	0.094	0.0015
Liters of water	0.0047	0.1342	0.0778	0.0557
Energy drink boosters	0.0381	0.8226	0.5607	0.297
Work shifts	0.9918	0.1833	0.6663	0.0144
Shift duration	0.1995	0.0534	0.4964	0.0004
Shift breaks	0.0207	0.1485	0.6923	0.276
Work overtime	0.0395	0.3514	0.3909	0.6722
Work duration without tiredness	0.5921	0.0082	0.6325	0.197
Work duration out of breath	0.2176	0.3055	0.0222	0.0104
Harassment experience	0.5445	0.6245	0.0024	0.2175
PPE fit	0.1781	0.4839	0.1035	0.9057

Table 69: Results of Chi-squared test for association between outcome variables and work condition factors for the surface worker subgroup

P-values from Chi-square test: Surface work *(shaded values indicate statistically significant p-value of < 0.05)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Toilets available	0.7752	0.934	0.176	0.1991	
Clean water source	0.6211	0.849	0.2281	0.5301	
Thirst frequency	0.2936	0.2003	0.015	0.5965	
Liters of water	0.4672	0.5315	0.7948	0.0005	
Energy drink boosters	0.6644	0.051	0.1589	0.0166	
Work shifts	0.017	0.2288	0.7261	0.0366	
Shift duration	0.0261	0.5712	0.2156	0.0653	
Shift breaks	0.5824	0.9602	0.3396	0.0157	
Work overtime	0.685	0.2511	0.3862	0.8517	
Work duration without tiredness	0.3859	0.5006	0.6759	0.5213	
Work duration out of breath	0.0001	0.0036	0.1292	0.0658	
Harassment experience	0.003	0.2221	0.1181	0.0383	
PPE fit	*0.1581*	*0.3609*	*0.1119*	*0.011*	*

Table 70: Results of Chi-squared test for association between outcome variables and work condition factors for the surface office worker subgroup

P-values from Chi-square test: Surface office *(shaded values indicate statistically significant p-value of < 0.05)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Toilets available	0.5004	0.6651	0.0128	0.7132	*
Clean water source	0.309	0.0013	0.5217	0.0127	
Thirst frequency	0.0001	0.3869	0.6362	0.0011	
Liters of water	0.3717	0.3434	0.423	0.9152	
Energy drink boosters	0.0327	0.0038	0.0161	0.1471	
Work shifts	0.3285	0.5373	0.2182	0.4874	
Shift duration	0.3524	0.6514	0.8728	0.2744	
Shift breaks	0.8406	0.0081	0.8876	0.497	
Work overtime	0.5852	0.67	0.289	0.6047	
Work duration without tiredness	0.033	0.0851	0.7799	0.1298	
Work duration out of breath	0.0026	0.9002	0.0418	0.3863	
Harassment experience	0.3292	0.5181	0.0386	0.0961	
PPE fit	*0.6172*	*0.1961*	*0.4196*	*0.7192*	*

4.4.3.3 ***Personal factors***

The survey explored whether certain personal factors, such as whether the respondent smokes or is pregnant affected their exertion. The details of the analysis on these factors compared to the three outcome variables are shown in Table 71 to Table 74. Generally, age did not have a significant influence on outcomes within any of the subgroups or the total group, while the number of heat stress symptoms experienced (such as headaches and nausea – see survey question text) had a statistically significant influence across all groups. There seemed to be a noticeable difference amongst the different subgroups in terms of which measures influenced outcomes. Note that there were very few respondents who indicated that they are pregnant, and even a lower proportion who are breastfeeding, and so the analysis of those measures are inconclusive due to lack of data.

Table 71: Results of Chi-squared test for association between outcome variables and personal factors for the total respondent group

P-values from Chi-square test: all respondents *(shaded values indicate statistically significant p-value of < 0.05)*									
Underlying factor	**"Outcome" measure**								
	Muscle and joints pain	**Tired-ness**	**RPE**	**Anxious-ness**	**Concen-tration**	**Current feelings**	**Quality of Life**	**Health**	**Sick leave**
Age group	0.945	0.9893	0.8219	0.541	0.1243	0.2063	0.1023	0.8566	0.0446
Exercise interval	0.0035	0.1076	0.2637	0.0037	0.632	0.0017	0.0942	0.1616	0.0648
Travel time	0.1462	0.055	0.0354	0.575	0.4001	0.6101	0.1341	0.3244	0.0246
Household activities	0.3448	0.5074	0.04	0.4193	0.3379	0.4777	0.0477	0.25	0.0034
Sleep hours (not working)	0.0841	0.3804	0.8868	0.1151	0.5876	0.0256	0.0306	0.0415	0.5907
Sleep hours (working)	0.0246	0.2087	0.4452	0.332	0.1638	0.2794	0.4035	0.2562	0.0013
Sleep time delay	0.0909	0.9392	0.1913	0.4351	0.0925	0.6448	0.9247	0.7598	0.5032
Usually sleep	0.0001	0.0009	0.0097	0.0001	0.0137	0.0001	0.0005	0.0001	0.1278
Substance of sleep	0.0002	0.0015	0.1752	0.0004	0.0141	0.4411	0.0032	0.0042	0.0266
Arthritis / asthma / cardio / disease	0.0001	0.2218	0.8246	0.0022	0.0009	0.035	0.0013	0.0001	0.0398
Number of heat stress symptoms	0.0001	0.0001	0.0011	0.0001	0.0001	0.2205	0.0007	0.0001	0.0088
Smoke	0.139	0.1974	0.3981	0.1227	0.3292	0.0082	0.3416	0.7248	0.784
Pregnant	0.407	0.8321	0.8731	0.1906	0.5455	0.74	0.9968	0.8962	0.9129
Breastfeeding	0.3089	0.4534	0.4129	0.253	0.192	0.1868	0.4627	0.7882	0.765
Last period	0.0925	0.0558	0.0173	0.1979	0.105	0.3541	0.031	0.0426	0.3142

Table 72: Results of Chi-squared test for association between outcome variables and personal factors for the underground subgroup

P-values from Chi-square test: Underground *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Age group	0.4821	0.8996	0.0797	0.3481	
Exercise interval	0.0803	0.642	0.7651	0.6078	
Travel time	0.0838	0.0533	0.5674	0.0172	
Household activities	0.4063	0.1329	0.9216	0.0479	
Sleep hours (not working)	0.3251	0.0642	0.4782	0.3585	
Sleep hours (working)	0.0687	0.8521	0.3145	0.0975	
Sleep time delay	0.5465	0.6976	0.5379	0.0592	
Usually sleep	0.0375	0.2236	0.3341	0.249	
Substance of sleep	0.1927	0.9297	0.4737	0.9007	
Arthritis / asthma / cardio / disease	0.1952	0.4436	0.0565	0.0893	
Number of heat stress symptoms	0.0054	0.0011	0.1227	0.0281	
Smoke	*0.7787*	*0.2879*	*0.668*	*0.902*	*
Pregnant	*0.8057*	*0.7572*	*0.7771*	*0.8118*	*
Breastfeeding	*0.9315*	*0.1571*	*0.2463*	*0.932*	*
Last period	0.1295	0.0089	*0.0384*	*0.497*	

Table 73: Results of Chi-squared test for association between outcome variables and personal factors for the surface workers subgroup

P-values from Chi-square test: Surface work *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Age group	0.663	0.863	0.3897	0.3462	
Exercise interval	0.8903	0.5051	0.8821	0.0787	
Travel time	0.3122	0.3183	0.3536	0.7164	
Household activities	0.266	0.5865	0.6524	0.8138	
Sleep hours (not working)	0.0067	0.1279	0.6368	0.1999	
Sleep hours (working)	0.7594	0.0319	0.0155	0.0713	
Sleep time delay	0.6569	0.8064	0.4528	0.9614	
Usually sleep	0.0167	0.0348	0.277	0.1647	
Substance of sleep	0.002	0.018	0.0115	0.4282	
Arthritis / asthma / cardio / disease	0.5883	0.9077	0.0672	0.3219	
Number of heat stress symptoms	0.0051	0.2703	0.0407	0.4633	
Smoke	*0.001*	*0.3927*	0.4161	0.1844	*
Pregnant	*0.7518*	*0.3679*	0.8042	0.5863	*
Breastfeeding	*0.6334*	*0.9243*	0.9002	0.7495	*
Last period	0.6781	0.7861	0.1199	0.6628	

Table 74: Results of Chi-squared test for association between outcome variables and personal factors for the surface office workers subgroup

P-values from Chi-square test: Surface office *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Age group	0.7783	0.5583	0.3206	0.2963	
Exercise interval	0.2938	0.8906	0.8142	0.217	
Travel time	0.6366	0.9147	0.8359	0.2449	
Household activities	0.0089	0.0477	0.1928	0.01	
Sleep hours (not working)	0.92	0.6792	0.6344	0.7016	
Sleep hours (working)	0.3175	0.2976	0.4442	0.1695	
Sleep time delay	0.6695	0.1696	0.3069	0.619	
Usually sleep	0.2596	0.2232	0.1213	0.1116	
Substance of sleep	0.2616	0.2069	0.0518	0.0008	
Arthritis / asthma / cardio / disease	0.9236	0.6608	0.1435	0.1723	
Number of heat stress symptoms	0.0273	0.6227	0.0054	0.0365	
Smoke	0.4591	0.394	0.38	0.8722	
Pregnant	0.9906	0.8211	0.6981	0.802	
Breastfeeding	*0.6307*	*0.4515*	0.8909	0.3695	*
Last period	0.1599	0.4351	0.4608	0.762	

4.4.3.4 ***RFA measures***

Although an attempt was made to link the data collected in this survey to RFA assessments done for respondents in the past, due to practical and privacy issues, this was not entirely successful. A low proportion of respondents could be linked to their RFA results, and some of the RFA assessments were done quite a long time before the survey and therefore potentially not applicable to the respondent's current work conditions. As seen in Tables 75 to 78, numbers were too low within the subgroups to allow meaningful analysis. For the total group, it did seem that the maximum load test scores influenced the RPE outcome measure.

Table 75: Results of Chi-squared test for association between outcome variables and RFA measurement factors for the total respondent group

P-values from Chi-square test: all respondents *(shaded values indicate statistically significant p-value)*								
Underlying factor	**"Outcome" measure**							
	Muscle and joints pain	**Tired-ness**	**RPE**	**Anxious-ness**	**Concen-tration**	**Current feelings**	**Quality of Life**	**Health**
Maximum load handling test outcome	0.3372	0.5527	0.017	0.0639	0.4768	0.4768	0.1491	0.0714
Overall PWC requirement outcome	0.4185	0.9918	0.302	0.7068	0.9285	0.2287	0.7326	0.6971

Table 76: Results of Chi-squared test for association between outcome variables and RFA measurement factors for the underground subgroup

P-values from Chi-square test: Underground *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Maximum load handling test outcome	*0.4173*	*0.179*	*0.9412*	*0.4411*	*
Overall PWC requirement outcome	*0.8075*	*0.6348*	*0.7734*	*0.9055*	

Table 77: Results of Chi-squared test for association between outcome variables and RFA measurement factors for the surface workers subgroup

P-values from Chi-square test: Surface work *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Maximum load handling test outcome	*0.2994*	*0.4878*	*0.7415*	*0.3794*	*
Overall PWC requirement outcome	*0.577*	*0.1021*	*0.1153*	*0.9694*	*

Table 78: Results of Chi-squared test for association between outcome variables and RFA measurement factors for the surface office workers subgroup

P-values from Chi-square test: Surface office *(shaded values indicate statistically significant p-value)*					
Underlying factor	**"Outcome" measure**				**Low numbers**
	Tiredness	**RPE**	**Concentration**	**Sick leave**	
Maximum load handling test outcome	*0.2207*	*0.2231*	*0.5403*	*no data*	*
Overall PWC requirement outcome	*0.4652*	*0.0907*	*	*no data*	*

4.4.3.5 ***Anthropometry (body measurements)***

Although respondents were asked to provide certain body measurements, the survey did not allow for facilities to measure these in most cases, and so respondents had to provide their answer from past measures (or what they could recall of these). Also, they were not compelled to answer, and many chose not to. The data that was supplied were analysed against the outcome measures with a correlation analysis, but as can be seen from Table 79 to Table 82, the correlation coefficients were quite low – a correlation coefficient of above 0.4 or below -0.4 would be considered indicative of a strong correlation, and the values in the table are all well below these cut-offs. From this survey, it does not seem as if there is any strong, direct relationship between the outcome measures and any of the anthropometric measurements.

Note that the number of datapoints that could be included in the correlation is supplied in the tables to indicate the relatively low response on these questions.

Table 79: Correlations between outcome variables and anthropometry measures for total respondent group

Correlation coefficients (all respondents)									
Measure-ment	**Muscle and joints pain**	**Tired-ness**	**RPE**	**Anxious-ness**	**Concen-tration**	**Feelings**	**Quality of life**	**Health**	**Sick leave**
Body weight (in kg)	0.103 (n =459)	0.049 (n =453)	0.063 (n =454)	0.086 (n =457)	0.105 (n 387)=455)	-0.108 (n =453)	-0.082 (n =456)	-0.12 (n =454)	0.074(n =460)3
Body height (in cm)	0.022 (n = 391)	0.01 (n = 386)	-0.013 (n = 387)	0.049 (n = 389	0.039 (n = 388)	0.044 (n = 386t)	-0.021 (n = 389)	-0.033 (n = 387)	0.031 (n = 392)
Waist girth (in cm)	0.092 (n = 281)	0.023 (n = 278)	0.024 (n = 276)	0.054 (n = 278)	0.121(n = 276)	-0.049 (n = 277)	-0.033 (n = 279)	-0.021 (n = 277)	0.004 (n = 282)
Hip girth (in cm)	0.057 (n = 255)	0.017 (n = 252)	0.021 (n = 250)	0.095 (n = 252)	0.1 (n = 250)	-0.052 (n = 251)	-0.031 (n = 253)	-0.044 (n = 251)	-0.052 (n = 256)
BMI	0.116 (n = 380)	0.015 (n = 375)	0.060 (n = 376)	0.105 (n = 378)	-0.111 (n = 377)	-0.045 (n = 375)	-0.125 (n = 378)	0.046 (n = 376)	0.105 (n = 381)
Waist-to-hip ratio	0.035 (n = 253)	0.038 (n = 250)	0.012 (n = 248)	0.041 (n = 250)	0.016(n = 248)	-0.015 (n = 249)	-0.071 (n = 251)	0.021 (n = 249)	0.041 (n = 251)

Table 80: Correlations between outcome variables and anthropometry measures for the underground subgroup

Correlation coefficients (underground)				
Measurement	**Tiredness**	**RPE**	**Concentration**	**Sick leave**
Body weight (in kg)	0.066 (n =190)	-0.023 (n =186)	0.011 (n =187)	0.054 (n =191)
Body height (in cm)	0.002 (n = 164)	-0.039 (n = 166)	-0.053 (n =167)	0.033 (n =170)
Waist girth (in cm)	0.045 (n = 147)	-0.001 (n = 146)	0.002 (n =146)	-0.005 (n =151)
Hip girth (in cm)	0.041 (n = 141)	-0.050 (n = 140)	-0.080 (n =140)	0.063 (n =145)
BMI	0.114 (n = 163)	-0.014 (n = 165)	0.020 (n =166)	0.057 (n =169)
Waist-to-hip ratio	0.045 (n = 140)	-0.022 (n = 139)	0.062 (n = 139)	-0.109 (n =144)

Table 81: Correlations between outcome variables and anthropometry measures for the surface worker subgroup

Correlation coefficients (surface workers)				
Measurement	**Tiredness**	**RPE**	**Concentration**	**Sick leave**
Body weight (in kg)	-0.039 (n =127)	0.096 (n =127)	0.050 (n =127)	0.146 (n =127)
Body height (in cm)	0.134 (n = 107)	0.144 (n = 107)	0.088 (n =107)	0.035 (n =107)
Waist girth (in cm)	-0.23 (n= 59)	-0.156 (n = 59)	0.158 (n =59)	-0.0002 (n =59)
Hip girth (in cm)	-0.183 (n = 51)	0.059 (n = 51)	0.183 (n =51)	-0.182 (n =51)
BMI	-0.210 (n = 103)	-0.007 (n = 103)	0.032 (n =103)	0.083 (n =103)
Waist-to-hip ratio	-0.073 (n = 50)	-0.150 (n = 50)	-0.007 (n =50)	0.138 (n =50)

Table 82: Correlations between outcome variables and anthropometry measures for the surface office worker subgroup

Correlation coefficients (surface office workers)				
Measurement	Tiredness	RPE	Concentration	Sick leave
Body weight (in kg)	0.106 (n =142)	0.164 (n =141)	0.231 (n =141)	0.042 (n =142)
Body height (in cm)	-0.046 (n = 115)	-0.049 (n = 114)	0.075 (n =114)	0.073 (n =115)
Waist girth (in cm)	0.165 (n = 72)	0.267 (n = 71)	0.28 (n =71)	0.076 (n =72)
Hip girth (in cm)	0.149 (n = 60)	0.197 (n = 59)	0.325 (n =59)	-0.122 (n =60)
BMI	0.076 (n = 109)	0.261 (n = 108)	0.237 (n =108)	0.006 (n =109)
Waist-to-hip ratio	0.097 (n = 60)	0.236 (n = 59)	0.065 (n =59)	0.208 (n =60)

4.4.4 Determining the factors with the strongest influence on outcome measures

In the previous subsection, it was reported which “factors” seemed to influence “outcome” variables. However, to answer the question of which of these had the **strongest influence**, a further step was carried out in the analysis. For each “outcome” measure, the various factors from the survey questions, including the anthropometric measures, but excluding the RFA data (due to low numbers of respondents for whom this data could be found) were included in a step-wise Logistic regression model. This method conducts a number of steps – in each step the measure with the strongest influence amongst all the factors not yet in the model were selected for inclusion into the model, by considering the Chi-squared value and associated p-value. Once the measure was included, the new model was assessed for statistical significance, and some measures were then excluded again. These steps are carried out until the group of “best” possible measures are included in the model. Note that the measures included at each step considers the measures already included in previous steps, thereby taking into account relationships between “factors” and not just the individual “factors” themselves. The results, i.e. a summary of the Logistic Regression model-fitting steps for each “outcome” measure, are provided below.

4.4.4.1 ***Factors affecting Musculoskeletal pain***

The number of heat stress symptoms was the strongest influencing “factor” for musculoskeletal pain, since that was selected in the first step of the step-wise procedure, followed by how often the respondent exercised per week, mining experience, age, humidity and whether the respondent was a smoker or not (Table 83).

Table 83: Results of stepwise Logistic regression for Muscle and joint pain for total respondent group

Summary of Stepwise Selection						
Step	Effect		DF	Number of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Number of heat stress symptoms		3	1	21.3489	<.0001
2	Exercise Interval		3	2	10.6126	0.014
3	Mining experience		4	3	10.8469	0.0283
4	Age		2	4	6.7042	0.035
5	Humidity		1	5	5.4401	0.0197
6	Smoking		1	6	4.3643	0.0367

Since there was no statistically significant difference between workplaces for musculoskeletal pain (as indicated previously), the pattern for the entire respondent group is assumed to be similar for all sub-groups as well.

4.4.4.2 ***Factors affecting Tiredness***

The results for the step-wise Logistic regression for the outcome variable Tiredness indicated that whether respondents had to walk a long way during their shift had the strongest influence. Household activities, whether the person works overtime, how often they get thirsty during a shift or drank energy boosters were next, and travel time was also a strong influence (Table 84).

Table 84: Results of stepwise Logistic regression for Tiredness for total respondent group

Summary of Stepwise Selection						
Step	Effect		DF	Number of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Walk long distances		1	1	12.9337	0.0003
2	Household activities		3	2	13.7041	0.0033
3	Work overtime		3	3	12.7137	0.0053
4	Thirst frequency		2	4	8.8541	0.0119
5	Energy drink boosters		2	5	7.8732	0.0195
6	Travel time		4	6	9.7959	0.044

The logistic regression was also repeated for the three workplace subgroups. However, since logistic regression requires each respondent to have answered all the questions in to order to test all relationships between them, data for respondents who did not answer all questions had to be excluded. For the underground subgroup, only 76 respondents answered "Yes", and this limited the analysis. Only the number of heat stress symptoms could be identified as a strong influence on Tiredness in this sub-group – while reported breastfeeding was identified as a potential for the logistic regression model, it was first included and then removed after re-assessment. The final model for this sub-group therefore only has one measure in it as “factor”, namely “number of heat stress symptoms” (Table 85).

Table 85: Results of stepwise Logistic regression for Tiredness for underground subgroup

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	Number of heat stress symptoms		3	1	9.3519	0.025
2	Breastfeeding		1	2	5.1749	0.0229
3		Breastfeeding	1	1		0.9861

For the other two subgroups, the logistic regression could not pinpoint the strongest influencing variables, since amongst Surface workers only 15 respondents with "Yes" answers, for surface office workers only 21 respondents who answered "Yes" had complete records.

4.4.4.3 ***Factors affecting RPE***

For the RPE “outcome”, four influencing variables were identified, in order of strength: when the respondent had their last period, how long it takes them to fall asleep, whether they work in shifts, and whether they work in a humid environment (Table 86).

Table 86: Results of stepwise Logistic regression for RPE for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	Last period		6	1	20.5374	0.0022
2	Sleep time delay		3	2	15.8334	0.0012
3	Work shifts		1	3	8.5833	0.0034
4	Humidity		1	4	5.4283	0.0198

The same four “factors” were the strongest influencers for the underground subgroup, as shown in Table 87, although the order of selection was slightly different. The number of heat stress symptoms, whether they take breaks during shifts, and their usual sleep pattern also has a strong influence in this subgroup. How well PPE fits could be a contributing influence, since it entered the model but was removed in the re-assessment of the model.

Table 87: Results of stepwise Logistic regression for RPE for underground subgroup

Summary of Stepwise Selection						
Step	Effect		DF	Number of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Last period		6	1	20.9962	0.0018
2	Humidity		1	2	9.2671	0.0023
3	Work shifts		1	3	6.4231	0.0113
4	Sleep time delay		3	4	11.2255	0.0106
5	PPE fit		2	5	9.6308	0.0081
6	Number of heat stress symptoms		3	6	8.1052	0.0439
7	Shift breaks		3	7	9.4032	0.0244
8		PPE fit	2	6	4.0255	0.1336
9	Usually Sleep		2	7	6.4142	0.0405

However, influencing factors were different amongst the surface workers subgroups, with humidity of the work environment and delay falling asleep the same as for the total group, but a number of other "factors" selected for the model, such as mental demands and cold temperatures (Table 88).

Table 88: Results of stepwise Logistic regression for RPE for surface workers subgroup

Summary of Stepwise Selection						
Step	Effect		DF	Num-ber of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Mental demands		1	1	6.585	0.0103
2	Temperature cold		1	2	4.5397	0.0331
3	Harassment Experience		2	3	6.3092	0.0427
4	Sleep time delay		3	4	9.0205	0.029
5	Work duration without tiredness		3	5	7.9371	0.0473
6	Arthritis / asthma / cardio disease		1	6	5.801	0.016
7	Energy drink boosters		2	7	10.8571	0.0044
8	PPE fit		2	8	14.5574	0.0007
9		Harassment Experience	2	7	0.5635	0.7545
10		PPE fit	2	6	3.7177	0.1558
11	Harassment Experience		2	7	19.9889	<.0001

For the surface office workers subgroup the step-wise Logistic regression could not identify any influencing factors due to this sub-group having only five respondents who indicated "high" RPE (amongst those with complete records for this subgroup).

4.4.4.4 ***Factors affecting Anxiousness***

The results for the step-wise Logistic regression for the outcome variable Anxiousness indicated that there was only one “factor” that had a strong influence, namely how well the respondent usually sleeps (Table 89).

Table 89: Results of stepwise Logistic regression for Anxiousness for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Usually sleep**		2	1	11.2102	0.0037

4.4.4.5 ***Factors affecting Concentration***

The results for the step-wise Logistic regression for the outcome variable Concentration, as summarised in the table below, that workplace had the strongest influence, followed by factors in the working environment: noise, poor lighting and humidity (Table 90).

Table 90: Results of stepwise Logistic regression for Concentration for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Workplace**		2	1	6.9702	0.0307
2	**Noisy environment**		1	2	7.3982	0.0065
3	**Poorly lit environment**		1	3	4.301	0.0381
4	**Humidity**		1	4	4.5273	0.0334

For the underground workers, as seen in Table 91, some workplace factors (commodity, hot or cold temperatures, dust, mental demand) were influences, but personal factors (how well usually sleeps, how much water is drunk) also played role.

Table 91: Results of stepwise Logistic regression for Concentration for underground subgroup

Summary of Stepwise Selection						
Step	Effect		DF	Number of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Noisy environment		1	1	7.3792	0.0066
2	Usually sleep		2	2	6.8968	0.0318
3	Temperature: hot		1	3	5.3644	0.0206
4	Work duration without tiredness		3	4	10.7	0.0135
5	Liters of water		4	5	13.6492	0.0085
6	Dusty environment		1	6	6.8034	0.0091
7	Commodity		4	7	11.7974	0.0189
8		Noisy environment	1	6	1.8202	0.1773
9	Work duration before out of breath		2	7	7.1179	0.0285
10	Mental demand		1	8	5.8936	0.0152
11	Temperature: cold		1	9	4.6845	0.0304

For Surface workers, no strong factors could be identified. Amongst surface office workers, humidity of the environment was identified as an influencing factor, with harassment experience of some importance, but not sufficient to remain in the model (Table 92).

Table 92: Results of stepwise Logistic regression for Concentration for surface office subgroup

Summary of Stepwise Selection						
Step	Effect		DF	Number of vars	Chi-Square Score	p-value
	Entered	Removed				
1	Humidity		1	1	4.0078	0.0453
2	Harassment experience		2	2	6.5737	0.0374
3		Harassment experience	2	1	3.8516	0.1458

4.4.4.6 ***Factors affecting Feelings***

The results for the step-wise Logistic regression for the outcome variable Feelings (Table 93) indicate that how well the respondent usually sleeps and whether the working environment is well lit has a strong influence.

Table 93: Results of stepwise Logistic regression for Feelings for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Usually sleep**		2	1	13.7233	0.001
2	**Poorly lit environment**		1	2	6.0178	0.0142

4.4.4.7 ***Factors affecting Quality of life***

For the Quality of life outcome variable the results for the step-wise Logistic regression (in Table 94 below) shows that an anthropometric variable, body height, had the strongest influence, followed by how well the respondent usually sleeps.

Table 94: Results of stepwise Logistic regression for Quality of life for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Body Height**		1	1	9.4439	0.0021
2	**Usually sleep**		2	2	10.4372	0.0054

4.4.4.8 ***Factors affecting Health***

Whether a respondent suffered from a disease (arthritis, asthma or cardio) had the strongest influence on their perception of health, as the results of the step-wise Logistic regression for the outcome variable Health shows. How long a person works before being out of breath, and whether PPE fits were also influences (Table 95).

Table 95: Results of stepwise Logistic regression for Health for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Arthritis / asthma / cardio disease**		1	1	11.989	0.0005
2	**Work duration before out of breath**		2	2	9.6052	0.0082
3	**PPE Fit**		2	3	6.6771	0.0355

4.4.4.9 ***Factors affecting Sick leave***

The results for the step-wise Logistic regression in Table 96 for the outcome variable Sick leave, puts PPE fit as strongest influence, followed by body height, age, and availability of toilets. The other three tables shows that similar factors were influencers for underground and surface office workers, while for surface workers a different set of factors were identified as influences, including whether breaks could be taken in the shift, whether work involves working with vibrating equipment and exposure to harmful chemicals in the workplace.

Table 96: Results of stepwise Logistic regression for Sick leave for total respondent group

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**PPE Fit**		2	1	12.4244	0.002
2	**Body height**		1	2	4.9405	0.0262
3	**Age**		2	3	5.6515	0.0593
4	**Toilets available**		1	4	3.5249	0.0605

Table 97: Results of stepwise Logistic regression for Sick leave for underground subgroup

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Toilets available**		1	1	11.054	0.0009
2	**Temperature: hot**		1	2	7.8075	0.0052
3	**Travel time**		4	3	11.4751	0.0217
4	**Repetitive work**		1	4	3.3557	0.067

Table 98: Results of stepwise Logistic regression for Sick leave for Surface worker subgroup

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Shift breaks**		3	1	17.2664	0.0006
2	**Vibration: work**		1	2	4.7922	0.0286
3	**Chemical exposure**		1	3	6.5882	0.0103

Table 99: Results of stepwise Logistic regression for Sick leave for Surface office subgroup

Summary of Stepwise Selection						
Step	**Effect**		**DF**	**Number of vars**	**Chi-Square Score**	**p-value**
	Entered	**Removed**				
1	**Body height**		1	1	6.2378	0.0125
2	**Toilets available**		1	2	5.5971	0.018

*4.4.4.10 **Summary of logistic regression outputs***

The following two tables (Table 100 and 101) summarise the findings from the logistic regression relation to the main influencing factors. This summary was compiled for the overall respondent group only, for details on differences per workplace on Tiredness, RPE, Concentration and Sick leave, please refer to the relevant subsection discussion. Table 100 first lists which “factors” were linked to which “outcomes”, and Table 101 indicates what type of influence is associated with each “factor” relative to the “outcome”.

Table 100: Summary of influencing "factor" variables for each "outcome variable

Factors	Outcome measures								
	Muscle and joint pain	Tired -ness	RPE	Anxious-ness	Concen -tration	Current feeling s	Quality of Life	Healt h	Sick leave
Working environment									
Workplace					X				
Mining experience	X								
Walk long distances		X							
Poorly lit environmen t					X	X			
Noisy environmen t					X				
Humidity	X		X		X				
Work conditions									
Toilets available									X
Thirst frequency		X							
Energy drink boosters		X							
Work shifts			X						
Work overtime		X							
Work duration before out of breath								X	
PPE Fit								X	X
Personal factors									
Age	X								X
Exercise Interval	X								
Travel time		X							
Household Activities		X							
Sleep time delay			X						
Usually sleep				X		X	X		
Arthritis / asthma / cardio disease								X	
Number of heat stress symptoms	X								
Smoking	X								
Last period			X						
Body Height							X		X

Table 101: Description of influencing "factor" variables for each "outcome variable

Factors	Description of factor effect
Work environment	
Workplace	More pronounced negative outcomes for surface workers
Mining experience	The higher the mining experience, the more "yes" on muscle and joint pains
Walk long distances	Longer distances associated with "yes" on tiredness
Poorly lit environment	Poorly lit "Yes" associated with negative outcomes
Noisy environment	Noisy "Yes" associated with fewer "Medium" concentration
Humidity	Humidity "Yes" associated with negative outcomes
Work conditions	
Toilets available	Toilets available "Yes" associated with higher sick leave days taken
Thirst frequency	Thirsty "Often" associated with tiredness "Yes"
Energy drink boosters	Those who drink one or more energy boosters associated with tiredness "Yes"
Work shifts	Day shift workers associated with fewer "High" RPE
Work overtime	Work overtime "Often" associated with higher proportion of tiredness "Yes"
Work duration before out of breath	Out of breath "Never" associated with higher proportion of "High" health
PPE Fit	PPE fit "Yes" associated with higher health and lower sick leave days
Personal factors	
Age	< 35 higher on health and 35-44 age group lower on sick leave days
Exercise Interval	Exercise "never" have more muscle and joint proportion pain "Yes", any exercise level have more "No" proportion on pain
Travel time	Tiredness "Yes" proportion lower for short travel times
Household Activities	Tiredness "Yes" proportion higher with more household activity time, highest if > 4 hours
Sleep time delay	< 10 minutes sleep delay, more "low" RPE, generally shorter delay associated with lower RPE
Usually sleep	Usually sleep "Well" associated with lower anxiousness, "High" health and "High" quality of life
Arthritis / asthma / cardio disease	Disease "No" associated with health "High"
Number of heat stress symptoms	The more symptoms, the higher proportion of "Yes" on muscle and joints pain, highest for > 2 symptoms experienced
Smoking	Lower proportion of muscle and joints pain "No" for smoking "No"
Last period	Generally, higher proportion of "High" RPE for last period "Now" or "About a week ago"
Body Height	Generally higher values of height, lower quality of life and lower sick leave

4.4.5 Potential for the reduction in survey questions

Although one of the sub-goals of the analysis was to identify whether any of the survey questions could be removed because they do not provide significant information, unfortunately the analysis was not very successful in achieving that. Table 102 shows that almost every measure was either statistically significant when tested one-on-one in contingency tables with "outcomes", or was identified as an important influence with the step-wise Logistic regression, or both. One can conclude that over-exertion is very complex to measure, and that the factors contributing to it are very many, and very inter-related.

Table 102: Potential for reducing number of variables in survey tool

"Factor" variables included in analysis	Statistically significant on Chi-square	Included in Logistic regression
Workplace	X	X
Commodity	X	
Mining experience	X	X
Lifting work	X	
Repetitive work	X	X
Confined spaces	X	
Walk long	X	X
Temperature hot	X	X
Temperature cold	X	X
Dusty environment	X	
Poorly lit environment	X	
Noisy environment	X	
Humidity	X	X
Vibration: body	X	
Vibration: work	X	X
Chemical exposure	X	X
Mental demands	X	X
Toilets available		X
Clean water source	X	
Thirst frequency	X	X
Liters of water	X	
Energy drink boosters	X	X
Work shifts	X	
Shift duration	X	
Shift breaks	X	X
Work overtime	X	X
Work duration without tiredness	X	
Work duration out of breath	X	X
Harassment experience	X	X
Age group		X
Exercise interval	X	X
Travel time	X	X
Household activities	X	X
Sleep hours not working	X	
Sleep hours working	X	
Sleep time delay		X
Usually sleep	X	X
Substance of sleep	X	
Arthritis / asthma / cardio disease	X	X
Number of heat stress symptoms	X	X
Smoke	X	X
Pregnant		
Breastfeeding		
Last period	X	X
PPE fit	X	X
RFA measures	too low numbers to assess properly	too low numbers to assess properly
Anthropometry (body measurements)	Not applicable	X

4.5 Discussion

The survey assisted to gain data relating to the capacity and demands of WIM in the SAMI, and these were assessed to gain an indication of over-exertion. A few of the findings are discussed in this section. Findings from further data triangulation to integrate and better explain findings from the literature review and qualitative data gathered from participants is included in Chapter 8.

The main workplace exposures that were reported in the survey were those of noise, dust, and mental demands (thinking and planning). Underground workers appeared to face the highest number of exposures, and also reported more heat stress symptoms than the other categories of workers. The reported incidence of harassment was also highest amongst underground workers. In addition, while strides have been made to improve the PPE for WIM, some still indicated their PPE did not fit properly, or had suggestions to improve the PPE, which could impact their ability to conduct work safely and comfortably.

Lack of access to adequate toilet facilities and drinking water in the workplace was reported by over 10% of the respondents. A third of the sample indicated often feeling extreme thirst during a shift, and this could be linked to the availability of drinking water and exposure to heat. The majority reported drinking between 1 and 2 litres of water during a shift; this amount could be insufficient, especially for those working in physically demanding jobs and/or in hot environments.

The majority of participants (57%) usually obtained less than seven hours of sleep before a work shift. Furthermore, a sleep debt was evident, as participants needed to catch up on sleep on off days. A lack of sleep can lead to fatigue and safety incidents, and could be associated with shift work, overtime, and demands outside of work. Around half worked shifts of longer than 8 hours, and a large portion of the sample worked overtime. In the sample 71% spent over two hours doing household chores outside of work each day. Long commuting times to work and home from work further contribute to a lack of time to sleep. Furthermore, over a third of the sample usually took longer than 30 minutes to fall asleep once in bed, and 10% reported using medication or beverages to help them sleep.

A lack of breaks during strenuous work can also be associated with fatigue. It was evident that over a quarter of underground workers did not take breaks during work, which was a concern due to the harsher underground environment and could lead to poor health and safety outcomes. The majority of the participants reported feeling tired after working for between 4 and 6 hours, which also indicates the importance of rest breaks.

Medical conditions could be a cause or consequence of over-exertion, and were reported by 16% of the sample. It was evident that there were high levels of obesity in the sample, with 63% categorised as obese, according to BMI values. Obesity can have an impact on health, safety, and the ability to perform work. Lifestyle factors, such as lack of exercise, could have an impact on this value. Over half of the sample never or rarely participated in recreational exercise.

The outcome variables used in the study to indicate over-exertion, included musculoskeletal pain or discomfort, subjective health, sick days taken, tiredness after a shift, and RPE. In addition, anxiety or sadness, lack of concentration, present emotional state, and perceived quality of life were assessed. Various relationships between the variables were evident. For example, a higher number of heat stress symptoms experienced was associated with musculoskeletal pain or discomfort, as well as lower quality of life, and could be a result of the associated physical job demands. Hot working environments was a predictor of increased sick leave. Subjective health was further predicted by factors such as medical conditions reported and heat stress symptoms. Aspects including workplace exposures and overtime were associated with tiredness after work. Tiredness during a shift was associated with perceived exertion, as well as a lack of concentration. Meanwhile, sleep obtained and experience of harassment was associated with emotional state and anxiety or sadness. It is evident that numerous factors, alone or in combination, can lead to the experience of over-exertion and its related health, safety and wellbeing outcomes.

4.5.1 Limitations

As indicated in prior milestones, there are evident limitations relating to the quantitative data collection. These limitations include those relating to the use of self-report data, sample size, the measurement of over-exertion and ethics of data collection.

As indicated in previous sub-sections, no existing single, overarching, industry standard could be located for measuring over-exertion, and no survey existed for measuring over-exertion (specifically relating to women in the SAMI). Therefore, various quantitative measures had to be defined in the survey for measuring different facets of over-exertion. This study was to some extent an exploration of how to measure over-exertion, as well as how to identify which aspects affect the various facets of over-exertion. It is likely that there are variables not included in the survey that could have an impact on over-exertion; however, the survey tool aimed to be as comprehensive as possible without being too long and arduous to complete.

The survey included obtaining some sensitive information, and therefore ethics clearance (as indicated in subsection 4.2.3), permission from participating mines (as described in subsection 4.2.4), as well as agreement from respondents had to be obtained before collection of data from respondents. Since this implied the use of convenience sampling and that participation in the survey was voluntary, it was not possible for the sample to be fully representative of the all women working within the SAMI. However, a range of mine types and commodities were included, and women from a range of occupations participated in the project, to maximise representativity in the sample. Since the study cannot claim complete representativeness, care was taken to interpret results as indicative and to limit the amount of extrapolation / inference from results accordingly.

The survey made use of the self-report data, for which the limitations include potential biases in the responses. The linkage of the tool to the RFA database assisted to draw in more objective information, but since not all of the respondents carried out RFA tests or were tested recently, this was not entirely successful. Further expansion of such linkages could improve the amount of information that can be gained. Furthermore, the sample incorporated a range of commodities and occupations in the SAMI; however, there are differing numbers of responses according to sub-groups, such as per occupation.

In addition, data collection was primarily conducted using online platforms at a number of the mine sites. In these cases, the accessibility is expected to have been higher for office-based workers, and those who have access to computers or smartphones during work; this resulted in a higher proportion of responses from surface office workers. Meanwhile, data collection in the goal and platinum sectors (n = 55 and 65, respectively), for most in the coal sector (n = 178), and around half in the chrome sector (n=32) took place using hard copy versions of the questionnaire, which were then captured electronically. The use of online versions could pose limitations for those without access to smartphones, computers, or data/Wifi, and due to potential technology resistance. Furthermore, there could be literacy and language barriers within the workforce. However, it was noted that the official workplace language was English and many sites have an educational requirement of Matric (Grade 12). In some of the cases where the questionnaires were completed using hard-copies, assistance was provided by facilitators (e.g. medical staff or the research team).

A further project limitation related to the anthropometric measurements, namely, height, weight, waist girth and hip girth, in the survey. These questions were not compulsory to complete and in the assessment tool, participants were told they could leave these questions blank if they were not sure of the measurements. As a result, not all of the participants completed these questions, and there could be recall bias for those who did complete the questions. Meanwhile, these measurements were recorded in RFA data, and were used, where possible, when the values were not included in the questionnaire. Furthermore, some of these measurements were taken during in-person data gathering.

4.6 Milestone conclusions

In conclusion, numerous factors can lead to over-exertion, and can impact the health and safety of women in mining. This survey, conducted in the SAMI has enabled a better understanding of some of these factors. These factors include job demands and exposures, while personal factors can also impact the capacity of women in mining. Health, safety, and wellness (over-exertion) outcomes include those of fatigue, musculoskeletal disorders, reduced mood, concentration, and quality of life. An assessment of these factors is useful towards the identification of interventions to improve health, safety and productivity in the sector, and inclusivity of women in mining.

It was evident that the assessment tool was effective in measuring contributors to and OHS impacts of over-exertion at the participating mines. The tool (questionnaire) appeared to be generally useable and understandable, as concerns were not raised during the data collection phase of the milestone. The information gathered from the tool linked successfully to the RFA database, and could be downloaded for subsequent analysis. Further stakeholder validation of the efficacy of the tool is provided in Milestone 7 (Chapter 7).

It is possible that the assessment tool developed for this study can be refined for optimal applicability in the mining industry, based on the data gathered. Further analysis of the data gathered using the survey tool included triangulation of the data with qualitative information on the topic, such as that collected for Milestones 5 and 6 (Chapters 5 and 6). In addition, the tool, project findings, and recommended interventions relating to the identified factors that can contribute to over-exertion of WIM were discussed with stakeholders during a workshop in Milestone 7 (Chapter 7).

4.7 Next milestone

The following milestone entails a report on channels for women's OHS concerns. The related objective is to determine the existence of reporting channels for women's OHS concerns and exposure and the effectiveness of these, including determining whether sufficient aspects of over-exertion are well incorporated. The assessment tool could potentially be considered in relation to these reporting channels. Data gathering for this upcoming milestone (Milestone 5) entails the use of interviews and focus group discussions from industry stakeholders, including women in mining, on the topic. The findings further incorporate qualitative data relating to the causes and consequences of over-exertion of women in mining. This data will help to better understand the findings gathered using the assessment tool, and the resulting recommendations.

5. REPORTING CHANNEL ASSESSMENT

5.1 Introduction

Women in mining (WIM) experience unique physical and psychosocial hazards, and research suggests that over-exertion contributes to fatigue, injury and poor well-being. The Mine Health and Safety Council (MHSC) recognised this gap and this part of the project evaluates whether occupational health and safety (OHS) reporting channels address exposures that lead to over-exertion. The need for this work is underscored by evidence that current mechanisms for managing workplace violence and harassment as well as health and safety issues for women are often absent or obsolete; as a result, many female workers do not formally report incidents and instead deal with them on their own. Effective reporting systems are therefore essential to identify and mitigate exposures that compromise women's health, safety and dignity.

The fifth project milestone entailed an evaluation of available reporting channels. The purpose of this milestone is to determine the existence, access to and effectiveness of reporting channels for women's OHS concerns. This evaluation involved determining whether sufficient aspects of over-exertion are well incorporated and identifying gaps in existing reporting channels. The results will be used towards Milestone 6, to recommend additions to the existing channels of OHS reporting for women (working in hazardous environments), in relation to the evolution of these mechanisms available to WIM for legal, technical, and social and health issues reporting.

This chapter therefore synthesises information from three data sources: (1) desktop reviews of existing reporting systems and literature, (2) focus group discussions with more than ninety stakeholders from nine mining companies and an industry organisation, and (3) link to the assessment tool and survey of over five hundred women working in mines across South Africa. Open-ended survey questions sought input on factors causing or resulting from over-exertion, recommendations for improving women's health, safety and wellness, and comments regarding personal protective equipment (PPE).

Thematic analysis was used to identify recurring patterns. This report summarises the findings, highlighting how specific workplace conditions contribute to over-exertion and describing the effectiveness of current reporting channels. It concludes with recommendations for strengthening reporting mechanisms and addressing the underlying causes of over-exertion.

5.2 Methodology overview

5.2.1 Desktop review

Literature and policy documents on OHS reporting in mining were reviewed. The review identified formal channels (supervisors, safety representatives, OHS committees, incident reports, suggestion boxes, digital reporting systems, hotlines, human-resources departments, women-in-mining committees and external regulators) and noted that most of these channels were not designed to address gender-specific issues or exposures such as over-exertion. The review recommended integrating reporting systems into comprehensive OHS management, training women on how to report over-exertion and other hazards, collecting gender-disaggregated data, using inclusive language, and ensuring confidentiality and non-retaliation

5.2.2 Focus group discussions

Focus group discussions with various industry stakeholders were held to gain their insights and inputs on women's OHS concerns and exposures, and to gain their input related to existing reporting channels. Eleven focus groups were held with more than ninety participants representing different job categories, nine mining companies and an industry association. These sessions explored existing OHS reporting channels, perceived barriers to reporting, and suggested improvements. Discussions also covered conditions that contribute to over-exertion. The focus group interview guide, informed by the desktop study, was used to conduct the group discussions. The consolidated findings are used towards reporting channel recommendations (Milestone 6).

5.2.3 Survey of women in mining

A structured assessment tool (discussed in Chapter 3 and 4) was administered to over five hundred women employed in the South African mining industry. Focus group information supplements the findings of the assessment.

5.3 Desktop review on reporting channels findings

Effective reporting channels for OHS concerns and exposure are crucial in ensuring workplace health and safety, particularly for women in mining, who may face unique OHS risks. Women's health issues in the workplace are often compounded by the burden of domestic work at home, a "double jeopardy" that adds a second shift of physical labour, responsibility, and exposure to chemicals on top of their job-related demands (Badenhorst, 2009). Whilst women have worked in the mines more in recent history, there is limited research that focuses on their specific OHS needs.

Various channels for reporting instances of over-exertion and other safety concerns exist in South Africa, which include but are not limited to Human Resources (HR) departments, health and safety departments, supervisors, and the Mine Health and Safety Council (MHSC) through various regional WIM committees. These channels enable workers to voice concerns, report hazards, and seek timely interventions, ultimately improving health outcomes, reducing risks, and fostering a safer, more inclusive work environment.

The desktop review identified numerous OHS reporting channels, ranging from direct reporting to supervisors and safety officers to anonymous hotlines, suggestion boxes and digital platforms. Unions, WIM committees, human-resources departments, national regulators and third-party auditors also serve as channels.

This subsection will unpack the existing reporting channels available to women, to report on concerns as well as their effectiveness. Furthermore, it will explore whether over-exertion of women or issues related to over-exertion forms part of the reporting.

5.3.1 International context

5.2.1.1 Global reporting channels

In the global mining industry, various channels, platforms and mechanisms are available for mine workers, including female workers, to report OHS concerns and exposures. The effectiveness of these platforms varies by country, company, and the maturity of the regulatory framework. The reporting channels generally found in most countries and mining companies are highlighted in Table 103, as obtained from a range of internet sources (e.g., Ansari, 2023; USAGov, 2025).

Table 103: Reporting channels for OHS concerns and exposure in the mining industry internationally

Reporting channel	Description
Internal OHS committees and safety representatives	Most mining companies have safety committees with worker representation to address OHS concerns (Walters *et al.*, 2018). Over-exertion risks may be reported, but the focus is often on general safety rather than gender-specific concerns. There are also designated safety officers or supervisors to whom concerns are reported. Reporting can be done in various ways such as in incident reporting forms or logbooks, suggestion boxes, customisable checklists, digital reporting systems (applications or intranet portals) and real-time data sharing with management (e.g., Ansari, 2023; Eiter *et al.*, 2024; USAGov, 2025). It was not clear from the literature who the reports go to, or processes followed when handling the reports. However, it was noted that the OHS committees and safety representatives are often the first line of reporting in many mining companies; these may be underutilised due to fears of retaliation, lack of trust or poor response time.
Whistleblower hotlines and anonymous reporting systems	Many multinational mining companies and OHS bodies have confidential reporting mechanisms (e.g., ethics hotlines, and online portals). Such channels are essential for sensitive cases such as harassment or systemic safety issues. They help mitigate fear and stigma, especially for women, but the response depends heavily on company culture and legal follow-through.
National OHS regulatory agencies	Agencies such as the Mine Safety and Health Administration (MSHA) (United States of America) (MSHA Safety Services, 2024), Safe Work Australia (WorkSafe, 2025), Canadian Centre for Occupational Health and Safety (CCOHS; CCOHS, n.d.), and the Health & Safety Executive (United Kingdom) enforce workplace safety. Reporting on these channels is typically effective for serious or escalated matters, but bureaucratic delays can occur. Over-exertion risks are assessed (e.g., Eiter *et al.*, 2023), but usually in general terms rather than tailored for women's specific challenges.
Mining industry associations and unions	Organisations like International Council on Mining and Metals (ICMM; ICMM, 2012) and national mining unions advocate for safety standards. These bodies have legal authority to investigate.
Non-governmental organisations and advocacy groups	Groups like Women in Mining, Industry ALL Global Union, and the International Labour Organisation (ILO) advocate for women's safety (International Labour Organisation, 2013; Women in Mining, 2025). Such platforms can be effective in influencing policies but do not always have enforcement power. Some research is conducted on over-exertion and ergonomic design for women in mining.
Third-party audits and certifications	Environmental, Social and Governance frameworks such as ICMM's Mining Principles (ICMM, 2012), ISO 45001 (OHS), and Global Reporting Initiative standards require companies to report safety concerns. Reporting from third-parties are effective in companies committed to sustainability and responsible mining. Over-exertion is generally considered under broader occupational health but not always in a gender-specific manner (US Department of Labor, n.d.).

Beyond the reporting channels indicated in Table 103, countries have various regulations and laws by which these reporting channels are governed. For example, Mongolia has the Labor Safety and Hygiene Law (2008) that mandates that employers report workplace accidents, occupational diseases, and hazardous occurrences to relevant authorities (Chen & Zorigt, 2013). Employees are also entitled to report hazards or unsafe practices without fear of retaliation. The General Authority for Specialised Inspection (GASI) oversees the enforcement of these health and safety laws in Mongolia, including its mining sector. According to Otgonbayar (2022), there is a need for enhanced gender-responsive policies and practices in Mongolia's mining industry to address the unique challenges faced by women. This includes aspects related to OHS reporting and working conditions.

In the USA, the Mine Safety and Health Administration (MSHA), an external regulatory body, has a toll-free emergency line (1-800-746-1553) for reporting accidents or hazardous conditions (MSHA Safety Services, 2024). However, on the list of potential hazards and accidents, over-exertion is not explicitly mentioned (US Department of Labor, n.d.). Furthermore, there is the National Institute for Occupational Safety and Health (NIOSH) that conducts research and provides recommendations for preventing work-related injuries and illnesses. NIOSH is not necessarily a direct reporting channel, but its resources can guide workers on how to address over-exertion concerns (Eiter *et al.*, 2023).

In Australia, each state has a Work Health and Safety (WHS) regulatory body that is responsible for receiving and investigating OHS complaints and exposure incidents (including from mine workers) and enforcing WHS laws in workplaces, including mines (WorkSafe, 2025). Safe Work Australia is a key regulatory body responsible for developing national policy related WHS in Australia, including the mining sector, but it is not a direct reporting channel for individual workplace incidents or OHS concerns. Reporting channels would adhere to recommendations highlighted by Safe Work Australia (WorkSafe, 2025).

Canada has a Canadian Centre for Occupational Health and Safety (CCOHS) that does not handle individual complaints but provides resources and guidance on OHS matters and can direct workers to appropriate channels (CCOHS, n.d.). Mining operations that fall under the federal jurisdiction encourage workers to report concerns to the Employment and Social Development Canada under the Canada Labour Code (Government of Canada, 2023). Issues such as unsafe work conditions, exposure to hazardous substances, over-exertion and ergonomic hazards, mental health and harassment concerns and work refusal situations can be reported (Government of Canada, 2023).

5.2.1.2 Reporting channels in Africa

The mining industry in African countries mostly constitutes large-scale mining, and artisanal and small-scale mining (ASM). Various gaps have been identified regarding legislation and policy frameworks on women's OHS concerns and exposure. In various Southern African Development Community (SADC) countries, OHS is neglected and unregulated, especially OHS matters relating to women, and in informal sectors such as ASM. This neglect leaves ample room for women to be exposed to harsh OHS challenges (Moyo *et al.*, 2024). The neglect also implies that there are limited platforms or mechanisms for women to report what they constantly experience, leading to missed opportunities for improvement of systems and overall health, safety, and productivity for the mines.

Over the years, many women in mining associations (WIMA) have been formed and registered. These platforms were developed due to the rapid increase of women participating in mining and are meant to improve health and safety in mining, particularly factors affecting women. The WIMAs include the Emerging Mining Association of Namibia (EMAN), Association of Women in Mining (AWIM) in Madagascar, Association of Zambian Women in Mining (AZWIM), and the Lesotho Women in Mining Association, just to mention a few. These associations' greatest challenge has been to fulfil their purpose of implementing OHS programmes across their regions. This challenge is caused by inadequate legislation, lack of policy frameworks, and insufficient financial resources. Lack of human resources with the right expertise also contributes to the problem. Considering the knowledge of OHS challenges in ASM in SADC, a future requirement is the enactment of legislation that is gender-sensitive to OHS issues (Moyo *et al.*, 2024).

Table 104 shows existing reporting channels for OHS concerns and exposures in Africa.

Table 104: OHS concerns and exposure reporting channels in Africa

Reporting channel	Description
National OHS regulatory agencies	Enforced by agencies such as the Directorate of Occupational Safety and Health Services (DOHSH; Kenya; GenerisGlobal, 2024), and the Ministry of Energy and Mineral Development (MEMD; Uganda) (MEMD, n.d.). Regulations exist, but enforcement is weak in many countries. Over-exertion risks are considered under general OHS laws, with limited gender-specific policies.
Mining industry associations and unions	Bodies like the African Mining Vision (AMV), Miners' Unions, and WIM (Women in Mining) chapters (Women in Mining, 2025). Ergonomic issues and over-exertion are starting to gain attention, but progress is slow.

While ASM is prominent in African countries, there are also multinational companies found in countries such as Ghana. These companies do have internal OHS committees and safety representatives where OHS concerns and exposures can be reported. However, their effectiveness is not fully understood, particularly regarding female-specific concerns and reporting (AkosuaGanson, 2014).

5.3.2 Local (South African) context

South Africa has the Mine Health and Safety Act (MHSA), which requires mining companies to ensure they have in-house safety protocols established and assigned officials who manage reported safety concerns. It also encourages women to report any unsafe working conditions directly to the mine's health and safety representatives or through formal communication channels within the organisation. In addition to the Act, there are laws that ensure the protection and safety of women in any work environment. These laws include the Constitution, the Employment Equity Act, the Basic Conditions of Employment Act 75 of 1997 (BCEA), and the Code of Good Practice on the Protection of Employees during Pregnancy and after the Birth of a Child (Badenhorst, 2009). All injuries, accidents and OHS violations ought to be reported to the Department of Mineral and Petroleum Resources (DMPR), which oversees monitoring mining operations' compliance with mining regulation. Reporting channels available in South Africa are summarised in Table 105, and relate to a range of sources (e.g., MHSC, 2021; Minerals Council South Africa, 2025; NIOH, 2021; The National Union of Mineworkers, 2025; Women in Mining South Africa, 2025).

Table 105: Reporting channels in South Africa

Reporting channels	Description
Women's health and safety committees	Many mines have specific Women's Health and Safety Committees or designated OHS representatives who focus on the unique challenges and needs of women in the workforce. These committees are integral in ensuring that women's health concerns, particularly related to gender-specific issues, are given attention.
OHS departments in large mining companies	Larger mining companies often have dedicated OHS departments, where women can confidentially report concerns related to their health and safety in the workplace. These departments handle issues like exposure to hazardous substances (e.g., dust, chemicals), musculoskeletal problems, and psychological stress. Female workers can consult these departments to report their specific concerns, such as reproductive health risks or exposure to gender-related harassment.
Trade unions and advocacy groups	Trade Unions like the National Union of Mineworkers (NUM), Solidarity, and the United Democratic Movement (UDM) advocate for workers' rights, including those of women in the mining sector (e.g., National Union of Mineworkers, 2025). Women can report OHS concerns through union representatives, who then escalate issues to management or relevant

Reporting channels	Description
	authorities. Unions also engage in negotiations for better working conditions and gender-sensitive policies. Some unions have dedicated female representatives or advocacy groups that focus specifically on the needs of women workers, including ensuring safe working environments.
Whistleblower hotlines	Many mining companies have whistleblower hotlines that allow for confidential anonymous reporting. Women can report any OHS concerns on this platform. Most mines have a 24/7 hotline which is managed by third-party services.
Mine Health and Safety Council (MHSC) Regional WIM Committees	The MHSC is a public entity that comprises a tripartite board represented by State, Employer, and Labour under chairmanship of the Chief inspector of mines. Its main task is to advise the Minister of Mineral Resources on occupational health and safety legislation and research outcomes focused on improving and promoting OHS in South African mines (MHSC, 2021). The MHSC initiatives for WIM include the Women in Mining Advisory Committees (WIMAC).
Company-specific reporting channels	HR is crucial in handling employee concerns and ensuring compliance with safety regulations.
Pathology Disease Surveillance Database (PATHAUT)	This electronic database, developed by the South African Medical Research Council and maintained by the National Institute for Occupational Health (NIOH), provides data from autopsy examinations and clinical files for researching and monitoring disease trends in the South African mining industry, primarily for occupational lung disease (NIOH, 2021).
South African Mining Occupational Diseases database/Department of Mineral and Petroleum Resources	The South African Mining Occupational Diseases database was initiated in 1998, and is managed by the Department of Mineral and Petroleum Resources, to record morbidity and mortality of occupational diseases in the South African mining industry (Murray *et al.*, 1998).
Minerals Council South Africa Women in Mining Task Team	An initiative by the Minerals Council South Africa focused on promoting gender diversity, inclusion and safety within the mining sector (Minerals Council South Africa, 2025). While it addresses various issues faced by women in mining, like workplace facilities and personal protective equipment (PPE), it does not serve as a direct reporting channel for individual concerns like over-exertion or ergonomic issues (Women in Mining, 2025).
Women in Mining South Africa (WIMSA)	A non-profit organisation aimed at supporting and empowering women in the South African Mining industry. The organisation is not a formal reporting channel for workplace issues but provides networking, mentorship and advocacy for women. It can provide support and guidance (Women in Mining South Africa, 2025).

5.3.3 Internal processes for reporting within reporting channels

Reporting of OHS concerns and exposure mostly includes the following (Eiter *et al.*, 2023; Vella, n.d.):

- Injuries and incidents (both major and minor, including near misses);
- Exposure to harmful substances (chemicals, dust, noise, etc.);
- Unsafe working conditions (inadequate ventilation, poor lighting, PPE etc.);
- Ergonomic risks;
- Harassment or discrimination (especially gender-based); and
- Mental health and fatigue-related concerns.

These concerns and exposure are not gender-specific.

Over-exertion is a recognised occupational hazard, which is generally linked to conditions such as fatigue and musculoskeletal disorders. However, studies have shown that over-exertion may be underreported due to cultural stigmas and the fear of being seen as less capable (MHSA Safety Services, 2024). Cultural stigmas include those relating to the history of male-dominance in the industry along with entrenched gender discrimination. Furthermore, over-exertion symptoms may develop slowly, resulting in women not linking them to work.

Workers report to various representatives within the various reporting channels. For some institutions, it is not explicitly mentioned who the representatives are. However, it is noted that for channels within mining companies, reports go to supervisors or line managers, health and safety representatives, union representatives, and HR or compliance department representatives (Eiter *et al.*, 2023). For other reporting channels, reports go to national or regional labour, safety authorities, and whistleblower protection agencies (Eiter *et al.*, 2023).

When an OHS concern is reported, it is typically documented, either digitally or manually, and may involve interviewing the affected worker (Eiter *et al.*, 2023). The issue is then assessed based on its risk and urgency, often using safety rating tools. Corrective actions, such as equipment repairs or job redesigns, are implemented, while preventive measures might include training or updates to procedures and protective gear. Workers should receive feedback on how the issue was handled, sometimes through formal close-out meetings (Eiter *et al.*, 2023). If the concern involves serious injury or a significant hazard, it is escalated to national safety regulators.

5.3.4 *Effectiveness of reporting channels*

Reporting channels for women's OHS concerns and exposures in the mining industry are essential. However, some reporting channels are not gender-focused but are available for any OHS concern and exposure. Furthermore, it is important that the available reporting channels are effective. Measurement, therefore, is vital to identify gaps and potential areas of improvement.

The effectiveness of reporting channels can be measured through tracking key performance indicators, measuring engagement with employees, and adherence to established standards. The following key indicators can be used to measure reporting channels' effectiveness (ICMM, 2012):

- **Rates of reporting:** The frequency of reports often gives an indication of the level of trust and awareness amongst female workers regarding the reporting channel. Understanding women's perceptions of reporting channels is crucial. Surveys and interviews can reveal whether employees feel safe and supported when reporting incidents.
- **Accessibility and anonymity:** reporting channels that are easily accessible and allow for anonymous reporting tend to be more effective, as they reduce barriers to reporting and protect workers from potential backlash.
- **Responsiveness:** How promptly and effectively the reported issues are addressed by the organisation or regulatory body indicates the effectiveness of the reporting channel. In the previous sections where various reporting channels are discussed, the respective channels' responsiveness could not be explicitly understood in literature. This is an area of potential in-depth research.
- **Closure rates:** The proportion of reported incidents that are resolved satisfactorily demonstrates the system's effectiveness.
- **Repeat incidents:** A high recurrence of similar incidents may suggest underlying issues not adequately addressed by the reporting mechanism.
- **Gender-disaggregated data:** Collecting and analysing data separately for men and women helps identify specific challenges faced by female miners and assess whether the reporting system effectively addresses their concerns.

Reporting channels for women's over-exertion can be more effective if they are developed with consideration for women-specific challenges in mining. Women continue to face unique challenges in mining environments, from physical capacity and anatomical-related issues to equipment compatibility. Therefore, research studies, such as the current project, are required to fully comprehend the extent of challenges faced by women in mining which go beyond just the perceived physical challenges. Reporting channels should be able to address the unique needs of women in mining. They should consider confidentiality and non-retaliation elements, while keeping processes simple and clear.

5.3.5 Gaps in reporting channels

There are institutions that conduct external reviews of large mining companies on work culture and challenges faced by women. During these reviews, OHS challenges such as sexism, sexual harassment, and sexual assault are reported through surveys conducted. The Responsible Mining Foundation published a report that highlighted OHS challenges identified across 30 mining companies. These included a lack of properly fitting PPE for women, the absence of zero-tolerance policies toward gender-based harassment and discrimination, as well as gender-based pay gaps (Eiter *et al.*, 2023).

Most reporting channels do not explicitly focus on women-related OHS issues and/or over-exertion. It is therefore suggested that reporting channels ought to be enhanced to improve and encourage reporting for women. The following is recommended (International Labour Organisation, 2013; Podgórski, 2015):

- Integrate reporting channels into comprehensive OHS management systems, such as those compliant with ISO 45001 standards. This integration will ensure that reporting channels are part of a continuous improvement process, with regular audits and performance reviews to maintain their effectiveness;
- Train women on how to report over-exertion and OHS concerns and exposures safely;
- Track gender-disaggregated data;
- Use inclusive language; and
- Maintain confidentiality and non-retaliation policies.

5.4 Findings from focus group discussions

5.4.1 Introduction

Focus group discussions were held with individuals from mining companies and organisations to discuss challenges faced by women in mining, opportunities to improve working conditions for women in mining, reporting channels for women to report OHS concerns faced at work, and recommendations for improving OHS reporting channels. The question guide included more detailed questions relating to these main topics and is included in Appendix B. Where appropriate, follow-up questions were asked in order to gain further detail.

5.2.1.3 Process and participants

A total of ten focus group discussions were held with individuals from participating mines and an industry organisation (Table 106). The focus group discussions were held between July and October 2025. The commodities represented from the participating mines included: Gold, Platinum Group Metals, Coal, Chrome, Iron Ore, Manganese, Aggregates and construction materials. More than 90 individuals participated in these discussions. The focus group sizes ranged from 3 to 19 people. The occupations of the participants varied from site-to-site, and included, among others, Occupational Medicine, Occupational Hygiene, Health and Safety, Technical Services, WIM Committee members, Supervisors, Team Leaders, Development and Construction workers, Operators, Mining Teams, Miners and Learner Miners. Most of the focus group discussions took place online, while three took place in person (for the Gold mine and the two Chrome mines). The focus group discussions were voice-recorded, and summary notes were taken during each session. The discussions took place primarily in English, but the project team facilitator and participants spoke in other official languages (e.g., Setswana, Sepedi, and isiXhosa) for better understanding and relatability, where appropriate. Thematic analysis was used to analyse the findings for recurring themes and topics in relation to the milestone objectives.

Table 106: Focus group discussion participants

Commodity	Participant occupations	Number of participants
Gold	WIM committee, including a range of occupations, such as Mining Team, Development/Construction, Pump Attendant, Engineering Assistant, Winch Operator, Learner Miner, Shift Overseer, etc.	17
Platinum	Occupational health professionals (including OMP, Senior Professional Nurse, Acting Nursing Services Manager, Audiometrist), and women's structure members, including the Chairperson of Health and Safety, and Secretary	6
Coal – Mine 1	WIM Committee members, and a range of occupations from the shafts, workshop and plant areas	19
Coal – Mine 2	WIM Committee Chairpersons	3
Iron Ore	OMP, Nursing Sister, Occupational Therapists, Rehabilitation representative, Head of Technical Services, and WIM Chairperson	8
Chrome – Mine 1	Women in mining from a range of occupations, including Belt Attendants, Mining Attendant, Pipes Tracks and Ventilation (PTV), Utility Vehicle (UV) Attendants/Assistant, Operator, Administrator, Cleaner and Supervisor	14
Chrome – Mine 2	Women in mining from a range of occupations, including PTV, Blasting Attendant/Assistants, Team Leader, Miner, Clerk, Cleaner, Logistics Coordinator	11
Manganese	HSEC Manager, Compliance Officer, and WIM Chairperson	3
Aggregates/ construction materials	Included Health and Safety Managers, Officers and System Specialist, and Occupational Hygiene and Medicine Coordinator	10
Industry organisation	Head of Health, Deputy Head of Health, and WIM Project Specialist	3
Total		***94***

5.4.2 Challenges faced by women in mining

Four of the focus group discussion questions related primarily to the challenges faced by women in mining, namely:

- What challenges are faced by women in mining?
- What do you understand by over-exertion, that is, what makes work demanding for women in mining physically or mentally? And what are the outcomes of this (e.g., fatigue, injury or illness)?
- How does work affect the roles and responsibilities of women outside of work (and vice versa – how do the responsibilities outside of work affect the work)?
- What would you identify as activities or tasks that contribute to over-exertion as a woman in mining? (e.g., doing shift work, use of heavy equipment, family responsibilities etc.)

Many of the responses to the initial questions related to those specifically queried in further questions. As such, the additional questions did not need to be asked - specifically in cases where information was already provided. The main topics are summarised in Table 107 according to the themes of "consequences of over-exertion", "challenges faced by women in mining", "tasks or activities", and "household responsibilities".

Responses relating to the question of understanding of over-exertion included, for example, "Performing beyond my own physical capabilities". The most cited outcomes of over-exertion included tiredness or fatigue, and physical or mental strain. A few noted the possibility of injury, which could be related to repetitive strain, or resulting from an incident. A loss of productivity and absenteeism were also noted. Mental or psychological strain incorporated aspects such as depression and stress, and a lack of concentration, which could lead to impaired safety at work. Over-exertion was further reported to have an impact on time spent with families, could create relationship conflict, and also result in a lack of focus on one's health and fitness. Meanwhile, a common finding across the industry was that over-exertion relating to job demands resulted in vulnerability to sexual harassment, as male colleagues expected sexual favours in exchange for assisting women with strenuous work.

Table 107: Summary of challenges faced by women in mining

Question	Findings
Consequences of over-exertion	• Fatigue/tiredness • Mental and physical strain • Health and safety impacts • Injuries at work • Musculoskeletal disorders • Lack of concentration • Loss of productivity • Absenteeism • Depression • Frustration • Stress • Lack of time for own health/fitness • Impact on families and relationships • Vulnerability to harassment
Challenges facing women in mining	• Intimidation and harassment • Tribalism • Discrimination • Workplace culture • Women having to prove themselves • Lack of development • Lack of recognition • Lack of support from leadership • Lack of access to amenities • Lack of access to emergency sanitary pads • Lack of hygiene in toilets and change houses • Change houses too small • Use of white PPE • Poor quality of PPE, e.g., overalls • Design of overalls for women • Rescue pack is heavy • Uncomfortable safety boots • Differences in how women and men are built • Age • Obesity
Tasks or activities that contribute to over-exertion	• Long travelling distances to workplaces (underground) • Physical (manual) work • Lifting heavy objects • Climbing stairs • Heat • Confined spaces • Sitting long hours • Shift work • Overtime • Lack of (human) resources • Not enough equipment and tools • Work pressure / production pressure • Vibration of machinery • Machines and equipment design based on males' physique • Access to vehicles (e.g., height of dump truck steps) • Limitations of applying "quick-fixes" to equipment
Household responsibilities	• Difficult work-life balance • Multiple roles of women in society • Role of mother and wife, e.g., looking after children, cleaning houses, cooking, and going shopping • Impact of commuting times

Women in mining often face deep-rooted stereotypes that question their competence and strength compared to men. These negative perceptions can lead to exclusion from critical tasks, lack of trust in their abilities, and limited access to leadership roles. In terms of over-exertion, there was an understanding that the differences in the anatomy and physiology between men and women play a role in how each gender performs or tolerates strain. The underlying expectation that women should carry as heavy or perform at the same level as men perpetuates the burden on women. The participants highlighted the negative impact of the undue pressure and strenuous work on family, social, and community responsibilities.

A related comment was, “mining is demanding in terms of handling machinery, the production-based environment, and the ability to produce on time, which would have an impact both physically and psychologically”. On the one hand women are expected to keep up with the physical demands of the job and to meet production targets. On the other, they are expected to fulfil their family and community responsibilities. This dual burden may lead to chronic stress, sleep deprivation, burnout, and reduced job satisfaction. Over-exertion and repetitive tasks may lead to work related musculoskeletal disorders such as carpal tunnel syndrome, tennis elbow and back injuries. While this may be true for women in any industry, those in mining are at a greater risk due to the physical demands, heavy workloads, and prevalence of poorly fitting equipment in mining.

Sexual vulnerability was one of the most concerning issues brought up. Participants noted examples or incidents where women could not carry some of the equipment and would therefore find themselves giving men sexual favours in exchange for assistance. It is these challenges that women in mining face daily that make ground for research that would contribute to solutions that would cultivate safer and healthier working environment for women in mining.

Numerous factors were listed as challenges faced by women in mining in the focus group discussions. Participants noted that “there are quite a number of challenges considering that it is a male-dominated industry”, which filters into the work environment and how women are perceived, leading to a lack of career growth opportunities, lack of appropriate PPE, and lack of amenities both above and underground. There is also bias in the sector, which leads to women having limited opportunities for development. The limited opportunities result in women being under represented across various job categories. The bias also makes women in mining more vulnerable to risks such as gender-based violence (GBV) as well as gender inequality. All these factors can contribute holistically to mental or physical over-exertion of women in mining.

In some mines, tribalism continues to influence workplace dynamics, often to the detriment of women. Women may face exclusion from opportunities, informal networks, or decision-making processes. This cultural bias can lead to unequal treatment in hiring, promotions, and access to training, further marginalising women who are already underrepresented in the sector. Favouritism also undermines merit-based advancement, creating a hostile environment for women who must work harder to prove their worth. Women are often expected to perform tasks with the same physical intensity as men, without adjustments or support. This unrealistic expectation can result in over-exertion injuries, long-term health issues, and reduced productivity.

Participants mentioned that women in mining often face slower career progression compared to their male counterparts. Opportunities for leadership, technical training, or specialised roles are limited, and the selection criteria for advancement are frequently perceived as biased or opaque. This was also noted for individuals from the LGBTQI+ community, who may face discrimination based on sexual orientation. The lack of visible role models and mentors further discourages women from aspiring to higher (potentially less labour-intensive) positions, perpetuating the cycle of inequality.

A further challenge relating to over-exertion included the pressure for women to prove their capability and gain acceptance. A related comment was, “A lot of women still feel like they have to prove themselves if they belong in the mining industry. They have to work twice as hard for everything.” An example mentioned in the focus group discussions was of a female electrician who, shortly after completing her learnership, was assigned the physically demanding task of pulling cabling. Despite the task exceeding her physical capacity, she refrained from asking for help due to fear of being perceived as weak or incapable. Her desire to fit in and not stand out as the only woman on the team led her to push beyond reasonable limits, resulting in lower back injuries. She was told she had to complete the task regardless of the strain, reflecting a lack of empathy and understanding from her colleagues and supervisors. This experience highlights the harsh reality many women face, where the pressure to conform and prove themselves often comes at the cost of their health and well-being. The industry, while evolving, still harbours cultural and structural barriers that make it difficult for women to thrive without facing backlash or physical harm.

Physical differences between men and women were frequently highlighted by the participants. It was noted that women are generally not as strong or as tall as men. Levels of obesity, and high body mass indices (BMIs) among women were further concerns. Obesity was noted to be a potential contributor to slip, trip and fall accidents in mining. Hormonal cycles, that could affect heat tolerance, and the potential for women to become pregnant was also noted, as this has an impact on the work that can be done. Older age was another personal factor that could have physical and mental impacts.

Women in mining face another safety critical issue, namely the mismatch between PPE design and women's physical needs, even more so for African women. This mismatch poses serious safety risks. Ill-fitting gear can lead to tripping, restricted movement, and exposure to hazardous materials. Additionally, the mental strain of working in an unsupportive environment can affect focus and well-being, further increasing the risk of accidents. The physical layout of workplaces, such as steep stairs and confined spaces, can also be more challenging for women, especially when equipment does not accommodate their body structure.

Personal protective equipment (PPE) was a frequently mentioned topic in the discussions. The quality of PPE was a common concern. Some noted that the design or fit of PPE, including overalls and safety boots, were problematic. It was noted that the overalls sometimes get torn between the thighs, or is too tight around the arms when doing overhead work. The safety boots were also reported to not be comfortable and women complained that the boots hurt their feet. A few participants commented that they should be provided with PPE more frequently. The use of white overalls was considered problematic, especially when sweating and in relation to menstruation. This concern was particularly evident in underground environments, and the hot environment and use of heavy machinery was reported to result in period overflow. Rescue packs were noted to be too heavy by a few participants. However, it was acknowledged that there have been interventions to make PPE more accommodative of women in mining, including the fit of overalls, and availability of smaller sizes of safety boots. Improved design and quality of PPE would help to mitigate from over-exertion relating to discomfort or constraints in movement.

Other commonly noted challenges across the participating organisations included a lack of access to hygienic toilet facilities, adequate change houses, and emergency sanitary products. Health and hygiene are critical concerns for women in mining, especially those working underground. This neglect of basic needs reflects a broader systemic failure to accommodate women in the design and operation of mining infrastructure. A lack of hygiene in change houses and ablution facilities was noted at a number of the workplaces. The toilets at some workplaces were far away or did not have water systems. Change houses were noted to be too small to accommodate the required numbers of women, and sometimes the sanitary bins smelt bad. Numerous participants indicated not having access to sanitary towels in the event that this might be required. The lack of emergency sanitary towel facilities for underground workers could compromise women's dignity, comfort, and health. Meanwhile, it was noted that one of the mines had a vending machine for sanitary towels underground. Furthermore, some mining sites lack accessible clinics, including those located far from the work areas, making it difficult to seek timely medical attention (e.g., to get chronic medication), when considering the range of shift times worked. These matters can contribute to the overall strain faced by women in the SAMI.

Improved accessibility of ablution facilities in the workplace could assist to mitigate over-exertion of women in mining, in terms of a reduction of walking distance required, and prevention of dehydration caused by potentially restricted water consumption to avoid the need to use the facilities. Improved sanitation in facilities for women in mining would also contribute to improved health and its associated impacts in the workplace and for the individuals.

Various tasks and activities in the workplace were reported to contribute to over-exertion. Long travelling distances, particularly relevant to underground workplaces, was a noted challenge. The mineworkers used different means to travel to the workplace, including cages, man-carriages, riding belts, and walking long distances. The travelling times were up to 1.5 hours each way. It was mentioned that "you tired by the time you get to work". Climbing stairs, uneven surfaces, work in confined spaces, and exposure to heat or cold added to the physical demands of the work. Furthermore, in underground workplaces most of the work is primarily physical (manual). Participants frequently mentioned that lifting heavy loads or equipment was a cause of over-exertion. Operating equipment and sitting for long hours were also evident contributors to over-exertion. Production pressure was noted to have physical, psychological, and safety impacts. Long shifts, and shift rotations, were also reported to be mentally and physically draining. A lack of (human) resources can result in employees needing to do multiple tasks. Meanwhile, a lack of tools and equipment was an issue for some who needed to "planisa" (make a plan) to get things done, such as by reclaiming materials in the workplace.

In operator and maintenance roles, including those involving callouts for breakdowns and urgent repairs, the pressure to perform quickly and efficiently can lead to over-exertion. The nature of these tasks, often requiring physical strength, endurance, and rapid response, places a heavy burden on workers, especially those who may already be physically strained or new to the role. For women in these positions, the pressure is often intensified by the expectation to handle demanding tasks without complaint, combined with limited support or understanding, which can result in physical injuries and long-term health issues. The constant urgency and lack of recovery time contribute to a stressful work atmosphere, where over-exertion becomes normalised and safety may be compromised.

Ergonomics is also an important consideration, including that most machines within the mining environment were designed for males' physical structures, hence women may struggle to work with this equipment. An example provided was that of difficulty in getting on to machines that were operated by women. Additionally, as of late there are legal restrictions for "quick fixes" in terms of safety, which means that one cannot make *ad hoc* adjustments to a piece of equipment to accommodate certain body structures.

A prevalent challenge faced by women in mining included those relating to household responsibilities, and the various roles that women must take on such as motherly, wifely, professional, and social roles. Participants reported that it was difficult to maintain a work-life balance, and one noted that women "have to juggle work-life balance twice as hard as men." It was noted that more is expected out of women in society. These responsibilities cause physical and mental strain, and the participants mentioned always being tired. It was also noted that fatigue could lead to a lack of performing household responsibilities, such as cooking, cleaning, and that of a mother and wife, and also lead to a lack of concentration at work. Long commuting times, such as those prevalent in some mining communities, can also reduce the time to manage responsibilities and to sleep.

A participant noted, for example, that balancing the responsibilities of being a single mother with the demands of a full-day, dynamic job presented significant emotional and logistical challenges for women in mining. With a child who requires support with assignments, extracurricular activities, and sports events, there is a constant internal conflict between professional commitment and parental presence. Many mothers in this situation hesitate to leave work early or take leave for school-related events, fearing it may reflect poorly on their dedication or reliability. At the same time, they carry the emotional weight of not wanting their children to feel neglected or unsupported. This tension is further compounded by a lack of relatable peers; other women may not share similar life circumstances, making it difficult to form meaningful connections or receive empathetic support. As a result, personal relationships at work may suffer, and the sense of isolation can grow, even while trying to maintain a strong front – both at home and on the job.

In conclusion, mineworkers perform critical tasks that require high levels of concentration and physical resilience. However, women in mining face ergonomic risks at work that may be linked to both the physical and mental demands of the job. Discrimination and lack of support, along with inadequate accommodation in terms of facilities and equipment, contribute to this strain. Additionally, the dual burden of work and family responsibilities can lead to absent-mindedness, increasing the risk of workplace accidents. When personal and professional roles are closely intertwined, a lack of support or imbalance in one area can negatively impact performance and safety in the other.

5.4.3 Opportunities to improve working conditions for women in mining

Table 108 summarises suggestions made to improve the working conditions of women in mining, including those relating to equipment and PPE. The related questions that were posed in the focus group discussions were:

- What opportunities are there to improve the working conditions for women in mining?
- Is there a need to modify any piece of equipment currently being used in mining to accommodate women? If yes, what equipment and what modifications would be necessary?
- Is there a need to modify any piece of PPE currently being used in mining to accommodate women?

The opportunities for improvement noted by the participants included exploring opportunities for adjusting PPE and equipment for women to "making strict ergonomic assessments to ensure that women are deployed in areas that are suitable for women". Linkages between health and hygiene are important to ensure that doctors are involved in this ergonomic assessment; additionally, cultural awareness training should be done to sensitise men regarding the pressure and demands on women. It was noted that the allocation of tasks in teams should be done in an inclusive manner, while considering different capabilities of women compared to men. These interventions would help to mitigate over-exertion.

Additionally, to improve safety and inclusivity in mining, workplaces must be adjusted to better accommodate women through the hierarchy of controls, starting with the elimination of hazards and redesigning of equipment, PPE, and machinery to suit diverse body types and physical capabilities. This includes addressing challenges such as obesity and heat stress, which disproportionately affect women. Conducting ergonomic assessments is essential to ensure that workstations and tools are designed with considerations for women's needs in mind, reducing the risk of injury and fatigue to women. It was acknowledged that it is difficult to change equipment, activities, and processes in conventional mines. The ability to make ergonomic adjustments to machinery was also noted to be affected by the availability of funds and market conditions. However, the addition of supporting equipment, such as for lifting loads, was recommended. The use of machinery could enhance the way in which jobs are done.

Table 108: Opportunities to improve the working conditions for women in mining

Question	Findings
Opportunities	• More appreciation and support for women in mining • Opportunity for growth and development for women • Workshops to raise awareness • Leadership training (e.g., soft skills) • Culture transformation process • Gender equality training • Employment equity • Inclusion of women in mining in decision-making, e.g., in policy development • Hierarchy of controls • Better inclusivity e.g. teamwork • Training of doctors (linkage of health and hygiene) • Enhance wellness programmes (mental and physical health awareness), including addressing obesity • More research • Better accommodation of pregnant women • Improved work-life balance
Equipment and facilities	• Ergonomics assessments • Adjust workplace to fit women as far as possible (equipment, PPE, machinery, etc.) • Adjustment in machinery, e.g., extensions to ladders • Supporting equipment, e.g., lifting tools • Minimum standards of fitness • Risk-based medical surveillance • Availability of emergency sanitary products underground • Better quality products, e.g., toilet paper • Larger, more hygienic change houses • Improved ablution facilities • Lactation rooms
PPE	• PPE design for women (e.g., overalls and boots) • Good quality overalls • More frequent issuing of PPE • More stock to be available • Use of zips instead of buttons in overalls • More sizes of safety boots • Darker colour overalls • Lighter rescue packs and detectors • Women's safety harnesses

Health and hygiene must also be integrated into workplace practices by training medical personnel to recognise and treat gender-specific health issues common in mining environments. This includes musculoskeletal disorders, heat-related illnesses, and reproductive health concerns. Minimum standards of fitness to work at a mine and risk-based medical surveillance for the prevention of injuries were considered important. Additionally, gender equality training for both men and women is crucial to transform workplace culture, reduce discrimination, and promote mutual respect. Such training should be ongoing and embedded into company values. The enhancement of wellness programmes was also recommended, to address issues such as high BMI.

Leadership plays a vital role in driving change. Managers and supervisors must be sensitised to women's issues, including the psychological and physical demands that they face. Supervisors should receive training on respectful communication and fair treatment of subordinates, while individuals promoted into leadership roles should be equipped with soft skills to manage teams effectively and empathetically. This helps to foster a more supportive and inclusive environment.

To empower women and promote career advancement, companies should offer development opportunities such as training, workshops, mentorship programs, and awareness campaigns. These initiatives not only build skills but also raise visibility of women's contributions in mining. It was also noted that women needed to take advantage of opportunities that are available. Finally, recognition and appreciation of women's work must be prioritised, reinforcing their value and encouraging retention in the sector.

To foster a more inclusive and supportive work environment for women, organisations should prioritise work-life balance and recognise the unique needs of female employees. The suggested interventions included offering flexibility to mothers who juggle demanding roles with parenting responsibilities, and consideration for those working shifts. Acknowledging that women's bodies function differently from men's, especially during menstruation, pregnancy, and postpartum periods, is essential. Pregnant employees, for example, should be supported through modified duties, allowing them to maintain their income and dignity without compromising their health, as some fear reporting pregnancies due to potential loss of income. Having lactation rooms available at mines for breastfeeding mothers was also a recommendation for intervention. Ensuring access to emergency sanitary products in the workplace was commonly noted, along with the need for toilets that are hygienic and easily accessible, and adequate change houses. These interventions would help to improve well-being, safety, and performance at work.

Additionally, companies must invest in gender-specific PPE to ensure safety and comfort. Ill-fitting overalls and boots not only hinder performance but also pose safety risks. Providing properly fitted gear demonstrates respect for women's physical needs and helps them carry out tasks effectively. These changes, along with a shift in workplace culture that values empathy and equity, can significantly improve the experience of women in technical and physically demanding roles, reducing over-exertion, isolation, and long-term health risks.

In addition to the design of PPE to better suit women's physiques, the need for better quality PPE (e.g., overalls and boots) was also frequently noted by the participants, for improved health and safety. The suggestion of darker colour overalls to accommodate women was also frequently mentioned, particularly for underground workers, in relation to menstruation (although this could pose a safety risk due to poor visibility). It was also commonly requested that PPE can be issued more frequently. Stock availability, including of a range of sizes of safety boots, was important. The suggestion to make lighter rescue packs and detectors was also made, where applicable. The use of women's safety harnesses was also recommended. It was also considered important for the women to be involved in decision-making on policies that could affect them, such as relating to dress codes.

In conclusion, there is a growing recognition of the need to match mining machinery and equipment with women's body structures to improve safety and comfort. Ongoing discussions with Original Equipment Manufacturers (OEMs) are focused on enhancing equipment adaptability through targeted research and development. One key area of concern is BMI, which is a potential contributing factor to trip and fall injuries, health concerns, and incompatibility of equipment. Addressing these ergonomic and physiological challenges is essential to creating a safer and more inclusive working environment for women in mining.

5.4.4 Reporting channels for women to report occupational health and safety concerns faced at work

Table 109 provides responses relating to reporting channels available for women in mining to report on OHS concerns, including over-exertion, in the workplace. The related questions asked were:

- What channels are there for women to report occupational health and safety concerns faced at work?
- What challenges do females encounter in relation to reporting mechanisms?
- Have you ever been victimized/intimidated for raising concerns?
- What recommendations do you have for improving the occupational health and safety reporting channels for women in mining?
- Is the support of the company through Employee Wellness Programmes enough to cater for women?

Responses to the latter two questions are described in the following section.

Table 109: Channels for women to report OHS concerns faced at work

Question	Findings
Reporting channels	• Safety office (health and safety representatives, safety officers, health and safety committee, management) • Supervisors • Complaint books/workbooks • Foremen • Clinics/medical centres • Unions • HR • WIM Committees (and sub-committees) • Anonymous hotlines (including call centres, email, and WhatsApp platforms) • Reporting systems (e.g., Isometrix) • Surveys
Challenges	• Inaction • Time taken to resolve issues • Lack of feedback • Poor communication • Late reporting • Acceptance of risk • Fear of victimisation, intimidation or punishment • Fear of losing job if disclosing • Fear of others losing job • Concerns about confidentiality • Lack of trust in anonymity of hotlines • Vulnerability in reporting • Discomfort reporting some issues to males • Misuse for personal gain • Lack of active leadership

Participants at the various mines noted that there are formal reporting channels available, including supervisors, health and safety representatives and committees, safety officers, human resources (HR), clinics or medical centres, and sub-committees under the WIM committees. It was reported that there are also anonymous reporting hotlines available, along with workbooks, electronic reporting systems, and external support structures, which play a role in addressing health and safety-related issues. The reporting channel used would largely depend on the matter being reported, such as health, safety, or psychosocial concerns.

However, despite the presence of these reporting channels, a number of shortcomings were evident. It was noted that there were low numbers of reports coming through, and it was indicated that some were afraid or not comfortable enough to report. Commonly mentioned challenges amongst the participants were fear of victimisation or loss of jobs, concerns about confidentiality, and the lack of action after reporting. While some women were confident enough to report, there were still several of them who were hesitant due to past experiences of being ignored or punished. They are concerned that the anonymous tip-off and reporting channels may not be as anonymous as they were made out to be. In one mine, they said there was only one case of sexual harassment reported but many were understood to have occurred in the past 12 months.

The organisations had implemented various mechanisms to address OHS issues, such as committees to address workplace safety and gender inclusivity. Safety, Health, and Environment (SHE) committees oversee general safety and health matters, while Women in Mining (WIM) committees focus on gender-specific concerns. The WIM committees may include several sub-committees, such as: Hygiene and Wellness, Safety and Security, Development, and PPE. These sub-committees report during SHE meetings to ensure that issues affecting women in mining are addressed. It was reported that the WIM Committees are effective at some on the mines. However, it was noted that there was still a lack of LBGTQI+ representatives in the committees at some mines, indicating a gap in inclusivity that needs attention.

Multiple channels exist for reporting concerns, including anonymous whistleblower platforms, departmental surveys, and complaint dashboards or workbooks. Employees also report to full-time health and safety representatives (both male and female), who escalate issues to the SHE committee. Weekly meetings with supervisors provide additional opportunities for feedback. Dashboards are also used to track GBV incidents and their resolution rates. These dashboards operate at the mine level and feed into broader statistics compiled by the Minerals Council of South Africa. This system helps monitor trends and evaluate the effectiveness of interventions. However, the low reporting rates through anonymous channels may hinder the accuracy and completeness of these statistics. Support services are available to address medical, health, and training needs in the workplace. These include Thuthuzela Care Centres operated by the National Prosecuting Authority, the Group Health Team, and Safety Officers. These resources play a critical role in promoting employee wellness and ensuring that health and safety standards are maintained. Continued development of inclusive platforms and improved trust in reporting mechanisms will further strengthen the workplace environment.

Despite these systems, the number of anonymous tip-offs remains low, suggesting that employees may feel uncomfortable using these platforms or lack trust in their effectiveness. Additionally, participants mentioned a lack of accountability mechanisms to ensure that women’s concerns are addressed. Without meaningful inclusion in policymaking and enforcement, women would remain sidelined in discussions that directly affect their safety, well-being, and professional growth.

Reported challenges included the length of time taken for resolution of issues, inaction, or that feedback was not provided on complaints. Poor communication was a concern. Some may also not be comfortable to report issues to male foremen, while others noted that it was difficult to report to supervisors, as they were the ones who were treating them badly. A lack of trust in reporting issues was a general concern, along with the potential for victimisation or intimidation. One of the related comments was "if you report, they will gang up on you. They will destroy you." Another reported challenge, particularly in relation to reporting of sexual harassment by a supervisor, is that the woman did not want the supervisor to lose his job, as he was the provider for his family. Late reporting and a culture of accepting safety risks were also noted concerns.

Mixed reports were received when the participants were asked whether they had experienced victimisation when reporting. Some said that they had not experienced this, while others said that victimisation did take place. Others were not comfortable in disclosing this information. Meanwhile, some commented that there were cases when women had bad intentions and reported this taking place for their own benefit, and or that some women victimise themselves.

5.4.5 Recommendations for improving occupational health and safety reporting channels for women in mining

Table 110 captures the recommendations on how to improve the reporting methods for women in mining. Improvements in reporting concerns, including those relating to the multiple potential contributors to mental and physical over-exertion, would help to address these challenges and, hence, mitigate the effects. If there is more awareness and understanding of the problems, along with the desire to address these, then interventions could be put in place to address many of the barriers that can compromise the holistic health and safety of women in the SAMI along with their performance and participation.

Participants recommended that individuals who specifically handle safety complaints are assigned, to ensure responsiveness and accountability. Risk management software, such as Isometrix, could be helpful to report issues and assign responsibility to someone to action and close-out. Monthly health and safety meetings were suggested to improve awareness as some participants were uncertain about where to report concerns. Another suggestion was to introduce boxes and anonymous platforms that are inclusive of the LGBTQI+ members. Linkages of WIM platforms with health and safety structures were considered important to effectively report concerns to the relevant people. The recommendations from the participants indicate that there is a need for a safe and reliable reporting system in the mining industry which will allow women to speak up without fear.

Table 110: Recommendations for improving OHS reporting channels for WIM

Question	Findings
Recommendations	• Other channel for anonymous reporting • Implementation of suggestion box • WhatsApp reporting (including voice notes) • Encourage reporting and suggestions from the workforce • Meetings for women to attend • Support of WIM platforms • Interlinkages of structures e.g., WIM and H&S • Mentorship for WIM • Roles for receiving and actioning complaints • Culture transformation • Ergonomic risk assessments • Survey on current communication channels • Education and training • Management support
EWP	• Do have but could be improved • Prioritisation of mental health • Counselling services • Suggest screenings at clinics • Low utilisation (e.g., online platforms) • More awareness for males and females • Various wellness programmes

Cultural awareness training for both men and women was recommended to promote understanding and respect for the needs of women in mining. Participants mentioned that there is a need for ergonomic risk assessments and equipment adjustments to ensure that women are tasked with jobs that are suited to their physical capabilities. This will reduce the physical strain that they are faced with and ensure comfort. Mental health also emerged as an area of concern, with participants suggesting the need for regular screening and support services. They noted that Employee Wellness Programmes (EWPs) exist, that is, the presence of social workers and Employee Assistance Programme (EAP) services, but their effectiveness may be undermined because of mistrust and lack of confidentiality. Communication is still a common factor amongst the various mines for reporting and wellness support. Participants also mentioned that there is a lack of communication channels and engagement with managers, which is seen as a barrier to trust.

In relation to employee wellness and assistance programmes, as mentioned above, most of the participants noted that these were available. However, it was evident that utilisation (e.g., of counselling services) was low due to fears relating to confidentiality, and as the platforms were not face-to-face. It was recommended that mines have social workers on site. Drives for mental health screening were recommended, and could be implemented at clinics, along with health services tailored for women's needs. The need to strengthen and align wellness and health topics was noted. It was evident that numerous initiatives and events were taking place, including campaigns and celebrations. Leadership support appeared critical to the success of women's initiatives.

It was also recommended that dedicated roles be assigned for receiving and actioning complaints. These individuals should be trained and empowered to respond promptly and confidentially. Introducing a WhatsApp hotline and suggestion boxes can offer more accessible and anonymous channels for reporting. Sustaining WIM workstreams was recommended, including attendance and communication. Monthly Health and Safety meetings should be held to clarify reporting structures and ensure that all employees are aware of available platforms. Enabling employees to make suggestions for improvements was recommended.

A survey was recommended to evaluate which communication platforms are the most effective and why, which would guide improvements in internal communication and ensure that employees feel heard. Driving culture change through mentorship programs, awareness campaigns, and inclusive leadership will help build a workplace where all employees feel safe, respected, and empowered to speak up. Wellness programs have been actively implemented to support the health and well-being of employees in the mining sector. Initiatives such as cancer awareness drives, HIV and TB campaigns, "The Biggest Loser" wellness challenge, and community outreach efforts aim to promote physical and mental health while fostering a culture of care and social responsibility. Additionally, whistle-blowing mechanisms have been introduced to encourage transparency and accountability, ensuring that safety and ethical standards are upheld across operations.

5.5 Synthesis of key themes and implications

High physical demands and poorly designed equipment place significant strain on women's bodies. Inadequate amenities and ill-fitting PPE add discomfort and undermine safety. Psychosocial stressors including harassment, discrimination, and pressure to prove competence compound physical fatigue and deter women from reporting concerns.

Limited career development, insufficient wellness programmes, unhealthy diets and poor work-life balance further erode well-being. The resulting fatigue, stress, anxiety, depression, injuries and strained relationships underscore the health toll of over-exertion.

The triangulated data (assessment tool, desktop review and focus group findings) highlight interrelated physical, psychosocial and organisational factors that contribute to over-exertion among women in mining.

Reporting channels are essential for identifying and addressing these hazards, yet many current mechanisms are poorly utilised due to fear of retaliation, lack of anonymity, perceptions of inaction and cultural stigma.

Effective reporting systems require confidentiality, trust and prompt responses. International guidance emphasises providing multiple pathways (self-help, informal, formal and anonymous) and ensuring that even anonymous reports trigger action.

Reports should be de-identified, when necessary, but employers must still act to protect workers and address systemic issues. Organisations should avoid treating unsubstantiated complaints as false; instead, they should record them as 'unsubstantiated' and reassure complainants that they will not be victimised.

Several challenges highlighted above hinder the effectiveness of the reporting channels for WIM:

- Fear of retaliation and lack of trust. Women may not report incidents if they fear victimisation or believe their concerns will not be addressed. A 2014 study on safety and security challenges found that most female victims of workplace violence and sexual harassment either did not formally report incidents or opted to manage them themselves because policies were non-existent or outdated.
- Poor response times and limited feedback. Bureaucratic delays and lack of follow-through discourage employees from using formal channels.
- Cultural barriers. Workplace norms may downplay women's concerns or stigmatise those who speak up.
- Gender-blind systems. Many reporting mechanisms do not explicitly consider women-specific exposures (e.g., over-exertion, menstruation-related issues) and thus fail to capture these concerns.

To address these deficiencies, the recommendations include:

- Integrating reporting channels into broader OHS management systems;

- Training women to recognise and report over-exertion and other hazards;
- Collecting gender-disaggregated data;
- Adopting inclusive language; and
- Maintaining confidentiality and non-retaliation policies.

These measures align with international best practices that emphasise multiple accessible reporting pathways (e.g., self-help, informal resolution, formal complaint and third-party anonymous reporting) and stress that even anonymous reports must trigger action to protect workers.

In summary:

- **Integrate reporting systems into comprehensive OHS management.** Establish clear procedures for reporting exposures related to over-exertion, harassment, discrimination, amenity deficiencies and PPE issues. Ensure that reporting systems are aligned with risk management processes and that data can be analysed to identify patterns and inform interventions.
- **Provide multiple accessible reporting pathways.** Offer self-help options, informal resolutions (e.g., mediation), formal complaint procedures and third-party anonymous channels. Ensure that anonymous reports trigger investigation and action. Provide digital platforms (e.g., apps or WhatsApp lines), suggestion boxes and in-person avenues. Make complaint forms available in multiple languages and ensure that WIM committees are empowered to receive and act on reports.
- **Ensure confidentiality and non-retaliation.** Protect the identity of reporters and maintain privacy. Communicate non-retaliation policies, and train supervisors to handle complaints sensitively. When complaints are not substantiated, record them as such rather than labelling them false. Provide regular feedback to complainants about actions taken.
- **Strengthen the culture of respect and inclusivity.** Conduct gender-sensitivity and anti-harassment training for all employees, including management and male colleagues. Promote leadership programmes for women and ensure their participation in decision-making. Encourage men to act as allies in preventing gender-based violence and discrimination.
- **Conduct regular ergonomic and organisational assessments.** Identify tasks that lead to over-exertion and redesign them. Introduce mechanical aids, automation and

appropriate staffing levels. Consider flexible work arrangements and shorter shifts to support work-life balance.

- **Improve amenities and PPE.** Upgrade change-houses and sanitary facilities; provide access to clean toilets and emergency sanitary products. Engage women in PPE procurement, and source equipment designed for female body shapes. Ensure high-quality materials, a range of sizes and more frequent replacement. Evaluate the weight and design of rescue packs and other equipment to minimise strain.
- **Enhance health, safety and wellness programmes.** Offer regular medical screenings, mental-health support and counselling services. Provide education on nutrition, exercise and hydration. Establish onsite gyms or recreation areas and organise fitness programmes. Support pregnant and breastfeeding women with flexible schedules and dedicated facilities.
- **Expand opportunities for development.** Provide training, mentorship and leadership development programmes to enhance women's career progression. Offer short courses and scholarships for further education. Create talent pools and transparent pathways to senior positions.
- **Develop a streamlined assessment tool.** Simplify the survey instrument used in this study and integrate it into existing reporting systems at mines. Use the tool to collect anonymous, gender-disaggregated data on over-exertion and related issues. Designate personnel responsible for reviewing data and implementing interventions.
- **Monitor and evaluate reporting system performance.** Track indicators such as reporting rates, response times, resolution rates, repeat incidents and gender-specific trends. Use the data to drive continuous improvement and share outcomes with employees to build trust.

5.6 Limitations

Substantial information was gathered during the focus group discussions, and common themes emerged across different groups and occupations. The findings presented here are subject to several limitations.

Participation in the survey and focus groups was voluntary; therefore, the sample may not fully represent the diversity of the South African mining industry. It was originally planned that two focus group discussions be held per mine, namely one with those in management or professional positions (not only including women in mining), and another with women in mining from a range of occupations. However, due to practical limitations, this was not feasible. As a result of the different occupations represented in the focus group discussions across the different commodity groups, the findings were not grouped specifically per commodity or occupation (role). The size of the focus groups in some of the commodities was also small, which could limit their representativeness, and comparability. The findings do, however, provide a broad view across a range of roles and commodities in the South African mining industry.

Additionally, due to the nature of focus group discussions, there could be hesitance of participants to share sensitive information with those present in the group. Sensitive topics such as harassment and over-exertion may have been under-reported due to concerns about anonymity and confidentiality. While confidentiality could be assured in terms of the project team's sharing of information, it was evident that participants might fear victimisation by those in the group. Resistance and lack of trust was noted in both in-person and online sessions but could be more of a challenge with online platforms. Some issues are of a personal nature (e.g., harassment and GBV) and therefore it was not expected for participants to share information of this nature freely. As a result, there could be further challenges and potential impacts of over-exertion of women in mining that were not mentioned in the focus group discussions.

Lastly, the study provided limited information on potential new reporting channels beyond those already identified. Legal and regulatory analyses were outside the scope of this chapter, although they will be addressed in subsequent project milestones.

Despite these limitations, the triangulated data offer valuable insights into contributors to over-exertion and the effectiveness of current reporting mechanisms. By triangulating the data from the assessment, the desktop review and the focus groups the data offer meaningful insights into contributors to over-exertion and the effectiveness of current reporting mechanisms. The qualitative research has therefore reached its saturation point.

5.7 Milestone conclusions

There was evident alignment in findings obtained from the desktop review and the focus group discussions. Various reporting channels are available for women to report OHS concerns, including those relating to over-exertion. These channels include health and safety representatives, WIM committees, and health and safety committees. Reports can also be made on anonymous whistleblower hotlines, and on platforms including emails, note books, and WhatsApp channels. The effectiveness of these platforms was seen to vary according to site and issue. Adequate anonymity and trust of reporting channels was a concern. As a result, aspects relating to over-exertion could be under-reported. The reporting channels would need to be relevant to the concern faced, which can range from those related to PPE, physical workloads, mental health issues, or harassment and GBV. The insights gained from this study assist with understanding the current needs of women in mining and opportunities for improvement, in relation to over-exertion and the impacts thereof. Better reporting and response would intend to address impacts of over-exertion of women in mining including that of fatigue, injury and mental or physical strain.

In conclusion, while there are various reporting channels available for women to report OHS-related concerns, including over-exertion, there were numerous evident short-comings. A number of the barriers include those relating to workplace culture, such as a lack of trust, confidentiality, communication, leadership and accountability. As there are multiple facets of over-exertion, there are a broad range of factors that could be reported and addressed. The barriers to reporting should be addressed, and channels for reporting (e.g. WIM Committees and anonymous systems) should be supported. A better understanding of the issues relating to over-exertion and reporting channels available could empower individuals to make the necessary adaptations. Further recommendations to mitigate over-exertion-related concerns, included improved mental and physical health programmes.

5.8 Next milestone

The following Chapter (Milestone 6) entails formulating recommendations towards existing channels of OHS report for women. The milestone closely follows on from Milestone 5 and includes a consolidation of findings from the desktop review and focus group discussions. Furthermore, it contains an assessment of qualitative data collected from women in mining, which includes recommendations towards improvements of working conditions for WIM. Milestone 7 of the project involved a stakeholder workshop and an additional survey to refine recommendations and develop practical tools. Findings from that engagement will inform final guidelines and recommendations for the mining sector. Ultimately, creating safe, responsive and inclusive reporting channels is crucial for protecting the health, safety and dignity of women in the mining industry and for advancing gender equality in this vital sector.

6. REPORTING CHANNEL EVALUATION

6.1 Introduction

This milestone evaluates how effectively current reporting channels in the South African mining industry (SAMI) enable women in mining (WIM) to report exposures and symptoms associated with over-exertion, and how these channels can be strengthened. Over-exertion is treated in this study as a progressive occupational health and safety (OHS) risk, driven by cumulative physical demands (e.g., manual handling, awkward postures, heat, extended shifts) and compounded by psychosocial stressors (e.g., harassment, discrimination, low control, pressure to "prove" capability).

The core objective is therefore not to restate broad OHS challenges that have been highlighted in Chapters 3,4 and 5, but to assess whether reporting systems are:

- Accessible;
- Trusted;
- Confidential and non-retaliatory;
- Able to capture gender-specific exposures; and
- Able to convert reports into timely controls (engineering, administrative, medical, and psychosocial interventions).

The objective of this report is to provide recommendations towards reporting channels for women's occupational OHS concerns. The relevance of the findings towards the project is linked to the need for aspects of over-exertion, as experienced by WIM, to be considered in reporting channels available in the mining industry. This chapter therefore integrates evidence from the qualitative survey comments from WIM who completed the project assessment tool as well as the focus group discussions with industry stakeholders (Milestone 5) and the findings are triangulated to identify:

- The over-exertion drivers WIM experience,
- The points where reporting currently fails (under-reporting, distrust, delayed resolution), and
- Practical improvements to reporting architecture and governance.

The recommendations included in this report are not limited to reporting channels, but also include those made by the participants in relation to over-exertion of WIM in general. Better understanding of challenges facing WIM is needed to inform the type of reporting channel required and, as such, qualitative information collected during the study is reported in this chapter. Furthermore, many of the recommendations that the participants made were linked to the way in which current reporting channels could be improved, and to the culture change needed in industry to drive better reporting.

6.1.1 Overview of methodology (reporting-focused)

The findings reported in this milestone are primarily based on information gathered during focus group discussions, which are detailed in the Milestone 5 report (Chapter 5). The focus group discussions were held with over 90 individuals, from a range of occupations, from nine mining companies and an industry organisation. Information gathered using the assessment tool developed for the project was also used when considering reporting channel recommendations in relation to over-exertion of WIM. The survey using the assessment tool was completed by over 500 WIM. Further detail on the survey questions, process, and participants is provided in the Milestone 4 report (Chapter 4), along with the quantitative analyses. The findings from the qualitative questions of the survey are included in this report. These questions included open-ended questions relating to factors concerning over-exertion of WIM, recommendations to improve OHS of WIM, including recommendations for PPE adjustments, more specifically, and any additional comments.

6.1.2 Analysis approach

A thematic analysis was conducted, but for this milestone, themes were re-coded through a reporting lens:

- What exposure/symptom is being described (over-exertion pathway)?
- What reporting route is implied/used/avoided?
- What barrier prevents reporting or timely response?
- What system improvement would convert the report into action?

6.2 Findings from qualitative survey data

The findings from the desktop reviews and focus group discussions with industry stakeholders should be considered with an understanding of the qualitative findings obtained from the survey of women in mining that was conducted for the study in relation to over-exertion. During the survey, participants were asked to respond to three open-ended questions to gain further insights relating to the project, namely:

- Please list factors that you can think of that lead to, or result from, over-exertion of women in mining, that may not have been mentioned in this questionnaire;
- Please provide recommendations that you can think of for improving the health, safety, and wellness of women in mining; and
- Please provide any additional comments that you may have.

These questions were not compulsory to complete. Around half of the respondents answered each of these questions, including several responses such as “none”, “no”, or N/A”. When excluding the latter responses, approximately 580 comments were received in total. It was evident that there was an overlap in the responses to the three questions and, as such, the combined findings are reported in this section, according to theme or topic, rather than per question. The topics related to the following sub-headings:

- The physical work environment and job demands;
- Amenities and PPE;
- Psychosocial factors at work;
- Opportunities for development;
- Health, safety and wellness programmes;
- Diet and exercise; and
- Personal factors and work-life balance.

Another more specific question in the survey, for those who wore Personal Protective Equipment (PPE), was as follows: “What adjustments do you believe will help to improve your PPE?” Around half of the participants (260) responded to the non-compulsory question relating to adjustments to improve their PPE. Around 50 respondents indicated answers such as “None” or “N/A”, and when these answers were excluded, 210 responses were analysed and are detailed in this section (6.2.8. “Recommended PPE adjustments”).

Over-exertion drivers that require routinised reporting are indicated below. Survey comments show over-exertion is driven by repeated exposure, not single incidents. This matters because many mining systems prioritise acute incidents, while cumulative strain needs routine, low-threshold reporting. Key exposure clusters include the following:

- Physical workload and environment, e.g., high workload, heavy lifting, awkward tasks, long travel distances underground, heat, confined spaces, prolonged standing, shift work, overtime, understaffing, poor ergonomics.
  - Reporting implication: These are often "normalised" and therefore under-reported unless systems explicitly request and accept fatigue/strain/near-miss reporting.
- Amenities and hygiene constraints (e.g., toilets, change houses, sanitary products). Poor access increases stress, discomfort, and health risk; it also increases fatigue and distraction.
  - Reporting implication: These are frequently not treated as OHS hazards, so they fall between channels (HR vs OHS vs line).
- PPE and equipment fit/compatibility. Ill-fitting PPE increases physical strain (restricted mobility, extra effort) and can increase injury risk.
  - Reporting implication: PPE defects are often reportable, but systems may not classify "fit-for-women" failures as defects needing corrective action.
- Psychosocial hazards (harassment, discrimination, bullying, pressure to prove competence). These amplify fatigue, stress and burnout and directly suppress reporting behaviour (fear and distrust).
  - Reporting implication: If reporting channels are not trusted/confidential, psychosocial hazards remain hidden—yet they are key contributors to over-exertion.
- Work–life load and pregnancy-related concerns. Cumulative fatigue is intensified by long commutes, caregiving, and inconsistent maternity/pregnancy support.
  - Reporting implication: Workers may conceal pregnancy or health issues if reporting leads to perceived penalty (loss of allowance/bonuses), undermining risk management.

The project data indicates over-exertion in SAMI is best managed through systems that capture cumulative exposure and early symptoms, not only injury events. Reporting channels must therefore include fatigue/strain reporting, ergonomics hazard reporting, and psychosocial hazard reporting as routine—not exceptional—pathways.

Various causes and consequences of over-exertion were listed by participants, along with suggestions for improvement. The causes included those relating to physical workplace exposures, access to amenities, PPE, psychosocial factors at work, development, exercise and diet, personal factors, and work-life balance.

These factors are detailed further in section 6.2 below of this report. Listed consequences of over-exertion included fatigue, stress, anxiety, depression, lack of motivation, injury, and relationship issues. Recommendations reported by the respondents towards improving these matters are also summarised.

6.2.1 Physical work environment and job demands

Numerous comments related to factors influencing the physical work environment and job demands, associated with over-exertion of WIM were submitted by the participants. These factors included high workloads, lifting heavy loads, shift work, overtime, long working hours, irregular work schedules, long travelling distances, standing for long times, heat, confined workplaces, and working in isolation. Understaffing and a lack of materials were mentioned. Poor ergonomics was a further concern. Comments included:

- "Heavy workload exceeding body capacity like lifting and shovelling may result in back pain, joint injury, or fatigue";
- "Lack of water sometimes and heat is too much which leads me to dizziness";
- "Vibration that comes from bumpy roads when travelling to site may cause womb problems for women";
- "Physical demands and exposure to certain substances may lead to reproductive health issues"; and
- "Mining equipment and workplaces may not be designed with women's physical characteristics in mind".

Related recommendations included that they should work in pairs or groups for safety, the provision of transport to work areas, and increased consideration when it comes to lifting heavy equipment. Some commented that lighter duties should be available for women, in line with their physical capacity, or for assistance in lifting things that they cannot handle alone. Aspects such as improved ventilation, better access to drinking water, reduced noise, better dust control, and cleaner work environments were also mentioned in relation to specific workplaces. Filling vacant positions and increasing the available assistance were recommended. Resting during work was also recommended. Some of the related comments are as follows:

- "Conduct regular ergonomics assessments to identify and mitigate hazards";
- "Women must work according to their strength and be able to seek assistance from the males";
- "Introduce mechanical devices to help where body strength is a problem";
- "We must gradually charge in line with the technology – automate most of the equipment to reduce lot of physical work that must be done"; and
- "Women should work with men especially underground there are places underground that are not safe for women to work alone".

6.2.2 Amenities and PPE

A number of respondents noted concerns relating to amenities at work, such as change houses and toilet facilities. Some indicated that their change houses were too small and overcrowded, or not clean. Others mentioned that there were no proper ablution facilities for women. A lack of hygiene was a concern. Larger change houses, improved cleanliness of toilets, and better quality toilet paper was also recommended. Several respondents commented that it would be helpful if they could get access to sanitary pads during their periods, including sanitary facilities underground. Some also mentioned that women should get time off during their menstrual periods, as it is a cause of discomfort at work. Related interventions could help to mitigate over-exertion in terms of absence of disease, mental loads and stress, and working when in pain. Related comments included:

- "We need toilets at the working places";
- "We really need clean toilets because we contract sickness";
- "We as women we are asking to use proper tissue, quality one to avoid infections"
- "Provide secured lockable and well-maintained ablution facilitates and sanitary management";
- "Ensure clean, private, and accessible toilets and changing rooms, sanitary pads";
- "Sanitary pads stations should be provided near working stations";
- "Provide ladies with small sanitary bags that they can carry around their waist for your pad, panty liner, small lotion and lip balm";

- “If the women is in periods we must have a day off because it’s too painful and work at the same time”; and
- “Seldom / no sanitary products available at clinic, shops, or change houses. In an emergency situation, you need to ask female colleagues to assist, or you need to ask your supervisor if you may leave (if you have your own transport) to buy sanitary products at the nearest town, which is 23 km away.”

Comments relating to PPE included poor fit or quality of overalls, and that rescue packs were too heavy. These limitations can add to discomfort, impaired mobility, safety concerns, and increased workloads, thus contributing to over-exertion. It was suggested that PPE and tools be provided that are designed to fit women, and that PPE should be provided more frequently. Others noted that the colour of their overalls should be changed from white to a darker colour, such as blue. A few requested the provision of PPE including sports bras, belts, warm jackets, raincoats, safety gloves, better dust masks and ear plugs, and clothes to put inside their overalls. Others mentioned that the weight of the rescue packs should be reduced. Examples of comments included:

- “Provide us overalls that is suitable for women”;
- “Provide designed PPE for women's body and ensure proper fit”;
- “Change in white overall they are not good for women during their periods”;
- “I recommend if they can make a portable rescue pack that doesn't affect our waist”;
- “Provide enough PPE”; and
- “By providing PPE every 6 months because due to the hard work we do, we sometimes damage our PPE”.

Some comments were also made relating to facilities for pregnant and breastfeeding women. Suggestions included, “Breast pumping stations for women who just came from maternity leave”, and “Rest room for pregnant women”.

An additional comment related to further equipment that could support women in mining, including “Cameras in confined spaces to reduce incidents of harassments. Put panic buttons at all areas in meters for rapid assistance needed for women in trouble”.

6.2.3 Psychosocial factors at work

Psychosocial factors associated with over-exertion included cultural expectations, women having to prove their competence, a lack of respect, discrimination, and potential bullying or harassment. Respondents reported being pressured by management. Poor communication was also a concern. Respondents commented:

- “Women trying to prove that they can work in the mining industry end up taking more tasks, pushing themselves to the limit accepting anything that comes their way, end up working double output which might lead to incidents or accidents. They are also subjected to harassment and bullying by other team members or superiors, which can affect their mental status or end up with them not performing their duties. Women not reporting their pregnancies in time because they don’t want to lose allowance and bonuses. Career advancement not progressing as it should”;
- “Emotional over-exertion trying to prove yourself in a male dominated environment”;
- “Managers bullying women and making them feel inadequate”;
- “Women in mining are treated badly by their bosses, especially when you are black. We are not treated like our male colleague(s)”; and
- “Communication between employees and employers is not good”.

It was noted that it was important to have increased respect, and for women and men to be treated equally. It was recommended that a positive work culture be cultivated. The need for effective communication was noted, along with the need for women’s voices to be heard. Comments included:

- “We need our supervisor to respect us at our working places”;
- “Recognise women in mining”;
- “Train male colleagues about respect and gender inclusivity to prevent harassment”;
- Men in mining can be taught on how to treat or talk to women”;
- “Involve women in leadership positions and decision-making processes to ensure their voices and their needs are addressed”; and
- “Stop women harassment”.

6.2.4 *Opportunities for development*

A lack of development was a commonly noted concern, and women wanted higher positions and opportunities for improvement. Some commented on working in the same positions for a long time without promotions. Examples of comments included "Women in mining face barriers to career advancement, leading to frustration and demotivation", and "We want to be developed." Respondents desired opportunities for training. Related suggestions for upliftment and training included:

- "Women [should be] given fair chances, opportunities on senior positions, and actually given chances to relieve and be developed as men do";
- "Send us to school even if it's for short courses it's also fine";
- "Support groups and empowerment and career growth";
- "Mentoring and talent pool for all bands across the company";
- "Uplifting women in different positions"; and
- "Offer leadership development programs to empower women".

6.2.5 *Health, safety and wellness programmes*

Many of the suggested recommendations to improve OHS and address over-exertion related to wellness programmes, health and safety awareness campaigns, and counselling or support for women in mining. Respondents recommended health and safety events for women, wellness days, women in mining workshops, and team building activities. More awareness on health and safety measures, as well as on mental wellness, was recommended. Training for both men and women was suggested. The need for counselling services was reported, along with regular physical and mental health checks, including height, weight, pap smears, mammograms, HIV testing, cancer screening, and family planning. Examples of comments were as follows:

- "Constant engagement about physical health and mental health because those are the main contributors of illnesses";
- Hosting wellness workshops";
- "On-site wellness initiatives; safety training tailored for women; leadership and assertiveness training";
- "Wellness – offer mental health support services, counselling, and stress management resources";

- “Share wellness programs feedback on the mining industry to encourage women to take care of their health and safety”;
- “We need emotional and physical support”;
- “Provide access to mental health professionals and confidential support”;
- “More activities that are motivational and inspirational to women”;
- “Men to form part of the solution and be included to eradicate GBVF”; and
- “There should be an anonymous self-reporting whereby a person will feel free to talk about whatever she is going through if she is not ready to talk to anyone”.

6.2.6 Diet and exercise

Diet and exercise were associated with staying healthy. A few respondents indicated poor eating habits or unhealthy diets to be a problem. Unhealthy eating could result from a lack of time or from inadequate one-site food options. A lack of physical fitness was also noted and could contribute to over-exertion. Poor health and being overweight were noted concerns. A large percentage of the recommendations made for improving the health, safety, and wellness of women in mining related to exercise and diet. Getting regular exercise, provision of exercise programmes and facilities such as gyms, increasing awareness related to exercise, drinking lots of water, and workshops to promote healthy living were recommended. The need for healthy eating was noted, and the provision or availability of health food at mine sites was suggested. Comments included:

- “Some people do not have time to exercise and it would be nice to have such services in the workplace”;
- “Mining needs to introduce a sports day for employees”;
- “Having a gym or recreational programmes”;
- “Implement workout sessions for women and implement diet support and guidelines”;
- “I think we should get place where we can exercise and get healthy food around the mine”; and
- “Fitness program also nutritious meals on site to maintain wellness”.

6.2.7 Personal factors and work-life balance

Comments that were categorised under personal factors included differences between females and males, age, sleep, commuting times, socioeconomic factors, personal problems, and work-life balance. Respondents commented on differences in how females and males are built, and this included acknowledging that women are not generally as physically strong as men, and recognising the hormonal fluctuations of women. Lack of sleep and rest was mentioned, and could be related to changes in shifts worked. Long travelling distances to work was a further potential cause of over-exertion or fatigue. Additionally, personal problems could lead to over-exertion and could include relationship issues, financial strain, or emotional demands. Financial problems or debt were mentioned, and could result from bad financial planning. Respondent recommendations included teaching financial planning to women, providing sufficient housing closer to the mines, and providing transportation to and from the mines.

A few comments related to the changing needs of women as they get older (e.g., over 50 years). Related suggestions included having reasonable work tasks, lighter jobs, or longer leave to prevent fatigue, or being removed from working underground.

A few other participants made comments relating to pregnancy, including those relating to pay and pregnancy procedures. Comments included:

- "During pregnancy, we must get our whole salary";
- "Offer support to pregnant women before and after post-natal, like flexible hours when returning to work. Encourage women to report pregnancies and not cut all allowance and pay during and after giving birth, HR to come up with mechanisms for pay issues"; and
- "Maternity leave can be increased and this should apply to the business partners/contractors. The issue of EE regarding pregnancy, some companies don't support or pay employees which makes it difficult for women to grow their own families because of fear of not having emotional and financial support".

Work-life balance was a commonly noted challenge, with pressure from work and home. Respondents referred to family responsibilities, including those of being wives and mothers, household chores, and cooking. Examples of comments are:

- "Women work at work and at home";
- "Mothers in mining are extremely tired. We travel very far to provide for our families and when we get home, we must make sure the homework is done, and ensure that the cooking gets done. Bath children, spend time with families and with their husband.

It is just not sustainable in the long run. In fact, the same as for the male employees. Somewhere employees will get a burnout"; and

- "Balancing work in remote mining locations with family responsibilities can be challenging, leading to stress and decreased well-being".

Related suggestions included working from home or on a hybrid basis, where feasible, working from home when their children are sick, flexible working hours, and a four-day work week (e.g., for officed-based workers). Some recommended being allowed family responsibility leave to take care of their spouses or children when they were ill. The allocation and structuring of shifts should be considered, for example, for women with young children. A respondent suggested, "Shorter shifts because when we get home we still have to cook, clean, and look after our families which is also a full-time job on its own". Other recommendations included the provision of children's facilities (e.g., creche, school, and aftercare at work).

6.2.8 Recommended PPE adjustments

This section details responses to the standalone question regarding recommended adjustments to improve PPE. These improvements would help to ensure compatibility of PPE with WIM and thus reduce associated OHS and over-exertion risks. The most commonly occurring themes regarding PPE adjustments related to the quality, fit, and availability. A number of comments referred to specific types of PPE such as overalls, jackets, boots, belts, hardhats, and gloves.

6.2.8.1 Design/fit

In terms of fit, it was evident that PPE needs to be designed to accommodate women's body shapes and sizes. The respondents noted that the correct sizes needed to be available. This was noted in relation to a range of PPE, including overalls, trousers, boots, and gloves. The need to accommodate "curved" or "oversized" women was commonly reported. However, some respondents commented that smaller sizes needed to be available, also noting that women are generally shorter or smaller than males. Furthermore, it was noted that it is important for the women to be able to try on the PPE to ensure that it fits. Examples of comments include:

- "Redesign PPE to accommodate females, addressing different body sizes and shapes";
- "Correct PPE for my body type as I am voluptuous";

- “Correct sizing accommodating smaller sizes also”;
- “Design to fit all body types”;
- “We need to fit PPE first”; and
- “Women structure must bring samples of PPE of woman to fit before any changes can apply”.

6.2.8.2 Quality

Poor quality PPE was a commonly mentioned concern. This concern was mentioned in relation to a range of PPE, including overalls, boots, and belts. In particular, a number of suggestions indicated the need for stronger materials for overalls. Some of the comments included:

- “Quality is very poor”;
- “Change the materials of the overalls”;
- “The material they are now using is not too strong”;
- “Increase the material on the groin and thighs area of the pants”;
- “We need a better quality of overalls, belts, and boots”; and
- “We need a better quality of overalls and gumboots”.

6.2.8.3 Availability

Numerous respondents commented on the availability or frequency of receiving new PPE. This was also related to the quality and fit of the PPE, as some mentioned that the quality was not good enough to last six months. The recommended length of time for receiving PPE, such as overalls, varied amongst the respondents, from every second month to quarterly to twice a year. Others suggested getting more PPE. Stock availability was important. Better availability and range of types and sizes of PPE was recommended. The location and opening times of the PPE stores should also be convenient. Some of the related recommendations were:

- “If they can reduce the period of changing overalls from 6 months to 3 months”;
- “At least 2 months must issue PPE, not 3 months, cause if you have big body trousers tear between the legs”;
- “To be given enough PPE to change with”’
- “Be given 2 overalls”;
- “To be given second jackets in case the other one is not dry after wash in winter”;
- “To always have all sizes for PPE because we can’t work without it”; and
- “Always to have PPE available and proper PPE.”

6.2.8.4 Overalls

In addition to suggesting overalls designed for women's body shapes, other considerations were made. A number of participants noted that they wanted one-piece overalls available for women. Meanwhile, some preferred two-piece overalls, such as for convenience when going to the toilet. Others noted that that overalls and trousers with zips, rather than buttons, would be better, or that the buttons and zips should be repositioned. Some suggested that an elasticated waist would assist. Others noted a need for overalls that were heat and flame resistant. Numerous comments were made relating to the colour of the overalls. Where white overalls were supplied, women requested that they be provided with darker colour overalls (e.g., dark blue or black). The reason for this was to avoid stains, especially during menstruation. In relation to overall sizes, it was also mentioned that it was important to consider that these shrink after washing. Related comments included:

- "Woman cut overalls";
- "If we as women can be provided with overalls for women not male overalls";
- "For overall jackets to accommodate larger bust sizes";
- "Pants should be designed for woman's bodies. To accommodate our curved bodies";
- "Please if we can get one piece overall with a zip it would be much appreciated"; and
- "Stretchy overall for flexibility".

6.2.8.5 Jackets

A number of respondents wanted to receive winter jackets, reflective jackets, or freezer suits, and warm PPE in winter. Others noted that the design should accommodate women's curved figures, or for them to be longer. The quality of freezer suits provided was also a noted problem. Examples of comments were:

- "The only adjustment is that we should all be provided with warm jackets";
- "During winter to be issued warm socks and long johns"; and
- "If they can give us proper PPE jacket and freezer and warm socks".

6.2.8.6Boots

There were a few recommendations to change the safety boots, as smaller sizes needed to be available; comfort was also a concern. Related comments included:

- "Safety shoes for women are not comfortable";
- "We need a size 3 on the boots"

- “Nicer more comfortable safety boots”; and
- “To make safety boots more stronger, and safety belts”.

6.2.8.7 Gloves

There were a few recommendations relating to sizes of gloves available, as these or did not fit properly, and should accommodate smaller hands. Examples of suggestions included, “Smaller hand gloves for people with small hands is needed so that they can fit properly” and “Better fitting working gloves for women”.

6.2.8.8 Other PPE

Comments were made regarding a range of other PPE. Some noted it would be helpful to be provided with sports bras, especially for those working on vibrating machinery. Some noted that the belts should be adjusted. Others suggested changing the socks that they received. Other requested items included reflective shirts. Further suggestions included:

- “Lining in Hard Hat to prevent hair damage”;
- “Correct dust mask”;
- “We need proper dust musk since we’re working with stone dust”;
- “Implementation of knee guards”;
- “My adjustment is arm guard and the safety net in a hard hat”;
- “Lighter rescue pack”;
- “I think if they can adjust on some of PPE like safety goggles, sometimes when there's dust, it's not easy to see with the safety goggles that we're using. Otherwise other than that other PPE is great”; and
- “Welding vests to protects our breast as well as helmets for underground that protects us from any falling objects since the one we use now doesn't cover our heads”.

6.2.8.9 General comments relating to PPE

A few participants commented that they were satisfied with their current PPE. Others recommended taking better care of their PPE. Examples of comments were:

- “PPE is perfect”;
- “Currently we have WIM PPE”;
- “No adjustments needed”;
- “My PPE is suitable for me”; and
- “By taking good care of it and keep it clean all the time”.

6.2.9 General comments

A few general comments were made relating to the survey conducted. Respondents appreciated the recognition and support for women in mining. Some recommended this initiative, and suggested that it be done regularly. Examples of comments are, “I appreciate your efforts in everything you do for us. It shows that you care for your workers”, and “Can we have this on a monthly basis”.

6.3 Summary of findings

6.3.1 Findings from the desktop review

The findings from the desktop analysis, assessment survey, and focus group discussions conducted in the project were triangulated towards determining recommendations for reporting channels for women’s OHS concerns. The desktop review conducted in Milestone 5 assessed existing reporting channels available for OHS concerns, including whether aspects relating to over-exertion are well incorporated. Identified reporting channels included the following:

- Supervisors
- Safety representatives
- Safety officers
- OHS committees
- Incident reports
- Suggestion boxes
- Checklists
- Digital reporting systems
- Whistleblower hotlines and anonymous reporting systems
- Human Resources (HR) departments
- WIM committees
- National OHS regulatory agencies
- Mining industry associations
- Unions
- NGOs and advocacy groups

- Third party audits and certifications

Related challenges that were identified included:

- Fear of retaliation
- Lack of trust
- Poor response time
- Workplace culture
- Lack of follow-through
- Bureaucratic delays
- Lack of sufficient financial and human resources
- Lack of gender-focussed channels

It was evident from the desktop review that most reporting channels do not address women-related OHS issues and/or over-exertion. The following recommendations were made (International Labour Organisation, 2013; Podgórski, 2015):

- Integrate reporting channels into comprehensive OHS management systems
- Train women on how to report over-exertion and OHS concerns and exposures
- Track gender-disaggregated data
- Use inclusive language
- Maintain confidentiality and non-retaliation policies

6.3.2 Findings from focus group discussions

The focus group discussions conducted in the study further provided insights into reporting channels available, as well as potential shortcomings and challenges relating to these platforms. In addition, insights were provided into potential recommendations or additions to existing OHS reporting channels. Available reporting channels discussed by focus group participants in the project included:

- Safety offices (health and safety representatives, health and safety committee, management)
- Supervisors
- Complaint books
- Foremen

- Clinics/medical centres
- Unions
- HR
- WIM Committee (and sub-committees)
- Anonymous hotlines (including call centres, email, and WhatsApp platforms)
- Surveys

Challenges relating to reporting channels were also noted, including:

- Fear of victimisation, intimidation or punishment
- Concerns about confidentiality
- Lack of trust in anonymity of hotlines
- Inaction
- Time taken to resolve issues
- Lack of feedback
- Poor communication
- Fear of losing job if disclosing
- Fear of others losing job
- Vulnerability in reporting
- Discomfort reporting some issues to males
- Late reporting
- Acceptance of risk
- Misuse for personal gain
- Lack of active leadership

The participant recommendations included:

- Other channel for anonymous reporting
- Implementation of suggestion box
- WhatsApp reporting (including voice notes)
- Encourage reporting and suggestions from the workforce
- Meetings for women to attend
- Support of WIM platforms
- Mentorship for WIM
- Roles for receiving and actioning complaints

- Culture transformation
- Ergonomic risk assessments
- Survey on current communication channels
- Increased awareness

It is important for the reporting channels to incorporate aspects that can lead to (or result from) over-exertion of women in mining. The findings from the project indicated aspects relating to over-exertion that could be considered, including:

- Intimidation and harassment
- Discrimination
- Lack of development
- Design and quality of PPE
- Lack of access to adequate toilets, change houses, and emergency sanitary pads
- Travelling distances underground
- Lifting heavy loads
- Heat
- Confined spaces
- Shift work
- Overtime
- Equipment design
- Lack of resources
- Work-life balance
- Fatigue
- Injuries
- Mental and physical strain

These aspects could be considered by multiple departments, who should receive and action the reports. Opportunities for improvement suggested by the participants to mitigate over-exertion included, amongst others:

- Increased respect, inclusivity and support for women in mining
- More growth and development of women
- Workshops, training and awareness campaigns
- Culture transformation programmes
- Ergonomics assessments and adjustments

- Supporting equipment
- Improved availability to hygienic toilets and change houses
- Access to emergency sanitary pads
- PPE designed for women
- Better quality PPE
- More frequent provision of PPE
- Darker colour overalls

6.3.3 Assessment survey data

Themes from the data in the assessment survey were identified based on patterns of meaning from the text. The qualitative data in the assessment survey revealed the following themes, relating to mental or physical over-exertion of women in the South African mining industry:

- **Physical work environment and job demands:** e.g., high workloads, lifting heavy loads, shift work, overtime, long working hours, irregular work schedules, long travelling distances, standing for long times, heat, confined workplaces, working in isolation, understaffing, lack of materials, and poor ergonomics.
- **Amenities:** e.g., lack of hygienic change houses, proper ablution facilities, and access to emergency sanitary pads.
- **PPE:** e.g., poor fit or poor quality PPE, heavy rescue packs.
- **Psychosocial factors at work:** e.g., cultural expectations, women having to prove their competence to men, a lack of respect, discrimination, bullying or harassment, pressure from management, and poor communication.
- **Opportunities for development:** e.g., lack of opportunities for development and promotion.
- **Health, safety, and wellness programmes:** e.g., the need for enhanced wellness programmes, health and safety awareness campaigns, and counselling or support for women in mining.
- **Diet and exercise:** e.g., unhealthy eating and a lack of physical fitness.
- **Personal factors and work-life balance:** e.g., differences between men and women, pregnancy, impact of aging, lack of sleep, long commuting times, personal problems, and difficult work-life balance.

Impacts of over-exertion that were mentioned included fatigue, stress, anxiety, depression, lack of motivation, injury, and relationship issues. Recommendations were made relating to these themes, such as:

- Conduct ergonomics assessments
- Increase the use of technology such as mechanical devices
- Work in pairs or groups for safety
- Increased consideration of women when lifting heavy equipment
- Larger, cleaner change houses
- Hygienic and accessible toilets
- Access to sanitary materials
- Time off during periods
- PPE designed to fit women
- Availability of correct sizes of PPE
- Better quality PPE
- Provide PPE more frequently
- Darker colour overalls
- Provision of facilities for breastfeeding women
- Inclusion of women in decision-making
- Training on respect and gender inclusivity
- Promotion of a positive work culture
- Effective communication
- Opportunities for development and training
- Wellness programmes
- Health and safety awareness campaigns
- Counselling and support for women in mining
- Physical and mental health screening
- Exercise programmes
- Promotion of healthy eating
- Lighter work tasks for women over 50 years
- Increased support for pregnant workers

6.4 Recommendations

There was evident alignment in what was found in the desktop review, assessment survey, and the focus group discussions. Factors that were noted to be associated with over-exertion included the job demands and work environment (e.g., lifting heavy loads, long travelling distances, heat, confined spaces, unergonomic equipment design, lack of resources, shift work and overtime), lack of access to amenities (e.g., adequate toilets, change houses, and emergency sanitary pads), the poor design or quality of PPE, psychosocial factors at work (e.g., intimidation, harassment, discrimination, and lack of development), and difficulty to maintain a work-life balance. Noted consequences of over-exertion included fatigue, injuries, and mental and physical strain. Numerous related suggestions for improvements were made by the participants. These opportunities included, for example, ergonomic assessments and adjustments, use of technology, improved access to adequate toilets, change houses and emergency sanitary towels; improved PPE design, quality and availability; awareness campaigns; increased inclusivity; training and development; health, safety, and wellness programmes.

Different reporting channels are available for OHS concerns, including reports to health and safety departments and anonymous whistleblower hotlines. The channel used would be dependent on the matter being reported (e.g., workplace concerns to safety representatives to relay to the OHS Committee, PPE concerns to the WIM Committee, harassment or discrimination concerns to HR or whistleblower hotlines). However, there were related challenges that need to be addressed for the channels to be more effective. For example, cultural transformation is required to improve understanding and mitigate the effects of victimisation or intimidation of those making reports. Training and awareness programmes would assist with cultural transformation, gender awareness, and with an understanding of available reporting channels and what can be reported.

It was evident from the data gathered in the project that it is important for these channels to be confidential, and for anonymous channels to be available. Women in mining committees appeared to be valuable platforms for reporting challenges faced by women in mining. However, their effectiveness could vary from mine-to-mine. Employee wellness programmes are also available, particularly for employee mental health, while having more face-to-face, rather than virtual or telephonic, engagements were considered important to improve accessibility. Additional reporting channels could include WhatsApp platforms, suggestion boxes, or online OHS management systems. Related recommendations include training and awareness of over-exertion and reporting channels available; cultural transformation initiatives; improving the support and effectiveness of WIM Committees; the availability of anonymous reporting channels; ease of access to support; and improved feedback mechanisms.

The assessment tool developed in the project could be used to report matters relating to over-exertion of women in mining. A streamlined version of the tool is recommended for better focus and ease of use. It would be important for the data gathered to remain anonymous. The information could be used to identify areas in need of intervention. The tool could be integrated into current reporting systems at mines. The availability of personnel responsible for identifying and acting on reported issues would be important for the success of the implementation of initiatives. The reporting channel's effectiveness would depend on the cultural maturity of the workplace, along with management commitment and support. Meanwhile, greater awareness and education is key for the implementation of interventions to reduce over-exertion of women in the mining industry. In addition, it is important to train women on how to report over-exertion, OHS concerns, and exposures safely. It is crucial to educate women on what over-exertion actually is. Since it develops gradually over time, it is not always easy to identify or report. Without proper awareness and training, symptoms may be overlooked or misattributed, especially given the cultural stigmas and fear of being perceived as less capable.

The findings of this study are useful in providing insight into contributors to over-exertion in the SAMI. However, improved reporting systems at mines would assist to provide details on specific aspects where interventions are required in particular areas. Barriers to reporting are evident, including a lack of trust and fear of victimisation. Therefore, improvements to reporting systems and workplace culture are recommended, for improved reporting. Related indicators include the rates of reporting, accessibility and anonymity, responsiveness to addressing reported issues, closure rates, repeat incidents, and the availability of gender-disaggregated data (ICMM, 2012). The reporting channels and contexts of mining sites (e.g. size, demographics, and existing reporting channels) differ and, hence, specific recommendations or prioritisation is not made for the industry as a whole. Interventions will assist with non-discriminatory practices and gender equity, safe and healthy work environments, and improved participation of women, as enshrined in the Constitution, Mine Health and Safety Act, Mining Charter, the Mineral and Petroleum Resources Development Act, GBVF Guidance note, and the United Nations (UN) Sustainable Development Goal (SDG) 5 (DMR, 2018; DMRE, 2024; South Africa, 1996a, 1996b, 2002, United Nations, 2024).

6.5 Limitations

The study provided limited information on additional potential reporting channels for the industry. The information provided in this report indicates opportunities to address challenges in the mining industry, amongst others through improved reporting channels. While reporting channels are available in the SAMI, recommendations have been made to improve these, along with driving industry culture change to make the reporting channels more effective. The reporting channels should be appropriate for the specific concerns. Additionally, the implementation of interventions based on the reports and the provision of feedback is important to its success.

Further project limitations have been highlighted in previous milestone reports. Amongst these limitations are the sampling methods employed. Due to the voluntary nature of participation and the wide range of commodities, types of mining and related geographical contexts, the data collected could not be fully representative of the South African mining industry as a whole. Furthermore, due to sensitivity of the topic and fears relating to anonymity and confidentiality, it is possible that not all of the issues experienced by women in mining were reflected in the data gathered.

The project findings were presented and discussed with interested stakeholders during a workshop for Milestone 7 of the project. An anonymous survey is planned to formed part of the workshop to gain related information. The recommendations for reporting channels were evaluated further following this engagement and are included in Chapter 8.

6.6 Milestone conclusions

Various recommendations were made in this report relating to improving the health, safety and wellness of women in the mining industry. These recommendations include those relating to reporting channels for OHS concerns. Improvements to current reporting channels and culture change in the industry were recommended. In addition, it is important to train women on how to report over-exertion, OHS concerns, and exposures safely. Other recommendations related to interventions to reduce physical and psychosocial exposures at work, to increase access to amenities and PPE for WIM, improve work-life balance, and towards health, safety and wellness programmes. The survey tool used in the study could be used as a means for the reporting of over-exertion of WIM. The specific reporting channels used depend on the nature of the concern, and the context of the mines. In general, it did not appear that new reporting channels needed to be made available. However, improvements to the current channels available are needed, and increased trust and culture change in the mining industry would contribute to the success of these channels.

6.7. Next milestone

The following milestone (Milestone 7) entailed a workshop with stakeholders to present the study findings and solicit further input. Milestone 7 will validate and refine these recommendations through stakeholder engagement. During the workshop, a Mentimeter survey was conducted to, amongst other matters, gain inputs on recommendations to improve reporting channels in the SAMI. These findings are detailed in the Milestone 7 report (Chapter 7). The findings obtained during the different project milestones were then compiled and analysed to obtain project conclusions and recommendations (Chapter 8).

7. WORKSHOP

7.1 Introduction

The objective of this milestone (Milestone 7) was to host a stakeholder engagement workshop to present findings and solicit industry inputs on the project. The workshop was held in a hybrid format, with in-person attendance taking place at the CSIR International Convention Centre in Pretoria, Gauteng, and virtual attendance taking place on MS Teams. The workshop took place on 3 October 2025.

The workshop invitation (Appendix E) was prepared and shared with various industry stakeholders, including relevant Mine Health and Safety Council (MHSC) committee members, mining houses and organisations, unions, government, occupational medical practitioners, consultants and academia. A total of 140 people registered for the workshop, which included online and in-person attendance. In total, 48 people documented attending the workshop in person, and approximately 90 people attended online .

The programme for the workshop is attached in Appendix F. Several presentations were compiled, including the following that were presented by the project team:

- Project overview and purpose of the workshop
- Literature review findings
- Survey tool findings
- Statistical analysis
- Focus group discussion findings

In addition to the above-mentioned presentations shared by the project team, addresses by MHSC representatives included the opening and welcome, presentations of mine health and safety statistics, and the closure and thanks. A moment of silence was led by a union representative. In addition, a presentation was given by an industry stakeholder to set the scene of the workshop, and related to frameworks for improving health and safety culture.

This report summarises the comments and queries made by the participating stakeholders following the presentation of the project findings. Furthermore, a Mentimeter survey was conducted during the workshop to gain insights from the stakeholders into the project and potential recommendations, and these findings are detailed in this report.

7.2 Workshop discussion

In the introductory section of the workshop, a number of comments relevant to the project were made by the speakers. For example, the journey of the mining sector in advancing health, safety and security of women was acknowledged. Progress has been made in terms of the MHSC's contribution to policy and practices, including those relating to customised personal protective equipment (PPE) for women in mining (WIM), appropriate ablution facilities, and safety and security. Meanwhile, areas for continued advancements of solutions to cater for WIM were highlighted. Health and safety statistics were presented, including those of fatalities, injuries and occupational disease in the SAMI. Aspects such as ill-fitting safety boots could contribute to slip, trip and fall incidents. Furthermore, musculoskeletal disorders (MSDs) were reported to be an emerging risk. It was acknowledged that unique hazards are faced by WIM, including that exposure to toxic gases can compromise reproductive health and safety. It was reported that most mines have inadequate harassment policies, especially noting the gap between big mining houses versus emerging miners. In terms of infrastructure, it was evident that there was a lack of rest rooms, sanitary bins, changing rooms, lactation facilities and emergency sanitary pads. Recommendations included tripartite collaboration between state, labour and business, and specialised training programmes in relation to the above-mentioned aspects.

Following the presentation of the project findings, question and answer sessions were held with the workshop stakeholders. Numerous comments, queries and recommendations were made by those involved in the workshop and are summarised below. Practical considerations for the use and potential updates to the assessment tool developed were queried, to better understand and address over-exertion of WIM.

There was a discussion around heat tolerance screening (HTS), and whether this could be adjusted for WIM, as many are not able to pass this test. However, it was evident that the workload needed to be maintained, along with good physical capacity, and medical screening for the health and safety of women.

The possibility of improving inclusivity in assessment standards for physical work capacity (PWC) tests of women compared to men was also queried. However, it was noted that risk assessments were done, and functional work capacity (FWC) tests are a scientific tool to simulate work demands of specific occupations. Assessment standards (PWC and FWC) are determined by the job demands. The job is the same for both genders therefore the fitness standards will be the same. Additionally, the recurring issue of women failing assessments due to obesity and returning to rehabilitation without long-term support was mentioned; this highlighted the need for continuous overall wellness support throughout women's careers.

The accuracy of risk assessments was queried, including its applicability from surface to underground workplaces. The reality of the different people and departments involved was mentioned, including that of the Rehabilitation and Functional Assessment (RFA) centres, Occupational Medical Practitioners (OMPs), and Human Resources (HR). Furthermore, further observation underground, and involving workers in the risk identification process, were recommended.

Additionally, the feasibility of ergonomic risk assessments was queried, noting that it is difficult to practically accommodate everyone in mining, also noting potential adjustability requirements for the shortest female and the tallest male. In response, it was noted that ideally the workplace should be adapted to suit the workforce (not *vice versa)*; however, it was noted that it may not be practically feasible to accommodate everyone in physically demanding mining environments (referring to the need for worker selection and screening processes). It may take time for these solutions to be available; however, some adjustments can be made to the workplace, equipment, or tools to make it more accessible, such as by lengthening ladders to make it easier for shorter individuals to access high vehicles. It was further indicated that there is no one-size-fits-all solution in terms of ergonomics, but small steps assist to make the workplace as accommodative as possible.

More equipment to make it easier for mine workers was recommended, such as those to uncoil scraper winch ropes safely, and hydraulic rock drill equipment. In terms of walking distances, the use of equipment to assist would apply to both men and women. Additionally, the physique of women was noted to be an issue to consider, such as in relation to winch design.

In terms of the study findings, some participants recommended lighter duties for women, while others mentioned the need for equality, which appeared conflicting. The need for risk assessments and teamwork was suggested in terms of conducting work tasks. Furthermore, equality should be balanced with practical physical limitations. Additionally, better understanding of colleagues' capacities and over-exertion could help improve cooperation. However, it should also be noted that, in reality, high absenteeism rates at all sites impacts teamwork. High absenteeism disrupts team dynamics, often leaving teams understaffed and under pressure. When less capable members are present, the workload shifts disproportionately, increasing the physical strain on stronger team members and raising the risk of over-exertion.

It was noted that different challenges, both mentally and physically, were faced by different groups of workers, and that the categories of jobs should be considered, such as for underground workers conducting physical work. It was also queried whether there was a variation of challenges or risks between deep-level and other mining, such as in terms of accidents and occupational disease. Occupational risk exposure profiles (OREPs) for those more prone to over-exertion, including the work done and shift types was seen to be important. The need for disaggregation of health and safety data according to gender was mentioned. It was also suggested that the assessment of tiredness could be broken down into components relating to mental, physical, and production stress.

It was evident that the impact of the job might only be felt after years of mining (e.g. MSDs or neck pain); the need to train affected women early was recommended, including on aspects such as proper lifting techniques. The need to consider mining engine drivers and the risk of sitting for more than eight hours a day was also evident, along with the associated risk of bladder infections, deep vein thrombosis, and sciatic nerve pain. Education and identification of risks was considered to be important, including the need to walk around during rest breaks. Additionally, deficiencies in Vitamin D, K, and potassium were mentioned due to sweating. The potential impact of menopause on over-exertion was a further potential addition to the tool. Substance abuse in mining was also noted, including that of drugs and dagga. A wage gap and work-life balance concerns were noted, including for women in leadership positions. It was recommended that women be involved in policy and recruitment decision-making.

In terms of interventions, the provision of a pouch to hold sanitary materials was recommended. A query was made around lactation facilities, and whether these were feasible underground. The need for clean and appropriate spaces for women to express breastmilk to take home for their babies was noted, at least in surface areas of the mines. In terms of childcare, the hours of creches for children were noted to differ from shift hours. Another noted difficulty was that of getting hold of women underground when a child was sick or when someone had died; it was also difficult to take family responsibility leave.

Bullying was a common concern, along with retaliation if this was reported; it was noted that people resigned without reporting because of this retaliation associated with reported bullying incidents. Legislation for bullying was highlighted, along with codes of practice (COPs) and the need for harassment policies at mines. Bullying was also linked with the ability for workplaces to be granted Employment Equity and BBBEE certificates. The effectiveness of Employee Wellness Programmes (EWPs) was queried, noting the reported intimidation or fear of raising concerns without victimisation. In response, it was noted that the effectiveness differs from mine to mine. Additionally, as there is a level of mistrust from the ladies, use or access might be a challenge. The need for anonymous and accessible reporting systems was highlighted. Suggestions included hotline support, periodic surveys, and education on existing channels. Employee Assistance Programme (EAP) hotlines were suggested for immediate reporting, and for women to talk to someone for support. In addition, it was noted that assertiveness of women in mining was a challenge for men, in consideration of positions such as women miners; this was related to cultural factors.

It was noted that broader potential impacts of over-exertion should be considered, such as people moving from mining to administrative positions because of exertion or moving jobs. This impact was also noted in terms of study findings that positions might be available, but women may not be considered for them. Furthermore, the length of time worked in strenuous positions could be an important indicator of over-exertion.

In general, the participants expressed appreciation for the project and the time taken to look after WIM and to listen to their concerns. The progress made to improve the inclusion of WIM was evident, but it was acknowledged that more work needs to be done. The value of the research was noted, such as filling a gap in the understanding of the compound risks facing WIM. Identified changes that could be made based on the findings included modifications to COPs, including those relating to minimum standards of fitness, general risk, and medical surveillance. A further suggested intervention included modifications to the training of occupational health professionals on the risks that women face, changing advocacy around WIM, and changes in how walkabouts are done and what aspects will be assessed. Education and awareness were recommended, along with implementable short- and long-term interventions to manage the impact of over-exertion of WIM. Continued collaboration was recommended, including with the Department of Mineral and Petroleum Resources (DMPR). In terms of the aim of the study, the outcomes included having evidence to enhance policies towards better inclusion of WIM. In conclusion, the value of inputs received in the workshop were acknowledged.

7.3 Mentimeter survey

A Mentimeter survey was conducted to gain insights from the stakeholders in the workshop relating to the project. A total of 43 people participated in the survey. As such, this sample represented a portion of the participating stakeholders. A virtual link to access the Mentimeter survey was shared with the workshop attendees, and a facilitator presented each question and the summarised responses as the stakeholders completed the survey questions. Eight questions were asked, namely:

- In which industry do you work?
- In which field do you work?
- What main issues come to mind in relation to over-exertion of women in mining?
- How would you describe the assessment tool developed in this project?
- What opportunities are there to mitigate over-exertion of women in the mining industry?
- Is there a willingness for women in mining to report over-exertion or strain in the mining industry?
- What recommendations do you have for additions to existing reporting channels for women's occupational health and safety concerns?
- What suggestions do you have for implementation for interventions based on the findings?

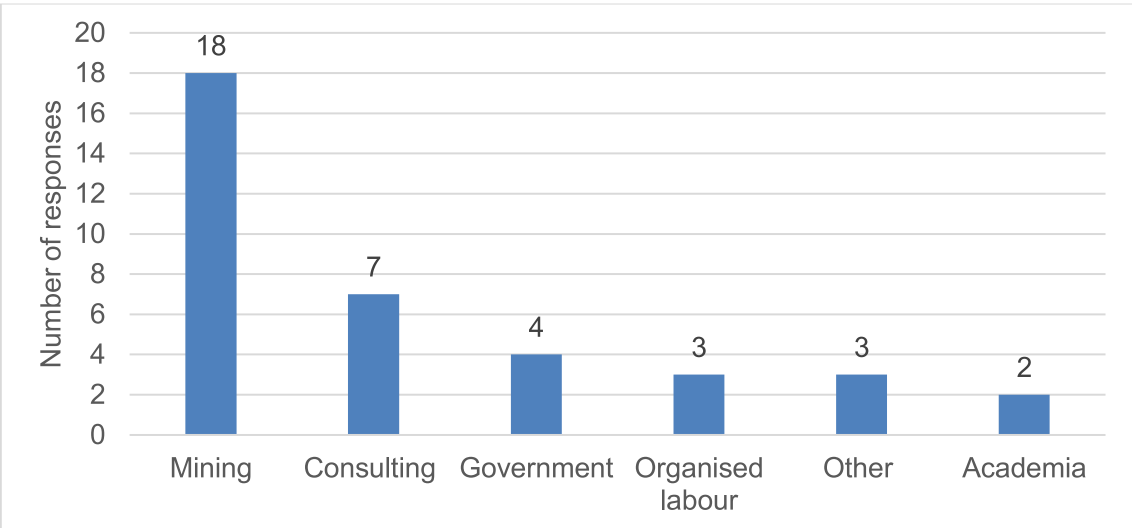


Figure 32: Participant industry

The first two questions were introductory, to gain information of the participants, and to get them familiarised with using the Mentimeter platform. These were multiple-choice-style questions. It was evident that most of the participants worked in the mining industry (Figure 33) and the majority were in the fields of Health and Safety, or Occupational Medicine (Figure 34), according to the options provided. These groupings broadly appeared to reflect those of the stakeholders attending the meeting.

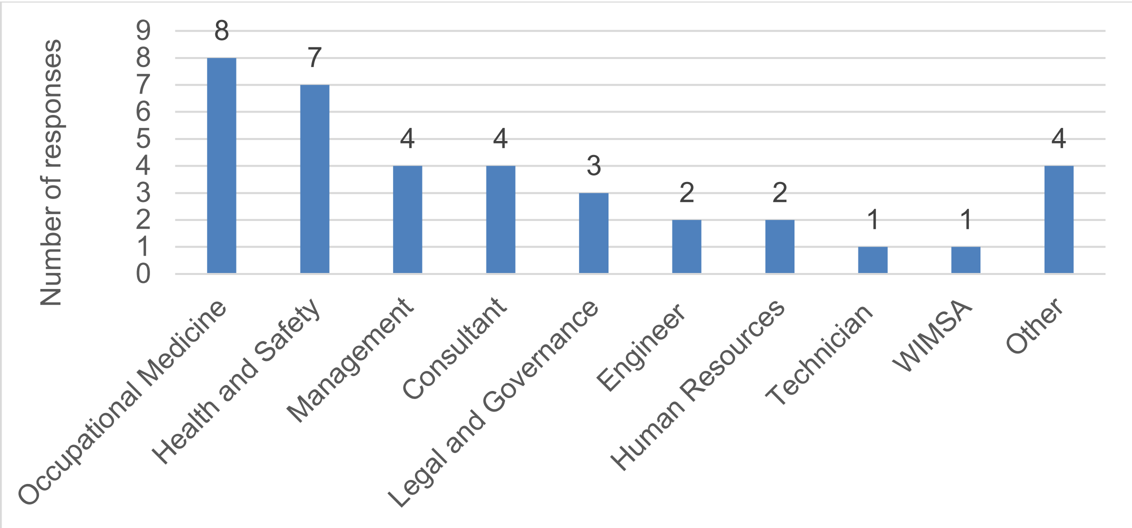


Figure 33: Participant field of work

Answers to the next two questions were presented in a word cloud format during the workshop, but are summarised in a table format below. In terms of the question on the main issues that came to mind in relation to over-exertion of women in mining, 70 comments were received from 39 participants. The comments were grouped into themes for analysis, as shown in Table 111. The most commonly reported issues were those of fatigue, along with bullying and harassment. Fatigue and tiredness were noted in 12 comments. Similarly, 12 comments were also made in relation to bullying, harassment, and gender-based violence (GBV). A number of comments related to aspects such as injuries and musculoskeletal disorders, reproductive health, accidents, and occupational disease. Similarly, mental health was a frequent topic, and issues such as stress and burnout were mentioned. Further comments related to aspects such as inequality, the harsh working environment and heavy workloads, ergonomics, physical capacity, fitness and nutrition.

As such, these findings related to the topics that were assessed during the project, including the various potential outcomes of over-exertion. It is evident that over-exertion is multi-faceted, and incorporates aspects relating to physical and mental health, as well as the physical and psychosocial environment. The link between over-exertion and bullying and harassment of WIM came out strongly in the qualitative data that was gathered for the project, and the extent of the linkage was unexpected during project planning.

Table 111: Main issues in relation to over-exertion of women in mining

Category	Comments
Fatigue	Fatigue (x9) Tiredness (x3)
Bullying and harassment	Bullying (x5) Harassment (x4) Bullying and harassment GBV Sexual harassment
Accidents / Injury / Health	Injuries (x2) Reproductive health (x2) Pregnancy complications Accidents Physical over straining Musculoskeletal disorder Back pain Occupational diseases
Mental health	Mental health (x2) Mental health negligence Mental challenges Stress Burnout Not coping Irritable Misunderstood
Psychosocial factors	Inequality (x2) Gender equality Mans-world Oppressed Not recognised Over-compensating
Ergonomics	Being overly stretched (x2) Accommodation Modify jobs Ergonomics Not fit for purpose Not matching Extra efforts
Working environment and job demands	Harsh working environment Heavy materials Too heavy Physical demands Workload Strenuous work
Physical capacity	Physical capacity Natural ability Physical challenges Inherently unable
Lifestyle	Fitness Fitness challenges Nutrition Obesity Physical condition Quality of life

A total of 39 participants responded to the question relating to how they would describe the assessment tool developed in this project, and a total of 61 comments were made. These were categorised and listed in Table 112. Several individuals noted that it was a “good start”, “work in progress”, or comments relating to these (n=20). Many comments (n=20) related to the value of the assessment tool, and included those such as, “excellent”, “game-changer”, and “informative”. Some comments regarded the length or detail of the tool, whereby six comments indicated that it was comprehensive and detailed, three indicated the data could be skewed, while others commented that it was too broad or long. Other comments that were made included those of innovativeness, support, and making it more available.

Table 112: Description of assessment tool

Category	Comments
Good start	Good start (x8) Work in progress (x5) First step (x2) Conversation starter Foundation Phase 1 Sets a platform Start of a new thing
Valuable	Excellent (x3) Game-changer (x3) Informative (x2) Valuable (x2) Useful Good Very good Good innovation Great initiative Fit-for purpose Will bring change Improve reporting Motivational Opportunity to accommodate women on surface mining
Length / detail	Comprehensive (x5) Skewed data (x3) Too broad (x2) Detailed Need more information Too long Very lengthy To be refined – length
Other	Risk exposure profiles Advocacy Support systems Innovation Novel Make more available Unsure

As such, it was evident that the assessment tool was a valuable initiative, while further work should be done to make more useable. Revisions could include those to refine the content and make the questionnaire shorter, and make it more accessible.

The next question (along with the final two questions) were in an open-ended format, and participants were able to make longer responses than for the word cloud format. A total of 69 responses were provided by 40 participants relating to opportunities to mitigate over-exertion of women in mining. Many of the factors listed under the different categories were interrelated (Table 113). A number of the suggestions related to training and awareness (n=15), such as on issues affecting women in mining, and to improve physical and mental health. In terms of training, a number of comments related to development (n=7), but these were considered in relation to opportunities for job progression. Ten comments related to job placement or opportunities, including that of matching worker capability with job demands. Meanwhile, 12 comments related to tools and equipment, including recommendations for mechanisation, the use of technology, and ergonomic design. Twelve comments also related to aspects such as risk assessments, for which the inclusivity of women was recommended, along with consideration of job profiles, demography, fatigue management, and task rotation. Improved employee wellness programmes were suggested, along with safe platforms for women's challenges to be expressed and addressed. Cultural transformation, increased trust and acceptance, mobilisation of leaders, and inclusion of women in decision making were also recommended. Furthermore, good working policies and improved application of legislation were identified as opportunities.

Table 113: Opportunities to mitigate over-exertion of women in mining

Category	Comments
Training and awareness	Awareness to improve physical/mental conditions (x2) Awareness to improve physical and medical conditions/state Raising awareness on issues affecting women Raising awareness on women issues in mining More trainings on understanding of over-exertion Training women on what is over-exertion More awareness More training Education Training Educate direct managers Training of management Training of senior management Implement learning
Tools, equipment and workplace	Mechanisation (x2) Mechanised mining Mechanised operation of equipment. Less physical demand. Adoption of technology Auto tools

Category	Comments
	Better PPE Better transport Creating good working space Ergonomic tool design Ergonomic adaptation where possible Improving facilities
Job placement	Informed placement Change in working opportunities Give them less demanding work Match worker abilities to job demands Match physical capability with job demands Re-deployment to positions more suited Job accommodation Job modifications or adaptations Type of work Ask for assistance and multi-skilling
Development	Development Develop and appoint Give women development Skills development Set targets for progression Training and skills development programs Training opportunities Training in every aspect of mining
Risk management and standards	Development of related standards Embed women in mining risk assessment Embracing co-creation and inclusivity during the risk assessment process Involve women in risk assessments processes Inclusion of all the risk factors into risk assessments Realistic mining that considers demography Occupational Risk Exposure Profiles Different structures, but the focus should be on hazardous job profiles and mining women underground to get the real picture Implement task rotation to avoid repetitive strain and distribute physical workload Fatigue Management (shifts) Fatigue management programs
Wellness programmes	Better design of Employee Wellness Programs Employee Wellness Program to be more comprehensive Introduce stress management programs More targeted wellness programs Employee wellness and good working policies Give women a safe platform to express their challenges Strengthening women empowerment forums that advocate for women in mining.
Workplace culture	Cultural transformation Mobilise mining leaders to lead the challenge of gender equality Leadership, Executive management Equal work and acceptance Have more women as part of decision making Support women to form part of decision makers Trust Women empowerment Change Improve application of legislation Promoting Gender-Sensitive Policies

Therefore, there are various opportunities to mitigate over-exertion of women in mining. Training and awareness, development, improved equipment and job design, better job placement, participatory risk management, and cultural transformation are all recommended.

There was a mixture of responses regarding the willingness of WIM to report over-exertion or strain (Figure 35). While 45% of the participants indicated “yes”, 48% indicated “maybe”, and 8% indicated “no”. These responses could be linked to workplace culture and trust, potential fear of victimisation, and the anonymity or confidentiality of the reporting channel.

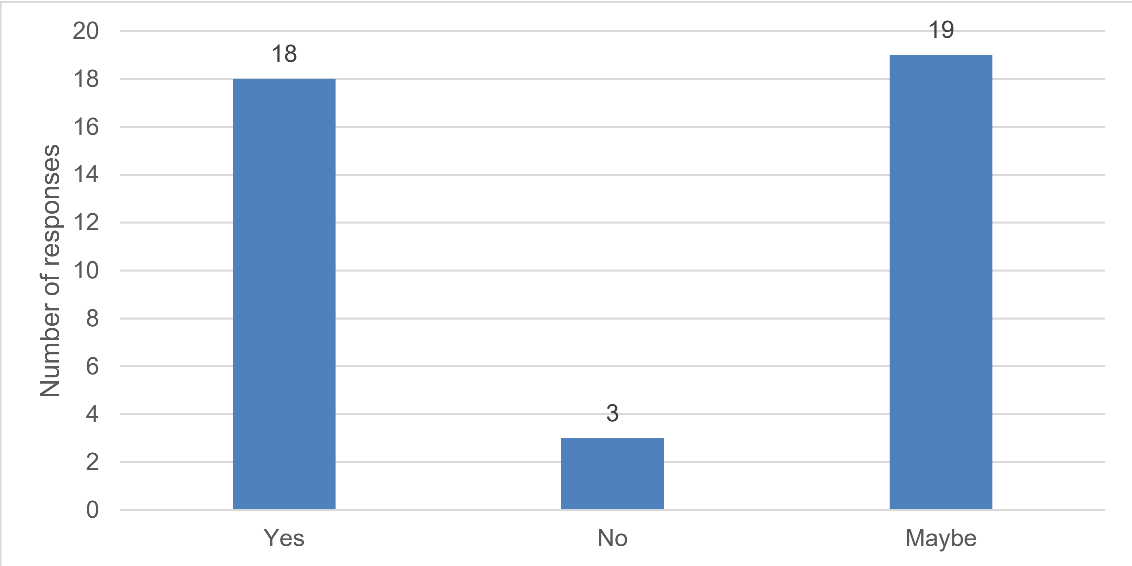


Figure 34: Willingness for WIM to report over-exertion or strain in the mining industry

Recommendations for additions to existing reporting channels for women’s health and safety concerns were provided by 38 participants, and a total of 69 responses were received. These comments are listed in Table 114. Common recommendations were to have more training, education, awareness, and skills development, including on understanding reporting channels available. Some comments related to workplace culture and communication, such as building trust, and increasing feedback and transparency. More specific recommendations relating to reporting platforms included those of suggestion boxes, hotlines, and periodic surveys or reports. Furthermore, strengthened legislation and implementation of GBV and sexual harassment policies were recommended. The need for anonymity and confidentiality of these channels was frequently highlighted, both as standalone comments and integrated into other recommendations.

Therefore, in addition to the recommendations previously made, improved reporting channels for women’s OHS concerns could further assist to address over-exertion of WIM. Suggestions to improve the reporting channels similarly include more training and awareness, improved accessibility of reporting channels, anonymity and confidentiality of reporting, better communication or response, and use of reporting channels such as surveys.

Table 114: Additions to reporting channels for women's health and safety concerns

Category	Comments
Education and awareness	More awareness (x2) More training (x2) Skills development (x2) Knowledge management (x2) Awareness campaigns Continuous awareness Continuous education – training centre to educate and refresher training on the subject Continuous education training centre to include as a training and refresher for all employees Create over-exertion awareness programme Education Education and awareness of ladies Give more opportunities to develop Mining Day More info sharing More training about reporting structures More training for men Team building efforts Training Training and awareness Unconscious bias trainings for men Women to understand the available reporting channels
Workplace culture and communication	Culture transformation Gender mainstreaming Build on trust Like GBVF, I believe women struggle with fear of consequences of reporting matters like overexertion Make it more accessible for persons to report without judgement Encourage management to be more open about issues being investigated Management must intentionally champion for safe spaces Mitigate bullying Protect Whistleblowers when they report Work with Unions Communication departments Effective communication via mine safety meetings Encourage women to speak up For the process of addressing concerns to be transparent Include colleagues when reading suggestions from the box Provide feedback to people that raise concerns
Surveillance/reporting	Suggestion boxes (x3) Underground surveys / suggestion and complaint book or boxes on levels Anonymous hotlines Hotline to report underground any bullying, sexual harassment, etc. anonymous and telephonic guidance on policies when they experience challenges like EAP Allowance for focus groups and intermittent anonymous surveys Independent reporting channels Mandatory mining house/site periodic reports Conduct period surveys quarterly

Category	Comments
	Proper statistical reporting Report Formalise investigations Having customised medical surveillance for women In the light of the MHSC dashboard, add reporting systems to the initiative Including female health services into medical surveillance Integrate Reporting into Broader Wellness Program Implementation of GBV and sexual harassment policies Mandatory implementation (legislated) Strengthen legislation
Anonymity and confidentiality	Anonymous (x3) Anonymous reporting opportunities Anonymous to remain anonymous no leaking of information Be more anonymous Confidentiality Confidentiality and anonymity Confidentiality and trust Ensure confidentiality of the reporting channel Assure confidentiality Women must be given the assurance that their complaints will be treated with a high level of confidentiality

The final Mentimeter question sought to obtain recommendations from the stakeholders on the implementation of interventions based on the project findings. A total of 50 comments were received from 33 participants, and are summarised in Table 115. Many of the comments related to training and awareness. Information dissemination could, more specifically, take place in WIM meetings, workshops, roadshows, induction programmes, conferences, publications, or media platforms. Other comments related to policies and procedures, along with cultural transformation initiatives. Legislation changes were recommended to promote compliance. Policies and guidelines could be enhanced based on the study findings. It was suggested that initial interventions should focus on issues with easy solutions or “quick wins”. Furthermore, more assessments were recommended, including attendance at WIM meetings or visits to mining houses, to better understand progress in terms of aspects measured using the assessment tool. It was also clear that collaboration with different departments and organisations was important in making requisite changes to improve the occupational health and safety of women in mining. Different stakeholders that were mentioned included WIM committees, Regional Tripartite Forums (RTFs), MHSC through Women in Mining Advisory Committees (WIMAC), safety teams, the DMPR inspectorate, and mine associations or professional bodies.

The findings from the workshop helped to frame interventions based on the project. Knowledge transfer appeared to be key so that those with influence can drive the appropriate interventions. Moreover, changes to legislation or guidelines were recommended so that the changes can be enforced.

Table 115: Suggestions for implementation of interventions based on the findings

Category	Comments
Awareness/ Information dissemination	Awareness training (x2) Awareness Awareness and training Communicate it in WIM monthly meetings Creating awareness Disseminate information at RTFs and various WiM workshops Dissemination workshops Education Include some findings in induction programs Knowledge transfer Consider using conferences for findings dissemination and social media platforms to enhance awareness More workshops for women Present at WIM RTF meetings Publications Repackaging the research outcomes for the different target audience Road show for female employees Stakeholder engagements Training Training (incl. management and males) Translate them into different languages and disseminate through local radios or newspapers Workshops
Policies and practices	Accountability Add to standards procedures of workplace Adding to legislation to force change Change management initiatives be implemented Cultural transformation initiatives Engage DMRE Inspector to make someone of the recommendations mandatory Enhancing WiM policies and guidelines using the study outcomes Include the intervention as a milestone where mining houses must report on Identify quick wins then implement Make resolution a KPI Prioritisation and addressing issues with easy solutions as first steps Proper risk assessments Publish as Guidelines. Operations respond better to regulatory bodies Robust induction program Some need to be added an Legislation to enforce compliance There is still work to be done to get solutions
Assessments	Annual assessments Assessment Attend different WiM meetings and assess Do it more frequent at more mine houses Frequent visit to the mines to monitor the implementation and progress Suggestion boxes at the strategic areas at the shafts
Collaborate	Dedicated project team per mine Discussions on safety meetings Liase with authorities, MHSC through WiMAC Mine Associations/ Professionals bodies Mobilisation of industry leaders as champions, supported by WIM Committees Speak to female underground employees directly

7.3.1. Limitations

The Mentimeter survey was helpful to gather insights from the workshop participants, in addition to the discussion that was held with these stakeholders. Potential limitations of the Mentimeter survey was that there was potentially uneven participation from different stakeholder groups. As the survey was voluntary, not all of the workshop attendees completed it. However, useful information was obtained from those who chose to provide responses, and the platform provided a means for stakeholders to provide anonymous inputs. Similarly, participation in the workshop discussion may not have been representative of all groups, although responses were invited from those present.

7.4 Milestone conclusions

The stakeholder engagement workshop enabled the dissemination of information and inputs from stakeholders relating to the project. It was evident that over-exertion of WIM is a complex topic, and there are various aspects that contribute to it. A number of recommendations were made relating to the assessment tool developed in the project, and for interventions going forward. Some of findings may be applicable for both women and men in mining, although the focus of the project was on WIM, due to a number of factors that disproportionately affect females. It was recommended that interventions should initially focus on those that can be easily and quickly implemented. A few key highlights are listed as follows:

- OHS impacts of over-exertion include fatigue, injuries, accidents, impaired health, reproductive complications, and mental health impacts such as stress and burnout;
- Risk assessments should be conducted to assess potential risks facing WIM (e.g., including the work environment, workloads, shifts, and physical capacity) to ensure optimal OHS, and inputs from workers should be included in these. Occupational risk exposure profiles were considered to be important;
- Ergonomics interventions and the application of new technologies can help to make the workplace more accessible to WIM;
- In terms of infrastructure and facilities, improvements can be made to change houses, PPE, and the availability of rest rooms and emergency sanitary pads;
- Updates to COPs and/or guidelines should be made based on the findings of the project, including relating to fitness for work and medical surveillance;
- Bullying and harassment are a concern, and better policies should be put in place at mines in this regard;

- Efforts should be strengthened towards culture transformation, improved trust, understanding, and better communication;
- Enhanced training and awareness is key to mitigate over-exertion and its associated impacts, and to better understand reporting channels available. Training programmes can be tailored for various stakeholders, including WIM, men, and leadership;
- The development of WIM is important, also considering placement in roles that are most suited to individual's physical capability;
- Collaboration is important for successful implementation of changes, and should include tripartite stakeholders including the DMPR, organised labour, and industry. WIM forums are considered an effective means to support related initiatives;
- There is a need for anonymous and accessible reporting systems, which could include hotlines, suggestion boxes and surveys. Improvements to EWPs is also recommended for improved support;
- Periodic assessments relating to over-exertion are recommended; and
- The assessment tool was seen as a good start towards assessing and mitigating over-exertion of WIM. Revisions to the tool are recommended, such as inclusion of sitting for long hours. Furthermore, it is suggested that the tool should be streamlined for easier application following this project.

In conclusion, the workshop highlighted issues affecting women in the SAMI, particularly in relation to over-exertion and its impact on OHS. Stakeholders emphasised the need for improved infrastructure, inclusive policies, and targeted health and wellness programs. Continued collaboration and data-driven approaches are essential to drive meaningful change and ensure the safety and well-being of WIM.

7.5 Next milestone

The following milestone (Milestone 8) entailed the draft final report. The information contained in Milestones 1 to 7 was consolidated into this report. Further recommendations and analysis of the findings obtained in the study were drafted for inclusion in the Milestone 8 report (Chapter 8). These recommendations include those relating to potential updates to the assessment tool developed in this project, and relating to identified areas for intervention.

8. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This chapter details the consolidated findings for the project. The data includes that obtained from a literature review, assessment tool (qualitative and quantitative findings), focus group discussions, and stakeholder engagement workshop. The conclusions and recommendations from the project are detailed thereafter.

8.2 Overview of project

The aim of this project was to assess the impact of over-exertion on women's health and safety in the South African mining industry (SAMI). Over-exertion was defined as when the demands placed on a person exceed their capability. Consequences of over-exertion include fatigue, injuries, musculoskeletal disorders, occupational disease, decreased productivity, impaired reproductive health, lack of concentration, and psychological stress. The project used a mixed-methods research approach, and both qualitative and quantitative data were gathered. Desktop research was conducted to inform the design and content of the assessment tool (questionnaire) and qualitative question guides. Data collection took place between June and October 2025. Data was collected from 549 women in mining (WIM) using the assessment tool developed during the project. Ten focus group discussions were held with over 90 participants from a range of occupations in the mining industry. In addition, a hybrid stakeholder engagement workshop was held and attended by approximately 140 people. Ethical clearance was obtained from the CSIR Research Ethics Committee (REC) (Ref: 478/2024).

8.3 Summary and discussion of findings

During the project, numerous factors were identified that could contribute to or result from over-exertion of women in mining. Reporting channels for occupational health and safety (OHS) concerns, including over-exertion, were also assessed. The findings are summarised and discussed below, under the following topics:

- Physical work environment and job demands
- Amenities and personal protective equipment (PPE)
- Psychosocial factors

- Personal factors and work-life balance
- Health, safety and wellness
- Reporting channels available

8.3.1 Physical work environment and job demands

Numerous factors relating to the work environment and job demands were considered to contribute to over-exertion. In the focus group discussions and from the survey comments, some of the factors that were identified included high workloads, lifting heavy loads, long travelling distances underground, standing for long periods of time, exposure to heat, confined workplaces, working in isolation, and a lack of (human and material) resources. In addition, shift work, overtime, long working hours, and irregular work schedules were identified as challenges, along with poor ergonomics and equipment that was not designed based on women's physiques. These findings supported those from literature (e.g. Hodgskiss *et al.*, 2017; Pelders, 2020; Stanton *et al.*, 2007). In the workshop, another factor identified as a risk for over-exertion was sitting for long periods, especially when operating heavy machinery.

In the questionnaire the main reported physical demands included walking long distances (44%), lifting and lowering (43%) and repetitive motions (42%). The most frequently reported environmental exposures were noise (66%) and dust (65%). Mental demands were reported by 68% of the sample. Shift work, overtime, and insufficient breaks during work are associated with fatigue and impaired safety outcomes (Pelders *et al.*, 2019; Pelders, 2020). Of the questionnaire respondents, 68% worked day shifts and 55% worked 8-hour shifts, while the remainders worked unusual hours and shifts of longer than 8 hours, respectively. Only 39% of the sample took regular breaks of 30 minutes or more, which are recommended (Folkard *et al.*, 2007). In addition, 65% of the sample worked overtime (sometimes or often), and this percentage was higher amongst underground workers. Underground workers were also the most likely to not take breaks, indicating a potentially elevated fatigue risk for these respondents.

A total of 8% of the questionnaire respondents (and 13% of the underground workers) indicated having experienced harassment in the workplace, while 9% indicated they would rather not say. The evident link between over-exertion and harassment was a concern. Female focus group participants admitted to giving sexual favours to men in the workplace in exchange for assistance with job tasks that they could not handle. This finding supports previous literature that has reported on the existence of sexual harassment and discrimination of WIM in the SAMI (Botha, 2016). This factor is discussed a bit further in this chapter, relating to psychosocial factors.

8.3.2 Amenities and PPE

Amenities in the workplaces referred to access to toilets, change houses and water. Sufficient access to hygienic change houses and toilet facilities was a recurring theme in the focus group discussions and in the qualitative survey data. Lack of access to emergency sanitary pads was also frequently mentioned. In the survey, 14% of the respondents reported not having adequate access to toilets in the workplace, and this frequency was higher for those in underground workplaces and surface workplaces with environmental exposures. Inadequate access to toilet facilities could further result in women not drinking enough fluid to avoid the need to use the facilities (Zungu, 2012). While access to clean drinking water and thirst was not frequently mentioned in the focus group discussions, based on the survey tool data, it was evident that these were issues that should be addressed. High levels of thirst, and low levels of water intake were reported, which could lead to dehydration and heat stress symptoms. A total of 10% of the sample (and 19% of underground workers) reported not having drinking stations available in their workplace. Meanwhile, 32% of the sample indicated that they often experienced extreme thirst during their shifts. Heat stress symptoms were reported by 51% of the sample, and higher numbers of symptoms were evident for those working underground.

In the survey tool, 6% reported having PPE that did not fit properly; meanwhile, this question was not applicable to some (12%), such as those working in surface offices. Poor PPE fit can affect comfort, protection, job performance, and increases the risk of accidents (Badenhorst, 2009; Botha and Cronjé, 2015; Eiter *et al.*, 2023). Challenges relating to PPE were frequently mentioned in the focus group discussions, the comments sections in the survey, and workshop, including issues relating to the design, quality or availability of PPE. It was noted that PPE (e.g. overalls and safety boots) needed to be made to fit women's physiques and be available in a range sizes. The quality of PPE was a concern, and sometimes did not last until new PPE was due to be issued. Uncomfortable PPE, including those of safety boots, was a further concern. It was noted that ill-fitting safety boots could contribute to slip, trip and fall incidents among women in mining. The weight of rescue packs and detection instruments were also noted to be too heavy, and this could contribute to strain due to increased workload.

8.3.3. Psychosocial factors

Aspects relating to the psychosocial work environment were frequently mentioned in the focus group discussions and survey comments. It was mentioned that women had to work harder than men to prove themselves in the male-dominated industry. There were reports of intimidation, bullying, and harassment, including by the women's supervisors. A lack of respect, recognition, support and development opportunities were highlighted. Further issues included cultural expectations, pressure from management and poor communication. Psychosocial factors at work were not explicitly detailed in the assessment tool, apart from the question relating to harassment, as the focus of the assessment tool is on OHS. However, it is acknowledged that psychosocial factors have an important role to play in the development of musculoskeletal disorders and health and safety outcomes (Oakman and MacDonald. 2019; Schutte *et al.*, 2003).

8.3.4 Personal factors and work-life balance

Personal factors that were indicated in the study in relation to over-exertion included those of differences between men and women, pregnancy, the impact of aging, commuting times, lack of sleep, personal problems, and difficulties in work-life balance. These findings were aligned with literature on the topic (e.g., Badenhorst, 2009; Dlamini, 2016; Jones *et al.*, 2019; Pelders, 2020; Van Aardt *et al.*, 2008; Zungu, 2012). The dual burden of household responsibilities and work were commonly mentioned as contributing to physical and mental strain, and included aspects such as childcare, cooking, cleaning, and roles in the community. In the survey, it was evident that 71% usually spent longer than 2 hours on household responsibilities outside of work each day.

It is likely that, along with shifts worked, household responsibilities and commuting times affect how much rest and sleep a person can get. The average commuting time reported in the survey was between 30 to 60 minutes, while 12% took longer than an hour to travel to or home from work. Long commuting times were mostly a challenge for those who worked at remote mining sites. Approximately 30% of the survey respondents reported getting less than 6 hours of sleep before a work shift, which may be considered insufficient (Ferguson *et al.*, 2010; 2011). An average, longer sleep times were reported on off days, indicating a potential sleep debt during the shift cycle. Sleep problems could be evident in some of the sample, and may be related to aspects such stress or health. Poor sleep quality was reported by 11% of the sample, and 10% reported using medication or beverages to help them sleep.

The study participants often mentioned the differences in how men and women are built, and that this has an impact in the work environment, as they are not able to work at the same level as men. It was also evident that equipment and machinery were also often not designed to accommodate women's physiques. Meanwhile, a few participants commented that older workers may not be able to do the same level of work as younger workers. Older workers could be more prone to over-exertion relating to reduced strength and agility (Jones *et al.*, 2019). In the survey, the majority of the sample (76%) were between the ages of 25 and 44, while 21% of the respondents were over the age of 45 years.

Hormonal cycles, including menstrual phase and the onset of menopause, could be associated with over-exertion (Lurati, 2017; Wen *et al.*, 2025). The participants mentioned that it was difficult to work when menstruating, especially when exposed to heat and when using vibrating machinery. The use of vibrating machinery was noted to be a cause of reproductive problems. In the survey, 21% reported not getting periods, and this could be relating to menopause. Although there were not a high percentage of pregnant (3%) or breastfeeding women (2%) in participating in the survey, these topics were mentioned in the focus group discussions and comments section of the survey tool. Important considerations relating to pregnancy included that some fail to disclose pregnancies, due to fear of losing income or jobs, thus putting themselves and their babies at risk. Some also commented on the need for lactation facilities at mines.

High levels of obesity among women were a reported challenge in the industry. Obesity could have health and safety implications (The Work Expert, 2025). According to body mass index (BMI) data, 63% of the respondents were classified as obese. Meanwhile, the body dimensions of WIM need to be taken into consideration in terms of the workplace and machinery that is used. As females are generally shorter than males, accommodation for women should be made. An example provided in the focus group discussions was that of the difficulty of women being able to reach the high steps needed to access large vehicles in mines, and potential adjustments for these. Many of the recommendations made by the participants qualitatively related to exercise and healthy eating. In the study sample, only 48% reported engaging in recreational exercise at least once a week, and most of this was of a low intensity, which, depending on the intensity of work-related exercise, are below recommended levels (WHO, 2026).

Substance abuse is a potential challenge in the mining industry, and could be linked with over-exertion as an unhealthy coping mechanism. We could not ethically ask participants about the use of illicit substances in the study. However, 6% of the participants reported smoking.

8.3.5. Health, safety and wellness

Consequences of over-exertion that were mentioned in the focus group discussions and survey comments included a range of aspects such as fatigue/tiredness, mental and physical strain, injuries, musculoskeletal disorders, absenteeism, lack of concentration, loss of productivity, lack of motivation, depression, stress, relationship issues, and vulnerability to harassment. Similarly in the workshop, identified impacts of over-exertion included that of fatigue, injuries, accidents, impaired health, reproductive complications, and mental health impacts such as stress and burnout. These findings were in alignment with those from the literature review (e.g., Badenhorst, 2009; Botha, 2017; Eiter *et al.*, 2023; Jones *et al.*, 2019).

The health, safety and wellness variables of the questionnaire could be considered as outcomes of over-exertion. These included those of musculoskeletal pain or discomfort, tiredness/fatigue and ratings of perceived exertion (RPE). Further factors that were assessed included anxiety or sadness; concentration; mood; quality of life; subjective health; and sick leave. Musculoskeletal pain or discomfort was experienced by 37% of the survey respondents. This pain was most commonly experienced in the back (29%), legs/knees (22%), shoulders (11%), and ankles/feet (10%). While only a few respondents felt tired before a shift (5%), around half reported feeling very tired or exhausted after work. A modified RPE scale was used to assess levels of physical exertion in the survey. While the majority reported working moderately hard (43%), office workers had the lowest frequency of reports of working from hard to maximal levels. Anxiety or sadness was experienced often or always by 14% of the sample, while 6% reported always or often finding it difficult to concentrate. In terms of mood, 17% reported negative emotions, 26% neutral, and 56% were feeling positive. Most considered their quality of life to be good (61%). Most also considered their health to be good (70%). In terms of sick leave, the majority (64%) reported taking less than 5 days in the past year.

A full discussion on the impact of medical conditions and medication on over-exertion is provided in the following section.

8.3.6 The impact of medical conditions and medications on over-exertion

Exertion refers to the use of physical or mental energy with the intention to achieve a task. Over-exertion occurs when the physical or mental energy required for an activity exceeds the individual's current capabilities. Personal and environmental factors have an impact on exertion and over-exertion. One of the personal factors that may impact an individual's capability to exert efficiently is medical conditions. Diseases in general alter the normal function of the human body, physiologically, physically, and mentally. They therefore carry potential to impact an individual's capacity to apply effort either for social or work purposes. The severity of the impact on exertion depends on factors such as the type of the medical condition and the severity thereof, the demography of the individual, and how poorly or well managed the condition is. While the extent of the impact on exertion may depend on the various factors mentioned, it is evident that it is mostly negative (Storer *et al.*, 2014).

8.5.3.1 Respiratory diseases

Respiratory diseases limit exertional capacity by causing breathlessness (dyspnea). People with chronic lung conditions may also experience leg discomfort during exertion, which limits their ability to continue. Furthermore, in respiratory diseases like asthma, exertion may trigger bronchoconstriction which causes coughing and shortness of breath, temporarily disabling the employee to meet the physical requirements of their normal duties (Gotshall, 2012). In acute and chronic infections such as bronchitis or sinusitis, inflammation and congestion of the airways or sinuses impact negatively on exertion.

Respiratory diseases are generally treated with bronchodilators, antihistamines, and steroids. Bronchodilators such as Asthavent and Sereflo mostly improve exertion capacity and reduce breathlessness, while maintenance treatments like Foxair and Montair act by reducing inflammation in the airways, which in turn reduces breathlessness and increases exertional capacity. Long-term use of oral steroids may cause insomnia, which will indirectly impact exertion in a negative way. However, oral steroids paired with antibiotics are used for short durations to relieve airway inflammation caused by acute infections. Antihistamine-containing medications such as Sinutab or Allergex, also used during flare-ups of respiratory conditions, may cause drowsiness or dizziness, thus affecting capacity to exert.

8.3.5.2 Cardiovascular diseases

Cardiovascular diseases (CVD) can limit exertion by reducing the heart's ability to supply oxygenated blood, making physical activity harder and potentially leading to symptoms like shortness of breath, fatigue, or chest pain. In individuals living with hypertension, exertion can cause a rise in blood pressure (exercise-induced hypertension), which is a risk factor for developing sustained hypertension and experiencing cardiovascular events, including left ventricular hypertrophy and arrhythmias. This risk is higher when the individual is over-exerted (O'Keefe *et al.*, 2012). The treatment for CVD depends on the specific condition and severity but often includes a combination of lifestyle changes, medications (for blood pressure, cholesterol, heart failure), and surgical interventions.

Antihypertensive medications can impact exertion by causing symptoms of over-exertion. Beta-blockers such as Cardiloc significantly reduce peak heart rate and exertion capacity, while ACE inhibitors such as Enap or Enalapril and calcium channel blockers such as Amloc may also impair performance and increase perceived exertion, although they are often better tolerated than beta-blockers. Other drugs, such as diuretics, typically have a less direct negative impact on exercise performance but can cause metabolic issues. Meanwhile, diuretics can increase the risk of heat-related illness due to dehydration, electrolyte disturbances, and impaired thermoregulation. Patients may experience increased fatigue, weakness, or dizziness when exerting while on antihypertensive medication (Nystoriak and Bhatnagar, 2018).

8.3.5.3 Metabolic diseases

Metabolic conditions impair over-exertion tolerance by reducing energy availability (e.g., glycogen depletion), causing muscle damage (rhabdomyolysis), and creating exertion-induced pain and cramps. Individuals with metabolic myopathies may experience fatigue and severe muscle pain after over-exertion. Even more concerning and risky is the fact that over-exertion for people with metabolic diseases, particularly diabetes, can cause a dangerous drop in blood sugar (hypoglycemia) or, in some cases, a spike (hyperglycemia), along with increased fatigue (Duke and Lovering, 2020).

Treatment for metabolic diseases primarily involves healthy lifestyle changes, including a balanced diet, regular exercise, and weight management, often supplemented by medications to manage blood pressure, cholesterol, and blood sugar. In some cases, weight-loss surgery, treatment for sleep disorders, and managing stress may also be recommended. If lifestyle changes are insufficient, medications may be prescribed to help. These can include statins to lower cholesterol and triglyceride levels and antidiabetic drugs such as Metformin, SGLT2-inhibitors, or GLP-1 agonists (Wake, 2020).

Antidiabetic medications can impact over-exertion primarily by increasing the risk of hypoglycemia (low blood sugar) with certain drugs like insulin (e.g., Rapid-acting insulins such as Novorapid or Optisulin) and sulfonylureas, requiring carbohydrate intake or dose adjustments before exertion. Other drugs, like Metformin or Jalomet, may affect exercise capacity by influencing energy metabolism and increasing lactate, while SGLT-2 inhibitors and GLP-1 agonists can also have complex interactions with exertion.

8.3.5.4 Musculoskeletal diseases

Musculoskeletal diseases are often caused by over-exertion, but their presence also makes individuals more susceptible to over-exertion, leading to a vicious cycle of unresolving pain and injury. Conditions like tendinopathy, sprains, strains, arthritis, and back pain impair muscle performance, increase fatigue, and reduce range of motion, making the musculoskeletal system more vulnerable to breakdown from even moderate physical demands, let alone over-exertion.

This creates a painful feedback loop where the existing condition is aggravated by exertion, further damaging the affected tissues and creating new injuries (Soares *et al.*, 2020). This is especially so for gout, as uric acid levels, which are a key factor in gout flare-ups, may be raised by over-exertion.

Treatment for musculoskeletal diseases involves a range of options that may include physical therapies (exercise, physical and occupational therapy), medications (NSAIDs, muscle relaxants), interventional procedures (injections, surgery), and complementary therapies (acupuncture, massage). A healthcare provider determines the best treatment plan based on the specific musculoskeletal condition, its severity, and the individual patient's needs. For the purposes of this research project, the focus shall be on medications. Nonsteroidal anti-inflammatory drugs (NSAIDs) can hinder muscle adaptations to exertion, impairing long-term muscle growth and recovery by interfering with the body's normal response to micro-damage.

Additionally, NSAID use, particularly during intense work activities (over-exertion), is linked to potential risks of kidney injury, gastrointestinal issues, and cardiovascular harm, which can outweigh the benefits of pain reduction (Fitzpatrick, 2025). It is for these reasons that acetaminophen painkillers that have paracetamol as an active ingredient (e.g., Dapamol) are often recommended over NSAIDs like ibuprofen. Colchicine and Puricos are used for the acute and chronic management of gout respectively. These medications do not have any negative impact on exertion.

8.3.5.5 Mental illnesses

Mental health negatively affects exertion by reducing motivation, energy, and the ability to handle the physiological stress of activity, which can trigger symptoms like panic attacks. Conversely, over-exertion can also worsen mental health by leading to burnout, fatigue, and negative mood disturbances. Over-exertion can lead to or exacerbate several mental health issues, including depression, anxiety, mood changes, and poor sleep. It can also cause mental fatigue, leading to brain fog, difficulty concentrating, and reduced motivation. The mental stress associated with chronic over-exertion can contribute to major depression.

The mainstay in the treatment of mental illnesses are antidepressants and anxiolytics. Antidepressants such as Cilift can impact physical performance by decreasing exertion tolerance, particularly with selective serotonin reuptake inhibitors (SSRIs) like paroxetine, which may reduce the fatigue in people with higher aerobic capacity. Common side effects such as drowsiness and muscle weakness can also reduce the ability to perform exercise, though these are often temporary. However, the effects vary by medication type, dosage, and individual factors, and some antidepressants, like bupropion, may even increase physical performance in certain situations (Hirschbeck *et al.*, 2022). Common side effects of antidepressants include fatigue, drowsiness, and muscle weakness, which can make physical activity more difficult. Furthermore, these medications can affect thermoregulation, thus leading to an increased risk of heat-related disorders.

Anxiolytics, on the other hand, particularly benzodiazepines, can negatively impact physical performance by causing sedation, drowsiness, dizziness, and impaired motor skills. These side effects impose a health and safety risk in activities requiring fine-tuning or precision. However, some anxiety medications, like SSRIs, may indirectly improve physical performance by reducing anxiety and improving energy, motivation, and mood. The specific impact varies depending on the type of anxiolytic, its mechanism of action, dosage, and the individual's response. Benzodiazepines also suppress the activity of the hypothalamus, impacting thermoregulation, which can lead to risk of heat stress or cold stress.

8.3.5.6 Other medical conditions

HIV and pulmonary tuberculosis (PTB) are highly prevalent in the mining industry. HIV can cause over-exertion challenges through symptoms like fatigue, muscle weakness from wasting or neuropathy, and reduced physical capacity due to chronic or recurrent infections. These effects are most pronounced in advanced disease stages but can also impact individuals with early-stage HIV. However, with effective HIV treatment (ART), the risk of these challenges decreases significantly. PTB significantly reduces exertion capacity, making individuals more susceptible to over-exertion due to compromised lung function, muscle loss (sarcopenia), and reduced oxygen saturation. Employees may experience shortness of breath, fatigue, and impaired muscle function, which limits their ability to perform physical activities and can lead to long-term disability and reduced quality of life.

Antiretroviral medications (ARVs) do not directly impact over-exertion, but their side effects, such as weight gain, muscle changes, and potential fatigue or metabolic issues, can impact a person's ability to tolerate physical activity or perceive over-exertion differently. Similarly, anti-TB therapy does not directly increase the risk of over-exertion. It is rather the impact of the disease and its treatment that affect patients with PTB in a way that they experience reduced exertion capacity and functional limitations. While anti-TB drugs improve health-related quality of life, the lingering effects of the illness, such as impaired lung function and weakness, contribute to a lower exertion tolerance and a greater risk of symptoms like dyspnea (McCree *et al.*, 2019).

8.3.7 Reporting channels

A range of reporting channels were available in the SAMI for OHS-related matters, including over-exertion. These channels include health and safety representatives, safety officers, supervisors, foremen, health and safety committees, and managers. WIM committees were considered effective platforms for women to report issues, including those related to over-exertion, which can be taken forward and be addressed by the relevant parties. Other reporting channels included anonymous whistleblower hotlines, human resources personnel, medical personnel, and unions. The platforms for reporting include incident reporting systems, suggestion boxes, complaint books, and checklists.

Concerns were commonly raised relating to current reporting platforms, such as fear of victimisation, fear of retaliation (including potential job loss), a lack of trust in their confidentiality or anonymity, and a negative workplace culture. Furthermore, poor response time, inaction, lack of feedback, and a lack of resources were reported.

Recommendations relating to the reporting platforms included implementation of suggestion boxes, WhatsApp reporting, or an additional channel for anonymous reporting. Meanwhile, suggestions to improve reporting included improved support for WIM platforms, culture transformation in the industry, increased awareness of reporting channels available, and roles for receiving and actioning complaints.

8.4 Recommendations

Numerous recommendations to address challenges faced by women in mining, including those related to over-exertion, were made by participants in the focus group discussions, survey comments, and workshop. The recommendations included interventions relating to policy, awareness training, risk assessments, and those for improving reporting channels. These recommendations are summarised and reflected on in this section for potential uptake and interventions by the SAMI. Inputs from tripartite stakeholders were further incorporated. The recommendations were categorised into the following sections:

- Updates to policy or regulations (legislation)
- Continuous monitoring and support
- Quick-wins
- Training and awareness
- Updates to the survey tool
- Future research

8.4.1. Updates to policy or regulations (legislation)

Significant positive change may be brought by modifying mandatory codes of practice (COPs), which are legally binding, industry-specific guidelines that mandate employer-driven safety, health, and operational procedures to manage high-level risks. The specific mandatory COPs that could be modified or reviewed in order to manage the risks and challenges that women in mining face are:

- Minimum standards of fitness to work a mine (DMPR, 2013)
- Thermal stress (DMPR, 2025)
- Risk-based fatigue management (DMR, 2014)
- Women in mining (DMRE, 2024)
- Medical incapacity management (DMRE, 2023)

In particular, Occupational Risk Exposure Profiles (OREPs) must be a critical component in fitness-to-work assessments, not only to allow for risk-specific medical surveillance, but also to make informed decisions on placement of workers taking their limitations and capabilities into consideration. DMPR guidelines on fitness to work must be adapted to clearly outline the content of OREPS to fulfil this function. OREPs must:

- **Clearly define job specific demands and environmental exposures**, including physical, chemical, biological, ergonomic, and psychosocial hazards inherent to the role.

- **Overall strenuousness of each job needs to be quantified to reflect the strenuousness of the work (roaming, light, moderate, heavy and very heavy).**
- **Incorporate a structured risk rating framework**, with clearly articulated thresholds for each hazard category to support consistent and defensible decision making.
- **Assess ergonomic risks against standardised exposure criteria**, with definitions for high, medium, and low exposure ratings to ensure uniform interpretation and application.
- **Specify anthropometric requirements**, ensuring alignment between worker physical characteristics and task demands.

Well-defined OREPs will also facilitate the identification and implementation of **practical job adaptations**, for worker limitations enabling reasonable accommodation without compromising operational safety, productivity, or compliance with occupational health and safety standards.

Furthermore, the assessment of women during medical surveillance could be supplemented with a few questions to prompt reporting of over-exertion or the results thereof.

In addition, as bullying and harassment are concerns, better policies should be put in place at mines in this regard.

8.4.2. Continuous monitoring and support

8.4.2.1 Risk assessments

Risk assessments including baseline, post incident, and Occupational Medical Practitioner (OMP) walkabouts should be conducted with cognisance of the unique risks faced by women in mining. Occupational risk ergonomic assessments should form part of the baseline risk assessment with *ad hoc* reviews indicated whenever new machines or processes have been introduced. It is advisable that the female end users are involved in the ergonomic reviews of as they may give valuable input in terms of making processes ergonomically friendly.

Ergonomics assessments and adjustments are recommended in relation to the work environment and job tasks. Ergonomic interventions aim to ensure that the equipment, tools, and tasks are accommodative of WIM, who differ physiologically and anatomically from men. The use of supporting equipment and technologies could further assist WIM, such as lifting devices to reduce strain. Increased consideration of differing strengths and weaknesses in a team should also be made when allocating work responsibilities. Meanwhile, OREPS are important to consider. There are potential limitations of fitting the task to the person and, in such cases, it is important to ensure that individuals are placed in appropriate positions based on their capabilities. Furthermore, it is important for controls to be implemented to address the identified risks.

8.4.2.3. Medical surveillance

The medical surveillance design should incorporate investigations or tests of which the results would alert the occupational health practitioners when women are at risk of over-exertion and need intervention. A questionnaire that could prompt women in mining to report signs of over-exertion should be designed and form part of the surveillance.

High risk job categories should have clear fitness requirements so as to enable the occupational health practitioners to establish not only medical fitness but also physical fitness as part of the assessment. Through the help of health professionals such as bio-kineticists and occupational therapists, employers could assist women to achieve and maintain fitness levels required for their current jobs.

8.4.2.4. Return to work assessments

Post an extensive leave of absence, be it for reproductive reasons or other medical reasons, women should be afforded a more gradual return if the OMP establishes grounds to do so.

8.4.3. Quick-wins

Continued interventions are important towards improvements in infrastructure and facilities, such as hygienic change houses, accessible toilets, and drinking water. The need to have emergency sanitary pads available is apparent. The provision of lactation facilities for nursing mothers to express breastmilk for their babies is also recommended.

Numerous recommendations are evident relating to PPE for women, including that it needs to fit women's shapes and sizes, should be of better quality, and be provided more frequently. The use of darker colour overalls is recommended for women, particularly those working underground. However, consideration must be made in relation to the use of darker coloured overalls underground, as this might pose safety risks due to reduced visibility. In addition, the use of dark overalls for surface work in the sun could contribute to heat strain as these absorb heat. A potential solution is the use of darker coloured bottoms (trousers) and lighter coloured tops (jackets), the use of reflective strips, and materials that allow for heat transfer and evaporation.

The importance of timeous provision of comfortably fitted PPE is vital for the safety of women in mining. It is recommended that an occupational health nurse be involved in the process of issuing PPE as they can advise not only the correct type of PPE for the hazard but the correct fit too, especially for women.

8.4.4. Training and awareness

Continued culture transformation programmes are important towards improved trust, understanding and better communication. Workshops, training and awareness campaigns are recommended. Training programmes could include those on respect and gender inclusivity. Meanwhile, training is important for increased understanding of over-exertion and its impacts, as well as reporting channels available. Training programmes can be tailored for various stakeholders, including WIM, men, and leadership. In addition, increased training, development and promotion opportunities are important for WIM.

Continued collaboration is important for successful implementation of changes, and should include tripartite stakeholders including the DMPR, organised labour, and industry. Academic institutions could contribute to cultural transformation by including sessions focusing on the unique challenges faced by WIM in the OHS professionals' curricula. Furthermore, toolbox talks about over-exertion and the effects thereof would bring much needed awareness on the topic. Women should be involved in decision-making processes. WIM forums are considered an effective means to support initiatives to enhance women's OHS in the SAMI, including in the response to issues that are reported. Leadership support for WIM committees has clear benefits.

Occupational health practitioners in training and in practice should be taught about the physiological, physical and psychosocial limitations and how to manage the risks that women in mining are exposed to without discriminating against them. The research outcomes could be summarised into a lecture to be shared with academic institutions offering post graduate qualifications in occupational health e.g. University of Cape Town (UCT), University of Pretoria (UP), University of KwaZulu-Natal (UKZN), and Tshwane University of Technology (TUT).

Regulatory or authority bodies should educate industry about the outcomes of the research.

The women in mining forums could spearhead awareness campaigns highlighting the outcomes of the research, ensuring that the information is widely shared.

Given the significance of work related and personal psychosocial stressors, it would create an excellent working environment if a psychologist or social worker could be part of the occupational health, safety and wellness team.

Wellness programs focused specifically on women's needs should aim at providing platforms where women feel safe to report signs of overexertion, harassment or psychosocial burdens.

Enhancement of employee wellness programmes and the provision of counselling or support for WIM would be beneficial. Services may include physical and mental health screening. The promotion of healthy eating and exercise is recommended. Healthy food alternatives should be available at mine sites, along with exercise programmes and the provision of exercise facilities.

There is a need for anonymous and accessible reporting systems, which could include hotlines, suggestion boxes and surveys. Periodic assessments relating to over-exertion are recommended.

8.4.5 Assessment tool updates

The potential to simplify and streamline the assessment tool was assessed based on analysis of the data gathered. From the statistical analysis, it was evident that almost all of the variables included in the questionnaire were associated with an indicator of over-exertion. As such, from that point of view it did not appear appropriate to remove any of the questions from the questionnaire. However, there were some questions that were not included in the statistical analysis, as only some of the participants were required to answer these based on responses to previous questions. An example of this is the intensity of recreational exercise performed. It would make more sense to update the question regarding recreational exercise frequency to include the aspect of intensity, if necessary.

Possible additions to the questionnaire were identified based on findings from the qualitative data obtained in the study. For example, long sitting times, and long standing times were challenges that WIM faced relating to over-exertion. Exposure to toxic gases and particulates is a further risk in mining. In addition, further detail could be added in relation to harassment. Only one question in the survey tool related to this; however, due to potential differences in understanding, and the importance of addressing this problem in industry, further detail could be added. The survey tool could therefore also support with monitoring and evaluation in terms of the GBVF guidance note (DMRE, 2024). Further aspects that were commonly mentioned across the focus group discussions and qualitatively included concerns with development, mining culture, and other psychosocial issues. These aspects could be considered for incorporation as they are important factors affecting WIM.

It would be helpful if feedback of responses from the questionnaire could be provided to participants, such as to give an indication of levels or risk of over-exertion. For example, a scoring system could be applied, based on the findings from this project, to identify which factors are associated with over-exertion. The different aspects of exertion could be separated, to get an indication of risk, including those relating to workplace exposures, job demands, mental and psychological factors, organisational factors, and personal factors such as work-life balance. Tables could be provided to as an indicative scoring system for each variable. A draft example of this risk-rating tool is provided is Appendix G. Further work would be required to confirm the validity of the scoring system.

It is recommended that space for open-ended comments is also allocated. These comments could also be submitted independently from the entire survey tool to allow respondents to anonymously report issues. Opportunities for further updates could include the availability of dashboards to reflect trends in industry. Meanwhile, in the assessment tool, there could be noticeboards or information repositories provided on the topic, such as there are in Successful Application of Technologies Around People (SATCAP) programme tools that are available on open-source platforms along with guidelines for use (Mandela Mining Precinct, 2025).

8.4.6 Future research

Further research is recommended to refine and implement the assessment tool in industry. Options for both hard copy and electronic versions are recommended. Implementation is suggested through mine's WIM committees. However, implementation from OHS departments and medical centres would be feasible alternatives. Governance and oversight will be important to ensure that responses are handled ethically and responsibly.

Additionally, further research comparing the assessment tool data with objective data relating to over-exertion is recommended. For example, data relating to functional physical work capacity, including that from RFA centres, is valuable to compare physiological responses and questionnaire data. Validation of the tool is important prior to implementation.

Further work is recommended on training programmes in the industry relating to over-exertion. This includes training for women in mining, men in mining, and for OHS practitioners, including OMPs and medical centre staff.

8.5 Project limitations

There are a number of limitations of this research, as discussed in the previous chapters of the report. These project limitations are described below.

As convenience sampling was used in this study, it is not possible for the data to be fully representative of the SAMI. A range of commodities and occupational groups were, however, included in the study, to make it as representative as possible.

The use of online surveys could pose challenges for those without access to computers, smartphones, and/or internet (Wifi or network data). Security or firewall settings at some mines might also block access to the web-based survey platforms. Literacy and language barriers could also be present. The use of hard-copy versions of the survey, and in-person data gathering (by project team members or medical teams at the mines) assisted to mitigate these concerns.

Furthermore, sensitivity of the topics could limit the amount of information that was shared by the participants in the study. Confidentiality in focus group discussions was a concern, as some might fear retaliation or intimidation if sharing information with others in the group, or may not be confident in sharing information with the project team.

Limitations regarding self-reporting are generally applicable to questionnaire-based research. Aspects such as differences in understandings of the questions and mood could have influenced the responses. In addition, direct measurement of anthropometric data (height, weight, waist girth, and hip girth) was not possible at all of the mine sites, and as such this resulted in less data for these variables, as well as potential recall bias.

A difficulty with the analysis of questionnaire data was the lack of a single industry standard for measuring over-exertion. As a result, various measures were used to provide an indication of over-exertion, including musculoskeletal pain or discomfort, fatigue, and a modified RPE scale. It is also likely that variables not assessed in the survey could have an impact on over-exertion; however, the survey tool aimed to be as comprehensive as possible without being too long and arduous to complete.

It is acknowledged that men in the mining industry also experience over-exertion, along with associated exposures and impacts. There has not been a study to specifically assess over-exertion of men in the SAMI. A comparative study could be helpful to determine issues primarily affecting women, or men, versus those that are applicable throughout the industry. For example, while the industry has recently placed an emphasis on PPE to suit WIM, PPE fit and comfort may be a challenge for all mineworkers SAMI. However, it is acknowledged that the current project was important based on the need for enhanced inclusivity of WIM, and the numerous factors that impact WIM that may not face men in the industry (including biological differences).

8.6 Conclusion

It is evident that over-exertion of women in mining is a complex topic. Various considerations need to be made relating to the work environment, job demands, workplace culture, work-life balance and individual differences. The assessment tool developed in the project could be implemented in industry towards identifying risk factors for over-exertion of women in mining. The data gathered using the survey tool was supported by insights obtained during engagements with stakeholders. Based on the project findings, the tool could be updated for future use.

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APPENDICES

Appendix A: Assessment tool questions

Survey: Over-exertion of women in mining

The purpose of this survey is to identify potential causes and impacts of over-exertion of women working in the South African mining industry. Women in mining are invited to participate. The questionnaire consists of 5 sections and around 55 questions. It should take approximately 15 to 20 minutes to complete.

* Required

1. Please note that participation in this survey is voluntary, and your responses will be kept anonymous. Please confirm that you are willing to take part in this survey *

- ☐ Yes, I agree to participate
- ☐ No, I do not want to participate

Work environment

2. For which company do you work? ______________________

3. At which mine/site do you work? ______________________

4. What is your occupation?*

- ☐ Artisan
- ☐ Artisan assistant
- ☐ Banksman / onsetter
- ☐ Belt attendant
- ☐ Cleaner
- ☐ Construction worker (pipes, tracks, ventilation etc.)
- ☐ Development and construction worker
- ☐ Driver (e.g. dump truck, forklift, light vehicle etc.)
- ☐ General miner
- ☐ General surface worker
- ☐ Health worker (e.g. nurse, doctor, therapist, radiographer etc.)
- ☐ Loco operator
- ☐ Manager
- ☐ Mining team (e.g. rock drill operator, scraper winch, water jet, cheesa, etc.)
- ☐ Office worker
- ☐ Operator (e.g. plant, chairlift etc.)
- ☐ Plant operator
- ☐ Professional (e.g. geologist, engineer, hygienist, heat and safety officer, metallurgist etc.)
- ☐ Shaft assistant
- ☐ Supervisor
- ☐ Winding engine driver
- ☐ Other: ______________________________

2

5. At what workplace do you work? *

☐ Surface workshop

☐ Surface office

☐ Surface plants

☐ Surface with environmental exposure

☐ Underground workshops

☐ Underground cool

☐ Underground hot - restricted/slopes

☐ Underground hot - unrestricted/development

☐ Marine - vessels

6. In which commodity do you work? *

☐ Gold

☐ Platinum

☐ Coal

☐ Iron ore

☐ Manganese

☐ Diamond

☐ Other: ______________________________

7. How long have you been working in mining? *

☐ <5 years

☐ 5-9 years

☐ 10-14years

☐ 15-19 years

☐ 20-24 years

☐ 25 or more years

8. Workplace exposures *

	Yes (/frequently)	No (/rarely)
Do you work in a dusty environment?	☐	☐
Do you work in a noisy environment?	☐	☐
Do you work in a badly lit area?	☐	☐
Do you work in a humid environment?	☐	☐
Do you work with hazardous chemicals?	☐	☐
Is your work conducted in confined spaces?	☐	☐
Do you work with vibrating hand tools or equipment?	☐	☐
Are you subjected to whole-body vibration?	☐	☐
Does your work involve listing and lowering of loads, tools, or equipment?	☐	☐
Does your work involve repetitive motions?	☐	☐
Does your work involve a high amount of thinking and planning?	☐	☐
Does your work involve long walking distances to the workplace?	☐	☐
Is your workplace too hot?	☐	☐
Is your workplace too cold?	☐	☐

9. Does your personal protective equipment (PPE) fit properly? *

☐ Yes
☐ No
☐ Not applicable

10. What adjustments do you believe will help to improve your PPE?

____

____

4

11. Do you have adequate access to toilets in the workplace? *

☐ Yes
☐ No

12. Is there a source of clean drinking water where you work? *

☐ Yes, drinking stations are available nearby
☐ Yes, but drinking stations are not spaced frequently
☐ No, there aren't drinking stations available in my workplace

13. How often do you feel extreme thirst during your shift? *

☐ Never
☐ Rarely
☐ Sometimes
☐ Often
☐ Not applicable

14. Approximately how many litres of water do you usually drink during a shift? *

☐ Half a litre
☐ 1 - 1.5 litres
☐ 2 litres
☐ More than 2 litres
☐ I don't know
☐ Not applicable

15. How many energy drinks/boosters do you take a day? *

☐ None
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ More than 5

16. What shifts do you work? *

☐ Day
☐ Night
☐ Other: ______________________________

17. How long are your shifts? *

☐ 8 hours
☐ 12 hours
☐ Other: ______________________________

18. Do you take breaks during your shift? *

☐ Yes, 30 minutes or more
☐ Yes, short (around 15 minute) breaks only
☐ Sometimes
☐ No

19. Do you work overtime? *

☐ Often

☐ Sometimes

☐ Rarely

☐ Never

20. How long can you work without feeling tired? *

☐ Less than 2 hours

☐ 2 - 4 hours

☐ 4 - 6 hours

☐ 6 - 8 hours

☐ 8 - 10 hours

☐ 10 - 12 hours

☐ More than 12 hours

21. How often do you feel out of breath during work?*

☐ Never

☐ Rarely

☐ Often

☐ Always

22. Have you experienced any form of harassment (e.g. physical/sexual) while at work?

☐ Yes

☐ No

☐ I would rather not say

Personal factors

23. How old are you? *

☐ 18-24 years
☐ 25-34 years
☐ 35-44 years
☐ 45-54 years
☐ 55-64 years
☐ 65 or more years

24. How often do you engage in recreational exercise (e.g. running, or playing soccer) for more than 30 minutes? *

☐ Never
☐ Seldom
☐ Once a week
☐ Two to three times a week
☐ More than three times a week

25. What is the level of intensity of the exercise that you do? *

☐ Light (e.g. walking)
☐ Medium (e.g. jogging)
☐ High (e.g. weight-lifting, competitive sport, athletics, soccer)

26. How long does it take you to travel to work? *

☐ Less than 15 minutes

☐ 15 to 30 minutes

☐ 30 to 45 minutes

☐ 45 to 60 minutes

☐ 60 to 90 minutes

☐ 90 minutes - 2 hours

☐ More than 2 hours

27. How much time, on average, do you spend on household activities (e.g. washing, cooking, looking after young children) outside of work each day? *

☐ Less than 1 hour

☐ 1 - 2 hours

☐ 2 - 3 hours

☐ 3 - 4 hours

☐ More than 4 hours

28. When you are working, how many hours of sleep do you get each day (24 hours), on average? *

☐ Less than 4 hours

☐ 4 - <5 hours

☐ 5 - <6 hours

☐ 6 - <7 hours

☐ 7 - <8 hours

☐ 8 - <9 hours

☐ More than 9 hours

29. When you are not working, how many hours of sleep do you get each day (24 hours), on average? *

- ☐ Less than 4 hours
- ☐ 4 - <5 hours
- ☐ 5 - <6 hours
- ☐ 6 - <7 hours
- ☐ 7 - <8 hours
- ☐ 8 - <9 hours
- ☐ More than 9 hours

30. How long does it take you to fall asleep once you are in bed? *

- ☐ Less than 10 minutes
- ☐ 10 to 20 minutes
- ☐ 20 to 30 minutes
- ☐ 30 to 40 minutes
- ☐ 40 to 50 minutes
- ☐ 50 to 60 minutes
- ☐ More than 60 minutes

31. How well do you usually sleep? *

- ☐ Very badly
- ☐ Fairly badly
- ☐ Moderately
- ☐ Fairly well
- ☐ Very well

32. Do you take any medication or beverages to help you sleep? *

- ☐ Yes
- ☐ No

33. Do you have any medical condition (e.g. arthritis, asthma, or cardiovascular disease)? *

☐ Yes

☐ No

34. If so, what medical condition(s) do you have? ______________________________

35. What medication are you taking, if any? ___________________________________

36. Do you experience any of these symptoms during work? *

☐ Dizziness

☐ Nausea

☐ Weakness

☐ Headache

☐ Confusion

☐ Excessive sweating

☐ Rapid heart rate

☐ Swelling of the limbs

☐ Muscle cramps

☐ Heat rash

☐ None

37. Do you smoke? *

☐ Yes

☐ No

38. Do you believe you may be pregnant?

☐ Yes

☐ No

39. Are you currently breastfeeding?

- ☐ Yes
- ☐ No

40. When was your last period?

- ☐ Now
- ☐ About a week ago
- ☐ About two weeks ago
- ☐ About three weeks ago
- ☐ More than three weeks ago
- ☐ I don't get periods

Health, safety, and wellness

41. Are you experiencing any pain or discomfort in your muscles and joints? *

☐ Yes

☐ No

42. If so, where in your body are you experiencing pain or discomfort?

____

____

43. On a scale of 1 (very slight discomfort) - 10 (extreme discomfort), how would you rate the level of pain/discomfort?

☐ 1 😊

☐ 2

☐ 3 😐

☐ 4

☐ 5 🙁

☐ 6

☐ 7 😣

☐ 8

☐ 9 😫

☐ 10

44. How tired do you feel at various times throughout a work day? *

	Not tired at all 😐	**Slightly tired** 😐	**Moderately tired** 🥱	**Very tired** 😫	**Exhausted** 😴
Before a shift	☐	☐	☐	☐	☐
Halfway through a shift	☐	☐	☐	☐	☐
After a shift	☐	☐	☐	☐	☐

13

45. How hard do you usually feel your body is working during your shift, on a scale from 0 (minimum) to 10 (maximum)? *

- ☐ 1: Resting (minimum)
- ☐ 2: Very light activity
- ☐ 3-4: Light activity
- ☐ 5-6: Moderate activity
- ☐ 7-8: Hard activity
- ☐ 9: Very hard activity
- ☐ 10: Maximum

46. How often do you feel anxious or sad? *

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

47. How often do you have trouble concentrating on your work tasks? *

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

48. How are you feeling on a scale of 1 (terrible) to 10 (great!)? *

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☐ 7
☐ 8
☐ 9
☐ 10

49. How would you rate your quality of life? *

☐ Very poor
☐ Poor
☐ Neither good nor poor
☐ Good
☐ Very good

50. How is your health?*

☐ Very bad
☐ Bad
☐ Neither good nor bad
☐ Good
☐ Very good

51. How many day of sick leave did you take in the past year?

- ☐ None
- ☐ 1 – 4 days
- ☐ 5 – 9 days
- ☐ 10 or more days

Body measurements

52. What is your body weight (in kilograms)? ____________________

53. What is your body height (in centimetres)? ____________________

54. What is your waist girth (in centimetres)? ____________________

55. What is your hip girth (in centimetres)? ____________________

56. Have you completed a Rehabilitation and Functional Assessment (RFA) assessment?

☐ Yes
☐ No
☐ I'm not sure

Comments

57. Please list factors that you can think of that lead to, or result from, over-exertion of women in mining, that may have not been mentioned in this questionnaire

____

____

____

58. Please provide recommendations you can think of for improving the health, safety and wellness of women in mining

____

____

____

59. Please provide any additional comments you may have

____

____

____

Appendix B: Focus group discussion guide

1. What challenges are faced by women in mining?

2. What do you understand by over-exertion i.e. what makes work demanding for women in mining physically or mentally? And what are the outcomes of this (e.g. fatigue, injury or illness)?

3. How does work affect the roles and responsibilities of women outside of work (and vice versa – how do the responsibilities outside of work affect the work)?

4. What would you identify as activities or tasks that contribute to over-exertion as a woman in mining? (e.g. doing shift work, use of heavy equipment, family responsibilities etc.)

5. What opportunities are there to improve the working conditions for women in mining?

6. Is there a need to modify any piece of equipment currently being used in mining to accommodate women? If yes, what equipment and what modifications would be necessary?

7. Is there a need to modify any piece of personal protective equipment (PPE) currently being used in mining to accommodate women?

8. What channels are there for women to report occupational health and safety concerns faced at work?

9. What challenges females encounter in relation to reporting mechanisms?

10. Have you ever been victimized/intimidated for raising concerns?

11. What recommendations do you have for improving the occupational health and safety reporting channels for women in mining?

12. Is the support of the company through Employee Wellness Programmes enough to cater for women?

Appendix C: Ethics clearance certificate

CSIR Research Ethics Committee
PO Box 395 Pretoria 0001 South Africa
Tel: +27 12 841 4060
Fax: +27 12 841 2476
Email: RandDEthics@csir.co.za

Touching lives through innovation

02 May 2025

Dear: **Ruth Teleka**

Approval of Protocol: **The Impact of Over-Exertion on Women's Health and Safety in the South African Mining Industry.** This is to confirm that your protocol reviewed by the CSIR REC has been approved. The reference number of this research project is **REF: 478/2024.**

This approval is granted under the conditions that:

1. The researcher remains within the procedures and protocols indicated in the proposal, as well as the additions made to the procedures and protocols as indicated in the responses submitted to the questions of the CSIR REC, particularly in terms of any undertakings made and guarantees given.
2. The researcher notes that **any deviations to the approved project/protocol must be submitted to the CSIR REC for approval before implementation, failure to do so the CSIR REC has the right to withdraw this clearance**.
3. The researcher remains within the parameters of any applicable national legislation, institutional guidelines and scientific standards relevant to the specific field of research.
4. This **approval is valid for the duration of the project (April 2026).**
5. The researcher submits bi-annual progress reports to the CSIR REC failure to do so the CSIR REC has the right to withdraw this clearance.,
6. The researcher immediately alerts the CSIR REC of any adverse events that may occurred during the course of the study, as well as the actions that were taken to immediately respond to these events.
7. The researcher alerts the CSIR REC of any new or unexpected ethical issues that emerged during the course of the study, and how these ethical issues were addressed. If unsure how to respond to these unexpected or new ethical issues as they emerge, the researcher should immediately consult with the CSIR REC for advice.
8. The researcher submits a short report to the CSIR REC on completion of the research in which it is indicated (i) that the research has been completed; (ii) if any new or unexpected ethical issues emerged during the course of the study; and if so, (iii) how these ethical issues were addressed.

We wish you all the best with your research project.

Kind regards,

Tarirai

Prof Clemence Tarirai
(CSIR REC Chairperson)

Ms Brenda Kgasago
(CSIR REC Secretariat)

Appendix D: Permission letter

MHSC
Mine Health and Safety Council

PO Box 395 Pretoria 0001 South Africa
Tel: +27 12 841 2911
Email: Enquiries@csir.co.za

Established in terms of Section 41(1) of the Mine Health and Safety Act, 1996 (Act 29 of 1996)

Woodmead Office Park, B7 Maple North, 145 Western Service Road, Woodmead
Tel. No. (011) 656 1797 | Fax: (011) 656 1796

Dear Mining Industry Professional

Re: Research Project on the Impact of Over-Exertion on Women's Health and Safety in the South African Mining Industry (SAMI)

The Mine Health and Safety Council (MHSC) has appointed the Council for Scientific and Industrial Research (CSIR) to execute the abovementioned project.

Through a review of best international and local practices and both qualitative and quantitative data collection, the research aims to develop a health and safety assessment tool that can be utilised to assess and mediate over-exertion for women working within the South African Mining Industry (SAMI).

Information gained from surveys and focus groups, together with historic data on physical work capacity, will be used to determine what aspects to be included in the tool.

a) This assessment tool will be cognisant of:
   - The different occupations and work conditions in different types of mines and relation to hazardous conditions in these mines
   - Body Mass Index as a proxy for fitness to work in the mining environment and if this has an impact on risk in hazardous areas of mining environments

b) The assessment tool will be utilised to determine the relationship between hazardous working conditions in SAMI and the emotional and physical wellbeing of women working in these areas.

c) The research will explore available reporting channels to women in SAMI where they are able to:
   - Voice occupational health and safety concerns
   - Whether these reporting channels incorporate aspects of over-exertion
   - To identify additional channels and mitigating measures in relation to Occupational Health and Safety

We would like to formally request permission to collect relevant data through the survey tool and Rehabilitation and Functional Assessment (RFA) data from the relevant personnel at your mine.

To achieve the objectives of the project, we propose collecting data on the following criteria for the assessment of potential over-exertion: physical ability, environmental aspects of the work, personal

Every mine worker returning from work unharmed every day. Striving for Zero Harm in our lifetime.

MHSC
Mine Health and Safety Council

protective equipment (PPE), medical history and mental health.

We understand the importance of confidentiality and data protection. We assure you that all data collected will be treated with the utmost care and confidentiality. The data will be used for research purposes and will not be shared with any third party without your explicit permission. If required, we are prepared to sign a confidentiality agreement outlining the terms and conditions of data access and usage. Additionally, we are open to discussing any specific requirements or concerns that your company may have.

Please inform us of the necessary procedures and requirements to facilitate this access, including any documentation or scheduling preferences that you may have. Should you require any further information or clarification, please contact the Research Delivery Specialist (Occupational Health) at the MHSC, Dr. Nonhlanhla Tlotleng (ntlotleng@mhsc.org.za), or the Project Leader at the CSIR, Dr. Jodi Pelders, at JHodgskiss@csir.co.za (Cellphone: 011 358 0057).

Thank you for your attention to this matter.

Yours in Health and Safety

FBrovko

Fatheela Brovko
Chief Research Operations Officer

10 December 2024
Date

If you grant permission for the data collection to take place at your organisation/with your organisation representative, kindly complete and sign the approval below:

I ______________________________ [full name], in my capacity as ________________

[designation], hereby grant permission to the researchers to undertake data collection for the Impact of Over-Exertion on Women in the SAMI project at ____________________________

[company/operation name].

____________________________ ____________________________

Signature Date

Board members: V. Jarana (Chairperson), Prof. Y. Ballim, M. Fakir, M. Govender, M. Matolong, Dr V. Mthethwa, M. Mulcahy, J. Newton, Dr C. Render, Prof. A. Van Zyl, Dr T. Dlamini (CEO)

MHSC Mine Health and Safety Council

www.csir.co.za

Appendix E: Workshop invitation

MHSC
Mine Health and Safety Council

INVITATION

STAKEHOLDER ENGAGEMENT WORKSHOP

RESEARCH PROJECT COE 210903

"THE IMPACT OF OVER-EXERTION ON WOMEN'S HEALTH AND SAFETY IN THE SOUTH AFRICAN MINING INDUSTRY"

Aim of the workshop:

The workshop intends to present findings and solicit industry inputs on research project CoE 210903, **"The impact of over-exertion on women's health and safety in the South African Mining Industry."**

Who should attend?

- Representatives from the DMRE, DOH, DOEL
- Organised Labour
- Organised Business
- Mining Industry Professional Associations
- Academia
- Mining Companies
- Interested Persons

The project is executed by the Council for Scientific and Industrial Research, in collaboration with The Work Expert and Mishumo Health Group on behalf of the MHSC and the SAMI.

EVERY MINEWORKER RETURNING FROM WORK UNHARMED EVERY DAY. STRIVING FOR ZERO HARM IN OUR LIFETIME.

Appendix F: Workshop programme

Stakeholder Engagement Workshop: Over-exertion of women in mining
CSIR International Convention Centre / MS Teams
3 October 2025, 09:00 – 14:00

Purpose of workshop: **To present findings and solicit industry inputs on research project CoE210903, "The impact of over-exertion on women's health and safety in the South African mining industry"**

Topic	Responsibility	Time
Facilitator: Emma Matjila		
1. Registration and refreshments	All	08:30 – 09:00
2. Opening and welcome	Fleckson Magweregwede	09:00 – 09:10
3. Safety briefing	Venue official	09:10 – 09:15
4. Mine Health and Safety statistics	Dr Nonhlanhla Tlotleng Lester Martin	09:15 – 09:25
5. Lest we forget	MHSC	09:25 – 09:30
6. Setting the scene: Frameworks for improving health and safety culture	Dr Basi Marumo	09:30 – 09:45
7. Purpose and overview: The impact of over-exertion on women's health and safety in the South African mining industry	Dr Jodi Pelders	09:45 – 10:00
8. Literature review outcomes: Challenges in the workplace for women in mining	Tia-Mari Hofmann	10:00 – 10:20
9. Comfort break	All	10:20 – 10:50
10. Survey findings: Assessment tool results	Dr Jodi Pelders	10:50 – 11:30
11. Survey findings: Inferential analysis of data	Renee Koen	11:30 – 11:45
12. Research findings: Focus group discussions	Ruth Teleka	11:45 – 12:15
13. Q&A	All	12:15 – 12:30
14. Mentimeter survey	Ruth Teleka	12:30 – 12:45
15. Discussion	All	12:45 – 13:25
16. Closure and thanks	Dr Nonhlanhla Tlotleng	13:25 – 13:30
17. Lunch	All	13:30

Appendix G: Draft example of over-exertion risk assessment tool

Occupation:

Age:

BMI:

Workplace:

Commodity:

Score:

Severe risk
Moderate
Mild

Environmental Strain	Physical Strain	Cognitive/ Psychosocial	Organisational /Lifestyle	Health/ Tiredness	Total Over-exertion

		Low	Medium	High
	Environmental strain			
1.	Workplace	Surface office	• Surface plants • Surface with environmental exposure • Underground cool • Underground workshops • Surface workshops	• Underground, hot restricted • Underground, hot unrestricted • Marine vessels
2.	Exposure to dust	No	-	Yes
3.	Exposure to noise	No	-	Yes
4.	Heat	No	-	Yes
5.	Cold	No	-	Yes
6.	Humidity	No	-	Yes
7.	Poor lighting	No	-	Yes
8.	Hazardous chemicals	No	-	Yes
9.	Confined spaces	No	-	Yes
	Physical strain			
10.	Occupation (physical intensity)	Sedentary/roaming	Light	Moderate – Heavy (=strenuous work)
11.	Repetitive motions	No	-	Yes
12.	Hand-arm vibration	No	-	Yes
13.	Whole-body vibration	No	-	Yes
14.	Lifting and lowering	No	-	Yes
15.	Long walking distances	No	-	Yes
16.	Sitting for long periods	No	-	Yes

		Low	Medium	High
17.	Out of breath	Never/rarely	-	Often/always
18.	Heat stress symptoms	None	1	2 or more
19.	Rating of perceived exertion	Resting/light activity	Moderate activity	Hard activity
	Cognitive/psychosocial			
20.	Workplace mental demands	No	-	Yes
21.	Anxiety/sadness	Never/rarely	Sometimes	Often/always
22.	Trouble concentrating	Never/rarely	Sometimes	Often/always
23.	Mood/emotional state	Negative	Neutral	Positive
24.	Harassment	No	-	Yes
25.	Quality of life	Good	Moderate	Bad
	Organisational			
26.	PPE fit properly	Yes/Not applicable	-	No
27.	Adequate access to toilets	Yes	-	No
28.	Clean water source	Yes	-	No
29.	Extreme thirst	Never/rarely	Sometimes	Often/always
30.	Shift type	Day	Other	Night
31.	Shift length	≤8 hours	9-11 hours	12 hours
32.	Shift breaks	Yes (≥30 min)	Sometimes	No
33.	Overtime	Rarely/never	Sometimes	Often
	Demographic/Lifestyle			
34.	Recreational exercise	Never	Occasionally	Often (>twice a week)
35.	Commuting time	<30 minutes	30-60 minutes	>1 hour
36.	Household activities per day	≤1 hour	1-3 hours	>3 hours
37.	Sleep – work day	>6 hours	-	<6 hours
38.	Sleep – off day	>6 hours	-	<6 hours
39.	Sleep latency	10-60 minutes	<10 minutes	>60 minutes
40.	Sleep quality	Good	Moderate	Bad
41.	Smoke	No	-	Yes
42.	Pregnant	No	-	Yes
43.	Breastfeeding	No	-	Yes
	Health/tiredness			
44.	Musculoskeletal pain/discomfort	No	-	Yes
45.	Medical condition	No	-	Yes
46.	Subjective health	Good	Moderate	Bad
47.	Medication or drinks to sleep	No	-	Yes
48.	Tiredness – before shift	No/slightly tired	Moderately tired	Very tired/ exhausted
49.	Tiredness – during shift	No/slightly tired	Moderately tired	Very tired/ exhausted
50.	Tiredness – after shift	No/slightly tired	Moderately tired	Very tired/ exhausted
51.	Sick leave (past year)	<4 days	5-9 days	10 or more days