

# South African guideline for the selection and provision of personal protective equipment for women in mining

LI Zungu

Department of Health Studies, University of South Africa, Pretoria

Correspondence: Prof. Lindiwe I Zungu, Department of Health Studies, University of South Africa, PO Box 392, UNISA, 0003. E-mail: zunguli@unisa.ac.za

## ABSTRACT

The South African mining industry is male-dominated and involves hazardous, labour-intensive work. Many aspects of the work environment offer little or no gender-appropriate modifications for women in mining (WIM). For example, personal protective equipment (PPE) and clothing for mine workers is designed exclusively for the male physique. The amended Mine Health and Safety Act (No. 29 of 1996) does not regulate the provision of PPE for different gender groups. A two-phase study was conducted among 118 WIM from selected gold and platinum mines to investigate the suitability of their PPE. All participants complained about the ill-fitting and uncomfortable PPE provided by the mining companies. A guideline, adopted from the South African Bureau of Standards for approved women's workwear, is suggested for the re-design of PPE for WIM. This would accommodate WIM's unique body structures, and ensure proper fit, comfort and maximum protection from mining hazards.

**Keywords:** guideline, personal protective equipment, clothing, women, mining, Mine Health and Safety Act, gender, South Africa

## INTRODUCTION

The South African mining industry is male-dominated and, as such, involves hazardous, labour-intensive work, many aspects of which offer little or no gender-appropriate adaptations for women in mining (WIM). Personal protective equipment (PPE) and clothing are examples where designs are exclusively matched to the male physique. PPE is used as a last resort, when all other engineering control measures have failed, or are not adequate, to prevent exposure to hazards associated with mining activities and conditions.<sup>1</sup> PPE should therefore be carefully selected, based on the nature of the hazard(s), the levels of risks associated with those hazards, and the physical attributes of the individual workers.

Section 6(2) of the South African amended Mine Health and Safety Act (MHSA) No. 29 of 1996 stipulates that "Every manager must ensure that sufficient quantities of all necessary PPE is available so that every employee who is required to use that equipment is able to do so."<sup>1</sup> The Act also stipulates that

workers should use PPE in the required manner and ensure adequate maintenance of the equipment.<sup>1</sup> The MHSA does not regulate the provision of PPE for different gender groups and, as a result, available PPE suits the male physique. Women are very different to men, anatomically and physiologically<sup>2</sup> thus, PPE provided for WIM needs to be aligned with their body structures and should be based upon female anthropometric data.<sup>3</sup>

In general, PPE provided for use in the mines and other heavy duty work environments, such as the construction industry, does not adequately fit female workers. A study on the cost, appropriate use, and effectiveness of PPE in the South African mining industry published in 2005, showed that PPE plays a major role in the protection of workers' health and safety.<sup>4</sup> However, the efficiency of PPE is not determined exclusively by the protection it affords but also depends on conformity with the anthropometric features of the individual, the task at hand, and the work environment.<sup>5</sup>

Most of the literature reviewed identified hazards that are prevalent in the mining industry and highlighted those that indicate a requirement for the use of PPE.<sup>4,6-8</sup> A survey of multiple occupational health hazards in the South African mining industry revealed that female mine workers are mostly exposed to chemical hazards such as degreasers, paints and welding fumes, as well as ergonomic hazards from lifting of loads.<sup>4</sup> The authors used the identified hazards to categorise the PPE requirements for work in the mines or construction industries according to the body part to be protected. However, no studies have focused on PPE requirements for WIM or women working in heavy duty sectors.

This paper is based on a study that investigated the health and safety challenges experienced by WIM in South Africa.

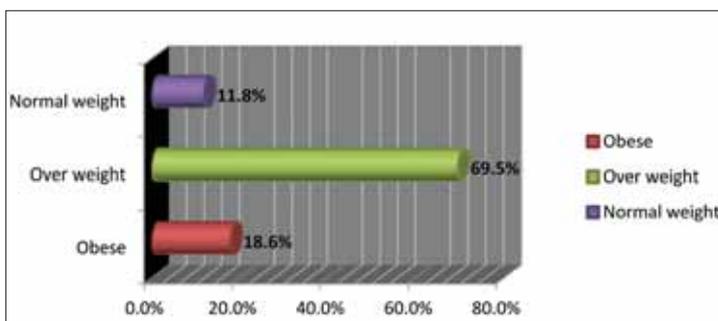


Figure 1. Participants' body mass index (n=118)



Figures 2a and 2b. Gumboots, safety shoes and hand gloves used by WIM

Findings of the first phase of the study were published in 2012 and showed that WIM experience occupational health and safety (OHS) challenges related to PPE and unhygienic sanitary facilities underground that compromise their productivity as well as their health and safety at work.<sup>2</sup> In trying to better understand the gender issues at play, this second phase of the study investigated the health and safety effects of ill-fitting PPE among WIM in order to develop comprehensive and systematic guidelines to assist the South African mining industry in the selection and provision of appropriate and suitable PPE for WIM.

## METHODS

A cross-sectional descriptive survey was conducted among 200 women miners from a gold and a platinum mine in Limpopo province, as previously described in the paper regarding occupational health and safety challenges reported by WIM.<sup>2</sup> In brief, structured questionnaires were self-administered to participants to collect demographic data and to determine PPE suitability in terms of body fit, style, level of protection and comfort. Ethical approval to conduct the study was obtained from the Ethics Committee of the University of South Africa prior to data collection (Ethical clearance no: 9016-705-8). Data management was performed using SPSS version 18.0.1.

## RESULTS

### Participants' body mass index

A total of 118 WIM participated in the study (59.0% response rate) with an average body mass index (BMI) of 27.97 kg/m<sup>2</sup> (SD=3.55). As shown in Figure 1, most of the participants (n = 82; 69.5%) were overweight (BMI 25 to <30 kg/m<sup>2</sup>) or obese (n = 22; 18.6%) (BMI ≥30 kg/m<sup>2</sup>) as defined by the World Health Organization.<sup>9</sup>

### Nature of PPE used by WIM

Both mines had similar lists of PPE supplies for underground mine workers, which were provided according to occupational categories of mine workers and not gender, i.e. no specific PPE was available for WIM. All participants reported that they were neither consulted nor involved in the selection process of their PPE.

All 118 participants complained that the PPE was ill-fitting

and uncomfortable, particularly that the overall suits were tight, and the gumboots and safety hand gloves oversized (Figures 2a and 2b). They also reported that PPE was available in male sizes only. They complained about the quality of the fabric from which the overall suits were manufactured, including stating that their overall suits became smaller after washing; their perceptions were that the fabric 'shrank' after washing.

### Participants' style preferences for overall suits

The majority of the participants (n=114; 96.6%) preferred a

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**Figures 3a and 3b. Participants wearing nylon tights and oversized thick woollen socks as undergarments**

two-piece overall suit compared to the one-piece suit for various reasons, including increased flexibility and user-friendliness. Dark coloured overall suits (green or dark blue) were preferred by all participants, primarily because they do not show dirt and stains easily, especially during menstrual cycles.

#### **Participants' coping mechanisms to deal with unsuitable PPE**

Participants reported various coping mechanisms which they used to deal with ill-fitting and uncomfortable PPE, including wearing nylon tights as undergarments to prevent friction caused by the overall pants fabric against the inner thighs (Figure 3a), and wearing thick woollen or double pairs of socks to make up for the oversized gumboots (Figure 3b).

#### **DISCUSSION**

Most participants were overweight or obese. The World Health Organization defines obesity as "a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired."<sup>9</sup> Arguably, in this study, obesity among participants is one of the reasons for ill-fitting PPE, particularly the overall suits, as most of the male miners are not overweight or obese. PPE provided for WIM needs to be designed more effectively to align with the physiological and

anatomical forms of female mine workers and should be based upon female anthropometric data.<sup>3</sup>

#### **Nature of PPE used by WIM**

Poor fit and discomfort are the main reasons for non-compliance with wearing PPE. This was previously shown in a local study on mine workers in two South African gold mine clinics.<sup>4</sup> Non-compliance predisposes workers to occupational injuries and ill-health: all workers in this study complained of calluses, blisters and general foot infections, annulling the protection intended to be provided by safety shoes.<sup>4</sup> This finding is consistent with those from similar studies conducted in the United States of America, Australia and Canada.<sup>10-12</sup>

Various studies have consistently reported that men and women differ in terms of their anthropometry. However, the most readily available PPE and working tools are designed for male workers, resulting in female workers who do not meet male height and weight dimensions being left unprotected and unable to perform their tasks efficiently. This undermines efforts to protect women workers against health and safety hazards.<sup>13-16</sup>

PPE manufacturers do not offer users enough information to select PPE with confidence, including information on the ergonomics and physiological aspects of garments and other items.

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PPE comfort is mainly a consequence of interaction between the body, climate and clothing.<sup>17</sup> Consequently, the weight, thickness and stiffness of PPE worn, as well as friction between layers of PPE, can affect the wearer's physical performance and limit movements of the extremities.<sup>17</sup> These results support findings from other studies where women complained about the unsuitability of full-body suits that were designed for men.<sup>10,11</sup> In South African mines, female workers have previously complained about protective overalls and gloves, in particular the one-piece suit.<sup>4</sup> These and findings from the current study confirm that "one size does not fit all" and PPE needs to be provided on an individual basis.

### Participation of WIM in PPE selection

Several studies have highlighted the need for consultation with workers as PPE end-users during the selection process to encourage them to voice their concerns about fit, comfort and style preferences.<sup>11,15-20</sup> Consultation with PPE end-users will instil a sense of responsibility and co-operation to comply with the use of PPE provided.<sup>1</sup>

### Coping mechanisms used by WIM

The women in this study wore nylon tights as undergarments to prevent friction against their thighs. A Nigerian study revealed that women wearing tight fitting undergarments, "specifically nylon tights" or other "synthetic pants" are at a higher risk of developing bacterial and fungal infections compared to those who wear cotton tights or cotton pants.<sup>21</sup> Thus, the use of nylon tights as undergarments by WIM could predispose them to adverse health effects, and should be discouraged.

### Recommendations

There is a need to re-design PPE for WIM to accommodate their unique body structures, and to ensure proper fit, comfort and maximum protection from mining hazards. The proposed guidelines will assist the mines to select and provide suitable PPE for WIM. Educational health programmes must also be designed to increase awareness of health risks associated with obesity among WIM.

### Guidelines for selection and provision of PPE for women in mining

#### General

- In line with sections 1, 2, 6 and 21 of the amended MHSA, there is a need to regulate the mining sector with respect to specifications for provision of PPE for WIM.<sup>1</sup> A systematic participatory approach (in consultation with PPE end-users) should be adopted to incorporate ergonomic and comfort aspects into PPE selection, as well as female anthropometric measurements and other individual female attributes, such as body mass index (BMI).

#### Fabric and design

- The SABS has stipulated measurements for all dimensions of the intended wearer (women workers).<sup>22</sup>
- The design and pattern of PPE (specifically protective clothing) for WIM should conform with the requirements and specifications of the relevant standards stipulated and approved by the SABS, with regard to the fabric, style, shape,

dimensions, stitching and lining for women's workwear.<sup>22,23</sup> Areas to be re-designed to suit WIM include torso length, shoulders, chest/breast, waist, and hips.

- Design of custom-made two-piece overalls, including fabric, etc. for women of all sizes, is essential. For example, to ensure that PPE manufacturers design appropriate apparel for WIM, they must use fabric to maximise thermal and tactile comfort, and to allow for ease and flexibility of body movement (dexterity). "Breathability" and "comfort" of the fabric is crucial. Effective material for overall suits for WIM and other workers should allow the transmission of moisture vapour while still providing adequate protection from workplace hazards.<sup>22,24</sup>

#### Gumboots

- Gumboots should be designed in smaller, women's sizes (as small as a size 4).

#### Surveys

- Regular surveys of PPE that is currently in use should be conducted to ensure appropriateness, and to identify challenges experienced by WIM, particularly in relation to fit and comfort.

### Guidelines for re-design of PPE for women in mining

*Specifications for protective clothing: Fabric type for WIM overall suits*

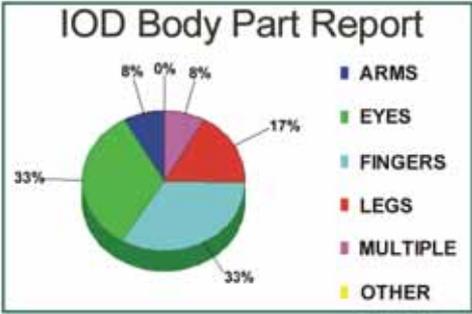
- The outer material should be of a fabric that complies with



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the requirements of SANS 1261-2 for woven overall fabric.<sup>22</sup>

- The use of treated light density cotton fabric for overall suits for WIM is advisable, as cotton fabrics adapt well to changing workplace temperatures and are comfortable as well as fire resistant. Treated cotton clothing protects against dust, abrasions, and rough and irritating surfaces.<sup>22</sup> Light density cotton fabric is recommended to allow for more “breathability” during ovulation cycles. The fabric should be of an acceptable fusible woven or non-woven fabric suitable for both hand washing and dry cleaning. Fabrics of high temperature fibres such as Nomex, Kevlar and PBI, should be avoided as these can increase the body temperature.<sup>22</sup>
- A four-hole dope-dyed plastic button should be used for protective clothing and the nominal diameter should be specified by the purchaser.<sup>22</sup> Slide fasteners should be one way closed-end for overall pants and a one-way open end for overall jackets with synthetic elements as per SANS 1822 guideline cited in the standard for women workwear.<sup>24</sup> Elastic webbing for overall pants should be 25 mm width, in line with the requirements for type 1 of SANS 142.<sup>22</sup>

#### *Style and size variations for WIM overall suits*

- Re-design the two-piece overall suits in various sizes with women’s dimensions in mind, in line with the following SABS approved standards for women workwear:<sup>22</sup>
  - o shorter torso length
  - o narrower shoulders
  - o chest/breast (considering women of all sizes)
  - o smaller waist
  - o larger hips
- Reference to standards should be considered by PPE manufacturers when designing protective clothing for WIM. For example, the overall pants and jackets should be supplied in women sizes (i.e. normal and loose fit) as stipulated in the SABS-approved standard which recommends nominal finished garment measurements in centimetres based on SANS 1360-2.<sup>22</sup>
- Overall pants should have plain fronts, a ruched back waistband, a slide fastener fly, and slanted or straight side pockets as prescribed in the SABS standard. The use of elastic in the design of the waist for the overall pants should be avoided as it can cause discomfort for women who are overweight or obese. Elastic bunches and is not aesthetically pleasing for women,<sup>22</sup> thus the use of darts on either side of the bottom garment (at the top hem) is advisable for a more comfortable and aesthetic finish. The band with a dart lining should be made from 100% cotton and not be blended with other fibres, to prevent perspiration.<sup>22</sup>
- The overall jacket for women workwear should fasten at the centre front with either a slide fastener or buttons and should have a step collar with lapel, one-piece long sleeves and three pockets, and the back of the jacket should be plain. The overall suits should be supplied with long or short sleeves.<sup>22</sup>

#### *Hand protection: Technical considerations for providing well-fitting gloves for WIM*

SANS (1228:2009) specifies the requirements for the type, design, construction, material, dimensions and service-related properties of protective gloves made from fabric-lined polymeric material, which may be a plasticised poly (vinyl chloride) or a synthetic rubber. The gloves can be used in operations where abrasion resistance is common.<sup>25</sup>

- The glove’s finger length, width and palm circumference must fit the average woman’s hand. Hand gloves should offer a safe grip to prevent tools or materials from sliding out of women’s hands.

#### *Foot protection: Technical considerations for providing well-fitting gumboots and protective shoes for WIM*

Specifications provided in SANS (492-1:2002) and SANS (492-2:2003) must be considered when designing gum boots and safety shoes for WIM.<sup>26,27</sup>

- Suitable gumboot sizes should include an array of sizes from 4 to 8 as these are average South African women’s shoe sizes. If these sizes are not available, manufacturers can make moulds of women’s feet as these are close to the actual shoe size, shape and bone structure which will result in a closer, more comfortable fit.

## **CONCLUSIONS**

The current PPE provided by mining companies is not suitable for WIM as it is ill-fitting and uncomfortable to wear, primarily because it is designed for a male physique. Gender variations in body shapes and structures require the re-design of current PPE worn by WIM. Ill-fitting PPE contradicts the notion that effective health and safety protection for workers can be achieved by using appropriate PPE that is correctly fitted, maintained and properly used. The situation is aggravated by the eccentric coping mechanisms used by women to adjust or correct the ill-fitting PPE, which further increase the risk of adverse health effects. In addition, being overweight or obese are health and safety risk factors for WIM that need to be addressed.

## **ACKNOWLEDGEMENTS**

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## **CONFLICT OF INTEREST**

None declared.

## **LESSONS LEARNED**

- Women have a unique anatomical body makeup that differs from men.
- PPE provided for women must be based upon female anthropometric data.
- Poor fit and discomfort are the main reasons for non-compliance with wearing PPE.
- Coping mechanisms to adjust or correct the ill-fitting PPE increase the risk of adverse health effects.
- Consultation with PPE end-users is crucial during PPE selection to enhance compliance with the use thereof.

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