

Socio-demographic contributors to health and safety of mine workers in South Africa

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Abstract.

BACKGROUND: Mine workers in South Africa face various health and safety risks, and socioeconomic challenges.

OBJECTIVE: This study aimed to assess the associations between socio-demographic factors and health, safety and wellness in the South African mining industry.

METHODS: Qualitative and quantitative data were collected from 64 interviews with mine management and labour representatives, 14 focus groups with mine workers, and 875 questionnaires completed by mine workers from three platinum, two gold, one coal, one diamond, and one manganese mine in South Africa.

RESULTS: Health challenges included non-communicable diseases, HIV/AIDS, tuberculosis (TB), and respiratory diseases, while safety challenges included worker behaviour, stress and fatigue. Socio-demographic factors associated with disease, sick leave, fatigue, accidents and job satisfaction included age, length of service, race, nationality, education, mining sector, work status, income, housing, domestic crowding, sleep, exercise, alcohol use, and perceived quality of life.

CONCLUSION: Socio-demographic factors should be taken into consideration when developing workplace health and safety programmes.

Keywords: Disease, sick leave, fatigue, work accidents, job satisfaction

1. Introduction

Occupational health and safety risks are prevalent in the mining industry [1–3]. Mine hazards can result in injuries and fatalities, cumulative trauma disorders, noise-induced hearing loss, and heat stroke or exhaustion [1–6]. Pulmonary diseases, including silicosis and lung cancer, can result from exposure to dust and hazardous chemicals, while fatigue and shift work are accident risks [1, 5, 7]. Psychosocial job demands, poor work environments, job dissatisfaction, job stress, and older age have also been associated with occupational injuries [4, 6]. Psy-

chosocial risks associated with mining include drug and alcohol abuse, stress from being separated from families in the case of migrant workers, working conditions, a lack of control over the work that is performed, high workloads, the work schedule, stress resulting from incidents and accidents, and socioeconomic consequences of occupational injuries [4, 5, 8–11]. Reduced health, safety and job satisfaction of workers has negative impacts for the industry and the communities surrounding mines, as a result of direct and indirect costs, including absenteeism and a loss of productivity [7, 11].

The South African mining industry historically relied on a male-dominated migrant workforce that was housed in substandard conditions in mining compounds ('hostels'), which had negative effects on health, productivity and social well-being [12–14].

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The preference for mining compounds was formally abandoned in 1986, and strategies to improve the housing and living conditions of mine workers have since been implemented [12, 14–18]. Furthermore, a baseline of 10% participation of women in the workforce is now required [16, 17].

Nevertheless, most South African mining towns have poor social and economic conditions, including poverty, unemployment, bad housing and infrastructure, prostitution, and a high number of single migrant labourers [19–21]. Migrancy is linked to tuberculosis (TB) risk factors, including HIV/AIDS, healthcare service disruptions and low socioeconomic status [22]. Mine workers have been estimated to be three to four times more likely to be infected with HIV than non-mine workers [22]. Additionally, silicosis and HIV/AIDS have been found to pose an interactive risk for developing TB, and mine workers in sub-Saharan Africa have been reported to have a higher incidence of TB than any other working population in the world [7, 22, 23]. Lim et al. (2011) found that the presence of HIV was also associated with an increased risk of work-related injury in gold miners [24]. South Africa, as a whole, is faced with a quadruple burden of disease, namely, the epidemics of poverty-related illnesses, non-communicable diseases, HIV/AIDS, and violence and injuries [25].

Indicators of socioeconomic status include income, occupation, education, household conditions and race [26–30]. Low socioeconomic status is associated with poorer education, poorer health, higher psychological distress, and reduced quality of life, along with higher rates of cigarette smoking and heavy drinking, a higher likelihood of being sedentary, domestic crowding, and violence [26, 31]. d'Errico et al. (2007) reported that the occurrence of injury at work was higher in those with lower education and those in lower occupational classes [27]. This might be because those working in higher socioeconomic strata are generally employed in less hazardous jobs, while lower education could act as an independent risk factor, through lower risk perception, or because of less access to information [27]. Socioeconomic conditions and lifestyle factors, including employment status, education, economic hardship, and physical inactivity, are further associated with self-rated health, which is an established predictor of morbidity and mortality [32].

It is evident that socioeconomic conditions are associated with health, safety and wellbeing. As a result of related changes and challenges within the South African mining industry, further study was war-

ranted to identify where intervention efforts can be better focused. The aim of this study was to examine associations between socio-demographic factors and the health, safety and wellbeing of mine workers in South Africa.

2. Methods

This was a cross-sectional mixed methods study, as both qualitative and quantitative data were gathered. Methodological triangulation was used to analyse the results.

Data were gathered at three platinum, two gold, one coal, one diamond, and one manganese mine. In total, more than 50 000 people were directly employed by these participating mines. The eight mines were located in six of the nine provinces of South Africa, and were purposively selected to best represent the South African mining industry. There were approximately 1 700 operating mines and quarries in South Africa, and the industry directly employed around 496 000 people in 2014, with the highest numbers employed in the platinum and gold sectors [33, 34]. Participants from each mine included management, labour representatives, and mine workers. Individuals in mine management and the labour representatives were purposively selected based on their positions. Those in management included the mine, human resource, industrial relations, occupational health and wellness, safety, residence, and transformation managers, or those in equivalent or representative positions. For the purposes of this study, the term 'mine worker' refers to labourers rather than individuals in management or in office-based positions at the mines. The mine workers were selected using convenience sampling, and were recruited from places such as training centres or work groups at the start of shifts, so that production would not be disturbed by removing individuals from workplaces. Workers from a range of job categories, including production workers and artisans, were selected, to enhance the representivity of the study participants.

Interview and focus group guides, and questionnaires, were developed for the study. The guides included open-ended questions to establish what the participants considered to be the main health and safety challenges at the mines, along with the potential contributors. The questionnaires included forced-choice questions regarding socio-demographics, health and safety. Socio-demographic

variables (16-items) related to worker demographics, work factors, socio-economic and living conditions, lifestyle and quality of life. Health and safety were inferred from the presence of a disease, sick leave taken in the previous year, fatigue at work, involvement in an accident at work in the previous year, and job satisfaction. Job satisfaction has previously been associated with both health and safety outcomes [6, 35].

Data collection took place from June to November 2014. The interviews and focus group discussions were conducted in languages understood by the participants. A total of 53 interviews with mine management, 11 interviews with labour representatives, and 14 focus group discussions with mine workers were held, with a total of 205 participants. Voice recordings of the interviews and focus group discussions were made. Questionnaires were completed by 875 mine workers. Research assistants were available to assist the mine workers to complete the questionnaires and to translate questions, where required, to eliminate literacy or language barriers.

The interviews and focus group discussions were translated, where necessary, and transcribed. Thematic analysis was used to identify the main topics from the discussions. Questionnaire responses were captured electronically. Descriptive and inferential statistics were performed. Chi-squared analyses were performed to assess associations between socio-demographic and health, safety and wellness data ($p < 0.05$). Data were grouped or omitted, where necessary, to allow for appropriate statistical analyses. Comparisons were made between the qualitative and the quantitative data.

Ethical approval to conduct this study was obtained from the CSIR Research Ethics Committee (reference number 85/2013) and from the University of the Witwatersrand Human Research Ethics Committee (clearance certificate number M140222). Permission to conduct the study was granted by each of the participating mines. Voluntary informed consent was received from each of the study participants. All of the data collected in this study remain confidential.

3. Results

3.1. Perceptions of health and safety

Various health and safety challenges were reported in the interviews and focus group discussions. Those in mine management and the labour representatives

generally considered HIV/AIDS and TB to be the main health challenges that were faced by the mine workers. The migrant labour system was seen to contribute to this, as some workers had partners both at the mine and in the areas from where they originated. Prostitution was also noted as a contributing factor. A manager stated: “*HIV/AIDS and TB are the main challenges*” while one of the workers admitted: “*... since we are staying here without our wives, there are challenges there as we have needs. We end up getting infected with diseases*”.

Respiratory diseases, such as asthma and chronic obstructive respiratory disease, were mentioned by all participant groups, and were the main concerns amongst the participating mine workers. Silicosis was, to a lesser extent, also identified as a problem. These respiratory diseases were considered to result primarily from dust from the mines. A labour representative said: “*Underground there is the dust, and it’s making people sick*” while one of the workers commented that “*Dust and smoke from the machines is killing us*”. Smoke from coal or wood fires that some cooked on, and dust from the roads, were also perceived to contribute to these conditions. A participant added: “*There is also dust in the township, as there are not tarred roads; this leads to coughs. People also don’t have enough money for electricity and therefore use coal; this smoke also leads to coughing*”. Other occupational diseases, including noise-induced hearing loss, were also mentioned. The mine workers said that working conditions, such as exposure to chemicals, heat, and poor hygiene, were additional problems.

Chronic or non-communicable diseases, such as high blood pressure and diabetes, were reported to be prevalent. The participants related these diseases to lifestyle, such as poor nutrition, and a potential lack of recreational exercise, particularly in the more mechanised mines. For example, one manager said: “*Lifestyle diseases are a big problem ... People don’t exercise and activity levels are relatively low*”. A lack of nutrition or balanced diets, and alcohol and drug abuse, were further challenges. More common diseases like influenza and pneumonia, and headaches and stomach cramps, were also mentioned. Participants commented: “*In the informal settlements there is poorer food and nutrition, and this leads to illness such as flu and stomach cramps, which in turn affects performance at work*”, “*If you get little money you can’t afford to buy healthy food. Then you become unhealthy. We are dependent on loans*”, and “*If people don’t have enough money and there*

is not enough recreation available then this leads to high levels of drinking over weekends". The participants also associated poor living conditions, such as a lack of access to water, electricity, decent sanitation, or refuse removal, and cramped living conditions, with the spread of illness. Participants mentioned: "Hygiene issues at the community are also a concern. You'll find that 30 people are renting rooms in one block. Of those 30 rooms you'll find that there are only two pit toilets", and "In the villages there are pit latrines and these could leak into the water systems. For refuse removal, people are burning their rubbish, which can be poisonous." Aspects such as fatigue and stress were also perceived to contribute to poor health. Poor health, in turn, was perceived to lead to absenteeism and poor performance at work.

Safety was a reported priority at the mines. However, the work environments were hazardous, and incidents and injuries occurred, such as those related to fall of ground, mobile machinery, manual materials handling, and slips, trips and falls. Worker behaviour and non-compliance with rules were the main safety challenges that were reported. Workers often took shortcuts to get their work completed quickly. A manager said: "We've got procedures in place, but my main worry is people taking chances, people not complying with procedures, and they end up getting injured". A culture of non-compliance with rules outside of the workplace was seen to contribute to these problems at work. It was noted that workers faced a high level of risk outside of the workplace and, as a result, became tolerant of risks within the workplace. A participant commented: "As South Africans we have a high tolerance to risk... For example, on the streets people don't stop at stop streets and (they) speed... (People drive on) non-roadworthy taxis... People grow up in such an environment of non-compliance, and then we expect people to have a different approach to work and have a different mind-set to safety".

Additionally, workers were seen to take shortcuts when there was a lack of materials with which to work or when under pressure to meet their production targets. Related comments by participants included: "When we don't have enough equipment we take shortcuts and we end up getting injured", "Workers start taking shortcuts when working under pressure", "Even us, we do take shortcuts sometimes. You see every day before we work, we talk about safety, but when you work it's a different story", and "Safety is preached but not practiced in the work environment. Everything is about production". The bonus

system was a potential problem, and some felt that production was incentivised over safety.

Insufficient supply of personal protective equipment (PPE) was also a potential cause for accidents. A worker commented: "A lack of PPE is a problem. We only get one overall. So if I want more they have to deduct (the cost) from my salary". Workers sometimes felt unable to practice safety laws or to refuse to work in unsafe conditions, for fear of being penalised for poor work performance or because of pressure from their superiors, including management, shift bosses and supervisors. A worker commented: "Sometimes even if the conditions are not good, people are just told to go in and work because they are scared of shift bosses, so they just work in unsafe areas". A culture of blame was a related problem. Other safety challenges that were noted included a lack of education and understanding.

Fatigue and stress were further safety risks. Fatigue was attributed to various factors, such as the physically demanding work performed, harsh work conditions, long work hours, shift configurations, long travelling distances to work, poor health, use of medication, poor diets, alcohol use, insufficient sleep, potentially poor conditions in which to sleep, and psychological problems. Participants commented: "Fatigue is a challenge, as a result of the travelling distances to the mine, along with shift configurations", and "Even the areas that you live counts. Because you find that if there is too much noise you can't rest well". Stress was seen to lead to a lack of focus and concentration at work. Stress was associated primarily with financial problems. Examples of participant comments were: "People are suffering from emotional strain and bring their problems to work", "Stress results from the conditions of the work, and finances", and "Immediately when you are stressed and lose concentration you end up making mistakes".

3.2. Mine workers' data

Characteristics of the mine workers who completed the questionnaire are shown in Table 1. Two thirds of the participants (67%) were recruited from gold and platinum mines. Most were male (89%); this reflected the proportion of males to females in the industry at the time. The majority were aged 30 to 39 years (44%), and were black (92%). Most were South African (86%), while the remainder came from neighbouring countries. More than half (59%) had an educational qualification of Grade 12 (completed

Table 1
Participant characteristics (N = 875)

Variable	Category	Number of participants	Percentage of participants
Sex	Male	746	89
	Female	96	11
Age (years)	<30	218	25
	30–39	370	44
	40–49	174	21
	≥50	88	10
Race	Black	793	92
	Other	68	8
Nationality	South African	749	86
	Other	118	14
Education	≤Grade 7	143	17
	Grade 8–11	199	24
	Grade 12	334	40
	>Grade 12	158	19
Commodity of mine	Gold	261	30
	Platinum	325	37
	Coal	91	10
	Diamond	110	13
	Manganese	88	10
Work status	Permanent	705	82
	Contract	154	18
Length of service (years)	<1	100	12
	1–4	323	37
	5–9	232	27
	≥10	207	24
Average monthly income	≤R5000	247	29
	R5001–R7500	256	30
	R7501–R10000	139	16
	>R10000	212	25
House type	Formal brick dwelling	317	39
	Flat/townhouse/cottage	100	12
	Hostel	126	15
	Shack/Informal housing	116	14
	Backroom	161	20
Sharing of room (number of people)	0 (no one else)	307	36
	1	278	32
	2	127	15
	≥3	144	17
Sleep received	<6 hours	449	52
	≥6 hours	409	48
Exercise	Never	393	46
	Once a week or less	237	28
	More than once a week	229	27
Smoke cigarettes	Yes	201	24
	No	622	76
Alcohol use	Never	397	48
	Once a month or less	205	25
	Once a week or less	146	17
	More than once a week	87	10
Quality of life	Good	432	51
	Not good	421	49
Disease	None	607	71
	One or more	247	29
Sick leave (previous year)	<5 days	622	73
	≥5 days	228	27
Fatigue	Not fatigued	702	84
	Fatigued	138	16
Accident at work (previous year)	No	773	92
	Yes	67	8
Job satisfaction	Satisfied	472	55
	Not satisfied	386	45

secondary education) or higher. The majority (82%) were permanent employees. Around half (49%) had been working at the respective mines for less than five years. Only a quarter (25%) usually earned a net monthly income of more than R10 000. Participants resided in a range of dwellings, including formal brick houses, flats or townhouses, mine hostels, informal housing and backrooms. Over a third (36%) did not share a room with anyone, 31% shared with one other person, and 32% shared with two or more others. Around half (52%) usually received less than six hours of sleep in the 24 hours before a work shift. A quarter (24%) smoked, 27% drank alcohol more frequently than once a month, and 46% never exercised physically in their leisure time. Around half (51%) rated their quality of life as "good".

In terms of health, safety and wellness, 29% of the participants reported having at least one disease or disorder. High blood pressure was the most commonly reported condition, while hearing loss, high cholesterol, diabetes, tuberculosis, and silicosis were also listed. Over a quarter (27%) had taken five or more days of sick leave in the previous 12 months. Fatigue was indicated by 16%, who usually felt "very sleepy" when at work; and 8% of the participants had been involved in an accident at work in the previous 12 months. Over half (55%) were satisfied with their jobs.

Associations between the socio-demographic and the health, safety and wellness variables are shown in Table 2. No significant differences were evident in terms of sex. According to age, it was evident that the older workers tended to have more diseases, but higher levels of job satisfaction than the younger workers. The black participants reported a lower rate of disease, but a higher prevalence of fatigue, and lower job satisfaction than the participants of other races. The South African participants reported a lower rate of disease and relatively fewer accidents than the foreign migrant workers. Those with lower levels of education had a higher prevalence of disease and accidents, but higher levels of job satisfaction than those with higher qualifications.

According to work sector, the highest prevalence of disease was in the gold and manganese mines, the highest rate of accidents at work was in the gold and platinum mines, while the highest rating of job satisfaction was in the coal sector. Permanent employees reported a higher rate of disease, sick leave, and fatigue than the contract workers. Increased length of service was associated with a higher prevalence of disease; those who had been working for less than a

year had the lowest rate of sick leave; and job satisfaction was lowest for those who had been working for one to 10 years.

Lower incomes were associated with increased fatigue and more accidents at work. The lowest rates of disease and fatigue were reported by those living in formal brick houses, the highest accident rates were reported by hostel-dwellers, and the lowest job satisfaction was reported by those living in informal dwellings and backrooms. Higher room occupancy rates were associated with increased prevalence of accidents at work. Those who usually received less sleep were more likely to be fatigued and to have lower levels of job satisfaction than those who received more sleep. Those who did not exercise had a higher prevalence of disease, fatigue and accidents than those who did recreational exercise. Drinking alcohol more frequently than once a week was associated with a higher prevalence of disease. Those reporting better quality of life had lower levels of sick leave, fatigue and accidents, and higher job satisfaction.

4. Discussion

Socio-demographic characteristics were associated with the prevalence of disease, sick leave, fatigue, accidents and job satisfaction of mine workers at eight mines in South Africa. Health challenges faced by the mine workers included non-communicable illnesses, HIV/AIDS, TB, and respiratory diseases. Safety challenges that were highlighted included behavioural aspects such as non-compliance with rules and taking of shortcuts, production pressure, fatigue, and stress. These findings reflect what has previously been reported in the literature [4, 5, 22]. Additionally, poor health could result in increased fatigue, accidents, absenteeism and reduced job satisfaction; increased fatigue and accidents could lead to detriments in health and job satisfaction, and increased absenteeism; and reduced job satisfaction could result in increased accident risk, fatigue and absenteeism.

Age and length of service were related in terms of the associations with health and safety data. Data from the questionnaires suggested that health was better in younger individuals, and it was expected that those who were older would have a higher incidence of disease [35, 36]. In this case, the "healthy worker effect", which refers to healthier workers remaining in work longer, did not appear to apply. Length of

Table 2
Associations of socio-demographic characteristics with health, safety and wellness variables* (N = 875)

Variable	Category	Disease (%)		Sick leave (%)		Fatigue (%)		Accident at work (%)		Job satisfaction (%)	
		No	Yes	<5 days	≥5 days	No	Yes	No	Yes	Satisfied	Not satisfied
Sex	Male	71	29	73	27	83	17	92	8	54	46
	Female	77	23	72	28	86	14	95	4	60	40
Age (years)	<30	85	15	73	27	84	16	95	5	56	44
	30–39	75	25	70	30	82	18	93	8	50	50
	40–49	56	44	76	24	84	16	90	10	57	43
	≥50	52	48	80	20	87	13	91	9	72	28
Race	Black	73	27	73	27	82	18	92	8	53	47
	Other	55	45	75	25	96	4	97	3	69	31
Nationality	South African	73	27	73	27	84	16	93	7	54	46
	Other	61	39	77	23	80	20	84	16	63	37
Education	≤Grade 7	54	46	72	28	85	15	87	13	71	29
	Grade 8–11	68	32	72	28	81	19	90	10	55	45
	Grade 12	78	22	74	26	83	17	95	5	49	51
	>Grade 12	77	23	72	28	86	14	95	5	51	49
Commodity of mine	Gold	57	43	68	32	79	21	88	12	60	40
	Platinum	79	21	75	25	82	18	92	8	48	52
	Coal	74	26	80	20	94	6	97	3	68	32
	Diamond	81	19	78	22	88	12	96	4	58	42
	Manganese	64	36	69	31	83	17	96	4	50	50
Work status	Permanent	67	33	70	30	83	17	91	9	56	44
	Contract	88	12	86	14	86	14	95	5	50	50
Length of service (years)	<1	85	15	88	12	86	14	97	3	61	39
	1–4	79	21	71	29	86	14	93	7	49	51
	5–9	74	26	68	32	78	22	91	9	53	47
	≥10	49	51	75	25	86	14	90	10	63	37
Average monthly income	≤R5000	76	24	75	25	76	24	92	8	53	47
	R5001-R7500	68	32	69	31	83	17	89	11	53	47
	R7501-R10000	71	29	70	30	88	12	92	8	57	43
	>R10000	69	31	78	22	90	10	96	4	59	41
House type	Formal brick dwelling	76	24	75	25	90	10	94	6	58	42
	Flat/townhouse/cottage	61	39	71	29	82	18	90	10	56	44
	Hostel	65	35	72	28	76	24	82	18	62	38
	Shack/Informal housing	71	29	76	24	80	20	91	9	44	56
	Backroom	72	28	70	30	82	18	95	5	50	50
Sharing of room (number of people)	0 (no one else)	76	24	77	23	84	16	92	8	53	47
	1	69	31	75	25	87	13	96	4	59	41
	2	65	35	66	34	79	21	88	12	54	46
Sleep received	≥3	71	29	68	32	80	20	87	13	50	50
	<6 hours	69	31	72	28	77	23	91	9	50	50
	≥6 hours	71	27	74	26	91	9	93	7	60	40
Exercise	Never	67	33	71	29	79	21	89	11	54	46
	Once a week or less	74	26	76	24	89	11	96	4	52	48
	More than once a week	76	24	75	25	86	14	95	5	60	40
Smoke cigarettes	Yes	76	24	72	28	88	12	93	7	58	42
	No	70	30	74	26	82	17	92	8	54	46
Alcohol use	Never	69	31	76	24	83	17	90	10	58	42
	Once a month or less	79	21	73	27	87	13	93	7	53	47
	Once a week or less	73	27	68	32	85	15	94	6	50	50
	More than once a week	62	38	71	29	75	25	95	5	50	50
Quality of life	Good	73	27	78	22	92	8	96	4	72	27
	Not good	69	31	68	32	76	24	88	8	39	63

*Values in italics indicate statistical significance ($p < 0.05$).

service was associated with increased risk of disease, which was likely related to the age of the participants; increased length of service could also be associated with increased cumulative exposure to occupational

hazards. Meanwhile, job satisfaction was highest in the oldest group of participants, and in those with more than 10 years of service. It is possible that those with high levels of job satisfaction are likely

to stay in their jobs for longer periods. It is also possible that longer length of service can contribute to increased job satisfaction as a result of potential benefits, such as improved pay or promotion, and familiarity or experience that can enable jobs demands to be fulfilled more efficiently. Lowest rates of sick leave were found for those working for less than a year, which was attributed to the shorter reporting period.

Race and migrancy were associated with health, safety and wellbeing. Higher rates of fatigue and job dissatisfaction were reported by the black participants. Historical factors have often resulted in blacks having poorer socioeconomic status and health than other racial groups, and the findings could also reflect a higher prevalence of black workers in more physically demanding jobs [30, 37]. The finding that black mine workers had a lower incidence of disease was unexpected. South Africans reported better health and a lower rate of accidents than foreign workers, which could be a result of better access to health-care and better social and living conditions than those from neighbouring countries. Reported risks facing migrant workers included HIV/AIDs, TB, healthcare service disruptions, and stress from living apart from families [22].

Those with higher levels of education had better health and a lower rate of accidents. Molarius et al. (2006) found that low educational level was associated with poor self-rated health in males, but not in females, while Beemsterboer et al. (2009) reported higher sick leave frequency and duration in those with lower education [32, 35]. Those with higher levels of education may better understand and mitigate health and safety risks, and potentially have less hazardous working conditions and better income than those with lower levels of education [27, 28]. Meanwhile, those with the lowest level of education had the highest levels of job satisfaction. Those with higher levels of education might have felt that the menial work tasks and status were not suited to their qualifications.

Work-related factors were also associated with the health and safety variables. Poorer health was recorded by those in the gold and manganese mines, which could reflect tasks and environments in and surrounding these mines [28]. Williams et al. (2010) noted that specific work conditions are likely to have an effect on health due to differences in exposure to occupational hazards [30]. Participants from the coal, diamond and manganese sectors had lower rates of accidents, probably because these mines are generally less labour-intensive and more mechanised than

gold and platinum mines. Furthermore, salaries in the gold and platinum mines were generally lower than the other sectors that were included in the study. Those in the coal mine had the highest job satisfaction levels, which could reflect the nature of the work and socioeconomic conditions. Work status was associated with self-rated health in a study by Molarius et al. (2006) [32]. However, it was unexpected that permanent employees would report a higher prevalence of disease, sick leave, and fatigue than contract workers, as contract work in the industry is often associated with poorer work and economic conditions.

Income and housing were associated with both fatigue and accidents at work, and house type was further associated with the prevalence of disease and job satisfaction. Lower incomes could be associated with poorer safety outcomes because financial constraints lead to higher levels of stress which, in turn, lead to a lack of focus at work, and impaired sleep between shifts. Higher incomes could also be used to obtain better nutrition, living conditions, and access to health services [28]. Additionally, it is likely that those with lower incomes were employed in more labour-intensive and hazardous jobs than higher income earners [27]. Poorer living conditions are associated with poorer health and fatigue, for reasons including a lack of access to amenities and services [28, 38]. The lower prevalence of disease and fatigue reported by those living in formal brick houses could reflect the better conditions in these dwellings. Reduced job satisfaction was found for those in informal accommodation, and could be associated with poor socioeconomic status, not having housing provided by the employer, poorer living conditions and amenities, and increased stress. Social stressors of living away from families in hostel accommodation also possibly contribute to a lack of focus and accidents at work. Sharing a room with a number of individuals was also associated with increased accidents at work. This finding could potentially be a result of the mind-set of workers, as those with higher domestic crowding could experience higher strain. Galobardes et al. (2006) noted that overcrowded households are often those with few economic resources, and overcrowding may also have a direct effect on health through the spread of infectious diseases [28].

Lifestyle factors and quality of life were associated with health, safety and wellbeing. A lack of exercise was associated with an increased prevalence of disease and a higher fatigue and accident risk. Conversely, poor health, fatigue, and having been involved in a work accident could also contribute to

less exercise being performed. Molarius et al. (2006) reported that a lack of exercise is associated with obesity and chronic disease, and d'Errico et al. (2007) recorded exercise level as a risk factor for injury at work [27, 32]. Increased prevalence of disease was also found in those who frequently drank alcohol. A positive association between sick leave taken and alcohol consumption has been previously found [35]. Insufficient sleep (e.g. less than six hours before a work shift) was a significant contributor to fatigue, as expected, and was associated with reduced job satisfaction. Halvani et al. (2009) similarly noted that fatigue was a cause of job dissatisfaction [39]. Poorer reported quality of life was associated with higher levels of sick leave, fatigue, accidents and job satisfaction, as expected, and could be causal or consequential.

4.1. Limitations

This study relied on the use of self-report data. Thus, factors such as mood, attitudes, and personality could affect subjective responses, such as fatigue, quality of life, and job satisfaction. It is also possible that variables that were not recorded in the questionnaire could affect health, safety and job satisfaction. As this was not a longitudinal study, cause and effect between the independent and dependant variables were not assessed, but could only be assumed.

A further limitation is that the study sample does not fully represent the South African mining industry. Data were collected at only eight of the many mines in the country, and from a small proportion of participants compared to those directly employed in the industry. Furthermore, the use of convenience sampling as a method of selecting study participants was a limitation, as the participants may not represent workers at the study sites. However, random sampling was not feasible for this study, and the results might be biased, for example in terms of health and safety outcomes. Additionally, the study was conducted in 2014. Data were not published sooner because of one of the funders' concerns about the sensitivity of the findings. As such, numerous interventions in the industry over the past few years are not reflected in this paper. However, the long term health and safety outcomes resulting from changes in the industry may, in any case, take a number of years to manifest. Despite these limitations, the findings from this study provide valuable insight into a number of factors currently affecting the mining industry in the country.

5. Conclusion

Socio-demographic factors were associated with health, safety, and job satisfaction in mine workers in South Africa in this study. These socio-demographic factors included age, length of service, race, nationality, education, mining sector, work status, income, housing, sleep received, exercise, alcohol use, and quality of life.

Recommendations to improve health and safety in the South African mining industry can be guided by outcomes of this study. For example, improved education and awareness, improved working conditions, and continued improvements to housing available for workers could lead to improved health, safety and job satisfaction. Socio-demographic factors should be considered in workplace health and safety programmes. Furthermore, interventions already implemented in the industry, including those to improve the living conditions of mine workers, to increase local employment, and educational programmes, are expected to yield positive results. Improved health, safety and wellbeing in the South African mining industry will contribute to its sustainability.

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Conflict of interest

None to report.

References

- [1] Kramer DM, Holness DL, Haynes E, McMillan K, Berriault C, Kalenge S, Lightfoot N. From awareness to action: Sudbury, mining and occupational disease in a time of change. *Work*. 2017;58:149-62.
- [2] Nowrouzi-Kia B, Gohar B, Casole J, Chidu C, Dumond J, McDougall A, Nowrouzi-Kia B. A systematic review

- of lost-time injuries in the global mining industry. *Work*. 2018;60:49-61.
- [3] Sanmiquel L, Rossell JM, Vintró C, Freijo M. Influence of occupational safety management on the incidence rate of occupational accidents in the Spanish industrial and ornamental stone mining. *Work*. 2014;49:307-14.
- [4] Amponsah-Taiwah K, Jain A, Leka S, Hollis D, Cox T. Examining psychosocial and physical hazards in the Ghanaian mining industry and their implications for employees' safety experience. *J Safety Res*. 2013;45:75-84.
- [5] Donoghue A. Occupational health hazards in mining: An overview. *Occup Med*. 2004;54:283-9.
- [6] Ghosh AK, Bhattacharjee A, Chau N. Relationships of working conditions and individual characteristics to occupational injuries: A case-control study in coal miners. *J Occup Health*. 2004;46:470-80.
- [7] Hermanus MA. Occupational health and safety in mining – status, new developments, and concerns. *J South Afr Inst Min Metall*. 2007;107:531-8.
- [8] Bhattacharjee A, Bertrand J, Meyer J, Benamghar L, Otero Sierra C, Michaely J, Ghosh AK, d'Houtaud A, Mur J, Chau N, Lorhandicap Group. Relationships of physical job tasks and living conditions with occupational injuries in coal miners. *Ind Health*. 2007;45:352-8.
- [9] d'Souza MS, Karkada SN, Somayaji G. Factors associated with health-related quality of life among Indian women in mining and agriculture. *Health Qual Life Outcomes*. 2013;11:1-16.
- [10] Shandro JA, Veiga MM, Shoveller J, Scoble M, Koehoorn M. Perspectives on community health issues and the mining boom-bust cycle. *Resources Policy*. 2011;36:178-86.
- [11] Yokoyama K, Iijima S, Ito H, Kan M. The socio-economic impact of occupational diseases and injuries. *Ind Health*. 2013;51:459-61.
- [12] Bezuidenhout, A, Buhlungu S. From compounded to fragmented labour: Mineworkers and the demise of compounds in South Africa. *Antipode*. 2010;43:237-63.
- [13] Marais L, Venter A. Compound, but... Mineworker housing needs in post-apartheid South Africa. *Africa Insight*. 2016;36:53-62.
- [14] South Africa. Publication of the Housing and Living Conditions Standard for the Minerals Industry. *Government Gazette No. 32166 29 Apr*. Department of Minerals & Energy; 2009.
- [15] Lewis P. Housing and occupational health and safety in the South African mining industry. Final Report. Safety in Mines Research Advisory Council. SIM 02-01-01; 2003.
- [16] South Africa. Broad-Based Socio-Economic Empowerment Charter for the South African Mining Industry (Act No. 53 of 2003). Department of Minerals & Energy; 2003.
- [17] South Africa. Mineral and Petroleum Resources Development Act (Act No. 28 of 2002). Department of Minerals & Energy; 2002.
- [18] South Africa. Mineral and Petroleum Resources Development Amendment Act (Act No. 49 of 2008). Department of Minerals & Energy; 2008.
- [19] Bench Marks Foundation. Coping with unsustainability. Policy Gap 7: Lonmin 2003 – 2012. Johannesburg; 2013.
- [20] Cronjé F, Chenga S. Sustainable social development in the South African mining sector. *Development Southern Africa*. 2009;26:413-27.
- [21] South Africa. Assessment of the Broad-Based Socio-Economic empowerment Charter for the South African Mining Industry. Department of Mineral Resources; 2015.
- [22] Stuckler D, Basu S, McKee M, Lurie M. Mining and risk of tuberculosis in sub-Saharan Africa. *Am J Public Health*. 2011;101:524-30.
- [23] Dias B, Chunderdooj B, Hurkchund H. Effects of HIV/AIDS on Occupational Health and Safety. Safety in Mines Research Advisory Council. SIM 03-09-05; 2006.
- [24] Lim MSC, Murray J, Dowdeswell RJ, Glynn JR, Sonnenberg P. Unnatural deaths in South African platinum miners, 1992-2008. *PLoS ONE*. 2011;6:e22807.
- [25] Coovadia H, Jewkes R, Barron P, Sanders D, McIntyre D. The health and health system of South Africa: Historical roots of current public health challenges. *Lancet*. 2009;374:817-34.
- [26] American Psychological Association. Ethnic and racial minorities and socioeconomic status; 2013 [accessed 2018 April 25]. Available from: <http://www.apa.org/pi/ses/resources/publications/index.aspx>.
- [27] d'Erriço A, Punnett L, Cifuentes M, Boyer J, Tessler J, Gore R, Scollin P, Slatin C. Hospital injury rates in relation to socioeconomic status and working conditions. *Occup Environ Med*. 2007;64:325-33.
- [28] Galobardes B, Shaw M, Lawlor DA, Lynch JW, Smith GD. Indicators of socioeconomic position (part 1). *J Epidemiol Community*. 2016;60:7-12.
- [29] Galobardes B, Shaw M, Lawlor DA, Lynch JW. Indicators of socioeconomic position (part 2). *J Epidemiol Community*. 2006;60:95-101.
- [30] Williams DR, Mohammed SA, Leavell J, Collins C. Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. *Ann N Y Acad Sci*. 2010;1186:69-101.
- [31] American Psychological Association. Children, youth, and families and socioeconomic status; 2013 [accessed 2018 April 25]. Available from: <http://www.apa.org/pi/ses/resources/publications/index.aspx>.
- [32] Molarius A, Berglund K, Eriksson C, Lambe M, Nordström E, Eriksson HG, Feldman I. Socioeconomic conditions, lifestyle factors, and self-rated health among men and women in Sweden. *Eur J Public Health*. 2006;17:125-33.
- [33] Chamber of Mines of South Africa. Facts and Figures 2016. Johannesburg; 2017 [accessed 2018 April 25]. Available from: <https://www.mineralscouncil.org.za/industry-news/publications/facts-and-figures>.
- [34] Department of Mineral Resources. Operating Mines; 2017 [accessed 2018 April 25]. Available from: <http://www.dmr.gov.za/mineral-policy-promotion/operating-mines>.
- [35] Beemsterboer W, Stewart R, Groothof J, Nijhuis F. A literature review on sick leave determinants. *Int J Occup Med Environ Health*. 2009;22:169-79.
- [36] Koukoulis S, Vlachonikolis IG, Philalithis A. Socio-demographic factors and self-reported functional status: The significance of social support. *BMC Health Serv Res*. 2002;2:20. doi: 10.1186/1472-6963-2-20
- [37] Leibbrandt MV, Woolard I, Finn A, Argent J. Trends in South African income distribution and poverty since the fall of apartheid. *OECD Social, Employment and Migration Working Papers*, No. 101. Paris: OECD Publishing; 2010.
- [38] Pelders J, Nelson G. Living conditions of mine workers from eight mines in South Africa. *Development Southern Africa*. 2019;36:265-82. doi: 10.1080/0376835X.2018.1456909
- [39] Halvani G, Zare M, Hobobati H. The fatigue in workers of Iran Central Iron Ore Company in Yazd. *Int J Occup Med Environ Health*. 2009;22:19-26.