

Ergonomic Factors Associated with Lower Back Pain Amongst Load-Haul-Dump Truck Operators at Freda Rebecca Gold Mine, Bindura, Zimbabwe

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Abstract

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Background

Lower back pain is broadly defined discomfort or pain within the lumbar region of the human spine and it is the leading cause of function limitation, resulting in significant losses in productivity and billions of dollars in medical costs yearly. Its prevalence is estimated to be associated with a lower socioeconomic status and lower education levels. The intention of this study was to analyse the ergonomic factors linked with lower back pain amongst load-haul-dump truck operators at Freda Rebecca Gold Mine.

Methods

A descriptive non-interventional cross-sectional study was used with the probit model and the chi-square used as the estimation techniques. The simple random sampling method was adopted in the survey with a total of 140 respondents who are all employees at Freda Rebecca Gold Mine, Zimbabwe. The Statistical Package Stata was used 12.

Results

The study indicated that 77.8% of the respondents suffered lower back pain at one time or the other. Results showed an association between lower back pain with demographic factors such as experience, gender and age, organisational factors such as type and duration of shift work, biomechanical factors such as lifting and handling protocols, postures, whole body vibrations exposure resulting from work related conditions such as road conditions, equipment conditions and design and other psychosocial factors.

Conclusion

Therefore, the study promoted the adoption of a broad approach to reduction and management of LBP, including equipment engineering solutions to manage whole body vibration exposure, operator education, equipment assistive technology, strong equipment maintenance regime. Further interventions include adoption of best practice systems and improved clinical treatment systems.

Keywords: *Load haul and drive, whole body vibration, lower back pain*

INTRODUCTION

Globally, the use of earth-moving equipment in the mining sector is acknowledged as leading to hazardous levels of vibration exposure. The burden of lower back pain is huge in both the developed and the third world countries like Zimbabwe. Load-Haul-Dump (LHD) trucks are central to mining, and the operation of the trucks is characterised by repetitive tasks for instance driving on rough surfaces which exposes the operator to whole body vibration (WBV). Operators who use LHDs have the highest incidences of lower back pain (LBP) and also neck discomfort compared to other users of mobile pieces of machinery, become unprotected from WBV. Sedentary sitting positions, poor materials handling, awkward back, neck twisting and sitting with an awkward back posture are factors that are related to elevated risks of suffering from lower back pain. Technological changes in the mining sector and mining methods fueled by the need to excel and produce more has seen the traditional manual mining methods being replaced by mechanisation which exposes miners to sedentary routines in equipment operation [1]. This in particular, increases the exposure of operators of LHD trucks and risk of injury due to postural environments and whole-body vibrations [2].

It has elsewhere been observed and concluded that, LBP is probably the biggest cause of occupational disability and injury for LHD truck drivers [3]. LBP is a leading grievance of LHD truck drivers as well as personnel who are exposed to whole body vibrations.[4] LBP is a condition originating from multiple risk factors as well as conditions which are both individual, social, and occupational risk factors which research has linked with the occurrence of this condition, such as gender, age, anthropometric characteristics, historical back traumas, level of education, amount of physical work load, vibrations experienced by the whole body, psychological and psychosocial risk factors [5]. It is also noted that ergonomic risk factors comprising of force exerted, vibration, sitting or working postures, stress, force, repetitive and sedentary postures at extensive levels[4,5]. Ergonomic risk factors are defined as those factors of an occupation that create or, exert a biomechanical stress on the operator [1]. It has been suggested that LHD operators are victims of exposure to multivariate factors which bring about lower back problems. Included are situations like WBV, restrictive body postures and

repetitive bending and even twisting. [3]

These studies further found out that big mobile operators in gold miners are also at a higher LBP risk because of rugged terrain surface overlying gold ore, and usually this is said to be of lesser stability than that of coal deposits [6]. Occupational exposure to WBV by operators has seen a spike in the last twenty to thirty years and one can see clear pattern link between prolonged contact with WBV with certain occupational conditions or ailments like degeneration of the lower back, and disc injuries [6,4]. Other researches have also observed that work related exposure to WBV coming from driving LHD trucks as a critical risk causing LBP for miners [7].

The case study is at an operation called Freda Rebecca Gold Mine (FRGM) Limited, and is located in Bindura, Zimbabwe. The use of LHD vehicles at the organisation is central to the mining methods with an estimated 45 operators and as many as 9 dump trucks. LHD trucks are typically used at FRGM, meaning that the personnel may be exposed to various risky factors and hazards that come with the activity of loading and hauling ore. This research intends to explore ergonomic risk factors causing occupational LBP within LHD truck operators at FRGM, Bindura, Zimbabwe.

METHODS AND MATERIALS

Design and setting

The research adopted a descriptive non-interventional cross-sectional approach conducted at Freda Rebecca Gold Mine and this enabled the researcher to study the entire population at FRGM. The population under study consisted of all 1022 FRGM Mine employees working at the mine. The inclusion criteria covered all FRGM permanent employees and fixed term employees who have been employed for at least 12 months and are still at work. Those that were excluded were employees with lower back pain from previous accidents, deformities, previous injuries of the spine, and pathological backaches from hereditary problems. Temporary, seasonal or casual employees as well as senior management were also excluded from the study. The research thus sought to find out the prevalence of a phenomenon, in this case the prevalence of LBP is assessed to establish a relationship with ergonomic associated factors among employees. Taking a cross-section of the population was useful in obtaining an overall 'picture' at the particular time of the study, like in this case prevalence of LBP in relation to

ergonomic risks among LHD drivers obtained over twelve months at FRGM.

Data collection techniques

Primary data collection was done using questionnaires, with selected participants. Secondary data collection involved a desk review of the FRGM documents, such as reports, records, protocols and other reports as well as a search of any relevant publications. Quantitative data was gathered using closed ended questionnaires during survey. An individual based self-administered questionnaire was adopted as a tool for collection of data which together with an information sheet about the study was distributed to workers at their workplaces.

Secondary data was obtained from the mine clinic information data base where employees diagnosed with LBP are recorded in the clinic register, National Social Security Authority (NSSA) claim forms and compensation forms was also used for data collection. Records of employees discharged on medical grounds were collected and selected employees discharged due to LBP. Safety complaints recorded in safety complaints books which are placed in different places around the mine was used as secondary data to the study.

Statistical analysis

Data was gathered and coded using and analysis was done using Stata 12 package. The researchers then performed data synchronization or iteration, cleaning to ensure consistency and then removed the outliers in the system. Descriptive statistics was used on all explanatory variables to determine the behaviour of the data under this study. Chi square test also performed to determine

the association between our variables of concern. The probit model was adopted as an estimation technique to analyse the relationship of the variables under study. The probit model was then used to perform regression for binary outcome variables (dependent variables with two possibilities) and it estimates the probability of a value falling into either one or two possible binary outcomes.

RESULTS

Participants' demographics characteristics

The results indicate that 89.3% were males and 10.7% were females with n=140. The workers aged between 31 to 40 years constituted 37% (n=52) of the respondents. Those aged between 18-30 years accounted for 34% (n=48) while 19% (n=26) were between 41-49 years, and 10% (n=14) were 50 years and above. It was noted that 55% of respondents had secondary school education, primary level 26.1%, college 16% and university level had the least figure of 3.4%.

Increased pain sensitivity comparison box whisker plots

In a box whisker plot in figure 1. At least 50% of the workers who had pain their sensitivity was 0.4 compared to at least 70% of workers who experienced no increase in pain sensitivity at 0.4. A Wilcoxon signed-rank test highlighted that the median of an increase in pain sensitivity test was statistically insignificant compared to those that never had no increase in pain sensitivity with a p-value of 0.2157.

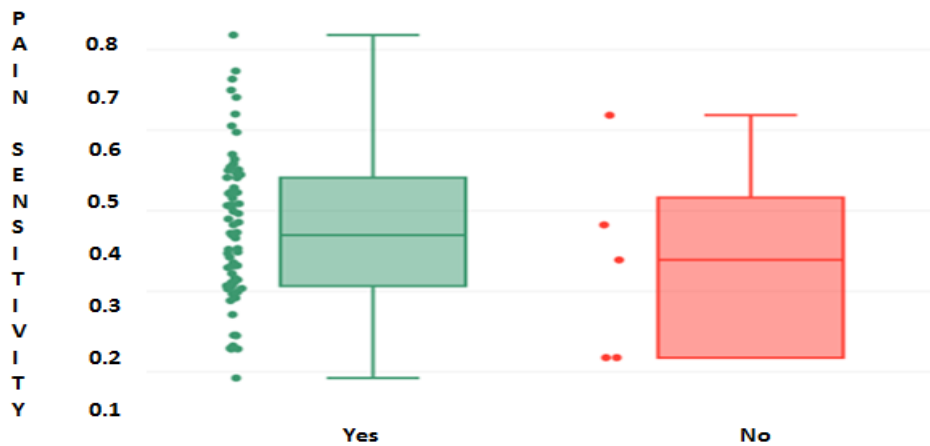


Figure 1: Increased pain sensitivity

Lower back pain conditions recorded across departments at FRGM

A total of 189 chronic and acute back pain conditions were recorded which is an 87% of the total respondents. The department of mining had the highest number of employees with acute and chronic back pain conditions. Acute back pain recorded 43.7% (n=67) while 47% (n=17) was recorded for chronic back pain. Plant processing

recorded a 21.6% with n=33 acute condition and chronic back pain condition 30.5% with n=11. Administration had the least in respect to back pain conditions which recorded 7.8% n=12 acute conditions and recorded 0% of chronic condition recorded. See Figure 2.

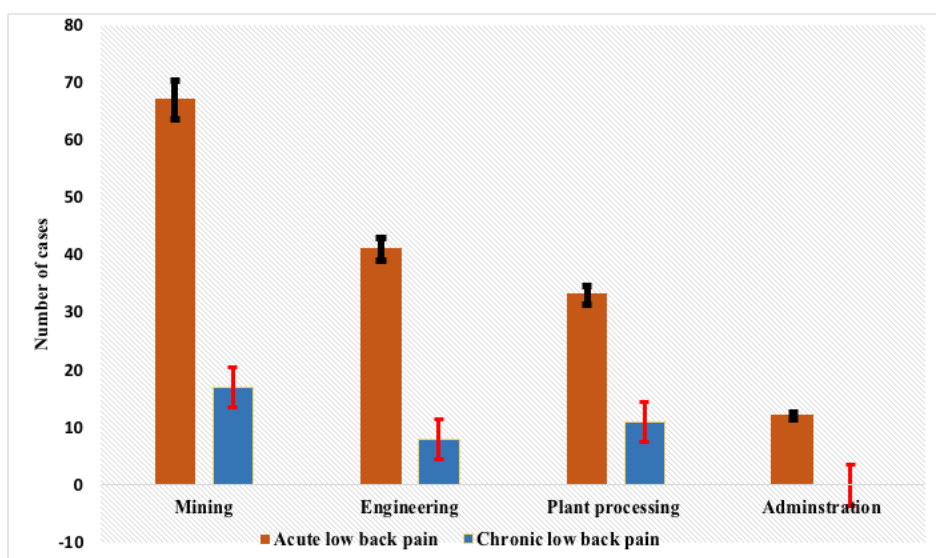


Figure 2: Distribution of lower back pain conditions recorded across departments

Results showing number of employees discharged on medical grounds due to back pain

In Figure 3. A 10.5% was recorded on employees discharged on medical grounds due to lower back pain. Department of mining had the highest employees discharged on medical grounds due to

lower back pain at 52%. Plant processing follows with 30.4% of the total respondents, department of engineering had 17% of the total respondents while, administration was the least with no case of employees discharged due to low back pain.

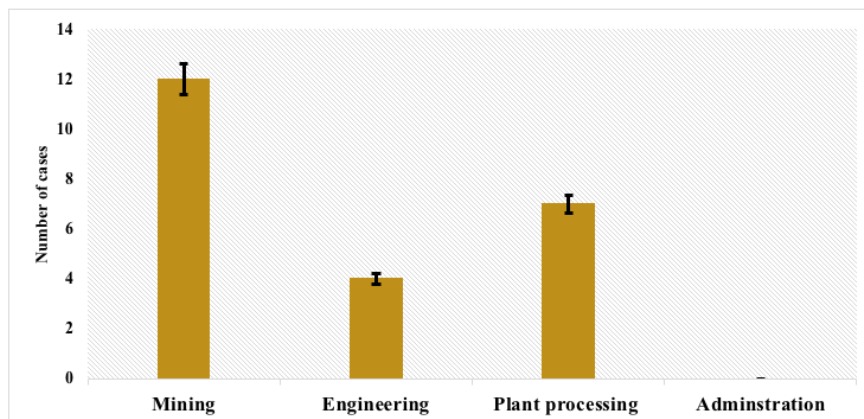


Figure 3: Number of employees discharged on medical grounds due to back pain

Results of occupational factors and lower back pain

Table 2 depicts an association between work experience and LBP with p-value 0.014. Employees feeling no pain recorded 47%, while 35.9% were feeling pain, followed by 12.9% which feels back ache while 9% of employees feel stiffness. Employment status had no association with LBP among mining employees with a p-value of 0.782. A total of 71 employees were feeling LBP from the total respondents of 140 while 63 employees were not feeling LBP out of the total 140 sampled employees regardless of employment status. Working hours equally had no indication of association with a p-value of 0.518. A total of 20 employees were not affected by lower back pain regardless of working hours, 55 were feeling pain, 32 were feeling ache and 33 were feeling stiffness regardless of working hours.

An indication of a relationship between posture and LBP among mining employees is reflected with a p-value < 0.001. Results showed that employees who worked whilst adopting the bending posture actually got affected with LBP. A total of 77.8% of employees feel either pain, stiffness or back ache while 22% felt no back pain regardless of adopting different working postures. There is a relationship between average weight lifted by employees to LBP with a p-value of <0.001. A total of 128 cases of back pain were recorded from the total respondents while 57 employees reported not to feel any pain although

they conduct manual lifting. Employees who lift objects of 50kgs and above have high prevalence of LBP compared to employees who feel back pain when they lift average weights less than 25kgs. A total of 50.8% cases were reported who lift objects weighing above 50kgs while those who lift objects of less than 25kgs had the least prevalence with 15.6%.

There was evidence of an association between shovelling and LBP with p-value of 0.001 and equally so an association between operation of machines (mobile mining equipment) and LBP at FRGM mine with a p-value of 0.035. A total of 141 cases of back problems, which is a 64% of employees sampled felt ache, pain or stiffness while operating mining mobile machinery and a total of 35% of employees reported not to feel back pain while 56 did not operate any machine and 20 did not feel back pain, but operated mining mobile equipment. Repetitive working postures showed evidence of an association with LBP, with a p-value of <0.001. A total of 72 employees were feeling either pain, stiffness or feeling ache regardless of position mostly adopted while working indicating a 51.4% of employees with back pain from the total sample. 68 (48.6%) employees felt no pain regardless of position adopted when executing.

Table 2: Occupational factors and lower back pain among mining employees (n=140)

Variable	No pain	Feeling pain	Feeling ache	Stiffness	P value
Shift hours					
8 hours	6	10	15	9	
9 hours	10	12	3	11	
10 hours	4	33	14	13	0.518
Employment					
Permanent	35	42	3	1	
Casual	28	29	2	0	0.782
Years of work					
0-5years	49	2	2	0	
6-10years	11	3	1	1	
11-15year	6	11	3	0	
16-20years	0	28	8	2	
+20years	0	6	4	3	0.014*
Working posture					
Standing	5	4	3	2	
Sitting	4	10	2	3	
Bending	5	22	23	5	
Standing & bending	5	6	16	6	
All positions	5	1	1	3	
Bending, standing & kneeling	12	0	1	1	<0.001*
Weight in kgs					
No lifting done	54	21	5	0	
<25 kgs	1	1	11	0	
26-50 kgs	2	3	4	2	
>50 kgs	0	27	1	8	<0.001*
Shovelling					
No shovelling	49	9	6	1	
<2hours	3	2	3	1	
>4 hours	5	17	8	4	
Occasionally	29	1	2	0	0.001*
Machine operated					
Drill rig operator	0	2	0	1	
No operation	33	7	8	1	
LHD	3	2	2	2	
Jack hammer	0	1	1	1	
Rock scaler	0	1	2	0	
ADT machines	2	19	23	8	
Tipper truck	11	4	3	3	0.035*
Repetitive working posture					
Standing	43	7	1	0	
Sitting	12	13	4	1	
Bending	13	33	11	2	<0.001*

* significant p-value

Results of the marginal effects from a probit regression model

To sum up, the marginal effects results indicate that a unitary increase in work related factors that is road condition, equipment condition, equipment risk will result in a -0.371 chance of having lower back pain whereas a one-year

increase in age will result in a 0.0205 chance of attaining. Furthermore, biomechanical and psychosocial factors result in about 0.681 and 0.4216 chances of having a LBP respectively. See Table 4.

Table 4: Results of the marginal effects from a probit regression model

Variable	dy/dx	Std. Err.	Z	P-value
Work Related Factors	-0.371	0.1257	-2.95	0.003*
Road conditions				
Equipment conditions				
Equipment design				
Age	-0.0205	0.00861	-2.38	0.017*
Organizational Factors	0.2729	0.1793	1.52	0.128
Environmental factors				
Structure of shift				
Command structure				
Workload				
Biomechanical Factors	0.681	0.08805	7.73	<0.001*
Movement/coordination				
Increased workload				
Physical activity				
Sustained postures				
Psychosocial Factors	0.4216	0.13641	3.09	0.002*
Depression				
Passive pain				
Occupation				
Alcohol & drug abuse				
Gender	0.1267	0.15416	0.82	0.411
Demographic Factors	-0.125	0.19162	-0.65	0.514
Age				
Education				
History of LBP				
Genetics				
Obesity/weight gain				
Increased pain sensitivity				

dy/dx: probability

DISCUSSION

This study sought to investigate the link between ergonomic factors associated with lower back pain amongst load-haul-dump truck operators at Freda Rebecca Gold Mine, Bindura, Zimbabwe.

The results from demographic characteristics of the study participants showed that males constitute the largest number of respondents. This can be attributed to the male domination in the mining sector due to nature of jobs that are in mining environments over females. The most dominant group of employees were between 31-40 years, and this may be attributed to the fact that in the mining industry the most productive age group fall into this category while the least group was recorded on 50 and above years.

The study showed that LBP across the operation mostly affected employees from the department of mining. The result of this research may be explained by the fact that miners are mostly susceptible to ergonomic risks which cause LBP like awkward postures and confined spaces.

Department of mining employees carry out lot more manual work than surface area employees. A similar study of 2008 in Zambia which produced results where department of engineering employees have high prevalence of LBP than any other departments due to exposures to awkward postures and manual lifting [8].

Results showed no indication of association to lower back pain and the findings of this study are actually conflicting and at variance with other studies conducted which indicate an association between working hours and LBP. Some studies are of the view that working long shifts and overtime exposes employees to injuries such as LBP and working in such schedules accounted for a higher injury hazard rate of 61% as compared to normal shifts among Canadian mining employees[9].

The results show that the status of either being a permanent employee or casual was a factor to be considered. This may be due to the fact that employees were exposed to the same ergonomic hazards at the same dose notwithstanding status. Results from a similar

conducted a study in Ghana resembled the current study where employees who are permanent or casual in the mining industry of the more than 38% who complained about back pain the employees had worked more than 36 hours in a week [10].

This research shows the years of service on the job as explanatory to the relationship between working postures and LBP in that the longer the period an employee is exposed to factors that cause LBP the more likelihood of lower back pain developing. Other findings of similar studies have indicated that long sitting, wrong lifting and poor materials handling techniques were also major drivers of the increased rate of LBP within the mining sector. [10,11,6] This is could be so because people who mostly adopted bending positions while working suffered more from LBP.

Results show evidence of an association between the average weights lifted by employees to LBP. This showed that employees who lift objects with weight of more than 50kgs reportedly suffered from LBP more than employees who lift materials with an average weight less than 25kgs. Cases of LBP increased with an increase in total weight lifted by employees. High occurrence of occupational LBP may be attributed to poor lifting practices of heavy loads and improper lifting techniques. The results of this current study are similar to findings by other studies, concluded that poor handling and lifting materials techniques, awkward sitting postures and lifting led to the high prevalence of LBP amongst Ghanaian mining employees [11,10]. Ergonomic aspects of workplace cited in most epidemiological and experimental science as being, hazards for work-related musculoskeletal injuries (WMSIs) for miners, are listed as including exertions, WBV exposures, awkward postures, forceful handling, twisting, jarring and jolting [12]

It has also been observed that repetition in lowering and lifting of objects contributes to the highest number of exposure to back pain problems which were reported amongst miners in China [13].

The results show that there is an association between shovelling or lashing in a mining environment and the incidence of LBP. As a mine related work activity can be explained in relation to LBP experienced by LHD operators as there is an evidence of association between shovelling and LBP with p-value of <0.05. Employees whose tasks did not involve shovelling but carried out other activities were proven to also suffer from back pain. Employees

who did shovelling for a period of <2hrs also suffered lower back pain. Employees who did shovelling for more than 4hrs per day with lower back pain were 47, implying that employees who did shovelling for longer periods of time were more prone to LBP. Employees who occasionally did shovelling recorded few cases of LBP.

The results showed an association between LBP and the operation of mobile mining equipment at FRGM. Cases of back pain reported are probably linked to poor road conditions, poor working postures and whole-body vibration. A research also gave similar results indicating that WBV is linked to high prevalence of LBP among mining employees although there may be some psychosocial risk factors at play like stress [14]. The study results indicated that repetitive working postures significantly contributed to the development of lower back pain among miners at FRGM. There is evidence of association between repetitive working postures and LBP, and this may be attributed to the difference in exposure time and dose response to ergonomic risk factors which mining employees are exposed to. Other previous studies established that, poor working postures for example, manual work, gripping, awkward postures, pulling and pushing, awkward positioning, and repetitive tasks contribute significantly to occurrences of occupational back pain in the mining industry [15].

Employees who adopted mostly bending positions constituted the highest prevalence of LBP, followed by sitting postures, while standing recorded least cases of back pain. This was in agreement with the findings of this current study where sitting and bending have had a prevalence of LBP. Standing posture came up in various studies as a leading cause of LBP in the mining sector. An indication that there is an association between standing for prolonged times and lower back pain among Canadian mining employees was found in another study [16, 12, 14].

In this study, organisational factors, gender, and demographic factors such history of LBP and weight gain were not significant explanatory factors for LBP. The hereunder factors were significant factors in the study.

Work related factors the probit regression analysis results indicated that work related factors were statistically significant in explaining LBP. This further indicated that road conditions, equipment conditions and equipment design result in LBP in the mining industry. The results also established an inverse association between work - related factors (WRF) and LBP

that is, there exists a trade-off between the two variables. Improved WRF can result in reduced LBP risk *ceteris paribus* (all other factors equal agree with these findings. Confirmatory evidence in other studies found factors which include physical set up of workstations, job environment, equipment, vehicular equipment and physical structures as being [17]

Age revealed a statistical significance in causing LBP as explained by the probit regression analysis results. Similar studies carried out in Ethiopia reported age as a significant risk factor for LBP; old age being associated with spine and vertebral disc degeneration as well as loss of connective tissue elasticity that can result in LBP [18]. A study in South Africa, it was established by researchers that age did not emerge as a significant predictor for LBP unlike the present study [19].

Biomechanical factors: the results indicated that these factors played a strong significant statistical explanation for LBP as indicated. This entailed that movement/coordination, increased workload, physical activity, sustained postures have an impact on LBP. These factors did result in LBP in as much as sustaining the same posture and increased work load, increased the chances of LBP by 0.6810 compared to the status quo.

The outcomes of this research showed that LBP was explained by work related factors like age, biomechanical factors, psychosocial factors, whilst organizational factors, gender and demographic factors such as history of LBP, genetics and weight gain are not significant explanatory factors for LBP. An increased degree of psychosocial factors resulted in increased LBP as explained by the positive marginal effect of these factors in the probit regression model analysis. This is actually conflicted with other studies conducted which indicate evidence of association between working hours and LBP. In a study in Ghana a finding was made that where there is low social support, poor job control, stressful psychological environments may cumulatively result in a person being psychosocially being stressed leading to an increase in the incidence of LBP [20,21].

On the basis of the probability of one having LBP as a result of these factors, biomechanical factors played a significant crucial role in causing LBP followed by psychosocial factors, followed by work related factors and lastly age of the individual plan.

CONCLUSION

Microcytic hypochromic anaemia was the most prevalent with no significant mean difference in haemoglobin levels across all ages.

All age groups ranging from toddlers to teens were affected equally in terms of anaemia types and severity. Also, anaemia ranged from moderate to severe. Therefore, if the problem is not looked into and solved, this will likely adversely affect the intellectual capacity of children and the future workforce of the country.

DECLARATION

Competing interests There were no competing interests from all authors in this study.

Ethics approval The study was approved by University of Lusaka Research Ethics Committee.

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