HEALTH STATUS OF LEARNERS OF EDUCATIONAL INSTITUTIONS WITHIN SELEBI PHIKWE Ni-Cu MINE AREA, BOTSWANA

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ABSTRACT

Health effects associated with Ni-Cu mining on learners living within the mining area at Selebi Phikwe were investigated through the administration of questionnaires. Results depicted learners suffering from a wide range of different symptoms and illnesses. 70% of the learners complained of coughs, 77% had influenza/common cold, and 80% had headaches. The repeated coughing, constant influenza/common cold and persistent headaches from which learners suffered, were very significantly higher than those at the control site; and incidences of their occurrence increased with closeness to the mining area. The unusual high occurrences of these ailments and illnesses coupled with associated diseases among learners were attributed to several environmental factors including contaminated particulate air matter (PAM) (rich in sulphur and heavy metals) linked to the mining and smelting of Ni-Cu.

Keywords: death, mining environment, health status, illnesses, Ni-Cu mining, particulate air matter, symptoms

1. INTRODUCTION

The operation of several mining industries such as diamond, gold, nickel, copper, cobalt kaolin and soda ash has been economically rewarding to Botswana. Mining activities unfortunately have adverse effects on the biophysical environment. The consequences of such effects include health hazards to human beings living in the affected areas. Of national strategic importance is how the health of learners (dwelling within the vicinity of mines) is affected. The youths of today and especially the learners are considered to be the leaders of tomorrow's society. In this regard, their health status is crucial.

Currently in Botswana, there is no data-based information available on the health status of learners of educational institutions which can be used to guide planners, decision makers and service providers to successfully organise and/or provide appropriate health services. This study was to assess the health status of learners of educational institutions in the Selebi Phikwe Ni-Cu mine area. It aimed to describe the prevalence of sicknesses and diseases affecting learners, which were more likely to have been caused by the mining and smelting of Ni-Cu. Selebi Phikwe is located in the north-eastern part of Botswana (E27º 47' - 27º 53' and S 22º 55' - 22º 00'S) (Figure 1). It covers an area of about 250 km^2, and has a population of about 50,000 (National

Census, 1991) since 1991. Rapid population expansion from < 5,000 in 1971 to the present population size, has led to pressure on existing social and economic infrastructures (Department of Town and Regional Planning, 1996).

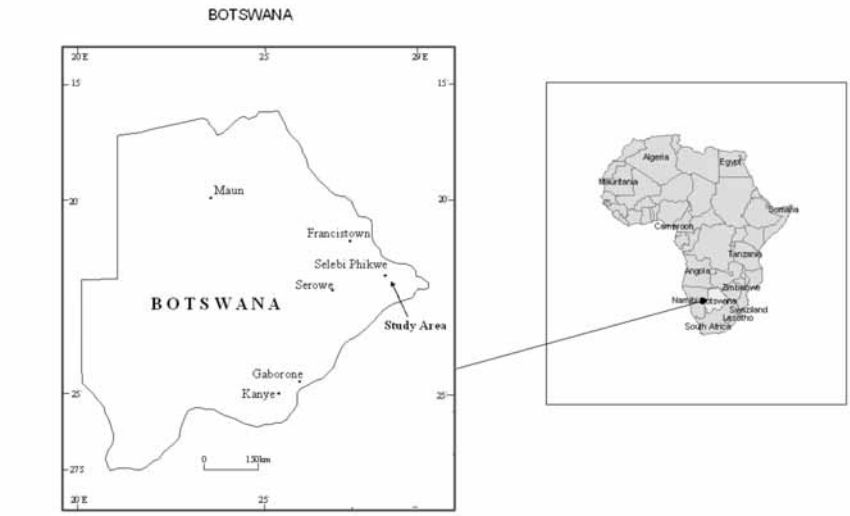

Figure 1: Map of Africa showing Botswana, and map of Botswana indicating the study area (Ekosse et al., 2006).

2. METHODS AND ANALYTICAL TECHNIQUES

2.1 Samples and sampling

This study is part of a wider project which focused on the biophysical environment and human health within a Ni-Cu mine area. The study area was divided into ten sites based on the previous work by Ekosse et al. (2003; 2004) (Figure 2 and Table 1). Sites were divided such that equal population representation was achieved. Each site had particular characteristics. Site one was the industrial area; site two the commercial setting; sites three, four and five were different townships; site six was the old township; site seven the oldest township; site eight the new township; and site nine the outskirting residential area. Site ten was the control site located 56 km from the study area; hence it is not reflected in the map. It was chosen because it had similar vegetation and soil types as the study area.

There were 30 educational institutions in the study area inclusive of the control site, and all of them responded to the questionnaires. In terms of distribution according to study sites, there was one educational institution each in sites one and five, two each in sites three, eight, nine and ten, three each in sites six and seven, five in site two, and nine in site four. Of the thirty educational institutions, nine of them belonged to the Government of Botswana, eleven to the Selebi Phikwe Town Council, eight were privately owned, one belonged to

the mining company, and the ownership of one was not specified. Educational institutions were limited to nursery/kindergarten (20%), primary (50%), secondary (27%) and technical (3%) schools.

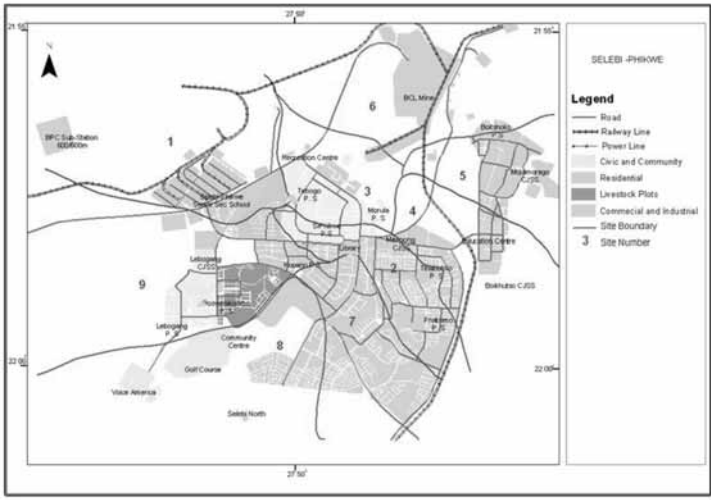

Figure 2: Map of Selebi Phikwe showing the different study sites

Table1: Location and details of sampling sites within the Selebi Phikwe study area

Site	Location and details
1	Industrial area (150 m from the railway crossing)
2	Bosele Hotel (commercial area) and new township
3	Between the township stadium and the mine (behind the
4	Botswana Power Corporation (BPC))
5	Between the township boundary and the railway line (directly behind a Community Junior Secondary School (CJSS))
6	Opposite the Mine hospital, close to the old township
7	Between the mine and explosives storage facilities (close to the old township)
8	Towards the airport (about 250 m from the Airport-Sefophe-
9	Selebi Phikwe Road juncture)
10	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)
	Penultimate bridge before entering the Selebi Phikwe township
	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road

Ten students majoring in Environmental Science from the University of Botswana were recruited as Research Assistants for this research project. Each of the Research Assistants was allocated to a site, and had to administer the questionnaires at their respective sites. The students chosen were those who had residence at Selebi Phikwe, and were bilingual, thus being able to speak, read and write both English and Setswana (the local language spoken by the inhabitants of Selebi Phikwe) languages very fluently. They underwent an orientation course of three days on the administration of questionnaires before being conveyed to Selebi Phikwe where they lived for one month and conducted the survey. The principals/headmasters or designated officials of the educational institutions responded to the questions. Respondents lived in Selebi Phikwe and were able to communicate with the Research Assistants effectively.

Primary data concerning the general health status of learners in educational institutions in the Selebi Phikwe area and those at the control site were obtained by means of structured interviews conducted on a sample sub-population of the different sites based on the overall population density of each site. The questionnaire consisted of three sub-sections: demographical data, general complaints of patients about personal health, and aspects of death. Respondents were advised to read through each question before making a choice. Answers were marked with a cross in the box provided below or next to the choice. Where a question required a written explanation as the response, the respondents were advised to write concisely in the space provided. Where a question required more than one answer, this was made clear. The respondents were encouraged to be very frank with their answers. Furthermore, a documentary search utilised both published and unpublished reports on health hazards of students living close to an area where exploitation of Ni-Cu activities were being conducted.

2.2 Administration of questionnaires and data analysis

Field data obtained through the administration of questionnaires were coded, processed and analysed both qualitatively and quantitatively. The data were processed, analysed and interpreted contextually using the Statistical Package for Social Sciences Version, 2003 (SPSS) software packages and techniques, and Microsoft Excel (MS Excel) was utilised. The data that was collected by means of the questionnaire on the health status of individuals at Selebi-Phikwe Cu-Ni mine area in Botswana was subjected to analysis using SPSS Version 11.0. The first stage of data analysis was coding, which involved the process of assigning numbers to individual observations reported in the questionnaires. Coding was done by assigning numbers from one to n (n being the last observation for each question in the questionnaire). The numbers assigned to these observations have nothing to do with any numerical weight of their own but rather refer to a form of classification scheme. The second stage of data analysis entailed the entry of the data codes directly in the Data Editor which displayed a convenient, spreadsheet-

like method for creating and editing data files. The Data Editor displayed the contents of the active data file and the information in the Data Editor consisted of variables which were used to represent the different types of data. The Data Editor provided two views of data: Data View (which displays the actual data values or defined value labels) and Variable View (which displays variable definition information, including defined variable and value labels and data type). In Data View, columns represented variables whereas in Variable View, each row was a variable, and each column an attribute associated with a specific variable.

With the data already captured in SPSS, the variables depicting the health status of learners of educational institutions were selected for the analysis. The variables in the data file were displayed in a dialog box for the procedure and the results were further displayed in the Viewer. Basically, two procedures were selected from the SPSS package, and these were the frequency and cross tabulation procedures. The frequencies procedure offered descriptive statistics and graphical displays that were useful in describing the variables. This procedure provided a good start by advancing a general frequency output where the results were given in frequency counts and percentages. The cross tabulation procedure formed two-way and multi-way tables. To generate the output using this procedure, a row, a column, and a layer factor (control variable) were specified. The procedure then formed one panel of associated statistics for each value of the layer factor or a combination of values for two or more control variables, as was the case for some variables. The cross tabulation tables displayed the relationship between two or more variables. This procedure reflected relationships between location site and gender (type) as the control variables with all other variables. The output was in form of frequency counts for each variable combination.

One sample test and Pearson correlation coefficients were computed from the results obtained through the administration of questionnaires. To get a graphic representation of the output, these cross tabulation tables were imported into Microsoft Excel to create charts showing percentage distribution. Microsoft Excel was basically used to produce clustered bar charts and line graphs to compare percentages across the variables. Clustered bar charts and line graphs were used to help summarise data for different groupings.

3. RESULTS

3.1 General complaints of learners about personal health

General complaints of learners about their personal health could be classified into three levels: high, moderate and low. On the low level, there were no learners who indicated passing urine with pain, 3% of them had unusual genital discharge, 10% had palpitations, 13% had constipation and 17% had unusual spitting. On the moderate level, 23% had pain in the lower abdomen, 27% had chest pain, 30% of the learners complained of general body

weakness and the same percentage was obtained for those who experienced loss of body weight, 33% for shortness of breath, 33% for nausea and vomiting, and a further 33% for diarrhoea. On the high level, 70% complained of coughs, 77% had influenza/common cold, and 80% had headaches (Figure 3).

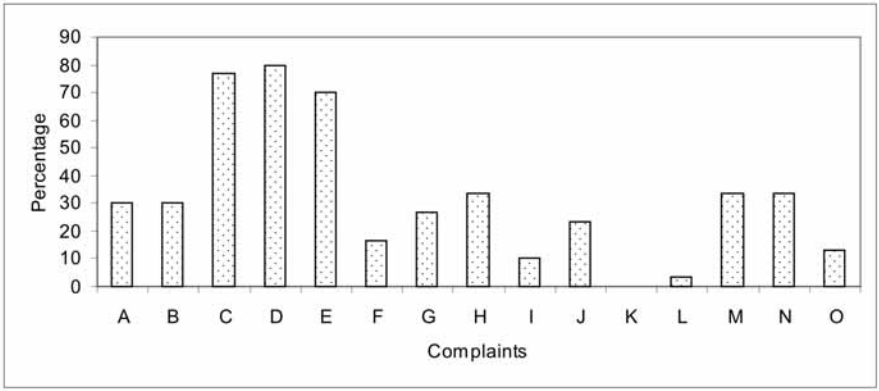

Figure 3: General complaints of learners about personal health within the Selebi Phikwe area (Note A = body weakness, B = loss of body weight, C = influenza/common cold, D = headache, E = cough, F = unusual spitting, G = chest pain, H = shortness of breath, I = palpitations, J = lower abdomen pain, K = urine with pain, L = genital discharge, M = nausea/vomiting, N = diarrhoea, and O = constipation)

The four classes used in the study to classify results were < 20%, 20 30%, 30 40%, and 40 50%. The < 20% class of learners attending school in Selebi Phikwe area, who experienced influenza/common cold, were all those from sites three and ten, 63% from site four, 67% from site six, and 50% from site nine. In the class of 20 30%, 25% of the learners were from site four, 50% from site seven, and all of those from site five. In the class of 30 40%, 33% of the learners were from site two and 50% of the learners were each from sites seven and nine. In the class of 40 50%, 33% of the learners were from site two, and all those from site eight suffered from influenza/common cold.

The percentage distribution of learners who suffered from headaches reflected as follows: class of < 20%, all learners in sites three and ten, 63% of the learners in site four, 67% of those in site six and 50% of those in site nine experienced headaches. In the class of 20 30%, 25% of the learners were from site four, 33% from site seven, 50% from site eight, and all of those from site five. In the class of 30 40%, 33% of the learners were from site seven and 50% of the learners were from site nine. In the class of 40 50%, all those from site one, and 50% from site eight suffered from headaches. Headaches experienced by learners were dull, moderate, acute, and at times dull and acute. For institutions where 20 30% of learners experienced dull headaches, 25% of them were from site four, and between 91 100% of those who had it,

50 % were from site nine. In the class of < 20%, all those in site five had dull, acute, and at times dull and acute headaches. Only in sites three and five did learners mention that they were having moderate headaches, and in sites four and five acute headaches.

Out of the class of < 20% of learners attending school in Selebi Phikwe area, who suffered from frequent coughing, there were all of those in site three, 33% each from sites two, six and seven, 40% from site four, and 50% from site nine. Twenty-one to 30% of the learners who suffered from frequent cough were distributed among the following sites: 33% each from sites two, six and seven, 20% from site four, and 50% from site nine. Thirty-three percent each from sites two and seven were of the class of 30 40% of learners who suffered from frequent coughing. All those who suffered from coughing in site eight were of the class of 40 50% as well as 33% of those in site six. Most of the learners who suffered from frequent coughs were not sure whether the type of cough they had was dry or wet. However most of those in sites three, four, five and six indicated having a dry cough, whereas a few in sites three, four and five acknowledged that their cough was wet.

The t-test results showed very high values for influenza/common cold, headaches and cough (Table 2). Strong positive correlations were obtained for chest pain/body weakness, shortness of breath/body weakness, cough/loss of body weight, headache/influenza/common cold, cough/influenza/common cold, chest pain/influenza/common cold, shortness of breath/influenza/common cold, headache/cough, headache/chest pain, headache/shortness of breath, cough/shortness of breath, and shortness of breath/chest pain (Table 3).

Table 2: One-Sample Test analysis for parameters of general complaints of learners about personal health

	Test Value = 2.5					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Body weakness	1.59	6	.16	.64	-.35	1.63
Loss of body weight	1.87	4	.14	.70	-.34	1.74
Influenza/common cold	6.61	8	.00	1.94	1.27	2.62
Headache	4.45	9	.00	1.90	.93	2.87
Cough	5.50	8	.00	1.83	1.06	2.60
Chest pain	.47	5	.66	.33	-1.47	2.14
Short breath	1.75	6	.13	1.07	-.43	2.57
Others	2.02	9	.07	29.50	-3.58	62.58

Table 3: Correlation coefficients for parameters of general complaints of learners about personal health

	Body weakness	Loss of body weight	Influenza /common cold	Head ache	Cough	Chest pain	Short breath	Others
Body weakness	1	.43	.28	.(a)	.41	.56	.74	.08
Loss of body weight	.43	1	.13	.(a)	.76	.17	.63	.13
Influenza/common cold	.28	.13	1	.61	.66	.63	.66	.28
Headache	.(a)	.(a)	.61	1	.50	.52	.70	.03
Cough	.41	.76	.66	.50	1	.60	.91(**)	.17
Chest pain	.56	.17	.63	.52	.60	1	.88(*)	.74
Short breath	.74	.63	.66	.70	.91(**)	.88(*)	1	.13
Others	.08	.13	.28	.03	.17	.74	.13	1

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2- tailed); a cannot be computed because at least one of the variables is constant.

3.2 Aspects of death

None of the institutions indicated that learners were admitted to health facilities because of constipation, diarrhoea, influenza/common cold, genital discharge, loss of body weight, pain in the lower abdomen, palpitations, or pain in passing urine, prior to dying. All the cases where learners were admitted to health facilities due to general body weakness prior to death occurred at all the sites except sites eight and ten. Less than ten percent of institutions that responded regarding having learners admitted into the facilities were from site two whereas 10 20% of those who responded for similar ailments consisted of 20% of the learners from site three, and for institutions where 81 90% of learners who were admitted for the same ailment, were all from site five. A substantial percentage of institutions indicated that they were not sure of the percentage of learners who were admitted into health facilities prior to death, and these were from sites one, three, six, seven and nine. Institutions in sites three and five indicated that < 10% of their learners suffered from shortness of breath at the time they were admitted to health facilities. Only in site four was it indicated that some of the pupils who had passed away were admitted to health facilities because of accidents. In site five, chest pain was indidated by <10% of those who had died) and 20% from site four were admitted because of cough, with 20% (site four) due to headache, nausea and vomiting.

Death-related cases were reported for AIDS, malaria, pneumonia and tuberculosis for learners from all the sites except sites eight and ten. For institutions where 10 20% of learners died due to malaria, these consisted of 40% of those from site four and 50% from site seven. For the institutions where 20 30% of learners died due to pneumonia, this consisted of 50% of those from site seven, and in the case of institutions reporting 41 50% deaths due to

pneumonia, 20% were from site four. Only in site seven was it indicated that 10 20% of the deaths were due to tuberculosis. A number of institutions in all the sites except sites eight and ten indicated that there were learners who passed away due to pneumonia and tuberculosis although they were not sure of the percentage. The research findings further indicated that none of the learners died of breast cancer, cancer of the colon, cardiac arrest, diabetes, heart disease, lung cancer, meningitis, other lung diseases, prostate cancer, or stroke.

4. DISCUSSIONS

4.1 General complaints of learners about personal health

Learners who experienced general body weakness were from primary, secondary and technical schools, whereas those who suffered from loss of body weight were from primary and technical schools. Pupils who had influenza/common cold, headaches and coughs respectively were from nursery/kindergarten, primary, secondary and technical schools. The orders of magnitude for categories of the learners in the different types of schools who suffered from influenza/common cold, headache and cough respectively were as follows: for influenza/common cold, secondary >primary > nursery/kindergarten > technical; for headaches, secondary >primary > nursery/kindergarten > technical; and for cough, nursery/kindergarten > primary > secondary > technical schools.

Primary school learners suffered more from chest pains than those from the other three types of educational institutions. Moreover, there were more learners from sites three, four and five who suffered from both chest pains and coughs than from the other sites of the study area. Of the few institutions that reported cases of unusual spitting, it was in sites three and four that there were learners who complained of having coughs and unusual spitting simultaneously. Shortness of breath and palpitations were experienced by learners in primary and secondary schools. Only in sites three and five were distinct cases of combined shortness of breath and cough, although cases were indicated to occur in the other sites. There were no cases for these ailments reported in site ten.

Only learners from primary and technical schools indicated suffering from constipation. Learners who complained of pain in the lower abdomen, nausea and vomiting and diarrhoea respectively were from nursery/kindergarten, primary, secondary and technical schools. The orders of magnitude for categories of the learners in the different types of schools who complained of pain in the lower abdomen, nausea and vomiting and diarrhoea respectively were as follows: for pain in the lower abdomen, secondary and nursery > primary > technical; for nausea and vomiting, nursery/kindergarten > primary > secondary > technical; and for diarrhoea, nursery/kindergarten > primary > secondary > technical schools. According to Yusufu (2002), the vomiting reflex evolved as a defensive centred mainly on the gastrointestinal tract. It is

also a symptom of many diseases of the gastrointestinal tract and other systems. Its occurrence with nausea is very associative.

4.2 Sicknesses and diseases

Diarrhoeal diseases have been listed to include cholera, typhoid fever, paratyphoid fever, salmonella, shigella, giardiasis, non-human Escherichia coli infection, and a variety of other diseases caused by bacteria, parasites and viruses (WHO, 1997). Most of the time, these diseases are related to environmental factors of poor sanitation and lack of access to clean water and safer food. However in Selebi Phikwe, the diarrhoeal burden is primarily due to the mining activities. This is further substantiated by Bastarache (2003) iterating nasal congestion, fever up to 39°C, chills, malaise, aching muscles, dryness in the mouth and throat, headache, and shortness of breath being among the ailments resulting from inhaling copper fumes.

In western Papua New Guinea where copper is mined, pneumonia accounts for 26% of infant deaths, diarrhoea for 19%, and malaria 11%. According to an international church non-governmental organisation (NGO), the major underlying cause is clearly malnutrition with over 20% of the population in the central highlands experiencing some degree of malnutrition. The percentage of immunised children is 40.8, well below the national average of 60.3. West Papua has the lowest life expectancy of all Indonesian provinces, particularly for women, who have a life expectancy of 50.3 years compared to the national average of 62.7 (Dulce & Estrella-Gust, 2003). These figures for Papua New Guinea are similar to those obtained from this study and reported by the Government of Botswana (2003).

Communicable diseases, including tapeworm infection, chlamydia and gonorrhea, acute respiratory tract infection and diarrhoea are also significant health problems affecting children in mining environments (Dulce & Estrella-Gust, 2003).Although the findings from the study indicated low figures for AIDS and AIDS-related cases, Botswana has an alarming percentage of HIV positive individuals, which includes sexually active learners. It is generally felt that AIDS transmission may have been facilitated by several means: more readily available artificial contraception (other than condoms) has led to more promiscuous behaviour; contamination through non-sterile medical equipment and the problem of weakened immune systems from the general ill health present in the community. Support services for people with AIDS are virtually non-existent (Dulce & Estrella-Gust, 2003).

Sexually active school children in Ghanaian mining areas are increasingly at risk of HIV and other sexually transmitted infections (Adu-Mireku, 2003), just as it could be applicable to the Selebi Phikwe mining area. As a primary agent of socialisation, the family can exert a strong influence on adolescent sexual behaviour. Therefore, to aid in the design and implementation of effective prevention programmes, it is important that the role of the family in influencing sexual behaviour among school-going adolescents becomes more defined

and articulated in Selebi Phikwe. In a separate study conducted by Abebe (2001), it was concluded that having a health problem showed a statistically significant association ($P<0.001$) with age, grade of the learners in school and educational status of parents. Most of the individuals living in Selebi Phikwe had only attained levels of education not higher than secondary. Consequently, home education, which could likely have a positive influence on the general health status of adolescents, may not have been given optimum concern by parents of learners in Selebi Phikwe. Other adolescent concerns related to emotional, sexual, social outlook and substance use could be contributory to high occurrences of headaches registered in the study area, and psychosocial disorders, which are beyond the scope of this study. Furthermore morbidity in females appeared to have been higher compared to that of males. Demise et al. (2002) are of the opinion that for females to perform better, attention should be given to their personal security, material support and assertiveness creation as well as personal health in addition to academic needs.

4.3 Aspects of morbidity and mortality

Slightly more males than females passed away. None of institutions reported cases of learners who passed away having lived in sites eight and ten. It should be also noted that most of the learners who passed away lived in sites three, four, five and seven. Cases of death were reported in sites that previous studies conducted by Ekosse et al. (2002, 2003, 2003a, 2004) had indicated as having higher contamination levels of heavy metals in soils, Imbrasia belina, Colophospermum mopane, and particulate air matter. It was furthermore observed that the pungent smell of SO_2 and related gases and fumes were stronger and more intensified in those sites than the other study sites. These observations could be substantiated with further research that may bring into play pathological examination of suspect cadavers.

Morbidity and mortality values were higher in sites which were close to the mine and the smelter/concentrator plant. Learners either living or attending school in sites three, four, five or seven were significantly more affected than those from the rest of the sites in the study area. The control site (site ten) was the least affected. Among the illnesses the learners suffered from were the respiratory tract diseases and gastro-intestinal disorders, with very high percentage values obtained for influenza/common cold, headaches, coughs, nausea and vomiting, and diarrhoea.

Mining wastes interact with the different components of the environment, thereby causing pollution. The various forms of primary and secondary pollution affect the learners residing at Selebi Phikwe. The relationship of the mining activities and other factors to the health of learners is summarised in Figure 4. It can be deduced from Figure 4 that the following factors: biological (including genetic), socio-economic, environmental (including noise, dust, fumes and gases) and others have a bearing on the human health status of the learners at Selebi Phikwe. These factors influence the general health

complaints of the different groups of residents. Either attending school or living in those affected sites causes the learners to be more frequently in contact with SO_2 and related gases and fumes, mineral dust and silica dust generated from the mining and smelting processes. Without doubt, there were serious health risks from dust in mining, quarrying, tunneling and ore crushing. The effects vary depending on the nature of the dust particles, particularly the silica content, and the size. These dust particles contain Cu, Ni, and Co among many other heavy metals (Ekosse et al., 2003). Gases and fumes with pungent smells appeared to be more perceived in sites whereby learners manifested more illnesses than in the other sites. Studies on mineral dust (Ekosse et al., 2003) show that threshold limit values (TLV) for both respirable and total dust concentration were generally exceeded at the mine, smelter/concentrator plant, as well as within the Selebi Phikwe area. Also reports from the Department of Mines (1998) in Botswana revealed that the annual mean concentration values for SO_2 in the atmosphere exceeded permissible level authorised by WHO.

In Figure 5, the schematic diagram of the human health status of learners at Selebi Phikwe is given based on the findings of this study. The health complaints are symptoms of different sicknesses and diseases. Sometimes some of the learners apply self medication, and they are relieved of the symptoms. More often they visit health services centres where medical and para-medical services are professionally rendered. In some cases, the symptoms develop into different sicknesses and diseases which are treated in the same way. Unfortunately not all patients are healed. Some of the patients do not recover from these sicknesses and diseases, and they eventually pass away (Figure 5).

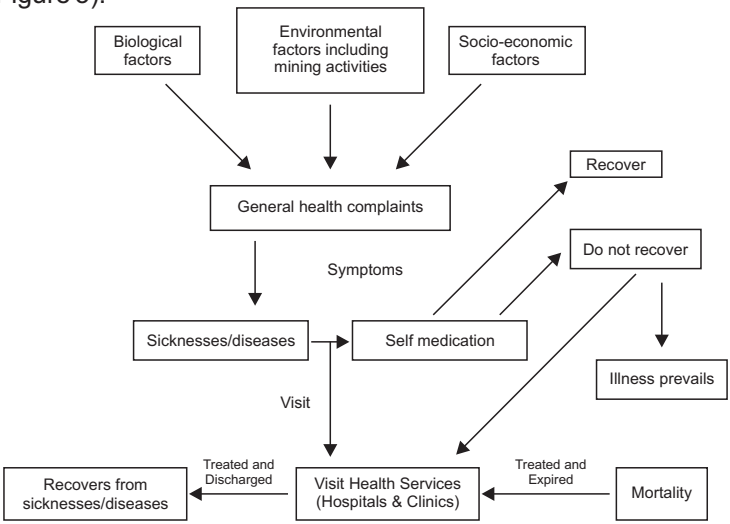

Figure 4: Relationship of mining activities and human health status at the Selebi Phikwe study area

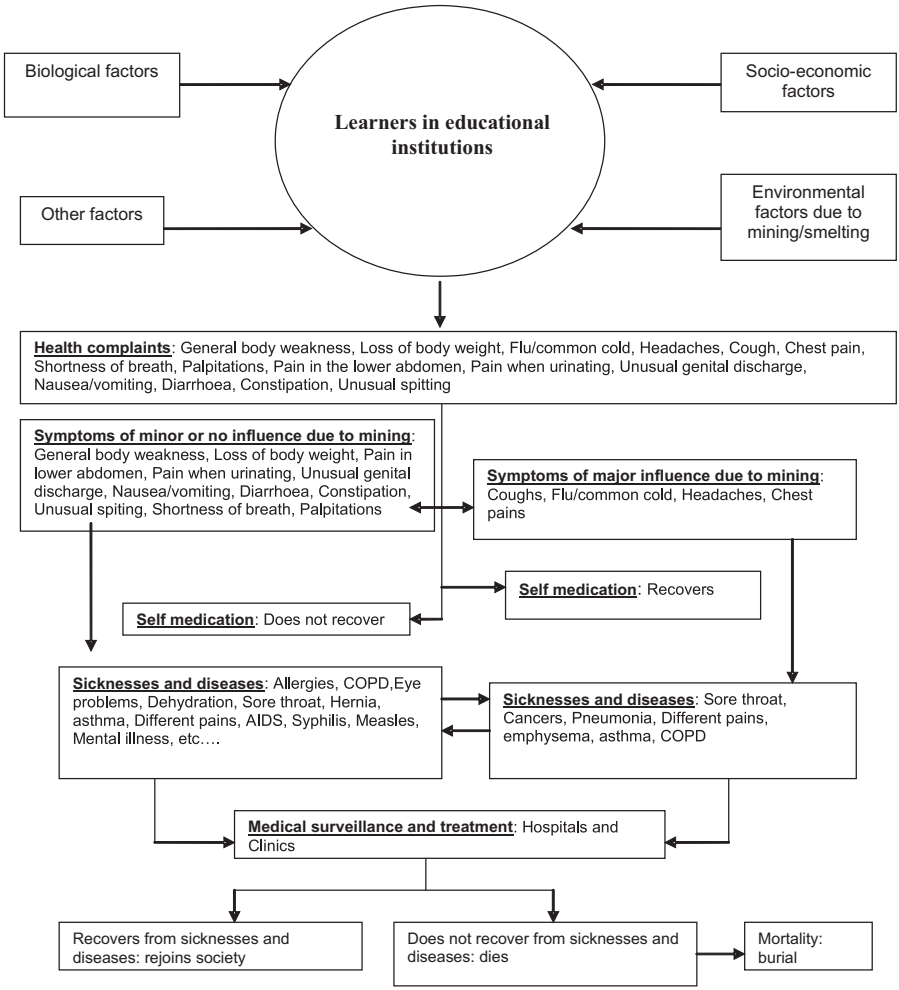

Figure 5: Schematic diagram of the human health status at the Selebi Phikwe study area

5. CONCLUSION

The findings of this study infer that mining and smelting activities at Selebi Phikwe could be contributory to the different sicknesses and diseases inclusive of repeated and frequent coughing, influenza/common cold and headaches which learners living in the area suffer from. Deaths have also been reported with the highest occurrences close to the areas where mining activities are carried out. Although the illnesses and diseases mentioned may have been contributory causes of reported deaths of learners, not all cases of mortality could be associated with mining activities. Only cases of lung

diseases, pneumonia and some cancers which could have been provoked by PAM, gaseous fumes, and heavy metals, could be linked to possible partial causes of some of the deaths which have occurred in the Selebi Phikwe area as a result of mining activities.

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