HUMAN HEALTH HAZARDS AT THE SELEBI PHIKWE Ni-Cu MINING AREA, BOTSWANA

EKOSSE GEORGES-IVO EKOSSE

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Promoter: Prof. Linda de Jager, PhD

Co-Promoter: Dr Dawid J. van den Heever, DTech

BLOEMFONTEIN

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DEDICATION

In memory of Regina B. Etombi Mofoke nee Ekosse

My sister, teacher and friend

CERTIFICATION

TO WHOM IT MAY CONCERN

This is to certify that the doctoral thesis of Mr Georges Ekosse, entitled *Human Health Hazards at the Selebi Phikwe Ni-Cu Mining Area, Botswana* has been edited in terms of language, punctuation and syntax:

N J Lötter [B.A. H.E.D.(R.U.) M.A. (Linguistics & Translation) APTrans (SATI)]

09 September 2004

Central University of Technology, Free State

DECLARATION OF INDEPENDENT WORK

I, EKOSSE GEORGES-IVO EKOSSE, do hereby declare that this research project submitted to the Central University of Technology, Free State, Bloemfontein, South Africa for the degree DOCTOR TECHNOLOGIAE: ENVIRONMENTAL HEALTH is my own independent work and complies with the Code of Academic Integrity, as well as relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself or any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

.... 02 March 2005

SIGNATURE OF STUDENT DATE

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SUMMARY

This thesis, which is presented in eleven chapters, discusses the health hazards affecting inhabitants of the Selebi Phikwe nickel-copper (Ni-Cu) mine area, Botswana. The setting up of Botswana's premier large scale economic enterprise was conducted without prior environmental impact assessment (EIA) studies. Consequently, both environmental and human health problems have been suspected within the Selebi Phikwe area. Inhabitants of the area often exhibit symptoms of sickness and disease, and ailments such as coughs, influenza, headaches, chest pains, shortness of breath, pneumonia, cardio-pulmonary health complications, tuberculosis, general body weakness, loss of body weight and poor sexual performances, among others, have been prevalent. The effects of both air and heavy metals pollution on human health are apparently intertwined. A need therefore to investigate the health status of residents within Selebi Phikwe with a bias to pulmonary health complications related to the exploitation of Ni-Cu ore, was eminent.

Primary data concerning the general health status of inhabitants in the Selebi Phikwe area and of inhabitants at a control site was obtained by means of a questionnaire and structured interviews conducted with selected individuals, health service providers, industries and educational Institutions. The study area was divided into nine sites and the tenth site was the control area located 56 km from Selebi Phikwe. The information obtained was supplemented by the administering of spirometry tests. The results obtained from the questionnaires and the spirometry work were processed, analysed

and interpreted contextually using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel software packages. Furthermore, hard copies and digital maps were used with the aid of ArcGIS software packages to spatially express selected aspects related to human health hazards.

Chapters One, Two and Three deal with the background to the study and the different methods and techniques which were used to carry out the research. Chapter Four focuses on the health status of individuals residing within the Selebi Phikwe mine area. Chapter Five investigates the health status of pupils/students attending educational institutions, and Chapter Six explores the health status of workers of businesses and industries, within the study area. The available health services and health status of patients within Selebi Phikwe area is reported in Chapter Seven. Chapter Eight reports on the use of the lung function test to evaluate the health status of residents within the study area. In Chapter Nine, Geographic Information System (GIS) techniques were applied, using the findings of the previous chapters, in an attempt to determine the health status of residents within the Selebi Phikwe area. Chapter Ten reports on an integrated approach combining data from the previous chapters, in understanding the human health status within the study area, and in Chapter Eleven the conclusions are given.

Common ailments, sicknesses and diseases found in the area included asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headache, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancers. Symptoms of these sicknesses and diseases include the four most frequent health complaints of the residents of Selebi Phikwe which are coughing often, frequent headaches, frequent influenza/common colds and rampant chest pains.

Responses revealed that individuals had respiratory tract-related problems which were considered to be linked to the effects of air pollution caused by the emission of sulphur dioxide (SO_2) from mining and smelting activities. Regarding pupils/students attending educational institutions within the study area and workers of businesses and industries, it was realised that they were frequently in contact with SO_2 and related gases and fumes, mineral and silica dust generated from the mining processes. There were no clearly demarcating differences in the health status of patients living in the control site from those in the other nine study areas in Selebi Phikwe.

The results of this study further indicated that similar sites identified in previous studies which were more contaminated in terms of heavy metals concentrations had higher percentage values of residents suffering from negative health effects than the other sites. Sites most affected were sites five, six and four; while sites eight, nine and ten were the least affected.

Models are postulated which summarise the interplay of biological (including genetic factors), socio-economic, environmental (including noise, fumes, gases and dust), and other factors bearing on the health status of the residents of Selebi Phikwe. Environmental factors resulting from mining and smelting activities, among others, could very well be contributory to the negative health effects occurring at Selebi Phikwe. It is therefore evident that mining and smelting activities could be contributory to some of the negative health effects identified in this study.

OPSOMMING

Hierdie tesis wat elf hoofstukke beslaan, bespreek die gesondheidsgevare wat die inwoners van die Selebi Phikwe Ni-Cu-mynarea in Botswana affekteer. Die totstandkoming van Botswana se vernaamste grootskaalse ekonomiese onderneming, is uitgevoer sonder omgewingsimpak-assesseringstudies (*EIA – Environmental Impact Assessment*), wat vooraf gedoen is. Die gevolg hiervan is dat beide omgewings- en menslike gesondheidsprobleme binne die Selebi Phikwe-area vermoed is. Inwoners van die area toon dikwels simptome van mislikheid en siektes en kwale soos hoes, griep, hoofpyn, borspyn, kortasemigheid, longontsteking, kardio-pulminêre gesondheidskomplikasies, tuberkulose, algemene liggaamswakte, gewigsverlies en swak seksuele prestasie is onder andere algemeen. Die effekte van beide lug- en swaarmetaalbesoedeling op menslike gesondheid is klaarblyklik verstrengeld. Die behoefte het dus ontstaan om die gesondheidstatus van inwoners binne Selebi Phikwe met 'n neiging tot pulminêre gesondheidskomplikasies wat verband hou met die eksploitasie van Ni-Cu-erts, te ondersoek.

Primêre data rakende die algemene gesondheidstatus van inwoners in die Selebi Phikwe-area en van inwoners by 'n kontroleperseel is verkry deur middel van 'n vraelys en gestruktureerde onderhoude wat afgeneem is op geselekteerde individue, gesondheidsdiensverskaffers, industrieë en opvoedkundige instellings. Die studie-area is in nege terreine verdeel en die tiende terrein, die kontrole-area is sowat 56 km vanaf Selebi Phikwe geleë. Die inligting verkry is aangevul deur die uitvoering van spirometriese toetse.

Die resultate verkry van die vraelyste en die spirometriese werk is geprosesseer, geanaliseer en kontekstueel geïnterpreteer deur gebruik te maak van die statistiese pakket vir geesteswetenskappe (SPSS) en Microsoft Excel-sagtewarepakette. Voorts is harde kopieë en digitale kaarte met die hulp van ArcGIS-sagtewarepakette gebruik om geselekteerde aspekte wat met menslike gesondheidsgevare verband hou, ruimtelik uit te druk.

Hoofstukke 1, 2 en 3 handel oor die agtergrond tot die studie en die verskillende metodes en tegnieke wat gebruik is om die navorsing uit te voer. Hoofstuk 4 fokus op die gesondheidstatus van individue wat binne die Selebi Phikwe-mynarea woon. Hoofstuk 5 ondersoek die gesondheidstatus van leerlinge/studente wat die opvoedkundige instellings bywoon en Hoofstuk 6 verken die gesondheidstatus van werkers van besighede en industrieë binne die studiegebied. Daar word in Hoofstuk 7 verslag gelewer oor die beskikbare gesondheidsdienste en die gesondheidstatus van pasiënte binne die Selebi Phikwe-area. Hoofstuk 8 lewer verslag oor die gebruik van die longfunksietoets om die gesondheidstatus van inwoners binne die studie-area te evalueer. In Hoofstuk 9 word Geografiese Inligtingstelsel (GIS)-tegnieke toegepas deur gebruik te maak van die vorige hoofstukke in 'n poging om die gesondheidstatus van inwoners binne die Selebi Phikwe-area te bepaal. Hoofstuk 10 lewer verslag oor 'n geïntegreerde benadering wat data van die vorige hoofstukke kombineer ten einde die menslike gesondheidstatus binne die studie-area te verstaan. In Hoofstuk 11 word die gevolgtrekkings weergegee.

Algemene kwale, mislikheid en siektes wat in hierdie area gevind word sluit in asma, bloedinggeneigdhede, hartsiektes, hoë bloeddruk, allergieë, algemene liggaamswakheid, borspyn, hoes, konstipasie, diarree, griep/gewone verkoue, hoofpyn, gewigsverlies, laer abdominale pyn, naarheid en braking, hartkloppings, kortasemigheid, ongewone geproes, genitale afskeiding en kanker. Simptome van hierdie mislikhede en siektes sluit die vier algemeenste gesondheidsklagtes van die inwoners van Selebi Phikwe in, naamlik 'n dikwelse gehoes, gereelde hoofpyne, gereelde griep/gewone verkoues en erge borspyne.

Response het aan die lig gebring dat individue respiratoriese lugpypverwante probleme het wat geglo word verband hou met die effek van lugbesoedeling veroorsaak deur die vrystelling van SO_2 van mynbou- en smelteryaktiwiteite. Wat betref leerlinge/studente wat opvoedkundige instellings binne die studie-area bywoon en werkers van besighede en industrieë, is daar besef dat hulle dikwels in kontak is met SO_2 en verwante gasse en dampe, minerale en silikastof gegenereer deur die mynbouprosesse. Daar was geen duidelik aangewese verskille in die gesondheidstatus van pasiënte wat in die kontroleperseel gewoon het,. in vergelyking met diegene in die ander nege studie-areas in Selebi Phikwe nie.

Die resultate van die studie toon verder aan dat soortgelyke persele, geïdentifiseer in vorige studies, meer besoedeld was met betrekking tot swaarmetaal-konsentrasies en hoër persentasiewaardes van inwoners gehad het wat gely het vanweë negatiewe gesondheidseffekte as die ander terreine.

Die terreine wat die meeste geaffekteer is, is persele 5, 6 en 4, terwyl persele 8, 9 en 10 die minste geaffekteer is.

Modelle word gepostuleer wat die wisselwerking van biologiese (insluitende genetiese faktore), sosio-ekonomiese, omgewings- (insluitende geraas, dampe, gasse en stof) en ander faktore wat 'n invloed het op die gesondheidstatus van die inwoners van Selebi Phikwe opgesom. Omgewingsfaktore wat onder andere die gevolg is van mynbou- en smelteryaktiwiteite, kan heel moontlik bydra tot die negatiewe gesondheidseffekte wat by Selebi Phikwe plaasvind. Dit is daarom duidelik dat mynbou- en smelteryaktiwiteite bydraend kan wees tot sommige van die negatiewe gesondheidseffekte geïdentifiseer in hierdie studie.

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AIDS	Acquired Immune Deficiency Syndrome
ATS	American Thoracic Society
BCL	Bamangwato Concessions Limited
BGCE	Botswana General Certificate of Education
BMI	Body Mass Index
BPC	Botswana Power Corporation
CDC	Centre for Disease Control
COPD	Chronic obstructive pulmonary disease
EIA	Environmental Impact Assessment
ETS	Environmental tobacco smoke
FAP	Financial Assistance Policy
FPAM	Fine particulate air matter
$FEF_{25\text{-}75}$	Forced expiratory flow between 25% and 75% of the vital capacity
FEF_{max}	Forced expiratory flow, maximum
FEV_1	Forced expiratory volume in one second
FVC	Forced vital capacity
GIDEON	Global Infectious Disease and Epidemiology Network
GIS	Geographic information system
HIV	Human immune deficiency virus
MAS	Mean annual standard
MMEF	Maximum mid-expiratory flow
MVV	Maximum Voluntary Ventilation
NEP	Negative expiratory pressure

NGO	Non governmental organisation
Ni-Cu	Nickel-copper
OPD	obstructive pulmonary disorders
PAM	Particulate air matter
PEF	Peak expiratory flow
PFT	Pulmonary function test
PM	Particulate matter
RV	Residual volume
SAPALDIA	Swiss Study on Air Pollution and Lung Diseases in Adults
SPSS	Statistical Package for Social Sciences
SPTC	Selebi Phikwe Town Council
STDs	Sexually transmitted diseases
TLC	Total lung capacity
TLV	Threshold limit values
UB	University of Botswana
UNEP	United Nations Environment Program
USA-EPA	United States of America – Environmental Protection Agency
VOA	Voice of America
WHO	World Health Organisation
esd	equivalent spherical diameter
$\mu g/m^3$	microgram per cubic metre
μm	micro metre
mg/day	milligram per day
mg/m^3	milligram per cubic metre
wt %	weight percent

Chapter One

General Introduction

1.1 Background

The natural resources of Botswana include range and arable farming, a very significant wildlife population and both gem and base metal minerals (Botswana Government, 1991). In 1996, Botswana had a population of 1 500 000 inhabitants with a 3.1% population growth rate and a population density of two persons per km^2 (Mbendi, 1998). The country has the fastest growing economy in Africa as well as among the less developed countries of the world. It exports mainly diamonds, nickel-copper (Ni-Cu) matte and beef, and imports petroleum products, food products, chemicals and textiles. In 1994, profits from Ni-Cu amounted to 5.7% (US $ 99 000 000) of the principal export earnings.

Diamond, soda ash, gold and Ni-Cu remain the mainstays of the mining industry in Botswana. With an increase in mining activities, there is bound to be a corresponding increase in the dumping of tailings and other contaminants into the environment. Relevant to environmental contaminants and possible health effects of these contaminants on the inhabitants is the Selebi Phikwe Ni-Cu mining area.

Previous studies have not specifically focused on understanding the possible health effects from mining activities; rather, they have focused on understanding the petrogenesis (Brown, 1987), structural geology (Gallon, 1986), socio-economic percep 99), mineralogy (Nkoma and Ekosse, 1999; Nkoma and Ekosse, 2000) of the orebodies and appraising the physical quality of the environmental (Ekosse, 2001; Ekosse, Van den Heever, De Jager, and Totolo, 2002).

Asare (1999) pointed out that a relationship could exist between the community health problems and the air pollution resulting from exploitation of Ni-Cu ore. In Ekosse (2001), it was suggested that the population could experience pulmonary health problems as a result of exposure to highly contaminated air and he suggested that they avoid staying outdoors when the risk of exposure to contaminated air is high. It was further suggested that contaminants present in the environment could result in serious health problems for people living in the area, specifically for those of frail health and the aged (Ekosse, 2001).

1.2 Area of study

The study area, Selebi Phikwe, is located in the north-eastern part of Botswana between longitudes $27^{\circ}47'$E and $27^{\circ}53'$E, and latitudes $22^{\circ}55'$S and $22^{\circ}00'$S (Figure 1.1). It has a population of about 50,000 with a 2.4% growth rate (Botswana Government National Census, 1991). Most of the working population is employed in mining and other industrial activities (Asare, 1999).

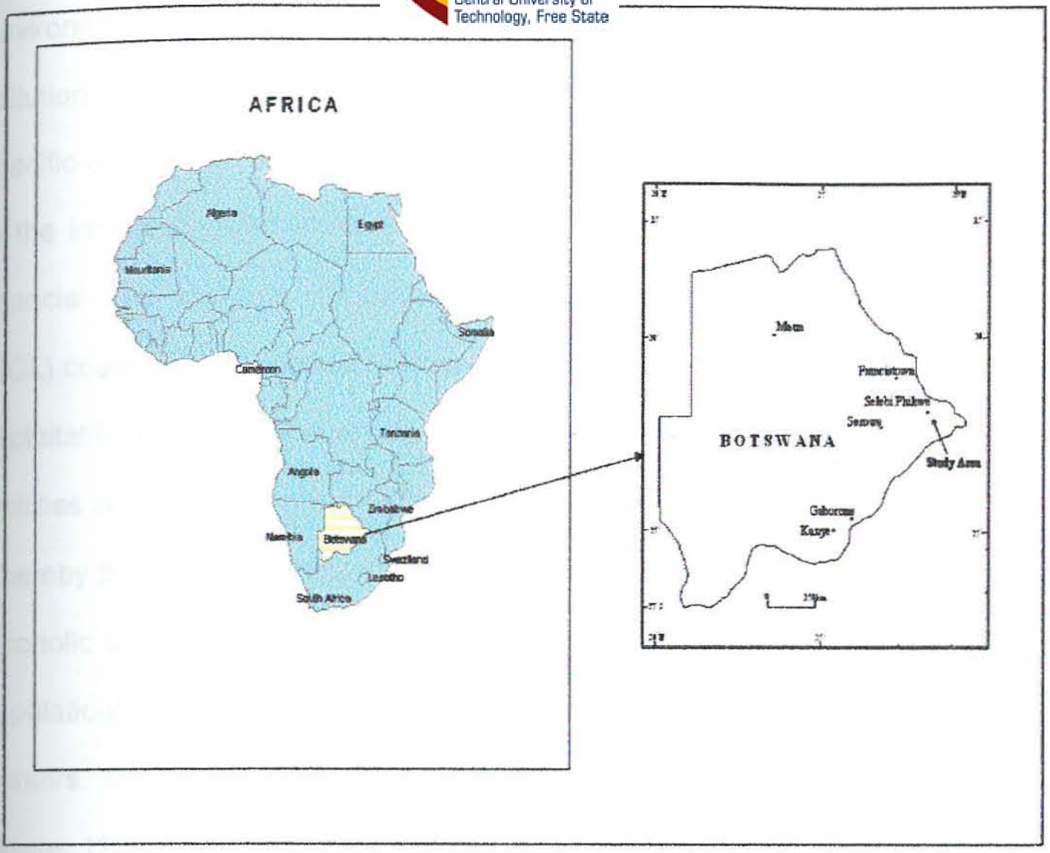

Figure 1.1: Map of Africa showing Botswana and map of Botswana indicating the study area

1.3 Statement of problem

The Selebi Phikwe Ni-Cu mine is one of the politically independent Botswana's premier large scale economic enterprise. Mining activities took off in 1973. There are underground mines from which Ni-Cu ore is mined, as well as a concentrator/smelter plant for the processing of the ore to Ni-Cu matte. Unfortunately, possible negative impacts such as environmental and human health hazards were not adequately considered before the commencement of mining activities (Bamagwato Concessions Limited, 1996; 1997).

Environmental risks associat[illegible]ining include water and soil pollution from tailings and air pollution from smelters (Ekosse, 2001). No specific environmental impact assessment (EIA) studies were carried out prior to the inception of the minerals exploitation activities (Asare, 1999). Due to financial and technical problems, the Bamangwato Concessions Limited (BCL) could not compensate inhabitants who were displaced as a result of the exploitation exercise. This resulted in the simultaneous construction of mining facilities and the rapid growth of the township. A symbiotic relationship ensued whereby the local population traded in livestock and dairy products, traditional alcoholic beverages and phane (larva of *Imbrasia belina* eaten by the local population), and the mine recruited a strong labour force of about 5000 workers. Consequently, squatter camps sprang up alongside urban areas (Asare, 1999; Ekosse, 2001).

The exploitation of Ni-Cu ore bodies at Selebi Phikwe has been active for more than twenty years. In a separate study, it was demonstrated that mining and smelting activities have a direct influence on the physical environment, affecting the soils, mopane vegetation, phane worm and the atmosphere (Ekosse, 2001; Ekosse, Van den Heever, De Jager, and Totolo, 2003).

Atmospheric pollution due to release of mineral dust (Ekosse, 2001) and sulphur-rich gases, commonly detected by an obnoxious smell, is eminent at Selebi Phikwe. It is thus suspected that the inhabitants of the area probably inhale polluted air. The residents of Selebi Phikwe generally complain of coughing, influenza, headaches, chest pains, cardio-pulmonary complications, tuberculosis, general body [illegible] poor sexual performances (Asare, 1999).

However, no known research study has been carried out to investigate various health effects associated with the exploitation of Ni-Cu orebodies at Selebi Phikwe, Botswana. In this regard, as recommended by Ekosse (2001), studies on health hazards and related sicknesses due to exploitation of Ni-Cu minerals at Selebi Phikwe may aid in setting guidelines for exposure limits and periods for workers and the population at large.

1.4 Research questions

The present research project attempts to explore the health effects of the Ni-Cu ore mining and processing activities at the Selebi Phikwe Ni-Cu concentrator and smelter plants on the inhabitants living in the area. The problems mentioned in 1.3 have led to the following research questions to be answered in the study:

- What are the general effects on human health caused by the mining and smelting of Ni-Cu ore at the Selebi Phikwe area?
- What are the negative health effects particularly those associated with possible pulmonary complications of residents of Selebi Phikwe because of the highly contaminated air in the area (Ekosse, 2001)?
- Is there any interplay of the biological, socio-economic, environmental and other factors influencing the health status of the residents of Selebi Phikwe?

1.5 Aims and objectives

On the basis of the issues raised above, the primary aim of this research study was to consider the effects on human health occurring at Selebi Phikwe and attributable to the mining of Ni-Cu ore. The main aim includes establishing whether mining activities affect the general health status of the inhabitants of Selebi Phikwe, and if it does, to establish the extent to which this takes place.

More specifically, the objectives include:

By means of questionnaires and structured interviews, generate information on the general health status of:

1. The population to determine possible ill effects caused by environmental conditions due to mining.
2. Learners attending schools within the Selebi Phikwe area to determine possible ill effects caused by environmental conditions due to mining.
3. Workers of industries and businesses working within the Selebi Phikwe area to determine possible ill effects caused by environmental conditions due to mining.
4. Patients visiting health services within the Selebi Phikwe area to determine possible ill effects caused by environmental conditions due to mining.
5. By means of questionnaires, determine the status of health service providers such as staff at clinics and hospitals within the Selebi Phikwe.

6. Compare informatic [illegible] atus of the control site used in a previous study (Ekosse, 2001) with that of the inhabitants of the Selebi Phikwe area.
7. Carry out lung function tests (LFT), also known as spirometric tests, on selected individuals based on the findings of objectives one through six.
8. Compare results with available information on the health status of inhabitants of similar mining areas around the world.
9. By means of a questionnaire ascertain whether health facilities available in the Selebi Phikwe area are adequate for the population and are properly utilised.
10. Based on the findings of the research according to points one to nine above, some useful recommendations are advanced in ameliorating and improving the health status of the individuals at Selebi Phikwe.

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Chapter Two

Literature Review

2.1 Introduction

Health is defined in the World Health Organisation's Constitution as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organisation (WHO), 2003). It not only depicts the absence of disease, but also has a dependence on a complex suite of physical, biological, environmental, economic, social, cultural and possibly spiritual factors. The WHO's definition of health is thus broad, holistic and challenging. In this regard, the influence of mining activities on the health of individuals living within Ni-Cu mining environments such as Selebi Phikwe, Botswana, needs to be given consideration. Environmental risks associated with Ni-Cu mining include water and soil pollution as well as air pollution from smelters (Ekosse, 2001).

Increases in outdoor particulate air matter (PAM) pollution levels have been associated with a number of adverse health outcomes including increased hospitalisation for cardiopulmonary diseases, premature mortality, exacerbation of asthma and other respiratory-tract diseases, and decreased lung function (United States of America – Environmental Protection Agency, 1996; Samet, Zeger, Dominici, Curriero, Coursac, Dockery, Schwartz and Zanobetti, 2000). Epidemiological studies that reported these findings have identified several susceptible subpopulations – individuals with respiratory diseases, the elderly, and children – as being at greater risk of adverse effects from PAM exposure (United a – Environmental Protection Agency, 1996).

Previous studies of the aetiology of respiratory disease have suggested that individuals with limited respiratory capacity are at increased risk of acquiring respiratory maladies such as chronic obstructive pulmonary disease (COPD) due to PAM exposure (Avol, Gauderman, Tan, London and Peters, 2001). According to Feinleib, Rosenberg, Collins, Delozier, Pokras and Chevarly (1989), COPD affects more than 10% of the USA population over the age of 55. It is ranked as the fourth leading cause of death, although it does not become manifest early in life (Joost, Wilks, Cupples, Harmon, Shearman, Baldwin, O'Connor, Myers and Gottlieb, 2002). In Switzerland, the Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) was institutionalised in 1991, to examine associations between air pollution and respiratory health, taking into consideration certain factors such as urbanisation, air pollution, meteorological conditions and altitude of Swiss communities (Schindler, Künzli, Bongard, Leuenberger, Karrer, Rapp, Monn, and Ackermann-Liebrich, 2001).

In this review, aspects of the human health status in Ni-Cu mining environments are discussed. Heavy metals and their effects on human health are explained, together with the effects of air pollution on human health. More specifically, PAM and its implications regarding human respiratory diseases are examined. The human lungs and how they function are described. Lung function tests are carried out and the relation of spirometry to human health status, especially for those l[illegible] nvironments is explored. The chapter also gives information on the application of a geographic information system (GIS) in presenting data on human health status.

2.2 Human health status at Ni-Cu mining environments

2.2.1 Heavy metals pollution and their effects on human health

Heavy metals mostly associated with the exploitation of Ni-Cu ore at Selebi Phikwe are zinc, cadmium, nickel, copper, iron, chromium, selenium and cobalt (Ekosse, 2001; Ekosse, Van den Heever, De Jager, and Totolo, 2003; 2004). Zinc (Zn) minerals usually occur with cadmium (Cd). Zinc pollutant is associated with mining and smelting and may occur in tailings dumping from Ni and Cu mine workings. Although generally considered to be non-toxic, it can cause vomiting, dehydration, electrolyte imbalance, abdominal pain, nausea, dizziness, lack of muscular coordination, and renal failure (World Health Organisation, 1993). Cadmium (Cd) is associated with the sulphides of Zn, nickel (Ni) and copper (Cu) and their ore minerals. It has a long biological half-life in the body and accumulates with age. At high levels above 60 μg/day, Cd is known to affect the renal, skeletal and respiratory systems, and causes itai-itai disease (World Health Organisation, 1993; Alloway and Ayres, 1993).

Selenium (Se) is associated with both Ni and Cu ore minerals. Although there is growing evidence that it may be essential for human health (World Health Organisation, 1993), an intake of 5 mg/day is considered toxic, and may lead to gastrointestinal disturbanc[illegible]ration, nausea and dermatitis (Alloway and Ayres, 1993). In living organisms it affects chlorosis, replaces essential atoms in biochemical reactions, and competes for sites with essential metabolites. Chromium (Cr) is associated with Ni ore minerals. Although Cr is a micronutrient essential for carbohydrate metabolism in animals, it is carcinogenic and causes cancer of the respiratory organs. It also causes chlorosis (Alloway and Ayres, 1993). Cobalt (Co) is an economic bye-product in the mining and smelting of Ni-Cu. An intake of > 500 mg/day is considered to be toxic (Alloway and Ayres, 1993).

Iron (Fe) occurs as an integral element in Ni and Cu mineral orebodies and is a by-product in their extraction metallurgy. Nickel is ubiquitous and Ni ore occurs in the form of sulphide minerals. It is extracted in concentrators and smelters creating serious environmental contamination. It can be carcinogenic, and may cause dermatitis, eczema, vertigo and dyspnoea to exposed human populations (World Health Organisation, 1993). Copper (Cu), like Ni, is ubiquitous. Cu is mined from its sulphide ores and smelted with the release of oxides of sulphur into the atmosphere. Cu is essential for human metabolism. However, excessive intake by humans leads to severe mucosal irritation and corrosion, capillary damage, hepatic and renal damage, gastrointestinal and nerve disturbances (World Health Organisation, 1993).

2.2.2 Particulate air matter and mining environments

Particulate matter can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the general size fractions provided in Table 2.1. The characteristics of the different size fractions are given in the same table. Inhabitants of environments of mining and heavy metals industries are generally exposed to a variety of health hazards particularly affecting the cardiovascular and respiratory systems. Although there are many agents emanating from the mining and metal processing industries, PAM has been isolated as one of the principal provocative factors of respiratory tract complications (United States of America – Environmental Protection Agency, 1995).

Table 2.1: Classification of particulate air matter according to size fractions

No	Particulate size fraction	Particulate size fraction characteristics
1.	PM_{10}	All particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung.
2.	$PM_{10-2.5}$	Also known as coarse fraction particles. This class consists of particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns.
3.	$PM_{2.5}$	Also known as fine fraction particles. The particles have an aerodynamic diameter of 2.5 microns or less.
4.	$PM_{0.1}$	These are the ultra fine particles and are less than 0.1 microns.

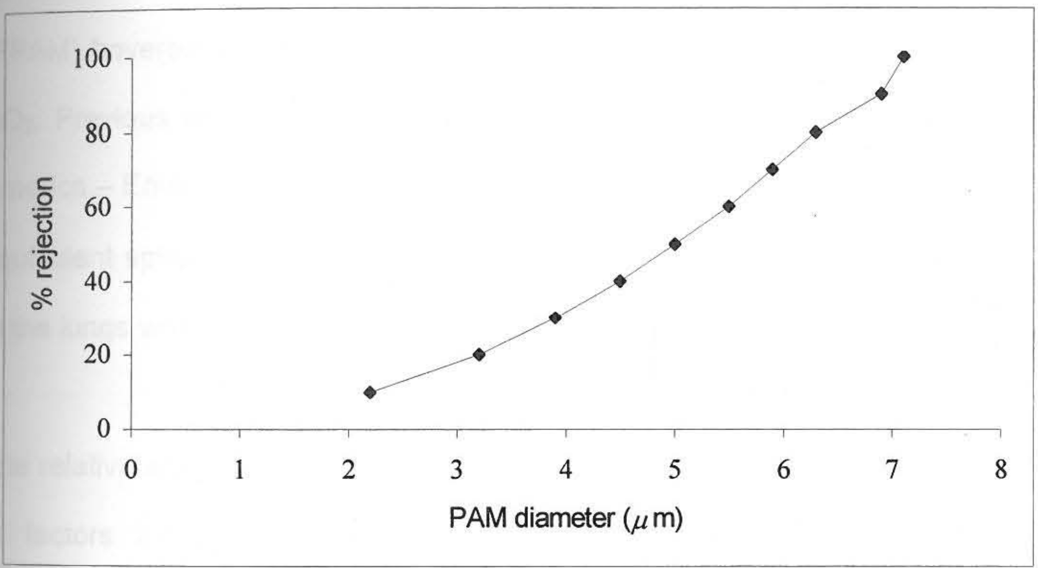
Note: PM = particulate matter (United States of America – Environmental Protection Agency, 1995)

Particulate air matter represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, mineral phases, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (United States of America – Environmental Protection Agency, 1995).

Apart from the Selebi Phikwe area in Botswana where PAM has been physico-chemically, chemically and mineralogically characterised (Ekosse *et al.*, 2003), there is no other mining environment in the country where studies have been carried out on PAM. At Selebi Phikwe, Botswana, PAM consists mainly of fine particles of sulphate and sulphide (Ekosse *et al.*, 2003; 2004), but nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals (Department of Mines, 1998) could also be present.

Analyses of PAM from the Utah Valley in the USA, indicated higher concentrations of Fe, Cu, Ni, and Zn, and the results were consistent with the hypothesised metal fine PAM air pollution toxicity resulting from Steel Mill operation (Beckett, 2001). At Selebi Phikwe, the PAM consisted mineralogically of quartz, pyrrhotite, chalcopyrite, albite and djurleite (Ekosse *et al.*, 2004). Concentration levels of heavy metals contained in the PAM could be related to mineral phases present. Quite significant is the occurrence of djurleite, which is not present in either the orebody or surrounding soils (Ekosse *et al.*, 2004). Djurleite polymorphs are formed from secondary mineralisation of chalcocite … hydrogen sulphide (H_2S) and sulphur dioxide (SO_2) released from concentration/smelting processes. In a reverse reaction, SO_2 is given off with possible environmental, chemical and human health effects (Ekosse *et al.*, 2003; 2004).

Particle rejection by the pulmonary system is proportional to its size as shown in Figure 2.1. The PAM of size > 10 μm can easily be removed from the nasal chamber; consequently it has little likelihood of penetrating the lungs (United States of America – Environmental Protection Agency, 1995).



(United States of America – Environmental Protection Agency, 1995).

Figure 2.1: Percent particle rejection by pulmonary system of human beings based on particulate matter diameter

Results from the composite PAM sample obtained at Selebi Phikwe area, showed that the particles were very fine in appearance and could very likely be composed of 80 wt % being < 5 μm (Ekosse, 2001). This implies that

> 80 wt % of the PAM might … e respiratory system of human beings living within the vicinity of Selebi Phikwe. The wt % of inhaled particles deposited in the pulmonary airspace of lungs, with a particle diameter of < 2 μm is 20 wt % (United States of America – Environmental Protection Agency, 1995).

2.2.3 Effects of air pollution on human health

During a recent study carried out at Selebi Phikwe (Ekosse, 2001), it was observed that a pungent odour of gases as well as fine particulate air matter (FPAM) hovered in the atmosphere. The smell was characteristic of H_2S and SO_2. Previous air pollution studies conducted in the USA (United States of America – Environmental Protection Agency, 1995) showed that PAM with an equivalent spherical diameter (esd) as small as $\leq 10\ \mu m$ could be deposited in the lungs when inhaled into the human respiratory system.

The relative amount of PAM deposited in the lungs is controlled by a number of factors including the tidal volume, the breathing frequency, particle morphology, particle chemistry and particle mineralogy (USA – EPA, 1995). Acute exposure to these gases and FPAM may lead to loss of lung function, aggravation of existing respiratory and cardiovascular diseases, loss of capacity to resist infection, carcinogenesis, and premature death (USA – EPA, 1995). Population groups mostly affected are asthmatics, individuals with chronic obstructive pulmonary cardiovascular disease, individuals with influenza, children and the elderly (USA – EPA, 1995). The United States of

America – Environment Prot 995) has set a mean annual standard (MAS) of 50 $\mu g/m^3$ of PAM provided sampling is calculated on 24 hrs/day and that the value of only one day in the whole year exceeds 150 $\mu g/m^3$.

2.2.4 Particulate air matter and its implications for human respiratory diseases

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as SO_2. High temperature process sources such as smelters produce emissions that contribute to fine particle formation. In contrast, coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities (Allan, 1995).

A number of epidemiological studies published in the last few years have examined the relationship between acute PAM exposures and respiratory and cardiovascular disease-related hospital admissions and deaths (Samet *et al.*, 2000). The results were generally consistent across studies, indicating that increases in ambient levels of PAM were associated with increases in adverse cardiovascular events and respiratory diseases, although the biologic mechanisms responsible for t[illegible]d increase in morbidity and mortality are unclear (Van Eeden, Tan, Suwa, Mukae, Terashima, Fuji, Qui, Vincent and Hogg, 2001). Furthermore, changes in ambient pollution levels due to PAM may have measurable effects on longer term lung function and health outcomes (Avol *et al.*, 2001; Pope III, Dockery, Kanner, Vollegas and Schwartz, 1999).

Some scientists have postulated that ultra fine particles, by virtue of their small size and large surface area to mass ratio, may be especially toxic (Peters, Frohlich, Doring, Immervoll, Wichmann, Hutchinson, Pepys and Koenig, 2001). Scientific research has shown that increased levels of this small particulate are responsible for a marked increase in Emergency Room visits, hospitalisations, and days lost from school or work (Samet *et al.*, 2000). Studies suggest that fine PAM may leave the lungs and travel through the blood to other organs, including the heart (Peters, Doring, Wichmann and Koenig, 1997; Pope III, Verrier, Lovett, Larson, Raizenne, Kanner, Schwartz, Villegas, Gold and Dockery, 1999a). This type of air pollution has been closely linked to aggravation of existing lung conditions and even increased death rates (Walsh, 2003). Children and senior citizens are most vulnerable to this type of air pollution (Liao, Creason, Shy, Williams, Watts and Zweidinger, 1999), and small PAM pollution is responsible for many thousands of premature deaths annually in USA (Pope *et al.*, 1999a). Studies of small PAM pollution also indicate a significant increase in the population death rate in areas where the population is exposed to prolonged pollution from small PAM (United States of America Department of Health and Human Services, 2000).

Short term and long term PAM exposure may cause adverse health effects by different mechanisms (Dockery, Pope III, Kanner, Villegas and Schwartz, 1999). Substantial efforts are now underway in the USA (United States of America – Environmental Protection Agency, 1995, 1996) and elsewhere (Joost *et al.*, 2002), to explore potential pulmonary mechanisms of PAM toxicity. Lung diseases in humans include cancers caused by cigarette smoke and asbestos as well as asthma, bronchitis, pneumonia, and Legionnaire's disease (United States of America Department of Health and Human Services, 2000). Irritating particles of carcinogens such as tar or asbestos fibres lodge in the lung tissue and may result in the formation of cancer cells depending on other environmental and genetic factors (Pulmonary World, 2002). Lung transplants are performed on many afflicted patients and there is some prospect for future lung tissue culture using human stem cells (Walsh, 2003).

2.2.5 Sulphur dioxide concentration levels and its health effects

The gas SO_2 is a colourless gas, belonging to the family of gases called sulphur oxides (SOx). It reacts on the surface of a variety of airborne solid particles, is soluble in water and can be oxidised within airborne water droplets. Its main sources include releases from volcanoes, oceans, biological decay and forest fires. The most important man-made sources of SO_2 are fossil fuels, combustion and the smelting of minerals to obtain base metals. Coal burning at Selebi Phikwe is thus also a source of SO_2.

The accepted WHO one hour air quality guideline for SO_2 is 350 $\mu g/m^3$. The permissible limits of SO_2 authorised by the Botswana Government are provided in Table 2.2. These figures are guidelines, which attempt to be in compliance with the World Health Organisation's safety standards for air pollution. According to the World Health Organisation (1988), annual mean levels for SO_2 released into the atmosphere must be between 40 $\mu g/m^3$ and 60 $\mu g/m^3$ (United Nations Environment Program, 1991).

Table 2.2: Guideline adapted by the Botswana Government for sulphur dioxide concentration levels in residential areas (Bamagwato Concessions Limited, 1998)

No	Sample period	$\mu g/m^3$	mg/m^3	ppm
1.	24 hourly average	> 90 % of the time < 300	> 90 % of the time < 0.3	> 90 % of the time < 0.12
2.	Monthly average	160	0.16	0.06
3.	Annual average	80	0.08	0.03

At Selebi Phikwe, prevailing winds blowing through the Ni-Cu concentration/smelter plant in a north-easterly direction means SO_2 pollution (probably exceeding the guideline concentration levels) directly affects certain areas of the town including the industrial site. With such levels of emission, the potential for an increase in the incidence of respiratory problems is very real. The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease (United Nations Environment Program, 1991).

The Government of Botswana recognises that industry would not appreciate stringent limits, presumably because of the cost and inconvenience, therefore this limit is presently being gradually decreased. It is fundamental however that the Botswana Government implement comprehensive and strict SO_2 limits for the emission of the gas and the research into the causative relationships between SO_2 and disease and sickness be carried out.

2.3 The respiratory system

The human respiratory system has been extensively discussed in published literature (American Lung Association, 2003; The Human Respiratory System, 2003; Turner, Mead and Wohl, 1968). The respiratory system consists of the nasal cavity, pharynx, larynx, trachea, bronchi, and lungs and is subdivided into upper and lower respiratory tracts (Turner *et al.*, 1968). The upper respiratory tract consists of the nasal cavity, pharynx, and associated structures. The lower respiratory is made up of the larynx, trachea, bronchi, and lungs (Encyclopaedia Britannica, 2003). Respiratory movements are accomplished by the diaphragm and the muscles of the thoracic wall (Australian Lung Foundation, 2003). In this review, the human lungs are very concisely described as well as the process of human respiration, and the anatomy and physiology of respiration are explained.

2.3.1 The anatomy and physiology of respiration

The respiratory system branches similarly to a tree, with about 17 levels of branching between the trachea and the bronchioles, and this results in about 130,000 bronchioles in the average pair of human lungs (National Heart, Lung and Blood Institute, 2003). Actual gas exchange occurs in the alveoli between the blood and the contents of the alveolar sac. Capillaries allow simple diffusion around the alveoli, which increase the surface area of the lungs to about 50 ml to 100 m^2 with a typical four litre content. The carbon dioxide (CO_2) - rich blood arriving by the pulmonary veins enters the alveolar capillaries and is released, leaving the haemoglobin in the red blood cells available to acquire oxygen (O_2) from the fresh air taken in via the nose and mouth (American Lung Association, 2003).

Inspiration and expiration usually takes place through the nose. The nasal cavity is located inside the nose and joins the pharynx. External openings to the nasal cavity are the external nares or nostrils and the posterior openings from the nasal cavity into the pharynx are the internal nares or conchae. The anterior portion of the nasal cavity just inside the external nares is the vestibule. The nasal septum divides the nasal cavity into two parts: the posterior half of the septum consists of bone (vomer and perpendicular plate of the ethmoid) and the anterior half is nasal cartilage (Encyclopaedia Britannica, 2003).

The floor of the nasal cavity is the hard palate and the lateral wall is modified by the presence of three bony ridges called conchae (National Heart, Lung and Blood Institute, 2003). De oncha is a passage way called the meatus. Within the superior and middle meatus are openings from the various paranasal sinuses and the opening of the nasolacrimal duct is within the inferior meatus (Australian Lung Foundation, 2003). The vestibule is lined with stratified squamous epithelial cells that are continuous with the stratified epithelia of the skin. The mucous membrane that lines the nasal cavity consists of pseudostratified ciliated columnar epithelium with goblet cells that secrete a thick layer of mucus (Encyclopaedia Britannica, 2003).

In the most superior part of the nasal cavity is the olfactory epithelium, which functions in the sense of smell (Brink, 1993; Walch, Taisne, Gascard, Nashashibi, Brink and Norel, 1997). Air enters the nasal cavity through the external nares, and the vestibule is lined with hairs that trap some of the large particles of dust in the air (National Heart, Lung and Blood Institute, 2003). The mucous also traps debris and the cilia on the surface of the mucous membrane sweep the mucus posteriorly to the pharynx where it is swallowed and eliminated by the digestive system (Australian Lung Foundation, 2003). Air is also humidified by the addition of moisture from the mucous membrane and is warmed within the nasal cavity before it passes into the pharynx, preventing damage to the more delicate linings in the rest of the respiratory passages (Encyclopaedia Britannica, 2003).

The pharynx is the common opening of the digestive and respiratory systems. It receives air from the nasal cavity and air, food and water from the mouth. Inferiorly, the pharynx leads to separate openings of the respiratory system (larynx) and digestive system [illegible] ncyclopaedia Britannica, 2003). The pharynx can be divided into three regions: the nasopharynx, the oropharynx and the laryngopharynx. The nasopharynx is the superior region of the pharynx and extends from the external nares to the level of the uvula and is lined by the posterior edge of the soft palate, eventually leading to the trachea (National Heart, Lung and Blood Institute, 2003).

The trachea or windpipe is a membraneous tube that consists of dense regular connective and smooth muscle reinforced with 15-20 "C"-shaped pieces of cartilage (Walch *et al.*, 1997). The trachea divides into the right and left primary bronchi. The right bronchus is shorter and wider and is more vertical than the left bronchus. The bronchi lead to the lungs, which are the principal organs of respiration and on a volume basis, they are one of the largest organs of the body (Encyclopaedia Britannica, 2003).

2.3.2 The human lungs

Human lungs are paired organs situated in the chest with the heart situated in between. The external surface of a lung is smooth and conforms to the shape and size of the thoracic cavity, bounded by the rib cage and below by the movable diaphragm (Australian Lung Foundation, 2003). Inspiration, or breathing air rich in oxygen, is achieved by enlarging the chest by contracting the diaphragm, thereby reducing the external pressure on the lungs, and allowing them to expand. This creates suction, taking in the fresh air. Expelling depleted air rich in CO_2 is achieved as the diaphragm returns to its resting position and the thor ened, adding external pressure to the paired lungs and squeezing air out of them (The Human Body Series, 2002).

The trachea, main bronchi and secondary bronchi, two to the left lung and three to the right lung, conduct air to each lung. The lungs consist of lobes, which are separated by deep prominent fissures on the surface of the lung (American Lung Association, 2003). Each lobe is divided into segments that are separated from each other by connective tissue, although the separations are not visible as surface fissures. Because major blood vessels and bronchi do not cross the connective tissues, individual diseased segments can be surgically removed. Secondary bronchi give rise to tertiary bronchi, which extend to the segments (Turner *et al*., 1968). The bronchial tree continues to branch several times, finally ending in bronchioles. The bronchioles also divide numerous times to become terminal bronchioles which then divide into respiratory bronchioles. Each respiratory bronchiole divides to form alveolar ducts that end as clusters of air sacs called alveoli (Australian Lung Foundation, 2003).

2.3.3 Human respiration

Respiration is the process of taking in of O_2 from the environment and returning CO_2 to it, and the O_2 consumption is directly related to energy expenditure (American Lung Association, 2003). The gas exchange of O_2 and CO_2 between cells and the surrounding environment is controlled by the principle of diffusion. In hu[illegible]sion and bulk flow move O_2 between the external environment and actively metabolising tissues. This movement occurs in four stages (Encyclopaedia Britannica, 2003):

- Movement by bulk flow of O_2 containing air into the epithelium.
- Diffusion of the O_2 across the epithelium into the blood.
- Movement by bulk flow with the circulating blood to the tissues where it will be used.
- Diffusion of the O_2 from the blood into the interstitial fluids, from which it diffuses into the individual cells.

The CO_2 that is produced in the tissue cells follows the reverse path as it is eliminated from the body.

Gases are exchanged between the air and the blood by diffusion. A pair of human lungs has about 300 million alveoli, providing a respiratory surface of about 70 m^2. The lungs are surrounded by the pleura, which line the thoracic cavity. Air flows into and out of the lungs when air pressure within the alveoli differs from the pressure of external air. When alveolar pressure is less than atmospheric pressure, air flows into the lungs, and inspiration occurs. The pressure in the lungs is varied by changes in the volume of the thoracic cavity. These changes are brought about by the contraction and relaxation of the muscular diaphragm and the intercostal muscles (Australian Lung Foundation, 2003).

The cardio-pulmonary interaction is where blood pumped from the heart goes into the lungs for O_2 enrichment and blood rich in CO_2 is exchanged for O_2.

Oxygen is relatively insoluble in blood plasma, and haemoglobin is the respiratory pigment of humans (American Lung Association, 2003). The haemoglobin consists of the heme unit, which is a porphyrin ring with one atom of iron (Fe) at its centre, and a polypeptide chain. The Fe in each heme unit can unite with one molecule of O_2, thus each haemoglobin molecule can carry four molecules of O_2. The O_2 molecules are added one at a time as shown in equations (2.1) to (2.4) (National Heart, Lung and Blood Institute, 2003):

$$Hb_4 + O_2 \rightarrow Hb_4O_2 \tag{2.1}$$

$$Hb_4O_2 + O_2 \rightarrow Hb_4O_4 \tag{2.2}$$

$$Hb_4O_4 + O_2 \rightarrow Hb_4O_6 \tag{2.3}$$

$$Hb_4O_6 + O_2 \rightarrow Hb_4O_8 \tag{2.4}$$

The CO_2 is continually produced as a by-product of cellular respiration and a diffusion gradient is established from tissue cells to the blood within the tissue capillaries (The Human Respiratory System, 2003). After blood leaves the venous end of the capillaries, it is transported to the lungs. The transport of CO_2 in the blood takes place in three major ways: approximately 8 vol % dissolved in plasma, 20 vol % is transported in combination with blood proteins and 72 vol % as HCO_3 (Encyclopaedia Britannica, 2003).

2.3.4 Diseases of the human lungs

Pneumonia, asthma, emphysema, chronic bronchitis, chronic obstructive pulmonary disease (COPD) and lung cancer are the most common diseases of the human lungs (The Human Respiratory System, 2003). Pneumonia is an infection of the alveoli and is caused by many kinds of bacteria and/or viruses. Tissue fluids accumulate in the alveoli reducing the surface area exposed to air.

In asthma, periodic constriction of the bronchi and bronchioles makes it more difficult to breathe in and especially out (Australian Lung Foundation, 2003a). Airborne irritants such as chemical fumes and cigarette smoke as well as airborne particles to which the patient is allergic, can provoke attacks of asthma. In this disorder, the delicate walls of the alveoli break down, reducing the gas exchange area of the lungs. Gradual loss of the gas exchange area in the lungs forces the heart to pump larger volumes of blood to the lungs in order to satisfy the body's needs. The added strain can lead to heart failure (National Heart, Lung and Blood Institute, 2003).

The immediate cause of emphysema seems to be the release of proteolytic enzymes as part of the inflammatory process that follows irritation of the lungs (Australian Lung Foundation, 2003a). Any irritant reaching the bronchi and bronchioles, thereby stimulating an increased secretion of mucous, causes chronic bronchitis. In chronic bronchitis the air passages become clogged with mucous, and this leads to a persistent cough especially if the individual indulges in cigarette smoking (Australian Lung Foundation, 2003a).

Irritation of the lungs can lead to asthma, emphysema, and chronic bronchitis. In fact, many people develop two or three of these together. This constellation is known as COPD. Lung c[illegible] common cancer and the most common cause of cancer deaths in U.S. males (National Heart, Lung and Blood Institute, 2003). Although more women develop breast cancer than lung cancer, since 1987 U.S. women have been dying in larger numbers from lung cancer than from breast cancer (The Human Respiratory System, 2003).

2.4 Lung function test

2.4.1 Spirometry

Spirometry is one of the ways of testing how efficiently the lungs and airways of a person are working (Eigen, Bieler, Grant, Christoph, Terrill, Heilman, Ambrosius and Tepper, 2001). It is widely used in occupational medicine for screening patients and workers for lung diseases. Spirometry is an important tool in the diagnosis, assessment, and management of respiratory diseases in adults and older children, and has more recently been used for children aged between three and six years (Eigen *et al.*, 2001). According to the American Thoracic Society (1995), spirometry is principally a screening technique used to show pulmonary changes within a person, although it cannot be used to diagnose specific pulmonary disorders in individuals. The test is performed by the individual taking a deep a breath, and then blowing out all of the air as fast and as hard as possible. Several blows are needed to ensure that the best performance is measured. Spirometry may be carried out while the person is sitting in a chair or while one is standing. In adults, the testing is usually carried out with the person sitting.

In spirometry, there are a number of lung function variables that can be monitored. In Table 2.3, these lung function variables are defined and explained. The ratio of forced expiratory volume in one second/forced vital capacity (FEV_1/FVC) less than 75% defines obstruction, and is used to detect obstruction in individuals (American Thoracic Society, 1995; Crapo, Morris and Gardner, 1981). All other flows may support or suggest obstruction but the definition rests with the ratio of FEV_1/FVC. The total lung capacity (TLC) is also used to predict lung restriction and hyperinflation. If TLC < 80% of predicted value, it is indicative of restriction, whereas if TLC > 120% of predicted value, a hyperinflation condition is reflected. Increased residual volume (RV) and increased RV/TLC ratio both imply air trapping (American Thoracic Society, 1995; Morris, Koski and Johnson, 1971).

Pulmonary function testing, or lung function testing, is a method of determining how well the lungs and airways are working. Spirometry is the pulmonary function test (PFT) most often used, and this is applied to detect obstructive lung diseases (American Thoracic Society, 1991; 1995). These diseases are depicted from the patterns of airflow during respiration. Infection and/or inflammation in the airways, mucous, and muscle constriction in the airways cause a lower than normal air flow at forced exhalation. However, studies have demonstrated that having normal lung function as measured by spirometry does not neccessarily imply that one's lungs are completely normal (Walsh, 2003). For instance, research has shown that patients with cystic fibrosis have evidence of lung inflammation or lung infection in the first few months of life (Apostol, Jaco[illegible], [illegible], [illegible], Williams, Townsend and Beckett, 2002). Spirometry does not necessarily pick up these very early changes.

Table 2.3: Explanation of lung function variables used in spirometry

No	Acronym	Definition	Explanation
1.	FVC	Forced vital capacity	The total amount of air measured in litres, blown out after inhaling as deeply as possible and then blowing out as hard and forcefully and long as possible.
2.	FEV_1	Forced expiratory volume in one second	The amount of air measured in litres, blown out in the first second of the forced vital capacity manoeuvre.
3.	FEF_{max}	Forced expiratory flow, maximum	The fastest flow that can be forcefully blown out in liters/second, (home peak flow meters measure this in liters/minute) (Also known as PEF, peak expiratory flow or PEFR, peak expiratory flow rate)
4.	FEF_{25-75}	Forced expiratory flow between 25% and 75% of the vital capacity	The fastest flow in liters/second that can be forcefully blown out within the middle half of the forced vital capacity manoeuvre. (Also known as MMEF, maximum mid-expiratory flow)
5.	MVV	Maximum Voluntary Ventilation	This is a test of the patient's ability to breath in and out as hard and fast as possible for 10 seconds (liters/min).

2.4.2 Applications of spirometry

Sicknesses and diseases related to the respiratory tract have an influence on the functioning of the lungs (De Gouw, Grnberg, Schot, Kroes, Dick and Sterk, 1998; U.S. Department of Health and Human Services, 2000). The results of spirometry tests, which included FEV_1 and FVC, to four communities in the USA, revealed that elderly African-American women showed significantly lower lung function values than thos of white women (Pulmonary World, 2002). Ten Brinke, De Lange, Zwinderman, Rabe, Sterk and Bel, (2001) investigated whether sputum induction as a non-invasive method of evaluating airway inflammation could be safely and successfully performed in patients with severe, difficult to control asthma, and whether the patients at risk could be identified by using such technique coupled with spirometry. Gottlieb, Wilk, Harmon, Evans, Joost, Levy, O'Connor and Myers (2001) used spirometry to determine changes in FEV_1, FVC and the FEV_1 / FVC ratio after adjusting for effects of age, height and weight, in order to understand heritability of longitudinal change in individuals.

Tantucci, Duguet, Giampiccolo, Similowski, Zelter and Derenne (2001) demonstrated, with the use of spirometry, that when they correctly perform FVC manoeuvre, the peak expiratory flow (PEF) does not rise by increasing the driving pressure between the alveoli and mouth through the negative expiratory pressure (NEP). It was possible for Gottlieb *et al.* (2001) to use spirometric measures of lung function as markers of preclinical diseases in assessing both genetic and environmental risk factors for COPD because COPD is preceded by years of accelerated lung function decline.

Studies conducted by Schilling, Letai, Hui, Beck, Schenberg and Bouhuys (1997), demonstrated that familial factors account for 40-50% of the variability in cross sectional lung function. Moreover, it was advanced by Gottlieb *et al.*, (2001) that age, as well as genetic factors, are contributory to the overall population variance in the rate of lung function decline. These authors further suggested gene-environment interactions to be equally influential. With the aid of spirometry, social habits among family members such as smoking have been suggested as having an effect on lung function changes (Gottlieb *et. al.*, 2001). In investigating the effect of cigarette smoking on lung function, Apostol *et al.* (2002), showed that early smoking initiation may injure lungs in childhood, or may support behaviours and pathology that could lead to lung injury in adulthood.

Research related to spirometry carried out by Ries, Kaplan, Limberg and Prewitt (1995) on patients with COPD indicates that participation in a regular exercise programme is linked to improvements in physical functioning and well-being. Emery, Honn, Frid, Lebowitz and Diaz (2001) conducted a study on the physiologic arousal of acute exercise contributing to the enhanced cognitive/neuropsychologic performance among patients with COPD. It has been suggested in a previous study by Dustman, Ruhling, Russell, Shearer, Bonekat, Shigeoka, Wood and Bradford (1984) that exercise-associated physiologic arousal could contribute to increased blood flow and neurotransmitter release, which are considered to be contributory to improvements in cognitive performance.

There are several other health related issues in which spirometry has been applied. With the upgrading of modern technology, new applications of spirometry techniques will be welcome, especially by the Health and Allied Science Service Providers.

2.5 Geographical Information Systems and Health

The Geographical Information Systems (GIS) analysis is concerned with cluster validation and with attribution of detected clusters to the appropriate factors that played a role in their occurrence (Cresswell, Morse, Thomson and Connor, 1999; International Development Research Centre, 2003; Reader, 2003; Rushton, 2003). Analysis also includes doing comparisons with other relevant patterns/clusters and trying to explain any differences or trends that may be spotted in a methodological way (Connor, 1995; Lang, 2000). Regardless of difficulties in data acquisition, map representation, scale, statistical analysis, and the interpretation and utility of results, the study of disease distribution may well be the most fascinating research area within the entire application of GIS analysis (Connor, 1999; Thomson, Connor, Rowlingson, Diggle, Cresswell and Greenwood, 1999).

Eco-epidemiology of vector-borne diseases using GIS and applications of local remote sensing techniques have been investigated by researchers of the Liverpool School of Tropical Medicine (MALSAT, 2003; Thomson, D'Alessandro, Bennett, Conı ... awara, Todd and Greenwood, 1994; Thomson, Connor, D'Alessandro, Bennett, Milligan, Aikins, Langerock, Jawara and Greenwood, 1996; Thomson, Connor, Milligan, and Flasse, 1997). Because spatial data can be represented in either vector or raster (polygon) forms, vector-borne diseases can be studied using GIS. This technique has been used to diagnose diarrhoea in infants living in France, Egypt and Jordan by applying the Global Infectious Disease and Epidemiology Network software package (GIDEON, 2003).

Geographic Information Systems and applications of local remote sensing techniques have been implemented to study the distribution pattern and other related health problems due to *filariasis* in the Nile Delta, the Lyme disease in the north-eastern part of the USA, *schistosomiasis* in China, *phlebotomus orientalis* in Sudan and malaria in tropical Africa (Connor, Thomson, Flasse and Perryman, 1998; Connor, Thomson and Molyneux, 1999; El naiem, Connor, Thomson, Hassan, Hassan, Aboud and Ashford, 1998; Thomson *et al.*, 1999; Thomson, El naiem, Ashford and Connor, 1999a). Malaria is one of the world's most prevalent diseases, with a worldwide incidence rate of 300-500 million clinical cases annually of which tropical Africa accounts for more than 90% of the total incidence and the great majority of malaria deaths (MALSAT, 2003). Malaria has been extensively researched and publications (Connor *et al.*, 1998; 1999) are available on its eco-epidemiology in sub-Saharan Africa.

As disease and health can vary from place to place, so too can a society's response to its health needs. Geographic research into health care services can aid in the efficient allocation of scarce health care resources. Some of the most interesting research in the geography of health care has focused on identifying inequities in health service delivery between classes, peoples and regions (Hall, 2000).

A number of publications describe the use of GIS in health care research (International Development Research Centre, 1994; Rushton, 2003). Physicians, public health professionals and medical geographers measure health strictly in terms of indicators of ill-health such as morbidity and mortality (Rushton, 2003). Three allied fields of medicine, namely Epidemiology, Public Health, and Medical Geography are concerned with examining the distribution of disease and death on various geographical scales, in an attempt to determine whether the presence or absence of a particular illness is associated with some factor(s) in the social or physical environment (International Development Research Centre, 1994).

In the case of infectious diseases like influenza and AIDS, the study of their geographic distribution frequently involves examining the diffusion of the disease using spatio-temporal mapping and analysis. Although the mapping of data on disease can be relatively straightforward, interpreting spatially referenced disease data can sometimes be challenging, particularly for non-infectious and chronic diseases (International Development Research Centre, 1994).

The geographical information [illegible] has been used in Botswana to characterise soils and vegetation, as well as desertification encroachment (Arntzen, Chanda, Musisi-Nkambwe, Ringrose, Sefe and Vanderpost (1994). The technique has not been implemented in the mining environments in Botswana. In this study, the GIS technique was applied to elucidate the environmental health status of the inhabitants of the Selebi Phikwe Ni-Cu mining environment in Botswana.

2.6 Conclusions

This chapter has discussed the human health status in Ni-Cu mining environments. It has addressed the health implications of human respiratory diseases emanating from PAM due to mining and processing of metals. The human lungs and how they function have been described, and an overview has been given on lung function tests and on how lung function variables are related to respiratory diseases. Furthermore, the utilisation of GIS has been considered for interpreting human health status.

There is no extensive literature available on the human health status of residents of Ni-Cu mining and smelter/concentrator environments. It is anticipated that contributions from subsequent chapters in this project could help in elucidating the human health status of individuals living in these environments.

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Chapter Three

Instrumentation, Methods and Analytical Techniques

3.1 Introduction

It is suspected that environmental and human health problems may have been caused within Selebi Phikwe, Botswana, by mining activities. Inhabitants of the area generally complain that they often display symptoms of diseases, and specifically diseases related to pulmonary health complications (Ekosse, Van den Heever, De Jager and Totolo, 2003; 2004). By means of this study, an attempt has been made to establish and verify the existing human health status at Selebi Phikwe. The intention was to identify pulmonary health complications of the inhabitants of Selebi Phikwe if prevalent, and to advance possible solutions to be implemented. Several field visits were made to the study site for the sake of reconnaissance, as well as to administer questionnaires and lung function tests in order to establish the health status of the individuals living within the Selebi Phikwe area.

3.2 Data collection and spirometry

3.2.1 Data collection

Primary data concerning the general health status of inhabitants in the Selebi Phikwe area and of inhabitants at a control site was obtained by means of structured interviews conducted with selected individuals, health service providers, industries and educational institutions. The information obtained was supplemented by a spirometry test and a review of patient records at health clinics and hospitals a literature search provided information from both published and unpublished reports on health hazards as a result of exploitation of Ni-Cu.

3.2.1.1 Questionnaires and structured interviews

A questionnaire as the primary research instrument was designed to guide the interviews. The questionnaire was divided into the following four main sections:

- Section one was the part of the questionnaire to be completed by individuals. It consisted of six subsections covering demographical and biographical data, family history, general complaints about personal health, past medical history (organic and physiological illnesses), past and present treatment/medication, and general profile, social and personal history.
- Section two of the questionnaire focused on health service providers, and the questions were answered by health service providers or designated officials of the health facility. This section was divided into three subsections covering demographical data, general complaints of patients about personal health, past medical history, and aspects related to death.
- Section three was the part of the questionnaire directed at industries, and the directors of industry or designated officials representing the different industries answered the questions. The three subsections of the questionnaire in this section included questions on demographical

data, general complaint t personal health, and aspects related to death.

- Section four targeted educational institutions. The principals/headmasters or designated officials of the educational institutions responded to the questions. There were three subsections covering demographical data, general complaints of pupils about personal health, and aspects related to death.

Respondents were advised to read through each question carefully before making a choice. Answers were marked by placing a cross in the box provided below or next to the question. 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 in their answers.

Ten students majoring in Environmental Science from the University of Botswana were recruited as Research Assistants for the research project. The students chosen were those who had lived in Selebi Phikwe, and were bilingual. They were able to speak, read and write both the English and Setswana (the local language spoken by the inhabitants of Selebi Phikwe) languages very fluently. They underwent an orientation course of three days regarding the administration of the questionnaires before being conveyed to Selebi Phikwe where they lived for one month to conduct the survey.

The study area was divid based on a previous study by Ekosse, Chaoka, Alemaw, Van den Heever and De Jager, 2002; Ekosse *et. al.*, 2003; 2004), as indicated in Figure 3.1 below. Site ten was the control site located 56 km from the study area, hence it is not reflected on the map. Each of the Research Assistants was allocated to a site (Table 3.1 and Figure 3.1), and had to administer 60 questionnaires to individuals and 20 questionnaires to industries. In each site, there were a number of educational institutions (Table 3.2).

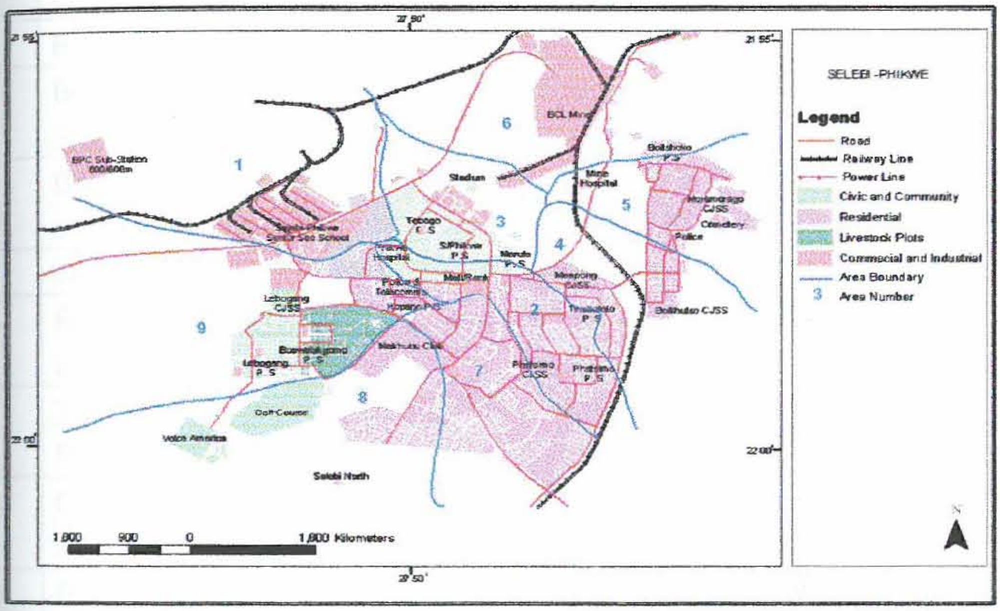

Figure 3.1: Map of the Selebi Phikwe showing the different study sites

There were 30 educational institutions in the study area inclusive of the control site (Table 3.2), and all of them responded to the questionnaires. Because there were only eight health service providers, a Research Assistant with previous experience in the administration of questionnaires related to health services was given the task of handling section two. Questionnaires were administered by me[illegible]ed interviews to a sample subpopulation of the different sites based on the overall population density of each site. It turned out that the subpopulations were very similar for all ten sites in the study area.

Table 3.1: 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 Botswana Power Corporation (BPC))
4	Between the township boundary and the railway line (directly behind a Community Junior Secondary School (CJSS))
5	Opposite the Mine hospital, close to the old township
6	Between the mine and explosives storage facilities (close to the old township)
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi Phikwe Road juncture)
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)
9	Penultimate Bridge before entering the Selebi Phikwe township
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road

Individuals selected to take part in the study were those who lived in Selebi Phikwe, and who were able to communicate with the Research Assistants effectively. A non-biased approach was followed whereby individuals were chosen based on where they lived, making sure that there was equal distribution of questionnaires to all ten sites. Equal distribution of questionnaires for individua ; (Table 3.2) was opted for because the subpopulation per site was almost the same.

Table 3.2: Number of questionnaires administered to different respondents

No	Section	Number of questionnaires administered	Remarks
1.	Section one. Questionnaire for individuals	600	The study area was portioned into ten different sites with an almost equal population distribution per site; 60 respondents were chosen at random per site including the control site.
2.	Section two. Questionnaire for health service providers	7	There are eight health service providers within the whole study area including the control site. The BCL hospital authorities refused to participate. Consequently only seven respondents participated.
3.	Questionnaire for industries	200	This number was chosen after reconnaissance visits. All the different types of industries at the ten different sites are statistically represented.
4.	Questionnaire for educational institutions	30	The number is for all the educational institutions within the study area including the control site.

The approach of equal number of samples per subpopulation where the subpopulation is same was suggested by Czaja and Blair (1996). Individuals were chosen at random ensuring the the area of a given site was adequately covered. Eight health service facilities (including the control site) were in the study area. However only seven questionnaires were administered to health service providers because t[illegible] refused to take part in the study despite assurances of anonymity by the researcher. All the educational institutions in the study area and control site participated in the study.

3.2.2 Spirometry

Pulmonary function tests (PFTs) were carried out to supplement the results of the findings of the questionnaires and of a previous study carried out by Ekosse *et al.* (2002). There are many other PFTs that can be performed, but this study limits itself to spirometry, as this is by far the test most frequently used to evaluate lung function (American Thoracic Society, 1995). Spirometry gives a series of values, which allows comparison of an individual's lung function with that of predicted lung function values.

Spirometric tests were carried out on 100 of the respondents. Individuals chosen for the spirometric tests were selected as a result of their medical history. Reference data was obtained from hospitals, clinics and individuals after receiving responses to the questionnaires. At each site ten of the 60 respondents were selected without bias. However, the individuals selected for spirometric tests were older than 18 years because the instrument parameter settings operated only if the individual was older than 18 years of age. Efforts were also made to have a gender balance in the sampled subpopulation for spirometric tests. In line with ethical standards, the informed consent of each individual was obtained before any test was performed. The results were anonymous and treated confidentially.

The lung function test was performed according to the American Thoracic Society (1995) specifications. In this study, a Spiroflow 2000, which was purchased from Penta Medical Systems in South Africa, was used to perform spirometric tests on the selected individuals. It was first calibrated using a 3l syringe, and following the instructions given in the Penta Medical Systems (2002) Software Package, which was run from a Mecer laptop with a Pentium II processor. A calibration log was maintained throughout the period when the individuals were tested. Parameters which were of interest for this study were FVC, FEV_1 and their FEV_1/FVC ratio.

Prior to the tests, the system was adjusted for general, environmental, and client (referred also as individual or respondent) settings. In the general setting, adjustments were made for sitting, full loop, automatic best test selection, (using FVC and FEV_1) as well as for application of the most appropriate equation. In the environmental settings, adjustments were made for room and flow temperatures, altitude and barometric pressure. In the client setting, adjustments were made for height, weight, age, sex, and whether the individual smoked or not.

References were made to the responses obtained from the administration of questionnaires and structured interviews prior to the performance of spirometric tests. It was emphasised to the individual being tested that his or her medical history, such as having had any serious heart or lung disease or any form of recent infections as reported in the questionnaires, had to be confirmed. Prior to the executi[illegible]ric test, the individual had to complete a lung function questionnaire in addition to the questionnaire for individuals, which had previously been completed. The questions in the lung function questionnaire included gender, age, occupation, duration and area of stay in Selebi Phikwe, smoking of cigarettes and cannabis, chest pain experiences, shortness of breath, coughing, and spitting. Furthermore individuals being tested were required not to have used any medication such as bronchodilators prior to testing. They should also not have smoked or eaten for at least one hour before undergoing the testing. These activities could interfere with lung function performance as mentioned by Vermaak (2003).

Figure 3.2 illustrates the administration of spirometric tests as were conducted in this study. In the administration of the tests, the individuals were requested to sit. In order for the individuals being tested to be quite relaxed, any tight clothing was loosened or removed. An explanation of how the test was to be performed was done in Setswana. The mouthpiece was demonstrated and nose clip fitted, and the person was made to sit properly upright, legs straight with both feet firmly on the ground, chin and neck straight and extended. Usually demonstrations were made by a member of the field research team. To do this test the individual was required to take in as deep a breath as possible, and then to blow out all of the air as fast and as forcefully as possible. Between three and five blows were needed to assure that the best performance of the person tested had been measured.

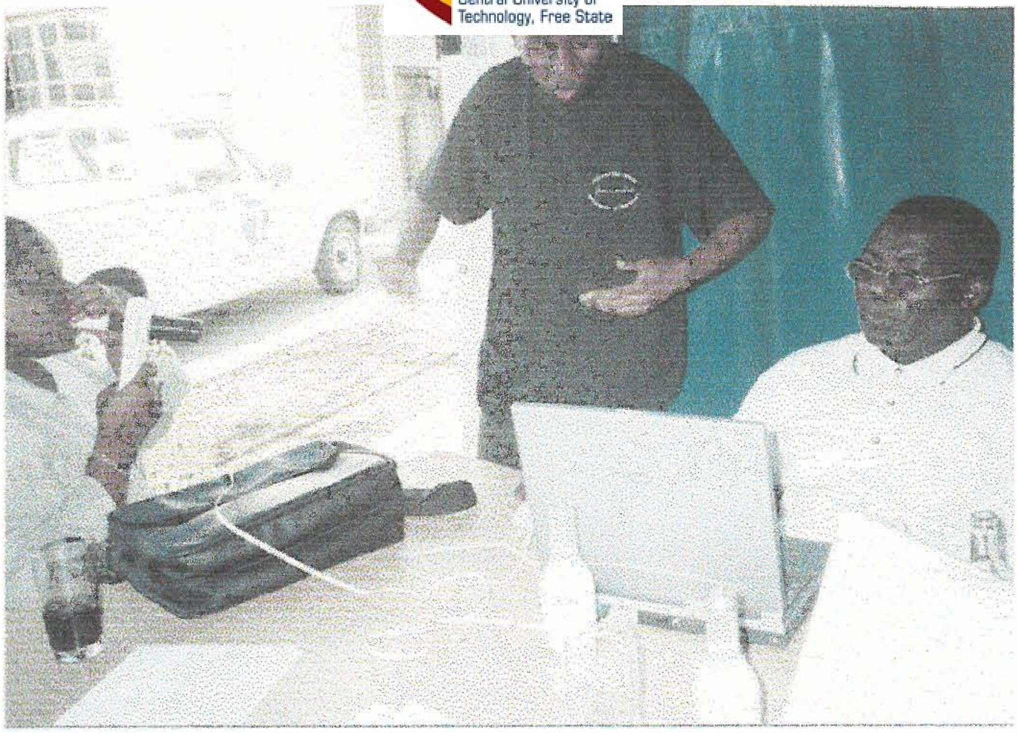

Figure 3.2: Administering the spirometry test at Selebi Phikwe

Tests were performed so that acceptable and reproducible flow volume loops were obtained. The acceptability criteria were applied before the reproducibility criteria. For the test to be accepted, certain conditions such as no unsatisfactory start of expiration, no coughing during the first second of manoeuvre, no early termination of expiration which was to last at least six seconds or two seconds zero flow, no closure of glottis, no leaks, and no obstruction of mouthpiece, had to be fulfilled (American Thoracic Society, 1995; Vermaak, 2003). Conditions for reproducibility of results during the test included the largest and second largest FVC of acceptable manoeuvres not varying more than 200 ml, and in addition the largest and second largest FEV_1 were not to vary more than 200 ml. The reproducibility criteria were implemented as a guide to whether more than three acceptable manoeuvres were needed. The obtained data was coded and processed using the Statistical Package for Social Sciences (SPSS), version 2003 software.

3.3 Data analyses and interpretation

The results obtained from the questionnaires and the spirometry work was processed, analysed and interpreted contextually using SPSS and GIS software packages and techniques.

3.3.1 Application of Statistical Package for Social Sciences

Field data obtained through the administration of questionnaires were coded, processed and analysed both qualitatively and quantitatively. Suitable software packages including SPSS (Statistical package for Social Sciences Version, 2003), and Microsoft Excel (MS Excel) were 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. This information was coded from the value of one to *n* (*n* being the last observation for each question in the questionnaire). It should, however, be noted that the number assigned to these observations has nothing to do with any numerical weight of their own, but refer rather to a form of classification scheme.

The second stage of data ana[illegible] capturing of data codes into the Data Editor. The Data Editor displays a convenient, spreadsheet-like method for creating and editing data files. The Data Editor provides 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 represent variables, whereas in Variable View, each row is a variable, and each column is an attribute associated with that variable. In both views, it is possible to alter information contained in the data file. The Data Editor displays the contents of the active data file and the information in the Data Editor consists of variables. Variables are used to represent the different types of data.

With the data already in SPSS, the variables depicting the health status of individuals, industries, health service providers and 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. Two procedures were selected from the SPSS package, namely the Frequency and Cross-tabulation procedures.

The Frequencies procedure provides descriptive statistics and graphical displays that are useful for describing many types of variables. This procedure provides a good start by generating a general frequency output where the results were given in frequency counts and percentages. The Cross-tabulation procedure forms 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.

These cross-tabulation tables, also known as the contingency tables, displayed the relationship between two or more variables. This procedure was used to display the relationships between the 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. This procedure was very useful for making a comparison of all the variables at the different sites where questionnaires were administered.

To obtain a graphic representation of the output, these cross-tabulation tables were imported into Microsoft Excel to create charts showing percentage distribution. In other words, 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 groups of cases.

3.3.2 Application of Geographical Information Systems

The main focus in cartographically creating the diagrams using variables reflecting the human health status was to generate GIS maps showing Selebi Phikwe's infrastructure and topography with data incorporated from the questionnaire survey. The main types of software used were: ArcGIS version 8.2, Excel 2000, Word 2000, and the operating system was Windows XP.

Hard copies and digital data of the Selebi Phikwe area were acquired from the Departments of Urban, Regional and Town Planning, and Surveys and Lands of the Government of Botswana. Data acquired from Department of Surveys and Lands was geographic, while that from Urban, Regional and Town Planning was projected. Geographic coordinate systems use latitude and longitude coordinates on a spherical model of the earth's surface. The digital data was in the form of shapefiles, which were incorporated, processed and analysed within ArcGIS version 8.2 which has the ability to access two types of coordinates, both geographic and projected.

Geographic coordinates from the Department of Surveys and Lands, Botswana, were then projected in order to properly lineate the previously projected data. The data was projected by importing the projected coordinate system parameters used by the other data source and then modifying the individual parameters as required. Shape files coordinate system parameters were stored in the same location as the shape files, which made it easier to place all the layers within the same view.

The projected coordinate system uses mathematical conversion to transform latitude and longitude coordinates that fall on the earth's three-dimensional surface. In this study, the projected coordinate system was preferred to the geographic system since the spatial analysis option for the projected data within ArcGIS enables the ArcMap tool to calculate the distance correctly. Area, shape, distance and direction of the map were thus preserved. Other segments within the maps were digitised on the screen incorporating more layers. Each layer was displayed in metre units. Editing shapefiles and tabular data was also done in addition to map analysis. Spatial integrity of the data was maintained by using the CAD-based tool for editing the data.

Some layers, which were imported from an earlier version of the GIS software package such as ArcView 3.2 (1994), were implemented by a geodatabase datamodel function within ArcGIS 8.2. The geodatabase function is managed by the ArcSDE (2002) tool within ArcGIS 8.2. The ArcSDE tool defines an open interface to database systems for the user, allowing ArcInfo to manage geographic information on a variety of different database platforms (ArcMap, 2002).

In order to keep data topologically integrated, feature datasets that shared boundaries were kept coincident. The advantage of ArcGIS 8.2 is that it automatically maintained the explicit topological relationships between network features that were in a geometric network (ArcGIS 8.2, 2002). Editing and tracing on the network, as well as managing the feature classes that participated in the network, were all handled automatically by ArcGIS 8.2.

The precision tab in the options dialog box was used for accuracy, as it defines the coordinate precision of new and derived coverages during an ArcToolbox (2002) session. Each time a new coverage was created, the coordinate precision of the new [illegible] efined automatically by the creation rule of the software.

Attribute data from Excel 2000 was imported after processing and analysing shapefiles within ArcGIS 8.2. Data was first imported from the statistical software, SPSS into Excel 2000, for the creating of graphs. Graphs were plotted as percentages of given parameters of the respondents against location sites, as illustrated on maps. Thereafter they were exported into ArcGIS and incorporated into map layouts. Graphs were used to show the percentage distributions in order to minimise congestion of different colours on each map. The final maps in ArcGIS were then exported to Microsoft Office 2000 Premium and Professional Word 2000, where titles and figure illustrations were done.

3.4 Conclusion

This chapter has outlined the instrumentation, different methods and analytical techniques that were used to obtain information regarding the human health status of the inhabitants of the Selebi Phikwe Ni-Cu mining environment.

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Chapter Four

Health Status of Individuals Living Within the Selebi Phikwe Ni-Cu Mine Area

4.1 Introduction

In Botswana, as in several other African countries, no studies have been carried out to appraise the human health status of individuals living within mining environments (Ashton, Love, Mahachi and Dirks, 2001). At Selebi Phikwe, Botswana, where Ni-Cu is mined, concentrated and smelted, environmental pollution due to the mining activities has been documented (Ekosse, 2001; Ekosse *et al.*, 2003). The possibility that the above mentioned environmental pollution might impact negatively on human health is very real. Ekosse (2001) reported on the obnoxious smell of sulphur-rich gases eminent at Selebi Phikwe, Botswana. It is thus suspected that the inhabitants of the Selebi Phikwe area inhale polluted air.

Asare (1999) suggested that a possible relationship could exist between community health problems and air pollution emanating from the exploitation of Ni-Cu ore. According to Asare (1999), individuals living within the Selebi Phikwe area complain of coughs, influenza, headaches, chest pains, cardio-pulmonary complications, tuberculosis, general body weakness and poor sexual performances. However, these complaints have not been substantiated and documented through any form of research.

This chapter reports on an investigation which was conducted to appraise the human health status of individuals living within the Selebi Phikwe Ni-Cu mine area. Through the administration of questionnaires, data has been generated related to demographical and biographical aspects, family history, general complaints about personal health, past medical history, past and present treatment/medication, and social and personal profiles of respondents. With the aid of SPSS software, attempts have been made to interpret the findings in order to elucidate the health status of individuals living within the Selebi Phikwe Ni-Cu area, Botswana.

4.2 Methods and analytical techniques

The methods and analytical techniques used in appraising the health status of individuals living around the Selebi Phikwe Ni-Cu mine area were discussed in detail in 3.1.1 and 3.2.1 of this document. The study area was divided into ten sites with the control site located 56 km from the mine being the tenth site. The questionnaire relating to the health status of individual has been included as appendix 4.1.

4.3 Results, interpretation and discussion

4.3.1 Demographical and biographical data

Feedback from 593 respondents showed that 43.7% were females, 55.3 % were males and 1 % did not specify their gender. Figure 4.1 gives the gender distribution pattern of respondents living in Selebi Phikwe according to the allocated study sites. Except for sites one and three where the male population surpassed that of the female, at all the other sites the female population was higher than that of the male with the female population in sites two, six, seven and nine overwhelmingly higher than that of the male population.

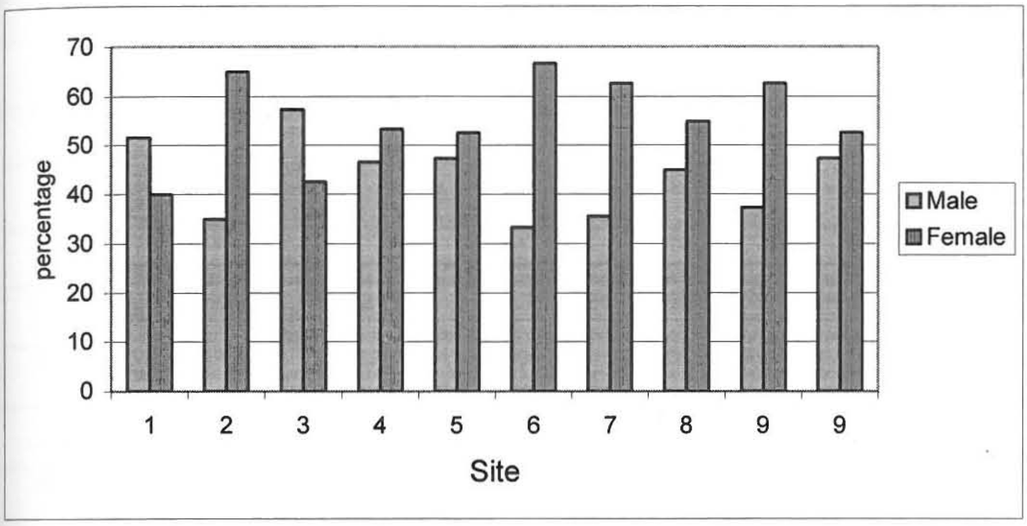


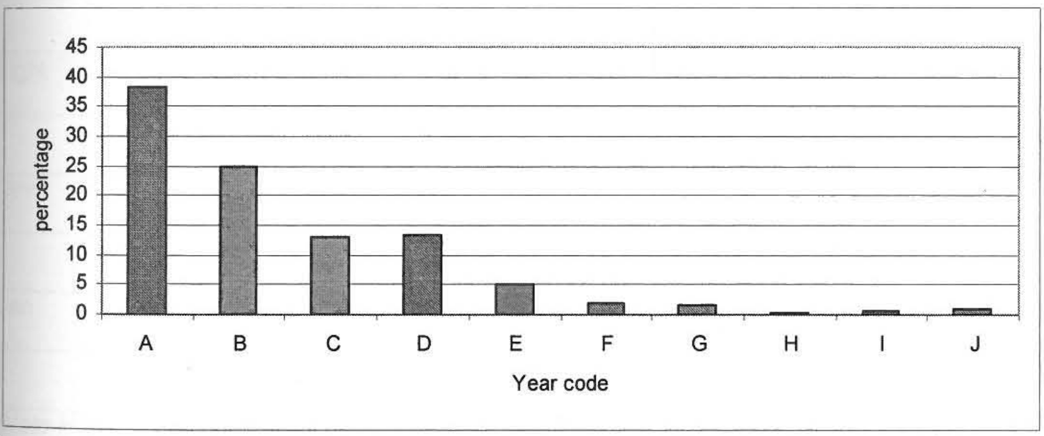
Figure 4.1: Gender of respondents living around Selebi Phikwe according to study sites

The main reasons why respondents live in the Selebi Phikwe area is presented in Table 4.1. The reasons mentioned were employment, schooling and because this is their home town. Some of the respondents came originally as visitors but have prolonged their stay to well over two years. As depicted in Table 4.1, except for sites eight and ten, substantial percentages of the female respondents living in Selebi Phikwe do so because the area is their home town. Most of the men, on the other hand, live there because of employment opportunities.

Table 4.1: Percentage distribution regarding purpose of stay of respondents at Selebi Phikwe according to study sites

Site	Gender	Employment	Schooling	Home town	Visiting	Unspecified
One	Male	65	19	6	10	
	Female	33	25	38	4	
	Unspecified	20	20		60	
Two	Male	43	29	24	5	
	Female	15	10	59	15	
Three	Male	46	20	29	6	
	Female	23	31	42	4	
Four	Male	43	11	36	11	
	Female	19	6	56	19	
Five	Male	41	11	41	7	
	Female	13	13	50	20	3
Six	Male	15	20	60	5	
	Female	20	10	65	5	
Seven	Male	62	10	24	5	
	Female	27	5	43	24	
Eight	Male	70	7	22		
	Female	67	3	21	6	3
Nine	Male	64	18	14	5	
	Female	30	11	43	14	3
Ten	Male	7	78	7	7	
	Female	17	53	20	7	3

There is an uneven distribution of duration of stay of the respondents in the Selebi Phikwe area as shown in Figure 4.2. Slightly > 80% of the respondents have lived in Selebi Phikwe area for more 20 years as reflected in Figure 4.2, of which > 35% have stayed for less than five years. Fewer than 5% have lived here for > 36 years. Further details of the gender distribution of the respondents related to the different sites are given in Table 4.2. The data reveals that females have lived longer in the area than males in the different age categories assigned for this study. Quite significant is the fact that not many of the respondents have lived in the Selebi Phikwe area for > 36 years, which is indicative of the less elderly population in the area (Figure 4.3). Figure 4.3 reflects the distribution of the respondents of the various study sites according to six age categories. The adult population of above 20 years was 58%. Sites one and ten are not represented in all the age categories.



(Note in years A = 0-5, B = 6-10, C = 11-15, D = 16-20, E = 21-25, F = 26-30, G = 31-35, H = 36-40, I > 45, and J is unspecified)

Figure 4.2: Overall average duration of stay of respondents living around Selebi Phikwe

Table 4.2: Average percentage of respondents per study site related to duration of stay at Selebi Phikwe area

Site		A	B	C	D	E	F	G	H	I	J
One	Male	52	26	3	13	6					
	Female	42	21	21	17						
Two	Male	43	29	14	5	10					
	Female	56	23	8	3	5	3	3			
Three	Male	26	23	23	9	11	9				
	Female	19	23	27	12	15	4				
Four	Male	39	32	14	11	4					
	Female	41	34	6	16	3					
Five	Male	48	22	4	19	4		4			
	Female	33	13	20	27	3		3			
Six	Male	20	40	30	10						
	Female	23	20	18	28	13					
Seven	Male	24	29	19	19	10					
	Female	46	24	11	14		3	3			
Eight	Male	44	19	11	4		7	7	4		4
	Female	48	21	9	9		3	3			6
Nine	Male	41	18	18	23						
	Female	38	22	3	14	11	5	3			5
Ten	Male	33	44	4	7		4			7	
	Female	33	27	17	10	3		3		7	

(Note in years A = 0-5, B = 6-10, C = 11-15, D = 16-20, E = 21-25, F = 26-30, G = 31-35, H = 36-40, I > 45, J is unspecified)

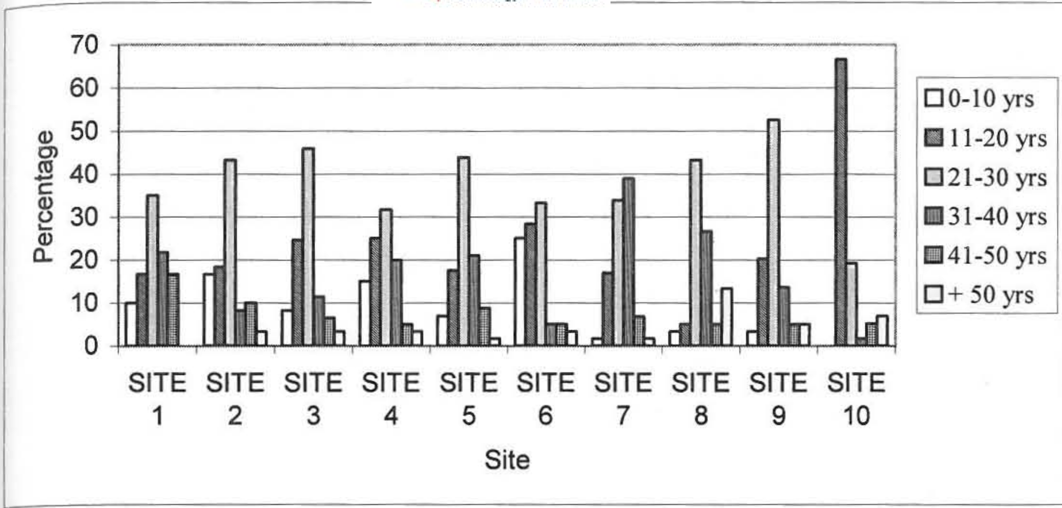
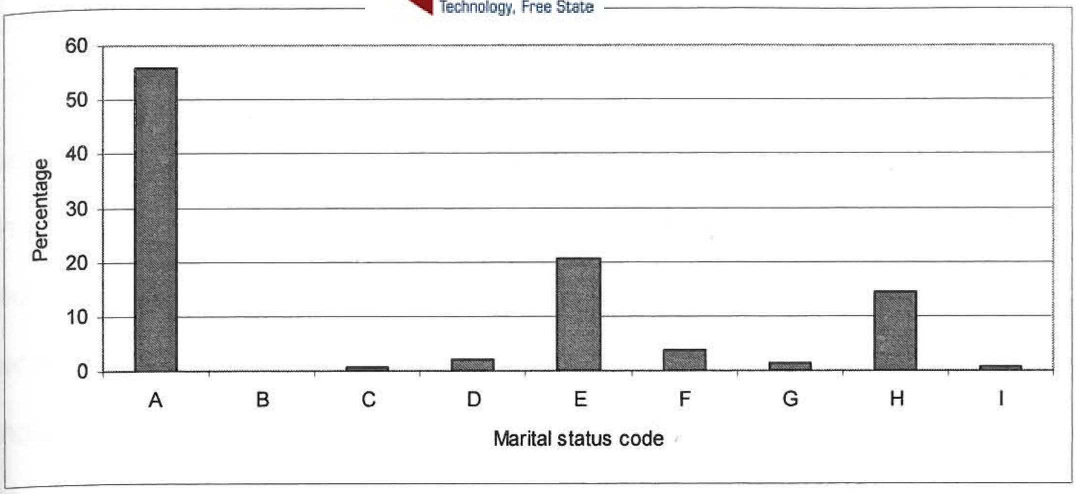


Figure 4.3: Age group of respondents living within the Selebi Phikwe area

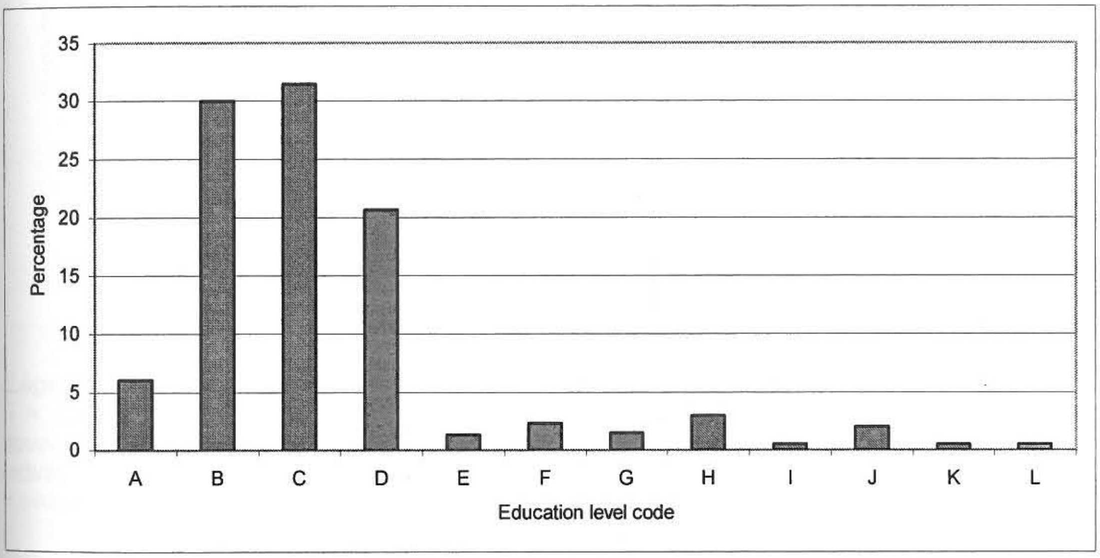
The responses obtained from the questionnaire indicate that 20% of the individuals were not of marriageable age, 15% of the population were married, 1% is divorced, 0.5% were separated, and 6% are cohabiting as reflected in Figure 4. 4. Furthermore, 55% of the population who were of marriageable age, were not married.

Figure 4.5 indicates the educational level of individuals living within the Selebi Phikwe area. In terms of educational level of the respondents, only 6.1% are considered to be illiterate, and 82.1% of the respondents have attained at least a primary school education. Whereas 33% of the respondents have completed junior secondary school, 20% have attained senior secondary school status. A sharp decline is observed in numbers of respondents that have proceeded to vocational and tertiary education. Only 3.5% of the respondents have attained university graduate standing.



(Legend A = not married, B = separated, C = divorced, D = widowed, E = not of marriagable age, F = living together, G = cohabiting, H = married, I = unspecified)

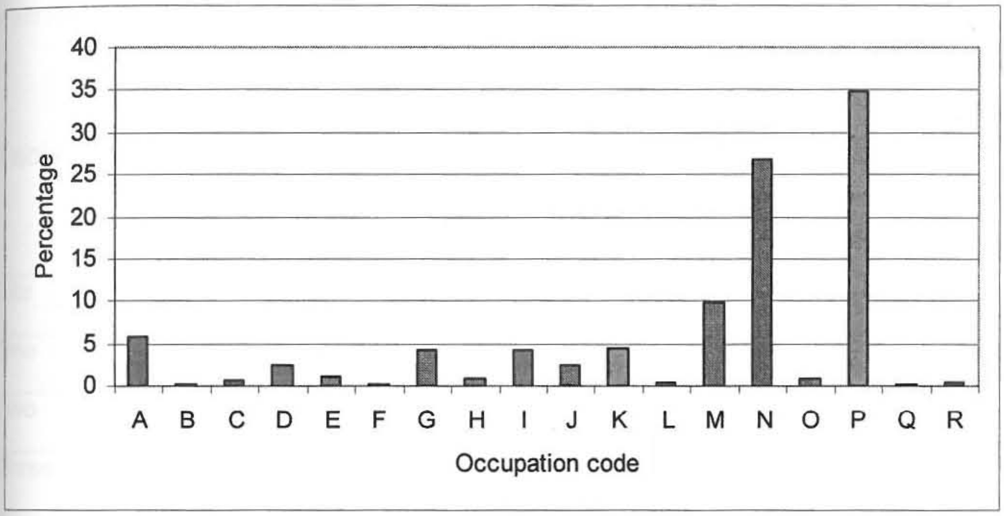
Figure 4.4: Marital status of respondents living within the Selebi Phikwe area



(Legend A = illiterate, B primary, C = junior secondary, D = senior secondary, E = vocational, F = technical, G = teacher, H = university graduate, I = university postgraduate, J = professional, K = adult education and L = unspecified)

Figure 4.5: Educational level of respondents living within the Selebi Phikwe area

Based on the responses from the questionnaire, the population is engaged in different types of employment as indicated in Figure 4.6. Different types of employment of respondents living within Selebi Phikwe area have been listed in Figure 4.6; between 5% and 6% of the population were employed as mine workers, business personnel and government staff. The same percentage of women served as full time housewives. A workforce of 10% was engaged in industrial class services whereas 35% of the population were unemployed.



(Legend A = mine worker, B = mine supervisor, C = smelter/concentrator worker, D = teacher, E = hospital staff, F = politician, G = business personnel, H = hotel/restaurant staff, I = government employee, J = shop/supermarket staff, K = housewife, L = apprentice, M = industrial class worker, N = student, O = farmer, P = unemployed, Q = traditional healer and R = unspecified)

Figure 4.6: Overall average distribution pattern of occupation of individuals living within the Selebi Phikwe area

The currency in Botswana is pula (P). Only 0.3% of the adult respondents had an annual income of > P 100 000.00 and they live in site two as shown in Table 4.3. Up to 67% of the adult respondents had no form of income. For those earning an income, the highest percentage of 13%, had an annual income that was < P 10 000.00, and all the sites were represented by individuals in this income bracket (Table 4.3 and Figure 4.7). Close to 10% of the workforce earned between P 20 000 to P 30 000 annually. The low literacy level of the respondents as shown in Figure 4.5 could be a major contributory factor to the low income levels of the majority of the workforce. Less than 2% of the workforce fell in the high income brackets (above P 40 000). Less than 3% of the workforce did not specify their annual income earnings.

Table 4.3: Average annual financial income according to study sites of respondents living within the Selebi Phikwe area

Site	A	B	C	D	E	F	G	H	I	J	K
One	17	7	10		7	5		2		50	3
Two	15	5	5						3	70	2
Three	3	11		7	2		2			72	3
Four	5	8	12	2	5					68	
Five	14	16	4	2		2				60	4
Six	17	2	3							78	
Seven	22	10	2	3	2			2		54	5
Eight	10	8	2							70	10
Nine	24	5								64	7
Ten	4	4	2	5		2				84	

(Legend, in pulas A = < 10 000, B = 10 001 - 20 000, C = 20 001 - 30 000, D = 30 001 - 40 000, E = 40 001 - 50 000, F = 50 001 - 60 000, G = 60 001 - 70 000, H = 70 001 - 80 000, I = > 100 000, J = No income, and K = unspecified)

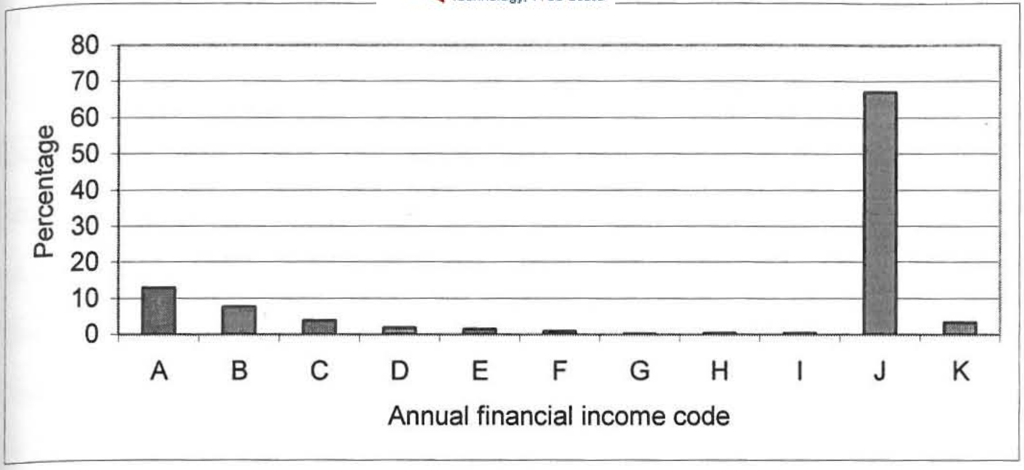


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Figure 4.7: Distribution trend of average annual financial income of respondents living within the Selebi Phikwe area

Table 4.4 depicts the occupation of respondents and their annual income. Most of the respondents living in Selebi Phikwe have been doing so because of employment, and the type of job they perform determines their annual income. The annual earnings of most of the workers were < P10 000.00 and the category of workers in this financial bracket included the following: mine worker, smelter/concentrator worker, teacher, politician, business personnel, hotel/restaurant staff, government employee, shop/supermarket staff, apprentice, industrial class worker and farmer.

Table 4.4: Occupation and annual percentage financial income (pula) of respondents living around Selebi Phikwe

Occupation of respondents	A	B	C	D	E	F	G	H	I	J	K
Mine worker	29	44	15	3	3						6
Mine supervisor					100						0
Smelter/concentrator worker	25	75									
Teacher	7	7	36	29	7			7			7
Hospital staff		29	14	14	14	14			14		
Politician	100										
Business personnel	36	12	20	4	8	4					16
Hotel/ restaurant staff	50	50									
Government employee	4	32	20	12	4	8			4		16
Shop/supermarket staff	64		7				7				21
Housewife										100	
Apprentice	33									67	
Industrial class worker	68	20	2		2	2		2		2	3
Student	1									99	0
Farmer	20									40	40
Unemployed										100	
Traditional healer				100							
Unspecified											100

(Legend, in pula A = < 10 000, B = 10 001-20 000, C = 20 001-30 000, D = 30 001-40 000, E = 40 001-50 000, F = 50 001-60 00000, G = 60 001-70 000, H = 70 001-80 000, I = >100 000, J = no income, and K = unspecified)

Most of the respondents who are farmers were not sure of how much money they made per annum. Others who did not specify their form of employment were also not sure of how much their annual income amounted to. Leading in the P 10 001-20 000 income bracket of individuals living in Selebi Phikwe, were workers in the sm[illegible]n plant (75%), followed by hotel/restaurant staff (50%), mine workers (44%), government employee (32 %), and hospital staff (29%). The highest earnings of > P 100 000.00 was recorded for 14% of hospital staff and 4% of government employees. These employees were medical doctors, the council secretary general and the mayor.

Based on the responses obtained from the questionnaires and structured interviews, most males were the breadwinners of their families, whereas most females were either married or attending school. Most of the income earnings were related to mining activities and businesses supporting the mining community. The town had grown because of mining and has continued to be one of the four fastest-growing cities/towns in the country after Gaborone, Francistown and Maun (Botswana Government National Census, 1991).

While the government health structures provide free health services to their citizens (Botswana Government, 2003), the availability of rich, healthy food and associated social facilities may be rare due to low income earnings. Furthermore, most of the respondents have not attained the educational standing to enable them to earn salaries to support comfortable lifestyles. However, because Setswana is an acceptable language of communication, government uses it as a vehicle to encourage individuals who are unemployed to develop skills (Valentine, 2000). Loans made possible by the financial assistance and citizen empowerment policies of the government have helped several of the individuals living in Selebi Phikwe to set up small and medium-sized businesses (Valentine, 2000).

Respondents who have lived for longer periods (possibly more than five years) in the Selebi Phikwe area, may have been more exposed to the obnoxious gases than those who have lived there for shorter periods. Consequently, their heath status may have been more negatively affected than those whose stay was short.

Quite noticeable is the low educational level of most of the respondents. Education is important in the management of the physical environment. According to the Botswana Government (2003), the improvement of environmental health within the country is very important because individual health is often an outcome of the environment within which the individual, the family and the community live. In this vein, the Government is carrying out public education projects on aspects related to heath and sanitation. However, there are other health and sanitation issues related to the standard of living, information upon which is acquired through formal education over a period of time. These issues cannot be covered through the Government's public education programme.

Most of the respondents in the low income bracket live in the squatter camps where living conditions are not hygienic. Furthermore, the overall recorded low income of the respondents affects their purchasing power. In this regard, they are not able to afford some of the basic necessities of life such as balanced meals. They therefore become very susceptible to sicknesses and diseases.

4.3.2 Family history

From Figure 4.8, it can be deduced that both parents were alive of > 40% of respondents living in Selebi Phikwe area. The percentage of mothers alive surpassed that of fathers at all the study sites inclusive of the control site (site ten). On the other hand, as revealed in Figure 4.9, respondents had an almost equal percentage of brothers and sisters alive in all the study sites except for site eight where there were 16% more brothers than sisters.

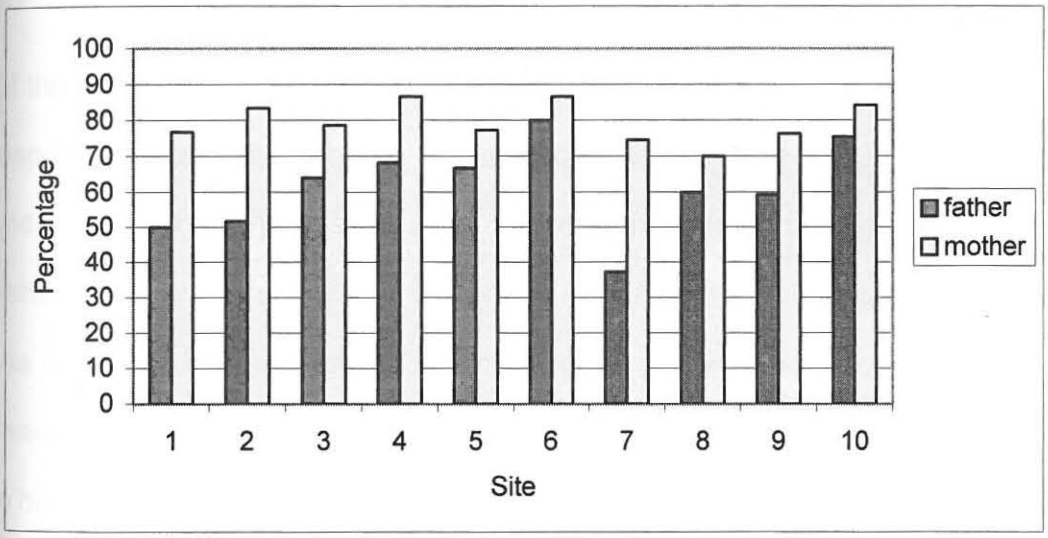

Figure 4.8: Distribution trend of respondents whose fathers and mothers were alive and were living within the Selebi Phikwe area

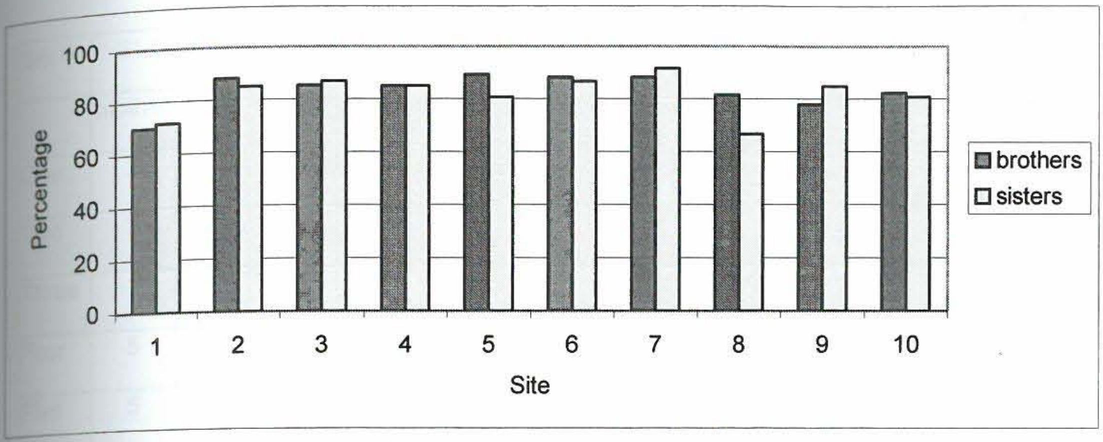

Figure 4.9: Distribution trend of respondents whose brothers and sisters were alive and were living within the Selebi Phikwe area

Of the six age brackets grouped for this study the ages of most mothers of the respondents fell within three of the age brackets (21-30 years, 31-40 years, and 41-50 years) whereas the ages of most fathers fell in two age brackets: between 31-40 years and 41-50 years, as indicated in Table 4.5. Except for site two, there were apparently no fathers of respondents younger than thirty years. As a general trend, the brothers and sisters of respondents appeared to have lived longer than parents.

More than 35% of mothers, brothers and sisters and 27% of fathers of respondents had never lived in the Selebi Phikwe area (Figure 4.10). Moreover, a sizable percentage of all the family members of respondents interviewed at the control site (site ten) had never lived in Selebi Phikwe.

Table 4.5: Percentage age [illegible]ers and mothers of respondents living within the Selebi Phikwe area

Site	21-30 yrs		31-40 yrs		41-50 yrs		51-60 yrs		> 60 yrs		Do not know	
	mother	father	mother	father	mother	father	mother	father	mother	father	mother	father
One	2		22	3	22	15	22	10	7	18	3	3
Two	3	2	20	8	35	23	13	10	12	8	0	
Three			26	3	34	26	8	15	10	13	2	8
Four	5		22	8	32	22	20	30	8	8	0	
Five	5		12	4	21	12	26	21	11	28	2	2
Six	5		18	8	33	20	17	32	7	12	7	8
Seven	2		12	3	20	12	22	14	19	8	0	
Eight	0		8	2	18	7	10	10	17	18	17	25
Nine	0		17	5	37	14	15	20	7	20	0	
Ten	2		46	30	21	25	7	14	7	7	2	

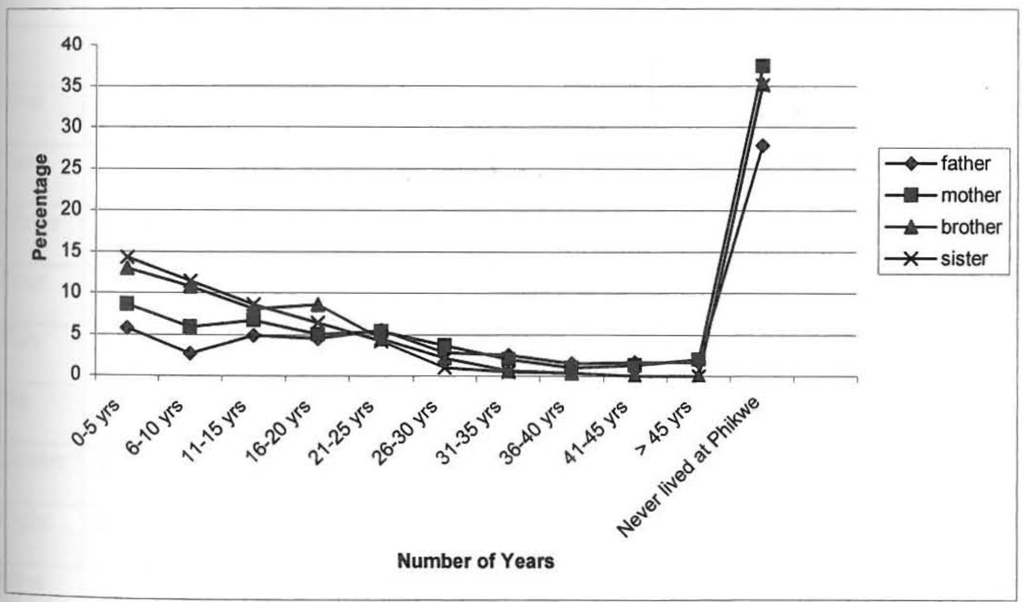

Figure 4.10: Duration of stay of fathers, mothers, bothers and sisters of respondents living within the Selebi Phikwe area

Table 4.6 shows the percentages of parents and siblings of respondents who live in the Selebi Phikwe area (i.e. the respondents live there and not necessarily the family), who experience asthma, bleeding tendencies, high blood pressure (hypertension), and allergies. In general, heart disease, high blood pressure, and allergies were more prevalent among the mothers, whereas asthma was more prevalent among the sisters. Bleeding tendencies occurred in almost equal proportions in mothers (16%) and in brothers (17%). In site four, no asthma cases were reported, and the respondents reported that only their sisters seemed to be affected by allergies.

Table 4.6: Asthma, bleeding tendencies, heart disease, high blood pressure and allergies of fathers, mothers, brothers and sisters of respondents who live within Selebi Phikwe area

Site	Asthma				bleeding tendencies				heart disease				High blood pressure				Allergies			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
One		5	1	4		1			1	2	1	1	2	18		3	3	1	1	1
Two			4	3						1		3	1	7	1	1	2	3		3
Three	1	2	3	2								1	5	15		5			2	
Four						2	1	4		1	1	1		3		2				3
Five	1	4	2	3	2		3			1	1		2	8		1	2	1	1	
Six	2	1	2		2		2				1	1	1	10	1	1	1	1	3	1
Seven	1		2	5		2	4		3	6	2	4	2	9	4	5	2	10	7	3
Eight	2			2	1		3	1	1	5		1	1	2		1	6	6	1	1
Nine			2	2		10	2		1	1	1		2	12		1	3	3	1	1
Ten	2	2	5	2	3	1	2	1	1	2			4	14	1	2	3	7	2	1

(Legend A = father, B = mother, C = brother and D = sister)

There were few reported cases of diagnosed cancer among families of respondents. Prostrate cancer was reported for a father in site three and another father in site seven. Two mothers in site five and one in site seven, as well as three sisters in site four and one each in sites three and seven, had breast cancer. Colon cancer was reported for one sister each in sites four and seven, and a mother in site seven. No cancer cases were reported in sites one, two, six, eight, nine and ten.

Except for sites five and ten, most of the parents had died after they had reached the still very young age of thirty years, as shown in Table 4.7. High death rates for parents were recorded for the age brackets of 41-50 years for sites one and seven, 51-60 years for sites one and nine, and > 60 years for sites two and seven. As a general trend, more fathers had died at an earlier age than mothers of respondents.

Percentage values for necrologic age of parents of respondents living in Selebi Phikwe appeared to be below the normal ages for life expectancy of both males (61 years) and females (67 years) in the country, as reported for 1995 (Botswana, 2003). This early death tendency may have been influenced by the mining activities. It may be suggested that mining and smelting activities could have contributed slightly to the sicknesses and diseases experienced by parents of respondents living in the study area, but direct contribution of genetic influences deduced from family history could not be firmly established within the limits of the study, and no evidence for genetic influence seems to be present.

Table 4.7: Necrologic age percentage of mothers and fathers of respondents living within the Selebi Phikwe area

Site	<20yrs	21-30		31-40		41-50		51-60		>60 yrs		Not sure	
	mother	mother	father	mother	father	mother	father	mother	father	mother	father	mother	father
One				3	5	5	20	10	10	5	10		5
Two				5	2	2	10	3	15	7	22		
Three				2	2	7	7	8	10	3	15	2	3
Four				3	2	5	5	3	13	2	12		0
Five		2	2	4	5	5	2	5	14	4	7	4	2
Six				2	8	3	2	3	2	2	8	2	0
Seven				3	3	7	20	7	10	7	24	2	5
Eight				2	0	3	2	7	8	8	15	10	15
Nine				7	3	3	5	5	15	8	15		2
Ten	2			5	4	2	4	4	7	4	9		2

From the responses obtained in the administration of the questionnaire, it was not certain whether the family history had influenced the health status of individuals living within the Selebi Phikwe area. Not many family members (residing in Selebi Phikwe) of individuals living in Selebi Phikwe suffered from asthma, heart disease, bleeding tendencies, high blood pressure, and allergies. It was, however, reported by respondents through structured interviews that individuals received family support when sick.

Education of parents living in poor housing environments such as the squatter settlement in Selebi Phikwe may prove helpful in alleviating some of the respiratory tract diseases. Washing of hands regularly, drinking boiled water, good house ventilation, and cleaning the surroundings are key issues to alleviating some of the diseases prevalent in households. However, it should be pointed out that when the environment becomes overwhelmingly contaminated, the effect of education could be undermined (D'Souza, 1997). In Selebi Phikwe, the Government has been involved in public health education mainly because contamination levels within the environment are high (Ekosse, 2001).

4.3.3 General complaints about personal health of individuals

Complaints that were previously reported by individuals in the Selebi Phikwe included **general body weakness** of individuals (Asare, 1999). Responses from questions in the current study on general body weakness revealed that between 18% and 50% of respondents experience general body weakness (Figure 4.11). Except for sites four, five and six, males suffered more from body weakness than females. At site five, 70% of the female respondents indicated that they suffered from general body weakness. This figure is very high when compared to the data from the other sites. At site four, only < 3% of the respondents experienced general body weakness. 60% of males and 53% of females living in site ten experienced general body weakness.

Regarding the periods during the day in which respondents experienced body weakness, Table 4.8 shows that this occurred mostly at night and in the mornings. However, at sites three, seven, eight, nine and ten, a sizable number of the respondents experienced body weakness throughout the day.

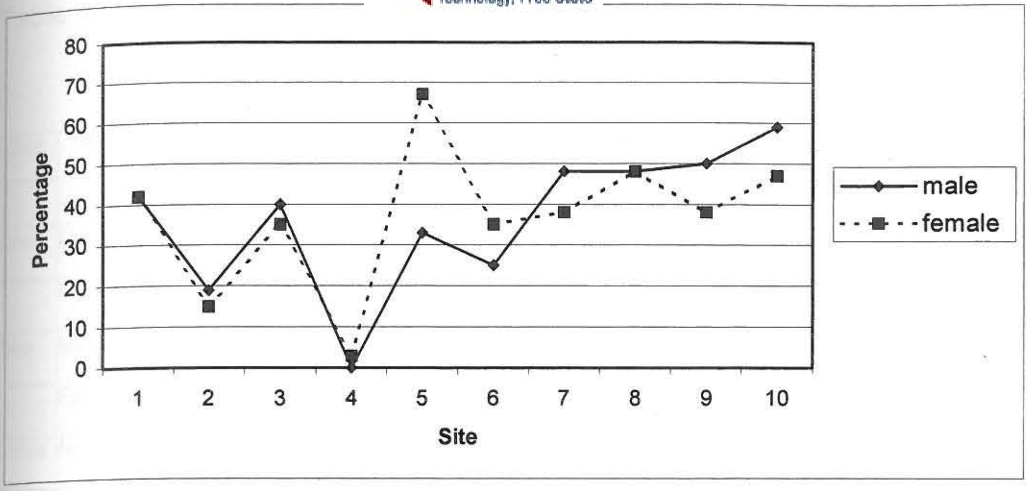

Figure 4.11: Distribution trend of general body weakness of respondents living within the Selebi Phikwe area

According to Asare (1999), the inhabitants of Selebi Phikwe complained of general body weakness. General body weakness has been attributed to several causes including metabolic, neurologic, primary muscular diseases, and toxic disorders as well as association with infectious diseases and influenza/common cold (General Health Encyclopaedia, 2004). The causes of these symptoms could also include other, possibly unidentified, diseases and medications. Furthermore, the causes may vary based on age and gender of the affected person, as well as on the specific characteristics of the symptom such as location, quality, time course, aggravating factors, relieving factors, and associated complaints.

Table 4.8: Period of day in which respondents living within the Selebi Phikwe area who experience body weakness

Site	Gender	Morning (%)	Afternoon (%)	Evening (%)	Night (%)	All day (%)	morning+ evening (%)	morning+ afternoon(%)	Varies (%)	night+ morning(%)
One	Male	6		3	19	23				
	Female	4	4			29				
Two	Male	5			5		5			
	Female	3			3					
Three	Male	11	3	3	6	6			3	6
	Female	12	4	4	8				8	
Four	Male	7			4	21				
	Female	3			9	6	3	3		3
Five	Male	4	15	4	11	11			4	
	Female	13	7	3	10	20				
Six	Male	0		10	0	10	5			
	Female	3		3	8	8				
Seven	Male	5		10	24	5	5			
	Female	0			16	3	3		5	
Eight	Male	0				15			15	
	Female	0			6	9	3		3	
Nine	Male	0	5	5	27	5		5		
	Female	5		3	16	19				
Ten	Male	4		7	7	15				
	Female	3	7	10	13	7	3	3		

The inhalation of gaseous fumes rich in sulphur and the ingestion of phane worms with high levels of heavy ion concentrations (Ekosse, 2001) by the inhabitants of the study area may be one of the causes of general body weakness of the respondents. In site five, the values were extremely high and this could be attributed to the high concentration levels of heavy metals in the phane worms at that site (Ekosse, 2001). However, even values at the control site were above 50%. This may therefore imply that there could be additional factors which could be contributing to the causes of complaints of general body weakness in the study area.

Percentage values for respondents from the different study sites in the Selebi Phikwe area experiencing **chest pains**, ranged from 5% for females in site two to 54% for females in site five (Figure 4.12). The incidence of chest pains experienced by males was higher than that of females at all the sites except for site five.

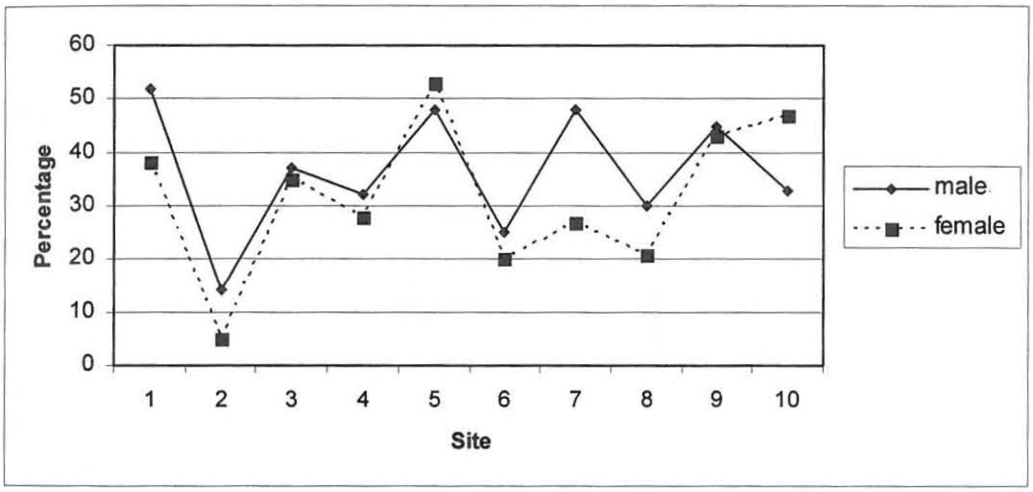

Figure 4.12: Distribution trend of chest pain among respondents living within the Selebi Phikwe area

It was revealed through the responses that the numbers of individuals experiencing chest pains at night as well as all day were significantly higher than those experiencing the pains at certain times during the day. Most of the respondents were not sure of the frequency with which they experienced chest pain. However, more respondents reported experiencing chest pains on a weekly basis than those who suffered on a monthly basis. Respondents living in sites closest to the mine and the smelter/concentrator plant (sites four, five and six) reported a higher incidence of chest pains. This was true for most of the respondents of both the mine and plant. Table 4.9 indicates the severity of chest pains experienced by individuals living within the Selebi Phikwe area.

Table 4.9: Description of chest pain experienced by respondents living within Selebi Phikwe

Site	Gender	Dull	Moderate	Acute	Dull and acute	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male		23	3	19	6
	Female	4	13	4	8	8
	Unspecified					
Two	Male	5	5		5	
	Female		3		3	
Three	Male	6	11	11		9
	Female		12	12	12	
Four	Male		4	21	4	4
	Female	3	3	19	3	
Five	Male	4	4	22	11	7
	Female		13	13	10	17
Six	Male		5	5	10	5
	Female		8	10		3
Seven	Male		29	5	14	
	Female		14	8	5	
Eight	Male		4	19	4	4
	Female		6	15		
Nine	Male		9	18	18	
	Female	3	11	22	5	3
Ten	Male		11	11	7	4
	Female	10	20	7	3	7

Some of the respondents living close to the mine and smelter/concentrator plant complained of moderate to acute, and at times both moderate and acute chest pains. A few of the respondents complained that they experienced mild chest pains, whereas a few others were not sure whether the chest pains they experienced were mild, moderate or severe.

More males in sites one, three, five, seven and nine complained of chest pains than those at the control site. However, females at site five only, complained more of chest pains than those at the control site. It was nevertheless generally observed that within the study area there were widespread complaints of chest pains. Inhabitants of Selebi Phikwe could attribute complaints of chest pains to the inhalation of sulphur rich gases.

Chest pains have been related to breathing of gaseous fumes by the people living in Selebi Phikwe (Asare, 1999). Some of the gases, such as SO_2 and to a lesser extent H_2S have a choking effect on human beings, affecting their respiratory system and causing them to have chest pains (Nichols, 2001). In this regard, it may be assumed that the mining and roasting of Ni-Cu rich ore bodies could have provoked the chest pains experienced by individuals living in Selebi Phikwe.

The distribution trend of respondents suffering from habitual **coughing** is given in Figure 4.13. More males than females suffered from repeated coughing bouts in the Selebi Phikwe area, with the highest percentage being 81% for males in site one. In sites three and eight the male population suffering from repeated cou[illegible] lower than that of the females. Almost equal percentages were observed for both males and females at sites five, seven and nine. Sites three, four, five, six, seven and nine had values of respondents experiencing coughing (between 50% and 70%) higher than that of the control site (37%).

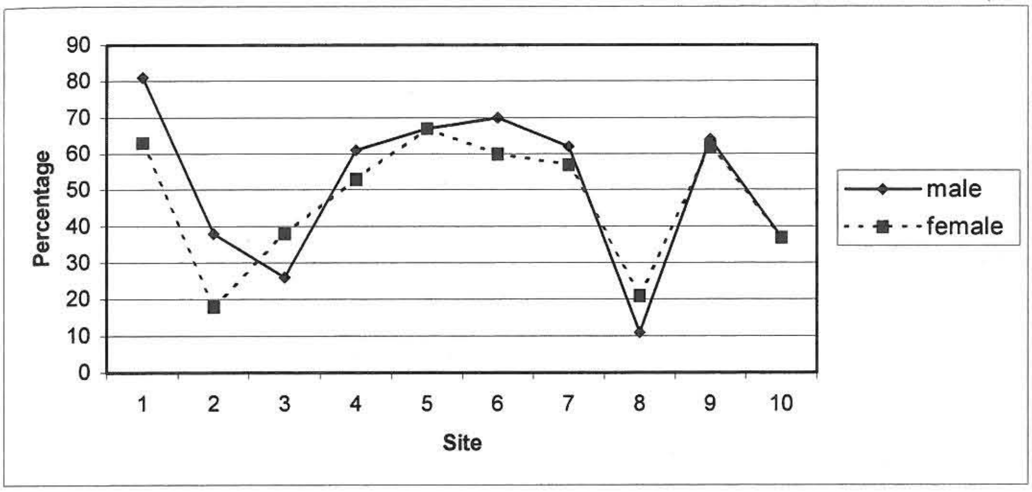

Figure 4.13: Distribution trend of respondents experiencing persistent coughing living within the Selebi Phikwe area

Most of the respondents were not really sure of the frequency with which they experienced coughing bouts (Table 4.10). However, a substantial percentage of the respondents often experienced coughing every day. The remaining fraction of respondents reported that they experienced coughing once a day, once a week or once a month. The percentage values of respondents in Selebi Phikwe who suffered from coughing at night were conspicuously higher than those who suffered from it throughout the day, as could be seen in

Table 4.10. Some respondents suffered from coughing in the mornings whereas others suffered in the afternoon.

Table 4.10: Frequency of experiencing coughing bouts of respondents living within the Selebi Phikwe area

Site	Gender	Regularly everyday	Once a day	Once a week	Once a month	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male	19	6	3	3	48
	Female	21			4	38
Two	Male	10	10	5	5	10
	Female				8	10
Three	Male	9	3	3		11
	Female	12	8	4	8	8
Four	Male		11	11	25	14
	Female	3	3	13	19	16
Five	Male	15		4	15	33
	Female	13		3	23	27
Six	Male	35	10			25
	Female	18	8	8	3	25
Seven	Male	10	19	24		10
	Female	3	14	19	3	19
Eight	Male					11
	Female	3				18
Nine	Male	23	5	9	9	18
	Female	14	11	3	5	30
Ten	Male	7	7	4	7	11
	Female	13	3		13	7

Respondents who experienced chest pains also indicated suffering from frequent bouts of coughing. Respondents further indicated that some of the main causes of the coughing troubling them included fumes from the mine and smelter/concentrator, dust, weather and smoking of cigarettes. Furthermore most of the respondents coughed frequently at night because particles trapped during the day remain in the houses where night ventilation is poor as a result of closed doors and windows.

Table 4.11: Daily periods during which respondents living in the Selebi Phikwe area suffered from coughing bouts

Site	Gender	Morning	Afternoon	Evening	Night	All day	afternoon+ night	Varies	Morning+ night	Evening+ night
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
One	Male	3	6	6	35	23	3		3	
	Female	8			38	17				
Two	Male	5		5	14	10			5	
	Female		3	3	13					
Three	Male	3	3		9	11				
	Female	4	8		23	4				
Four	Male				29	32				
	Female		3		22	19			3	7
Five	Male	4	11	15	19	19				
	Female	10	3	7	33	13				
Six	Male	5	25	5	15	20				
	Female	5	13	5	15	23				
Seven	Male	14		5	24	19				
	Female	8	3	3	22	16	3	3		
Eight	Male					11				
	Female				3	12		6		
Nine	Male	9	5		32	14	5			
	Female	3	5	5	32	14	3			
Ten	Male	7		4	19	7				
	Female	3		17	10	7				

At the control site, however, a greater number of the respondents indicated that the cause of their coughing was more likely due to cigarette smoke than dust. The coughing experienced by respondents in areas one to nine was probably provoked by environmental conditions such as gases from mining and smelting activities, and climatic factors like the changing of seasons. During the winter season, it becomes very dry and windy in Selebi Phikwe, causing a large number of dust particles to be suspended in the air for longer periods. Residents of such environments inhale these particles, and eventually suffer from respiratory tract illnesses and diseases (Scott, 2003).

The distribution trend of respondents living in the different sites of the study area experiencing **constipation** is given in Figure 4.14. Generally more females suffered from constipation than males. However, at sites four, seven and ten, the males experienced more constipation than females. The highest percentage of respondents troubled by constipation was observed in site seven: for the males 52% experienced constipation, and for the females the percentage was 32%. Sites four and eight had the lowest percentage of respondents (< 5%) experiencing constipation. These were the only sites with lower values for females experiencing constipation than that of the control site which was 13%. Regarding the trend for the male population suffering from constipation, all the sites had values lower than that of the control site except for site seven (Figure 4.14). Although respondents experienced constipation, most of them were not sure of the frequency at which it occurred (Table 4.12). None indicated that they experienced constipation only every six months. For some it was weekly, and for others monthly or every three months. Not many of the respondents indicated that they suffered from constipation as can be deduced from Table 4.13. However, for those who did, the constipation was mild to moderate.

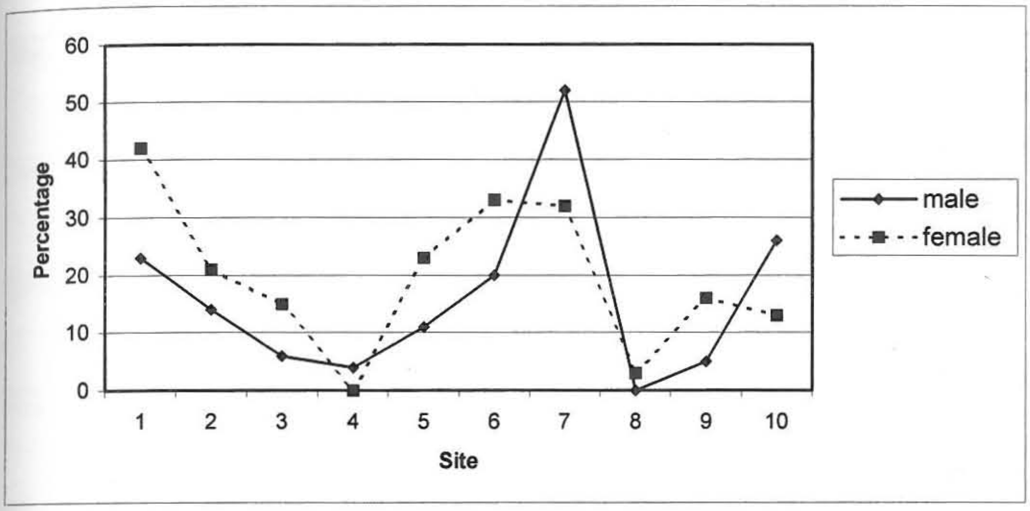

Figure 4.14: Distribution trend of respondents troubled by constipation and living within the Selebi Phikwe area

The graph in Figure 4.15 depicts the percentage distribution trend of respondents at Selebi Phikwe who suffered from **diarrhoea**. Except for sites three and eight, at all the other sites, more males suffered from diarrhoea than females. At the control site, 30% of the females and 40% of the males suffered from diarrhoea. Higher percentages of respondents who suffered from diarrhoea were observed at site one for both males and females, and for sites seven and nine for males.

Table 4.12: Frequency of experiencing of constipation of respondents living within the Selebi Phikwe area

Site	Gender	Weekly	Monthly	Three monthly	Not sure
		(%)	(%)	(%)	(%)
One	Male		10		13
	Female	8	8		25
Two	Male	5	5		5
	Female	8	3	8	3
Three	Male				6
	Female		4		12
Four	Male				4
	Female				
Five	Male	4		4	4
	Female	7	13		3
Six	Male			5	15
	Female	5			28
Seven	Male	5	38	5	5
	Female	11	8	3	11
Eight	Male				
	Female				3
Nine	Male				5
	Female	5			11
Ten	Male	11			11
	Female	3	3		3

Table 4.13: Type of constipation experienced by respondents in the Selebi Phikwe area

Site	Gender	Mild	Moderate	Acute	Acute and mild	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male	3	3		3	13
	Female	8	25		4	4
Two	Male	0	14			
	Female	3	10	5	3	
Three	Male	3				3
	Female	4	12			
Four	Male					4
	Female					
Five	Male	4	4		4	
	Female		10	3	3	7
Six	Male		10		5	5
	Female	8	15	3	5	3
Seven	Male	19	24	5	5	
	Female	5	16	8	3	
Eight	Male					
	Female				3	
Nine	Male					5
	Female	3		5	3	5
Ten	Male	7	4	11		4
	Female	3	3	3		3

Very low values for victims of diarrhoea were found in sites two and four (4% each) for females and site four (3%) for males (Figure 4.15). From

Table 4.14, it is evident that most of the respondents were not certain of the frequency of occurrence of diarrhoea attacks. A few, however, indicated that attacks occurred weekly, while others had attacks every three to six months.

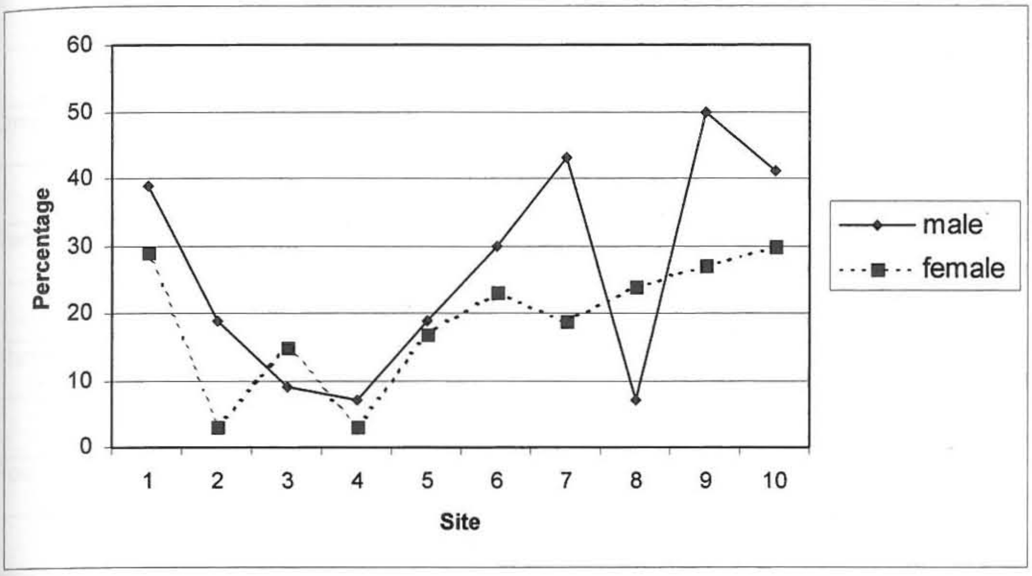

Figure 4.15: Distribution trend of respondents living within the Selebi Phikwe area who experience diarrhoea

The diarrhoea experienced by respondents was moderate to acute (Table 4.15). Diarrhoea patients had attacks occurring throughout the day. Moreover, some respondents reported that their stool was at times contaminated with blood. Moderate diarrhoea was observed in those living far away from the mine and smelter/concentrator environments (sites two, eight and nine), whereas those suffering from acute diarrhoea lived close to the mine and smelter/concentrator environments (sites four, five and six). A similar pattern was observed for those who suffered from coughing and constipation.

Table 4.14: Frequency of occurrence of diarrhoea in respondents living within the Selebi Phikwe area

Site	Gender	Weekly	Monthly	Three monthly	Six monthly	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male	6	3		3	26
	Female	4		8		17
Two	Male				10	10
	Female					3
Three	Male	3			3	3
	Female	4	4			8
Four	Male			7		
	Female		3			
Five	Male			4		15
	Female	7				10
Six	Male		5			25
	Female	3	3		3	15
Seven	Male		19	5	14	5
	Female		8	8	3	
Eight	Male					7
	Female					24
Nine	Male		5			45
	Female	5		3		19
Ten	Male	19				22
	Female	10	7			13

No investigations were carried out to determine the causes of either diarrhoea or constipation. However, the residents indulge in eating the phane worms, most of which have high levels of heavy metals (Ekosse, 2001). The ingestion of these heavy metals may be a contributing factor responsible for diarrhoea in some of the inhabitants, and constipation in others.

Table 4.15: Type of diarrhoea experienced by respondents in the Selebi Phikwe area

Site	Gender	Mild	Moderate	Acute	Acute and mild	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male	6	23	6	3	
	Female	4	17			8
Two	Male	10	5	5		
	Female		3			
Three	Male		3	3		3
	Female		4	4	8	
Four	Male		4	4		
	Female				3	
Five	Male	4	7	4		4
	Female			7	3	7
Six	Male	10	5	10		5
	Female	3	5	5	5	5
Seven	Male	5	33	5		
	Female		11	3	5	
Eight	Male			4		4
	Female		9	9		6
Nine	Male	23	5	5	14	5
	Female	11	5	3	8	
Ten	Male	15	11	4	4	7
	Female	13	7	3		7

Percentage values for respondents who reported having **influenza/common cold** ranged from 29% for both males and females at site two to 93 % for females at site four (Figure 4.16). In sites three, four, seven, eight and nine, there were more females suffering from influenza/common cold than males. Only in site two were the percentages of respondents troubled by influenza/common cold (29%) less than those of the control site (site ten) (48% for both males and females). Furthermore, percentage values of respondents suffering from influenza/common cold for all the rest of the sites were conspicuously higher than those for the control site.

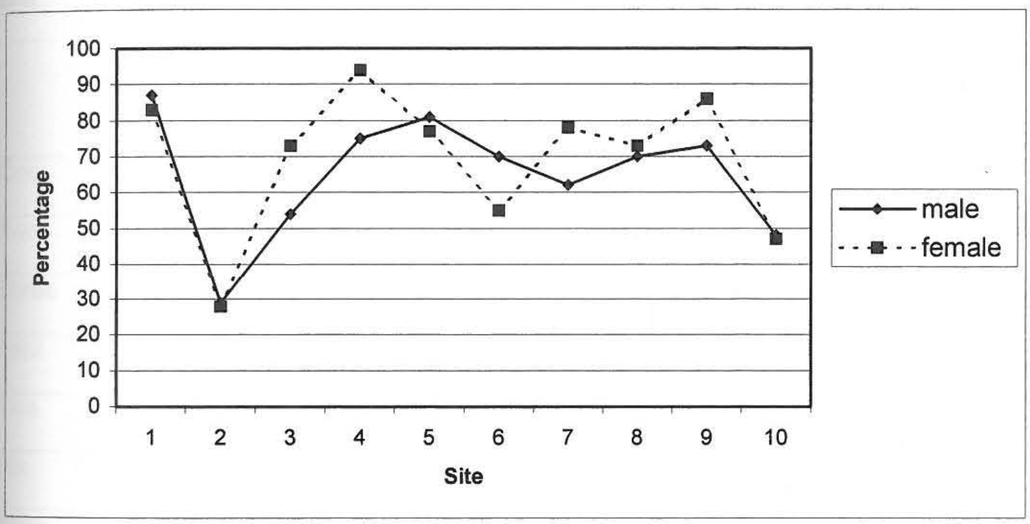

Figure 4.16: Distribution trend of respondents living within Selebi Phikwe who experience influenza/common cold

Symptoms evidenced by respondents suffering from influenza/common cold in Selebi Phikwe included sore throat, a runny nose, a blocked nose, body pains and high temperature (Table 4.16). Sore throat was more rampant in sites one, two, three and five than in the other sites. A runny nose was the most common problem. Respondents who lived in sites one and two and sites four, five, six and seven reported the highest incidence of runny nose. In all the sites, percentage values obtained for respondents with blocked nose were very high. In sites seven, eight and nine, a higher percentage of respondents experienced body pains that accompanied the influenza/common cold. Except for site two, > 50 % of the respondents who suffered from influenza/common cold also had high temperature (Table 4.16).

Table 4.16: Symptoms that accompany influenza/common cold of respondents living in the Selebi Phikwe area

Site	Sore throat		Runny nose		Blocked nose		Body pains		High temp	
	Male %	Female %	Male %	Female %	Male %	Female %	Male %	Female %	Male %	Female %
One	39	29	42	67	48	54	39	46	39	63
Two	19	15	14	18	10	10	0	5	5	3
Three	14	12	9	19	34	46	17	19	23	23
Four	4	6	57	69	71	88	11	9	75	94
Five	11	13	19	27	48	40	4	10	67	67
Six	0	10	30	38	40	20	10	15	60	43
Seven	5	8	52	65	52	70	29	41	29	30
Eight	7	9	11	24	41	27	33	45	26	33
Nine	0	11	45	41	14	14	23	11	55	49
Ten	4	7	11	17	26	33	4	7	44	27

Influenza /common cold is caused by several factors including air pollution. In all the sites the values obtained were higher that that for the control site. This may imply that the sulphur-rich particles in the air (Ekosse, 2001) that are frequently inhaled by the residents of Selebi Phikwe could be irritating to the respiratory pathway and could affect the respiratory tract of the inhabitants of the area, leading to a higher susceptibility to infectious diseases of the airways.

From Figure 4.17, it is indicative that respondents suffering from **headaches** were very numerous in the study area. Except for site two where the percentage of respondents suffering from headache was as low as 39% for females and 40% for males, in all the other sites the range was from 58% of males at sites three and eight, to 98% of males at site six. Most of the respondents suffering from headaches were not sure of the frequency of attacks. Some had attacks at least once a week although a fairly significant percentage also indicated having attacks once a month (Table 4.17). Some had headache attacks once every three months, and others once every six months. Few individuals indicated that they had headache attacks once a day, and even fewer indicated twice a week (Table 4.17).

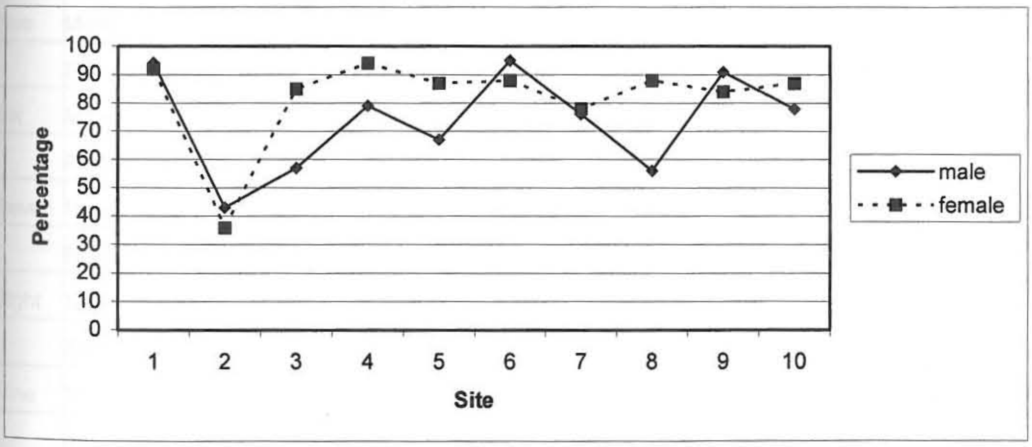

Figure 4.17: Distribution trend of respondents living within the Selebi Phikwe area who suffer from headaches

Based on the responses obtained from the questionnaires and structured interviews, respondents suffered primarily from temple headaches and frontal headaches (Table 4.18). A high percentage of respondents indicated that when they suffered from headaches, the pain was felt all over the head. It was generally observed that more females suffered from headaches than males in the study area.

Table 4.17: Frequency of headaches of respondents living within the Selebi Phikwe area

Site	Gender	Once a week (%)	Once a month (%)	Once every 3 months (%)	Once every 6 months (%)	Not sure (%)	Everyday (%)	Twice a week (%)
One	Male	10	13	3		68		
	Female	25	4			63		
Two	Male	0	29			10	5	
	Female	23	8			5		
Three	Male	26	14	3	3	11		
	Female	35	19	4	4	23		
Four	Male	7	29	36	7			
	Female	19	56	16	3			
Five	Male	7	7	4		48		
	Female	27	13			43	3	
Six	Male	35	15		5	40		
	Female	25	10	5	5	43		
Seven	Male	43	19	14				
	Female	35	16		5	19	3	
Eight	Male					48		4
	Female		3			85		
Nine	Male	18	9		5	59		
	Female	16	14	3		51		
Ten	Male	26				52		
	Female	30	10		10	37		

A recent broadcast on Voice of America (VOA) (2003) indicated that females generally suffer more from headaches than men. Headaches of females, as explained during the programme, are associated with hormonal and monthly physiological changes as well as menopause, unlike for men, whose headaches are usually stress-related. The most common form of headache attacks in the study area was the acute headache, followed by moderate, and then dull and acute (Table 4.19). A sizeable percentage of respondents in the control site, however, also suffered from headaches.

Table 4.18: Type of headache experienced by respondents living in the Selebi Phikwe area

Site	Gender	Front (%)	Temple (%)	Back (%)	Centre (%)	All over (%)	front+temple(%)
One	Male	19	19	13		42	
	Female	21	38			33	
Two	Male	14	19	5	5		
	Female	5	21	3	5	3	
Three	Male	9	23	9		17	
	Female	12	35	12	4	19	4
Four	Male	7	25		4	43	
	Female	13	41			41	
Five	Male	22	15	7	4	19	
	Female	33	27		10	17	
Six	Male	25	30	10	25	5	
	Female	18	40	8	13	10	
Seven	Male	19	33	5		19	
	Female	30	16	3	8	22	
Eight	Male	15	26			15	
	Female	27	33			27	
Nine	Male	9	45	5	14	18	
	Female	14	35	3	3	30	
Ten	Male	7	33	4	7	26	
	Female	17	57	3		10	

Table 4.19: Degree of severity of headaches experienced by respondents living in the Selebi Phikwe area

Site	Gender	Dull (%)	Moderate (%)	Acute(%)	dull and acute (%)	Not sure (%)
One	Male	3	26	23	29	13
	Female		21	33	33	4
Two	Male	14	14	5	10	
	Female	5	15	5	8	3
Three	Male	3	3	26	9	17
	Female	4	23	19	19	19
Four	Male	7	14	4	50	4
	Female	6	22	34	31	
Five	Male		15	22	7	22
	Female	10	20	27	7	23
Six	Male		40	40	15	
	Female	8	35	33	5	8
Seven	Male	5	38	33		
	Female		43	22	14	
Eight	Male		11	37	4	4
	Female	6	33	42	6	
Nine	Male		23	41	9	18
	Female	3	14	41	11	16
Ten	Male	7	15	15	11	30
	Female	10	33	33	3	7

There are several types of headaches, as well as different causes of headaches (Voice of America, 2003; Inflam-Med, 2004). The high incidence of headache in the control site could be indicative of the fact that there are other causes apart from air pollution which may be responsible for headaches suffered by inhabitants of the study area.

Percentage values of respondents suffering from recent **loss of body weight** ranged from 1% for males in site two to 52% for females in site nine as shown in Figure 4.18. In general, slightly more females experienced recent loss of body weight compared to males. Lower percentage values than those for the control site were obtained for both males and females in sites two and four, and for males in site three (Figure 4.18).

In terms of rate of recent loss of body weight, in general a slow rate was observed as indicated in Table 4.20. Moreover, the loss of body weight was slower for males than for females. Other respondents reported that the rate of loss of body weight they experienced were moderate, fast and constant respectively. Further details are given in Table 4.20.

Except for sites two and four, the percentage of respondents experiencing recent loss of body weight is higher at all the other sites than at the control site. Recent loss of body weight is caused by many factors including terminal illnesses and diseases (General Health Encyclopaedia, 2004). It is not certain to what measure recent loss of body weight is directly attributable to environmental factors. However, loss of body weight may indirectly be attributed to the environment if the causal agents such as contaminated air are responsible for the illnesses and diseases in which recent loss of body weight is symptomatic.

Table 4.20: Rate of loss of body weight of respondents living within the Selebi Phikwe area

Site	Rate of loss of body weight	Gender of respondents		
		Male	Female	Unspecified
		%	%	%
One	Slow	19	29	40
	Moderate	3	4	20
	Fast	0	4	0
	Irregular	6	4	0
Two	Slow	0	5	
	Fast	0	5	
Three	Slow	3	15	
	Fast	3	8	
	Irregular	3	0	
Four	Irregular		3	
Five	Slow	19	30	
	Moderate	4	0	
	Fast	4	0	
	Constant	4	3	
	Irregular	7	10	
Six	Slow	10	20	
	Moderate	0	10	
	Fast	5	8	
	Irregular	5	5	
Seven	Slow	5	14	
	Moderate	0	5	
	Fast	0	5	
	Constant	10	14	
	Irregular	29	8	
Eight	Slow	7	27	
	Moderate	4	3	
	Fast	11	0	
	Constant	4	0	
Nine	Slow	14	22	
	Moderate	14	19	
	Fast	9	5	
	Constant	14	8	
Ten	Slow	11	7	
	Moderate	0	3	
	Fast	4	0	
	Irregular	4	3	

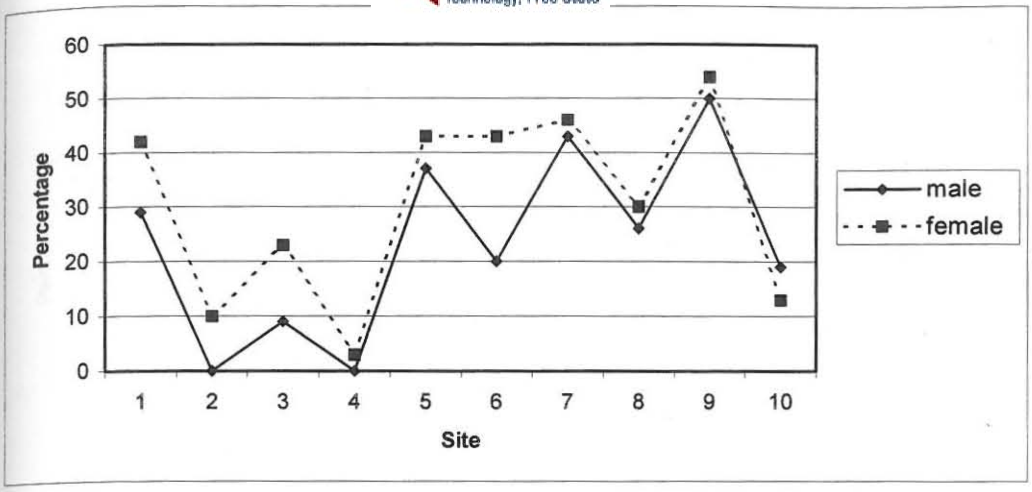

Figure 4.18: Distribution trend of respondents living around Selebi Phikwe who experience loss of body weight

Females reported suffering more from **lower abdominal pain** than males at all the sites of the study area (Figure 4.19). The percentage values obtained for both males (20%) and females (52%) suffering from lower abdominal pain at the control site were higher than those of all the other nine study sites, except for males in sites five (21%) and nine (45%). Percentage values for females in sites five, six, and seven were more than twice those of males for the same sites. In site four, the percentage values for both males and females were the same. Most of the females suffering from pain in the lower abdomen experienced it monthly, as reflected in Table 4.21. Some respondents, especially the males, had lower abdomen pains once a day, weekly or every three months. Others were also not sure of the frequency with which they suffered from pain in the lower abdomen (Table 4.21).

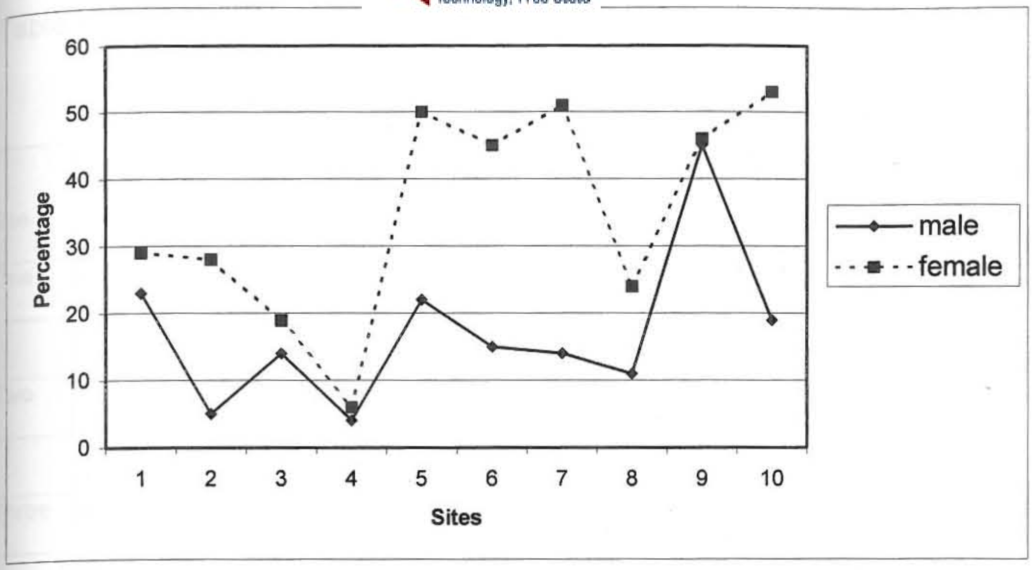

Figure 4.19: Distribution trend of respondents living around Selebi Phikwe who experience lower abdominal pain

According to the responses obtained from the questionnaires and structured interviews, not many individuals living in Selebi Phikwe suffer from pain in the lower abdomen. It was further deduced from responses obtained from the questionnaires that far more females than males did suffer from such pains. Most of the females indicated that the pains could be associated with their monthly periods. For some, the pains were acute, and for others dull. However, other respondents, including males, suggested that the pains they experienced in the lower abdomen could be associated with too much work. A few respondents in sites six and nine indicated that they suffered from such pains because they had sexually transmitted diseases (STDs). Others were not sure of the causes of the lower abdominal pain. The researcher is of the opinion that the responses were not indicative of mining and smelting activities being contributory to the pains of the lower abdomen.

Table 4.21: Frequency with which respondents living within the Selebi Phikwe area experience pain in the lower abdomen

Site	Gender	Once every day	Weekly	Monthly	Three monthly	Not sure	Not applicable
One	Male	3	3	10	3	3	24
	Female	4	0	17	0	8	17
Two	Male	5	0	0	0	0	20
	Female	0	0	28	0	0	28
Three	Male	0	0	6	0	9	30
	Female	4	0	8	4	4	21
Four	Male	0	0	0	4	0	27
	Female	0	0	0	6	0	30
Five	Male	0	7	0	0	15	21
	Female	3	10	7	0	30	15
Six	Male	0	5	0	0	10	17
	Female	0	5	38	0	3	22
Seven	Male	0	10	0	0	5	18
	Female	5	5	32	3	3	18
Eight	Male	0	0	0	0	7	24
	Female	3	3	3	0	15	25
Nine	Male	0	0	5	0	41	12
	Female	5	3	11	0	27	20
Ten	Male	4	4	0	0	11	22
	Female	3	7	23	7	13	14

The distribution trend of respondents suffering from **nausea and vomiting** is given in Figure 4.20. More females than males suffered from nausea and vomiting in the Selebi Phikwe area, with the highest percentage being 42% for both females and males in site ten. In all the other sites the male population who suffered from nausea and vomiting was lower than that of female. Almost equal percentages are observed for both males and females in sites four and ten. Only in site two did the female population suffer less from nausea and vomiting than the male population. All the sites had values of respondents suffering from nausea and vomiting lower than that of the control site (Figure 4.20).

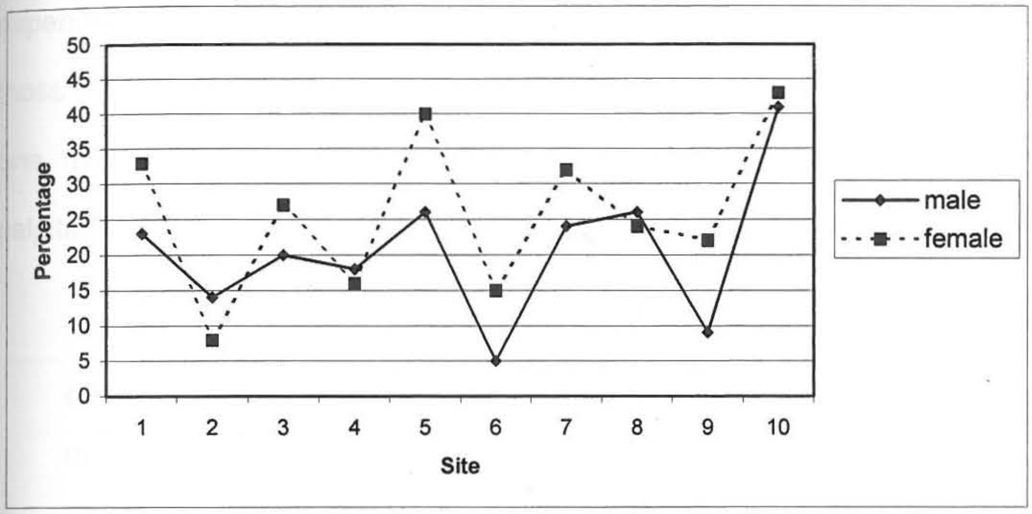

Figure 4.20: Distribution trend of respondents living around Selebi Phikwe who experience nausea and vomiting

Nausea and vomiting is caused by many factors including terminal illnesses and diseases, which include different types of cancer (General Health Encyclopaedia, 2004, National Comprehensive Cancer Network, 2004). It is not certain whether nausea and vomiting can be attributed directly to environmental factors. However, it may be indirectly attributed to the environment if the causal agents such as contaminated air are responsible for the illnesses and diseases in which nausea and vomiting is symptomatic (National Comprehensive Cancer Network, 2004).

The percentage values of respondents suffering from **palpitations** ranged from 1% for males in site four to 52% for females in site eight as shown in Figure 4.21. Percentage values for males and females in sites four, seven, eight, nine and ten were very similar. In general, slightly more females experienced palpitations compared to males. Lower percentage values than those of the control site were obtained for both males and females in sites one, two, three, four, six and nine (Figure 4.21). In terms of rate of palpitations, in general, a fast rate was observed as indicated in Table 4.21.

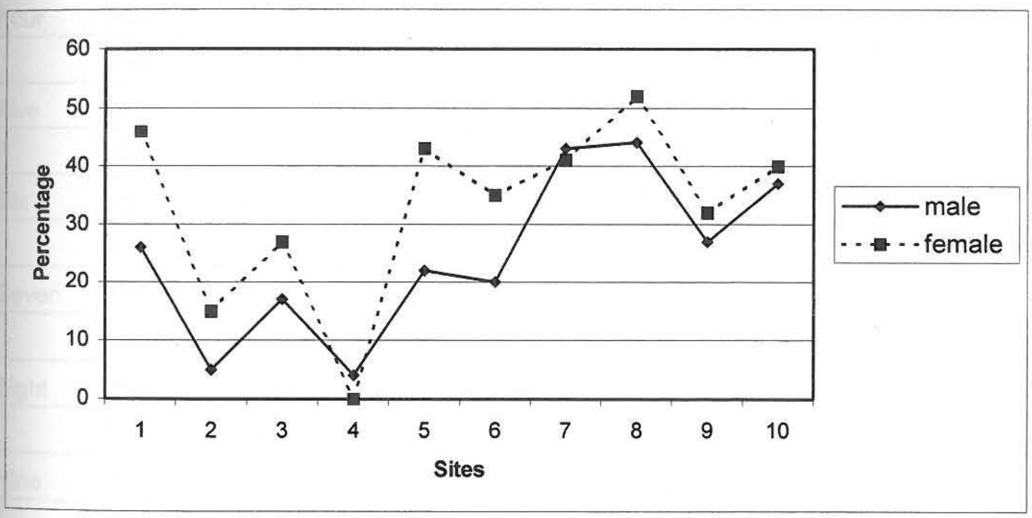

Figure 4.21: Distribution trend of respondents living within the Selebi area Phikwe who experience palpitations

Moreover, it appeared that more females experienced a faster rate of palpitations than males. Other respondents reported that the rate of palpitations they experienced was slow to moderate, and some said the rate fluctuated between slow and fast. A few respondents were not sure of how best they could describe the rate (Table 4.22).

Table 4.22: Rate of palpitations experienced by respondents living within the Selebi Phikwe area

Site	Gender	Slow (%)	Moderate (%)	Fast (%)	Slow and fast (%)	Not sure (%)
One	Male	3	3	3	16	
	Female		13	13	21	
Two	Male					
	Female		3	10		3
Three	Male			9	6	3
	Female			15	12	
Four	Male				4	
	Female					
Five	Male			15	7	
	Female	3	3	30	3	3
Six	Male		5	15		
	Female		3	18	13	3
Seven	Male		5	38		
	Female	3	3	24	11	
Eight	Male			41		4
	Female		6	39		6
Nine	Male				27	
	Female	3		11	22	
Ten	Male		11	11	7	7
	Female	7	7	20	7	

Palpitations could be caused by many factors including anaemia (Pregnancy Complications, 2004) and hypoglycaemia (Inflam-Med, 2004), as well as terminal illnesses and diseases (General Health Encyclopaedia, 2004). It is not clear how palpitations could be related to environmental factors at Selebi Phikwe. However, palpitations may indirectly be attributed to the environment if the causal agents such as contaminated air and heavy metals-contaminated phane worms are responsible for the illnesses and diseases in which palpitations are symptomatic, such as high blood pressure.

Based on responses obtained from the questionnaire, more females reported suffering from **shortness of breath** than males in all the sites of the study area except for sites one and two (Figure 4.22).

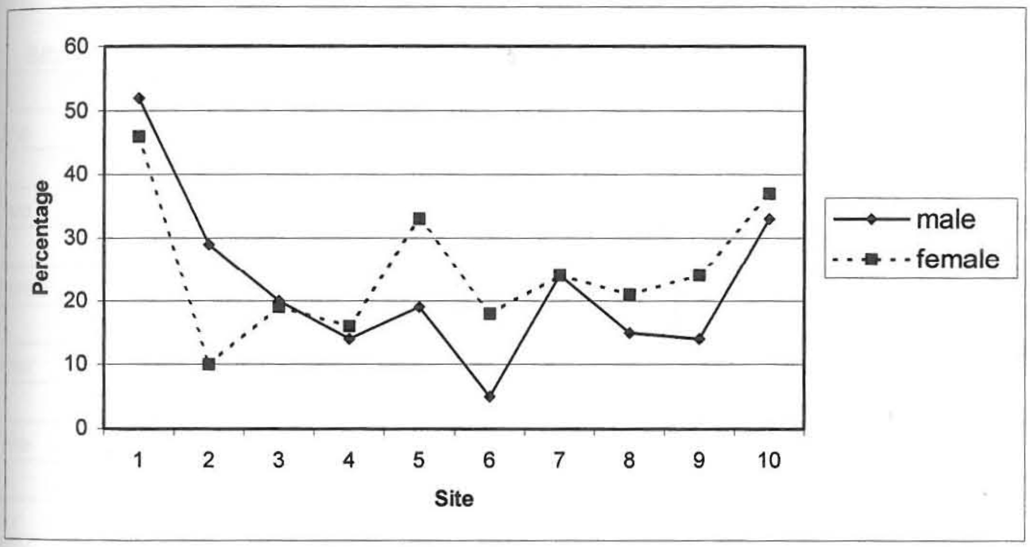

Figure 4.22: Distribution trend of respondents living within the Selebi Phikwe area who experience shortness of breath

The percentage values obtained for both males (33%) and females (38%) suffering from shortness of breath in the control site were higher than those of all the other study sites, except for site one (48% males and 52% females). In sites three, four and seven, the percentage values for both males and females were the same (Figure 4.22).

Responses obtained from the questionnaires and structured interviews indicated that the people of Selebi Phikwe who suffered from shortness of breath experienced mostly acute, followed by a moderate shortness of breath (Table 4.23).

Table 4.23: Type of shortness of breath experienced by respondents living in the Selebi Phikwe area

Site	Gender	Dull	Moderate	Acute	Dull and acute	Not sure
		(%)	(%)	(%)	(%)	(%)
One	Male		16	6	19	10
	Female			20	0	20
Two	Male	14		5	5	5
	Female		8		3	0
Three	Male	3	6	6		6
	Female			8	8	4
Four	Male	4		4	4	4
	Female		3		13	0
Five	Male			4	7	7
	Female		17	7	7	3
Six	Male				5	
	Female		13	5		
Seven	Male	5	5	5	10	
	Female		8	14	3	
Eight	Male		4	4		7
	Female			15	3	3
Nine	Male		5	9		
	Female	5	8	8		3
Ten	Male	15	7	4	7	
	Female	7	17	7	3	3

Some respondents experienced fluctuating dull and acute types of shortness of breath, and others were not sure of the acuteness of shortness of breath, even though they suffered from it. When questioned as to what they thought to be the main causes of shortness of breath which they experienced, the respondents indicated the following: fumes from BCL mine and the smelter/concentrator plant, influenza/common cold, and asthmatic attacks (Table 4.24). Other respondents thought the dust was responsible while still others considered the weather to be a contributory factor. A few indicated that their working environments caused them to experience shortness of breath.

Except for site one where the percentage of respondents who experienced shortness of breath was higher than that of the control site, percentages for all the other sites were lower. Shortness of breath is often indicative of allergic and/or asthmatic reactions in environmentally sensitive individuals. Shortness of breath may thus be linked to environmental factors at Selebi Phikwe; respondents indicated that fumes from the BCL mine could be the main factor responsible for their experiencing shortness of breath.

Values for respondents living within Selebi Phikwe who experienced the need to **spit** often ranged from 1% for females in site eight to 46% for males in site one (Figure 4.23). It was observed that respondents living at sites close to the mine experienced the need to spit often more than those living at sites further from the mine. Except for site three, males generally experienced the need to spit often, more than females did. Values for both males and females at sites two, four and eight were lower than those experienced by respondents living within the control site (Figure 4.23).

Table 4.24: Suspected causes of shortness of breath experienced by respondents living within the Selebi Phikwe area

Site	Gender	Fumes from BCL mine	Dust	Asthmatic Attacks	Working	Flu/ cold	Weather	Do not Know
		(%)	(%)	(%)	(%)	(%)	(%)	(%)
One	Male	23	0	0		6		23
	Female	25		4		0		17
	Unspecified	0		0		0		40
Two	Male	10		10		10		0
	Female	0		0		5		5
Three	Male	3		0		0		17
	Female	0		4	4	0		12
Four	Male	4		0	0	0		11
	Female	3	3	3	0	0		6
Five	Male	4	4		4	0		7
	Female	3			0	0		30
Six	Male	5				0		0
	Female	3				3		13
Seven	Male	10				0	5	10
	Female	3	3	5		5	0	8
	Unspecified	0		0		0	0	0
Eight	Male	7		0		4		4
	Female	6		3		0		12
Nine	Male	14				0		0
	Female	8				3		14
Ten	Male	0						33
	Female	0						37

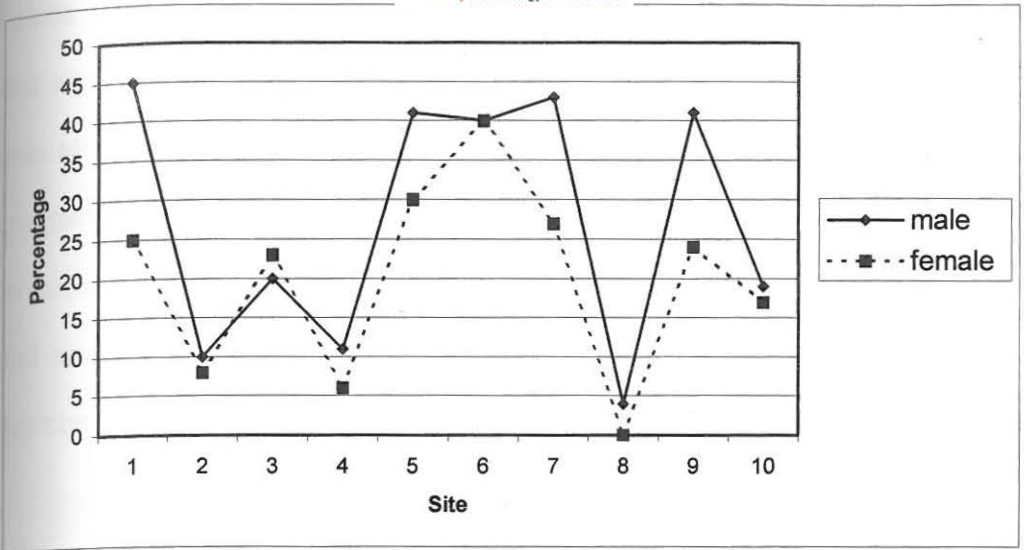

Figure 4.23: Distribution trend of respondents living within the Selebi Phikwe area who experience the need to spit often

Except for sites one and two where the percentage of respondents who experience the need to spit often was lower than that of the control site, percentages for all the other sites were higher than that of the control site. The need to often spit may be attributed to excessive secretion of phlegm by the mucous membrane of the nose, leading to a post nasal drip, which is indicative of an irritation of the respiratory tract by an environmental agent. Allergies to sulphur-rich fumes and gases may thus be a contributory factor. According to Asare (1999), fumes, as considered by many of the people living in Selebi Phikwe, could be one of the main causes of individuals experiencing the need to spit often.

From Figure 4.24, it is clear that respondents who experienced **unusual discharge from their genital systems** were generally few. Percentage values of those respondents ranged from 0% for both males (sites four, six and eight) and females (sites three, four and eight) to 25% for females in site one. More females experienced unusual discharge from their genital systems compared to males living in the same sites except for sites three and nine. For females, percentage values obtained for respondents living in sites one, five and seven were found to be higher than those for site ten (control site), as depicted from Figure 4.24.

Other than the percentages for females in sites one, five and seven, and for males in site nine, which were higher than that of the control site, percentages of respondents in all the other sites for both males and females were lower than that of the control site. Consequently, there is no link to the environment that can be established from the results obtained regarding respondents who experienced unusual discharge from their genital systems.

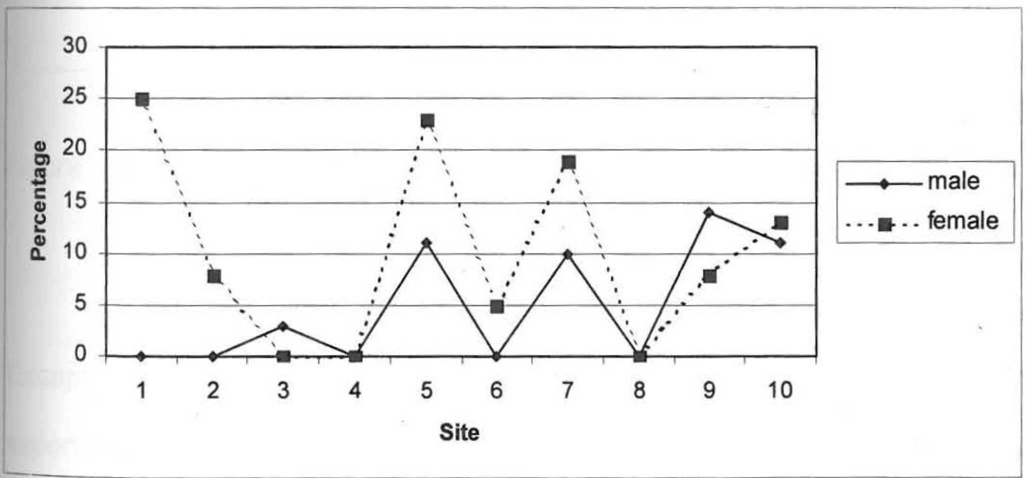

Figure 4.24: Distribution trend of respondents living within the Selebi Phikwe area who experience unusual discharge from the genital system

Based on the responses obtained from the questionnaires, the pattern for individuals living within the Selebi Phikwe area who experienced **pain when passing urine** (Figure 4.25) was rather similar to that of unusual discharge (Figure 4.24). Very low values (1%) were reported for males in sites two, four and ten, and for females in site four of respondents who also experienced unusual discharge from genital system. Except for sites two and four, the percentage values of respondents who experienced pain when passing urine in the other sites were higher than those in the control site (Figure 4.25).

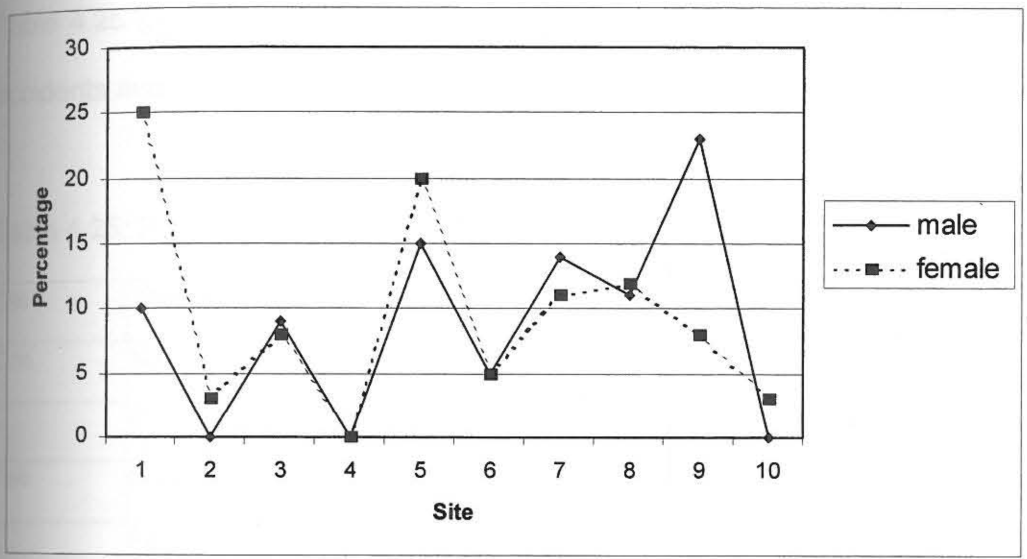

Figure 4.25: Distribution trend of respondents living within the Selebi Phikwe area who experience pain when passing urine

Except for sites two and four where the percentage of respondents who experience pain when passing urine was lower than that of the control site, percentages for all the other sites were higher than that of the control site. Many factors could be responsible for individuals experiencing pain when passing urine. It is not certain how this could be directly linked to environmental factors at Selebi Phikwe. Heavy metals contained in phane worms, which are regularly eaten by the inhabitants, may be considered as an indirect cause. The accumulation of heavy metals in the human body can lead to different types of illness and disease such as iron causing siderosis and cobalt causing "hard metal disease" (Langer, 1999).

4.3.4 Medical history of respondents

Table 4.25 gives the percentage of respondents who have been involved in accidents and live in Selebi Phikwe.

Table 4.25: Respondents who have been involved in accidents

Site	Gender	Percentage	Site	Gender	Percentage
One	Male	32	Six	Male	5
	Female	21		Female	8
Two	Male	19	Seven	Male	10
	Female	8		Female	5
Three	Male	9	Eight	Male	15
	Female	4		Female	12
Four	Male	7	Nine	Male	18
	Female	3		Female	5
Five	Male	19	Ten	Male	7
	Female	3		Female	10

More than 70% of the inhabitants of the Selebi Phikwe area who have had accidents were residing there when the accidents occurred, and about 80% of them have recovered completely. Most of the accidents have been with motor vehicles, although there have been sporadic cases of trees falling on respondents, fire incidents, and accidents at the mines. From Table 4.26, emotional/nervous problems did not appear to be common. In sites four, six, eight and ten no males indicated that they had emotional/nervous problems, and in sites four and eight there were no female cases of emotional/nervous problems reported. More females indicated having emotional/nervous problems than males.

Table 4.26: Percent distribution of emotional/nervous problems of respondents in the Selebi Phikwe area

Site	Gender	Percent	Site	Gender	Percent
One	Male	3	Six	Male	
	Female	13		Female	30
Two	Male	5	Seven	Male	10
	Female	10		Female	22
Three	Male	11	Eight	Male	
	Female	15		Female	
Four	Male		Nine	Male	14
	Female			Female	19
Five	Male	7	Ten	Male	
	Female	30		Female	7

The main causes of the problems as depicted from the results of the questionnaire reflected anger, stress and sadness, and a few respondents indicated frustration. Emotional/nervous problems of affected inhabitants occurred while they lived in Selebi Phikwe, and more than 50% of those affected consider themselves as having recovered.

A summary of the various illnesses and diseases that were experienced by the respondents in the Selebi Phikwe area is given in Table 4.27. The following illnesses and diseases were reported by means of the questionnaire and structured interview (represented as percentage of occurrence): asthma, heart disease, allergies, dehydration, sore throat, hernia and fever, headache, eye problems, back pains, tuberculosis, womb problems, numbness, tooth-ache, malaria, gout, stroke, headache, chest pain, hypertension, ear problem, arthritis, ulcers, lung disease, small pox, AIDS, syphilis, mental illness, measles, pneumonia, influenza and diarrhoea. The values were fairly low. There were no allergies and very low occurrence of asthma reported by the respondents. This was contrary to expectation because fumes and SO_2 cause allergic reactions and provoke respiratory tract problems.

Less than 5% of the respondents in sites one, five, six, seven and ten had been infected with bilharzia. Half of those infected in sites one, five and six were resident in Selebi Phikwe at the time of infection, and none had been infected more than three times. Incidences of sexually transmitted diseases such as gonorrhoea, syphilis and human immune deficiency virus (HIV) infection were very low. Respondents living in sites one, two, four and ten reported no incidence of diagnosed STDs. However, < 5% of respondents in sites six, eight and nine each indicated having had contact with someone who was HIV positive. Gonorrhoea infection was reported by 4% of respondents in site three, 7% in site five and 3% in site six. 4% of respondents in site three, 3 % in site five, and 5% in sites seven and nine had syphilis. Other types of STDs were indicated in sites three (4%), five (4%), and nine (14%).

Table 4.27: Different illnesses and diseases reported in the Selebi Phikwe area (presented as percentage of occurrence)

Site		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
One	m						3	3	6												3			3									
	f	13	4					4	4	4	4									4													
Two	m	10																															
	f							3									3																
Three	m								3		3							3	3														6
	f							4				4					4				4				4								12
Four	m										4				4						4	4											
	f	3						3		3					3	3		3			3	3						3					
Five	m								4													4											11
	f					3												3		7	3		3										7
Six	m																																
	f								3								3	3															
Seven	m									5					5	5										5	5						
	f	3	8			3			3		5												3										11
Eight	m		4						4	4	4		4																				
	f																			3									3				3
Nine	m								5		5																			5			9
	f	3	5								5	3						3				5								3	14	3	3
Ten	m	7			4				4					4				4															
	f	3							3			3	3		3																		7

(Legend A = asthma, B = heart disease, C = allergies, D = dehydration, E = sore throat, F = hernia and fever, G = headache, H = eye problems, I = back pains, J = tuberculosis, K = womb problem, L = numbness, M = tooth-ache, N = malaria, O = gout, P = stroke, Q = headache and chest pain, R = chest pain, S = hypertension, T = ear problems, U = arthritis, V = ulcers, W = lung disease, X = small pox, Y = AIDS, Z = syphilis, AA = mental illness, AB = measles, AC = pneumonia, AD = influenza, AE = diarrhoea, AF = unspecified, m = male and f = female).

Based on the responses obtained from the questionnaires, malaria had affected both males and females in an almost equal ratio with the least being 3% and the highest 17%. However, in sites two and three, no cases were recorded. Almost all of those who had been infected with malaria were resident in the Selebi Phikwe area at the time of infection. Fewer than 5% of the respondents had had rheumatic fever. All those who had had rheumatic fever were > 40 years old. Tuberculosis has affected <10% of the respondents, more than 70% of the cases having been contracted elsewhere. When asked how long they had been suffering from illnesses, most of the respondents who had been sick while living in Selebi Phikwe responded that the duration of illness was less than one year (Table 4.28).

It should be pointed out that > 98% of the population living in Selebi Phikwe have access to health services (Asare, 1999). The period for which respondents had suffered from different illnesses, diseases and ailments was, relatively speaking, not long; this could be suggestive that prompt medical attention is given to the citizens. Another factor responsible for relatively short periods of illness and disease, which was beyond the scope of this study to investigate, could include the resistance of respondents to these ailments.

The four main clinical tests which respondents living in the Selebi Phikwe area undergo during medical examination, are: X-ray, lung function, blood and urine tests (Table 4.29). A few also visit medical centres for sight and hearing tests.

Table 4.28: Duration of illness in years of respondents living within the Selebi Phikwe area

Site		< 1 yr	1-2 yrs	2-3 yrs	3-4 yrs	> 4 yrs
One	Male	3	3		3	6
	Female	4	8	4	13	8
Two	Male			5		5
	Female	3				3
Three	Male	3	3			11
	Female	15	4	8		4
Four	Male	4	4			7
	Female	13	3	6		6
Five	Male	7	7			4
	Female	7	3		3	13
Six	Male					
	Female	8				
Seven	Male	10	10	5		
	Female	14	8	5		8
Eight	Male	7	7			4
	Female	6		3		
Nine	Male	23				
	Female	35	5			8
Ten	Male	7	4	4		7
	Female	3	7			13

Except for site six, the percentage values for male respondents undergoing X-ray tests surpassed that of the control site. For female respondents, it was only in sites seven and nine that females indicated that they had undergone

X-ray tests. More females in these sites than those of the control site reported that they had been x-rayed.

Table 4.29: Percentages of respondents that underwent clinical tests and aspects for which they are tested during medical examination in Selebi Phikwe

Site	Gender	X-ray	Lung function test	Blood test	Urine test	Sight test	Ear test
		%	(%)	(%)	(%)	(%)	(%)
One	Male	13	10	6	13	3	
	Female	4	8	8	8		
Two	Male	10	5	19			
	Female	8	3	10	3		
Three	Male	20	3		3	3	
	Female	8		12	4		
Four	Male	7	11	11			
	Female	6	3	6			
Five	Male	11	19	7	4	4	
	Female	3	10	3	3	3	3
Six	Male	5	5	5			
	Female	8		3	3		
Seven	Male	29	14	29	14		
	Female	16	5	22	16		
Eight	Male	19	19	19	19	4	4
	Female	9	9	9	9		
Nine	Male	14	9	27	5		
	Female	22	3	14	3		
Ten	Male	7	4	4	4		
	Female	10	3	30	27		

More respondents from all the sites had undergone lung function tests, as compared to those from site ten. A similar trend was observed in blood and urine tests undergone by males. For females, the number who had undergone both blood and urine tests from site ten was much higher than those from the other sites. The clinical tests respondents undergone included X-Ray, lung function, blood and urine tests (Table 4.30). Most of the results, however, were negative (Table 4.30).

Table 4.30: Results of medical examination of respondents living within the Selebi Phikwe area

Site	Gender	X-Ray			Lung function		Blood test		Urine test		Sight test		Ear test	
		+ve	-ve	unsure	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
One	Male	3	6	3	3	6	3	3	3	10		3		
	Female		4		4	4		8		8				
Two	Male	5	5			5		24						
	Female	3	5			3		10		3				
Three	Male	9	11		3				3		3			
	Female	4	4					12		8				
Four	Male	0	7		4	7		11						
	Female	3	3		3			6						
Five	Male		11			19	4	4		4	4			
	Female		3		3	7		3		3			3	
Six	Male	5				5		5						
	Female		8					3		3				
Seven	Male		29			14	5	24		14				
	Female	5	11	3		5	5	14	3	16				
Eight	Male		19			19		19		19		7		4
	Female		9			6		6		6				
Nine	Male		14			9		27		5				
	Female	5	16			3		14		3				
Ten	Male	7			4			4	4					
	Female	10			3		27	3	27					

The responses obtained from the questionnaire (Table 4.30) were substantiated by discussions held with the Chief Medical Officer (2003) in charge of Selebi Phikwe. He mentioned that illnesses, diseases and ailments in Selebi Phikwe were mainly due to poor sanitation and hygiene as well as poor living conditions. He is of the opinion that the respiratory tract diseases were unusually higher than average for the country because of the SO_2 release into the atmosphere. However, no documents were available to substantiate his statements.

4.3.5 Past and present treatment/medication

Figure 4.26 depicts the distribution trend of respondents living within the Selebi Phikwe area who suffered from headaches, period pain, back pain, abdominal pain and chest pain. In general, percentage values for the cited aches and pains in the control site were conspicuously lower than those obtained for the remaining nine sites.

A fairly significant percentage of the population suffered from headaches compared to the other cited pains, as may be seen in Figure 4.26. Except for site one, more than 50% of respondents suffered from headache, with the highest percentage value occurring in site six (91%). The only percentage value below 50% for respondents suffering from headaches were 40% for site two.

The percentage values of respondents experiencing period pains, applicable only to females, ranged from 5% for site two to 22% for site eight. The highest percentage value for period pains was recorded in site eight (22%). This was closely followed by respondents living in sites four (20%) and one (19%).

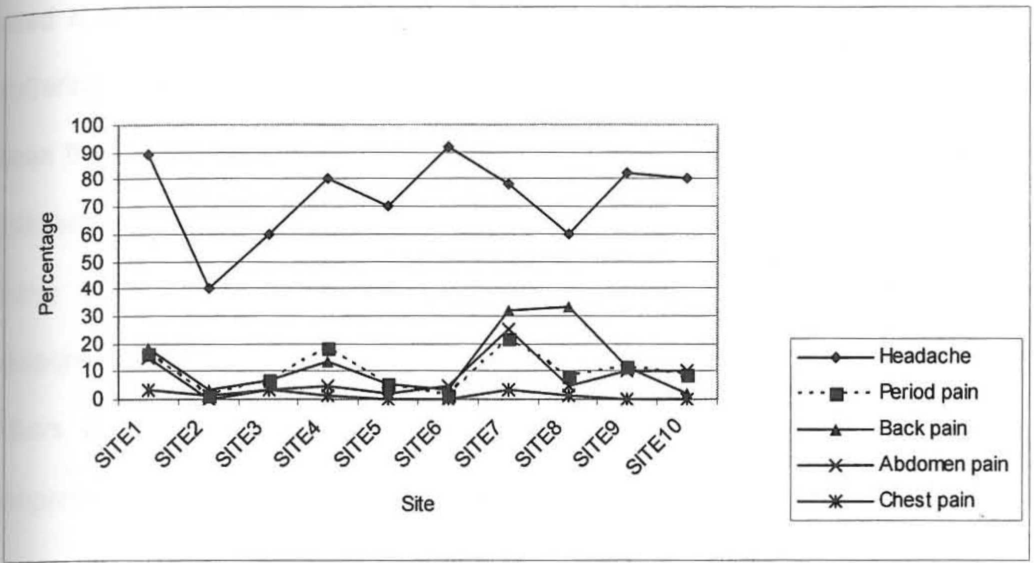

Figure 4.26: Distribution trend of individuals suffering from headaches, period pain, back pain, abdominal pain and chest pain within the Selebi Phikwe area

High values for respondents suffering from back pain were reported in sites seven and eight with percentage values of 32% each. 18% of individuals living in site one and 12% living in site four suffered from back pain. Percentage values of respondents who had suffered from both abdomen and chest pains were very low as reflected in Figure 4.26.

In terms of medication for headache, period pain, back pain, and abdominal pain, it was noticed that Panado, Aspirin, Penicillin and Ibuprofen were the most commonly administered drugs. During the structured interview it was reported that respondents could buy penicillin without prescription and that they took it for pain. This practice of taking penicillin for pain may be associated with some observed phenomena of the past where residents had used it and obtained positive results. Most of the individuals except those suffering from chest pain took these medicines. From Table 4.31, it may be seen that 88% of respondents suffering from headache took Panado, closely followed by 83% who took aspirin. Seventy two percent of the respondents living there took Ibuprofen and 40% Penicillin for headache. Some respondents took these medicines alternately. Most females who took pain killers for period pains indicated that they took Aspirin (33%). Others took Ibuprofen (25%), and only 17% took Panado (Table 4.31).

Table 4.31: Percentage distribution of type of medication for pain taken by respondents living within the Selebi Phikwe area

Medication	Headache	Period pain	Back pain	Abdominal pain	Chest pain
Panado	88	17	23	11	2
Aspirin	83	33	33	28	4
Penicillin	40	20	40	50	0
Ibuprofen	72	25	32	24	4

40% of the respondents living within the Selebi Phikwe area were given penicillin for back pain, whereas 33 % took aspirin. Aspirin was administered to 23% of the respondents, and 32% took Ibuprofen. For abdominal pains, 50% of the respondents in the study area used Penicillin. Aspirin was used by

28% of the respondents for abdominal pains, and 24% took ibuprofen (Table 4.31).

Some of the respondents who reported having cancer had been undergoing chemotherapy and radiotherapy. Others were not sure of the form of medication they were having for the treatment of their cancer.

It was noticed that penicillin, which is an antibiotic and normally prescribed by medical practitioners to combat bacterial infection, was used by some of the respondents as a pain killer. Respondents need to be informed that the drug is an antibiotic, and should be advised to seek medical opinion before purchasing it across the counter.

In terms of general community health issues, the respondents indicated that the Government of Botswana through its health services provided drugs free of charge. The Government is engaged in a zealous health care policy that focuses on a curative approach. This country, being one of the hardest hit by the AIDS pandemic, has, over the past three years, launched an aggressive "AIDS Free Botswana" campaign and has introduced a strongly curative and monitoring health programme for its citizens.

4.3.6 General profile, social and personal history

Figure 4.27 presents the percentages of respondents living within the Selebi Phikwe area who consume cigarettes, marijuana (which is locally referred to as dagga; the name which will be used in the rest of this document), coffee, coke (referring to Coca Cola) and alcohol. Percentage values for respondents living in site ten (control site) who smoked and drank the listed items in Figure 4.27 were significantly low compared to all the other sites of the study area. This could be because most of the smokers and those who drank alcohol were mine workers who lived close to the mine, especially in site five. It was further observed that the highest percentage of smoking and drinking occurred in sites five and nine. Coffee was the most consumed item followed by cigarettes, whereas dagga was the least consumed item followed by alcohol.

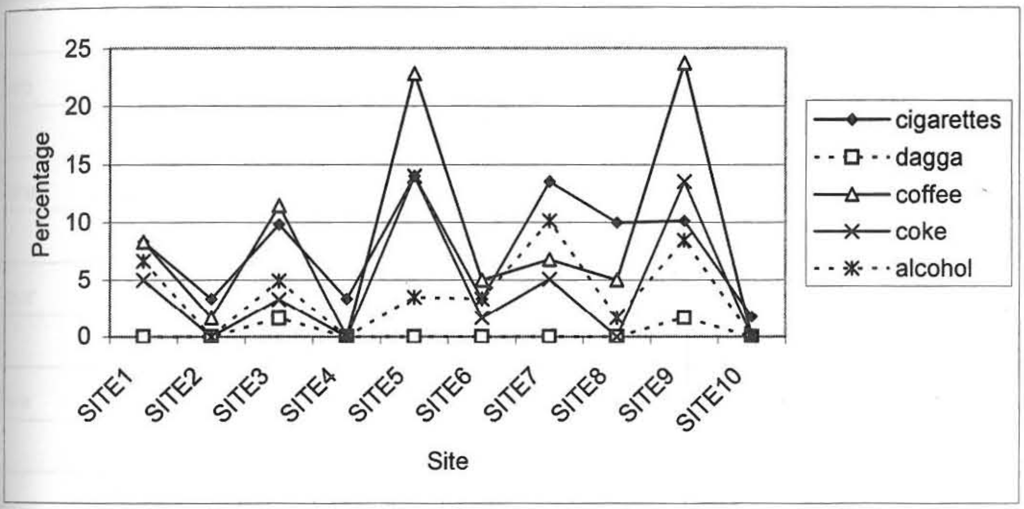

Figure 4.27: Consumption of cigarettes, dagga, coffee, coke and alcohol by respondents living within Selebi Phikwe

Based on the responses obtained from the questionnaires and structured interviews, no females in sites two, three, four, five, and ten were engaged in any form of smoking, either cigarettes or dagga, as can be deduced from Table 4.32. Males living in site seven smoked both cigarettes and dagga more often than those living within the other sites of the study area. In site six, all the individuals who responded to the questionnaires admitted to taking coffee. Coke consumption was observed to be generally very high. In terms of alcohol, beer was the most consumed followed by chibuku (traditional beer), while spirits and red and white wine were consumed in an almost equal proportion (Table 4.32).

Table 4.32: Drinking and smoking habits of respondents living within the Selebi Phikwe area

Site	Gender	A	B	C	D	E	F	G	H	I
One	Male	23	3	84	94	16	42	3	10	10
	Female	4	0	79	96	0	17	0	4	4
Two	Male	10	5	62	67	10	48	10	5	5
	Female	0	0	79	74	0	8	3	13	5
Three	Male	20	3	77	66	11	29	11	3	3
	Female	0	0	85	73	0	12	0	0	0
Four	Male	14	0	89	86	7	29	7	4	4
	Female	0	0	84	78	0	9	3	6	0
Five	Male	44	7	96	89	41	48	11	15	0
	Female	0	0	93	97	0	10	0	7	0
Six	Male	15	0	100	70	10	20	15	10	5
	Female	3	3	88	95	3	13	15	5	5
Seven	Male	67	10	86	67	38	62	14	14	14
	Female	3	0	81	62	3	14	3	8	8
Eight	Male	30	7	93	78	26	41	11	4	7
	Female	3	0	85	85	6	15	15	6	0
Nine	Male	23	5	95	86	27	41	9	5	0
	Female	5	0	92	76	5	11	0	0	0
Ten	Male	7	0	89	89	4	4	4	0	0
	Female	0	0	83	80	3	27	0	13	0

(Legend A = cigarettes, B = dagga, C = coffee, D = coke, E = chibuku, F = beer, G = spirits, H = red wine and I = white wine)

A substantial proportion of respondents in the Selebi Phikwe area live in squatter settlements (sites four, five and six). Standards of living were quite low in these camps compared to other parts of the township, and there was high alcohol consumption (sites four, five and six). What was clearly evident during the survey was that there were several vending places for alcohol especially in the sites close to the mine and the smelter/concentrator plant. On a different note, it was realised from the responses that a significant percentage of respondents living in the Selebi Phikwe area including those in squatter settlements, were involved in physical exercises, sports and hobbies which remain beneficial to their health.

Smoking affects both the smoker and those within the immediate environment. In Selebi Phikwe where the air is already polluted due to sulphur-rich gases and fumes (Ekosse, 2001), smoking may have some grave human health consequences. The health consequences of smoking include respiratory and non respiratory effects, addiction to nicotine, and the associated risk of other drug use (Centre for Disease Control, 1994). Cigarette smokers have a lower level of lung function than those persons who have never smoked. Smoking also reduces the rate of lung growth. In adults, cigarette smoking causes heart disease and stroke. Studies have shown that early signs of these diseases can be found in adolescents who smoke (Centre for Disease Control, 1994).

Smoking at an early age increases the risk of lung cancer (Lew and Garfinkel, 1987). For most smoking-related cancers, the risk rises as the individual continues to smoke (Centre for Disease Control, 1994). Teenage smokers suffer from shortness of breath almost three times as often as teens who do not smoke, and produce phlegm more than twice as often as teens who do not smoke (Centre for Disease Control, 1994; Lew and Garfinkel, 1987). Teens who smoke are more likely to use alcohol, marijuana, and cocaine. Smoking is associated with a host of other risky behaviours, such as fighting and engaging in unprotected sex (Lew and Garfinkel, 1987).

Respondents living within the Selebi Phikwe area have been involved in a variety of exercises for physical fitness including jogging, aerobics, soccer, handball, gymnastics, weight lifting, boxing, jogging, cycling, walking, netball, volleyball, cricket, karate, tennis, basketball, softball and dancing (Table 4.33).

Table 4.33: Type of exercise done by respondents living within the Selebi Phikwe area

Type of exercise	Male	Female	Type of exercise	Male	Female
Jogging	49	50	Netball	20	80
Aerobics	44	56	Volleyball		100
Soccer	89	10	Cricket	100	
Handball	20	80	Karate	100	
Gym / weight-lifting	87	13	Tennis	50	50
Boxing	100		Basket ball	100	
Jogging+ Soccer+ Weight-lifting	100		Softball		100
Cycling	75	25	Dancing		100
Walking	40	60			

Only the males in the Selebi Phikwe area were involved in boxing, weight-lifting, cricket, karate, and basketball, and only females in volleyball, softball, and dancing.

Some individuals performed certain sports for the sake of exercise and others performed these as hobbies. Regarding hobbies, the population was actively involved in a wide range of hobbies as reflected in Table 4.34. Males were involved in welding, watching TV, listening to music and gardening, cycling, chess, golf, cards, pool, swimming and boxing as hobbies. Females were predominantly involved in gardening, reading, watching TV, church activities, listening to music, cookery, netball and sewing. Males took the lead in woodwork, soccer and tennis (Table 4.34).

Table 4.34: Types of hobbies practised by respondents living within the Selebi Phikwe area

Type of hobby	Male	Female	Type of hobby	Male	Female
Woodwork	86	14	Cycling	100	
Welding	100		Chess	100	
Gardening	46	54	Golf	100	
Reading	34	65	Cards	100	
Watching TV	47	53	Basketball	50	50
Listening to radio	33	50	Tennis	67	33
Soccer	96	4	Travelling	50	50
Church activities	14	86	Pool	100	
Gardening+ reading	67		Volleyball		100
TV+Music +Gardening	100		Swimming	100	
Music	44	56	Pottery		100
Cookery	29	71	Creating friendship	50	50
Netball	20	80	Boxing	100	0
Sewing	10	90	Story telling		100

There are several health benefits to be gained by doing physical exercises and practicing hobbies. These include loss of body weight, living longer, building muscles, avoiding heart disease, preventing cancer, lowering cholesterol and blood pressure, staving off bone loss, and improving mental health (Wappes, 1996). Individuals living in Selebi Phikwe should be encouraged to exercise more because of the health benefits, especially as they live in an environment which is contaminated with contaminants of suphur gases and heavy metals to have a negative effect on human health.

An impressive response, as shown in Figure 4.28, was obtained from respondents regarding essential household facilities. In the control site, 85% of the houses were cement; and this value was found to be lower than those obtained for all the other nine study sites in the area. Only 40% of respondents in site ten live in homes supplied with electricity. Sites five, six, eight and nine were without electricity in < 40% of their houses. The highest percentage value for sites with houses supplied with electricity occurred in site two (94%). Toilet facilities were available in most of the houses in the Selebi Phikwe area with lower percentage values obtained from houses in site five (80%). 100% of the houses in sites two, four and eight had toilets. The lowest value for houses in the various sites for water facilities was 30% in site six, followed by 64% (site 5). All the houses in sites two and four had running water supplied. However only 30% of the houses in site six had running water (Figure 4.28).

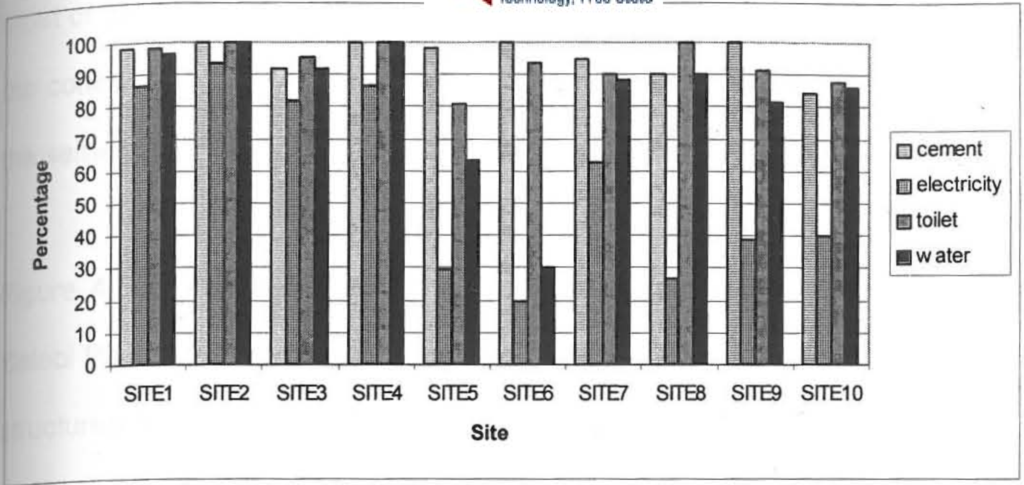

Figure 4.28: Distribution of essential household facilities among respondents living within the Selebi Phikwe area

Figure 4.29 displays the number of people living per house in the Selebi Phikwe area based on the responses obtained from the questionnaires and structured interviews.

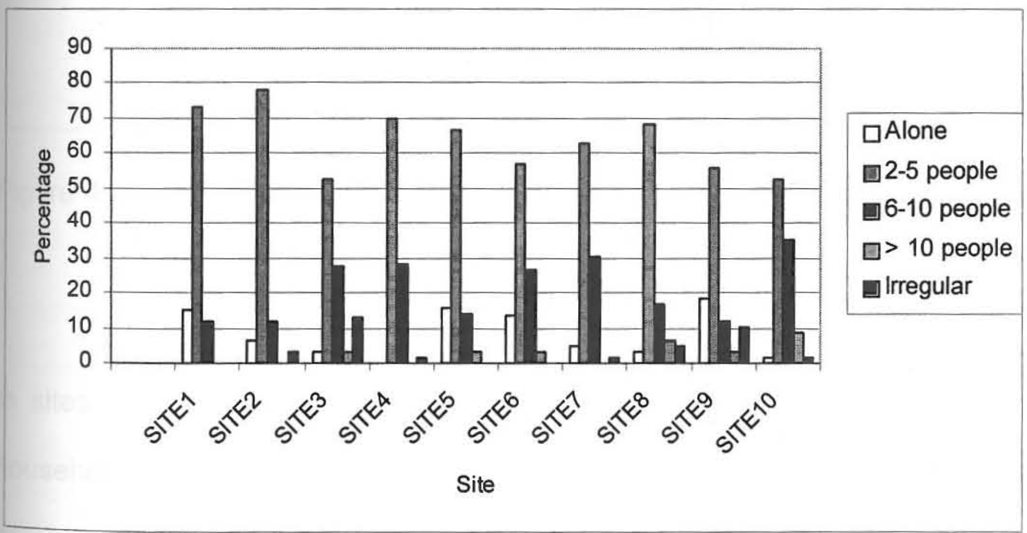

Figure 4.29: Number of people living per house in the different study sites in the Selebi Phikwe area

Most of the houses in Selebi Phikwe housed between two and five people. In the control site, 52% of the houses were occupied by two to five people, and the same percentage value was applicable to the houses in site two.

Figure 4.30 gives the number of people living per room per household in Selebi Phikwe based on the responses obtained from the questionnaires and structured interviews. Looking at the responses obtained from individuals, the highest percentage of respondents indicated that they had from two to five persons living per room in their houses (Figure 4.30).

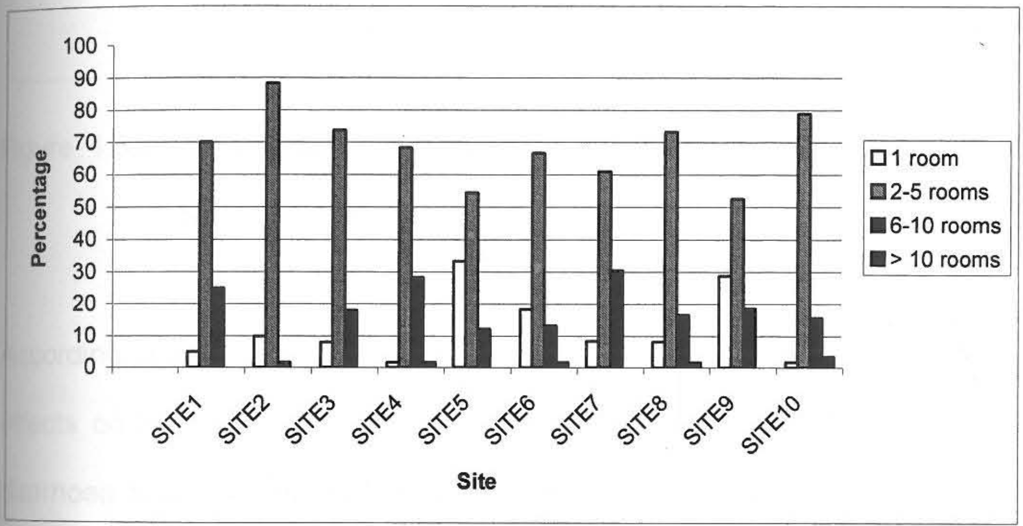

Figure 4.30: Percentage of people living per rooms per household unit in the different study sites in the Selebi Phikwe area

In sites two, four, six, eight and ten, there were between 1% and 3% of household units having > 10 rooms per household (Figure 4.30) High percentage values were obtained in the class of six to ten rooms per household. However, the density of people living per room was relatively high (Figure 4.31). This type of room density per household was, significantly, very high for Botswana. The average number of rooms per household is two (Botswana, 2003).

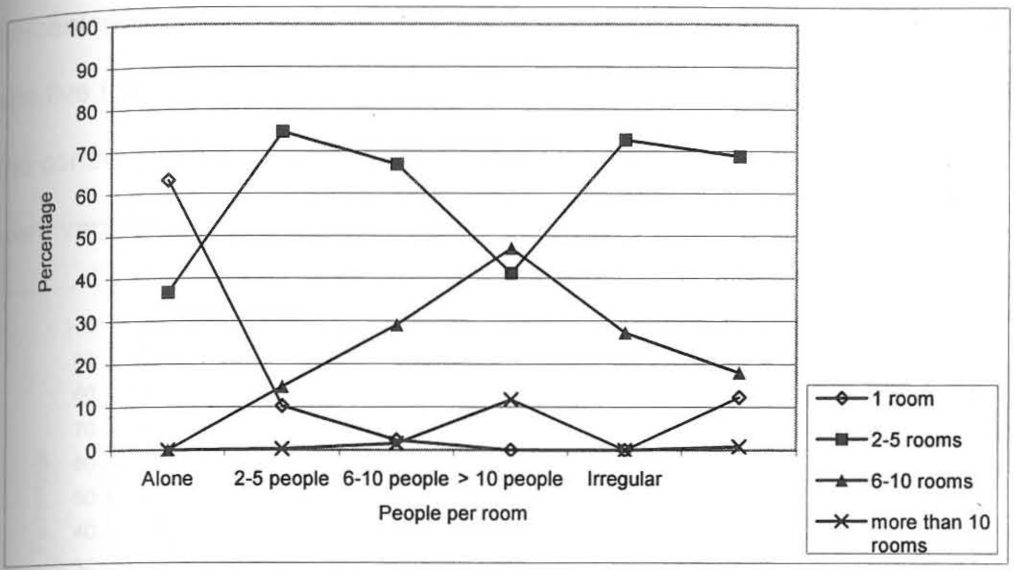

Figure 4.31: Percentage of people living per rooms per household in the Selebi Phikwe area

According to a study addressing housing and environmental factors and their effects on the health of children in slums (D'Souza, 1997), risk factors for diarrhoea and respiratory diseases include poor housing structure, crowded rooms and poverty. Although the factors researched by D'Souza (1997) do occur in Selebi Phikwe, there are other more imposing factors such as the fumes from the mine and the smelter/concentrator plant, the dust generated by the mining activities, vibrations due to rock blasts, and noise resulting from blasts and constant movement of heavy equipment (Figure 4.32) which have, according to their responses, a direct bearing on the health of respondents living there.

Distinctly clear is the fact that individuals have cited fumes of SO_2 to be the main aspect of mining and smelting activities which disturbs them. The lowest percentage value for disturbances by fumes reported by respondents was in site five (60%), and the highest was in site two (91%). This is not the case in the control site where percentage values for fumes, dust, vibrations and noise were very low (Figure 4.32).

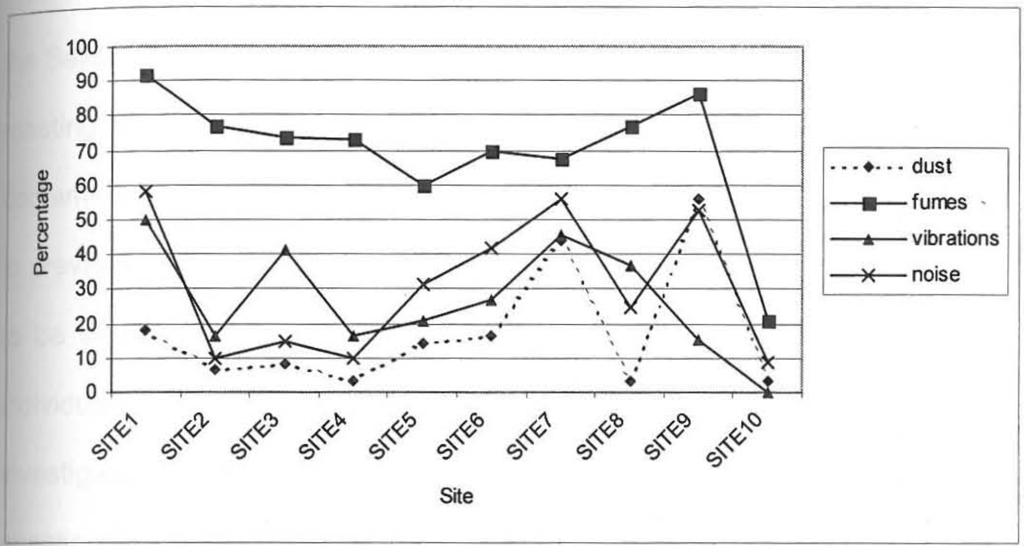

Figure 4.32: Aspects of mining and smelting activities, which disturb respondents living within the Selebi Phikwe area

A sizable percentage of the respondents of Selebi Phikwe are migrants who have come from the surrounding towns and villages or other parts of the country. Economic reasons have been the driving force for the migration. The presence of the mine, and the expansion of the industrial and commercial ventures greatly account for the high migration figures and continuous increase in population. Unfortunately, however, the increase in migration has led to the emergence and growth of squatter settlements. Housing structures are put up haphazardly. Furthermore, there are no organised sites for waste disposal, and, coupled with lack of essential facilities, these could all impact on the health status of the individuals.

4.5 Conclusions

This chapter aimed at elucidating the health status of individuals living within the Selebi Phikwe Ni-Cu mine area. Sulphur dioxide, which is emitted from the roasting of the ore, particulate air matter, tailings dump, contaminated soils, contaminated *Colophospermum mopane* and *Imbrasia belina* were identified in previous studies by Asare (1999), Ekosse (2001) and Ekosse *et al.* (2003) to be sources of pollution which could possibly be affecting the health of individuals living within this area. In this study we have reported on an investigation which was conducted through the administration of questionnaires and structured interviews. Data was generated in areas related to demographical and biographical aspects, family history, general complaints about personal health, past medical history, past and present treatment/medication, and general profile, social and personal history. With the aid of SPSS software, attempts were made to interpret the findings.

Common ailments, illnesses and diseases found in the area included asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headaches, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancer. Table 4.35 summarises sites in which the percentages of respondents s[illegible]se ailments, illnesses and diseases were higher than those at the control site. It also links ailments to environmental factors caused by mining and smelting activities, where applicable.

The respondents indicated that respiratory tract-related health problems found in the study area were considered to be linked to the effects of air pollution caused by the emission of SO_2 from the mining and smelting activities. The gas together with sulphate particulates aggravate respiratory diseases, reduce the effective functioning of lungs, irritates the eyes and the respiratory tract, among other health hazards (Mosweunyane, 2000).

Results obtained in this study indicate that mining and smelting of Ni-Cu do have an effect on the health of residents within the Selebi Phikwe area. These observations were also reported in other mining environments such as in Zambia (Simukanga, 1999) and Australia (Scott, 2003) where Ni and Cu are mined. Simukanga (1999) and the World Health Organisation (1988) have reported that most people have been affected by SO_2 pollution due to mining.

From Table 4.35, it may be inferred that a substantial portion of the health problems are perceived to be derivatives of air pollution in the environment. The Government of Botswana, the Selebi Phikwe Town Council and the Mining Authorities (BCL, 1998), are continually making efforts to address issues of environmental pollution and health in the Selebi Phikwe area.

Table 4.35: Sites in which percentages of respondents suffering from ailments, illnesses and diseases were higher than those at the control site

Ailment, illnesses and disease	Sites (Males)	Sites (Females	Remarks
Body weakness	-	five	Not certain if mining and smelting activities are responsible.
Chest pains	One, seven and nine	five	Could have relevance to environmental pollution from mines.
Coughs	One, four, five, six, seven and nine	One, four, five, six, seven and nine	Could be related to air pollution (possibly effect of sulphur rich fumes and gases).
Constipation	Seven	One, two, five, six, seven and nine	Could be as a result of heavy metals in phane worms affected by the pollution.
Diarrhoea	Seven and nine	-	Not certain if mining and smelting activities are responsible. If any influence, it could be from heavy metals in phane worms affected by the pollution.
Nausea and vomiting	-	-	Not certain if mining and smelting activities are responsible.
Influenza/common cold	One, three, four, five, six, seven, eight and nine	One, three, four, five, six, seven, eight and nine	Could be related to air pollution. Respiratory tract lining of individuals could be over sensitive to contaminated air which is breathed in.
Headaches	Two	One and six	Percentages at all sites were significantly high. Could be related to air pollution. Respiratory tract lining of individuals could be over-sensitive to contaminated air.
Recent loss of body weight	One, two, five, six, seven, eight and nine	One, three, five, six, seven, eight and nine	Heavy metals in phane worms affected by the pollution, and air pollution leading to different sicknesses and diseases.
Lower abdominal pain	One, five and nine	-	Not certain if mining and smelting activities are responsible. Heavy metals in phane worms affected by the pollution may have an effect.
Palpitations	Seven and eight	One, four and eight	Not certain if mining and smelting activities are responsible.
Shortness of breath	One	One	Could be related to air pollution. Respiratory tract lining of individuals could be over-sensitive to contaminated air which is breathed in.
Desire to spit often	One, five, six, seven and nine	One, three, five, six, seven and nine	Could be related to air pollution. Respiratory tract lining of individuals could be over-sensitive to contaminated air which is breathed in.
Unusual genital discharge	Nine	One, five and seven	Not certain if mining and smelting activities are responsible.
Pain when urinating	One, three, five, six, seven, eight and nine	One, three, five, six, seven, eight and nine	Heavy metals in phane worms affected by the pollution may have an effect.

It is therefore suggested that a tripartite alliance of Government Authorities, Local Councils and BCL should harness their resources in a combinatory effort to overcome both environmental and health hazards which are presently affecting the inhabitants of Selebi Phikwe. It is further anticipated that continued research should be applied in aiding to solve the Selebi Phikwe health problems.

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Appendix 4.1

Questionnaire on Human Health Hazards at the Selebi Phikwe Ni-Cu Mine Area, Botswana

SECTION 1: Questionnaire for individuals

Table of contents

Introduction

Thank you for your participation in the study by completing this questionnaire related to human health hazards at the Selebi Phikwe Ni-Cu mine area, Botswana. This study is undertaken for academic purposes only. All information collected will be treated confidentially and will not be revealed to anyone. It is suspected that environmental and human health problems may have been caused within Selebi Phikwe by mining activities. Inhabitants of the area are often infected with symptoms of illnesses and diseases related to pulmonary health complications. By means of the study, we would like to establish existing human health hazards, and identify the pulmonary health complications of the inhabitants of Selebi Phikwe, and then to advance solutions which could be implemented.

The basis of this study will consist of questionnaires, personal interviews, and the administration of lung function test to selected individuals based on the responses from the questionnaire and personal interviews as well as their medical histories. All the information obtained from this study will be streated in the strictest confidence, and made available as research findings at scientific conferences, seminars and workshops, and as an eventual publication in scientific journals. Any additional information provided will be very much appreciated.

This questionnaire is divided into the following main sections:

SECTION 1: Questionnaire for individuals, which should be answered by individuals.

SECTION 2: Questionnaire for health service providers, which should be answered by health service providers or designated official of the health facility.

SECTION 3: Questionnaire for industries, which should be answered by the Director of the industry or designated official of the industry.

SECTION 4: Questionnaire for educational institutions, which should be answered by principals/headmasters or designated official of the educational institution.

Kindly note the following:

- Please read through the entire question before making a choice.
- Your answer should be marked with a cross in the box provided below or next to your choice.
- Where a question requires a written explanation as the response, kindly write concisely in the space provided.
- Where a question requires more than one answer, this will be made clear.
- Be very frank with your answers.

SECTION 1: Questionnaire for individuals

Date of Interview……………………………………………………………………………

Name of Interviewee (optional)……………………………………………………………

Area (Address) ………………………………………………………………………………

……………………………………………………………………………………………………

1.1 Demographical and biographical data

1.1.1 Gender	Male		Female	

1.1.2 Age group	0-10 yrs	11-20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	+ 50 yrs

1.1.3 Occupation	Mine worker	Mine administrator	Mine supervisor	Smelter/Concentrator worker
	Teacher	Hospital Staff	Politician	Smelter/Concentrator administrator
	Business personnel	Hotel/Restaurant staff	Government employee	Smelter/Concentrator supervisor
	Shop/Supermarket staff	Housewife	Apprentice	Industrial Class worker
	Student	Farmer	Unemployed	Other (specify)
1.1.4 Annual financial income (pula)	< 10 000	10 001-20 000	20 001-30 000	30 001-40 000
	40 001-50 000	50 001-60 000	60 001-70 000	70 001-80 000
	80 001-90 000	90 001-100 000	> 100 000	Other (specify)

1.1.5 How long have you lived in the Selebi Phikwe area?

	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

1.1.6 Which area describes best where you live at Selebi Phikwe?

Sampling site	Location/Characteristics	
1	Industrial area (150 m after the railway crossing)	
2	Bosele Hotel (commercial area) and new township	
3	Between the township stadium and the mine (behind the Botswana Power Corporation, BPC)	
4	Between township boundary and the railway line (directly behind a Community Junior Secondary School, CJSS)	
5	Opposite the Mine hospital, close to old township	
6	Between the mine and explosive storage facilities (close to old	

	township)	
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi Phikwe Road juncture)	
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)	
9	Close to the second bridge before entering into the Selebi Phikwe township	
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road	

1.1.7 What is the purpose of your stay at Selebi Phikwe?					
	Employment	Schooling	Home town	Visiting	Other (specify)

1.1.8 Marital status	Not married	Separated	Divorced	Widowed
	Not of marriage age	Living together	Cohabiting	Married

1.1.9 Educational level	Illiterate	Primary	Junior Secondary	Senior Secondary
	Vocational	Technical	Teacher training	University graduate
	University postgraduate	Professional	Other (specify)	

1.2 Family history

1.2.1 Is your father alive?		Yes		No	
1.2.2 If yes, how old is he?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs

1.2.3 Does your father suffer from any of the following?						
Asthma	Cancer of the colon	Prostrate cancer	Bleeding tendencies	Heart disease	High blood pressure	Allergies

1.2.4 If answer to 1.2.1 is No, at what age did your father die?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs
1.2.5 Is your mother alive?		Yes		No	
1.2.6 If yes, how old is she?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs

1.2.7 Does your mother suffer from any of the following?						
Asthma	Cancer of the colon	Breast cancer	Bleeding tendencies	Heart disease	High blood pressure	Allergies

1.2.8 If answer to 1.2.6 is No, at what age did your Mother die?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs
1.2.9 Do you have brothers alive?		Yes		No	
How many?	One	Two	Three	Four	More than 4

1.2.10 Does any one of your brothers suffer from any of the following?													
Asthma		Cancer of the colon		Prostrate cancer		Bleeding tendencies		Heart disease		High blood pressure		Allergies	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No

1.2.11 If answer to 1.2.9 is No, how many are deceased?									
1.2.12 If deceased, at what age in years, and how many?									
< 20	No.	21-30	No.	31-40	No.	41-50	No.	51-60	No.	>60	No.

1.2.14 Do you have sisters alive?	Yes		No	
How many?	One	Two	Three	Four	More than 4

1.2.15 Does any one of your sisters suffer from any of the following?													
Asthma		Cancer of the colon		Breast cancer		Bleeding tendencies		Heart disease		High blood pressure		Allergies	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No

1.2.16 If answer to 1.2.14 is No, how many deceased?											
1.2.17 If deceased, at what age in years, and how many?											
< 20	No.	21-30	No.	31-40	No.	41-50	No.	51-60	No.	>60	No.

1.2.18 How long has your father in the Selebi Phikwe area?					
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs
1.2.19 How long has your mother lived in the Selebi Phikwe area?					
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs
1.2.20 How long have your brothers lived in the Selebi Phikwe area?					
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs
1.2.21 How long have your sisters lived in the Selebi Phikwe area?					
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

1.3 General complaints about personal health

1.3.1 Do you have general body weakness?	Yes		No	
1.3.2 If answer to 1.3.1 is yes, what time of the day do you have body weakness?				
Morning	Afternoon	Evening	Night	All day
1.3.3 Do you experience loss of body weight?	Yes		No	
1.3.4 If answer to 1.3.3 is yes, what is the rate of loss of body weight?				
Slow	Moderate	Fast	Constant	Irregular
1.3.5 Do you often have influenza/common cold?	Yes		No	
1.3.6 If answer to 1.3.5 is yes, is the influenza/cold accompanied by any of the following?				
Sore throat	Runny nose	Blocked nose	Body pains	High temperature
1.3.7 Do you experience headaches?	Yes		No	
1.3.8 If answer to 1.3.7 is yes, how often do you experience headaches?				
Once a week	Once a month	Once every three months	Once every six months	Not sure
1.3.9 If answer to 1.3.7 is yes, what part of your head aches?				

Front	Temple (sides)	E[illegible]	[illegible]entre	All over

1.3.10 If answer to 1.3.7 is yes, how often do you experience headaches?

Once a week	Once a month	Once every three months	Once every six months	Not sure

1.3.11 Severity of headache?

Dull	Moderate	Acute	At times dull and at times acute	Not sure

1.3.12 Do you cough often?	Yes		No	

1.3.13 If answer to 1.3.12 is yes, how often do you cough?

Regularly every day	Once a day	Once a week	Once a month	Not sure

1.3.14 What time of the day do you usually cough?

Morning	Afternoon	Evening	Night	All day

1.3.15 What is the cause of the cough?

1.3.16 Do you spit regularly?	Yes		No	

1.3.17 If answer to 1.3.16 is yes, what type of sputum?

Clear sputum	Milky sputum	Greenish sputum	Sputum with blood	Black sputum

1.3.18 What time of the day do you usually spit?

Morning	Afternoon	Evening	Night	All day

1.3.19 What is the cause of your spitting?

1.3.20 Does the spitting affect your work/lifestyle?	Yes		No	
1.3.21 Do you experience chest pain regularly?	Yes		No	

1.3.22 If answer to 1.3.21 is yes, how often do you experience chest pain?

Daily	Weekly	Monthly	Three monthly	Not sure

1.3.23 If answer to 1.3.21 is yes, what type of chest pain?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

1.3.24 What time of the day do you have chest pain?

Morning	Afternoon	Evening	Night	All day

1.3.25 What brings about the chest pain?

1.3.26 Does the chest pain affect your work/lifestyle?	Yes		No	
1.3.27 Do you experience shortness of breath regularly?	Yes		No	

1.3.28 If answer to 1.3.26 is yes, what type of shortness of breath?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

1.3.29 What time of the day do you experience shortness of breath?

Morning	Afternoon	Evening	Night	All day

1.3.30 What brings about the shortness of breath?

1.3.31 Does the shortness of breath affect your work/lifestyle?	Yes		No	
1.3.32 Do you experience palpitations?	Yes		No	

1.3.33 If answer to 1.3.31 is yes, what is the rate of the palpitations?

Slow	Moderate	Fast	At times slow and at times fast	Not sure

1.3.34 What time of the day do you experience palpitations?

Morning	Afternoon	Evening	Night	All day

1.3.35 What is the cause of the palpitations?				
1.3.36 Do you experience pain in the lower abdomen?	Yes		No	

1.3.37 If answer to 1.3.36 is yes, how often do you experience pain in the lower abdomen?

Once every day	Weekly	Monthly	Three monthly	Not sure

1.3.38 If answer to 1.3.36 is yes, what type of pain do you experience in the lower abdomen?

Dull	Moderate	Acute	At times dull and at times acute	Not sure

1.3.39 What time of the day do you experience pain in the lower abdomen?

Morning	Afternoon	Evening	Night	All day

1.3.40 What is the cause of the pain in the lower abdomen?				
1.3.41 Do you experience pain when passing out urine?	Yes		No	

1.3.42 If answer to 1.3.41 is yes, how often do you experience pain when passing out urine?

Once every day	Weekly	Monthly	Three monthly	Not sure

1.3.43 If answer to 1.4.41 is yes, what type of pain you experience when passing out urine?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

1.3.44 Do you experience any unusual discharge from your genital system?	Yes		No	

1.3.45 If answer to 1.3.44 is yes, is the unusual discharge from your genital system accompanied with what type of pain?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

1.3.46 What time of the day do you experience the unusual discharge from your genital system?

Morning	Afternoon	Evening	Night	All day

1.3.47 What is the cause of the unusual discharge from your genital system?

1.3.48 Do you experience nausea and vomiting?	Yes		No	

1.3.49 How often do you experience nausea and vomiting?

Once every day	Weekly	Monthly	Three monthly	Not sure

1.3.50 If answer to 1.3.48 is yes, what type of nausea and vomiting?

Mild	Moderate	Acute	At times acute and at times mild	Not sure

1.3.51 What time of the day do you experience nausea and vomiting?

Morning	Afternoon	Evening	Night	All day

1.3.52 What is the cause of the nausea and vomiting?				
1.3.53 Is there blood in the vomiting?	Yes		No	
1.3.54 Do you experience diarrhoea?	Yes		No	

1.3.55 If answer to 1.3.54 is yes, how often do you experience diarrhoea?

Weekly	Monthly	Three monthly	Six monthly	Not sure

1.3.56 If answer to 1.3.54 is yes, what type of diarrhoea do you experience?

Mild	Moderate	Acute	At times acute and at times mild	Not sure

1.3.57 What time of the day do you experience diarrhoea?

Morning	Afternoon	Evening	Night	All day

1.3.58 What is the cause of the diarrhoea?				
1.3.59 Is there blood in the stool when you experience diarrhoea?	Yes		No	
1.3.60 What is the colour of your stool?				
Normal	White	Black	Stool with blood	Not sure
1.3.61 Do you experience constipation?	Yes		No	
1.3.62 If answer to 1.3.61 is yes, what type of constipation?				
Mild	Moderate	Acute	At times mild and at times moderate	Not sure
1.3.63 How often do you experience constipation?				
Weekly	Monthly	Three monthly	Six monthly	Not sure
1.3.64 What time of the day do you experience constipation?				
Morning	Afternoon	Evening	Night	All day
1.3.65 What is the cause of the constipation?				
1.3.66 Do you experience pains with the constipation?	Yes		No	
1.3.67 What type of pains accompany the constipation?				
Dull	Moderate	Acute	At times dull and at times moderate	Not sure

1.4 Past medical history (organic and physiological illnesses)

1.4.1 Have you had any significant or major illness?	Yes		No	
1.4.2 If answer to 1.4.2 is yes, what type of illness?				
1.4.3 Where you resident at Selebi Phikwe when the illness occurred?	Yes		No	
1.4.4 For how long did you have the illness (in approximate years)?				
Less than one	Between one and two	Between two and three	Between three and four	More than four
1.4.5 What was the cause of the illness mentioned in 1.4.2?				
1.4.6 Are you now healed of the illness mentioned in 1.4.2?	Yes		No	
1.4.7 Have you had any operations?	Yes		No	
1.4.8 If answer to 1.4.7 is yes, for what reason?				
1.4.9 Where you resident at Selebi Phikwe when the operation occurred?	Yes		No	
1.4.10 Have you had any accidents?	Yes		No	
1.4.11 If answer to 1.4.10 is yes, what type of accidents?				
1.4.12 Where you resident at Selebi Phikwe when the accident occurred?	Yes		No	
1.4.13 Are you now healed of the injuries, which resulted from the accident mentioned in 1.4.10?	Yes		No	
1.4.14 Do you regularly undergo medical examination?	Yes		No	
1.4.15 Where you resident at Selebi Phikwe when the medical examination occurred?	Yes		No	
1.4.16 How often do you undergo medical examination?				
Once in three months	Once in six months	Once a year	Once every two years	Not sure
1.4.17 Indicate what kind of medical examination you had.				
X-ray	Lung function test	Blood test	Urine test	Other (specify)

1.4.18 Indicate if results were positive or negative.									
X-ray		Lung function test		Blood test		Urine test		Other (specify)	
+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve

1.4.19 Have you been hospitalised?	Yes		No	
1.4.20 Where you resident at Selebi Phikwe when you were	Yes		No	

hospitalised?				
1.4.21 If answer to 1.4.19 is yes, were you hospitalised at Selebi Phikwe?	Yes		No	
1.4.22 What was the reason for hospitalisation?				
1.4.23 Have you experienced any emotional /nervous problems?	**Yes**		**No**	
1.4.24 If answer to 1.4.23 is yes, for what emotional/nervous problem?				
1.4.25 Where you resident at Selebi Phikwe when the emotional or nervous problem occurred?	Yes		No	
1.4.26 Are you now healed of the emotional or nervous problem mentioned in 1.4.23?	Yes		No	
1.4.27 Did you have rheumatic fever as a child?	Yes		No	
1.4.28 If answer to 1.4.27 is yes, where you resident at Selebi Phikwe when you had rheumatic fever?	Yes		No	
1.4.29 Have you had tuberculosis?	Yes		No	
1.4.30 If answer to 1.4.29 is yes, where you resident at Selebi Phikwe when you had Tuberculosis?	Yes		No	
1.4.31 Have you had malaria?	Yes		No	
1.4.32 If answer to 1.4.31 is yes, where you resident at Selebi Phikwe when you had malaria?	Yes		No	
1.4.33 How many times have you had malaria?				
Once	Twice	Thrice	Four times	More than four times
1.4.34 Have you had Bilharzia?	Yes		No	
1.4.35 If answer to 1.4.34 is yes, where you resident at Selebi Phikwe when you had bilharzia?	Yes		No	
1.4.36 How many times have you had Bilharzia?				
Once	Twice	Thrice	Four times	More than four times
1.4.37 Do you have high blood pressure (hypertension)?	Yes		No	
1.4.38 Do you have allergies?	Yes		No	
1.4.39 Do you have asthma?	Yes		No	
1.4.40 If answer to 1.4.37 is yes, since what age have you had hypertension?				
1.4.41 If answer to 1.4.39 is yes, since what age have you had asthma?				
1.4.42Do you have bleeding tendencies?	Yes		No	
1.4.43 If answer to 1.4.42 is yes, since what age have you had bleeding tendencies?				
1.4.44 Do you have gonorrhoea?	Yes		No	
1.4.45 Do you have syphilis?	Yes		No	
1.4.46 Do you have any other sexually transmitted disease?	Yes		No	
1.4.47 Have you had intimate contact with someone who is HIV positive?	Yes		No	

1.5 Past and present treatment/medication

1.5.1 Do you take medication for pain?	Yes		No	
1.5.2 If answer to 1.5.1 is yes, how often do you take the medication?				
When the pain occurred	Three times a day	Two times a day	Irregularly	Not sure
1.5.3 What type of medicine do you take for the pain?				
Panado	Aspirin	Codeine	Ibuprofen	Other (specify)
1.5.4 What type of pain is the medication taken for?				
Headache	Period pains	Back pain	Abdominal pain	Other (specify)
1.5.5 Do you presently take medicine for hypertension?	Yes		No	
1.5.6 Do you presently take any diuretics	Yes		No	
1.5.7 Do you presently take insulin?	Yes		No	
1.5.9 Do you presently take anti-inflammatory medicine?	Yes		No	
1.5.10 Have you taken medicine in the past for	Yes		No	

hypertension?				
1.5.11 Have you taken diuretics in the past?	Yes		No	
1.5.12 Have you taken insulin in the past?	Yes		No	
1.5.13 Have you taken anti-inflammatory medicine in the past?	Yes		No	
1.5.14 Were you ever treated for cancer?	Yes		No	
1.5.15 If answer to 1.5.14 is yes, what type of cancer?				
1.5.16 If answer to 1.5.15 is yes, what type of treatment?				

Chemotherapy		Radiotherapy		Other (specify)	

1.6 General profile, social and personal history

1.6.1 Do you smoke cigarettes?		Yes		No
1.6.2 If answer to 1.6.1 is yes, how many cigarettes do you smoke per day?				
Less than five	Between five and ten	Between ten and twenty	More than twenty	Not sure
1.6.3 Do you smoke dagga (cannabis)?		Yes		No
1.6.4 If answer to 1.6.3 is yes, how many wraps of dagga do you smoke per day?				
Less than five	Between five and ten	Between ten and twenty	More than twenty	Not sure
1.6.5 Do you drink coffee?		Yes		No
1.6.6 If answer to 1.6.5 is yes, how many cups of coffee do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.7 Do you drink coke?		Yes		No
1.6.8 If answer to 1.6.7 is yes, how many cans (340 ml) of coke do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.9 Do you drink chibuku (local beer)?		Yes		No
1.6.10 If answer to 1.6.9 is yes, how packets (one litre) of chibuku do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.11 Do you drink beer?		Yes		No
1.6.12 If answer to 1.7.11 is yes, how many cans (340 ml) of beer do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.13 Do you drink spirits?		Yes		No
1.6.14 If answer to 1.6.13 is yes, how many bottles (200 ml) of spirits do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.15 Do you drink red wine?		Yes		No
1.6.16 If answer to 1.6.15 is yes, how many glasses (200 ml) of red wine do you drink per day?				
Less than two	Between three and five	Between six and ten	More than ten	Not sure
1.6.17 Do you drink white wine?		Yes		No
1.6.18 If answer to 1.6.17 is yes, how many glasses of white wine do you drink per day?				
Less than two	Between three and	Between six and	More than ten	Not sure

	five	ten		

1.6.19 Are you addicted to cigarette smoking?	Yes		No	
1.6.20 Are you addicted to dagga smoking?	Yes		No	
1.6.21 Are you addicted to drinking of coffee?	Yes		No	
1.6.22 Are you addicted drinking of coke?	Yes		No	
1.6.23 Are you addicted to alcohol?	Yes		No	

1.6.24 How many people are you living with in your house?				
Alone	Between two and five	Between six and ten	More than ten	Irregular
1.6.25 How many rooms does the house you are living in have?				
One	Between two and five	Between six and ten	More than ten	Not sure

1.6.26 Do you have a cement floor in the house?	Yes		No	
1.6.27 Is the house supplied with electricity?	Yes		No	
1.6.28 Is there a toilet in the house or compound?	Yes		No	
1.6.29 Do you have water available?	Yes		No	
1.6.30 Do you exercise regularly?	Yes		No	

1.6.31 If answer to 1.7.29 is yes, what type of exercise do you do?				
Jogging	Aerobics	Soccer	Handball	Other (specify)

1.6.32 Do you have a hobby?	Yes		No	

1.6.33 If answer to 1.6.31 is yes, what type of hobby do you do?				
Woodwork	Welding	Gardening	Reading	Other (specify)

1.6.34 Do you have sexual intercourse?	Yes		No	

1.6.35 If answer to 1.7.33 is yes, how many sex partners do you have?				
None	One	Two	Multiple	Varies
1.6.36 If answer to 1.6.33 is yes, how many times do you have sex per week?				
None	Once	Twice	Several times	Varies

1.6.37 Does the mining and smelting activities disturb you?	Yes		No	

1.6.38 If answer to 1.6.36 is yes, what aspect of mining and smelting activities disturb you?				
Dust	Fumes	Vibrations	Noise	Other (specify)

Chapter Five

Health status of Learners of Educational Institutions within Selebi Phikwe Ni-Cu Mine area

5.1 Introduction

The gigantic progress in the provision of educational facilities and services since Botswana's independence in 1966 has been remarkable (Botswana Government, 2003). In Botswana, children are admitted into nursery school from four years, and proceed to primary school at the age of six. School enrolment in the country has continued to be on the increase with a noticeably high decline in the rate of illiteracy. In Chapter Four, the educational levels of individuals living within the Selebi Phikwe area were depicted in Figure 4.5. It was found that only 6.1% of the population was considered illiterate.

The operation of several mining industries such as diamond, gold, base metals including nickel, copper and cobalt, and industries minerals including kaolin and soda ash has been economically rewarding to the country. Unfortunately mining activities often have adverse effects on the physical 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 students, who happen to be the leaders of tomorrow, is affected.

Currently, at both national and regional levels in the country, there is no data-base information available on the health status of learners at educational institutions which could be used to guide planners, decision makers and service providers to successfully organise and/or provide appropriate health services. Therefore the present study was to assess the health status of learners in the Selebi Phikwe Ni-Cu mine area.

The youth of today, and especially learners at educational institutions, are considered to be the leaders of tomorrow's society. In this regard, their health status is crucial. The work reported in this chapter is part of a programme aimed at determining and understanding the human health hazards at the Selebi Phikwe mine area, Botswana. In this chapter we shall examine the health status of learners attending educational institutions in the area. The chapter presents the results of a survey which was undertaken to assess the health status of students of educational institutions within the Selebi Phikwe Ni-Cu, mine area. The study aimed to describe the prevalence of illnesses and diseases affecting learners, which were likely to have been caused by the mining and smelting of Ni-Cu in the area.

5.2 Methods

The methods and analytical techniques used in appraising the health status of students of educational institutions within the Selebi Phikwe Ni-Cu mine area have been discussed in sections 3.1.1 and 3.2.1 of this document. A sample of the questionnaire which was administered, can be found in appendix 5.1 of this chapter.

5.3 Results and interpretation

5.3.1 Demographical data

There were thirty educational institutions in the Selebi Phikwe area and the control site at the time of this investigation. Figure 5.1 gives the percentage distribution of the educational institutions located according to the different study sites. In terms of distribution according to study sites, there was one educational institution each in sites one and five, and there were two each in sites three, eight, nine and ten (control site), three each in sites six and seven, five in site two, and nine in site four.

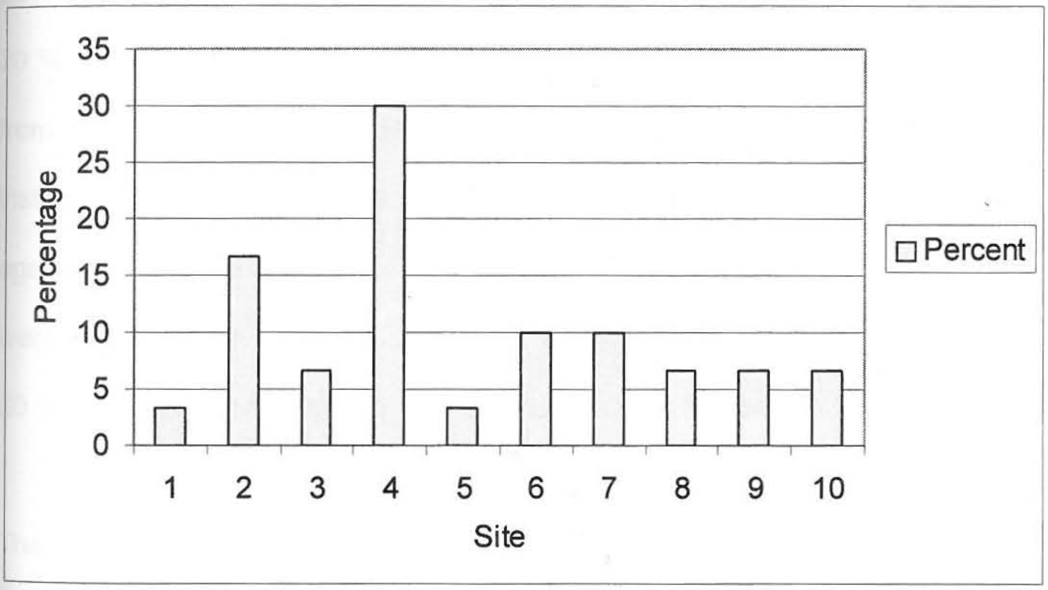


Figure 5.1: Percentage distribution of educational institutions located in different study sites within the Selebi Phikwe area

Based on where they lived, the ages of learners attending educational institutions in Selebi Phikwe were classified into six classes: < 10 years, 11 - 15 years, 16 – 20 years, 21 – 25 years, 26 – 30 years, and > 30 years. The percentage distribution of ages of the learners according to the six cited classes is given in Table 5.1. It was observed that there were virtually no students living in site five, and the age groups for those who lived in site one were not clear.

In Table 5.1, the percentages of learners aged < 10 years attending school in Selebi Phikwe is presented. Of the 10 – 20% of the learners aged < 10 years attending school in Selebi Phikwe area, 50% of them were from site three and 33% from site six. Of the 21 – 30% of the learners aged < 10 years in school, 20 % were from site two, 50% from site three, 11% from site four, and 50% from site nine. Of the 41 - 50% of the learners aged < 10 years in educational instititutions in the study area, 20% were from site two; of 51 – 60% of same age group 11% were from site four; and of 61 – 70% of same age group, 33% were from site six. Of 91-100% of the learners aged < 10 years in school, 60 % were from site two, 22% from site four, and 33% from site six.

The percentage of learners aged 11 – 15 years attending school in Selebi Phikwe is reflected in Table 5.1. Of the 31 – 40% of the students aged 11 – 15 years attending school in the Selebi Phikwe area, there were 33% each from sites four and six. Of the 51 – 60% of the learners aged 11 – 15 years in school, 20% were from site two, 50% from site three, and 33% were from site six. Of the 61 – 70% of the learners aged 11 – 15 years in educational instititutions in the study area, 20% were from site two; of 71 – 80% of same age group there were 50% each from sites three and nine. Of 91-100% of the learners aged 11 – 15 years in school, 22% were from site four, and 50% were from site eight.

The percentage of learners aged 16 – 20 years attending school in Selebi Phikwe is given in Table 5.1. Of the < 10% of the learners aged 16 – 20 years attending school, 50% of them were from site three and 33% from site seven. Of the 10 – 20% of the learners aged 16 – 20 years in school, 20% were from site two and 50% from site three. Of the 21 – 30% of the learners aged 16 – 20 years in educational instititutions in the study area, 33% were from site six; of 61 – 70 % of same age group 11% were from site four; and of 71 – 80% of same age group, a further 11 % were from site four. Of 91-100% of the students aged 16 – 20 years in school, 33% were from site nine and 50 % were from site ten.

The percentage of learners aged 21 – 25 years attending school in Selebi Phikwe is given in Table 5.1. Of the < 10% of the learners aged 16 – 20 years attending school in Selebi Phikwe area, 11% of them were from site four. Of the 41 – 50% of the learners aged 21 – 25 years in school, 33% were from site seven. Of the < 10% of the learners aged > 30 years attending school in the Selebi Phikwe area, 11% of them were from site four and 33% from site seven (Table 5.1).

Table 5.1: Percentages of learners, living in the different study sites, of different ages attending educational institutions in the Selebi Phikwe area

Percentage of learners aged < 10 years

Site	10-20%	21-30%	41-50%	51-60%	61-70%	91-100%	Not sure
One							100
Two		20	20			60	
Three	50	50					
Four		11		11		22	11
Six	33				33	33	
Seven							67
Nine		50					

Percentage of learners aged 11-15 years

Site	31-40%	51-60%	61-70%	71-80%	91-100%	Not sure
One						100
Two		20	20			
Three		50		50		
Four	33				22	11
Six	33	33				
Seven						67
Eight					50	
Nine				50		
Ten						50

Percentage of learners aged 16-20 years

Site	< 10%	10-20%	21-30%	61-70%	71-80%	91-100%	Not sure
One							100
Two		20					
Three	50	50					
Four				11	11		11
Six			33				
Seven	33					33	33
Ten						50	50

Percentage of learners aged 21-25 years

Site	10-20%	41-50%	Not sure
One			100
Four	11		11
Seven		33	33
Ten			50

Percentage of learners aged 26-30 years

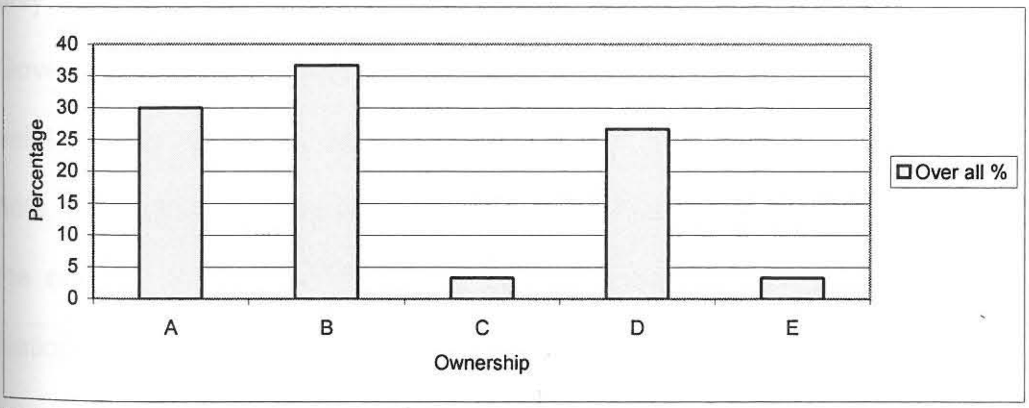
Site	< 10%	31-40%	Not sure
One			100
Four	11		11
Seven		33	33
Ten			50

Percentage of learners aged > 30 years

Site	< 10%	Not sure
One		100
Four	11	11
Seven	33	33

It was however reflected in the responses obtained from the administration of the questionnaire that the percentage distribution of age classes of a sizable portion of learners was uncertain (Table 5.1). It was further observed that the older learners were attending technical schools.

There were four owners of the educational institutions in Selebi Phikwe area, and these were the Government of Botswana, the Selebi Phikwe Town Council, the BCL, and private individuals (Figure 5.2). A fifth category of ownership, where the ownership was unspecified, is recorded for statistical purposes. Of the thirty educational institutions located in the study area, nine of them belonged to the Government of Botswana, while the Selebi Phikwe Town Council owned eleven. Of the remaining ten institutions, eight were privately owned, one belonged to BCL, and the ownership of one was not specified (Figure 5.2).



(Note: A = Government, B = Town Council, C = BCL, D = Private, E = unspecified)

Figure 5.2: Percentage distribution of ownership of educational institutions within the Selebi Phikwe area

Educational institutions in Selebi Phikwe were limited to nursery, primary, secondary and technical schools. There were no institutions offering tertiary education located in the study area. 50% of the schools were primary, 27% were secondary, 20% were nursery schools, and 3% were technical (Figure 5.3). Students who successfully completed their secondary education with good grades in the Botswana General Certificate of Education (BGCE) were given an opportunity to continue their studies at the University of Botswana (UB). Because UB is the only university in the country, competition is very stiff, and only the cream of the cream is admitted.

A few tertiary, professional, and technical institutions exist in the country such as the National Institute of Health with branches in Gaborone, Kanye and Serowe; Colleges of Education and Technical Education in Gaborone, Tonota, and Lobatse; a College of Agriculture in Sebele and Vocational Technical Colleges in Gaborone, Jwaneng and Maun. These institutions are only able to absorb < 30% of graduating secondary school students. The Government has embarked on an expensive policy of sending students to neighbouring countries, Australia, Europe and the Americas. On a related note, there are high level plans for the establishment of a second university in the country as reported in several daily newspapers and discussed in the National Parliament in 2004.

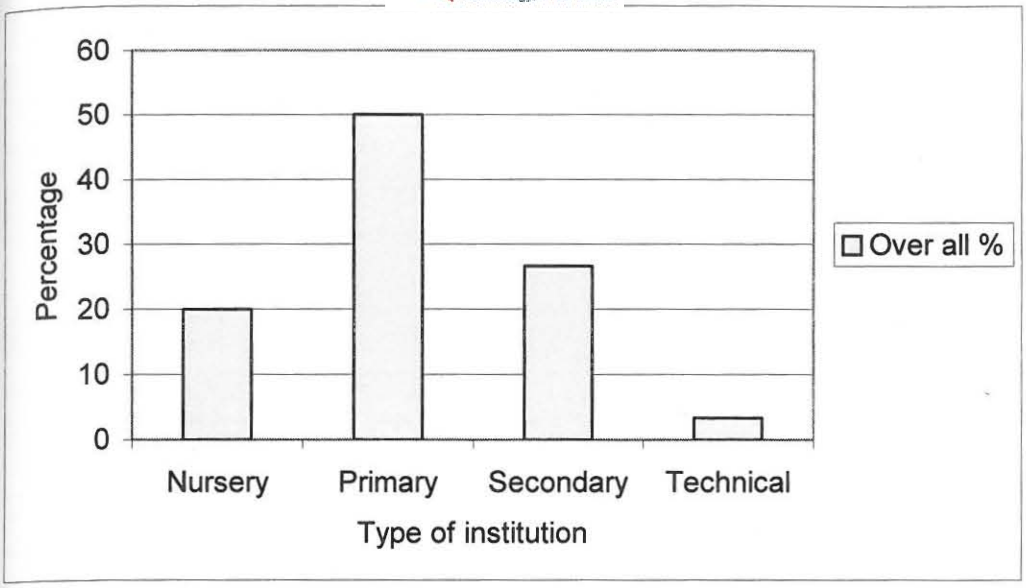


Figure 5.3: Percentage distribution of types of educational institutions in the Selebi Phikwe area

The bar chart in Figure 5.4 provides the percentage distribution of the number of years of operation of the educational institutions in the Selebi Phikwe area. None of the educational institutions has been in existence for more than half a century. From 1973 when the BCL mine began operations, the number of educational institutions in the area also began to increase. Ninety percent of the schools were opened during the last thirty years. Thirty percent of the schools are < 10 years old, 36.7% are between 10 and 20 years old, and 23.3% of the schools are between 20 – 30 years old (Figure 5.4). The first educational institutions in the area were primary schools, and these schools constituted the 10% of institutions which are > 30 years old.

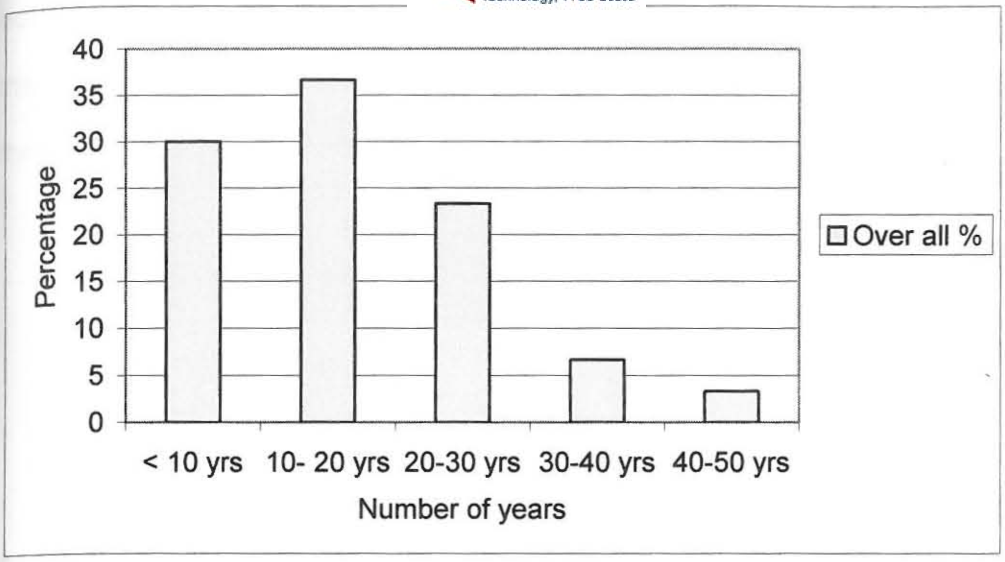


Figure 5.4: Percentage distribution of number of years of operation of educational institutions within Selebi Phikwe

The learners' population per school in this study was classified into eleven classes: < 100, 100 – 200, 300 – 400, 500 – 600, 700 – 800, 800 – 900, 900 – 1000, > 1000, and varying figures. The percentage distribution of the classes is given in Figure 5.5. Four of the classes of the learners' population had 3.3% each of learners and these were 100 – 200, 900 – 1000, > 1000, and varying figures. The four classes constituted each an educational institution. Two of the educational institutions had a learners' population of 700 – 800, and they represented 6.7% of the schools in the study area.

Three of the classes of learners' population had 10% of students each and these were 500 – 600, 600 – 700, and 600 – 900. The three classes constituted three educational institutions per class. One class (300 – 400) had four educational institutions and they constituted four of the schools in the area. Another class of the learners' population (400 – 500) consisted of five educational institutions, which was 16.7 % of the schools in the area. 20% of the educational institutions had < 100 learners attending the schools, and these were the nursery schools.

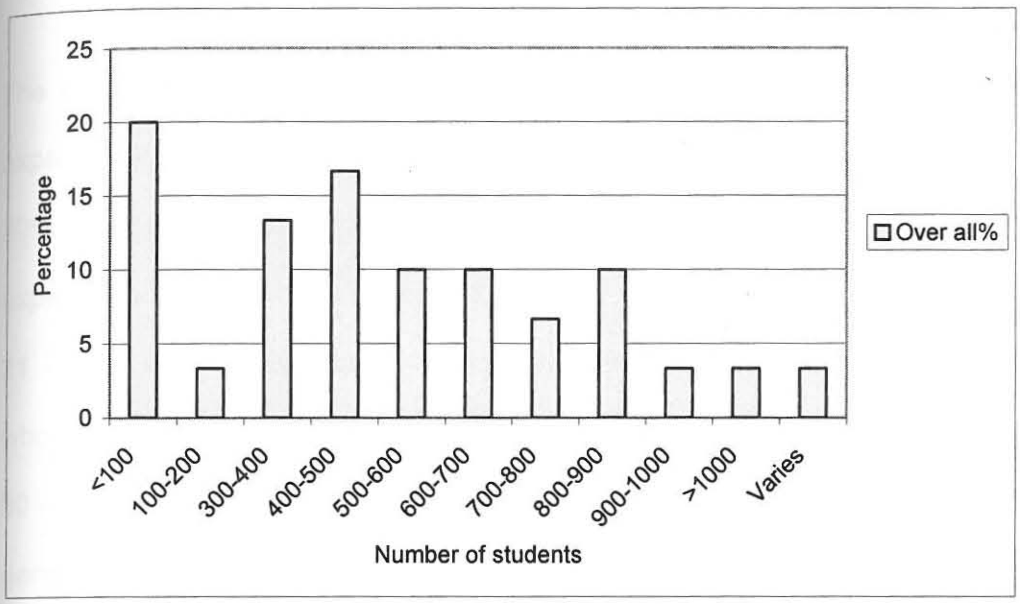


Figure 5.5: Percentage distribution of number of students per student population classification within Selebi Phikwe

5.3.2 General complaints of pupils/students about personal health

In this section of general complaints of learners about their personal health, and the responses from the headmasters and/or delegated officials were associated with the location of schools attended according to this study unless otherwise stated. The percentages of learners in individual schools who complained of general body weakness, influenza/common cold, headaches, shortness of breath, palpitations, pain in the lower abdomen, pain when passing urine, unusual genital discharge, nausea and vomiting, diarrhoea, and constipation were divided into four classes. According to the responses from the headmasters and/or delegated officials, four classes were used in the study and these were < 20%, 20 – 30%, 30 – 40%, and 40 – 50%. A fifth class created was where the percentage varied.

The percentage of learners attending school in the Selebi Phikwe area who experienced **general body weakness** is reflected in Table 5.2. Less than 20% of the students attending school in the Selebi Phikwe area who experienced general body weakness, were from sites three, four, six and nine. 21 – 30% each of the students attending school in the Selebi Phikwe area who experienced general body weakness were from sites seven and eight. 30 – 40% of the students in site five were not sure whether they experienced general body weakness. Regarding students who experienced loss of body weight, < 20% each were from sites three, four, six and seven; and 20 – 30 % of them were from site eight.

Table 5.2: Percentage of learners who experienced general body weakness

Site	< 20%	20- 30%	30-40%
Three	100		
Four	100		
Five			100
Six	100		
Seven		100	
Eight		100	
Nine	100		

The percentages of learners attending school in Selebi Phikwe who experienced **influenza/common cold** are given in Table 5.3. Of the < 20% class of learners attending school in Selebi Phikwe area who experienced influenza/common cold, 10% from sites three and ten, 63% from site four, 67% from site six, and 50% from site nine.

Table 5.3: Percentage of learners who experienced influenza/common cold

Site	**< 20%**	**20- 30%**	**30-40%**	**40-50%**	**Varies**
One					100
Two			33	33	33
Three	100				
Four	63	25			13
Five		100			
Six	67				33
Seven		50	50		
Eight				100	
Nine	50		50		

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 as shown in Table 5.3.

The percentage distribution of learners who suffered from **headaches** is given in Table 5.4. In the class of < 20%, all the 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 students 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 as indicated in Table 5.4.

Table 5.4: Percentage of learners who complained of headache

Site	< 20%	20- 30%	30-40%	40-50%	Varies
One				100	
Two					100
Three	100				
Four	63	25			13
Five		100			
Six	67				33
Seven		33	33		33
Eight		50		50	
Nine	50		50		
Ten	100				

Regarding the nature of the headaches experienced by the learners, these 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 in institutions where between 91 – 100% of those who complained of dull headaches, 50% were from site nine. In the class of < 20%, all those in site five experienced dull, acute, and at times dull and acute headaches. Only in sites three and five did the headmasters/delegated officials indicate that learners were having moderate headaches, and in sites four and five acute headaches. A sizable percentage of learners from all the other sites except site five were not sure of the nature of headaches they experienced.

Table 5.5 gives the percentage of learners attending school in Selebi Phikwe who complained of often **coughing**. Of the class of < 20% of the students attending school in the Selebi Phikwe area who suffered from repeated coughing, all of those in site three, 33% each from sites two, six and seven, 40% from site four, and 50% from site nine. 21 – 30% of the learners who suffered from repeated coughing were distributed among the following sites: 33% each from sites two, six and seven, 20% from site four, and 50% from site nine. 33% each from sites two and seven were of the class of 30 – 40% of learners who suffered from coughing. All of those who suffered from repeated coughing in site eight were from the class of 40 – 50% as well as 33% of those in site six. According to the responses from the headmasters/designated officials most of the learners who suffered from regular coughing 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 their cough to be wet.

Unusual spitting was reported in sites three, four, five and six. Less than 20% of those who indicated experiencing unusual spitting were from sites three, four and six, and the rest were from site five. Concerning learners who spat, there were no certain cases of those having blood in their spit, and also no greenish or milky colours were observed. In the category of 51-60% of pupils who acknowledged spitting, only 20% of them indicated that their spit had some sort of black colouring in it.

Table 5.5: Percentage of learners who complained of repeated coughing

Site	< 20%	20- 30%	30-40%	40-50%	Varies
One					100
Two	33	33	33		
Three	100				
Four	40	20			40
Five					100
Six	33	33		33	
Seven	33	33	33		
Eight				100	
Nine	50	50			

According to the responses from headmasters/designated officials, learners who complained of having **chest pains** were in sites one to seven. However, the < 20% of pupils/students who suffered from chest pains were from sites two, three and six, whereas the 30 – 40% of them were from sites one and five. Only in sites three and five did some learners complain of having moderate chest pains, while at sites two, three and four, they indicated having acute chest pains.

Only in sites one to six did the headmasters/designated officials responded that learners indicated suffering from **shortness of breath**. All those in sites two, three, four and six who complained of experiencing shortness of breath were in the class of < 20%. The 30 – 40% of learners who experienced shortness of breath were all from site eight and the 40 – 50% class had learners all from site one. They complained that they experienced moderate shortness of breath. No other categories of shortness of breath (dull, acute, at times dull and at times acute) were reported by those who indicated suffering from the malady.

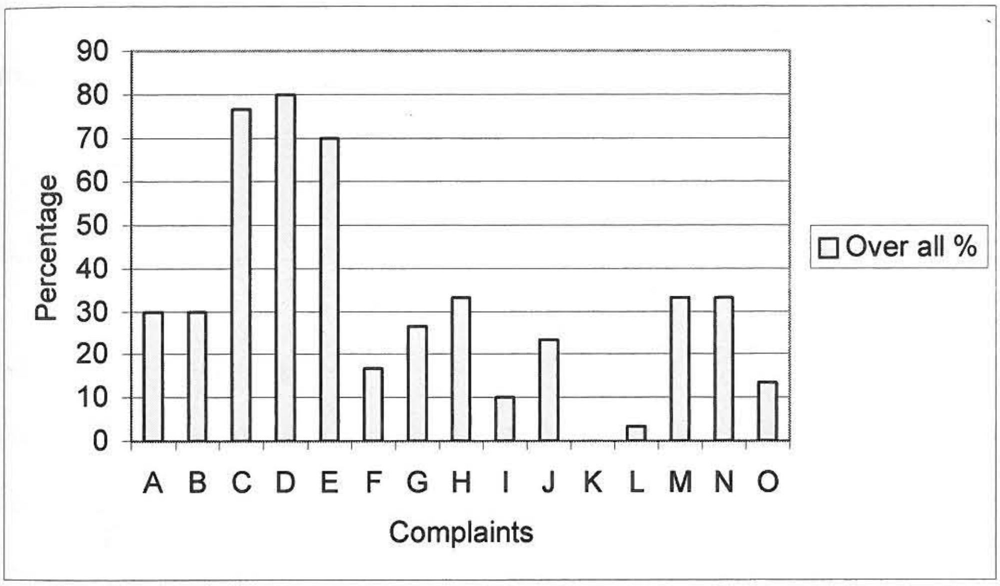
From the responses obtained from headmasters/designated officials, learners who experienced **palpitations** attended schools in sites four, five and six. Fewer than 20% of the learners who suffered from palpitations were from sites four and six, whereas 20 – 30% were from site five. All the learners in site five who experienced palpitations had the dull type, whereas those of sites four and six were not sure whether they had dull palpitations. Less than 20% of the learners who experienced palpitations that were at times dull and at times acute had their schooling in site five, and of 41-50% of those who had both dull and acute palpitations, all were from site four.

According to the responses from the headmasters/designated officials, out of the < 20% class of learners attending school in the Selebi Phikwe area who complained of experiencing pain in the **lower abdomen,** there were 50% from site four as well as all those from sites three and seven. In the class of 20 – 30%, 50% of the learners were from site four. In the class of 30 – 40%, all of the students were from sites two and five. All the learners from site five and half of those from site four who experienced pain in the lower abdomen had moderate pains. Only < 20% of the learners in site five complained of having dull abdominal pains. The rest of the learners who indicated suffering from abdominal pains were not sure of the type of abdominal pains from which they suffered.

There were no learners who reported having pains while passing urine. However, a response from one of the headmasters indicated that one student in the Technical College had pains in the genital organs, although with no unusual discharge. Learners who experienced nausea and vomiting were from sites two, three, four, five and six. In the class of < 20% of the learners who experienced nausea and vomiting, all those from sites three to six belonged to this class. Learners who suffered from nausea and vomiting from sites two and seven were of the class 20 – 30%. 20% of students who experienced dull pains with nausea and vomiting were from site five, 31-40% who experienced acute pains with nausea and vomiting were from site five, and 20% of those who complained of dull and acute pains with nausea and vomiting were from site five.

Learners who suffered from **diarrhoea** attended schools in all the sites except the control site. Fewer than 20% of the learners who suffered from diarrhoea were from sites three, four, five and seven, whereas 20 – 30% were from sites two and nine. Less than 20% of the learners who suffered from diarrhoea and had blood in their stool were from sites three and four, as well as half of those from sites two and seven. None of those who suffered from diarrhoea from sites six and nine were sure whether or not they had blood in their stool. Moreover, none of the learners who suffered from diarrhoea were sure if the stool they passed was normal, white, black or with blood. Only pupils/students in sites three, four, six and seven complained of **constipation**. They also indicated having acute pains accompanying the constipation.

The general complaints of learners about their personal health according to responses from headmasters/designated officials, are summarised in Figure 5.6. The responses could be classified into three levels: high (70% to 100%), moderate (21% to 69%) and low (below 20%).



(Legend: A = body weakness, B = loss of body weight, C = influenza/common cold, D = headaches, 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)

Figure 5.6: General complaints of learners about personal health within the Selebi Phikwe area

In the category classified as low, there were no learners, according to the headmasters/designated officials, passing urine with pain, although 3% of them had unusual genital discharge, 10% had palpitations, 13% had constipation and 17% had unusual spitting. In the moderate category, the headmasters/designated officials indicated that there were 23% of learners who had pain in the lower abdomen, 27% had chest pain, 30% complained of general body weakness, with the same percentage 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. In the high category, 70 % complained of cough, 77% had influenza/common cold, and 80% experienced headaches (Figure 5.6)

5.3 Aspects of death

Cases where learners had been admitted into health facilities due to general body weakness prior to death had occurred in all the sites except sites eight and ten (Table 5.6). Less than 10% of the institutions that indicated having learners admitted into the facilities were all from site two whereas 10 – 20% of those who responded for similar ailment consisted of 20% of the learners from site three, and for the institutions where 81 – 90% of learners who were admitted for the same ailment, these were all from site five. A substantial percentage of institutions from sites one, three, six, seven and nine indicated that they were not sure of the percentage of learners who had been admitted into health facilities prior to death (Table 5.6).

Institutions in sites three and five indicated that < 10% of their learners were suffering from shortness of breath at the time they were admitted into health facilities (Table 5.6). However, from all the sites except sites eight and ten, it was not certain what percentage of learners were admitted for shortness of breath.

Table 5.6: Percentage of learners admitted to health facilities due to general body weakness and shortness of breath

General body weakness

Site	<10%	10-20%	81-90%	Not sure
One				100
Two	100			
Three		20		80
Five			100	
Six				100
Seven				100
Nine				100

Shortness of breath

Site	< 10%	Not sure
One		100
Three	100	
Four		100
Five	100	
Six		100
Seven		100
Nine		100

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 had been indicated (<10% of those who died), while 20% from site four had been admitted because of repeated coughing, 20% (site four) due to headaches, nausea and vomiting. None of the institutions indicated that learners were admitted in 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.

Deaths were reported as a result of 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, it consisted of 40% from site four and 50% from site seven. For the rest of the institutions having learners who had paased away due to malaria, the percentage of students was not certain.

Figures reporting deaths from pneumonia were given for sites four and seven. For the institutions where 20 – 30% of learners had died from 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 caused by tuberculosis.

A number of institutions in all the sites except sites eight and ten indicated that there were learners who had passed away because of pneumonia and tuberculosis, although they were not sure of the percentage. The research findings further indicated that none of the learners had died of breast cancer, cancer of the colon, cardiac arrest, diabetes, heart disease, lung cancer, meningitis, other lung diseases, prostrate cancer, or stroke.

Educational institutions were asked to indicate the duration of stay of deceased learners in the Selebi Phikwe area prior to the deaths. None of the educational institutions indicated that there were learners in age groups 26 – 30 years, 31 – 35 years, and 36 – 40 years who had died in Selebi Phikwe. A few deaths were reported of learners who had lived in the Selebi Phikwe area for < 5 years, and these were particularly noted in sites four and six. Regarding death cases where educational institutions indicated that < 20% of their learners who died after having lived in Selebi Phikwe for a period of 6 – 10 years, 20% of those in site four and all in site five belonged in this category. For 41 – 50% of those who died, 20% of them were from site four, and between 91 – 100 % of those who passed away, 50% were from site seven.

Schools which indicated that they had learners who had passed away after having lived in Selebi Phikwe for 11 – 15 years were mainly from sites four and five, and those who had learners who had lived in the township for 16 – 20 years were all from site five. However, in site seven, institutions indicated that they had deaths of learners who had lived in Selebi Phikwe for 21 – 25 years. A number of institutions from all the sites except sites eight and ten indicated that they were not sure of the number of years some of the deceased learners had lived in the Selebi Phikwe area.

5.4 Discussions

5.4.1 Demographical data

Some of the schools were very overcrowded, with numbers exceeding 700 learners leading to extremely congested classrooms. These overcrowded schools were located in sites four, five and seven where higher levels of morbidity and mortality of school children had occurred. In the current Vision 2016 (Botswana Government, 2003), there are plans to increase the number of educational institutions in the Selebi Phikwe area. Efforts of the Government are such that the staff : student ratio will be greatly reduced to an average of 1:25 from the current 1: 54 in the area.

Thirty percent of the educational institutions were located in site four. No reasons were advanced as to why this site had far more schools than any of the other sites. Consequently there were many more learners attending school in site four than in any of the other sites. Findings from this study indicated that site four was among the sites with the highest levels of morbidity and mortality. It could be beneficial to the Selebi Phikwe community if some (or possibly all) of the schools in this site were relocated to sites having low morbidity and mortality such as sites eight and nine.

It was noticed that missionary bodies did not own any of the schools in the Selebi Phikwe area although they had educational institutions in other towns and cities in the country. In missionary-owned schools, moral and health education with aspects of basic hygiene are included in the curriculum. Basic hygiene such as washing of hands, wearing clean clothes, having baths regularly and so on, help curb communicable diseases. The morbidity and to an extent mortality levels could have been reduced if learners had been taught moral and health education embracing aspects of personal hygiene (Dev Pant, 1991).

5.4.2 General complaints of learners about personal health

The 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 experienced influenza/common cold, headaches and frequent coughing respectively were from nursery schools, primary, secondary and technical schools as shown in Table 5.7. 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 flu/common cold, secondary >primary > nursery schools > technical; for headaches, secondary >primary > nursery schools > technical; and for coughing, nursery schools > primary > secondary > technical schools (Table 5.7).

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

Table 5.7: Percentage of learners who suffered from influenza/common cold headaches and coughing

Influenza/common cold

Type of institution	< 20%	20- 30%	30-40%	40-50%	Varies
Primary	67	25		8	
Secondary	25	25	25		25
Technical			100		
Nursery	17		17	17	50

Headaches

Type of institution	< 20%	20- 30%	30-40%	40-50%	Varies
Primary	73	18		9	
Secondary	25	25	13	13	25
Technical			100		
Nursery	25	25			50

Coughing

Type of institution	< 20%	20- 30%	30-40%	40-50%	Varies
Primary	55	18	9	9	9
Secondary	25	25			50
Technical		100			
Nursery	20	20	20	20	20

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 schools, primary, secondary and technical schools as shown in Table 5.8. According to Yusufu (2002), the vomiting reflex evolved as a defensive mechanism 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.

Table 5.8: Percentage of learners who complained of pain in the lower abdomen, nausea and vomiting, and diarrhoea

Pain in the lower abdomen

Type of institution	< 20%	20- 30%	40-50%	Varies
Primary	75	25		
Secondary			100	
Technical				100
Nursery			100	

Nausea and vomiting

Type of institution	<20%	20- 30%	Varies
Primary	83	17	
Secondary	100		
Technical			100
Nursery	50	50	

Diarrhoea

Type of institution	<20%	20- 30%	30-40%	Varies
Primary	100			
Secondary		50		50
Technical				100
Nursery	33	33	33	

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 schools > primary > technical; for nausea and vomiting, nursery schools > primary > secondary > technical; and for diarrhoea, nursery schools > primary > secondary > technical schools (Table 5.8).

5.4.3 Illnesses 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 the Selebi Phikwe area, the diarrhoeal burden is primarily due to the mining activities. This is further substantiated by Bastarache (2003) in which he iterated nasal congestion, fever up to 39 ^{o}C, chills, malaise, aching muscles, dryness in the mouth and throat, headache, and shortness of breath as being among the ailments resulting from inhaling copper fumes.

In western Papua New Guinea where copper is mined, pneumonia accounts for 26% of infant death, diarrhoea 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 years (Dulce and 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 tape worm infection, chlamydia and gonorrhea, acute respiratory tract infection and diarrhoea are also significant health problems affecting children in mining environments (Dulce and Estrella-Gust, 2003). Although the findings from the study indicated low figures for AIDS and AIDS-related diseases, 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 prevalent in the community. Support services for people with AIDS are virtually non-existent (Dulce and 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); this problem could also 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.

The responses obtained from this study indicated that tuberculosis appeared not to be common among the Selebi Phikwe learners. However, national reflection indicates that incidence of the disease is fairly high and there are existing tuberculosis centres for research and treatment in the country - part of which is an initiative of the Centre for Disease Control (CDC) at Atlanta, Georgia, USA. A recent study on tuberculosis in children demonstrated that its diagnosis in children is difficult, particularly in HIV infected children, whereas other diseases such as pneumonia and bronchitis are easily confirmed (Kiwanuka, 2003). With this in mind, it may be understood why pneumonia, coughing and related respiratory tract infections were easily reported by the learners.

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 students in school and educational status of parents. In Chapter Four, the educational status of individuals living in the Selebi Phikwe area was considered, and it was clear that most of them had only attained levels of education not higher than secondary. Consequently, home education, which could possibly have a positive influence on the general health status of adolescents, may not be an optimum concern of parents of learners in the Selebi Phikwe area. Other adolescent concerns which touch on their emotional, sexual and social outlook, as well as on substance uses, could be contributory to the high occurrences of headaches registered in the study area, and psychosocial disorders, which is beyond the scope of this study. Furthermore morbidity in females appeared to have been higher compared to that of males. Demise, Shinebaum and Melesse (2002) are of the opinion that for females to perform better, attention should be paid to their personal security, material support, assertiveness creation and personal health in addition to academic needs.

5.4.4 Aspects of death

Details of sites learners lived prior to passing away are given in Table 5.9. In terms of gender, slightly more males than females died. 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. There were learners living in site two who attended school in sites four (20%) and seven (50%) who died.

Deaths 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, as well as *Imbrasia belina, Colophospermum mopane,* and particulate air matter. It was furthermore observed that the pungent smell of SO_2 and related gases and fumes was stronger and more intensified in those sites than the other study sites. These observations could be substantiated with further research that may bring about the pathological examination of cadavers.

Table 5.9: Percentage of deceased leraners indicating where they had lived in the Selebi Phikwe area

Males

Site	20-30%	31-40%	41-50%	51-60%	91-100%	Not sure
One		100				
Three	100					
Four		20	60	20		
Five	100					
Six	50					50
Seven		100				
Nine					100	

Females

Site	41-50%	51-60%	61-70%	71-80%	91-100%	Not sure
One			100			
Three				100		
Four	80	20				
Five					100	
Six					50	50
Seven		100				

5.5 Conclusions

Morbidity and mortality values were higher in sites close to the mine and the smelter/concentrator plant. Learners either living or attending school in sites three, four, five and 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, the respiratory tract diseases were most common together with gastro-intestinal disorders. Very high percentage values were obtained for influenza/common cold, headaches, coughing, nausea and vomiting, and diarrhoea.

Attending school or living in affected sites causes the leraners 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.*, 2004). Gases and fumes with pungent and obnoxious smells appeared to be more perceived in sites learners manifested more illnesses than in the other sites.

The total dust concentration refers to the amount of suspended particles in the air in the workplace, while respirable dust concentration refers to particles that can be inhaled deeply into the lungs. Studies on mineral dust (Ekosse *et al.*, 2003; 2004) showed that threshold limit values (TLV) for both respirable and total dust concentration were generally exceeded at the mine, smelter/concentrator plant, and within the Selebi Phikwe area. Reports from the Department of Mines (1998) in Botswana also revealed that the annual mean concentration values for SO_2 in the atmosphere exceeded the permissible level authorised by the WHO.

Prevention programmes that seek to educate school-going adolescents about ways of avoiding some of the illnesses, where possible, by making them aware of risks associated with sexual behaviours or certain foods, must strongly encourage communication between learners, teachers, family members and society. Exposure of learners through outdoor activities to mineral dust, SO_2 and related gases and fumes should be reduced as much as possible. This may however be difficult to address because they would still encounter contaminated environments in their everyday activities.

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Appendix 5.1

Questionnaire on Human Health Hazards at the Selebi Phikwe Ni-Cu Mine Area, Botswana

SECTION 4: Questionnaire for Educational Institutions

Table of contents

Introduction

Thank you for your participation in the study by completing this questionnaire related to human health hazards at the Selebi Phikwe Ni-Cu mine area, Botswana. This study is undertaken for academic purposes only. All information collected will be treated confidentially and will not be revealed to anyone. It is suspected that environmental and human health problems may have been caused within Selebi Phikwe by mining activities. Inhabitants of the area are often infected with symptoms of illnesses and diseases related to pulmonary health complications. By means of the study, we would like to establish existing human health hazards, and identify the pulmonary health complications of the inhabitants of Selebi Phikwe, and then to advance solutions which could be implemented.

The basis of this study will consist of questionnaires, personal interviews, and the administration of lung function test to selected individuals based on the responses from the questionnaire and personal interviews as well as their medical histories. All the information obtained from this study will be treated in the strictest confidence, and made available as research findings at scientific conferences, seminars and workshops, and as an eventual publication in scientific journals. Any additional information provided will be very much appreciated.

This questionnaire is divided into the following main sections:

SECTION 1: Questionnaire for individuals, which should be answered by individuals.

SECTION 2: Questionnaire for health service providers, which should be answered by health service providers or designated official of the health facility.

SECTION 3: Questionnaire for industries, which should be answered by the Director of the industry or designated official of the industry.

SECTION 4: Questionnaire for educational institutions, which should be answered by principals/headmasters or designated official of the educational institution.

Kindly note the following:

- Please read through the entire question before making a choice.
- Your answer should be marked with a cross in the box provided below or next to your choice.
- Where a question requires a written explanation as the response, kindly write concisely in the space provided.
- Where a question requires more than one answer, this will be made clear.
- Be very frank with your answers.

SECTION 4: Questionnaire for Educational Institutions

Date of Interview...
Name of Interviewee (optional)..
Area (Address) ....
....

4.1 Demographical data

4.1.1 Who owns this institution?

Government	Town Council	BCL	Private	Other (specify)

4.1.2 How many years has this institution been in operation?

Less than ten years	Between ten and twenty years	Between twenty and thirty years	Between thirty and forty years	Between forty and fifty years	More than fifty years	Not sure

4.1.3 How many learners attend this institution?

Less than one hundred	Between one hundred and two hundred	Between two hundred and three hundred	Between three hundred and four hundred	More than four hundred (specify)	Varies

4.1.4 What type of institution?

Primary	Secondary	Technical	Informal	Vocational	Professional	Other (specify)

4.1.5 Which area describes closest where this institution is located at Selebi Phikwe?

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

4.1.6 Indicate what percentage of the learners of this institution live in the different areas in Selebi Phikwe

Sampling site	Location/Characteristics	
1	Industrial area (150 m past the railway crossing)	
2	Bosele Hotel (commercial area) and new township	
3	Between the township stadium and the mine (behind the Botswana Power Corporation, BPC)	
4	Between Township boundary and the railway line (directly behind	

	a Community Junior Secondary School, CJSS)	
5	Opposite the Mine hospital, close to old township	
6	Between the mine and explosive storage facilities (close to old township)	
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi Phikwe Road juncture)	
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)	
9	Close to the second bridge before entering into the Selebi Phikwe township	
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road	

4.1.7 Indicate the gender percentage of the learners of this institution.	Male		Female	

4.1.8 Indicate the age group percentages of learners of this institution.

< 10 yrs	11-15 yrs	16-20 yrs	21-25 yrs	26-30 yrs	>30 yrs

4.2 General complaints of learners about personal health

4.2.1 Do learners complain of general body weakness?	Yes		No	

4.2.2 If answer to 4.2.1 is yes, what percentage of learners complain of general body weakness?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.3 Do learners experience loss of body weight?	Yes		No	

4.2.4 If answer to 4.2.3 is yes, what percentage of learners complain of body loss of weight?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.5 Do learners complain of influenza/common cold?	Yes		No	

4.2.6 If answer to 4.2.5 is yes, what percentage of the learners complain of influenza/cold?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.7 Do pupils/students complain of headache?	Yes		No	

4.2.8 If answer to 4.2.7 is yes, what percentage of the learners complain of headaches?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.9 Indicate what percentage of the learners complain of the different types of headache

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.10 Do the learners who complain of cough?	Yes		No	

4.2.11 If answer to 4.2.10 is yes, what percentage of the learners complain of coughing?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.12 Indicate what percentage of the learners who complain of coughing have the different types of cough mentioned below.

Dry cough	Wet cough	Cough with sputum	Cough with chest pains	Cough with shortness of breath

4.2.13 Do the learners complain of unusual spitting?	Yes		No	

4.2.14 If answer to 4.2.13 is yes, wnat percentage of learners complain of unusual spitting?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.15 Indicate what percentage of the learners who complain of unusual spitting have the types of spit as mentioned below.

Clear sputum	Milky sputum	Greenish sputum	Sputum with blood	Black sputum

4.2.16 Do learners complain of chest pains?	Yes		No	

4.2.17 If answer to 4.2.16 is yes, indicate what percentage of learners complain of chest pains.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.18 Indicate what percentage of the learners who complain of chest pains have the types of chest pains as mentioned below.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.19 Do learners who attend this institution complain of experiencing shortness of breath regularly?	Yes		No	

4.2.20 If answer to 4.2.19 is yes, indicate what percentage of learners complain of experiencing shortness of breath?

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.21 Indicate what percentage of the learners who complain of experiencing shortness of breath have the types of shortness of breath as mentioned below.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.22 Do learners complain of experiencing Palpitations?	Yes		No	

4.2.23 If answer to 4.2.22 is yes, indicate what percentage of learners complain of experiencing palpitations.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.24 Indicate what percentage of the learners who complain of experiencing palpitations have the types of palpitations as mentioned below.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.25 Do learners complain of experiencing pain in the lower abdomen?	Yes		No	

4.2.26 If answer to 4.2.25 is yes, indicate what percentage of learners who attend this institution complain of experiencing pain in the lower abdomen.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.27 Indicate what percentage of the learners who complain of experiencing pains in the lower abdomen have the types pain in the lower abdomen as mentioned below.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.28 Do learners complain of pain when passing urine?	Yes		No	

4.2.29 If answer to 4.2.28 is yes, indicate what percentage of learners who complain of experiencing pain when passing urine have the ypes of pain when urinating as mentioned below.

Dull	Moderate	Acute	At times dull andat times acute	Not sure

4.2.30 Do learners complain of experiencing any unusual discharge from their genital systems?	Yes		No	

4.2.31 If answer to 4.2.30 is yes, indicate what percentage of learners who complain of experiencing unusual discharge from their genital system have the types of pain in their genital organs as mentioned below.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.2.32 Do learners complain of experiencing nausea and vomiting?	Yes		No	

4.2.33 If answer to 4.2.32 is yes, indicate what percentage of learners complain of experiencing nausea and vomiting.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.34 Indicate what percentage of the pupils/students who complain of experiencing nausea and vomiting have the different types of pain accompanying the nausea and vomiting?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

4.2.35 Do learners complain of experiencing diarrhoea?	Yes		No	

4.2.36 If answer to 3.2.35 is yes, indicate what percentage of learners complain of experiencing diarrhoea.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.37 Indicate what percentage of the learners who complain of experiencing diarrhoea have blood in their stool when they have diarrhoea.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.38 Indicate what percentage of the learners have the different types of colour of their stool?

Normal	White	Black	Stool with blood	Not sure

4.2.39 Do learners complain of experiencing constipation?	Yes		No	

4.2.40 If answer to 3.2.39 is yes, indicate what percentage of learners complain of experiencing constipation.

Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	Varies

4.2.41 Indicate what percentage of the learners who complain of experiencing constipation have the types of pain as mentioned below, accompanying the constipation?

Dull	Moderate	Acute	At times dull and at times acute	Not sure

4.3 Aspects of death

4.3.1 Do deaths occur at this institution?	Yes		No	

4.3.2 When learners die, prior to death what percentages are admitted to health facilities because of one or more of the following complaints/diseases?

General body weakness	Loss of body weight	Influenza/common cold	Headaches	Coughing
Chest pains	Shortness of breath	Palpitations	Pain in the lower abdomen	Pain when passing urine

Unusual discharge from genital system	Nausea and vomiting	Diarrhoea	Constipation	Other (specify)

4.3.3 When learners die, what percentages die because of one or more of the following diseases/health complications as determined by clinical diagnosis and/or death certificate?

AIDS-related	Breast cancer	Cancer of the colon	Cardiac arrest	Diabetes
Heart disease	Lung cancer	Prostrate cancer	Malaria	Other lung disease (specify)
Meningitis	Pneumonia	Tuberculosis	Stroke	Other (specify)

4.3.4 For those pupils/students who died while attending this institution, indicate what percentage lived at Selebi Phikwe area for the different duration of stay?

	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

4.3.5 For those pupils/students who died while attending at this institution, indicate what percentage died within the corresponding age groups given?

	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

4.3.6 For those pupils/students who died at this institution, indicate the gender percentage?	Male		Female		

4.3.7 Indicate what percentage of the learners who died while studying at this institution lived in the different areas in Selebi Phikwe.

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

Chapter Six

Health Status of Workers in Businesses and Industries within the Selebi Phikwe Ni-Cu Mine Area

6.1 Introduction

The exploitation of Ni-Cu ore, among several other mineral resources being tapped in Botswana, has given the country an economic boost (Botswana Government, 2003). In addition to this, the challenges of developing a diversified economy with a strong commercial and industrial base have recently become a primary concern for the Government of Botswana. Partly as a result of this, legislation for the establishment of businesses within the private sector is rather lenient (Tombale, 2002).

The Government of Botswana has made available incentives such as the Financial Assistance Policy (FAP) for small and large scale businesses and industrial projects. Furthermore, incentives such as ease of registration of companies, coupled with minimal investment needs and security risks due to the existing healthy political climate, have facilitated investment and encouraged citizen ownership of businesses and foreign investment in the country (Mundi, 2003). The incentives have encouraged investment in commercial, textile, food/hotel, mining, agricultural, service provider, and liquor store enterprises in the country, and especially in mining towns such as Selebi Phikwe where rapid urbanisation is eminent (Tombale, 2002).

Although the political climate of the country is conducive to investment in the private sector, it is possible that the exploitation of mineral resources could have negative effects on the health of residents in mining the environments in the country. The validity of assumption has not yet been established: according to available literature, research to confirm the possibility of negative health effects associated with the mining activities has not yet been conducted in Botswana. Previous studies carried out on the physical environmental quality of the Selebi Phikwe area by Ekosse (2001) and Ekosse, Van den Heever, De Jager and Totolo (2003, 2004) concluded that mining activities in the area have, however, affected the atmosphere, plants, phane and soils, and the possibility of negative health effects is thus very real. In another study on socio-economic concerns within the Selebi Phikwe area, Asare (1999) also suggested that the exploitation of Ni – Cu could have a negative effect on the health of the residents in the area. This study did not, however, consider the different categories of residents in order to establish which class was the most affected. The present study, which investigated the possible negative human health effects in the Selebi Phikwe area as a result of the mining activities was thus conducted.

The work reported in this chapter is part of the research project aimed at understanding the health hazards to residents in the Selebi Phikwe mine area in Botswana. The health status of workers in businesses and industries in the study area was examined, and this chapter presents the results of a survey which was undertaken to assess this health status. This part of the study thus aims to report on the prevalence of illnesses and diseases affecting workers.

6.2 Methods

The methods and analytical techniques used in appraising the human health status of workers working in the Selebi Phikwe Ni-Cu mine area have been discussed in sections 3.1.1 and 3.2.1 of this document. The questions in the questionnaire were answered by the Director of the business or industry (who in some cases was the owner) or a designated official (usually the manager) of the business or industry. Businesses and industries were chosen to represent all the different types of undertakings established in Selebi Phikwe. Information concerning the types and locations of the different businesses and industries was obtained from the Selebi Phikwe Town Council and Local Government Offices, the Ministry of Trade and Commerce and the Department of Mines Botswana on industries.

A total of 300 industries were identified of which 200 participated in this study. This number was chosen after reconnaissance visits. The study area was divided into ten sites based on a previous study by Ekosse (2001). All the different types of industries at the ten different sites were statistically represented. Individuals selected to take part in the study were those who lived in Selebi Phikwe, and were able to communicate with the Research Assistants effectively. A non-biased approach was followed, whereby businesses and industries were chosen based on their location and type, and an equal distribution of questionnaires to all the ten sites was ensured. Equal distribution of questionnaires to businesses and industries was opted for because the subpopulations per site were very similar. This approach of an equal number of samples per subpopulations where the subpopulations are similar corresponds to the method suggested by Czaja and Blair (1996). A sample of the questionnaire which was administered, can be found in appendix 6.1 of this chapter. The questionnaire covered demographical data, general complaints of workers about personal health, and aspects related to death.

6.3 Results, interpretation and discussion

6.3.1 Demographical data

There were 200 businesses and industries in the Selebi Phikwe area and the control site. Figure 6.1 and Table 6.1 present the percentage distribution of the **ownership** of the businesses and industries that responded to the questionnaires and structured interviews.

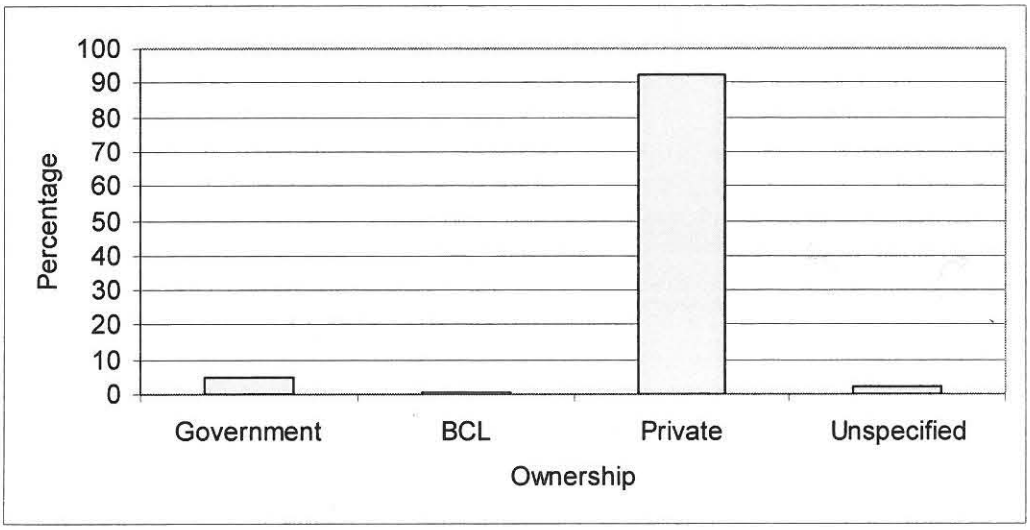


Figure 6.1: Percentage distribution of ownership of businesses and industries in the Selebi Phikwe area

Based on the responses, it is evident that the Government of Botswana, Bamangwato Concessions Limited (BCL) and private individuals are the principal owners of the enterprises in the Selebi Phikwe area. Results obtained from cross-tabulation to determine the percentage of these enterprises that belonged to the various owners, indicated that 92.5% of them were privately owned, 5% belonged to the Government and 5.5% to BCL. Ownership of 2% of the enterprises was unspecified.

Table 6.1 indicates the ownership of enterprises according to study sites. The responses obtained from the questionnaires reflected that all the industries located in sites five, seven, eight and nine that participated in this exercise were privately owned. Neither the Government nor BCL owned any of the enterprises in these four sites. In site one, 14% of the enterprises were Government owned and 81% private owned. 4% of the industries in site two belonged to the Government, 1% to BCL and 94% to private businessmen. The Government also owned 7% of the industries in site three and 13% of those in site ten. The ownership of 5%, 1%, 9% and 13% of industries in sites one, two, four and six, respectively was not specified (Table 6.1).

Figure 6.2, which was compiled from the responses obtained from the questionnaires administered to the Directors or delegated officials of the different enterprises, depicts the percentage distribution of **number of years of existence** of enterprises in the Selebi Phikwe area. 51% of the enterprises have been in existence for < 10 years, 30% of them are 10 –20 years old, 8%

of them enterprises are 21 – 30 years old, and 2.5% of the enterprises are 31 – 40 years old (Figure 6.2).

Table 6.1: Ownership of enterprises (in percentages) according to study sites in the Selebi Phikwe area

Site	Government	BCL	Private	Unspecified
One	14		81	5
Two	4	1	94	1
Three	7		93	
Four			91	9
Five			100	
Six			87	13
Seven			100	
Eight			100	
Nine			100	
Ten	13		87	

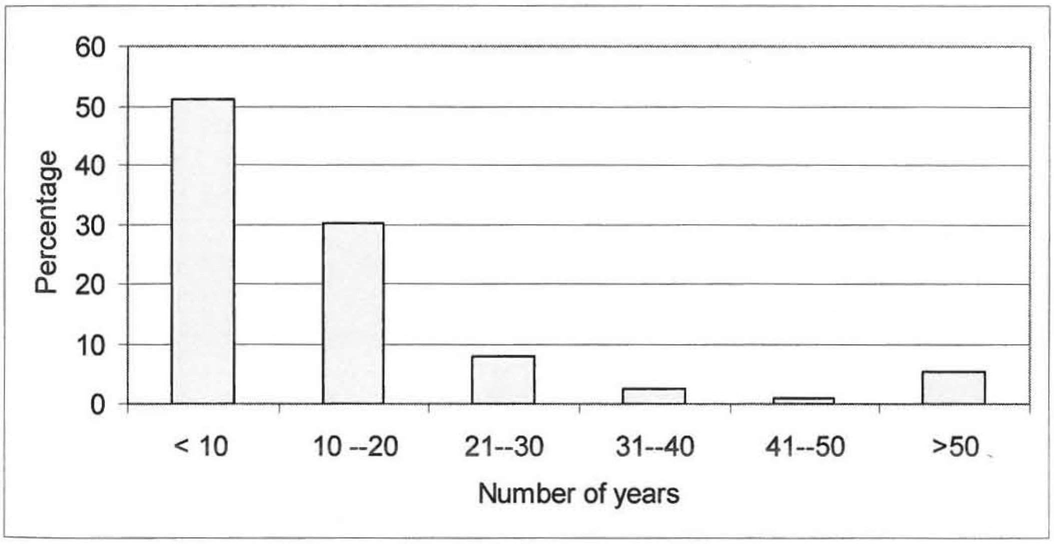


Figure 6.2: Distribution according to number of years of existence of enterprises in the Selebi Phikwe area (in percentages)

It is thus evident that > 50% of the businesses and industries in Selebi Phikwe are relatively young enterprises that have only been established in the area over the past 10 years. This was expected as industrial expansion and growth depends on the exploitation of Ni-Cu, and mining only became operational after the political independence of Botswana in 1966. Few businesses and industries (5.5% of them) have been in existence for > 50 years. These older enterprises were the commercial industries that had sustained the previous small population of Selebi Phikwe village before its growth to township status (Department of Town and Regional Planning, 1996).

According to Table 6.2, the older enterprises (> 50 years) in the township are located in sites one, two, three and six, while all sites have young businesses and industries of < 10 years old. 93% of the businesses and industries in site three are < 20 years old, 91% of them are < 10 years old, and 9 % are 21 – 30 years old. While 50% of the businesses and industries in site five are < 10 years old, the remaining 50% are 11 – 30 years old. In site six, only 76% of the businesses and industries are 11 – 30 years old. In site seven, 83% of the enterprises are < 10 years old (Table 6.2).

Based on the **number of workers** employed by the businesses and industries, most of them are small (Figure 6.3). 66% of the businesses and industries that participated in this study responded that they employed < 10 workers, 19% of the businesses and industries had between 10 – 20 workers, and 8% of them employed 21 – 30 workers. 3% of these enterprises had a workforce of between 31 – 90 people. Only 2.5% of the businesses and industries employed more than 100 workers, and the number of workers for 1.5% of the businesses and industries varied from time to time depending on the season and market forces such as foreign exchange, consumer demands and cost of production.

Table 6.2: Number of years of operation of enterprises according to study sites in the Selebi Phikwe area

Site	<10 yrs	11- 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	> 50 yrs	Not sure
One	38	33	19		5	5	
Two	51	32	6	4	1	5	2
Three	73	20				7	
Four	91		9				
Five	50	25	25				
Six	13	38	38			13	
Seven	83	17					
Eight	29	71					
Nine	38	38	13				13
Ten	47	27		7		20	

The businesses and industries with the highest number of employees as reflected in Table 6.3 are located in sites one, six and seven, whereas all the sites have enterprises with < 10 employees. The distribution of the number of workers in enterprises based on the responses from the questionnaires is presented as per Table 6.3.

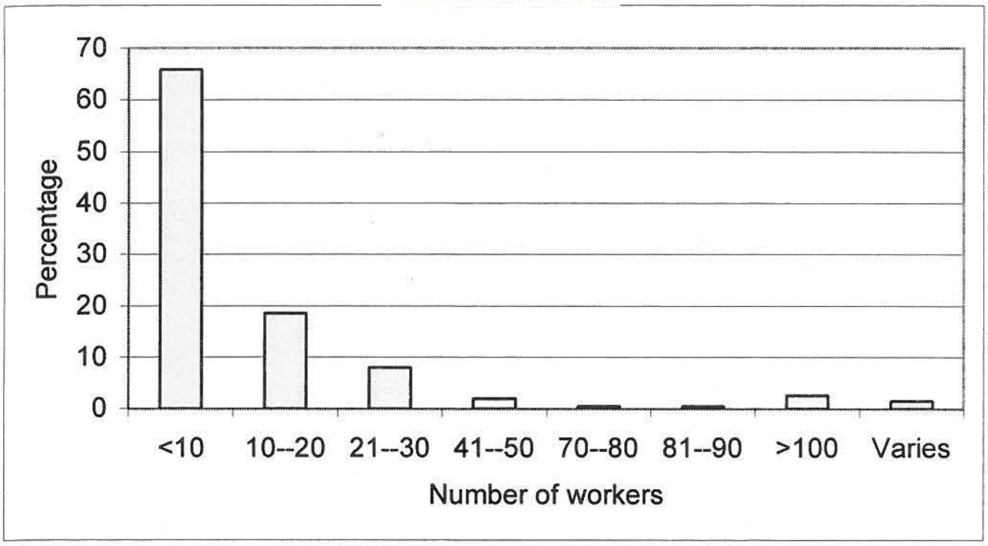


Figure 6.3: Percentage distribution of number of workers of businesses/industries in Selebi Phikwe

Table 6.3: Percentage distribution of workers employed in enterprises according to study sites in the Selebi Phikwe area

Site	< 10	10-20	21-30	41-50	71-80	81-90	100+	Varies	Unspecified
One	19	19	14	14	5		24		5
Two	69	23	7					1	
Three	100								
Four	55	27	9					9	
Five	75	25							
Six	75	13				13			
Seven	50		17	17				17	
Eight	100								
Nine	50	25	25						
Ten	73	13	13						

With relevance to the **distribution** of businesses and industries involved in the study, 52% of them are located in site two: the commercial area and new township (Figure 6.4), whereas close to 11% of the businesses and industries are situated in the industrial area, which corresponds to site one of this study. 7.5% each of the enterprises reported in this study are from sites three and ten respectively. 5.5% of the businesses and industries are from site four, and 4% of them are each from sites six and nine respectively.

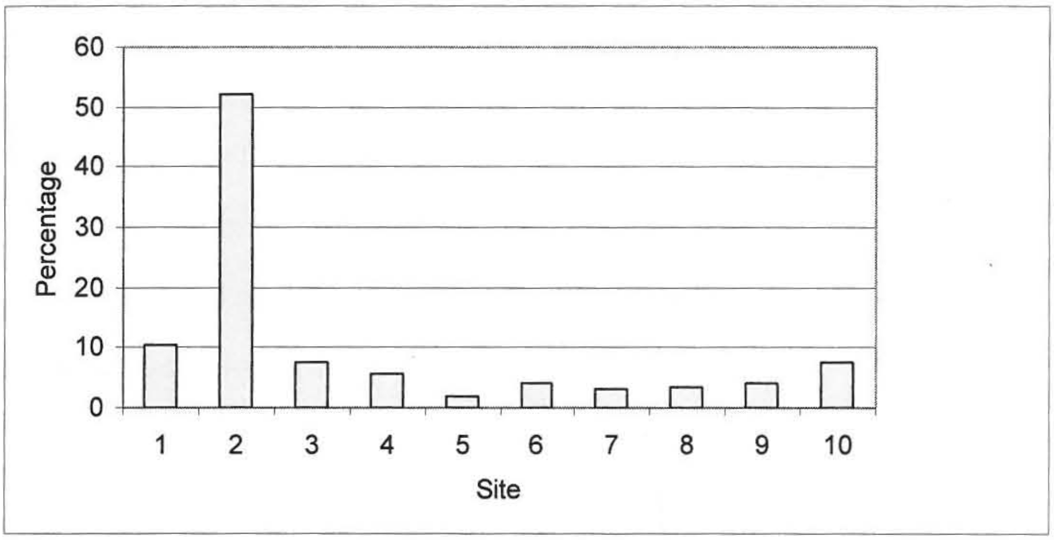


Figure 6.4: Percentage distribution trend of businesses and industries according to study site within the Selebi Phikwe area

3% of the businesses and industries are from site seven and the remaining 2% from site five. The topographic distribution of the businesses and industries in Selebi Phikwe was in accordance with the development plans for the township by the Department of Town and Regional Planning (1996).

Based on the responses obtained from the questionnaires and structured interviews, the **types** of businesses and industries represented in the study area included 41.2% commercial, 16.6% textile, 21.1% food/hotel, 0.5% mining, 2% agricultural, 9% service providers, 3.5% liquor store types of enterprises while 6% were unspecified. Table 6.4 gives the details of how the enterprises are distributed according to the study sites.

It may be deducted from the demographical data, which includes number of years of existence of businesses and industries and distribution of number of workers in the industries in Selebi Phikwe, that the town has grown as a result of Ni – Cu mining activities. This is substantiated by the fact that prior to the establishment of mining activities, Selebi Phikwe was a village with less than five thousand inhabitants (Department of Town and Regional Planning, 1996). Three other towns and cities in the country are also known to also have grown as result of mining activities. Both Jwaneng and Orapa towns grew as a result of the mining of diamonds (Nationmaster, 2004), and the city of Francistown grew from the mining of gold (Kerven, 1976). In neighbouring South Africa, there are a number of cities that also became urbanised as a result of mining activities. The growth of Johannesburg was strongly influenced by the mining of gold (South Africa, 2004), and Kimberley by the exploitation of diamonds (Longer Tours, 2004).

Table 6.4: Types of enterprises according to study sites in the Selebi Phikwe area

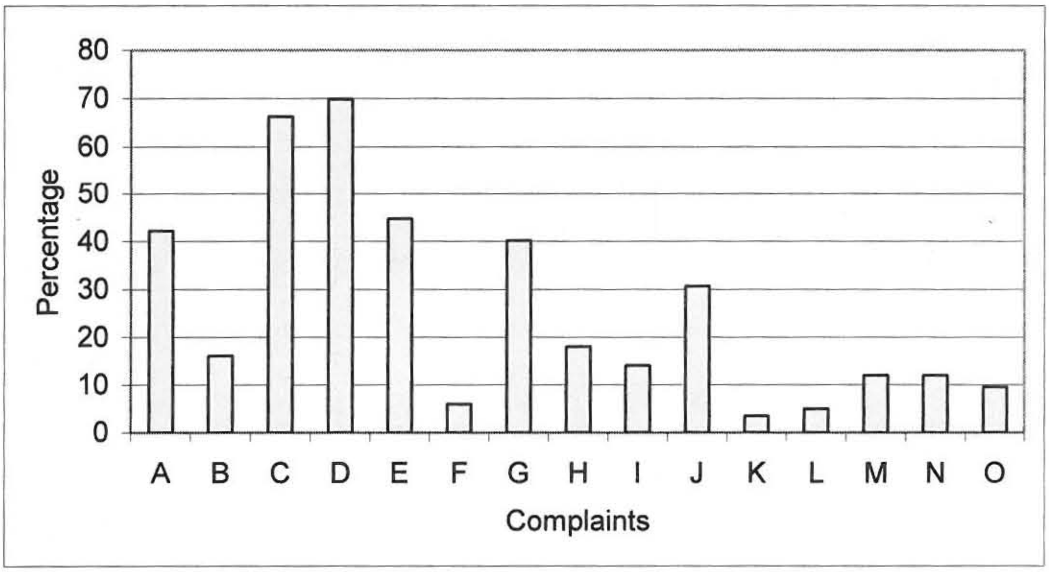
Site	A	B	C	D	E	F	G	H
One	29	14	19		14	10		14
Two	44	25	14			11		6
Three	53		33			13		
Four	18	9	27	9		18		18
Five	100							
Six	75		25					
Seven			100					
Eight			57			14	29	
Nine	50	13	13		13		13	
Ten	40	13	13				27	7

(*legend A = commercial, B = textile, C = food/hotel, D = mining, E = agricultural, F = service provider, G = liquor store and H = unspecified)*

Most of the businesses and industries within the study area were established only after the Ni-Cu mine and concentrator/smelter plant became operational. These enterprises are privately owned. The labour force came from neighbouring villages, and these have remained the source for manpower over the years (Tabelo, 2004). The availability of capital has affected the types of businesses and industries in the area, and with the Government financial assistance policy, many of the locals are becoming entrepreneurs and general business men (Tabelo, 2004; Valentine, 2000).

6.3.2 General complaints of workers about personal health

In this study, complaints of workers about general personal health included experiencing of body weakness, loss of body weight, occurrence of influenza/common cold, headaches, coughing, unusual spitting, chest pain, shortness of breath, palpitations, lower abdomen pain, urination with pain, genital discharge, nausea/vomiting, diarrhoea, and constipation. The details of percentage distribution of these health complaints of workers are presented in Figure 6.5.



(Legend A = body weakness, B = loss of body weight, C = influenza/common cold, D = headaches, E = coughing, F = unusual spitting, G = chest pain, H = shortness of breath, I = palpitations, J = lower abdomen pain, K = urination with pain, L = genital discharge, M = nausea/vomiting, N = diarrhoea, and O = constipation)

Figure 6.5: Percentage distribution of general health complaints of workers of businesses and industries in the Selebi Phikwe area

The responses obtained from the questionnaires and structured interviews directed to the designated officials of the enterprises showed that according to these officials 42% of the workers complained of body weakness, 16% of the workers experience loss of body weight, 66% experienced influenza/common colds, 70% of the workers regularly suffered from headaches, and 45% of the workers complained of repeated coughing. They also indicated that 6% of the workers complained of the need to spit often, 40% suffered from chest pain, 18% experienced shortness of breath, 14% of the workers complained of palpitations, 31% experienced lower abdominal pain regularly, 4 % suffered from pain when urinating, 5 % experienced genital discharge at some time, 12% often experienced nausea/vomiting, 12% regularly suffered from diarrhoea, and 10% often suffered from constipation. These values do not include those of the control site (site ten) reported in Table 6.5.

Table 6.5 gives a more detailed distribution of the various health complaints of the workers in the different businesses and industries in the Selebi Phikwe area based on the results obtained from the questionnaires and structured interviews, which were conducted in this study. According to Table 6.5, all the workers in sites four and nine often suffered from influenza/common colds, and all the workers in sites five and eight often suffered from headaches. In site one, 62% of the workers in businesses and industries suffered from body weakness, 90% often had influenza/common colds, 95% regularly suffered from headaches and 90% of the workers of businesses and industries complained of coughing regularly. Also in the same site, 71% of the workers suffered from chest pain, and 52% experienced shortness of breath.

In site two, 68% of the workers often had influenza/common colds, and 69% regularly suffered from headaches. In site three, 53% of the workers of businesses and industries suffered from body weakness, 82% often suffered from headaches and 55% complained of coughing regularly. 75%of the workers of businesses and industries often had influenza/common colds. In site five, 50% of the workers of these enterprises complained of often coughing and a further 50% of the workers suffered from chest pain. 53% of the workers in site 10 regularly suffered from headaches.

Table 6.5: General complaints of workers about personal health according to study sites in the Selebi Phikwe area

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
One	62	33	90	95	90	10	71	52	24	43	14	14	19	33	24
Two	42	18	68	69	43	8	38	18	14	28	3	6	13	10	11
Three	53	13	40	40	33		33	13	27	40	7		13	7	7
Four	27	9	100	82	55		27			9			18	18	9
Five	25		75	100	50	25	50								
Six	25	13	25	38			25			25					
Seven	33		67	50	50	17	17	17	17	33		17			
Eight			57	100			43			29					
Nine	50	13	100	88	75		75			63			25	38	
Ten	47	7	27	53	20		20	20	20	33				7	7

(Legend: A = body weakness, B = loss of body weight, C = influenza/common cold, D = headaches, E = coughing, 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)

In site seven, 67% of workers often had influenza/common colds, 50% regularly suffered from headaches and another 50% of the workers of enterprises complained of regular coughing. In site eight, 57% of the workers of businesses/industries often had flu/common colds. In site nine, 50% suffered from body weakness, 88% often suffered from headaches and 75% of the workers of enterprises complained of coughing regularly whereas another 75% of the workers suffered from chest pain. Also in the same site nine, 63% of the workers of enterprises experienced pain in the lower abdomen, 53% quite often suffered from headaches (Table 6.5).

More individuals at the control site suffered from general body weakness, desire to spit often, and shortness of breath than mean values of individuals for these complaints in the sites of the study area. However there were more individuals in sites close to the mine and smelter/concentrator plant who experienced general body weakness, desire to spit often, and shortness of breath than those at the control site. On the other hand, mean values of individuals in the study area who complained of all the other illnesses and diseases were higher than those at the control site.

Table 6.6 considers the distribution of the various health complaints of the workers in the different types of enterprises in the Selebi Phikwe area based on the results obtained from the questionnaires and structured interviews. According to Table 6.6, in the commercial enterprises, 51% of the workers suffered from body weakness, 60% often had influenza/common colds, 68% often suffered from headaches. In the textile enterprises, 73% of the workers often had influenza/common colds, and another 73% suffered regularly from headaches. In the food/hotel enterprises, 71% of the workers often had influenza/common colds, and 64% suffered regularly from headaches.

Table 6.6: Percentage distribution of types of general health complaints of workers of different types of enterprises in the Selebi Phikwe area

Industry	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Commercial	51	18	60	68	40	9	45	16	18	29	5	6	12	13	16
Textile	33	21	73	73	45	9	33	15	3	30		3	15	15	
Food/hotel	29	7	71	64	38	5	26	14	12	31		2	7	7	2
Mining			100	100	100										
Agriculture	75		100	100	100		100	50	25	25					
Unspecified	33	17	67	67	58		42	8		8	8		8	17	8
Service	50	28	67	72	56		50	44	28	50	11	17	28	17	22
Liquor/ bottle store	43		57	86	43		43	14	14	43					

(Legend: A = body weakness, B = loss of body weight, C influenza/common cold, `D = headaches, E = coughing, 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)

In the agricultural enterprises, 75% of the workers had suffered recently from body weakness, and 50% often experienced shortness of breath. All the workers in the agricultural and mining industries suffered regularly from influenza/common colds, headaches and complained of regular coughing. Moreover, all the workers in the agricultural industries also complained of chest pain. In the service industries, 50% of the workers suffered from recent body weakness, 67% of the workers often experienced flu/common colds, 72% of service provider enterprise workers suffered from regular headaches and 56% of these workers complained of coughing often. Also in the same service enterprise, 50% of the workers suffered from chest pain and another 50% had pains in the lower abdomen. In the liquor store enterprise, 57% of the workers often had influenza/common colds, and 86% regularly suffered from headaches.

There were a number of enterprises that did not specify the type of activities in which they were involved. In this category, 67% of the workers often experienced influenza/common colds, 72% of the workers of liquor store enterprises often suffered from headaches and 56% complained of coughing regularly. Also in the same liquor store enterprises, another 50% of the workers suffered from chest pain and 50% of the workers had pain in the lower abdomen.

Table 6.7 reflects the percentage distribution of workers within the different types of enterprises complaining of **general body weakness**. The distribution pattern based on the responses from the questionnaires and structured interviews indicated that there were varying percentages of workers in the different enterprises who complained of general body weakness. In site one as indicated in Table 6.7, all the textile businesses/industries, which participated in this study, indicated that 40 – 50% of their workers suffered from general body weakness. In site two, 88% of the textile enterprises had < 20 % of their workers suffering from general body weakness.

Table 6.7: Percentage distribution of workers of enterprises suffering from general body weakness according to study sites in the Selebi Phikwe area

Type of industry	Site	<20%	20- 30%	30-40%	40-50%	50-60%	60-70%	80-90%	90-100%	Varies	Not sure
Commercial	One				33		33			33	
	Two	24	16	4	20		8			24	4
	Three				40		20		20	20	
	Four				100						
	Five		100								
	Six									100	
	Nine	100									
	Ten	75			25						
Textile	One				100						
	Two	88	13								
	Nine	100									
	Ten									100	
Food/hotel	One	50		50							
	Two	67	33								
	Three	33		33					33		
	Four	100									
	Six		100								
	Seven	100									
Agriculture	One	33	33							33	
Service	One			50						50	
	Two	29	43			14		14			
Liquor store	Nine	100									
	Ten	50								50	

The distribution pattern of the various types of enterprises with a percentage distribution of workers who reported recent **loss of body weight** according to study sites in Selebi Phikwe is given in Table 6.8, based on the responses from the questionnaires and structured interviews as administered.

Table 6.8: Percentage distribution of workers of enterprises complaining of loss of body weight according to study sites in the Selebi Phikwe area

Type of industry	Site	<20%	20- 30%	30-40%	40-50%	60-70%	70-80%	90-100%	Varies
Commercial	One			20	40				40
	Two	22	22	17	17	6			17
	Three	25			25		25	25	
	Four				100				
	Five	50	50						
	Six	50	50						
	Nine	100							
	Ten	50							50
Textile	One				100				
	Two	70	10	10					10
Food/hotel	One	33			33				33
	Two	100							
	Three			100					
	Four								100
	Seven	100							
	Eight			50					50
	Nine		100						
Agriculture	One				67				33
	Nine	100							
Unspecified	One			50					50
	Two				33				67
Service	One				100				
	Two	43	14	14	14				14
	Four	100							
Liquor store	Eight								100
	Nine	100							
	Ten								100

All the commercial enterprises in site four which responded to the questionnaires indicated that 40 – 50% of their workers suffered from loss of body weight. However, all the commercial enterprises in site nine responded that < 20% of their workers suffered from loss of body weight.

In site one as indicated in Table 6.8, all the textile enterprises that participated in this study indicated that 40 – 50% of their workers suffered from recent loss of body weight. In site two, 70% of the textile enterprises indicated that < 20% of their workers who suffered from recent loss of body weight.

All the agricultural enterprises in site nine indicated that < 20% of their workers suffered from recent loss of body weight. In site one, all of the service provider enterprises responded that 40 – 50% of their workers suffered from loss of body weight. In site four, all the service provider enterprises stated that < 20% of their workers suffered from loss of body weight. In both sites eight and ten, as reflected in Table 6.8, all of the liquor store enterprises which participated in this study indicated that a varied number of workers suffered from recent loss of body weight.

The distribution pattern of the different types of enterprises with the percentage distribution of workers who complained of experiencing **acute chest pains** according to study sites in Selebi Phikwe is given in Table 6.9, based on the responses from the questionnaires and structured interviews.

Table 6.9: Percentage distribution of workers of enterprises complaining of acute chest pains according to study sites in the elebi Phikwe area

Type of industry	Site	20-30%	41-50%	61-70%	81-90%	91-100%	Not sure
Commercial	One				20		80
	Two	11					89
	Three						100
	Four		100				0
	Five						100
	Six						100
	Nine						100
	Ten						100
Textile	One						100
	Two			10			90
Food/hotel	One				33		67
	Two	50					50
	Three					100	0
	Four						100
	Seven						100
	Eight						100
	Nine						100
Agriculture	One						100
	Nine						100
Unspecified	One						100
	Two						100
Service	One						100
	Two						100
	Four						100
Liquor store	Eight						100
	Nine						100
	Ten						100

As indicated in Table 6.9, in site one, 20% of the commercial enterprises found that 81 – 90% of their workers complained of having acute chest pains, while 80% of the commercial enterprises had a varied number of workers who complained of having acute chest pains. In site two, 89% of the enterprises indicated that a varied number of workers complained of experiencing acute chest pains. Furthermore, all the commercial enterprises in site four indicated that 41 – 50% of their workers complained of having acute chest pains. In site three, all the responses from the food/health enterprises indicated that 91 – 100% of their workers complained of acute chest pains. In the study sites reflecting the different unspecified enterprises, the responses signalled an indeterminate number of workers with acute chest pains as can be deduced from Table 6.9.

The distribution pattern of the different types of enterprises with the percentage distribution of workers suffering from **coughing accompanying chest pains** according to study sites in Selebi Phikwe is given in Table 6.10. As indicated in Table 6.10, all the commercial enterprises in site four which responded to the questionnaires indicated that 40 – 50 % of their workers complained of regular coughing as well as of experiencing chest pains. All the commercial enterprises in site five indicated that 20 – 30% of their workers had the same symptoms, whereas in site nine, all the commercial enterprises which responded to the questionnaires indicated that < 20% of their workers complained of coughing regularly as well as experiencing chest pains. All the textile enterprises in sites nine and ten had 30 – 40% and 40 – 50% of their workers respectively who complained of coughing often as well as of experiencing chest pains.

Table 6.10: Percentage distribution of workers of enterprises complaining of coughing accompanying chest pains according to study sites in the Selebi Phikwe area

Type of industry	Site	<20%	20- 30%	30-40%	40-50%	50-60%	60-70%	Varies
Commercial	One	20			20			60
	Two	29	10	5	19		5	33
	Three	50						50
	Four				100			
	Five		100					
	Nine	100						
Textile	One			50				50
	Two	64	9		18			9
	Nine			100				
	Ten				100			
Food/hotel	One	25						75
	Two	50		25				25
	Three			100				
	Four	100						
	Seven	67						33
	Nine	100						
Mining	Four		100					
Agriculture	One							100
	Nine	100						
Unspecified	One							100
	Two	33	33					33
	Four							100
Service	One		50					50
	Two	33	17	17	17	17		0
	Three			100				0
	Four							100
Liquor store	Nine	100						
	Ten							100

All the mining enterprises in site four indicated that 20 – 30% of the workers complained of coughing regularly as well as experiencing chest pains. All the commercial enterprises in site four indicated that 40 – 50% of their workers complained of coughing often as well as of experiencing chest pains (Table 6.10).

Similarly, all the commercial enterprises in site five indicated that 20 – 30% of their workers had the same symptoms, whereas in site nine, all the commercial enterprises which responded to the questionnaires indicated that < 20% of their workers complained of coughing regularly as well and of experiencing chest pains. All the textile businesses/industries in sites nine and ten had 30 – 40% and 40 – 50% of their workers complaining of coughing often as well as of experiencing chest pains.

Regarding workers of enterprises having dull chest pains, all the respondents from the industries in the Selebi Phikwe area indicated that the workers were not sure of whether thay had dull chest pains. However, some of the workers (Table 6.11) complained of moderate chest pains. All the food/hotel enterprises in site nine found that 31 – 40% of their workers complained of moderate pains. In site nine, all the liquor store enterprises had 71 – 80% of their workers who complained of moderate chest pains.

Table 6.11: Percentage of workers of enterprises complaining of moderate chest pains according to study sites in the Selebi Phikwe area

Type of industry	Site	<20%	20-30%	31-40%	41-50%	61-70%	71-80%	91-100%	Not sure
Commercial	One								100
	Two	6	6	6	11			6	67
	Three								100
	Four		100						
	Five								100
	Six								100
	Nine						33		67
	Ten								100
Textile	One								100
	Two					10	10		80
Food/hotel	One								100
	Two								100
	Three								100
	Four								100
	Seven								100
	Eight								100
	Nine			100					
Agriculture	One		33						67
	Nine								100
Unspecified	One								100
	Two								100
Service	One								100
	Two								100
	Four								100
Liquor/ bottle store	Eight								100
	Nine						100		
	Ten								100

The distribution pattern of the different types of enterprises with the percentage distribution of workers often suffering from **constipation** according to study sites in the Selebi Phikwe area are given in Table 6.12, based on the responses from the questionnaires and structured interviews. As indicated in Table 6.12, in site two, 50 % of the commercial enterprises had < 20% of their workers who suffered from constipation. In site three, as shown in Table 6.12, all the commercial enterprises involved in this study had < 20%

of their workers who suffered from constipation. The enterprises were however not certain of the type of constipation (dull, moderate, acute) experienced by the workers.

Table 6.12: Percentage of workers complaining of experiencing constipation

Type of Industry	Site	<20%	20- 30%	30-40%	40-50%	Varies
Commercial	One	33			33	33
	Two	50			13	38
	Three	100				
Food/hotel	One			100		
Unspecified	Four					100
Service	One			100		
	Two	33	33			33

It can be deduced from the results depicted in Tables 6.6 to 6.12 that a significant number of workers in the various enterprises complained of experiencing general body weakness, recent loss of body weight, and suffering from frequent influenza/common colds. The results further indicated that a substantial number of workers in enterprises very often complained of headaches and were coughing regularly. Moreover, complaints of workers experiencing the desire to spit unusually often were also indicated. The results also indicated that workers of enterprises complained of experiencing chest pains, shortness of breath, palpitations, pain in the lower abdomen, pain when urinating, unusual genital discharge, frequent nausea/vomiting. The workers also complained of experiencing regular diarrhoea and frequent constipation.

Workers were admitted into health facilities because of some of the general health complaints. These general health complaints included all those cited in the above paragraph, excluding complaints of frequent coughing, regular headaches, pains when urinating, unusual desire to spit, and unusual genital discharge. They were also admitted into health facilities because of AIDS-related issues, asthma and complaints of chest pains.

It is not clear which of these illnesses and diseases affecting workers in the area are a direct result of the mining activities. However, illnesses and diseases such as chest pains, coughing, constipation, diarrhoea, influenza/common colds, headaches, recent loss of body weight, lower abdominal pain, palpitations, and pain when urinating could be a result of environmental air pollution or ingestion of contaminated phane worms. Irritation of the respiratory tract can lead to asthma, emphysema, and chronic bronchitis. and, in fact, many people develop two or three of these together. This constellation is known as chronic obstructive pulmonary disease (COPD) (American Thoracic Society, Centres for Disease Control, Atlanta, USA, and the Infectious Diseases Society of America, 2003).

Unexpected general body weakness which is not associated with physical effort such as dieting or exercises, sudden and significant loss of body weight, and frequent nausea and vomiting have been attributed to AIDS and AIDS-related diseases, tuberculosis and cancer (American Thoracic Society, Centres for Disease Control, Atlanta, USA, and the Infectious Diseases Society of America, 2003; Heilman, 2003; National Cancer Institute, 2004;

National Comprehensive Cancer Network, 2004). These three diseases (AIDS and AIDS-related diseases, tuberculosis and cancer) may be caused by several bacterial and viral agents which are not associated with the mining activities at Selebi Phikwe.

Health complaints of workers indicating persistent chest pains, frequent experiences of shortness of breath, asthmatic attacks, regular coughing and several occurrences of influenza/common colds could be symptoms associated with respiratory tract diseases that could ultimately lead to COPD or even lung cancer (Australian Lung Foundation, 2003; National Heart, Lung and Blood Institute, 2003; The Human Respiratory System, 2003). Frequent and persistent headaches, influenza/common colds and acute chest pains have been diagnosed as precursors of meningitis, malaria and stroke. At Selebi Phikwe workers complained of these symptoms, and deaths were reported of workers as a result of meningitis, malaria, cardiac arrest, diabetes and stroke. While there may be several causes of these diseases, at Selebi Phikwe PAM and gaseous fumes could be contributory.

Efforts in improving the health of residents of mining environments can only be done through teamwork cutting across a variety of inter-related professionals (Asare, 1999). It should be noted that the improvement of environmental health in the living and working environments is a multidisciplinary effort involving professions such as industrial hygiene, occupational epidemiology, industrial toxicology, occupational medicine, occupational health nursing, and specific health professionals such as the occupational health administrator, safety engineer, the environmental specialist and the compliance officer (McGill University, 2003). These specialists can be employed in developed countries. Unfortunately for growing economies such as that of Botswana, it would be difficult to recruit specialists for the environment unless the stakeholders first address other prioritised areas.

6.3.3 Aspects of death

In order to elaborate on deaths occurring in the enterprises located within the Selebi Phikwe study area, one should first consider the reasons for which workers are admitted to health facilities, and eventual causes of deaths of workers as depicted from the medical records. Figure 6.6 indicates the reasons for, and percentages of, workers admitted to health facilities in the study area. 1% of the enterprises responded that workers were admitted into health facilities because they experienced general body weakness, another 1% because they complained of chest pains, and another 1 % because of shortness of breath. A further 1% was admitted as a result of pain in the lower abdomen. Furthermore, 1% of the industries responded that workers were admitted into health facilities because of nausea/vomiting, 1% due to diarrhoea, another 1% because of constipation, and a further 1% as a result of asthma. 4% of the enterprises responded that workers were admitted into health facilities because of recent unexpected loss of body weight, and another 4 % of the enterprises indicated that workers were admitted into health facilities because they experienced influenza/common colds. A further 4% were admitted due to AIDS-related diseases, whereas 5% of the enterprises reported that workers were admitted into health facilities because they experienced headaches.

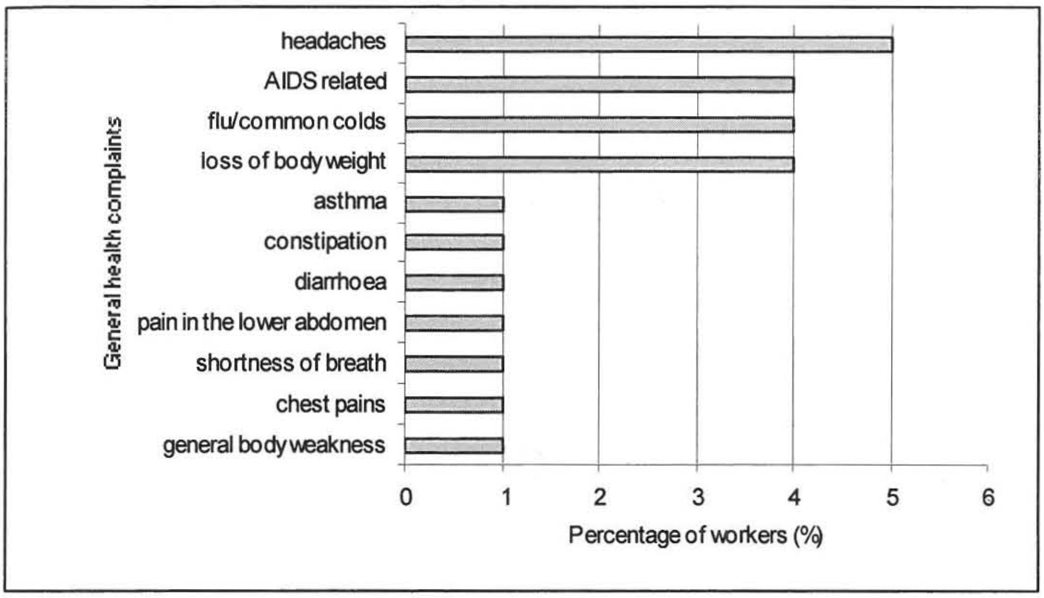


Figure 6.6: Reasons for, and percentage of, workers admitted to health facilities in the Selebi Phikwe area

Figure 6.7 indicates the causes of deaths of workers as depicted from the medical records. 1% of enterprises reported that workers died as a result of malaria, another 1% reported that workers died because of lung disease, and a further 1% of the enterprises reported that workers died as a result of meningitis. 1% of the enterprises reported that workers died as a result of stroke. 4% of the enterprises reported that workers died because of AIDS-related diseases, another 4% reported tuberculosis as the cause of death, and a further 4% mentioned having workers who died as a result of pneumonia. There were cases reported of workers who had passed away from the following diseases: prostrate cancer, cancer of the colon, cardiac arrest, diabetes and heart diseases. The designated officials who responded to the questionnaire indicated, however, that they were not sure of the specific cause of deaths of 2% of their workers but were certain that these causes could be attributed to one of the mentioned diseases.

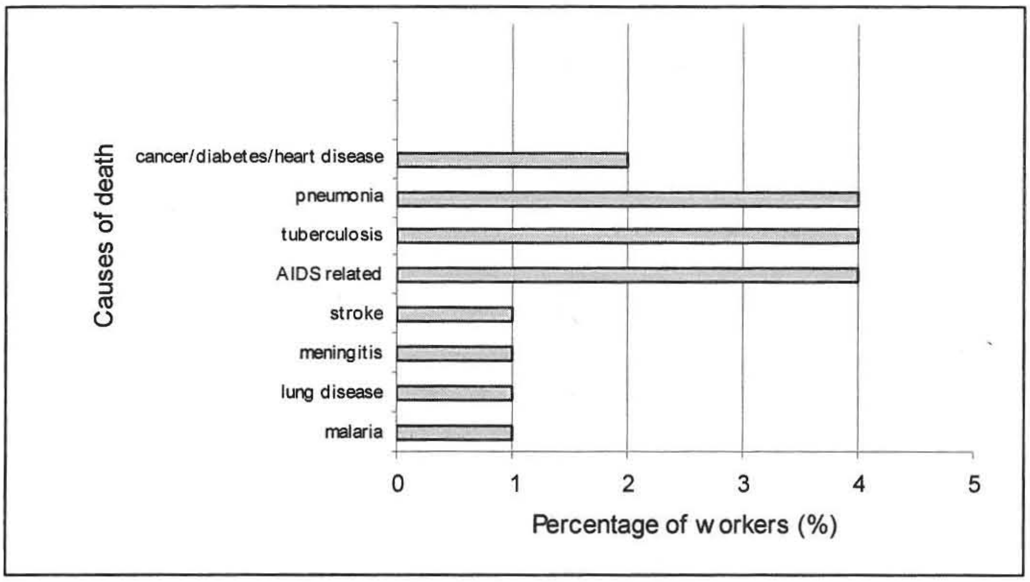


Figure 6.7: Causes of death of workers in Selebi Phikwe

21% of the respondents of enterprises indicated that deaths did occur in their undertakings. Figure 6.8, which was compiled from the responses obtained from the questionnaires and structured interviews that were administered to the Directors or delegated officials of the different enterprises, depicts the percentage distribution of death occurrences in the various enterprises in the Selebi Phikwe area. 48% of the enterprises in site one indicated that deaths of workers did occur in their enterprises. None of the enterprises in sites five, eight and nine, however, reported deaths of workers.

As indicated in Figure 6.8, in site two, 21% of the businesses/industries and in site ten 20% of the enterprises admitted they had had cases of death among their workers. In site four, 18% reported cases of death of workers and in site seven, 17% of the enterprises said that they had had deaths among their workers. 13% of the enterprises each in both sites three and six also indicated that deaths of their workers did occur.

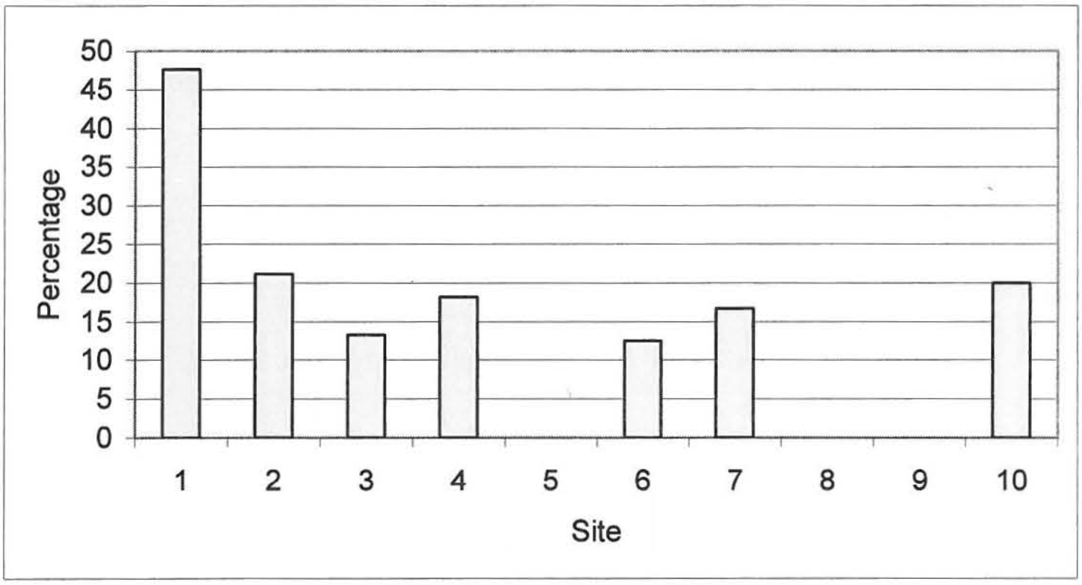


Figure 6.8: Occurrences of death at enterprises in different study sites

An attempt was also made to determine the duration of stay of workers in Selebi Phikwe prior to their death, as well as the ages of deceased workers and types of employment prior to death. In terms of duration of stay of workers prior to death, < 1% of the enterprises reported that these workers had lived in Selebi Phikwe for 11 – 15 years, another < 1% of the reported that workers who had died had lived in Selebi Phikwe for 16 – 20 years, and another < 1% of the enterprises reported that workers who had died had lived in Selebi Phikwe for 21 – 25 years, yet a further < 1% reported that workers who had died had lived in Selebi Phikwe for 26 – 30 years. There were a few cases reported of workers who had passed away having lived in Selebi Phikwe for 31 – 35 years and some others for > 36 years. 4% of the enterprises reported that cases had occurred of workers having died after living in the Selebi Phikwe area for < 5 years, and another 4 % reported a duration of stay of 6 – 10 years. The enterprises reported that most of the workers who had passed away were between 21 and 45 years old. 8% of the enterprises reported that the deaths occurred amongst male workers, while 10% reported that the deaths occurred amongst female workers. However, slightly more cases of death were were reported of workers who were engaged as smelter/concentrator workers and administrators, teachers, hospital staff, shop/supermarket attendants and housewives.

It is evident that lung diseases, pneumonia and lung cancers could be provoked by PAM, gaseous fumes, and heavy metals. These diseases have been identified to be causes of some of the deaths which have occurred in Selebi Phikwe. In this regard, whereas a variety of causes may exist for their manifestations, the mining activities could possibly have played a role.

AIDS, malaria and tuberculosis, on the other hand, are caused by bacterial and viral agents which are not associated with the mining activities in Selebi Phikwe. Consequently deaths related to these diseases could not be associated with the mining activities. Similarly, stroke is considered to be a stress-related condition resulting from high blood pressure, and this particular cause of death should be completely dissociated from the mining activities in the Selebi Phikwe area. A number of studies show that in unfavourable conditions 50%-100% of the workers in some hazardous enterprises be exposed to levels of chemical, physical or biological factors that exceed the occupational exposure limits applied in the industrialised countries (McGill University, 2003). This study has however not explored levels of chemical, physical, mechanical or biological factors likely to be considered as hazardous at Selebi Phikwe.

The occupational health standards of workers and workplaces vary substantially according to economic structure, level of industrialisation, developmental status, climatic conditions, and traditions in occupational health and safety. Mechanical factors and physical and chemical agents are the main problems in manufacturing industries, while pesticides, heavy physical work, organic dusts, biological factors and accidents are the occupational burdens of agricultural workers (McGill University, 2003).

According to the best available estimates by WHO sources as referred to by McGill University (2003), 100 million workers are injured and 200 thousand die annually in occupational accidents and, between 68 million and 157 million new cases of occupational disease are attributed to hazardous exposures or workloads. Occupational injuries and diseases play an even more important role in developing countries, where 70% of the working population of the world live. By affecting the health of the working population, occupational injuries and diseases have profound effects on work productivity and on the economic and social well-being of workers, their families and dependants.

Previous studies carried out by McGill University (2003) indicated that workers in the highest risk enterprises, which include mining and smelting, are often at an unreasonably high risk and one-fifth to one-third may suffer occupational injury or disease annually, leading in extreme cases to high prevalence of work disability and even to premature death. As well as this, other workers living in such mining environments are exposed to a wide range of hazards including contaminated air, thereby increasing their susceptibility to a variety of illnesses and diseases.

6.4 Conclusions

This chapter aimed at elucidating the general health status of workers in enterprises in the Selebi Phikwe Ni-Cu mine area as reported by their Directors or delegated officials. Sulphur dioxide, which is emitted from the roasting of the ore, particulate air matter, tailings dump, contaminated soils, contaminated *Colophospermum mopane* and *Imbrasia belina* were identified in previous studies by Asare (1999), Ekosse (2001) and Ekosse *et al.* (2003, 2004) to be sources of pollution which could possibly be affecting the health of individuals living within the Selebi Phikwe area. In this study, we have reported on an investigation which was conducted through the administration of questionnaires and structured interviews. Data was generated in areas related to demographical and biographical aspects, general complaints about personal health, and aspects related to death. With the aid of SPSS software, attempts were made to quantify the research findings.

Common ailments, illnesses and diseases reported to be affecting workers of enterprises in the area included high blood pressure, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headaches, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancer. Table 6.13 summarises the mean percentages of respondents suffering from ailments, illnesses and diseases compared to the control site. It also links causes to environmental factors due to mining and smelting activities, where applicable.

These general health complaints have been identified as symptoms of reported illnesses and diseases in workers of enterprises in the Selebi Phikwe area. The illnesses and diseases include cancer, cardiac arrest, diabetes, pneumonia, tuberculosis, AIDS, stroke, meningitis, lung diseases, and malaria.

Deaths have also been reported with the highest occurrences registered in the most industrialised part of the Selebi Phikwe area. Although the illnesses and diseases mentioned may have been contributory causes of reported deaths of workers, not all cases of mortality can be associated with the mining activities. Only cases of lung diseases, pneumonia and some cancers which could have been provoked by PAM, gaseous fumes, and heavy metals, can be associated as possible partial causes of some of the deaths which have occurred in the Selebi Phikwe area as a result of mining activities.

Table 6.13: Mean percentages of respondents suffering from ailments, illnesses and diseases compared to the control site

Ailments, illnesses and diseases	Mean from study sites (%)	Control site (%)	Remarks
Body weakness	42	47	Value below that of control site. Not certain if mining and smelting activities are responsible.
Chest pains	40	20	Value above that of control site. Could have relevance to environmental pollution from mines.
Coughing	45	20	Could be related to air pollution (possibly effect of sulphur-rich fumes and gases).
Constipation	10	7	Could be as a result of heavy metals in phane worms affected by the pollution.
Diarrhoea	12	7	Not certain if mining and smelting activities are responsible. If any influence, it could be from heavy metals in phane worms affected by the pollution.
Nausea and vomiting	12	-	Not certain if mining and smelting activities are responsible.
Influenza/common cold	66	27	Could be related to air pollution. Respiratory tract linings of individuals could be over-sensitive to contaminated air which is breathed in.
Headaches	70	53	Could be related to air pollution. Respiratory tract linings of individuals could be over-sensitive to contaminated air.
Recent loss of body weight	16	7	Heavy metals in phane worms affected by the pollution, and air pollution leading to different illnesses and diseases.
Lower abdominal pain	4	-	Not certain if mining and smelting activities are responsible. Heavy metals in phane worms affected by the pollution may have an effect.
Palpitations	31	-	Not certain if mining and smelting activities are responsible.
Shortness of breath	18	33	Not certain if mining and smelting activities are responsible.
Desire to spit often	6	20	Could be related to phlegm due to irritation.
Unusual genital discharge	5	-	Not certain if mining and smelting activities are responsible.
Pain when urinating	4	-	Not certain if mining and smelting activities are responsible.

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Appendix 6.1

Questionnaire on Human Health Hazards at the Selebi Phikwe Ni-Cu Mine Area, Botswana

SECTION 3: Questionnaire for Industries

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Central University of Technology, Free State

Introduction

Thank you for your participation in the study by completing this questionnaire related to human health hazards at the Selebi Phikwe Ni-Cu mine area, Botswana. This study is undertaken for academic purposes only. All information collected will be treated confidentially and will not be revealed to anyone. It is suspected that environmental and human health problems may have been caused within Selebi Phikwe by mining activities. Inhabitants of the area are often infected with symptoms of illnesses and diseases related to pulmonary health complications. By means of the study, we would like to establish existing human health hazards, and identify the pulmonary health complications of the inhabitants of Selebi Phikwe, and then to advance solutions which could be implemented.

The basis of this study will consist of questionnaires, personal interviews, and the administration of lung function test to selected individuals based on the responses from the questionnaire and personal interviews as well as their medical history. All the information obtained from this study will be treated in strictest confidence, and made available as research findings at scientific conferences, seminars and workshops, and as an eventual publication in scientific journals. Any additional information provided will be very much appreciated.

This questionnaire is divided into the following main sections:

SECTION 1: Questionnaire for individuals, which should be answered by individuals.

SECTION 2: Questionnaire for health service providers, which should be answered by health service providers or designated official of the health facility.

SECTION 3: Questionnaire for enterprises, which should be answered by the Director of Industry or designated official of the enterprise.

SECTION 4: Questionnaire for educational institutions, which should be answered by principalsheadmasters or designated official of the educational institution.

Kindly note the following:

- Please read through the entire question before making a choice.
- Your answer should be marked with a cross in the box provided below or next to your choice.
- Where a question requires a written explanation as the response, kindly write concisely in the space provided.
- Where a question requires more than one answer, this will be made clear.
- Be very frank with your answers.

Central University of Technology, Free State

SECTION 3: Questionnaire for Enterprises

Date of Interview……………………………………………………………………….
Name of Interviewee (optional)……………………………………………………..
Area (Address) ……………………………………………………………………….
…………………………………………………………………………………………….

3.1 Demographical data

3.1.1 Who owns this enterprise?				
Government	Town Council	BCL	Private	Other (specify)

3.1.2 How many years has this enterprise been in operation?						
Less than ten years	Between ten and twenty years	Between twenty and thirty years	Between thirty and forty years	Between forty and fifty years	More than fifty years	Not sure

3.1.3 How many workers are employed in this enterprise?					
Less than ten	Between ten and twenty	Between twenty and thirty	Between thirty and forty	More than forty (specify)	Varies

3.1.4 What type of enterprise?						
Commercial	Textile	Food/Hotel	Mining	Smelting	Agricultural	Other (specify)

3.1.5 Which area describes closest where this enterprise is located at Selebi Phikwe?		
Sampling site	Location/Characteristics	
1	Industrial area (150 m after the railway crossing)	
2	Bosele Hotel (commercial area) and new township	
3	Between the township stadium and the mine (behind the Botswana Power Corporation, BPC)	
4	Between Township boundary and the railway line (directly behind a Community Junior Secondary School, CJSS)	
5	Opposite the Mine hospital, close to old township	
6	Between the mine and explosive storage facilities (close to old township)	
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi Phikwe Road juncture)	
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)	
9	Close to the second bridge before entering into the Selebi Phikwe township	
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road	

3.1.6 Indicate what percentage of the workers of this enterprise live in the different areas in Selebi Phikwe?		
Sampling site	Location/Characteristics	
1	Industrial area (150 m past the railway crossing)	
2	Bosele Hotel (Commercial area) and new township	
3	Between the township stadium and the mine (behind the Botswana Power Corporation, BPC)	
4	Between Township boundary and the railway line (directly behind a Community Junior Secondary School, CJSS)	
5	Opposite the Mine hospital, close to old township	
6	Between the mine and explosive storage facilities (close to old township)	
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi	

	Phikwe Road juncture)	
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)	
9	Close to the second bridge before entering into the Selebi Phikwe township	
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road	

3.1.7 Indicate the gender percentage of the workers of this enterprise?	Male		Female	

3.1.8 Indicate the age group percentage of workers of this industry?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs

3.2 General complaints of workers about personal health

3.2.1 Do workers often complain of general body weakness?	Yes		No	
3.2.2 If answer to 3.2.1 is yes, what percentage of workers complain of general body weakness?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.3 Do workers experience loss of body weight?	Yes		No	
3.2.4 If answer to 3.2.3 is yes, what percentage of workers complain of body loss of weight?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.5 Do workers often complain of flu/common cold?	Yes		No	
3.2.6 If answer to 3.2.5 is yes, what percentage of the workers complain of influenza/cold?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.7 Do workers often complain of headache?	Yes		No	
3.2.8 If answer to 2.2.7 is yes, what percentage of the workers complain of headaches?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.9 Indicate what percentage of the workers complain of the different types of headache?				
Dull	Moderate	Acute	At times dull and at times acute	Not sure
3.2.10 Do the workers regularly complain of coughing?	Yes		No	
3.2.11 If answer to 3.2.10 is yes, what percentage of the workers complain of coughing?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.12 Indicate what percentage of the workers who complain of coughing have the different types of cough mentioned.				
Dry cough	Wet cough	Cough with sputum	Cough with chest pains	Cough with shortness of breath
3.2.13 Do the workers often complain of unusual spitting?	Yes		No	
3.2.14 If answer to 3.2.13 is yes, what percentage of workers complain of unusual spitting?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
3.2.15 Indicate what percentage of the workers who complain of cough have the different types of cough mentioned.				
Clear sputum	Milky sputum	Greenish sputum	Sputum with blood	Black sputum

3.2.16 Do workers complain of chest pains?	Yes		No	

3.2.17 If answer to 3.2.16 is yes, indicate what percentage of workers complain of chest pains.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.18 Indicate what percentage of the workers who complain of chest pains have the different types of chest pains mentioned?				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.19 Do workers complain of experiencing shortness of breath regularly?	Yes		No	

3.2.20 If answer to 3.2.19 is yes, indicate what percentage of workers complain of experiencing shortness of breath.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.21 Indicate what percentage of the workers who complain of experiencing shortness of breath have the different types of shortness of breath?				
Dull	Moderate	Acute	At times dull & at times acute	Not sure

3.2.22 Do workers complain of experiencing palpitations?	Yes		No	

3.2.23 If answer to 3.2.22 is yes, indicate what percentage of workers complain of experiencing palpitations.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.24 Indicate what percentage of the workers who complain of experiencing palpitations have the different types of palpitations mentioned.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.25 Do workers often complain of experiencing pain in the lower abdomen?	Yes		No	

3.2.26 If answer to 3.2.25 is yes, indicate what percentage of workers who visit the health facility complain of experiencing pain in the lower abdomen.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.27 Indicate what percentage of the workers who complain of experiencing pains in the lower abdomen have the different types pain in the lower abdomen as mentioned.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.28 Do workers complain often experiencing pain when passing urine?	Yes		No	

3.2.29 If answer to 3.2.28 is yes, indicate what percentage of workers who complain of experiencing pain when passing urine have the different types of pain as mentioned when urinating.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.30 Do workers complain of experiencing any unusual discharge from their genital system?	Yes		No	

3.2.31 If answer to 3.2.30 is yes, indicate what percentage of workers who complain of experiencing unusual discharge from their genital system have the different types of pain as mentioned in their genital organs.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.32 Do workers complain of regularly experiencing nausea and vomiting?	Yes		No	

3.2.33 If answer to 3.2.32 is yes, indicate what percentage of workers complain of experiencing nausea and vomiting.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.34 Indicate what percentage of the workers who complain of experiencing nausea and vomiting have the different types of pain mentioned accompanying the nausea and vomiting.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

3.2.35 Do workers complain of regularly experiencing diarrhoea?	Yes		No	

3.2.36 If answer to 3.2.35 is yes, indicate what percentage of workers complain of experiencing diarrhoea.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.37 Indicate what percentage of the workers who complain of experiencing diarrhoea have blood in their stool when they have diarrhoea.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.38 Indicate what percentage of the workers have the different types of colour of their stool.				
Normal	White	Black	Stool with blood	Not sure

3.2.39 Do workers complain of often experiencing constipation?	Yes		No	

3.2.40 If answer to 3.2.39 is yes, indicate what percentage of workers complain of experiencing constipation.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

3.2.41 Indicate what percentage of the workers who complain of experiencing constipation have the different types of pain accompanying the constipation.				
Dull	Moderate	Acute	At times dull & at times acute	Not sure

3.3 Aspects of death

3.3.1 Do deaths occur at this enterprise?	Yes		No	

3.3.2 When workers die, prior to death what percentages are admitted to health facilities because of one or more of the following complaints/diseases?				
General body weakness	Loss of body weight	Influenza/common cold	Headaches	Cough
Chest pains	Shortness of breath	Palpitations	Pain in the lower abdomen	Pain in passing urine
Unusual discharge from genital system	Nausea and vomiting	Diarrhoea	Constipation	Other (specify)

3.3.3 When workers die, what percentages die because of one or more of the following diseases/health complications as determined by clinical diagnosis and/or death certificate?				
AIDS-related	Breast cancer	Cancer of the colon	Cardiac arrest	Diabetes

Heart disease	Lung cancer	Prostate cancer	Malaria	Other lung disease (specify)
Meningitis	Pneumonia	Tuberculosis	Stroke	Other (specify)

3.3.4 For those workers who have died while working in this enterprise, indicate what percentage lived at Selebi Phikwe area for the different durations of stay.

	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

3.3.5 For those workers who died while working in this enterprise, indicate what percentage died within the corresponding age groups given

	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

3.3.6 For those workers who died at this enterprise, indicate the gender percentage?	Male		Female		Male

3.3.7 Indicate what percentage of the workers who died while working in this enterprise lived in the different areas in Selebi Phikwe.

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

3.3.8 Indicate the percentage of deceased Individuals employed as:	Mine Worker	Mine administrator	Mine supervisor	Smelter/Concentrator worker
	Teacher	Hospital Staff	Politician	Smelter/Concentrator administrator
	Business personnel	Hotel/Restaurant staff	Government employee	Smelter/Concentrator supervisor
	Shop/Supermarket staff	Housewife	Apprentice	Industrial class worker
	Student	Farmer	Unemployed	Other (specify)

Chapter Seven

Health Services Provided to Patients and Health Status of Patients in the Selebi Phikwe Ni-Cu Mine Area

7.1 Introduction

Nickel-Copper ore in the Selebi Phikwe area in Botswana is among the several mineral resources including diamonds, gold, soda ash and a wide range of industrial minerals being tapped in Botswana. Exploitation activities have lifted the national economic standard and catapulted the country into one of the fastest growing economies in the world (Botswana Government, 2003). Because of fluctuating market economies, the challenges of developing a diversified national economy with a strong commercial and industrial base have become a primary concern for the Government of Botswana.

Commercial and industrial activities in the mining towns in the country have been on the increase due to this economic boom. Such economic growth has caused a population exodus from other parts of the country to the mining environments. Like every other growing population, it is imperative that basic essential services such as electricity, water, schools, road infrastructure, telecommunications facilities and health services be available to the people settling there. It is, however, not certain whether the existing health facilities in Selebi Phikwe are adequate to handle the traffic of patients in the area, especially in terms of ailments and illnesses that are related to mining activities. In this chapter the health status of residents in the mining town of Selebi Phikwe is investigated from the perspective of available health service providers. The intention of this investigation was to highlight possible negative effects resulting from the mining activities.

It should be noted that the Government of Botswana has made available health services for all residents of the country without exception or discrimination (Botswana Government, 2003; 2003a; Chief Medical Officer, 2003). According to recent statistics from the Ministry of Health, Botswana (2004), the country's public health system consists of different kinds of health facilities: 23 district health teams, three referral hospitals (Princess Marina Hospital, Gaborone; Nyangabgwe Hospital, Francistown; and the Psychiatric Hospital, Lobatse), 12 district hospitals (of which six are operated by the government, three by missions and three by mining companies), 17 primary health care hospitals (at Bobonong, Gantsi, Gumare, Goodhope, Hukuntsi, Kasane, Letlhakane, Mmadinare, Palapye, Rakops, Sefhare, Thamaga, Tsabong and Tutume), 222 clinics, 330 health posts and 740 mobile stops.

Although Botswana enjoys the status of being one of the fastest growing economies in the world, the exploitation of mineral resources is considered to be having a negative effect on the health of its residents. This has, however, not been substantiated by research in the country. In previous studies conducted on the quality of the physical environmental of the Selebi Phikwe area by Ekosse (2001) and Ekosse, Van den Heever, De Jager and Totolo (2003, 2004) it was concluded that the mining activities have affected the atmosphere, plants, phane and soils. In another study on the socio-economic concerns within the Selebi Phikwe area, Asare (1999) advanced the opinion that the exploitation of Ni – Cu could possibly be having a negative effect on the health of the residents. His study failed, however, to consider the different types of illnesses and diseases which were most likely to have affected the residents there. In order to further explore the predominant types of illnesses and diseases affecting residents the most, the health status of patients who visited health service facilities in the study area was investigated. This chapter thus presents the results of a survey which was undertaken to assess the health status of patients who visited health service facilities and the status of health services as reported by the health service providers within the Selebi Phikwe Ni-Cu mine area. The study aimed to describe the prevalence of illnesses and diseases affecting patients who visited health service facilities, which were more likely to have been caused, by the mining and smelting of Ni-Cu in the area. This investigation furthermore afforded researchers to explore the health services that are provided in the area.

7.2 Methods

The methods and analytical techniques used in investigating the health status of patients who visited health service facilities as depicted by the health service providers living around the Selebi Phikwe Ni-Cu mine area have been discussed in sections 3.1.1 and 3.2.1 of this document. The study area was divided into ten sites based on a previous study by Ekosse (2001). The health service facilities were located in sites two, four, five, six, nine and ten (the control site). Except for site nine which had two health service facilities, the other five sites including the control site had one each. The control site was included to compare results to the other sites located in the Selebi Phikwe area. All the health service providers except one (a total of seven) in the study area were included in the survey.

Data was obtained from health service facilities owned by the Selebi Phikwe Town Council and the Botswana Government on patients who visited the facilities in Selebi Phikwe. A sample of the questionnaire that was administered can be found in appendix 7.1 of this chapter. The questionnaire covered demographical data of health services provided, general complaints of patients about personal health, and aspects related to death, as well as questions regarding the status of available health services. The health service providers or designated officials of the health facilities responded to the questionnaires.

7.3 Results, interpretation and discussion

7.3.1 Demographical data

There were seven health service providers in the Selebi Phikwe area and the control site (one each in sites two, four, five and six, two in site nine, and one in site ten) that participated in this study. The eighth health service provider, the Bamangwato Concessions Limited (BCL) hospital, which is owned by the mining and smelting industry, refused to take part in the study. It is not certain why the officials declined to respond to the questionnaire. It should however be pointed out that in this hospital, only workers of the mine and their families are treated. 85.8% of the health service providers that participated in this study are owned by the Selebi Phikwe Town Council (SPTC) and 14.2% by the Government.

Figure 7.1 depicts the location of health service providers in the Selebi Phikwe study area. In terms of percentage distribution of health service providers involved in the study, 14.2% of the health service providers are located in site two, the commercial and new township area, whereas none is situated in the industrial area, which is site one in this study.

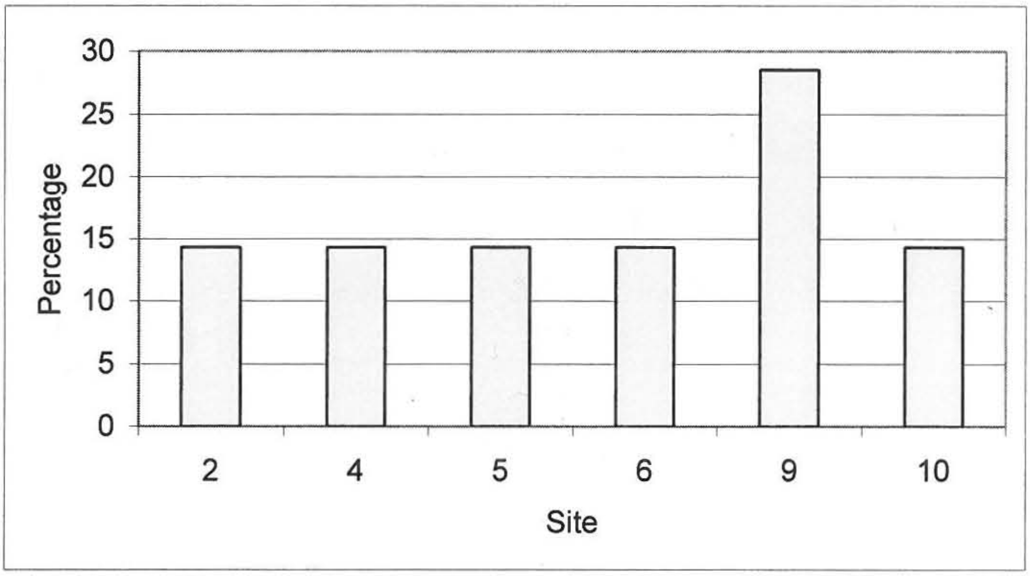


Figure 7. 1: Location of health service providers in the Selebi Phikwe area

Furthermore, 14.2% each of the health service providers included in this study are located in sites four, five and six respectively, whereas 29% of the health service providers are located in site nine, which is within the periphery of

Selebi Phikwe from Serule. A point also worth noting is that 14.2% of the health service providers reported in this study are located in site ten (control site). The physical locations of the health service providers in the Selebi Phikwe area were in accordance with development plans for the township by the Department of Town and Regional Planning (1996).

Staffing of health service provider institutions has remained a problem in Botswana because of the lack of specialised training institutions, a small population and very low population density (Botswana Government, 1998; 2003; Department of Town and Regional Planning, 1996). In the Selebi Phikwe area, the health service provider in site two employed five medical doctors and the one in site four had three. In site five, two medical doctors were employed. In sites six, nine, and ten no medical doctors were employed. A similar pattern was observed for nurses and midwives employed in the health facilities. In site two, the health service provider employed a varied number of nurses and midwives, and the health service providers in sites four and five had more than four nurses and three midwives each. In sites six and ten, one nurse and one midwife were employed in each of the facilities. In nine, four nurses and four midwives were employed. Apart from sites two and four, which recruited more than four para-professional staff, all the rest had two each.

One mining area with a similar set-up to that of Selebi Phikwe is West Papua in Indonesia, which remains a major transmigration receiving area. As in the Selebi Phikwe area in Botswana (Botswana Government, 1998; 2003), in

West Papua, the overall health status is the lowest in Indonesia and the problems of access to and availability of services imply that a high proportion of the population remains under-served (World Health Organisation, 2003). In West Papua in Indonesia, with its population of around 400 000, there is only one hospital with 70 beds, and 15 health centres with a doctor in the 13 sub-districts covering an area of 53,000 square kilometres (World Health Organisation, 2003). In Selebi Phikwe, however, the situation is a good deal better with a population of about 50 000 that have immediate access to two hospitals and six primary health facilities.

As depicted by the results obtained from the questionnaire and structured interviews, in terms of health services personnel in Selebi Phikwe, there are more than four doctors working in site two, three in site four and two in site five. None works in the control site. Sites six, nine and the control site have visiting doctors. All the health services have assigned nurses. The number of nurses assigned to the health service facility in site two varies between three and four depending on the number of patients. Sites four and five have more than four nurses each. There are three nurses in site six and four in site nine. At the control site, the health service facility has three nurses. Moreover, the health services also have assigned midwives to cater for ante and post natal health matters. The number of midwives assigned to the health service facility in site two varies between two and three depending on the number of patients. Sites four and five have three midwives each. There is one midwife in site six and two midwives in site nine. The health service in site ten has one midwife.

According to responses obtained from the questionnaires and structured interviews, the oldest health service facility is located in the control site (site ten), and has been there for > 50 years, while the newest is located in site four and is < 20 years old (Table 7.1). The health service facilities located in sites two and five are 20 – 30 years old, and the respondents were not sure of the ages of those located in sites six and nine. In a nutshell, 14% of the health service providers are < 20 years old, another 14% > 50 years old, 2 % are 20 – 30 years old and the age of 43% of the health service facilities was not known by the respondents.

Table 7.1: Number of years of operation of health service facilities according percentage distribution based on study sites in Selebi Phikwe

Site	<20yrs	20-30 yrs	> 50 years	Not sure
One		100		
Four	100			
Five		100		
Six				100
Nine				100
Ten			100	
Over all	**14**	**29**		**43**

The main reasons for patients living in the Selebi Phikwe area, as reported by the health service provider respondents is presented in Table 7.2. The reasons mentioned are employment, schooling and the fact that this is their hometown. Some of the patients came originally as visitors but have prolonged their stay to well over two years. As depicted in Table 7.2, the health service providers in sites two and five were not sure of the reasons why their patients were in Selebi Phikwe. The health service provider in site six and 50% of those in site nine indicated that their patients were in Selebi Phikwe because of employment. On the other hand, the health service provider in site ten and 50% of those in site nine indicated that their patients were in Selebi Phikwe because it was their hometown. However, the health service provider in site four indicated that a combination of reasons, which included employment, schooling, visiting and hometown, were responsible for patients' residence in Selebi Phikwe. Health service providers in sites two and five were not sure of the reasons why their patients were in Selebi Phikwe.

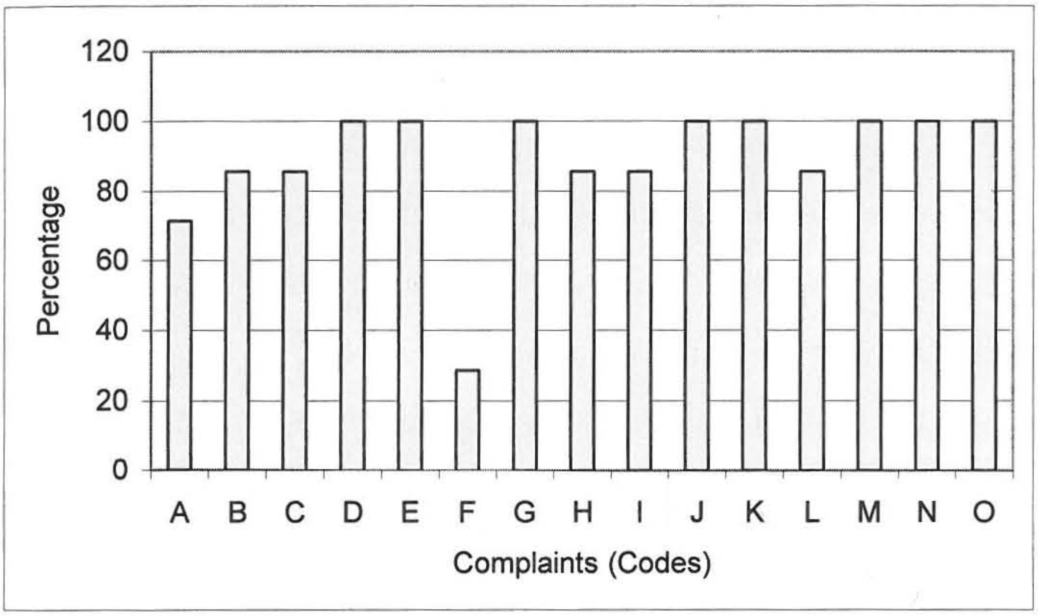
Table 7.2: Purpose of the patients' stay in the Selebi Phikwe area

Site	A	B	C	D
Two				100
Four			100	
Five				100
Six	100			
Nine	50	50		
Ten		100		
Over all	**29**	**29**	**14**	**29**

(A = employment, B = hometown, C = employment/schooling/visit/hometown, D = not sure)

7.3.2 General complaints of patients about personal health

Based on the responses obtained from the questionnaires and structured interviews of which the summary results are reported in Figure 7.2, 71% of the health service providers responded that their patients complained of body weakness, 86% of the health service providers responded that their patients suffered from recent loss of body weight, and another 86% of the health service providers responded that their patients had influenza/common cold. 100% of the health service providers responded that their patients suffered from headaches, and another 100% of the health service providers responded that their patients complained of persistent coughing, and 29% of the health service providers responded that their patients experienced the need to spit.



(Note: A = body weakness, B = loss of body weight, C = influenza/common cold, D = headaches, E = coughing, F = unusual spitting, G = chest pain, H = shortness of breath, I = palpitations, J = lower abdominal pain, K = urine with pain, L = genital discharge, M = nausea/vomiting, N = diarrhoea, and O = constipation)

Figure 7.2: Percentage distribution of general health complaints of patients who visited health service providers in the Selebi Phikwe area

Furthermore, 100% of the health service providers responded that their patients suffered from chest pain, 86% that their patients experienced shortness of breath, and another 86% that their patients complained of palpitations. 100% of the health service providers responded that their patients complained of lower abdominal pain, and another 100% that patients who visited their facilities complained that they experienced pain when urinating. 100% of the health service providers indicated that their patients experienced genital discharge, and a similar figure was obtained for patients with diarrhoea.

In terms of percentages of patients who complained of the various ailments, sicknesses and diseases, 33% of the health service providers reported that < 20 % of their patients complained of **general body weakness**, 17% of the health service providers mentioned that 30 – 40% of their patients complained of general body weakness and another 17% of health service providers reported that 40 – 50% of their patients complained of general body weakness; a further 33% of the health service providers reported that a varied number of patients complained of general body weakness.

For recent loss of body weight, 17% of the health service providers reported that < 20 % of their patients complained of **loss of body weight**, another 17% mentioned that 40 – 50% of their patients complained of loss of body weight and further 17% of health service providers reported that they did not have patients who complained of loss of body weight. Close to 50% of the health service providers reported that a varied number of patients complained of loss of body weight.

Regarding **influenza/common colds**, 86% of the health service providers reported that a varied number of patients complained of influenza/common cold, whereas 14% of health service providers reported that they did not have patients who complained of flu/common cold. This same percentage was applicable for **headaches, shortness of breath, coughing and chest pain**. All of the health service providers mentioned that they had patients who complained of dull, moderate and acute headaches but they were not sure of the different percentages. Similarly, all the health service providers reported that some of their patients complained of dull, moderate and acute chest pain, but again were not able to provide percentages. At all the health facilities, patients who visited these facilities complained about dry and wet coughs, as well as coughing with sputum and coughing with chest pains. 14% of those patients who suffered from all of these ailments were from site ten.

Regarding patients who need to **spit unusually often**, and patients **experiencing pain when urinating**, 33% of the health service providers reported that a varied number of patients complained of these symptoms. Furthermore, health service providers were not sure if the sputum of patients was coloured greenish, black, or were blood coloured.

For both the symptoms of **palpitations** and **pain in the lower abdomen**, 17% of the health service providers reported that < 20% of their patients complained of palpitations and pain in the lower abdomen, 17% mentioned that 30 – 40% of their patients complained of palpitations and pain in the lower abdomen and another 17% reported that 40 – 50% of their patients complained of these symptoms. A further 33% of the health service providers reported that a varied number of patients complained of palpitations and pain in the lower abdomen. However, there were 17% of the health service providers who indicated that they did not have patients who complained of palpitations and pain in the lower abdomen. 83% of the health service providers indicated that they had patients who complained of dull, moderate and acute palpitations and pain in the lower abdomen, but were not sure of the percentages.

Regarding **unusual discharge from the genital system**, 14% of the health service providers reported that a varied number of patients complained of this symptom, while 86% of health service providers reported that they did not have patients who complained of unusual discharge from the genital system. They indicated that patients complained of pains accompanying the unusual discharge from the genital system being at times dull and at times acute, but could not precisely quantify these.

For both the illnesses **nausea/vomiting** and **diarrhoea**, 33% of the health service providers reported that < 20% of their patients complained of nausea/vomiting and diarrhoea, 17% mentioned that 30 – 40% of their patients had these complaints and 17% reported that 40 – 50% of their patients complained of nausea/vomiting and diarrhoea. A further 17% of the health service providers reported that a varied number of patients complained of nausea/vomiting and diarrhoea, and another 17% of the health service providers indicated that they did not have patients who complained of nausea/vomiting and diarrhoea. 33% of the health service providers indicated that they had patients who complained of dull, moderate and acute pains that accompanied their vomiting. Furthermore, 83% of the health service providers mentioned that patients who suffered from diarrhoea also had blood in their stool. The results from the questionnaires indicated that 14% of the patients who complained of diarrhoea were from the control site.

With reference to complaints of **constipation** from patients, 33% of the health service providers reported that < 20% complained of constipation, whereas 67% of health service providers reported that they did not have patients who complained of constipation. None of the health service providers indicated that they were certain of the type of constipation their patients had. Results obtained from the health service providers indicated that 14% of the patients who complained of constipation were from site ten.

Patients were admitted into health facilities because of some of these general health complaints. These general health complaints included all those cited in the above paragraph excluding complaints of frequent coughing, regular headaches, pains when urinating, unusual desire to spit, and unusual genital discharge. They were also admitted into health facilities because of AIDS-related issues, asthma and complaints of chest pains.

It is not clear which of these illnesses and diseases affecting patients in the area are a direct result of the mining activities. However, ailments such as chest pains, coughing, constipation, diarrhoea, influenza/common colds, headaches, recent loss of body weight, lower abdominal pain, and palpitations could be the result of environmental air pollution or ingestion of contaminated phane worms.

Unexpected general body weakness which is not associated with physical effort such as dieting or exercises, sudden and significant loss of body weight, and frequent nausea and vomiting have been attributed to AIDS and AIDS-related diseases, as well as tuberculosis and cancer (American Thoracic Society, Centres for Disease Control, Atlanta, USA, and the Infectious Diseases Society of America, 2003; National Cancer Institute, 2004; National Comprehensive Cancer Network, 2004). These three diseases (AIDS and AIDS-related diseases, tuberculosis and cancer) may be caused by a variety of bacterial and viral agents which are not associated with the mining activities at Selebi Phikwe.

Health complaints of patients indicating persistent chest pains, frequent experiences of shortness of breath, asthmatic attacks, persistent coughing and several occurrences of influenza/common colds could be symptoms associated with respiratory tract diseases that could ultimately lead to COPD or even lung cancer (Australian Lung Foundation, 2003; National Heart, Lung and Blood Institute, 2003; The Human Respiratory System, 2003). Frequent and persistent headaches, influenza/common colds and acute chest pains have been diagnosed as precursors of asthma, lung cancer, high blood pressure and chronic bronchitis. At Selebi Phikwe patients had complained of these symptoms and deaths had been reported of patients as a result. While there may be several causes of these diseases, at Selebi Phikwe PAM and gaseous fumes could be contributory.

7.3.3 Medical history of patients

67% of the health service providers reported that they had patients who suffered from **nervous or emotional problems**. Furthermore, 33% of the health service providers indicated that < 20% of their patients suffered from nervous or emotional problems, while another 33% of the health service providers indicated that a varied number of their patients suffered from nervous or emotional problems.

All the health service providers indicated that they had patients who were infected with **tuberculosis**. 50% of the health service providers that participated in the study responded that < 20% of their patients suffered from tuberculosis. 17% of the health service providers indicated that 20 – 30% of their patients suffered from tuberculosis, and another 17% responded that 30 – 40% of their patients suffered from this disease. A further 17% of health service providers indicated having a varied number of their patients who suffered from tuberculosis.

Only 17% of the health service providers had patients suffering from malaria and they were not certain of the number of patients infected with **malaria**. A further 17% of the health service providers had patients who complained of **bleeding tendencies**. Concerning allergies, 50% of the health service providers indicated that < 20% of their patients suffered from **allergies**, and another 50% responded that a varied number of their patients suffered from this problem. 17% of health service providers had patients who were **asthmatic**, although only < 20 % of their patients suffered from this condition.

Regarding **high blood pressure**, all the health service providers indicated that they had patients who suffered from this condition. 17% of the health service providers indicated that < 20% of their patients suffered from high blood pressure, and another 17% responded that 40 – 50% of their patients suffered from this problem, while the remaining health service providers indicated that high blood pressure affected a varied number of their patients.

Considering **STDs**, all the health service providers indicated that they had patients who suffered from these diseases. 33% of the health service providers indicated that < 20% of their patients suffered from STDs, and 17% responded that 20 – 30% of their patients had these symptoms, while a further 17% of the health service providers indicated that 30 – 40% of their patients suffered from STDs. The remaining 33% of the health service providers mentioned that a varied number of their patients suffered from STDs.

Tuberculosis, malaria, bleeding tendencies, high blood pressure and STDs are not caused by the prevailing environmental factors in Selebi Phikwe. It should, however, be pointed that environmental air pollution or ingestion of contaminated phane worms, could ultimately result in allergies, asthma, bleeding tendencies and high blood pressure.

7.3.4 Health services provided

When health service providers were questioned on whether they had patients who suffered from major or significant illnesses, 67% of them responded positively. 33% of the health service providers reported that < 20% of their patients suffered from major or significant illnesses, while another 33% indicated that a varied number of their patients suffered from major or significant illnesses. Similarly, 33% of the health service providers indicated that their patients who had suffered from major or significant illnesses had been cured and another 33% of the health service providers indicated that their patients who suffered from major or significant illnesses had not been cured.

In cases where major or significant illnesses were concerned, 84% of the health service providers responded that they referred patients to better equipped health facilities in the country. Within the Selebi Phikwe area, 33% of the health service providers, which are primary health care units, referred their patients only to the hospital in Selebi Phikwe. Another 33% of the health service providers referred their patients either to the hospital in Selebi Phikwe or the Nyangabwe Government referral hospital, Francistown. 17% of the health service providers referred their patients to the Nyangabwe Government referral hospital, Francistown or the distant Princess Marina Referral hospital, Gaborone. Another 17% referred patients to other health facilities in Zimbabwe and South Africa.

When questioned on whether patients were medically examined, 67% of the health service providers responded affirmatively. The main tests performed included the following: x-ray, lung function, blood and urine tests. Health service providers were also asked if patients visited the health facilities because of nervous problems, tuberculosis, malaria, bilharzia, high blood pressure, allergies, asthma, bleeding tendencies and sexually transmitted diseases (STDs). Their responses were positive in all respects except for bilharzia.

As mentioned earlier in this chapter, West Papua in Indonesia has mining areas which are similar in setting to Selebi Phikwe. Comparing West Papua, Indonesia to Selebi Phikwe in terms of diseases, influenza/common cold and tuberculosis seem to occur in both areas. In West Papua, however, gonorrhoea is widespread (World Health Organisation, 2003). Chlamydia is the major cause of sterilisation among local women there and this disease has been allowed to spread untreated despite its simple treatment using antibiotics. As a result, the birth rate has dropped by 80% in some areas (World Health Organisation, 2003). In this study, sterilisation among the women in Selebi Phikwe was not investigated. Other diseases being treated in West Papua by missionaries in remote areas include ear disease, influenza, filariasis and ascaria. Infectious diseases such as tuberculosis and hepatitis are also widespread. Leprosy, despite its eradication around the world, is as high as 88 per 10,000 people in some regions in West Papua (World Health Organisation, 2003). There were no cases of leprosy identified in the Selebi Phikwe area.

It should be noted that the health services at Selebi Phikwe provide moderately for primary health care. Patients are however referred to the referral hospitals which are the Princess Marina Hospital, Gaboròne; Nyangabgwe Hospital, Francistown; and the Psychiatric Hospital, Lobatse for more serious illnesses. Prevalent diseases in the area are handled at the referral hospitals.

7.3.5 Aspects of death

In sites two, five and ten, health service providers reported that deaths of patients did occur in their facilities. However, prior to deaths, a wide range of ailments, illnesses and diseases were advanced as the causes for medical visits by patients, and these were: body weakness, loss of body weight, influenza/common cold, headaches, coughing, unusual spitting, chest pain, shortness of breath, palpitations, lower abdomen pain, pain when urinating, genital discharge, nausea/vomiting, diarrhoea, and constipation.

Health service providers reported that they had had patients who died because of asthma, diarrhoea, breast cancer, cancer of the colon, lung cancer, prostate cancer, malaria, AIDS-related diseases, cardiac arrest, diabetes, heart disease, meningitis, pneumonia, tuberculosis, and stroke.

Unfortunately they could not approximate the percentage of their patients who had died because of each of these ailments. The reason advanced was that the numbers were small and deaths were occasional.

In terms of duration of stay of patients in Selebi Phikwe prior to death, 67% of the health service providers responded that the duration of stay of their patients in the town varied widely from < 5 years to > 45 years. The health service providers further indicated in their responses that the ages of their deceased patients also varied from < 5 years to > 45 years, although most of those who died were between 25 years and 40 years – quite a young age to die.

In terms of study sites of the deceased, the health service providers responded that their patients who had died had lived in all the different sites included in this study. Also, with regard to previous employment of the deceased, all the different occupations were represented as indicated in the responses obtained from the questionnaires and structured questions. However, housewives, supermarket /shop staff and mine workers were the most affected professions. It is not certain why these categories of patients were the most affected by death but one could deduce that exposure to environmental air pollution and ingestion of contaminated worms may be some of the contributory reasons. Unfortunately the health service providers were not sure what percentages of the various occupations were affected.

7.4 Conclusions

This chapter aimed at investigating the health services provided and the health status of patients as reported by health service providers within the Selebi Phikwe Ni-Cu mine area. From previous studies by Asare (1999), Ekosse (2001) and Ekosse *et al.* (2003), sulphur dioxide, which is emitted from the roasting of the ore, particulate air matter, tailings dump, contaminated soils, contaminated *Colophospermum mopane* and *Imbrasia belina* were identified as sources of pollution which could possibly have contributed to the negative health effects of patients as depicted by their health service providers within Selebi Phikwe.

In this study, we have reported in a broad sense on an investigation which was conducted among health service providers through the administration of questionnaires and structured interviews. Data was generated in areas related to demographical aspects, general complaints about personal health, medical history, and aspects related to death. With the aid of SPSS software, attempts were made to quantify the research findings.

Common ailments, illnesses and diseases reported to be affecting patients as indicated by the health service providers in the area included asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headache, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancer. Deaths were also reported.

Considering the results obtained in this study, there were no clear demarcating differences in the health status of patients living in the control site (site ten) from that of patients in the other nine study sites. However, patients living in sites two, four, five, six and nine appeared to be more affected, probably because the health service providers were located in those sites, making medical visits much easier for the patients.

The fact that the BCL hospital did not participate in the study may have influenced our conclusions. This hospital caters for BCL staff that work in the mines and smelter/concentrator plants, and their families. However, the patients attending the BCL hospital share similar commonalities such as proximity to the mines and locality of habitation and neighbourhood with other residents of Selebi Phikwe. In this regard, non-participation of the BCL hospital in this study may have had only a small degree of influence on the findings.

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Central University of Technology, Free State

Appendix 7.1

Questionnaire on Human Health Hazards at the Selebi Phikwe Ni-Cu Mine Area, Botswana

SECTION 2: Questionnaire for Health Service Providers

Table of contents

Central University of
Technology, Free State

Introduction

Thank you for your participation in the study by completing this questionnaire related to human health hazards at the Selebi Phikwe Ni-Cu mine area, Botswana. This study is undertaken for academic purposes only. All information collected will be treated confidentially and will not be revealed to anyone. It is suspected that environmental and human health problems may have been caused within Selebi Phikwe by mining activities. Inhabitants of the area are often infected with symptoms of illnesses and diseases related to pulmonary health complications. By means of the study, we would like to establish existing human health hazards, and identify the pulmonary health complications of the inhabitants of Selebi Phikwe, and then to advance solutions, which could be implemented.

The basis of this study will consist of questionnaires, personal interviews, and the administration of lung function test to selected individuals based on the responses from the questionnaire and personal interviews as well as their medical histories. All the information obtained from this study will be treated in strictest confidence, and made available as research findings at scientific conferences, seminars and workshops, and as an eventual publication in scientific journals. Any additional information provided will be very much appreciated.

This questionnaire is divided into the following main sections:

SECTION 1: Questionnaire for individuals, which should be answered by individuals.

SECTION 2: Questionnaire for health service providers, which should be answered by health service providers or designated official of the health facility.

SECTION 3: Questionnaire for enterprises, which should be answered by the Director of enterprise or designated official of the enterprise.

SECTION 4: Questionnaire for educational institutions, which should be answered by principals/headmasters or designated official of the educational institution.

Kindly note the following:

- Please read through the entire question before making a choice.
- Your answer should be marked with a cross in the box provided below or next to your choice.
- Where a question requires a written explanation as the response, kindly write concisely in the space provided.
- Where a question requires more than one answer, this will be made clear.
- Be very frank with your answers.

Central University of Technology, Free State

SECTION 2: Questionnaire for Health Service Providers

Date of Interview…………………………………………………………………………………………

Name of Interviewee (optional)…………………………………………………………………………

Area (Address) ……………………………………………………………………………………………

……

Name of Health Facility……………………………………………………………………………………

2.1 Demographical data

2.1.1 Who owns this health facility?

Government	Town Council	BCL	Private	Other (specify)

2.1.2 How many years has this health facility been in operation?

Less than ten years	Between ten and twenty years	Between twenty and thirty years	Between thirty and forty years	Between forty and fifty years	More than fifty years	Not sure

2.1.3 How many medical doctors work in this health facility?

None	One	Two	Three	Four	More than four	Varies

2.1.4 How many nurses work in this health facility?

None	One	Two	Three	Four	More than four	Varies

2.1.5 How many midwives work in this health facility?

None	One	Two	Three	Four	More than four	Varies

2.1.6 How many medical para-professional staff work in this health facility?

None	One	Two	Three	Four	More than four	Varies

2.1.7 Which area describes best where this health facility is located at Selebi Phikwe?

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

2.1.8 What is the purpose of the patient's stay at Selebi Phikwe (in %)?

	Employment	Schooling	Home town	Visiting	Other (specify)

2.1.9 Indicate what percentage of the patients who visit this health facility live in the different areas in Selebi Phikwe.

Sampling site	Location/Characteristics	

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

2.1.10 Indicate the gender percentage of the patients visiting this health facility?	Male		Female	

2.1.11 Indicate the age group percentage of patients visiting this Health Facility?					
< 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	>60 yrs
2.1.12 Indicate the average number of patients who visit this health facility daily?					
Less than twenty	Between twenty and thirty	Between thirty and forty	Between forty and fifty	More than fifty	Varies

2.2 General complaints of patients about personal health

2.2.1 Do patients complain of general body weakness?	Yes		No	
2.2.2 If answer to 2.2.1 is yes, what percentage of patients complain of general body weakness?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
2.2.3 Do patients experience loss of body weight?	Yes		No	
2.2.4 If answer to 2.2.3 is yes, what percentage of patients complain of body loss of weight?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
2.2.5 Do patients complain of influenza/cold?	Yes		No	
2.2.6 If answer to 2.2.5 is yes, what percentage of the patients complain of influenza/cold?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
2.2.7 Do patients complain of headaches?	Yes		No	
2.2.8 If answer to 2.2.7 is yes, what percentage of the patients complain of headaches?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies
2.2.9 Indicate what percentage of the patients complain of the different types of headache mentioned.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure
2.2.10 Do the patients who visit the health facility complain of cough?	Yes		No	
2.2.11 If answer to 2.2.10 is yes, what percentage of the patients complain of				

coughing?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.12 Indicate what percentage of the patients who complain of coughing have the different types of cough mentioned.				
Dry cough	Wet cough	Cough with sputum	Cough with chest pains	Cough with shortness of breath

2.2.13 Do the patients complain of unusual spitting?	Yes		No	

2.2.14 If answer to 2.2.13 is yes, what percentage of patients who visit the health facility complain of unusual spitting?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.15 Indicate what percentage of the patients who complain of coughing have the different types of cough mentioned.				
Clear sputum	Milky sputum	Greenish sputum	Sputum with blood	Black sputum

2.2.16 Do patients who visit the health facility complain of chest pains?	Yes		No	

2.2.17 If answer to 2.2.16 is yes, indicate what percentage of patients who visit the health facility complain of chest pains.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.18 Indicate what percentage of the patients who complain of chest pains have the different types of chest pains mentioned.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.2.19 Do patients who visit the health facility complain of experiencing shortness of breath regularly?	Yes		No	

2.2.20 If answer to 2.2.19 is yes, indicate what percentage of patients who visit the health facility complain of experiencing shortness of breath?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.21 Indicate what percentage of the patients who complain of experiencing shortness of breath have the different types of shortness of breath mentioned.				
Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.2.22 Do patients who visit the health facility complain of experiencing Palpitations?	Yes		No	

2.2.23 If answer to 2.2.22 is yes, indicate what percentage of patients who visit the health facility complain of experiencing palpitations.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.24 Indicate what percentage of the patients who complain of experiencing palpitations have the following different types of palpitations.				
Dull	Moderate	Acute	At times dull & at times acute	Not sure

2.2.25 Do patients who visit the health facility complain of experiencing pain in the lower abdomen?	Yes		No	

2.2.26 If answer to 2.2.25 is yes, indicate what percentage of patients who visit the health facility complain of experiencing pain in the lower abdomen.				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.27 Indicate what percentage of the patients who complain of experiencing pains in the lower abdomen have the following different types pain in the lower abdomen.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.2.28 Do patients who visit the health facility complain of pain when passing urine?	Yes		No	

2.2.29 If answer to 2.2.28 is yes, indicate what percentage of patients who complain of experiencing pain when passing out urine have the different types of pain when urinating.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.2.30 Do patients who visit the health facility complain of experiencing any unusual discharge from their genital system?	Yes		No	

2.2.31 If answer to 2.2.30 is yes, indicate what percentage of patients who complain of experiencing unusual discharge from their genital system have the different types of pain in their genital organs.

Dull	Moderate	Acute	At times dull & at times acute	Not sure

2.2.32 Do patients who visit the health facility complain of experiencing nausea and vomiting?	Yes		No	

2.2.33 If answer to 2.2.32 is yes, indicate what percentage of patients who visit the health facility complain of experiencing nausea and vomiting.

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.34 Indicate what percentage of the patients who complain of experiencing nausea and vomiting have the different types of pain accompanying the nausea and vomiting?

Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.2.35 Do patients who visit the Health Facility complain of experiencing diarrhoea?	Yes		No	

2.2.36 If answer to 2.2.35 is yes, is yes, indicate what percentage of patients who visit the health facility complain of experiencing diarrhoea?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.37 Indicate what percentage of the patients who complain of experiencing diarrhoea have blood in their stool when they have diarrhoea.

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.38 Indicate what percentage of the patients who visit the health facility have the different types of colour of their stool.

Normal	White	Black	Stool with blood	Not sure

2.2.39 Do patients who visit the health facility complain of experiencing constipation?	Yes		No	

2.2.40 If answer to 2.2.39 is yes, indicate what percentage of patients who visit the health facility complain of experiencing constipation?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.2.41 34 Indicate what percentage of the patients who complain of experiencing constipation have the different types of pain accompanying the constipation.

Dull	Moderate	Acute	At times dull and at times acute	Not sure

2.3 Past medical history (organic and physiological illnesses)

2.3.1 Do patients who visit the health facility have any significant or major illnesses?	Yes		No	

2.3.2 If answer to 2.3.1 is yes, indicate what percentage of patients who visit the health facility have any significant or major illnesses?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.3 Are the patients who visit the health facility with significant or major problem mentioned in 2.3.1 normally healed?	Yes		No	
2.3.4 Are the patients referred to other health facilities?	Yes		No	

2.3.5 If answer to 2.3.4 is yes, which other health facilities are they referred to?

Selebi Phikwe Hospital	Nyangagwe Hospital Francistown	Princess Marina Referral Hospital, Gaborone	Government Hospital Serowe	Other (specify)

2.3.6 Is medical examinations done at this health facility?	Yes		No	

2.3.7 If answer to 2.3.6 is yes, indicate what percentage of patients are tested for the different aspects of medical examination.

X-ray	Lung function test	Blood test	Urine test	Other (specify)

2.3.8 Do patients who visit the health facility have any emotional or nervous problems	Yes		No	

2.3.9 If answer to 2.3.8 is yes, indicate what percentage of patients have emotional problems?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.10 Do patients who visit this health facility suffer from tuberculosis?	Yes		No	
2.3.11 Do any of those who suffer from tuberculosis eventually get healed?	Yes		No	

2.3.12 If answer to 2.3.10 is yes, what percentage of patients who visit the health facility suffer from tuberculosis?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.13 Do patients who visit this health facility suffer from malaria?	Yes		No	

2.3.14 If answer to 2.3.13 is yes, what percentage of patients who visit the health facility suffer from malaria?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.15 Do patients who visit this health facility suffer from bilharzia?	Yes		No	
2.3.16 Do any of those who suffer from bilharzia eventually get healed?	Yes		No	

2.3.17 If answer to 2.3.16 is yes, what percentage of patients who visit the health facility suffer from bilharzia?

Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.18 Do patients who visit this health facility suffer	Yes		No	

from high blood pressure?				
2.3.19 If answer to 2.3.18 is yes, what percentage of patients who visit the health facility suffer from high blood pressure?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.20 Do patients who visit this health facility suffer from allergies?	Yes		No	
2.3.21 If answer to 2.3.20 is yes, what percentage of patients who visit the Health Facility suffer from Allergies?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.22 Do patients who visit this health facility suffer from asthma?	Yes		No	
2.3.23 If answer to 2.3.22 is yes, what percentage of patients who visit the health facility suffer from asthma?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.24 Do patients who visit this health facility suffer from bleeding tendencies?	Yes		No	
2.3.25 Do any of those who suffer from bleeding tendencies eventually get healed?	Yes		No	
2.3.26 If answer to 2.3.24 is yes, what percentage of patients who visit the health facility suffer from bleeding tendencies?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.3.27 Do patients who visit this health facility suffer from sexually transmitted diseases?	Yes		No	
2.3.28 If answer to 2.3.27 is yes, what percentage of patients who visit the health facility suffer from sexually transmitted diseases?				
Less than twenty	Between twenty and thirty	Between twenty and forty	Between forty and fifty	Varies

2.4 Aspects of death

2.4.1 Do deaths occur at this health facility?	Yes		No	
2.4.2 When patients die, prior to death what percentages are admitted because of one or more of the following complaints/diseases?				
General body weakness	Loss of body weight	Influenza/common cold	Headaches	Coughing
Chest pains	Shortness of breath	Palpitations	Pain in the lower abdomen	Pain in passing urine
Unusual discharge from genital system	Nausea and vomiting	Diarrhoea	Constipation	Other (specify)
2.4.3 Whereby patients die, what percentages die because of one or more of the following diseases/health complications as determined by clinical diagnosis and/or death certificate?				
AIDS-related	Breast cancer	Cancer of the colon	Cardiac arrest	Diabetes
Heart disease	Lung cancer	Prostate cancer	Malaria	Other lung

				disease (specify)
Meningitis	Pneumonia	Tuberculosis	Stroke	Other (specify)

2.4.4 For those patients who died at this health facility, indicate what percentage died within the corresponding age groups given.

	0-5 yrs	**6-10 yrs**	**11-15 yrs**	**16-20 yrs**	**21-25 yrs**
	26-30 yrs	**31-35 yrs**	**36-40 yrs**	**41-45 yrs**	**> 45 yrs**

2.4.5 For those patients who died at this health facility, indicate the gender percentage?	Male		Female	

2.4.6 Indicate what percentage of the patients who died this health facility lived in the different areas in Selebi Phikwe.

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

2.4.7 Indicate the percentage of deceased individuals employed as:	Mine Worker	Mine Administrator	Mine Supervisor	Smelter/Concentrator Worker
	Teacher	Hospital Staff	Politician	Smelter/Concentrator Administrator
	Business personnel	Hotel/Restaurant Staff	Government Employee	Smelter/Concentrator Supervisor
	Shop/Supermarket Staff	Housewife	Apprentice	Industrial Class Worker
	Student	Farmer	Unemployed	Other (specify)

Using the Lung Function Test in Evaluating the Health Status of Residents of the Selebi Phikwe Ni-Cu Mine Area

8.1 Introduction

Botswana is one of the countries in the world where nickel-copper (Ni-Cu) ore is exploited for its base metal economic value. The Ni-Cu ore exploitation in Botswana is carried out at Selebi Phikwe. Moreover, in this country, several other mineral resources including diamonds, gold, soda ash and a wide range of industrial minerals are also being tapped. The exploitation of the mineral resources has brought huge economic benefits to the country (Botswana, 2003). Unfortunately, there have also been several negative effects on the environment as a result of the mining of the mineral resources.

Previous studies conducted by Ekosse (2001) and Ekosse, Van den Heever, De Jager and Totolo (2003; 2003a; 2004) focused on the physical environmental quality of the Selebi Phikwe area. The findings of the previous studies concluded that the mining activities there have affected the atmosphere, plants, phane and soils. In another study on socio-economic concerns within the Selebi Phikwe area, Asare (1999) advanced the opinion that the exploitation of Ni-Cu could possibly be having a negative effect on the health of the residents.

The mining and processing of sulphide minerals at Selebi Phikwe is accompanied by mine waste. This waste led to the formation of various gases such as sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxides (NO_x) and hydrogen disulphide (H_2S) as well as particulate air matter (PAM) contents, deposition of tailings dump, and contamination of surrounding soils, vegetation and animals. Fumes rich in sulphur, nitrous oxides (NO_x) and other associated gases were found to be deleterious to human life as well as to cattle and game (Prospero, 1999). The emissions of SO_2, CO, CO_2, and other gases from concentrator and smelter plants affect people, plants, wildlife, rocks and soils, buildings and landscape topography (Buseck and Posfai, 1999).

According to Ekosse (2001), air pollution resulting from PAM of sulphur rich gases, metals and minerals has led to depositing of contaminants on soils and vegetation. This might cause an increased bio-availability of metal ions in soils and more uptake by plants as suggested by Tagami and Uchida (1997). At Selebi Phikwe, Ekosse (2001) found that concentration levels of plant nutrients in the surrounding mining environment increased due to the introduction of contaminants; a condition that might eventually lead to certain vegetation types becoming either endangered or locally extinct (Chaney, Brown, Li, Angle, Homer and Green, 1995).

However, the above cited previous studies failed to consider the different types of illnesses and diseases which were most likely to have occurred in residents of the area. According to Asare (1999), residents complained that the fumes might well be affecting their health. Moreover, in previous investigations carried out by Ekosse (2001), it was suspected that the fumes could possibly be affecting the respiratory systems of individuals living within the Selebi Phikwe area. In order to establish whether mining activities in Selebi Phikwe were affecting the respiratory system of individuals, it was therefore necessary to conduct spirometry tests. Spirometry measures air flow and lung volumes, and is the preferred lung function test in chronic obstructive pulmonary disease (COPD) diagnosis (Martin, 1997).

The work discussed in this chapter is complementary to results obtained from the research findings reported in chapters four, five, six and seven. This chapter aims at evaluating the pulmonary health status of residents in Selebi Phikwe area, and the focus is on lung function tests of residents in the study area. The chapter presents the results of lung function tests, which were undertaken primarily to support the findings of questionnaires and structured interviews administered to residents, industries, educational institutions and health service providers within the Selebi Phikwe Ni-Cu mine area.

8.2 Methods

There are a number of lung function variables that can be monitored when applying spirometry. The main variables are forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and the diagnostic ratio FEV_1/FVC. According to the American Thoracic Society (1995) and Martin (1997), the FEV_1 is the amount of air maximally exhaled in the first second of exhalation, and the FVC is the total volume of air that can be exhaled with maximum force, from maximum inhalation to end maximal exhalation. These values can be expressed as volumes in litres as well as percentages of predicted values. The ratio of FEV_1/FVC is expressed as percentage predicted.

A ratio of < 75% predicted defines obstruction, and is used to detect obstruction in individuals (American Thoracic Society, 1995; Crapo, Morris and Gardner, 1981). In general, obstruction can be considered if FEV_1/FVC < 70% predicted, FEV_1 < 80% predicted, and in severe COPD the FVC may be < 80% predicted, although usually it is much less (Reid, 2003). Furthermore the degree of obstruction is determined as mild if FEV_1 is > 70% predicted; moderate if FEV_1 is 50 < 69% predicted; and severe if FEV_1 is < 50% predicted (Reid, 2003). Restriction on the other hand is considered if both FEV_1 and FVC are < 80% but the FEV_1/FVC ratio is normal or high. The degree of restriction is classified as mild if > 65 – 80% predicted; moderate if > 50 – 65% predicted; and severe if < 50% predicted. Examples of normal spirometry, mild and severe obstructions, and restriction are given in Figures 8.1, 8.2, 8.3 and 8.4 respectively. All other flows may support or suggest obstruction but the definition rests with the ratio of FEV_1/FVC.

Factors such as height, age, sex, race and posture influence normal values of the results (American Thoracic Society, 1995; Martin, 1997; Reid, 2003). Tall people have larger lungs, for instance, and respiratory function declines with age. Males in general have larger lung volumes than females. Blacks and Asians generally have smaller lung volumes. It is recommended that spirometry be done while sitting. Little difference is observed, however, between sitting and standing. The values are reduced in the supine position (American Thoracic Society, 1995; Crapo *et. al.*, 1981; Martin, 1997; Reid, 2003).

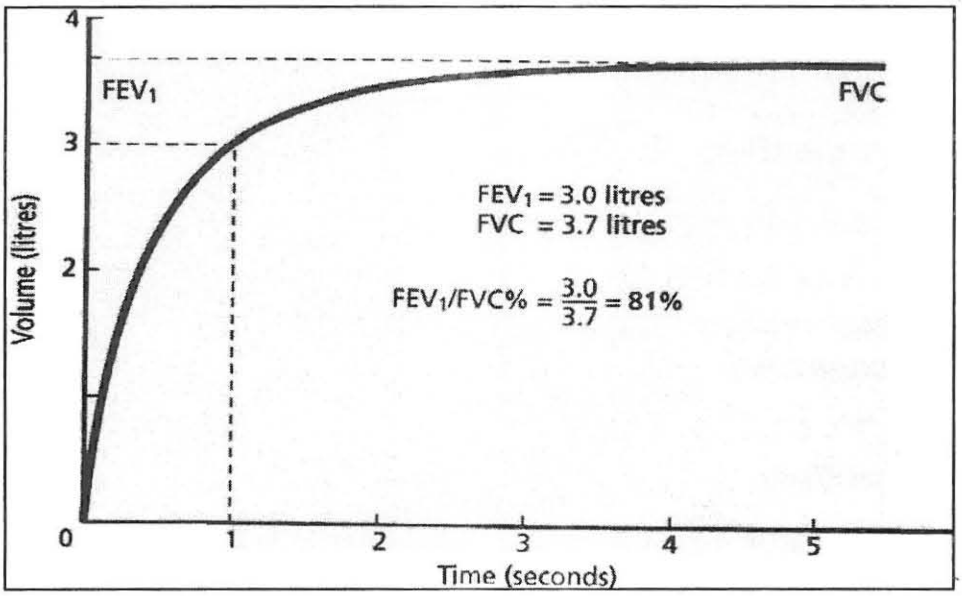


Figure 8.1: Normal spirometry (volume/time trace) (Reid, 2003)

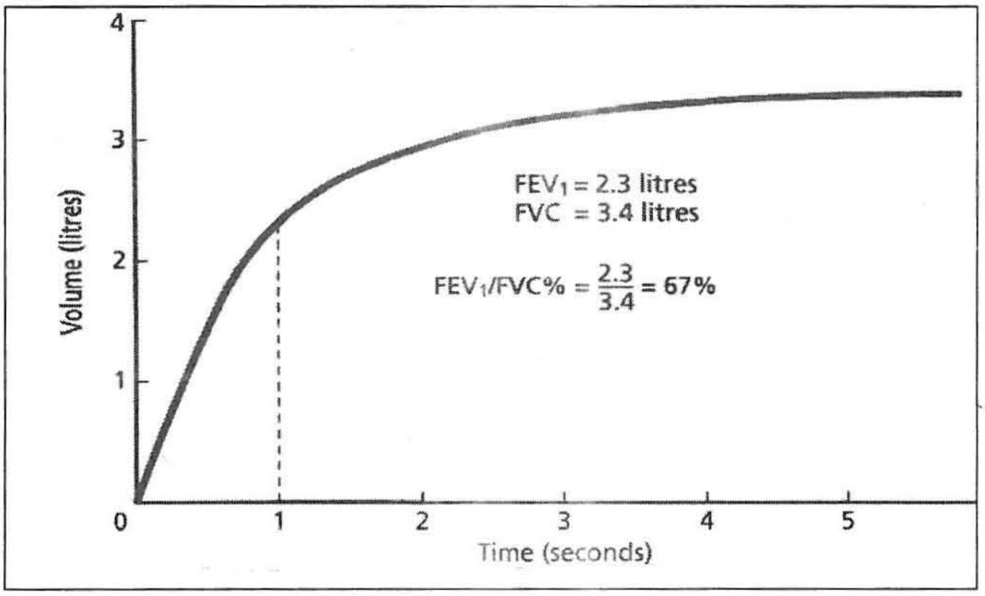


Figure 8.2: Mild obstruction (volume/time trace) (Reid, 2003)

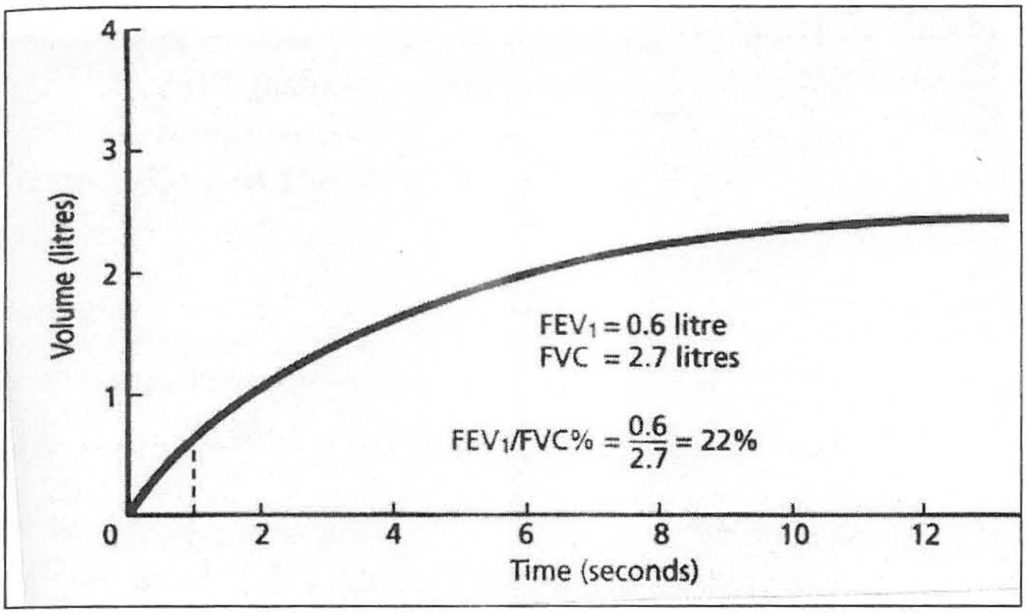


Figure 8.3: Severe obstruction (volume/time trace) (Reid, 2003)

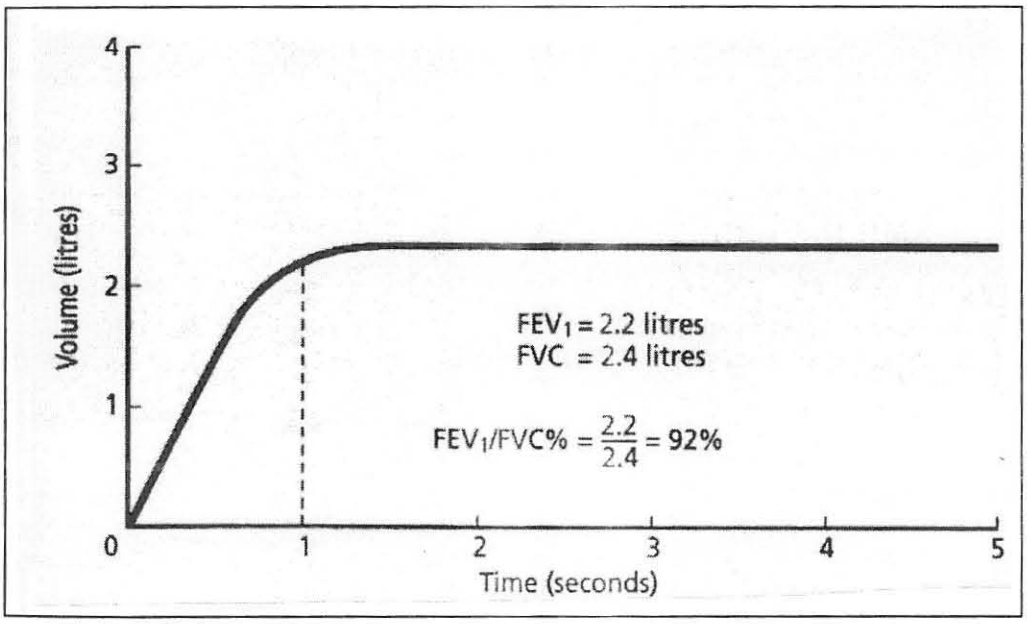


Figure 8.4: Restriction (volume/time trace) (Reid, 2003)

The methods used in evaluating the pulmonary health status of residents living in the Selebi Phikwe Ni-Cu mine area have been discussed in section 3.2.2 of this document. The main tool employed was a spirometer. The reason why spirometry was used is because this is an easy technique to identify pulmonary restriction or obstruction, which is a diagnostic indicator for disorders of the respiratory tract. Pulmonary restriction or development of obstructive pulmonary disorders (OPD) are diagnostic indicators of specific diseases, which are related to the respiratory system (American Thoracic Society, 1991, 1995). Values obtained for FEV_1 and FVC were used in evaluating the degree of pulmonary restriction or obstruction as suggested by the American Association of Respiratory Care (1991, 1996).

One hundred individuals were chosen from the ten sites of the study area to participate in this exercise, which focused on evaluating their pulmonary health status. Prior to conducting the spirometry test, the individuals were required to respond to questionnaires and structured questions. A sample of the questionnaire which is presented as appendix 8.1 of this chapter. The questionnaire covered gender, age, purpose of stay, occupation, duration and area of stay in Selebi Phikwe study area, weight, height, race, smoking habits, chest pains, coughing, shortness of breath and unusual spitting of individuals. The data obtained were coded, double entered and verified, similar to the treatment of data by Abramson, Sim, Fritschi, Vincent, Benke, and Rolland (2001). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS). Cross tabulations were undertaken to identify the relationships of study sites to different classifications of spirometry. Associations between lung functions and symptoms were established.

8.3 Results, interpretation and discussions

8.3.1 Demographical data

From the 100 individuals chosen to participate in the lung function test exercises, 88 of them were able to do the entire series tests. The results, interpretation and discussions reported in Table 8.1 considered only the 88 who satisfactorily completed the tests. There were six outliers in the results, which are reflected in the ratio column in Table 8.1. An example of the lung function test results sheet is presented in Figure 8.5. In Table 8.1, the details of age in years, height in centimetres (cm), and weight in kilograms (kg), of those who successfully responded to the lung function tests are given.

In this study, the software was used to adjust for the effects of age, height and weight. In a similar manner, Gottlieb, Wilk, Harmon, Evans, Joost, Levy, O'Connor and Myers (2001) used spirometry to determine changes in FEV_1, FVC and in FEV_1 / FVC ratio after adjusting for effects of age, height, weight, in order to understand heritability of longitudinal change in individuals. The ages, heights and weights of individuals who participated in this study are mentioned below. The youngest individual was 18 years old and the oldest was 67 years with the average age at 30.5 years. Regarding height, the shortest person was 153 cm and the tallest was 189 cm, with the average height at 166.25 cm.

Table 8.1: Personal details and interpretation of lung function test of respondents within the Selebi Phikwe area

1	2	3	4	5	6	7	8	FVC1%	FEV1%	RATIO %	9
18	163	54	NO	NO	NO	NO	NO	69.05	101.61	147	I
18	174	60	NO	NO	NO	NO	NO	71.06	94.97	134	I
18	157	45	NO	NO	NO	NO	NO	57.88	95.42	165	A
18	176	61	NO	NO	NO	NO	NO	71.29	84.91	119	C
18	169	49	NO	YES	NO	NO	NO	62.14	74.16	119	A
18	165	64	NO	YES	YES	YES	NO	69.7	110.25	158	F
20	167	78	NO	NO	NO	NO	NO	86.89	105.28	121	C
20	161	52	NO	YES	NO	NO	NO	74.88	111.1	148	C
20	174	51	NO	YES	NO	NO	NO	79.83	113.74	142	B
20	169	75	NO	NO	NO	NO	NO	103.69	77.1	74	I
20	161	79	NO	YES	YES	NO	NO	52.1	65.26	125	A
20	169	62	YES	NO	NO	NO	NO	84	99.3	118	B
21	162	59	NO	NO	NO	NO	NO	69.36	115.3	166	C
21	169	52	NO	NO	NO	NO	NO	63.71	115.19	181	I
21	159	43	NO	YES	NO	NO	NO	81.69	99.42	122	C
21	179	66	YES	NO	NO	NO	NO	90.08	86.56	96	B
21	163	58	YES	NO	NO	NO	NO	85.66	99.33	116	I
21	166	64	NO	NO	NO	NO	NO	84.55	44.15	52	A
21	173	63	NO	NO	NO	NO	NO	84.53	88.73	105	G
22	164	44	NO	YES	NO	YES	NO	39.07	83.54	214	A
22	156	60	NO	YES	NO	YES	NO	118.68	91.4	77	G
22	170	59	NO	NO	NO	YES	NO	3.63	120.12	3309 *	E
22	178	81	YES	NO	NO	NO	NO	96.98	101.7	105	C
22	168	52	NO	NO	NO	NO	NO	74.77	61.47	82	A
23	155	48	NO	YES	NO	YES	NO	59.63	117.69	197	I
23	159	58	NO	NO	NO	NO	NO	90.76	98.13	108	D
23	177	64	NO	NO	NO	NO	NO	80.96	33.1	41	A
23	171	68	NO	NO	NO	NO	NO	81.74	55.99	68	D
24	155	52	NO	NO	NO	NO	NO	53.15	59.91	113	A
24	172	57	NO	NO	NO	NO	NO	1.38	118.29	8572 *	E

24	160	56	NO	NO	NO	NO	NO	79.18	106.38	134	C
24	171	67	NO	NO	NO	YES	NO	79.54	106.9	134	C
25	162	62	NO	YES	NO	NO	NO	76.15	52	68	A
25	162	44	NO	YES	YES	YES	NO	48.01	97.58	203	A
25	173	61	YES	NO	NO	NO	NO	87.74	99.91	114	C
26	167	105	NO	NO	NO	NO	NO	8.89	118.82	1337 *	E
26	173	76	NO	NO	NO	NO	NO	80.1	50.95	64	A
26	158	50	NO	NO	NO	YES	YES	3.35	118.82	3547 *	E
26	163	50	NO	NO	NO	NO	NO	67.68	103.4	153	F
27	189	80	NO	NO	NO	NO	NO	106.34	99.47	94	B
27	170	64	NO	NO	NO	NO	NO	77.92	108.77	140	C
27	163	75	NO	NO	NO	NO	NO	95.09	111.8	118	C
28	167	80	NO	NO	NO	NO	NO	73.57	90.26	123	F
28	166	53	YES	NO	NO	NO	NO	83.24	102.09	123	C
28	162	60	YES	YES	NO	NO	NO	79.31	97.22	123	C
28	174	60	NO	NO	NO	NO	NO	88.38	89.83	102	C
28	164	64	NO	YES	NO	NO	NO	77.35	107.58	139	C
29	175	69	YES	YES	YES	NO	NO	85.2	78.71	92	D
29	172	65	YES	NO	NO	NO	NO	84.86	96.6	114	D
30	165	76	YES	NO	NO	NO	NO	72.6	108.26	149	I
30	162	46	NO	YES	NO	YES	NO	76.54	116.23	152	C
30	189	70	NO	NO	NO	NO	NO	66.78	114.67	172	C
30	169	65	NO	NO	NO	NO	NO	98.78	84.38	85	I
31	175	69	YES	NO	NO	NO	NO	103.35	97.49	94	B
32	153	47	NO	YES	NO	NO	NO	55.4	81.09	146	A
32	174	70	NO	NO	NO	NO	NO	115.22	17.89	16	K
32	166	62	YES	NO	NO	NO	NO	99.67	95.83	96	G
34	170	49	YES	NO	NO	NO	NO	82.17	87.91	107	I
34	172	67	NO	NO	NO	NO	NO	99.94	108.83	109	B
34	172	61	NO	NO	NO	NO	NO	101.66	116.3	114	B
34	163	58	NO	NO	NO	NO	NO	11.43	121.01	1059 *	A
35	174	72	NO	YES	NO	NO	NO	52.74	91.23	173	K
35	165	57	NO	YES	NO	NO	NO	105.13	84.46	80	H
35	154	68	NO	NO	NO	NO	NO	84.96	97.36	115	A

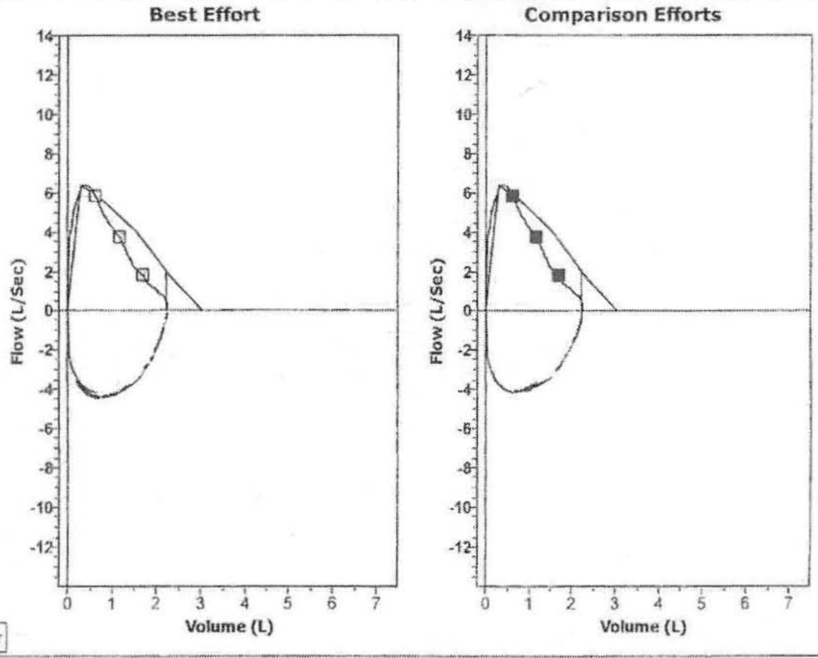
36	155	55	NO	NO	YES	NO	NO	74.17	120.09	162	B
36	160	73	NO	YES	NO	NO	NO	56.63	44.49	79	A
36	172	72	YES	NO	NO	YES	YES	57.19	34.88	61	K
36	156	62	NO	YES	NO	NO	NO	112.24	71.71	64	F
36	164	63	NO	NO	NO	YES	NO	73.46	111.15	151	B
37	169	73	NO	YES	NO	NO	NO	105.98	30.45	29	K
37	174	45	YES	NO	NO	NO	NO	73.72	37.55	51	A
37	163	67	NO	NO	NO	NO	NO	101.01	84.73	84	C
38	156	50	NO	NO	NO	NO	NO	77.08	113.57	147	C
38	182	102	NO	NO	NO	NO	NO	86.63	90.05	104	G
39	171	108	NO	NO	NO	NO	NO	86.68	107.13	124	C
40	176	87	NO	NO	NO	NO	NO	94.5	103.44	109	J
41	174	66	NO	NO	NO	NO	NO	40.07	113.88	284	A
42	170	64	YES	NO	NO	NO	NO	93.99	102	109	B
43	152	59	NO	NO	NO	NO	NO	82.59	116.73	141	F
45	170	79	NO	YES	NO	NO	NO	103.14	94.41	92	G
45	175	86	NO	NO	NO	NO	NO	92.41	113.58	123	B
48	160	75	NO	NO	NO	NO	NO	75.18	104.56	139	F
49	166	88	NO	YES	NO	NO	NO	4.99	125.33	2512 *	E
52	170	71	NO	NO	NO	NO	NO	75.21	122.92	163	B
53	168	67	NO	NO	NO	NO	NO	120.16	41.22	34	K
53	170	81	NO	YES	NO	NO	NO	74.97	126.13	168	F
61	180	85	NO	NO	NO	NO	NO	84.74	121.44	143	B
67	162	88	NO	NO	NO	NO	NO	63.22	116.06	184	I

*(Note: 1 = age (years), 2 = height (cm), 3 = weight (kg), 4 = smoking, 5 = chest pains, 6 = shortness of breath, 7 = coughing, 8 = spitting, A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be under-estimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction, * = outlier)*

SpiroFlow Spirometry

10 10

ID Number/Code	**10**	Date of Current Test	**2003/07/24 22:31:24**
Age (years)	**36**	Gender	**Female**
Weight (Kg)	**55 kg**	Height	**155 cm**
Smoking Habits	**Non Smoking**	Exam Type	**Pre Examination**
Test Position	**Standing**	Reference Equations	**ECCS 1983**



= FEV1 Marker

	Predicted	:: Best Effort:: Measured	% Pred	:: All Efforts :: Test 1	Test 2	Test 3	Test 4	Test 5	Te
FVC (l)	3.04	2.26	74.17 ✓	2.26	2.26	2.26		-	
FIVC (l)	3.08	1.88	61.01	1.88	1.88	1.88		-	
FEV1 (l)	2.62	2.23	84.94	2.23	2.23	2.23		-	
FEV1%	82.26	98.78	120.09 ✓	98.78	98.78	98.78		-	
PEFR (l/sec)	6.33	6.49	102.38	6.34	6.34	6.49		-	
FEF25 (l)	5.69	5.84	102.67	5.84	5.84	5.84		-	
FEF50 (l)	4.06	3.74	92.26	3.74	3.74	3.74		-	
FEF75 (l)	1.84	1.79	97.25	1.79	1.79	1.79		-	
FEF25-75 (l)	3.63	3.32	91.27	3.32	3.32	3.32		-	
RV (l)	1.28	0.95	74.55	0.95	0.95	0.95		-	
TLC (l)	4.36	2.83	64.98	2.83	2.83	2.83		-	
FRC	2.4	1.63	67.91	1.63	1.63	1.63		-	
Raw	1.75	1.37	78.07	1.37	1.37	1.37		-	
Kst (l)	0.13	0.1	79.68	0.1	0.1	0.1		-	

I-:: Interpretation::-

Consider Mild Obstruction.Obstruction may be under-estimated.

Penta Medical Systems
Penta Systems
4545
44544
454545

Figure 8.5: An example of the lung function test results sheet

For body weight, the lightest was 43 kg, the heaviest was 108 kg, and the average body weight of those tested was 65.18 kg. The average body mass index (BMI) was 23.62. According to Gottlieb *et al.* (2001), the impact of age on lung function results in a mean loss in the FEV_1 test of 52 ml/yr for men and 47 ml/yr for women. They rated this result substantially higher than the figures they estimated at the start of their study.

Table 8.2 reflects the gender of individuals in Selebi Phikwe who underwent the lung function tests. Of those who were tested in this study, 45% were males and 55% were females. The same percentages for both males and females were considered to have mild obstruction, with the possibility that the obstruction may have been underestimated. There were more females who were considered to have severe obstruction, borderline obstruction, and moderate obstruction, although the moderate obstruction may have been underestimated (Table 8.2).

Table 8.2: Interpretation according to gender

Interpretation	A	B	C	D	E	F	G	H	I	J	K
Male %	35	85	35	50	20		80		50	100	60
Female %	65	15	65	50	80	100	20	100	50		40

(Legend: A = Consider severe obstruction. Obstruction may be under-estimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be underestimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

In spirometry tests including FEV_1 and FVC which were applied in four communities in the USA, the results revealed that elderly African-American women showed significantly lower lung function values than those for white women (Pulmonary World, 2002). In this study, however, all the respondents are Black Africans, and are likely to have lung function values similar to those of the African Americans.

Table 8.3 reflects the purpose of stay of individuals in the Selebi Phikwe area. Most of the participants who underwent the lung function tests were living in Selebi Phikwe because of employment, and a fairly substantial number were also living there because it was their hometown. A few of the individuals tested were staying in Selebi Phikwe because they were attending schools, visiting or are married to individuals living there.

All the different classes of lung functions were found to occur in individuals living in the Selebi Phikwe area for the sake of employment. Individuals tested who were living in the study area because it was their hometown had neither normal spirometry results nor severe obstruction. Those attending schools had severe obstruction, borderline obstruction or mild obstruction: all of which may have been underestimated. Those visiting the study area manifested the same diagnosis as those there for the sake of schooling and also demonstrated mild obstruction (Table 8.3).

Table 8.3: Interpretation of spirometry results according to purpose of stay in the Selebi Phikwe area

Interpretation	Employment	Schooling	hometown	Visiting	Marriage
A	24	6	47	18	6
B	77		23		
C	45	10	40	5	
D	75		25		
E	40		60		
F	50		50		
G	80		20		
H	50		50		
I	40	10	50		
J	100				
K	100				
Total %	**52**	**5**	**38**	**5**	**1**

(Legend: A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be underestimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

Abramson *et. al.* (2001) showed that respiratory symptoms and cross shift declines in lung function were related to occupational exposure to tea dust. William and Hu (2002), and Huvinen, Uitti, Oksa, Palmroos and Laippala (2002) demonstrated that occupational exposure affects lung function. They indicated that heavy metals and more specifically cadmium (Cd) had been shown to influence the lung functions of females working in a jewellery manufacturing industry. Martin (1997) reported that the lung functions of workers of aluminium smelters were affected by occupational exposure.

Huvinen *et al.* (2002) proved that occupational exposure to chromite, trivalent Cr (Cr^{3+}) or hexavalent Cr (Cr^{6+}) causes respiratory diseases, an excess of respiratory symptoms, a decrease in pulmonary function or signs of pneumoconiosis among workers in stainless steel production. It can be deduced from these examples that the lung functions of workers of the Selebi Phikwe mines and smelter/concentrator plant may be affected as a result of occupational exposure to gases such as SO_2, CO, CO_2, NO_x and H_2S, and PAM found to be prevalent in the study area (Ekosse *et al.*, 2004).

Table 8.4 provides the details of spirometry results of individuals who were tested according to the study sites. Normal spirometry was recorded only in site nine. However, studies have demonstrated that having normal lung function as measured by spirometry does not necessarily imply that one's lungs are completely normal (Walsh, 2003). Of those classified as having severe obstruction with the possibility that the obstruction may have been underestimated, 12% were from sites one, six and eight respectively, 18% from sites two and five respectively, 24% from site three, and 6% from site nine. On the other hand, for individuals tested and considered to have severe obstruction, 20% were from site one and 40% from sites four and ten respectively.

There were cases where obstruction was underestimated and in this category of individuals tested, 8% each were from sites one, two, four, five, and eight respectively, 15% each were from sites seven and nine respectively, and 31% were from site ten. There were also cases of severe obstruction where air trapping was suspected and in this category of individuals, 20% were from site two and 80% from site six.

Results obtained for site ten were relatively low compared to those for sites four, five and six for the different types of obstructions. These three sites had individuals who were the most compromised. However, 40% of the individuals in site ten who underwent the lung function test were classified as having severe obstruction. This may be due to the fact that other factors may have influenced the situation apart from effects of mining.

Table 8.4: Interpretation of spirometry results according to study sites

Interpretation	One	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten
A	12	18	24		18	12		12	6	
B	8	8		8	8		15	8	15	31
C			15	20	5	10	5	10	25	10
D					50		25			25
E		20				80				
F			17	17			17	17	17	17
G			20	20				60		
H			50		50					
I		20	10	20	20	10	10			10
J									100	
K	20			40						40
Total %	**5**	**8**	**13**	**13**	**11**	**10**	**7**	**10**	**11**	**13**

(Legend: A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be underestimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

The class of borderline obstruction with the possibility that the obstruction may have been underestimated had the following percentage distribution of individuals: 15% were from site three, 20% from site four, 5% each from sites five and seven respectively, 10% each from sites six, eight and ten respectively, and 25% from site nine. For individuals tested and considered as having borderline obstruction, 20% each were from sites three and four respectively, and 60% were from site eight (Table 8.4).

Of those classified as having mild obstruction with the possibility that the obstruction may have been underestimated, 20% each were from two, four and five respectively, and 10% each were from sites three, six, seven and ten respectively. Of the individuals tested and considered as having mild obstruction, 50% were from site five, and 25% each from sites seven and ten respectively (Table 8.4).

Of those classified as having moderate obstruction with the possibility that the obstruction may have been underestimated, 17% each were from sites three, four, seven, eight, nine and ten respectively. Of those individuals tested and considered as having moderate obstruction, 50% each were from sites three and five respectively (Table 8.4).

Prospero (1999) reported that fumes rich in sulphur, nitrous oxides (NO_x) and other associated gases were found to be deleterious to human life. The findings obtained from the administration of spirometry tests showed that individuals living in sites four, five and six, which are closer to the smelter/concentrator plant, were affected by gaseous wastes and PAM. These gaseous wastes include SO_2, CO, CO_2, NO_x and H_2S. The emissions of SO_2, CO, CO_2, and other gases from concentrator and smelter plants affect people, plants, wildlife, rocks and soils, buildings and landscape topography (Buseck and Posfai, 1999).

8.3.2 Effects of selected ailments on lung function

Information regarding chest pains, shortness of breath, persistent coughing and unusual spitting of the respondents in relation to the spirometry tests is reported in Figure 8.6 and information given in Table 8.5 was obtained by means of the questionnaire.

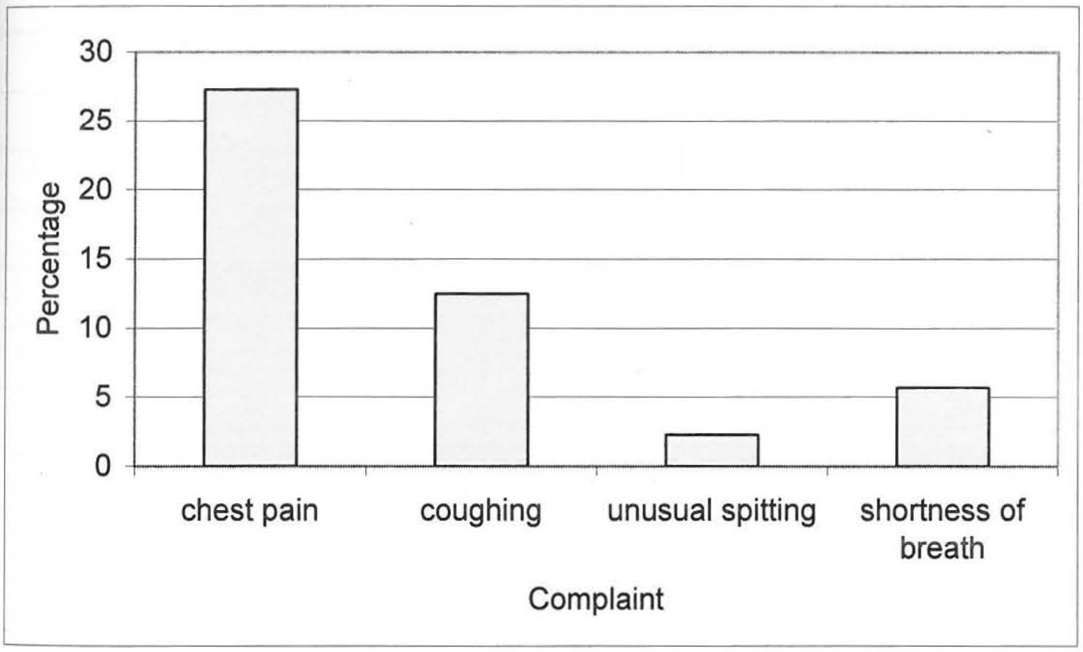


Figure 8.6: Percentage distribution of individuals who participated in the spirometry tests suffering from chest pain, coughing, unusual spitting and shortness of breath

Chest pains, coughing, shortness of breath and unusual spitting have been considered as some of the factors influencing lung function (De Gouw, Gronberg, Schot, Kroes, Dick and Sterk, 1998). The results of this study revealed that 48% of the individuals who were tested suffered from one or more of the four listed ailments. These ailments, which are symptoms of illnesses and diseases of the respiratory tract, have an influence on the functioning of the lungs (De Gouw *et al.*, 1998).

Table 8.5: Percentage distribution of individuals who participated in the spirometry tests suffering from chest pain, coughing, unusual spitting and shortness of breath

Site	Chest pain	Coughing	Unusual spitting	Shortness of breath	None of these ailments
One	50	25			25
Two	57	14		14	15
Three	36	9			55
Four	45	9		9	37
Five	40	10		20	30
Six	33	33	11	11	12
Seven	17				83
Eight	0	22			78
Nine	10				90
Ten		9	9		72
Over all %	**27**	**13**	**2**	**6**	**52**

Table 8.6 gives the details of the spirometry results of respondents who complained of **chest pains**. Up to 27% of those to whom the spirometry test

was administered complained of chest pains. Only 1% of the respondents who complained of chest pains had normal results. 19% of those with chest pains were classified as having severe obstruction with the possibility that the obstruction may have been underestimated, while 6% were considered to have severe obstruction, and another 6% had severe obstruction and suspected air trapping. There were cases whereby obstruction was underestimated and 15% of respondents who complained of chest pains were classified according to this category (Table 8.6).

Table 8.6: Interpretation of spirometry results of respondents who complained of chest pains

Interpretation	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Number	17	13	20	4	5	6	5	2	10	1	5
Total %	19	15	23	5	6	7	6	3	11	1	6

(Legend: A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be underestimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

23% of respondents with chest pains had borderline obstruction with the possibility that the obstruction may have been underestimated, and a further 6% of respondents with chest pains were considered to have borderline obstruction. 11% of the respondents with chest pains had mild obstruction with the possibility that the obstruction may have been underestimated, and another 5% were considered to have mild obstruction. 7% of respondents with chest pains were classified as having moderate obstruction with the possibility that the obstruction may have been underestimated, and a further 3% were considered as having moderate obstruction (Table 8.6).

Obviously, there are many different causes of chest pain. The most common causes are angina at rest and heart attack, although other causes include occlusion, pulmonary embolism and pneumothorax (Cardiology Channel, 2004). In chapter five, it is reported that 27% of pupils in Selebi Phikwe area complained of having chest pain. 40% of the workers complained of chest pain, as indicated in chapter six. Moreover, in chapter seven, it is reported that all the health service providers indicated that they had patients who complained of chest pains. Asare (1999) related complaints of chest pains to breathing of gaseous fumes by the people living in the Selebi Phikwe area. Some of the gases such as SO_2, and to a lesser extent H_2S, have a choking effect in human beings and affect their respiratory systems causing them to have chest pains (Nichols, 2001). In this regard, it may be assumed that the mining and roasting of Ni-Cu rich ore bodies could have provoked chest pains experienced by individuals living in Selebi Phikwe.

Table 8.7 provides the details of spirometry results of respondents who complained of persistent **coughing**. 13% of those to who underwent the spirometry tests complained of coughing regularly. None of the 13% of the respondents who complained of frequent coughing had normal spirometric results. 3% of those who complained of coughing regularly were classified as having severe obstruction with the possibility that the obstruction may have been underestimated. On the other hand, 1% of respondents with persistent coughs were considered as having severe obstruction, and another 3% had severe obstruction where air trapping was suspected. There were cases where obstruction was underestimated and 1% of respondents who complained of coughing regularly were classified in this category (Table 8.7).

Table 8.7: Interpretation of spirometry results of respondents suffering from persistent coughing

Interpretation	A	B	C	D	E	F	G	H	I	J	K
Number	2	1	2		2	1	1		1		1
Total %	3	1	3		3	1	1		1		1

(Legend: A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be under-estimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

3% of respondents who complained of coughing regularly had borderline obstruction with the possibility that the obstruction may have been underestimated, and a further 1% were considered as borderline obstruction. 1% of the respondents who complained of persistent coughing had mild obstruction with the possibility that the obstruction may have been underestimated. 1% of respondents who complained of coughing regularly were classified as having moderate obstruction with the possibility that the obstruction may have been underestimated (Table 8.7).

More males than females complained of persistent coughing in the Selebi Phikwe area. In chapter four of this document, the respondents indicated that some of the main causes of their coughing included fumes from the mine and smelter/concentrator, dust, weather and smoking of cigarettes. In chapter five, it is reported that 70% of the pupils complained of coughing regularly. 45% of the workers complained of regular coughing as indicated in chapter six. In chapter seven, it is mentioned that all of the health service providers responded that their patients complained of coughing regularly.

In a study conducted by Pope, Dockery and Schwartz (1995) it was observed that there were increased hospital admissions because of respiratory problems, and increased emergency room visits to hospitals due to respiratory problems caused by pollution resulting from PAM, SO_2 and toxic fumes in the Utah Valley, USA. Pope *et. al.* (1995) further observed that residents in the affected area had experienced an increase in asthmatic attacks, bronchodilator use, emergency visits and hospital admissions. Moreover, they experienced increased lower respiratory tract symptoms and coughing, significant decrease in lung function, and increased number of days of work or school missed. Although these observations by Pope *et al.* (1995) cannot be substantiated at the Selebi Phikwe area, the high percentage of individuals tested who complained of coughing regularly could be attributed to the presence of pollutants resulting from the mining and smelting activities.

Shortness of breath was experienced by 6% of those who underwent spirometric test. For those suffering from shortness of breath, 2% of the respondents who performed the test were considered to have severe obstruction with the possibility that the obstruction may be underestimated, while a further 1% of the tested individuals were classified as having severe obstruction. 1% of the tested individuals were classified as having obstruction which may be underestimated, and another 1% were considered to have mild obstruction. Yet a further 1% were considered to have moderate obstruction with the possibility of the obstruction being underestimated.

Shortness of breath is defined as difficult, laboured breathing. There are overlapping contributory causes but of interest to this study are COPD, anaemia, smoking, fear/anxiety, recurrent pulmonary emboli, congestive cardiac failure and asthma. Workers in a stainless steel production industry in which Cr is used complained of shortness of breath (Huvinen *et al.*, 2002) for instance. In chapter five, findings indicate that 33% of the pupils, and in chapter six, 18% of the workers complained of shortness of breath. Moreover, in chapter seven 86% of the health service providers responded their patients experienced shortness of breath. Heavy metals which included Cd, Cr, Co, Cu, Fe, Ni, Se and Zn have been identified in high contamination levels in the Selebi Phikwe area (Ekosse, 2001). Individuals who participated in this study and complained of shortness of breath were from sites two, four, five and six. These sites are the closest to the mines and the concentrator/smelter plant in Selebi Phikwe.

Only 2% of those to whom the lung function test were administered suffered from **unusual spitting**, and they were from sites six and ten (control site). The tested individuals from site six who suffered from unusual spitting, constituted 11%, and those from site ten, 9%. It is of interest that the values for both sites were almost the same even though site six is located close to the mine and site ten is the ontrol site. Consequently it is not certain that the mining activities have an influence on residents who suffer from unusual spitting.

In chapter five, it is reported that 17% of the pupils complained of unusual spitting with 6% of the workers having the same complaint, as indicated in chapter six. Moreover, in chapter seven, it was revealed that 29% of the health service providers responded that their patients experienced the need to spit often. Ten Brinke, De Lange, Zwinderman, Rabe, Sterk and Bel (2001) investigated whether sputum induction as a non-invasive method of evaluating airway inflammation could be safely and successfully performed in patients with severe, difficult to control asthma, and whether the patients at risk could be identified using such a technique coupled with spirometry. In this regard, medical personnel examining patients from Selebi Phikwe may be advised to make use of patients' sputum in evaluating whether there is any airway inflammation.

8.3.3 Effects of smoking on lung function

18% of those who underwent lung function tests did smoke, and they were from all the sites except sites one, two and three (Table 8.8). In Table 8.9 details of number of cigarettes smoked per day by smokers who participated in the spirometry tests according to the study sites is presented.

Table 8.8: Percentage distribution of smokers who participated in the spirometry tests according to the study sites

Site	One	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten
Yes (%)				18	40	22	50	11	30	9

Table 8.9: Number of cigarettes smoked per day by smokers who participated in the spirometry tests according to the study sites

Site	< 5	5-10	10-20	> 20	Not sure
Four	50	50			
Five	25			25	50
Six	50				50
Seven	67	33			
Eight		100			
Nine			33	33	33
Ten					100
Over all %	**31**	**19**	**6**	**13**	**31**

31% of the smokers smoked < 5 cigarettes per day and another 31% of the smokers were not sure of how many cigarettes they smoked per day. In site seven, 67% of the smokers smoked < 5 cigarettes per day, while 25% of those who smoked from site five smoked < 5 cigarettes per day and 50% of the smokers from sites four and six also smoked < 5 cigarettes per day.

19% of the smokers smoked 5 – 10 cigarettes per day. All those who smoked from site eight belonged to this category as well as 50% of those from site four and 33% from site seven. 6% of the smokers smoked 10 – 20 cigarettes per day: these represent 33% of the smokers from site nine. 13% of the smokers smoked > 20 cigarettes per day, constituting 25% of the smokers from site five, and 33% from site nine. 31% of those who smoked were not sure of how many cigarettes they consumed per day.

3% of those interviewed admitted that they smoked dagga (cannabis), constituting 17% of the smokers from site seven, and 20% from site nine. They were, however, not sure of how many wraps they took per day.

Table 8.10 gives the details of spirometry results of respondents who indulged in smoking. None of the respondents who smoked showed normal spirometry. 6% of those who smoked were classified as having severe obstruction with the possibility that the obstruction may have been underestimated. At the same time, 20% of respondents who smoked were considered as having severe obstruction, and none of the respondents who smoked regularly had severe obstruction where air trapping was suspected. There were cases whereby obstruction was underestimated and 31% of respondents who smoked were classified in this category (Table 8.10).

20% of respondents who smoked had borderline obstruction with the possibility that the obstruction may have been underestimated, and a further 20% of respondents who smoked were considered as borderline obstruction. 50% of respondents who smoked had mild obstruction, and 30% had mild obstruction with the possibility that the obstruction may have been underestimated. None of respondents who smoked were classified as having moderate obstruction with the possibility that the obstruction may have been underestimated (Table 8.10).

Table 8.10: Interpretation of spirometry results of respondents who smoked

Interpretation	A	B	C	D	E	F	G	H	I	J	K
Number	1	4	4	2			1		3		1
Total %	6	31	20	50			20		30		20

(Legend; A = Consider severe obstruction. Obstruction may be underestimated, B = Obstruction may be underestimated, C = Consider borderline obstruction. Obstruction may be underestimated, D = Consider mild obstruction, E = Consider severe obstruction. Obstruction may be under-estimated. Air trapping may be present, F = Consider moderate obstruction. Obstruction may be underestimated, G = Consider borderline obstruction, H = Consider moderate obstruction, I = Consider mild obstruction. Obstruction may be underestimated, J = Consider normal spirometry, K = Consider severe obstruction)

Subjects who reported that they suffered from respiratory diseases (emphysema and current asthma), who smoked, or who suffered from significant breathlessness upon exertion, had lower FEV_1 values. The effect of respiratory disease in this study on men was greater than on women. Similar observations have been reported by Gottleib *et al.* (2001); Pulmonary World, (2002) and Walsh (2003).

Apostol, Jacobs, Tsai, Crow, Williams, Townsend and Beckett (2002) demonstrated that initiation to early smoking may injure lungs in childhood, and may support behaviours and pathology that could lead to lung injury in adulthood. However, this study did not investigate whether those reported to be smoking in this research started the habit in childhood or not.

8.5 Conclusions

According to the American Thoracic Society (1995), spirometry is principally a screening technique used to show pulmonary changes within a person, but which cannot be used to diagnose specific pulmonary disorders in individuals. In the USA, nearly 16 million individuals suffer from some form of COPD, and COPD is the fourth ranking cause of death immediately after heart ailments, cancers and stroke (Lewis, 1999). Most of the victims contract COPD from cigarette smoke, or other PAM and toxins that pollute the air. In a study conducted by Rosas, Byrd, McMullen, Morandi, Smith and Stock (1995), five major types of air pollution were identified in the Houston, Texas area of the USA: these were air toxics, ozone, PAM, environmental tobacco smoke (ETS) and radon. In the Selebi Phikwe area, three of these environmental pollution types are evident and these are PAM, air toxics (gaseous fumes), and ETS. Pope *et al*., (1995) and Pope, Schwartz and Ransom (1992), further demonstrated that there is a decrease in lung function of human beings in the presence of PAM, SO_2 and related gases. Because of significant levels of PAM and sulphur rich gases in Selebi Phikwe (Ekosse *et. al*., 2003a), the potential certainly exists for most of the 48% of respondents in this study complaining of symptoms such as chest pain, coughing, shortness of breath and unusual spitting, to develop COPD.

Studies conducted by Cohen (1978), Petty (1997), and Skillrud, Offord and Miller (1986) have demonstrated that a close relationship exists between lung cancer and diseases characterised by airflow obstruction such as emphysema, chronic and asthmatic bronchitis. Spirometry is a non-invasive test that could be used in predicting lung health and monitoring diseases especially the COPDs (Blonshine and Fink, 2000). Furthermore, Pěrez-Padilla, Redgaldo-Pineda and Vázquez-Garcia (2001) advocated the use of spirometry in determining the status of workers claiming for disability. In Botswana, spirometry has not as yet been used in this regard. However, mining companies may explore this possibility.

In this study, we have used spirometry to determine the lung health status of residents of the Selebi Phikwe area, Botswana. Research findings reported in chapters four, five, six and seven on respondents who complained of chest pains, coughing, shortness of breath, and unusual spitting have been confirmed through the administration of both questionnaires and lung function tests. Values obtained for respondents who complained of chest pains and persistent coughing are high. It is suggested that mining and smelting activities at Selebi Phikwe may have played a major contributory role towards the complaints experienced by the respondents.

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Appendix 8. 1

Human Health Hazards at the Selebi Phikwe Ni-Cu Mine Area, Botswana

Lung function questionnaire

1.1.1 Gender	Male		Female			
1.1.2 Age group	0-10 yrs	11-20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	+ 50 yrs
1.1.3 Occupation	Mine Worker	Mine administrator	Mine supervisor	Smelter/Concentrator worker		
	Teacher	Hospital staff	Politician	Smelter/Concentrator administrator		
	Business personnel	Hotel/Restaurant staff	Government employee	Smelter/Concentrator supervisor		
	Shop/Supermarket staff	Housewife	Apprentice	Industrial Class worker		
	Student	Farmer	Unemployed	Other (specify)		

1.1.4 How long have you lived in the Selebi Phikwe area?					
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21-25 yrs
	26-30 yrs	31-35 yrs	36-40 yrs	41-45 yrs	> 45 yrs

1.1.5 Which area describes best where you live at Selebi Phikwe?		
Sampling site	Location/Characteristics	
1	Industrial area (150 m past the railway crossing)	
2	Bosele Hotel (commercial area) and new township	
3	Between the township stadium and the mine (behind the Botswana Power Corporation, BPC)	
4	Between Township boundary and the railway line (directly behind a Community Junior Secondary School, CJSS)	
5	Opposite the Mine hospital, close to old township	
6	Between the mine and explosive storage facilities (close to old township)	
7	Towards the airport (about 250 m from the Airport-Sefophe-Selebi Phikwe Road juncture)	
8	Off untarred road leading to the Selebi North mine (100 m out of township boundary, adjacent to the new township)	
9	Close to the second bridge before entering into the Selebi Phikwe township	
10	Control site located close to the road juncture leading to Selebi Phikwe from the Gaborone-Francistown main road	

1.1.6 What is the purpose of your stay at Selebi Phikwe?					
	Employment	Schooling	Home town	Visiting	Other (specify)

1.1.7 Personal details	Weight (kg)	Height (cm)	Race	

1.1.8 Do you smoke cigarettes?	Yes		No	

1.1.9 If answer to 1.1.8 is yes, how many cigarettes do you smoke per day?

Less than five	Between five and ten	Between ten and twenty	More than twenty	Not sure

1.1.10 Do you smoke dagga (cannabis)?	Yes		No	

1.1.11 If answer to 1.1.10 is yes, how many wraps of dagga do you smoke per day?

Less than five	Between five and ten	Between ten and twenty	More than twenty	Not sure

1.3.21 Do you experience chest pain regularly?	Yes		No	

1.3.22 If answer to 1.3.21 is yes, how often do you experience chest pain?

Daily	Weekly	Monthly	Three monthly	Not sure

1.3.23 If answer to 1.3.21 is yes, what type of chest pain?

Dull	Moderate	Acute	At times dull and at times acute	Not sure

1.3.24 What time of the day do you have chest pain?

Morning	Afternoon	Evening	Night	All day

1.3.25 What brings about the chest pain?

1.3.26 Does the chest pain affect your work/lifestyle?	Yes		No	
1.3.27 Do you experience shortness of breath regularly?	Yes		No	

1.3.28 If answer to 1.3.26 is yes, what type of shortness of breath?

Dull	Moderate	Acute	At times dull & at times acute	Not sure

1.3.29 What time of the day do you experience shortness of breath?

Morning	Afternoon	Evening	Night	All day

1.3.30 What brings about the shortness of breath?

1.3.31 Does the shortness of breath affect your work/lifestyle?	Yes		No	
1.3.12 Do you cough often?	Yes		No	

1.3.13 If answer to 1.3.12 is yes, how often do you cough?

Regularly every day	Once a day	Once a week	Once a month	Not sure

1.3.14 What time of the day do you usually cough?

Morning	Afternoon	Evening	Night	All day

1.3.15 What is the cause of the cough?

1.3.16 Do you spit regularly?	Yes		No	

1.3.17 If answer to 1.3.16 is yes, what type of sputum?

Clear sputum	Milky sputum	Greenish sputum	Sputum with blood	Black sputum

1.3.18 What time of the day do you usually spit?

Morning	Afternoon	Evening	Night	All day

1.3.19 What is the cause of your spitting?

1.3.20 Does the spitting affect your work/lifestyle?	Yes		No	

Chapter Nine

Using the Geographical Information System in Understanding the Human Health Status within the Selebi Phikwe Ni-Cu Mine Area

The materials reported in this chapter are presented in a landscape format because of the GIS generated maps. In the landscape format, the maps are better presented than in the portrait format.

9.1 Introduction

Data presented in this chapter mainly covers information reported in chapters four, five and six of this document which are related to the health status of residents, learners of educational institutions and workers of business and industrial enterprises within the Selebi Phikwe Ni-Cu mine area. It was not necessary to have a spatial presentation of data reported in chapter seven because not all the ten study sites had health service providers. Only six of the sites had health facilities. In this chapter, the focus is on a pictoral presentation of selected data which was considered to be having negative health effects on the residents, learners and workers of enterprises of the study area.

Limited studies have been carried out in Africa in which the spatial presentation of data is applied to environmental health. However, the importance of local variations in patterns of health and disease are increasingly recognised, and the Global

Positioning System (GPS) allows accurate and easy determination of latitude and longitude (Ghebreyesus, Byass, Witten, Getachew, Haile, Yohannes and Lindsay (2003). Unfortunately, sophisticated Geographical Information Systems (GIS) that can process the data may not be available and accessible where they are most needed (Ghebreyesus *et al.*, 2003), especially in developing countries where resources are very limited. That not withstanding, GIS techniques are quick identification methods of finding disease foci. If properly implemented, appropriate procedures could lead to better informed control and treatment activities which could represent a better application of resources as well as improved health for the community (Ghebreyesus *et al.*, 2003).

Geographical information system techniques have been used in Botswana to characterise soils and vegetation, as well as to determine desert encroachment patterns (Arntzen, Chanda, Musisi-Nkambwe, Ringrose, Sefe, Vanderpost, 1994). However, the technique has not been implemented in the mining environments in the country. In this study, the GIS technique was applied to elucidate the environmental health status of individuals, workers of enterprises and learners of the Selebi Phikwe Ni-Cu mining environment in Botswana. The study area, Selebi Phikwe, is located in the north-eastern part of Botswana between longitudes 27°47'E and 27°53'E, and latitudes 22°55'S and 22°00'S (Figure 9.1). It has a population of about 50,000 with a 2.4% growth rate (Botswana Government National Census, 1991). Most of the working population is employed in mining and other industrial activities (Asare, 1999).

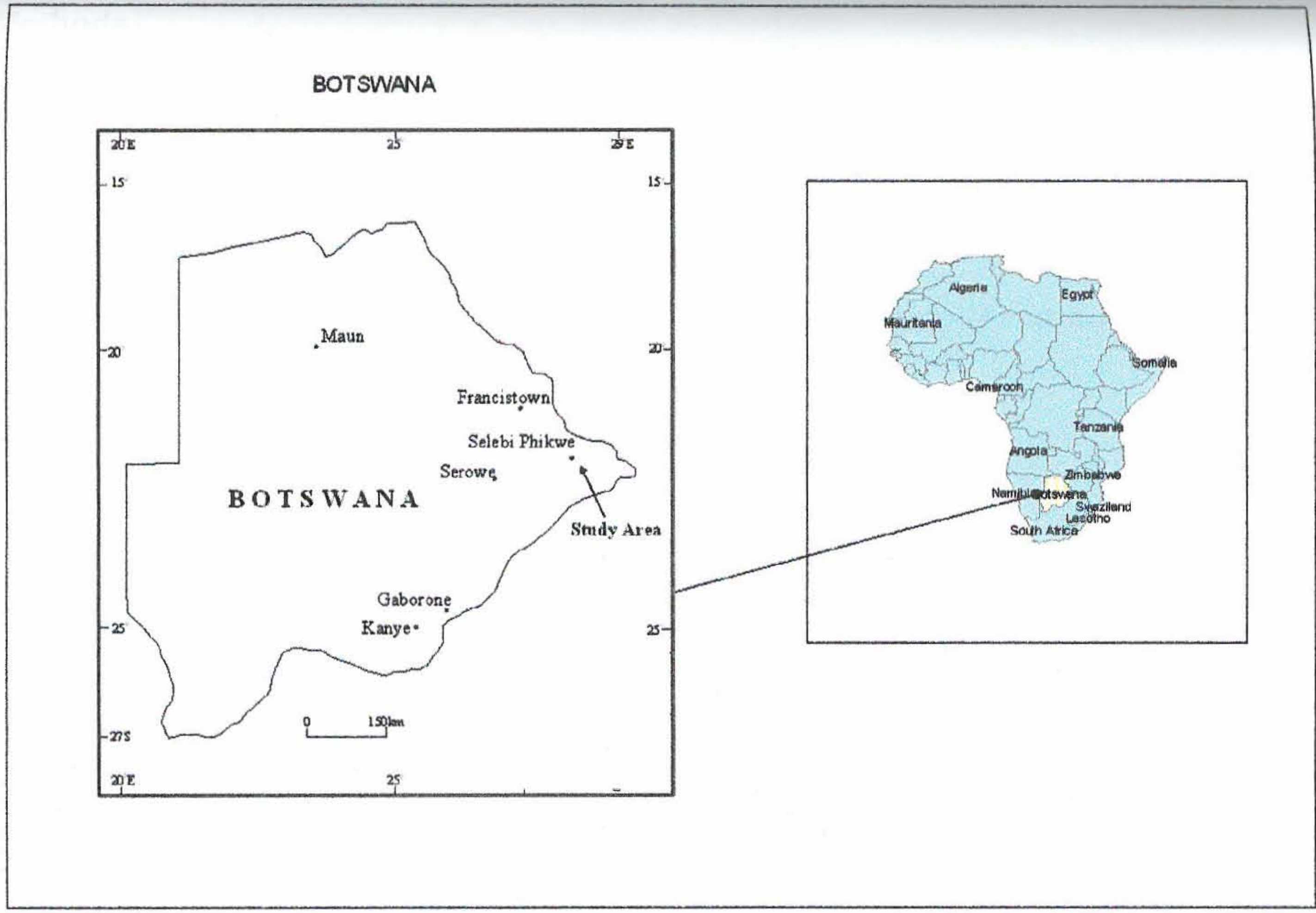


Figure 9.1: Map of Botswana indicating the study area, and map of Africa showing Botswana

9.2 Methods

The methods and analytical techniques used in spatially projecting the health status of individuals living around the Selebi Phikwe Ni-Cu mine area have been discussed in sections 3.2.1.1 and 3.3.2 of this document. Primary data concerning the general health status of inhabitants in the Selebi Phikwe area and of inhabitants at a control site was obtained by means of structured interviews conducted with selected individuals, business and industral enterprises and educational institutions (Table 9.1).

Table 9.1: Number and section of questionnaires administered to various respondents

No	Section	No of questionnaires administered	Remarks
1.	Questionnaire for individuals	600	The study area was portioned into ten different sites with an almost equal population distribution per site; 60 respondents were chosen per site including the control site.
2.	Questionnaire for businesses and industries	200	This number was chosen after reconnaissance visits. All the different types of industries at the ten different sites are statistically represented.
3.	Questionnaire for educational institutions	30	The number for all the educational institutions within the study area including the control site.

Geographical Information System (GIS) maps were generated which reflect Selebi Phikwe's infrastructure and topography, with data incorporated from the questionnaire survey. Hard copies and digital data of the Selebi Phikwe area were acquired from the Departments of Urban, Regional and Town Planning, and Surveys and Lands of the Government of Botswana. Data acquired from the Department of Surveys and Lands was geographic whereas that from Urban, Regional and Town Planning was projected. The main types of software used were: ArcGIS version 8.2, Microsoft Excel 2000, Microsoft Word 2000, while the operating system was Microsoft Windows XP. More than 50 maps were produced covering the various environmental health aspects. Twenty of these were chosen and are presented and discussed in this chapter. The 20 maps displayed in this chapter reflect demographic information, complaints about personal health, and social and environmental concerns which are considered to be directly related to the mining activities within the Selebi Phikwe study area.

9.3 Results, interpretation and discussions

9.3.1 Health status of residents

9.3.1.1 Demographical data

The age, occupation, and income status of respondents who completed the questionnaire were plotted and data displayed cartographically on the maps of the study area as shown in Figures 9.2, 9.3 and 9.4.The **age** status of residents is illustrated in

Figure 9.2. It can be deduced from the map (Figure 9.2) that more than 25% of the respondents from site 10 were > 50 years old, whereas none of those from site one who was > 50 years old. Furthermore, 28% of the respondents from site seven were 31 – 40 years old, and 60% of the respondents from site eight were not sure of their real ages even though they were adults.

Figure 9.3 shows the **occupations** of residents within the Selebi Phikwe study area. As depicted in this figure, there were mine workers who lived in all the sites except sites two and nine. Furthermore, 34% of the respondents from site one and 18% from site five were mine supervisors. 14% of the respondents from site four, 20% from site three and 24% from site nine were smelter workers. In site one, 40% of the respondents were industrial class workers. In sites four and five, 20% of the respondents from each of the sites were hotel/restaurant workers, and 42% of the respondents from site eight were not specific as to the type of employment in which they were engaged. In site 10, 24% of the respondents were farmers, 20% were apprentices, 18% were teachers and 5% were housewives (Figure 9.3). Figure 9.3 shows the **income** of residents within the Selebi Phikwe study area. The annual earnings of most of the workers were < P10 000.00. All the sites had workers with low income earnings (< P10 000.00) with the highest percentage being 33 % from site six. 50% of the workers from site eight did not specify their incomes. 55% of the workers from site three earned P60 000.00 – P70 000.00 annually, and 65 % of those from site two had an annual income of > P100 000.00.

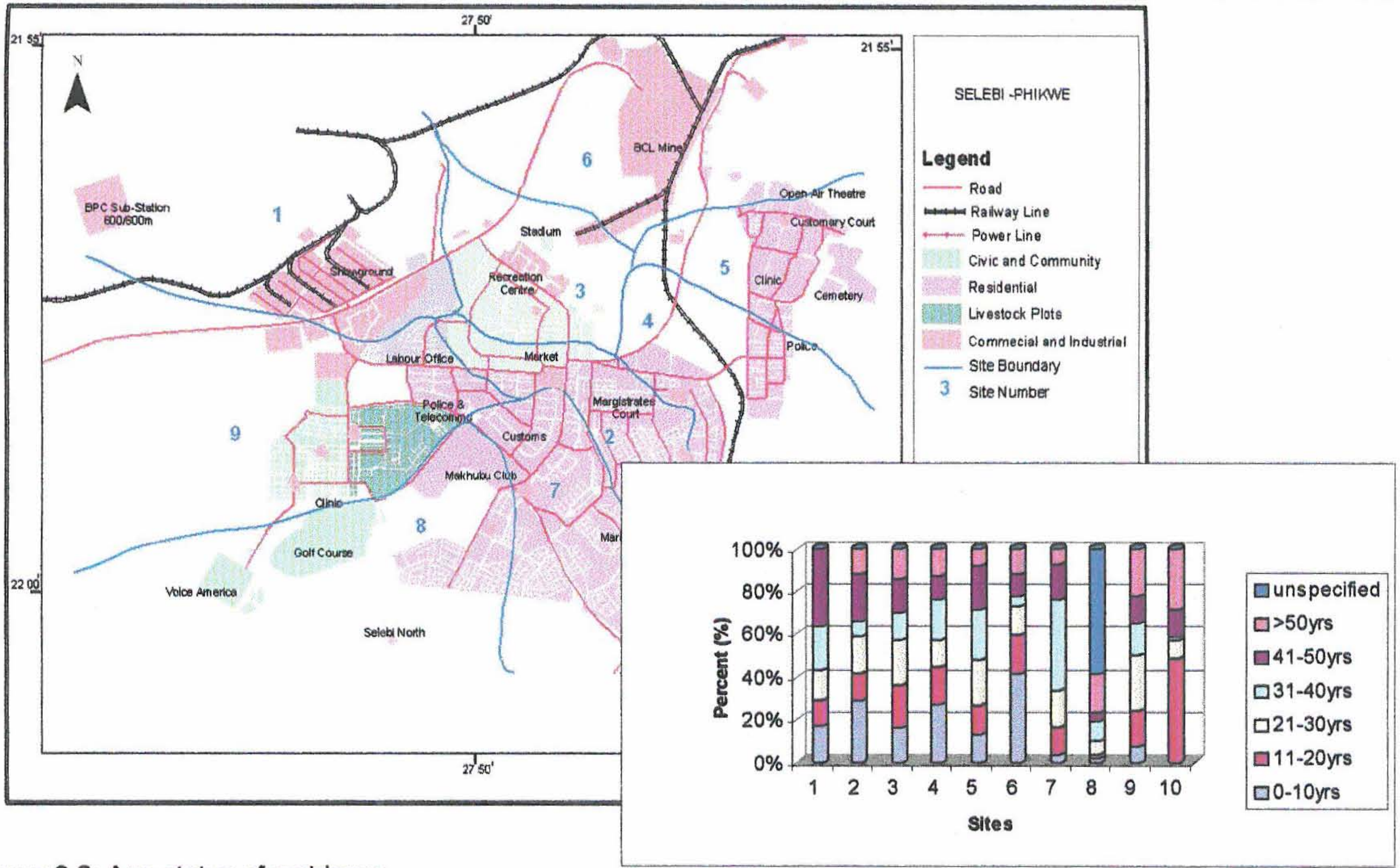
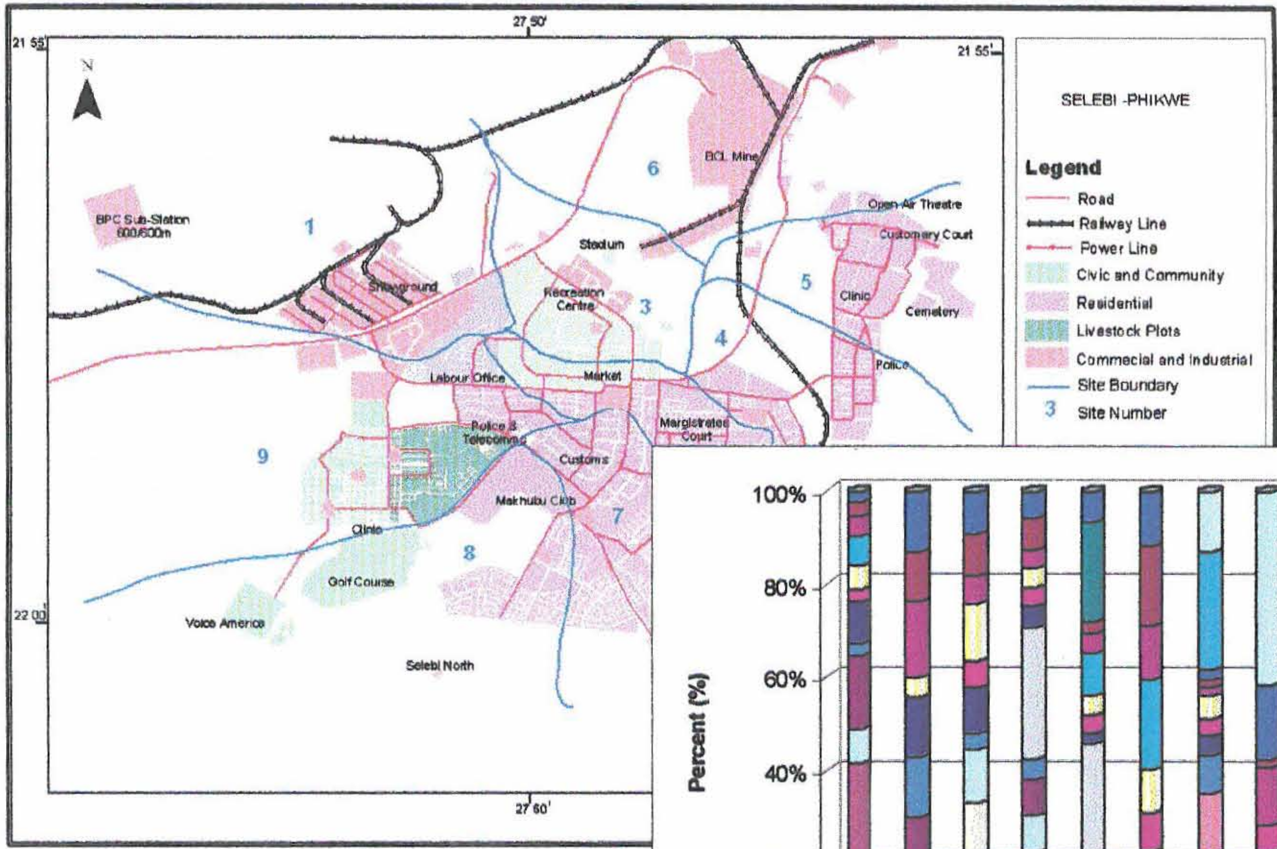


Figure 9.2: Age status of residence



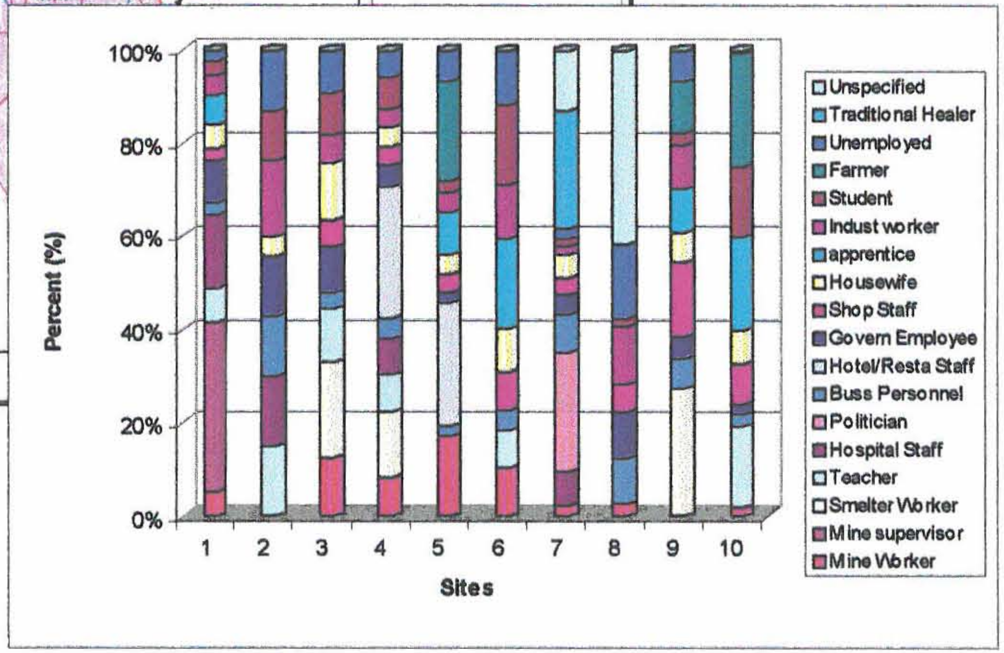


Figure 9.3: Occupation of residents

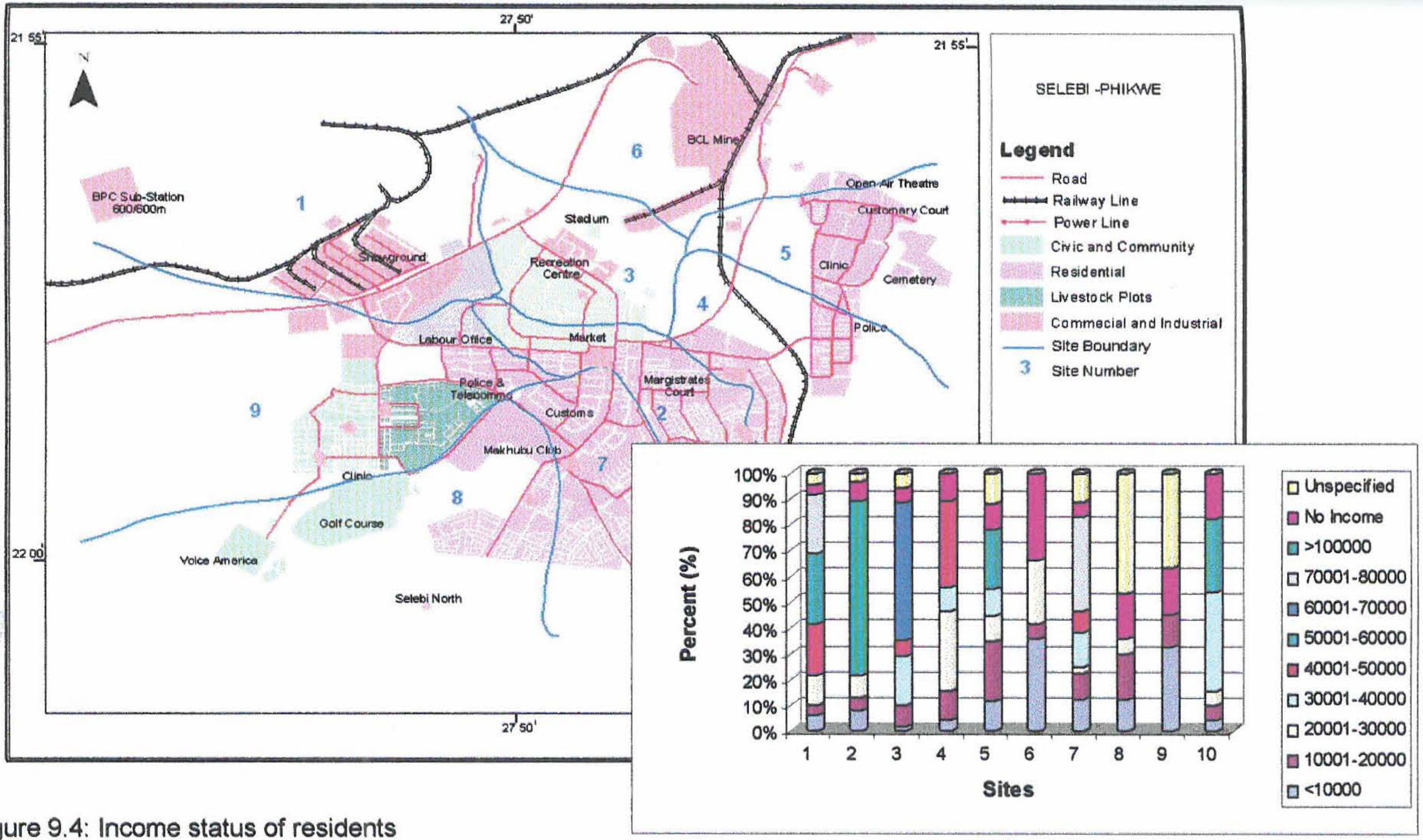


Figure 9.4: Income status of residents

9.3.1.2 General complaints of residents about personal health

From the answers given in the questionnaires, the respondents complained of experiencing palpitations, pain in the lower abdomen, shortness of breath, chest pains, unusual spitting, persistent coughing, and having frequent headaches. They further indicated that they experienced unusual loss of body weight, often had constipation, diarrhoea, and nausea and experienced vomiting. They also suffered from pain when urinating as well as having unusual discharge from genital organs. In the spatial presentation of the data concerning the general complaints of residents, as shown in Figures 9.5 and 9.6, residents suffered from frequent headaches, often had influenza/common colds, regularly had coughing bouts, and experienced chest pains frequently. A highly significant percentage of both males and females suffered from frequent headaches, high percentages of which occurred in sites three, four and eight. There were slightly more females who suffered from headaches than males. High percentages of respondents who complained of having frequent influenza/common colds were in sites three, four and eight for females, and in site eight for males. In site four, there were more males and females who complained of experiencing regular chest pains than in any of the other nine sites (Figure 9.6). In chapter eight of this document, we considered the lung functions of residents of the study area and related the results to their general health complaints, focusing on frequent headaches, regular influenza/common colds, chest pains and unusual shortness of breath. Headaches, chest pains and influenza/common colds stand out distinctly in all the investigations as the most frequent health complaints. This reality has been substantiated from the spatial presentation data displayed in Figures 9.5 and 9.6.

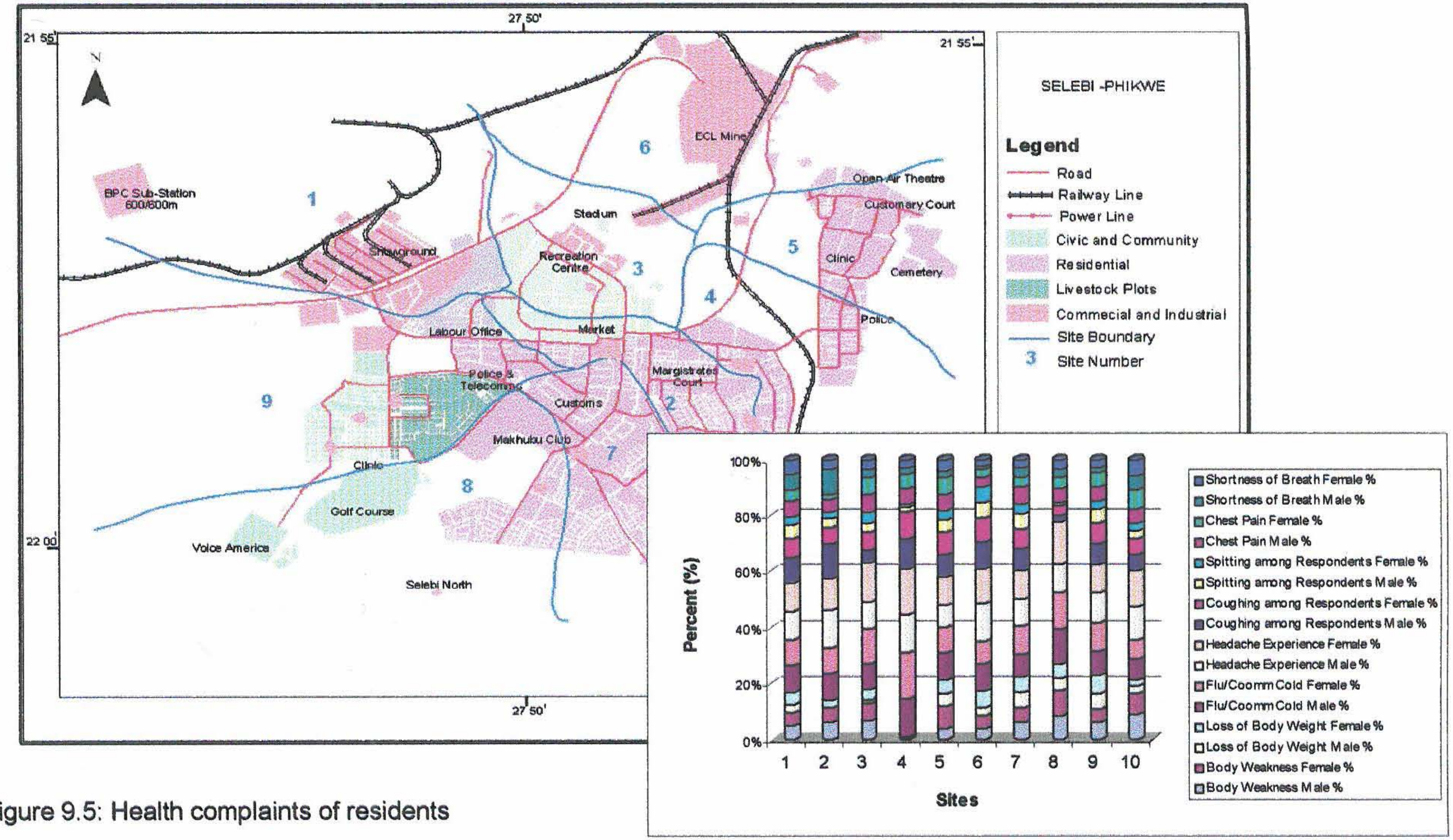


Figure 9.5: Health complaints of residents

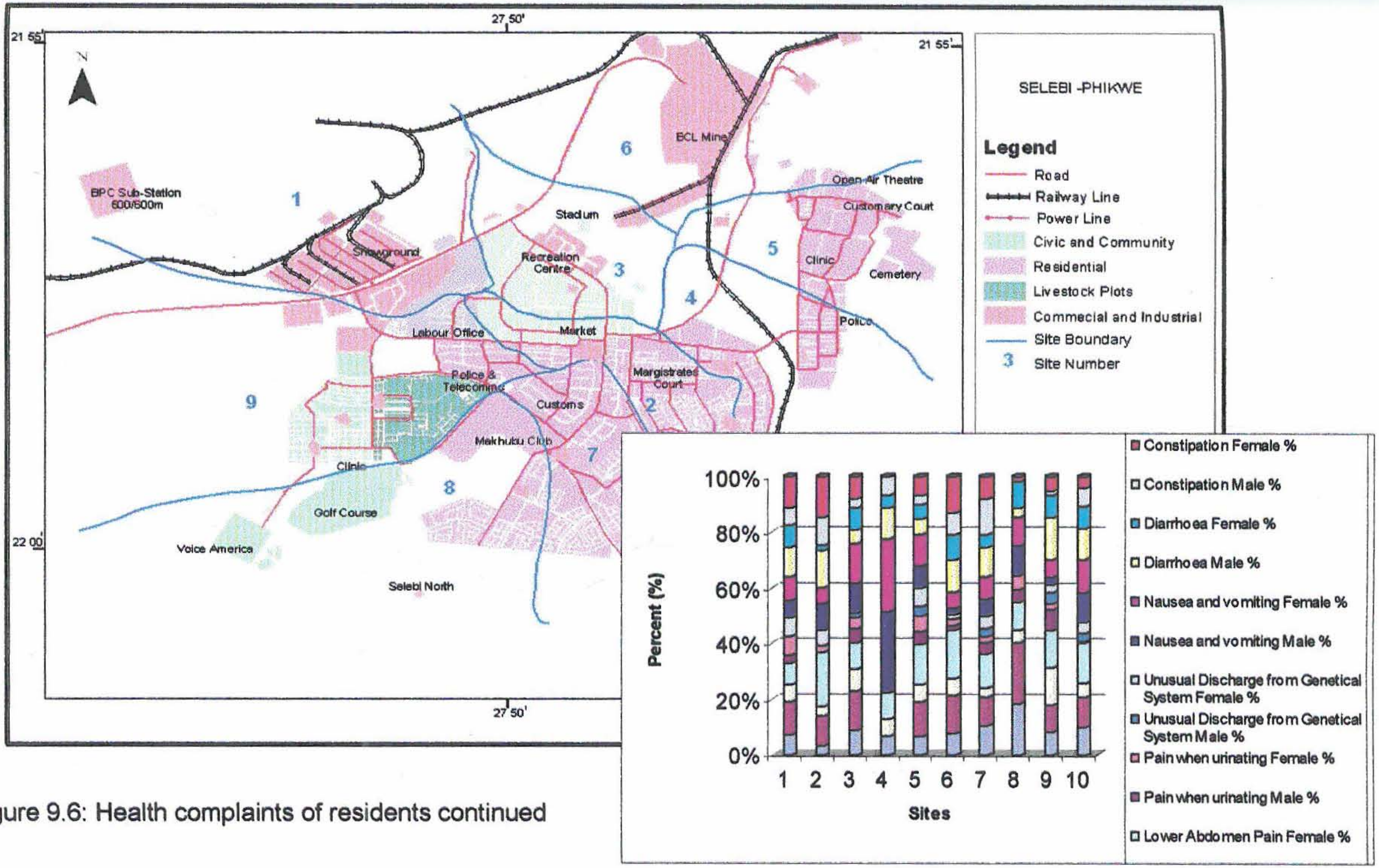


Figure 9.6: Health complaints of residents continued

9.3.1.3 Medication for pain

Figure 9.7 gives the distribution trend of respondents living the within Selebi Phikwe area who suffered from headaches, period pain, back pain, abdominal pain and chest pain. In general, percentage values for the mentioned aches and pains in the control site were statistically significant by lower than those which were obtained for the other nine sites. More than 50% of the respondents for both males and females from sites one, four, seven, eight and nine suffered from frequent headaches (Figure 9.7). Percentage values of both male and female respondents who suffered from the other pains were < 40% for each type of pain.

In terms of medication for headache, period pain, back pain, and abdominal pain, it was noticed that Panado, aspirin, penicillin and ibuprofen were the most commonly administered drugs. The respondents indicated that they could buy penicillin without a prescription and took it for pain. Most of the individuals, except those experiencing chest pains took these medicines. From Figure 9.8, it can be seen that 88% of respondents in site four suffering from pain took Panado. This was followed by 66% each from sites seven and nine, 60% from site eight and 50% from site one who all took Panado. 55% of the respondents from site seven took Ibuprofen (Figure 9.8).

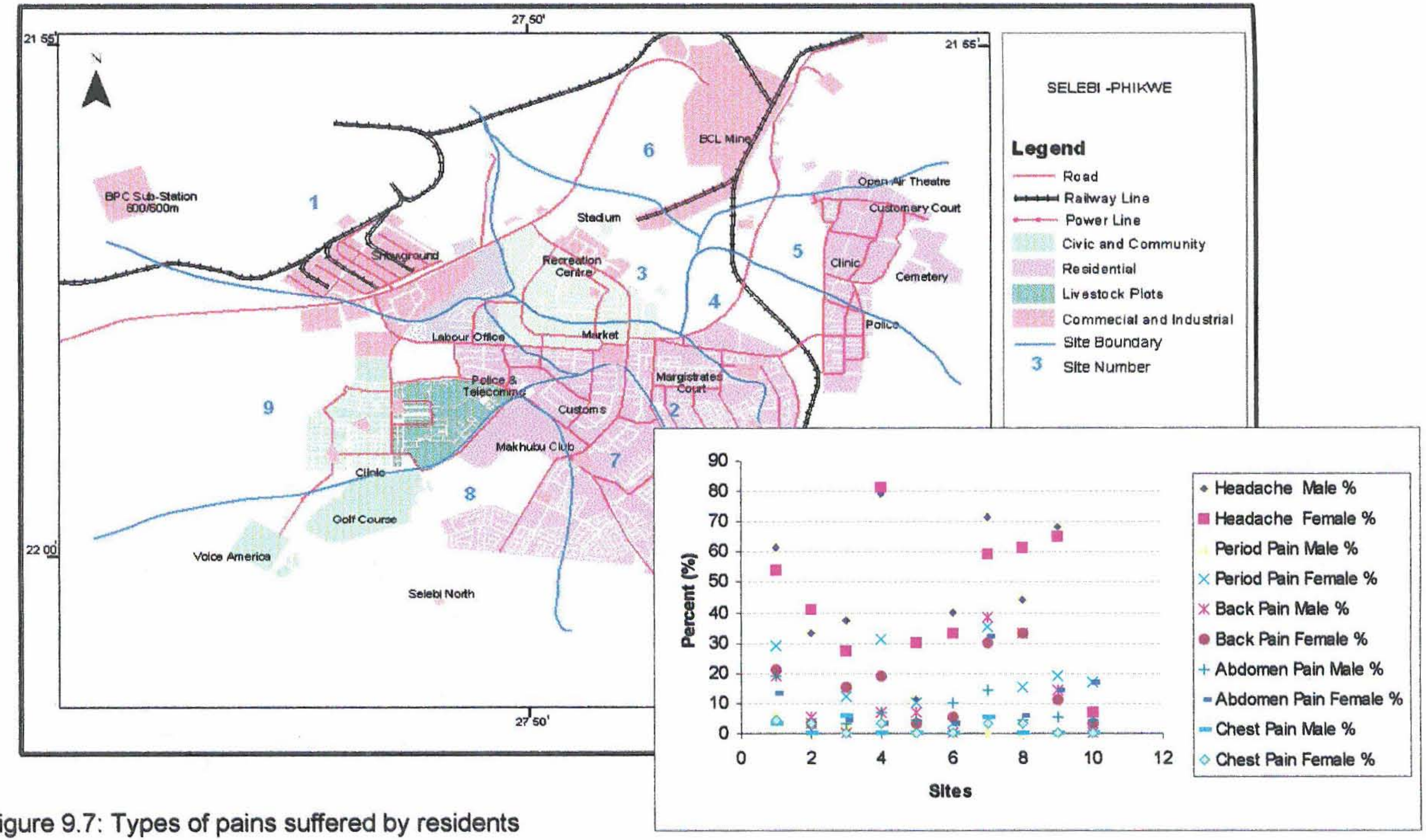


Figure 9.7: Types of pains suffered by residents

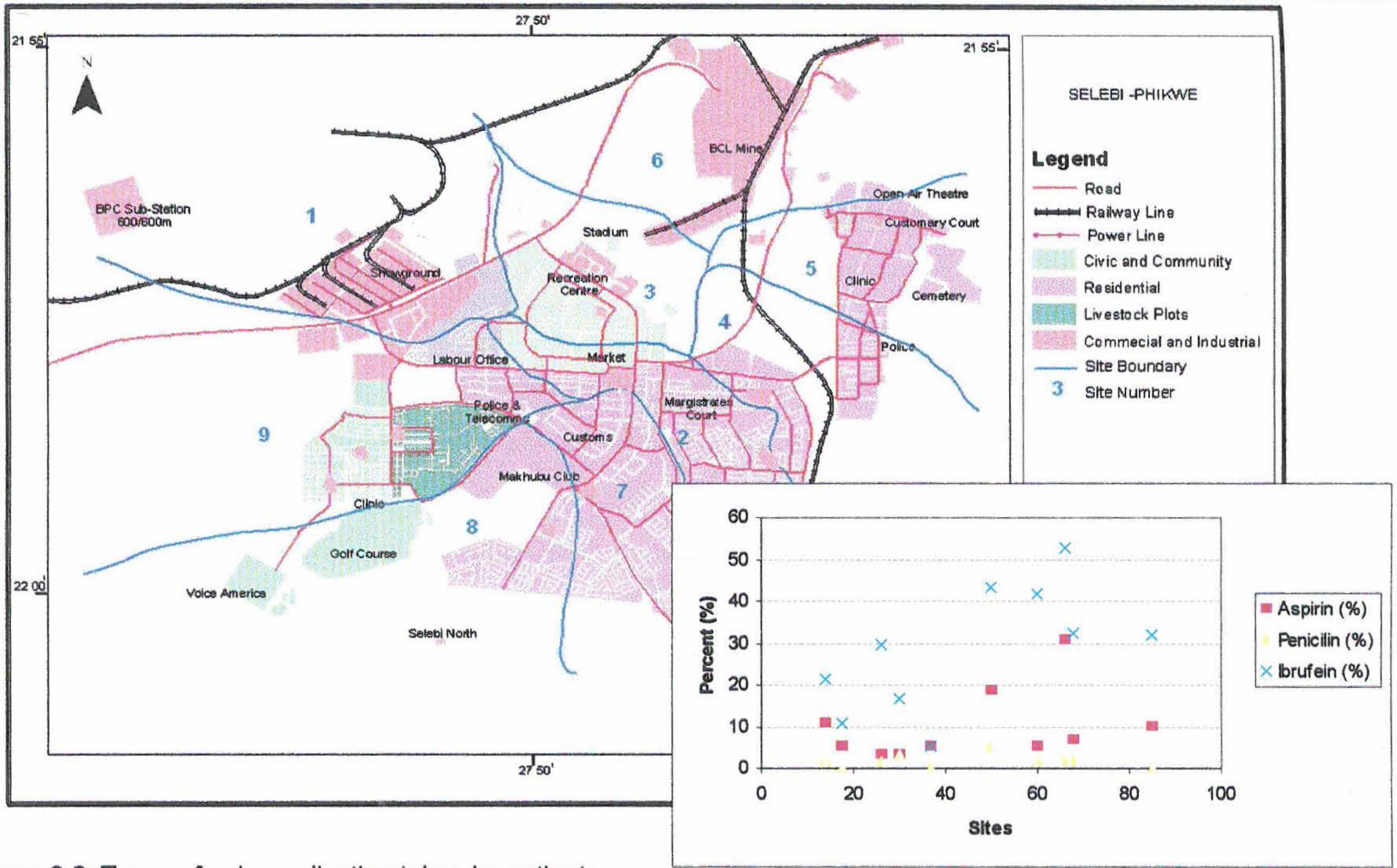


Figure 9.8: Types of pain medication taken by patients

9.3.1.4 Social and environmental aspects

Data related to consumption of cigarettes, drinks and related items by respondents living within the Selebi Phikwe study area were plotted and are presented in Figure 9.9. Generally speaking, coffee was the most consumed item followed by cigarettes, whereas alcohol and dagga were the least consumed items in that order. Considering the consumption of alcohol, beer was the most consumed followed by chibuku, while spirits and red and white wine were consumed in almost equal proportion (Figure 9.9).

The number of rooms per house in Selebi Phikwe based on the responses obtained from the questionnaires and structured interviews is given in Figure 9.10. According to the responses obtained, the highest percentage of respondents were living in houses with 2 – 5 rooms (Figure 9.10). In sites two, four, six, eight and ten, there were between 1% and 3% of household units having > 10 rooms per household. High percentage values were obtained in the class of six to ten rooms per household. However, where there were many rooms, there were also many people. This type of room density per household was significantly very high for Botswana where the average household density for Botswana is 2.4 persons, and the average number of rooms per household is two (Botswana, 2003). Overcrowding has been related to the spreading of illnesses and diseases (D'Souza, 1997), and influenza/common colds and coughs are contagious.

Imposing parameters such as the fumes from the mine and the smelter/concentrator plant, the dust generated by mining activities, vibrations due to rock blasts, and noise resulting from blasts, as well as the constant movement of heavy equipment, are considered by the residents to be disturbing environmental factors affecting their health and well being (Figure 9.11). Clearly evident is the fact that individuals have cited fumes of SO_2 to be the aspect of mining and smelting activities which disturbs them the most. The lowest percentage value for irritations by fumes reported by respondents was in site five (60%), and the highest was in site two (91%). This was not the case in the control site where percentage values for fumes, dust, vibrations and noise were very low (Figure 9.11).

There was a link between the health complaints of residents and aspects of environmental pollution which seemed to indicate that most of the people have been affected by SO_2 pollution due to mining activities. These observations have been discussed in Chapters Four, Five, Six, Seven and Eight. Furthermore, these observations have been reported in other mining environments such as in Zambia (Simukanga, 1999) and Australia (Scott, 2003) where Ni and Cu are mined. Key social and economic problems in Selebi Phikwe coupled with low level of education of the inhabitants have made it difficult for local communities to appropriately address health hazards affecting them. The efforts of the Government of Botswana in this venture are recognised and acknowledged.

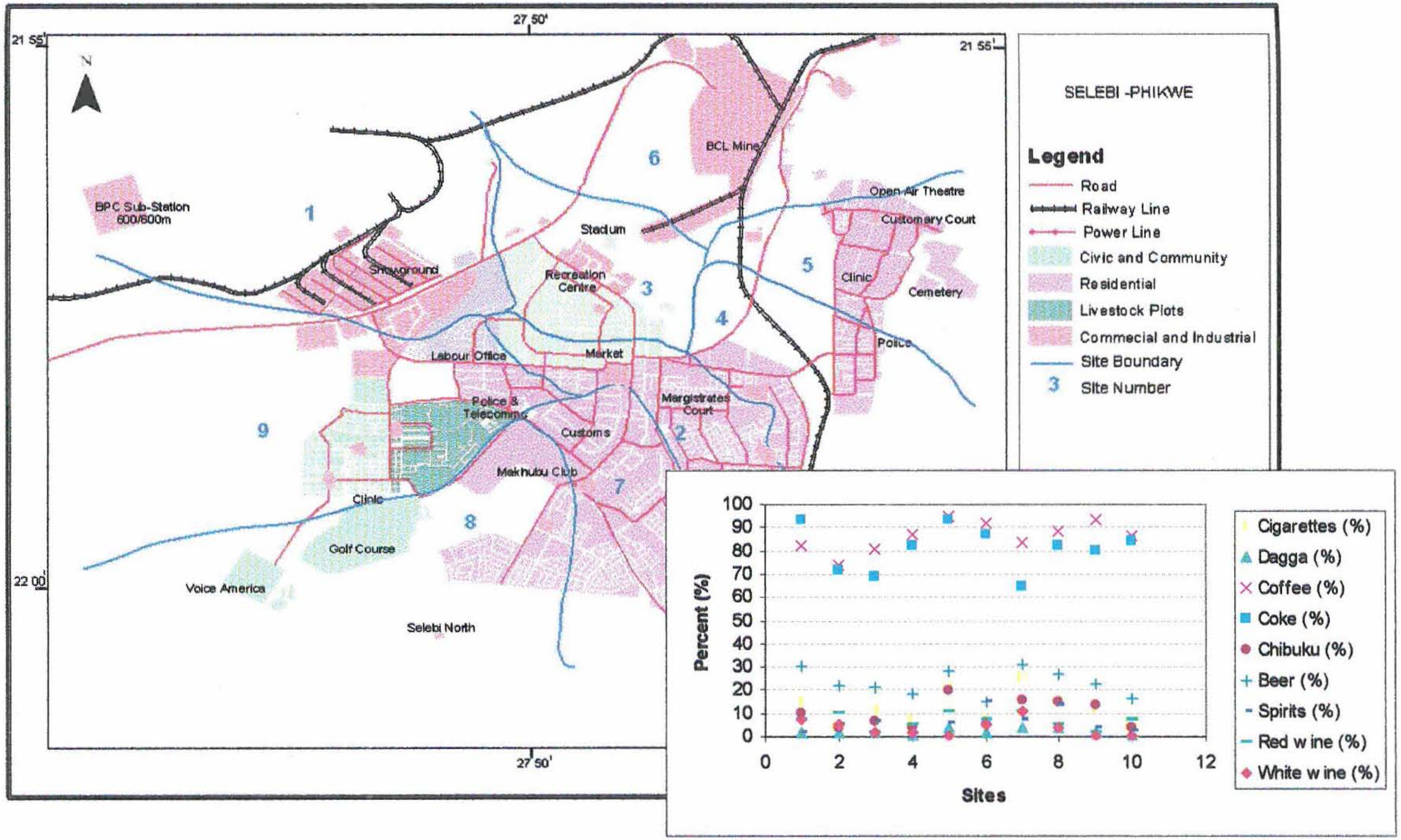
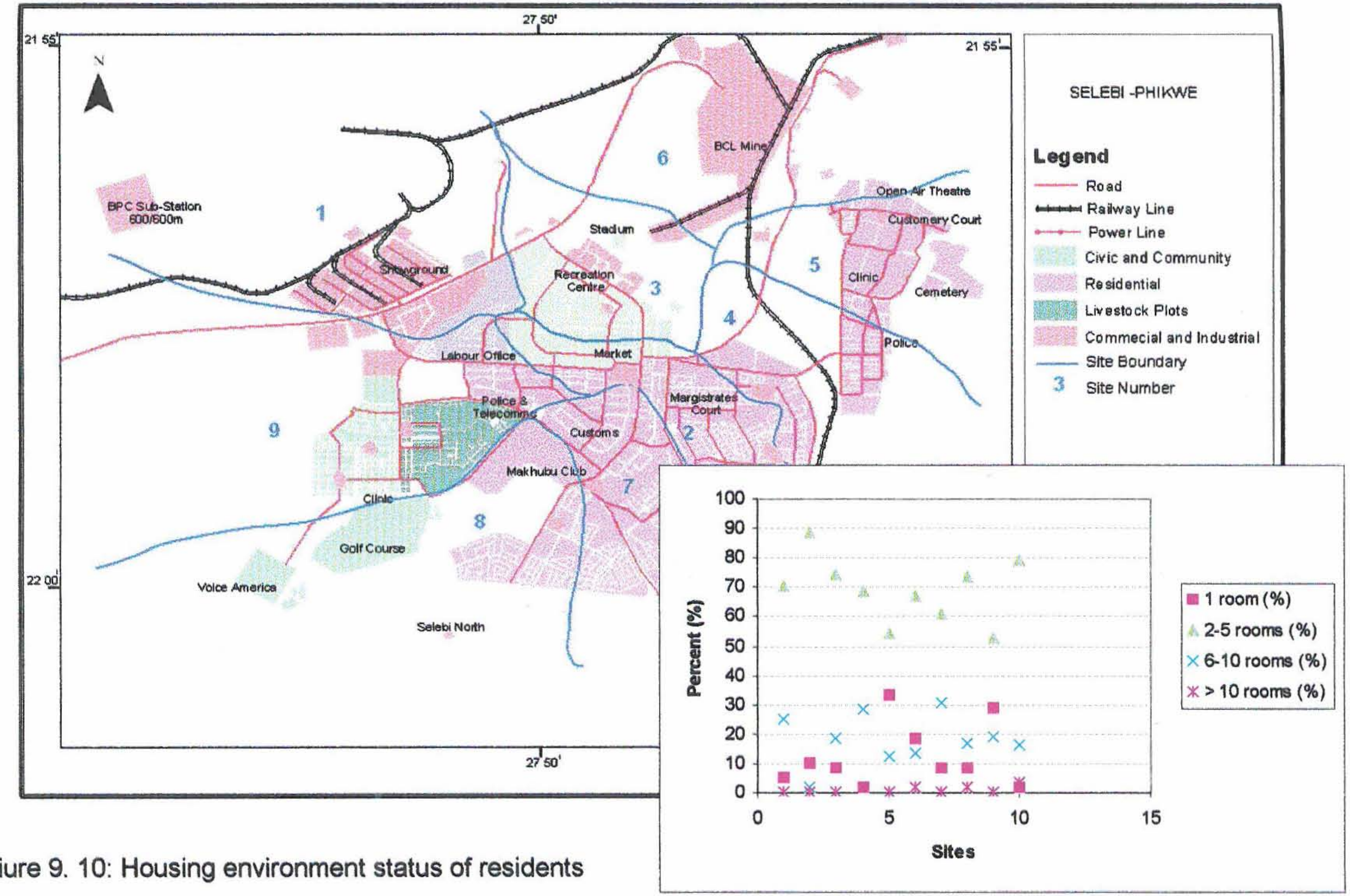


Figure 9.9: Consumption of cigarettes, drinks and related items by residents



Fiure 9. 10: Housing environment status of residents

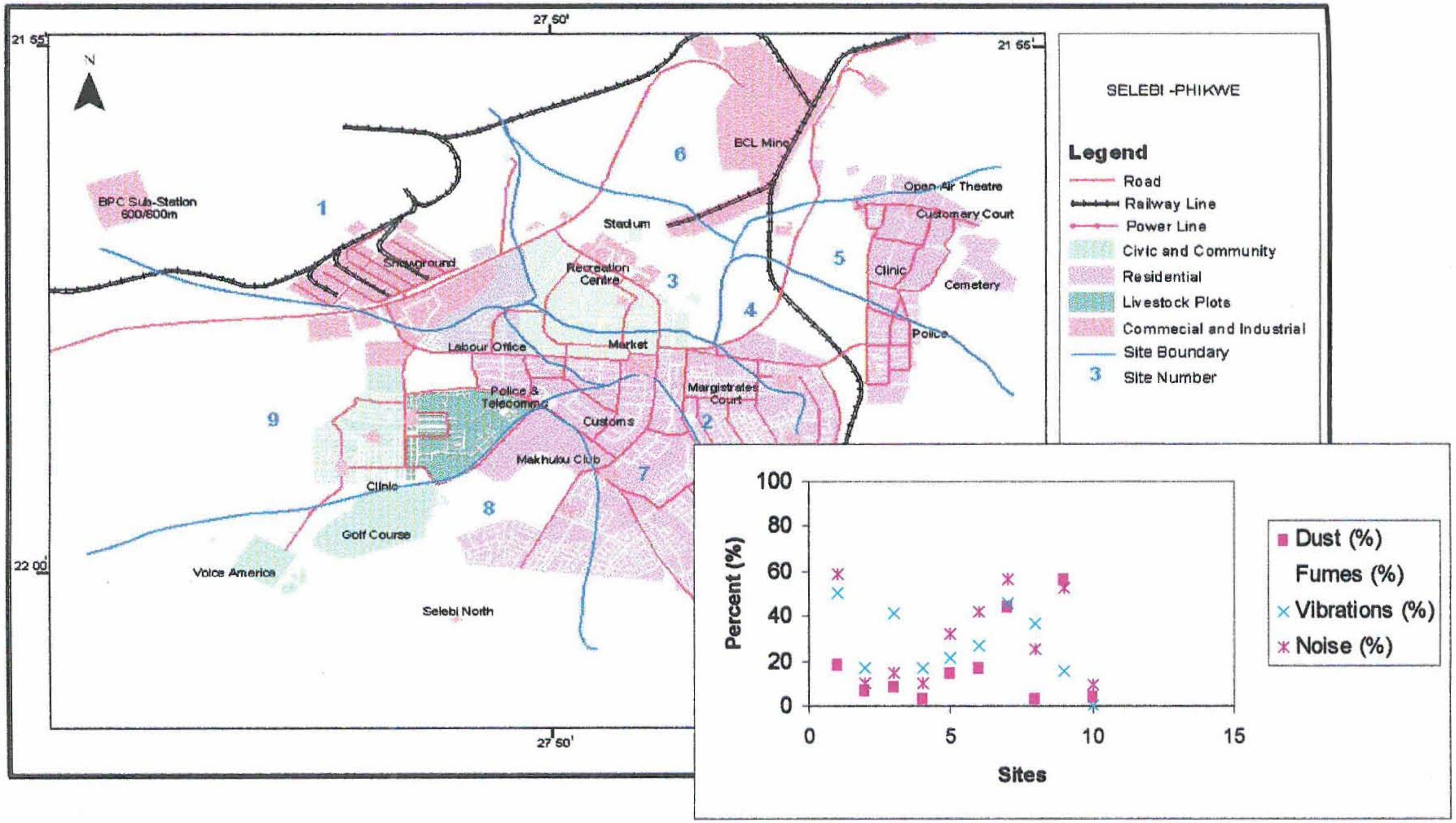


Figure 9.11: Most disturbing environmental parameters according to residents

9.3.2 Health status of learners

9.3.2.1 Demographical data

The educational institutions in the Selebi Phikwe area are owned by the Government of Botswana, the Selebi Phikwe Town Council, the BCL, and private individuals. These educational institutions were limited to nursery schools, primary, secondary and technical schools. There were no institutions offering tertiary education located in the study area. Details of types of educational institutions according to study sites are given in Figure 9.12. Nursery schools were located only in sites two, four and six, while primary schools were established in all the sites except sites one and five. Secondary and technical schools were located in all sites except sites two, three and six. Furthermore, all the schools in sites one and five were secondary and all those of site three were primary (Figure 9.12). Figure 9.13 gives the percentage distribution of number of years of operation of the educational institutions in the Selebi Phikwe area according to study sites. The first educational institutions in the area were primary schools, which constituted the 10% of institutions which were > 30 years old. These are located in sites one, two and three. While all schools in site one were 30 – 40 years old, all the schools in site five were 10 – 20 years old. 60% of the schools in site six and 50% in sites eight and ten were 20 – 30 years old (Figure 9.13). None of the educational institution has been in existence for more than half a century. From 1973 when the BCL mine started to operate, the number of educational institutions in the area also started to increase. 90% of the schools were opened over the past thirty years.

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9.3.2.2 General complaints of learners about personal health

The general complaints of learners about their personal health according to the responses given by the principals or designated officials were based on location of schools they attended according to this study. Students complained of experiencing palpitations, pain in the lower abdomen, shortness of breath, chest pains, unusual spitting, persistent coughing, and having frequent headaches. They further indicated that they experienced unusual loss of body weight, often had constipation, diarrhoea, and nausea and vomiting, and also suffered from pain when urinating as well as having unusual genital discharges. Concerning the general complaints of learners, as shown in Figure 9.14, all the institutions in site 10, 30 % of the institutions in site eight and 20% each of the institutions in sites one, four and nine indicated that their learners suffered from frequent headaches. 20% each of the institutions in sites one, two, four and nine had learners who often suffered from influenza/common colds. 20% each of the institutions in sites one, two and nine, and 15% of the institutions in sites four, five, six, seven and eight had learners who were regularly coughing. It should be noted that headaches, chest pains and flu/common colds stand distinctly in all the studies as the most frequently occurring health complaints of learners.

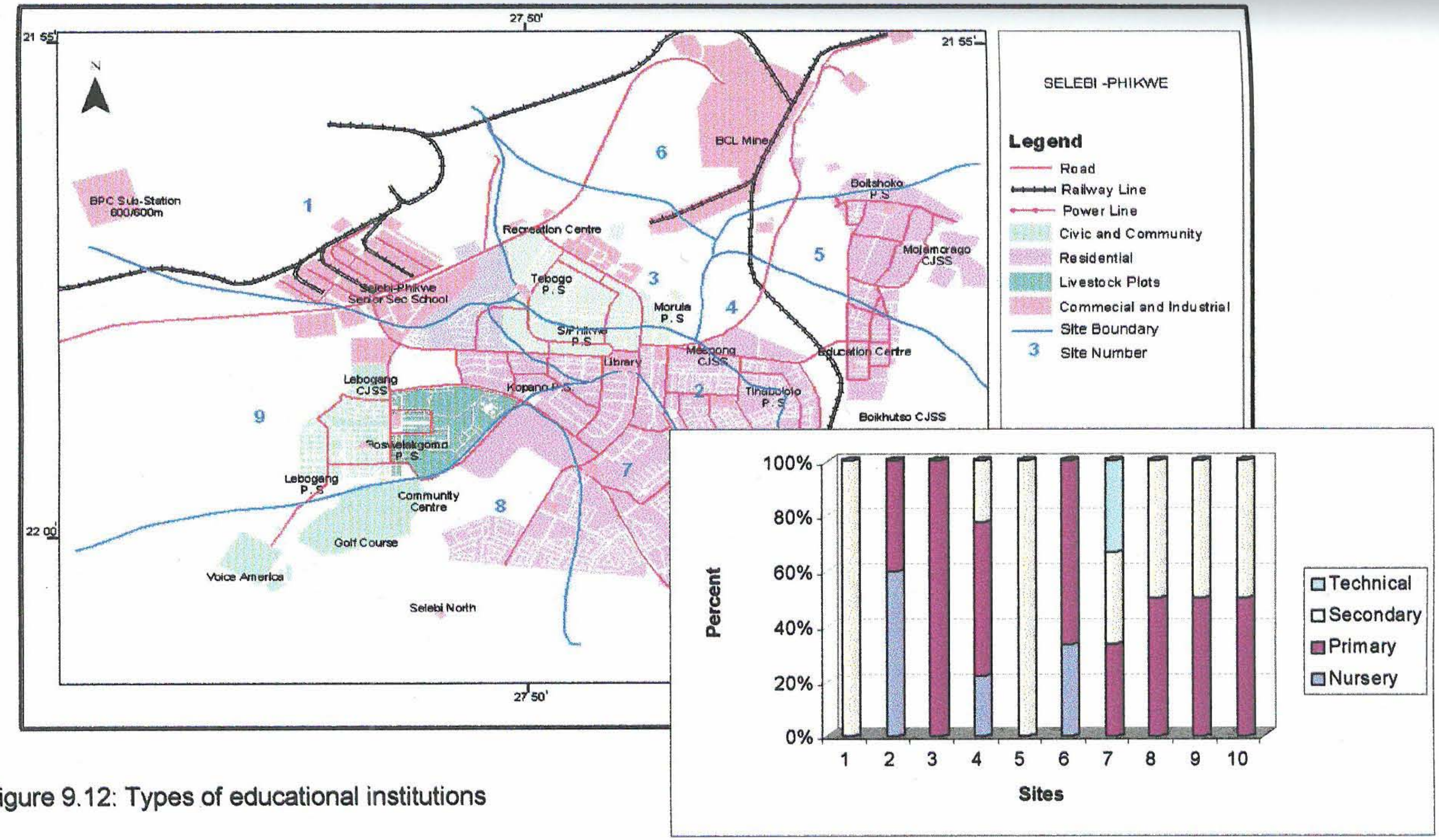

Figure 9.12: Types of educational institutions

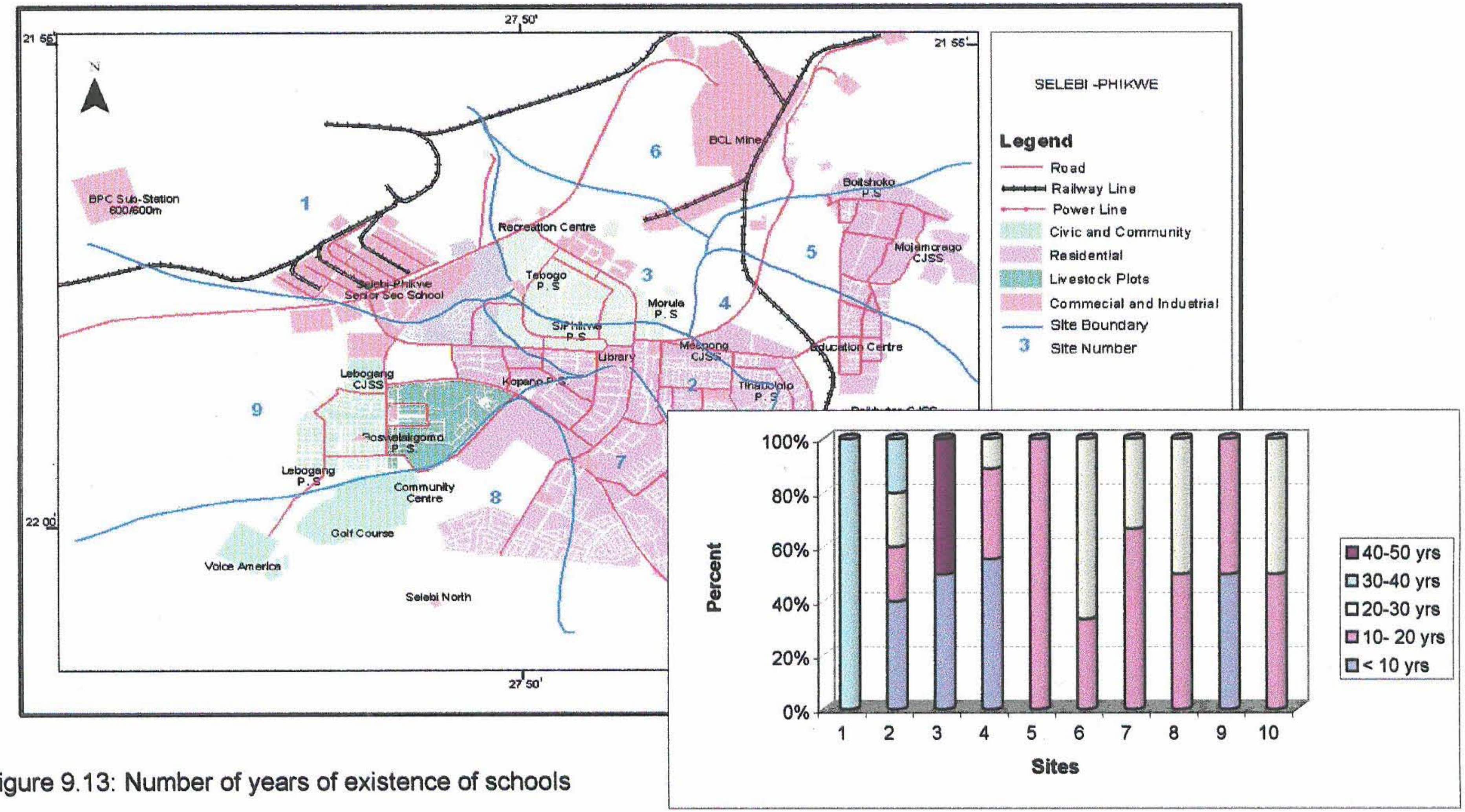

Figure 9.13: Number of years of existence of schools

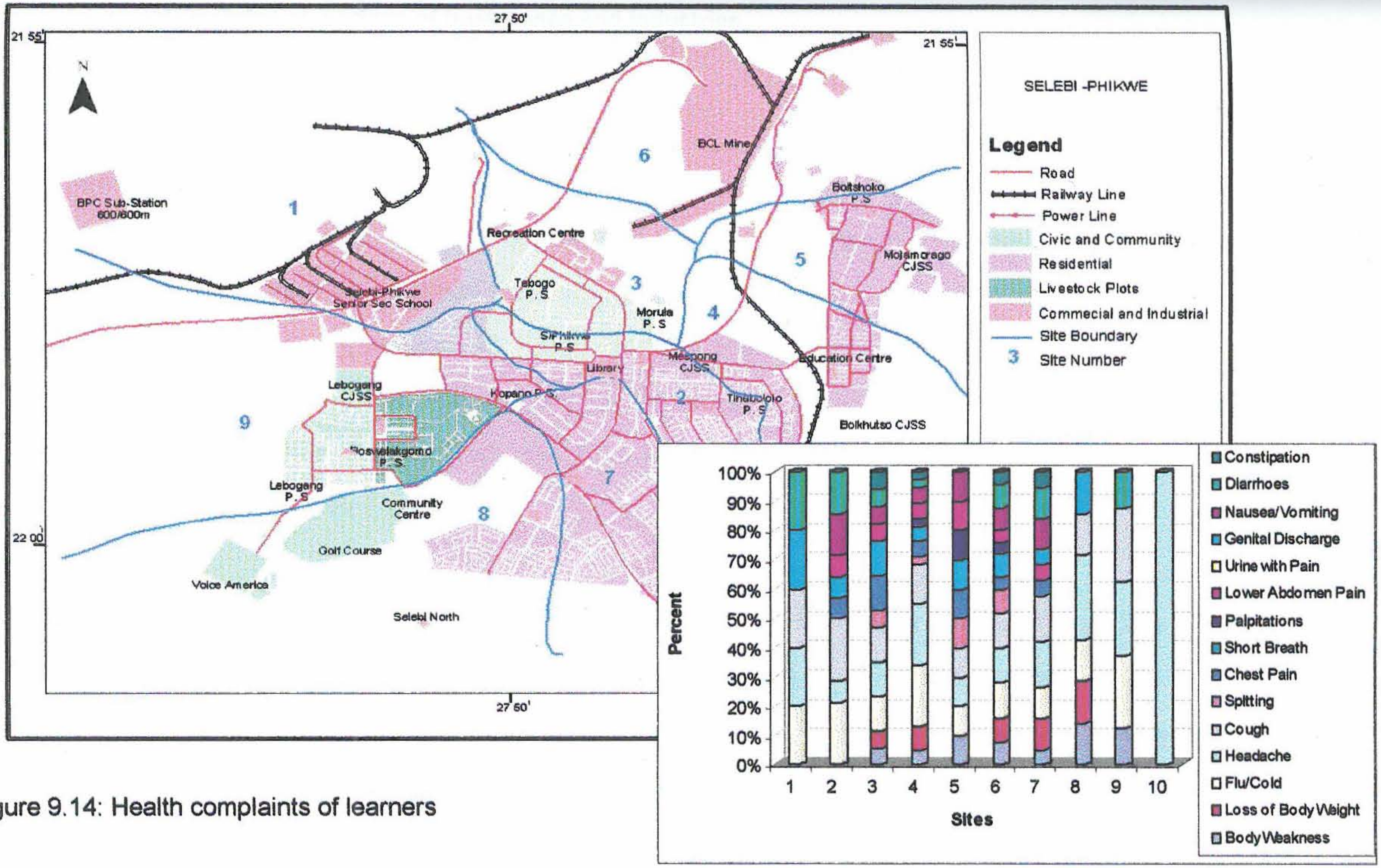

Figure 9.14: Health complaints of learners

9.3.3 Health status of workers of businesses and industries

9.3.3.1 Demographical data

Figure 9.15, which was compiled from the responses obtained from the questionnaires that were administered to the directors or delegated officials of the different industries, depicts the percentage distribution of **number of years of existence** of business and industrial enterprises in the Selebi Phikwe area according to the different study sites. 51% of the enterprises have been in existence for < 10 years and are represented in all the study sites; 30% of the enterprises are 10 –20 years old, 8% of the enterprises are 21 – 30 years old, and 2.5% of the enterprises are 31 – 40 years old. More specifically, 20% of the enterprises in site 10 are > 50 years old, > 50% of the enterprises in sites two, three, four and seven are < 10 years old, and 75% of the enterprises in site eight are 10 –20 years old (Figure 9.15).

Based on the **number of workers** employed by the enterprises, most of them are small scale enterprises (Figure 9.16). 66% of the responding enterprises that participated in this study responded that they employed < 10 workers, 19 % of the enterprises had between 10 – 20 workers, and 8% of the enterprises employed 21 – 30 workers. 3% of the enterprises had a workforce of between 31 – 90 people. Only 2.5% of the enterprises employed more than 100 workers, and the number of workers for 1.5% varied from time to time depending on the season and market forces such as foreign exchange, consumer demands and cost of production.

More specifically, as illustrated in Figure 9.16, > 50% of the enterprises, and in fact all those in sites three and eight each employed < 20 workers. 20% of the enterprises in sites one, two, four, five and nine each employed 10 – 20 workers, and a further 20% in site nine employed 20 – 30 workers. In site one, 20% of the enterprises employed > 100 workers, and in site six, 10% employed 80 – 90 workers (Figure 9.16). Based on the responses obtained from the questionnaires and structured interviews, the types of enterprises represented in the study area included 41.2% commercial, 16.6% textile, 21.1% food/hotel, 0.5% mining, 2% agricultural, 9% service providers and 3.5% liquor store-type enterprises with 6% unspecified. Figure 9.17 gives the details of how the enterprises are distributed according to the study sites. 100% of the enterprises in site five, 77% in site six and 55% in site three are commercial. All of the enterprises in site seven and 60 % of the businesses/industries in site eight are food/hotel ventures (Figure 9.17). The first businesses/industries were the commercial industries that sustained the then small population of Selebi Phikwe village before its growth to township status (Department of Town and Regional Planning, 1996).

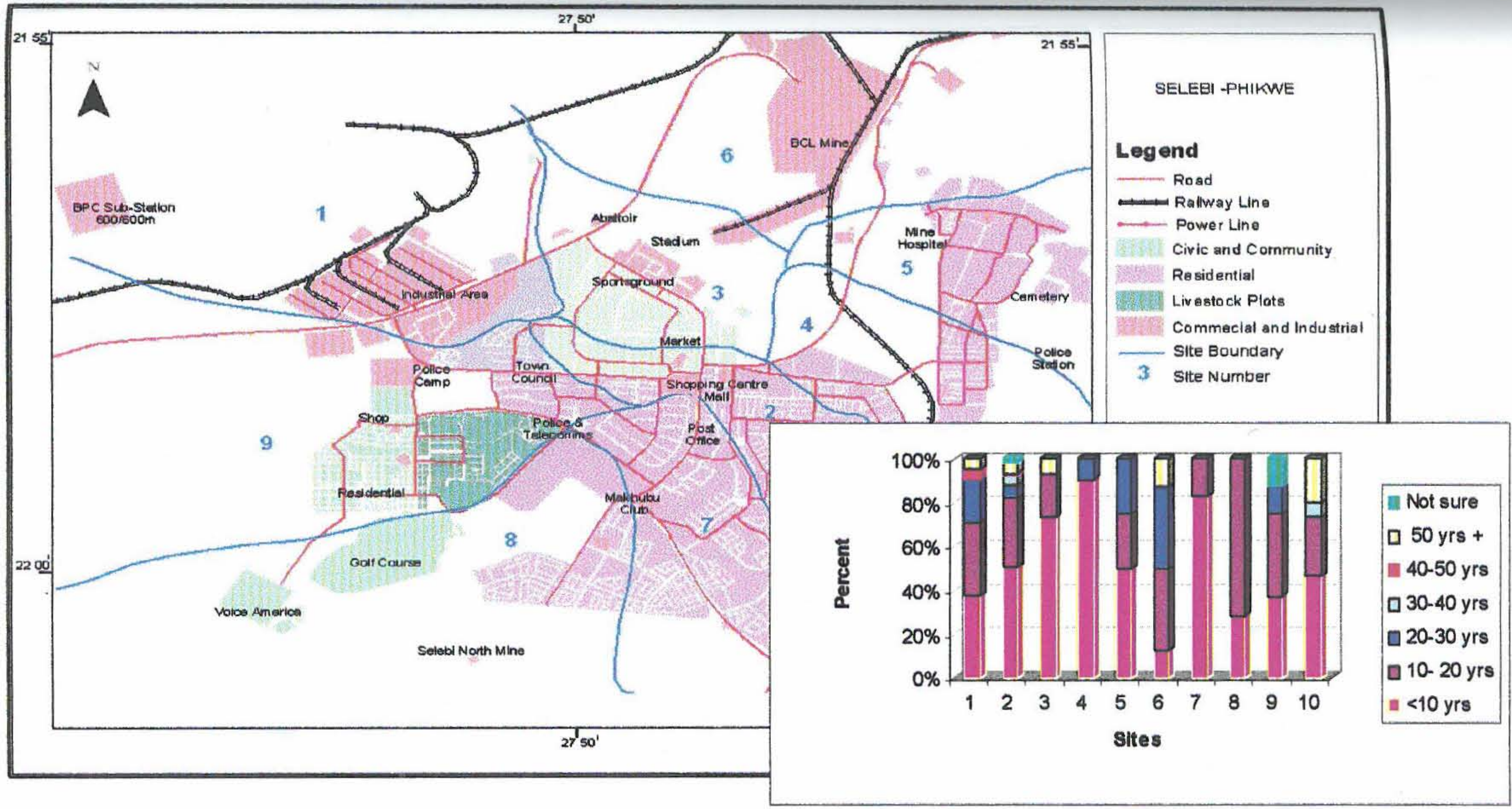

Figure 9.15: Number of years of existence of enterprises according to sites

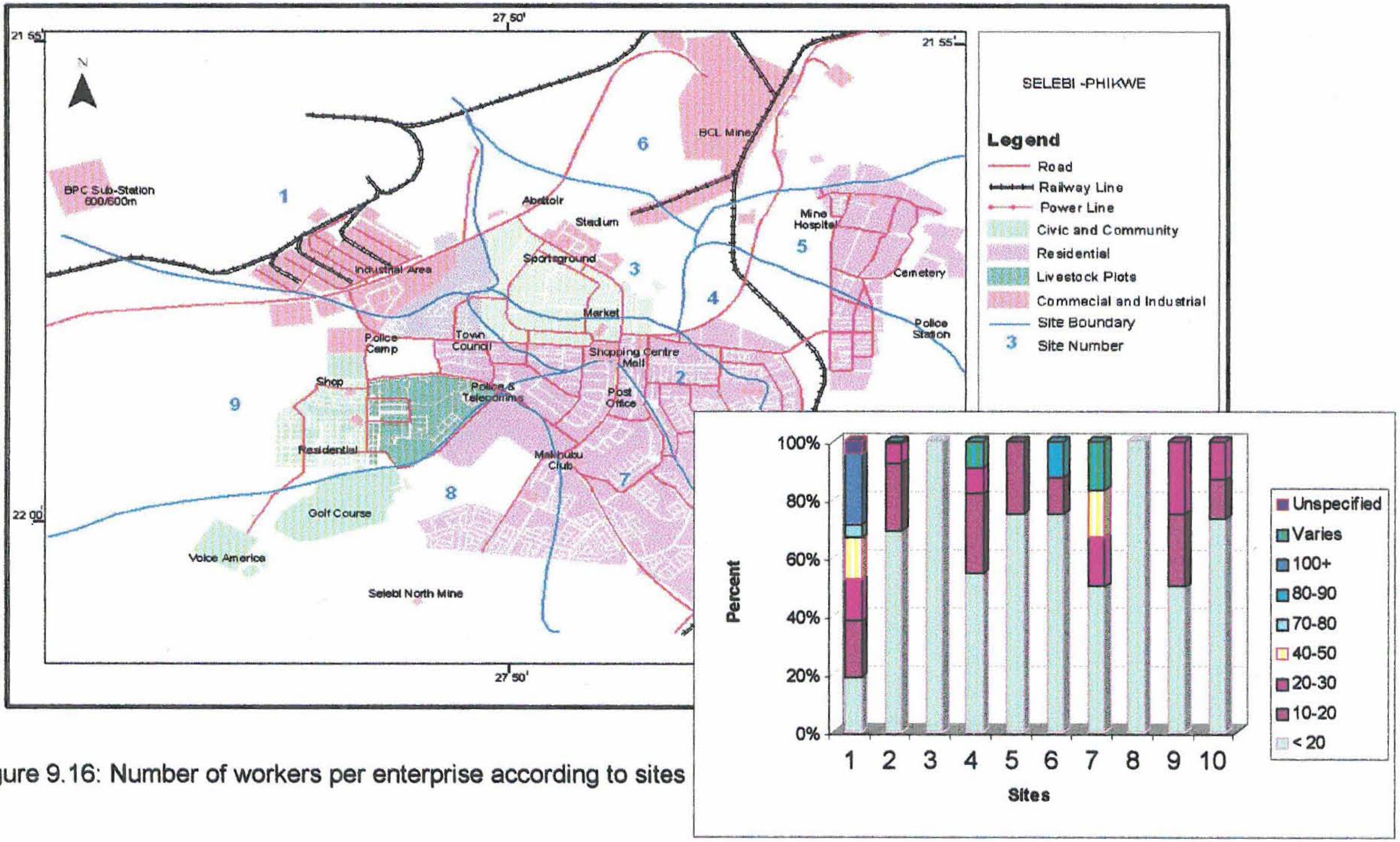

Figure 9.16: Number of workers per enterprise according to sites

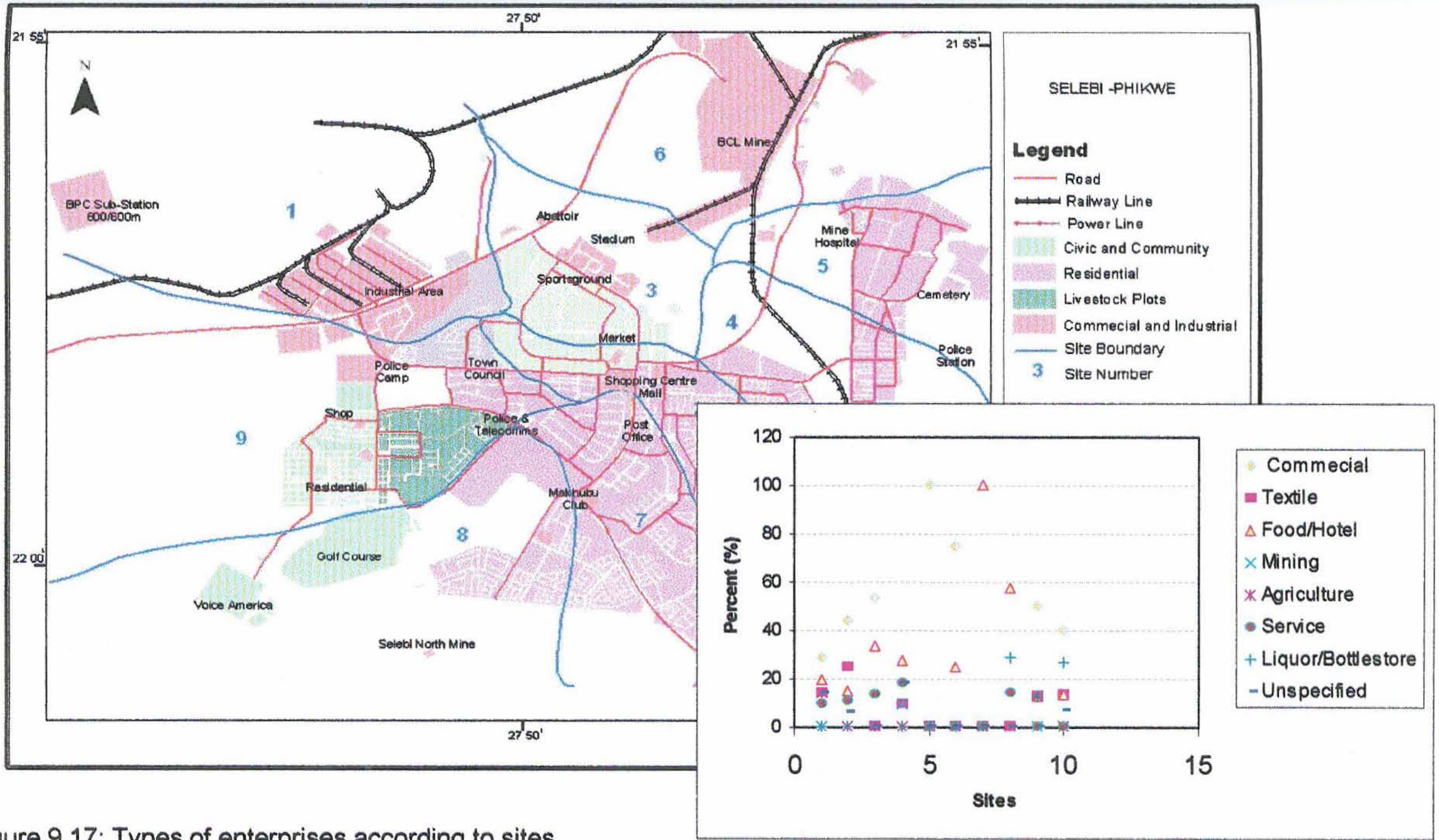

Figure 9.17: Types of enterprises according to sites

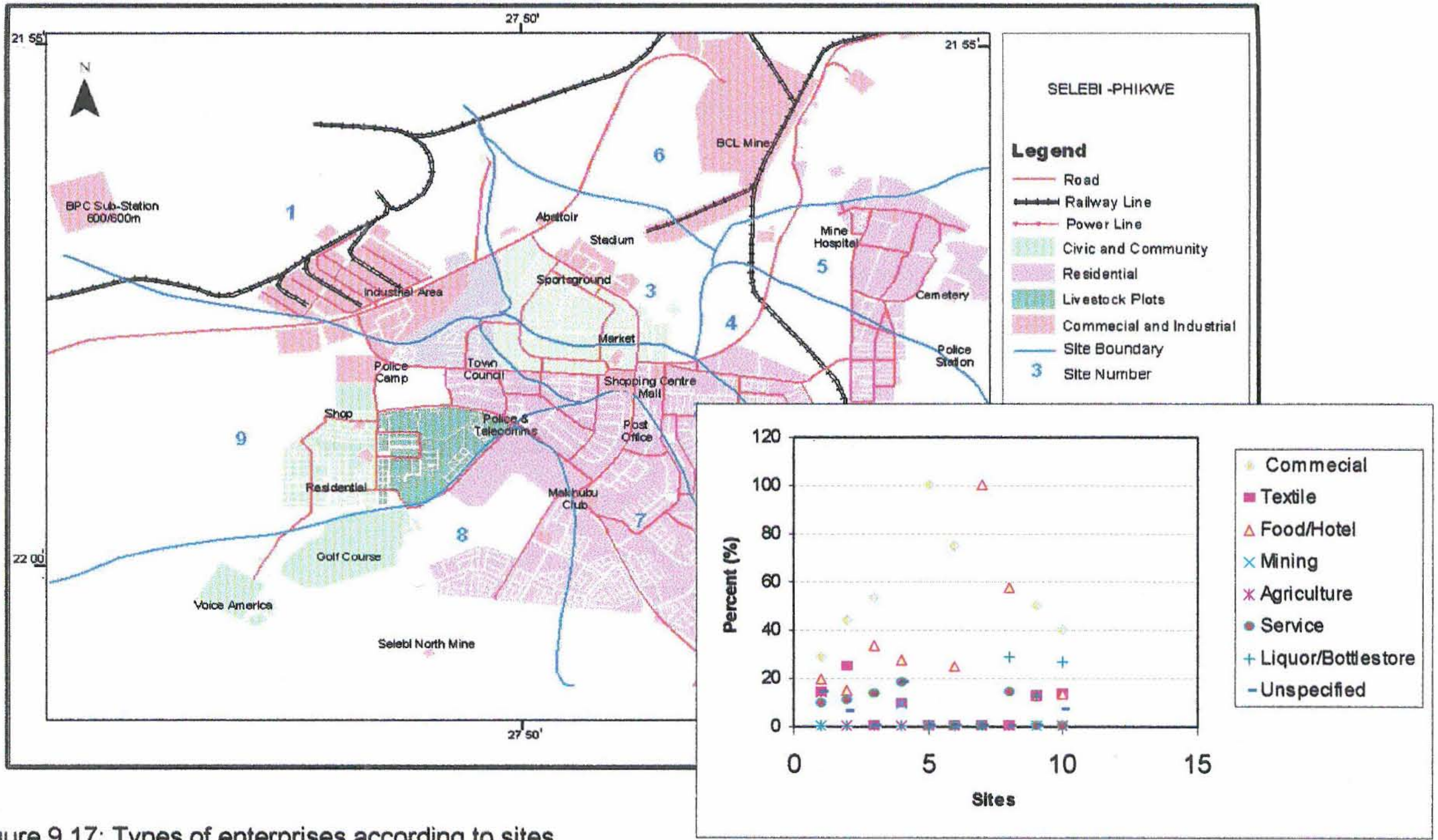

Figure 9.17: Types of enterprises according to sites

9.3. 3. 2 General complaints of workers about personal health

In this section we consider frequent complaints of workers of enterprises as reported by the directors or designated officials. These frequent complaints of the workers included headaches, influenza/common colds, chest pains, and coughing. They indicated that workers also experienced unusual loss of body weight, often had constipation, diarrhoea, and nausea and vomiting, and suffered from pain when urinating as well as having unusual genital discharges. In the spatial presentation of the data concerning the general complaints of workers of enterprises, as shown in Figure 9.18, workers suffered from frequent **headaches**. In Figure 9.18, the spatial distribution of workers of enterprises suffering from headaches as illustrated according to the types of industries per site. All the workers in sites five and six who suffered from frequent headaches were in the commercial businesses/industries, and all the workers in site seven as well as 50% of the workers in site eight who complained of often having headaches were in the food/hotel enterprises. 10% of the workers in site four who complained of regularly having headaches were in the mining enterprises.

High percentages of respondents who complained of having frequent **influenza/common colds** occurred for workers in all the sites. As revealed in Figure 9.19, all the workers in sites five and six and 50% of the workers from site three who suffered from frequent flu/common colds were in the commercial enterprises, and all the workers in site seven and 50% of the workers in site eight who complained of often experiencing influenza/common colds were in the food/hotel enterprises. Fifty percent of the workers in site 10 who complained of often having influenza/common colds were in the liquor store enterprises. Less than 10% of the workers in site six who complained of regularly having influenza/common colds were in the mining enterprises (Figure 9.19).

High percentages of respondents who complained of having frequent **chest pains** occurred for workers in all the sites. According to Figure 9.20, all the workers in sites five and six and close to 80% of the workers from site three who suffered from frequent chest pains were in the commercial enterprises, and all the workers in site seven and > 60 % of the workers in sites eight and 10 who complained of often experiencing chest pains were in the food/hotel enterprises (Figure 9.20).

In Figure 9.21, the spatial distribution of workers of enterprises suffering from frequent **coughing**, according to the types of industries per site, is illustrated. All the workers in site five who suffered from frequent coughing were in the commercial enterprises, and all the workers in site six who complained of this were in the food/hotel enterprises. 65% of the workers in site ten who complained of regularly coughing were in the liquor/bottle store enterprises.

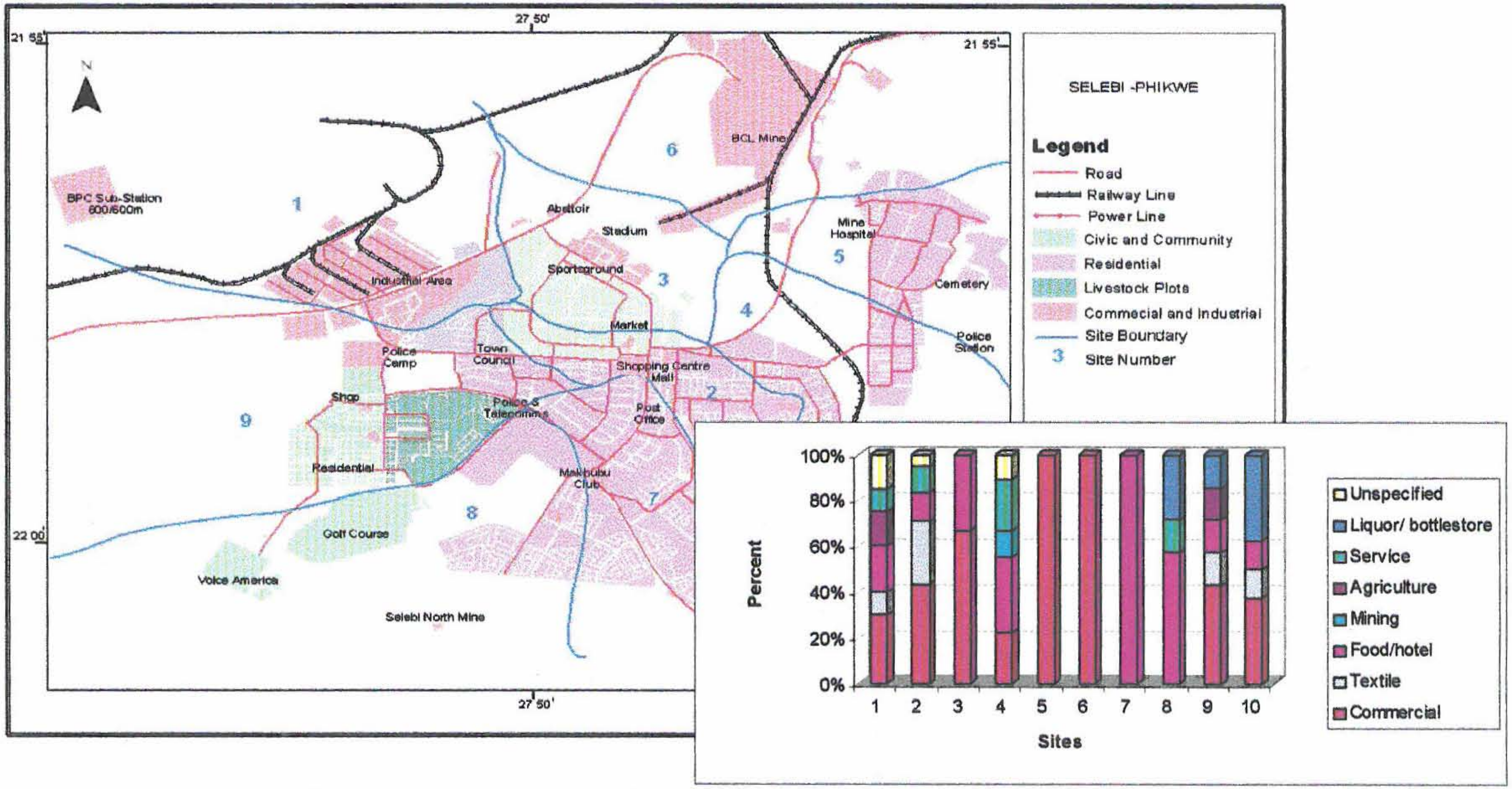

Figure 9.18: Percentage distribution of workers suffering from headaches according to study sites and types of enterprise

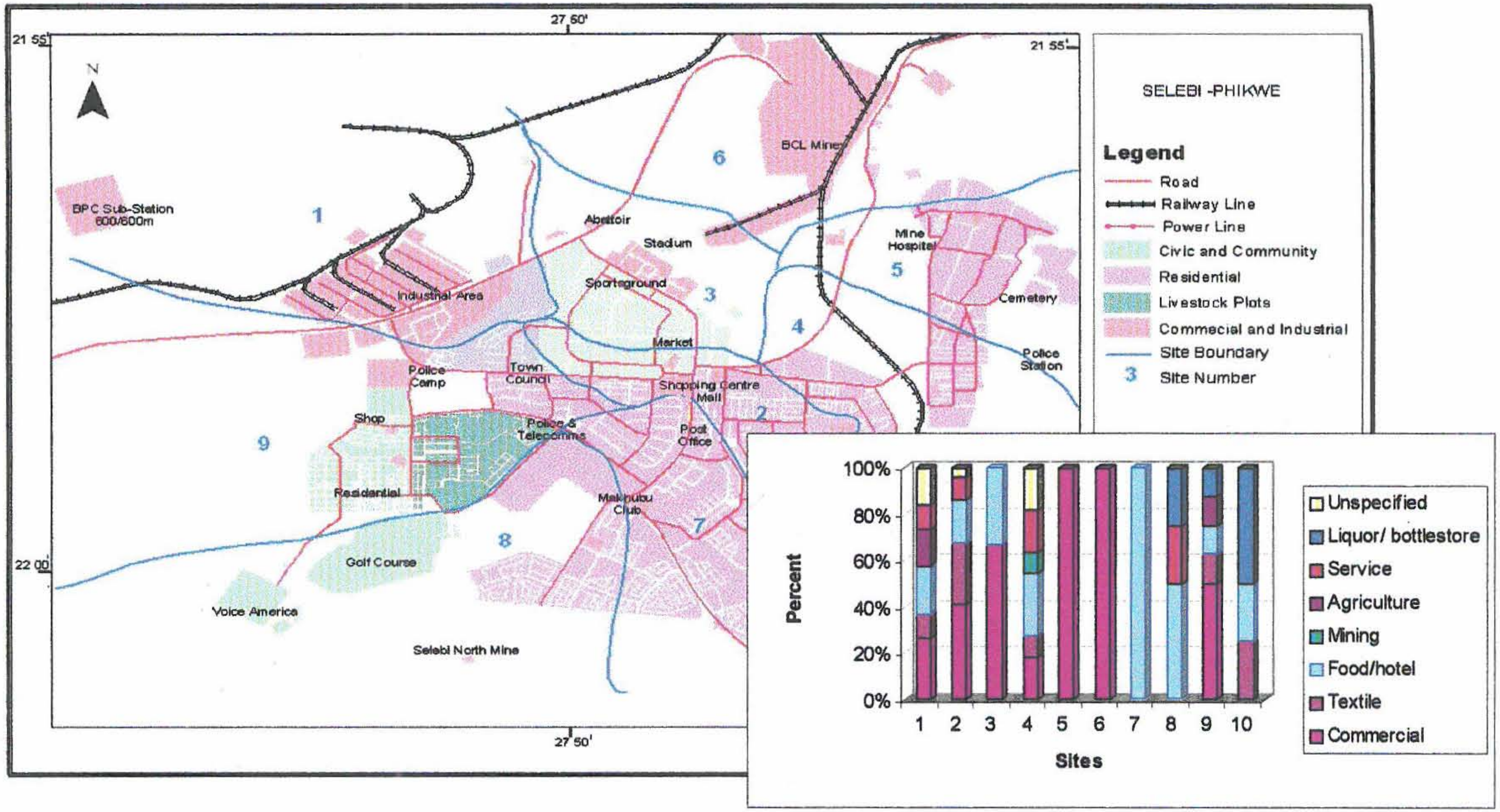

Figure 9.19: Percentage distribution of workers suffering from influenza/common cold according to study sites and type of enterprises

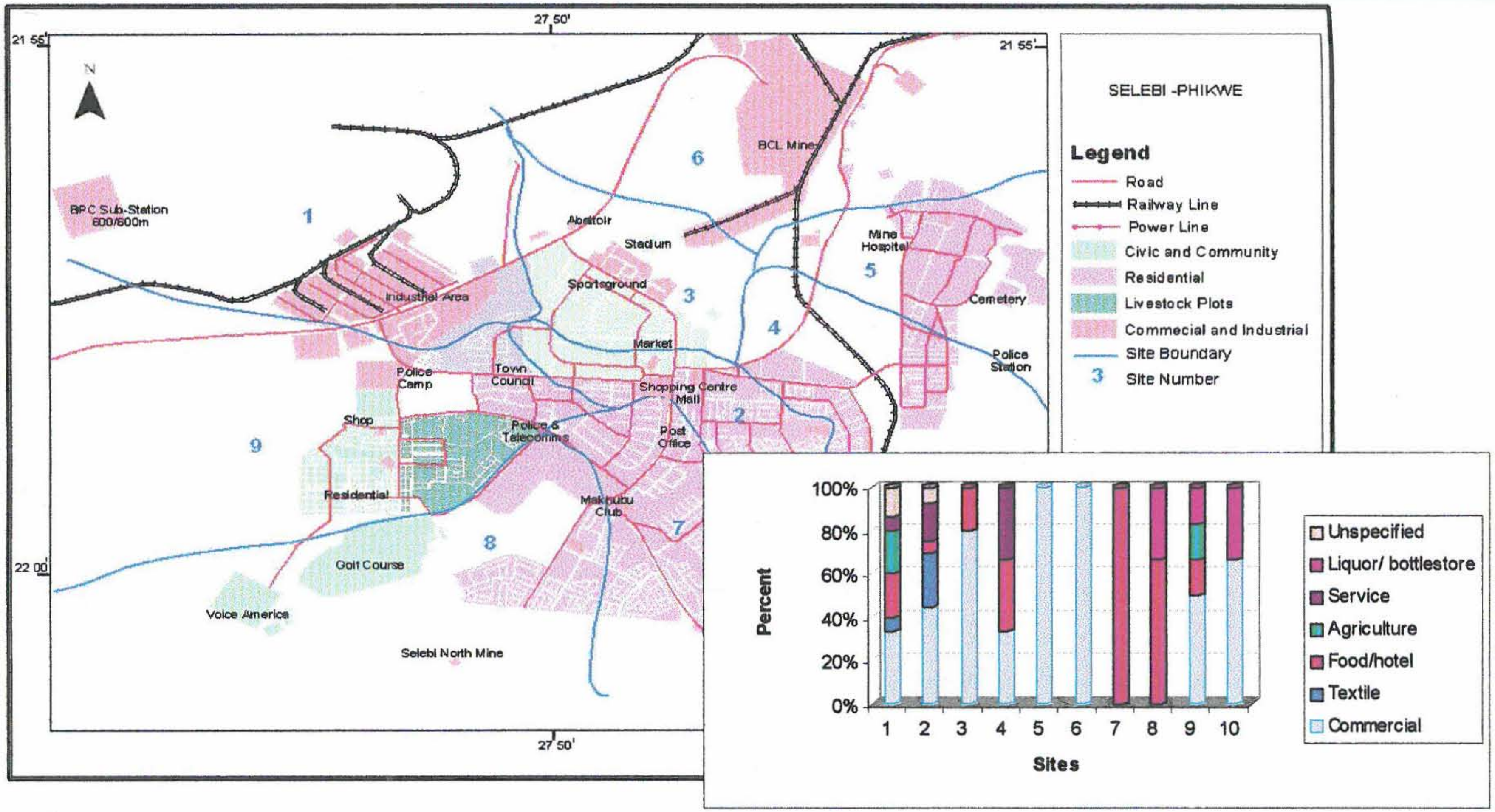

Figure 9.20: Percentage distribution of workers with chest pains according to study sites and types of enterprises

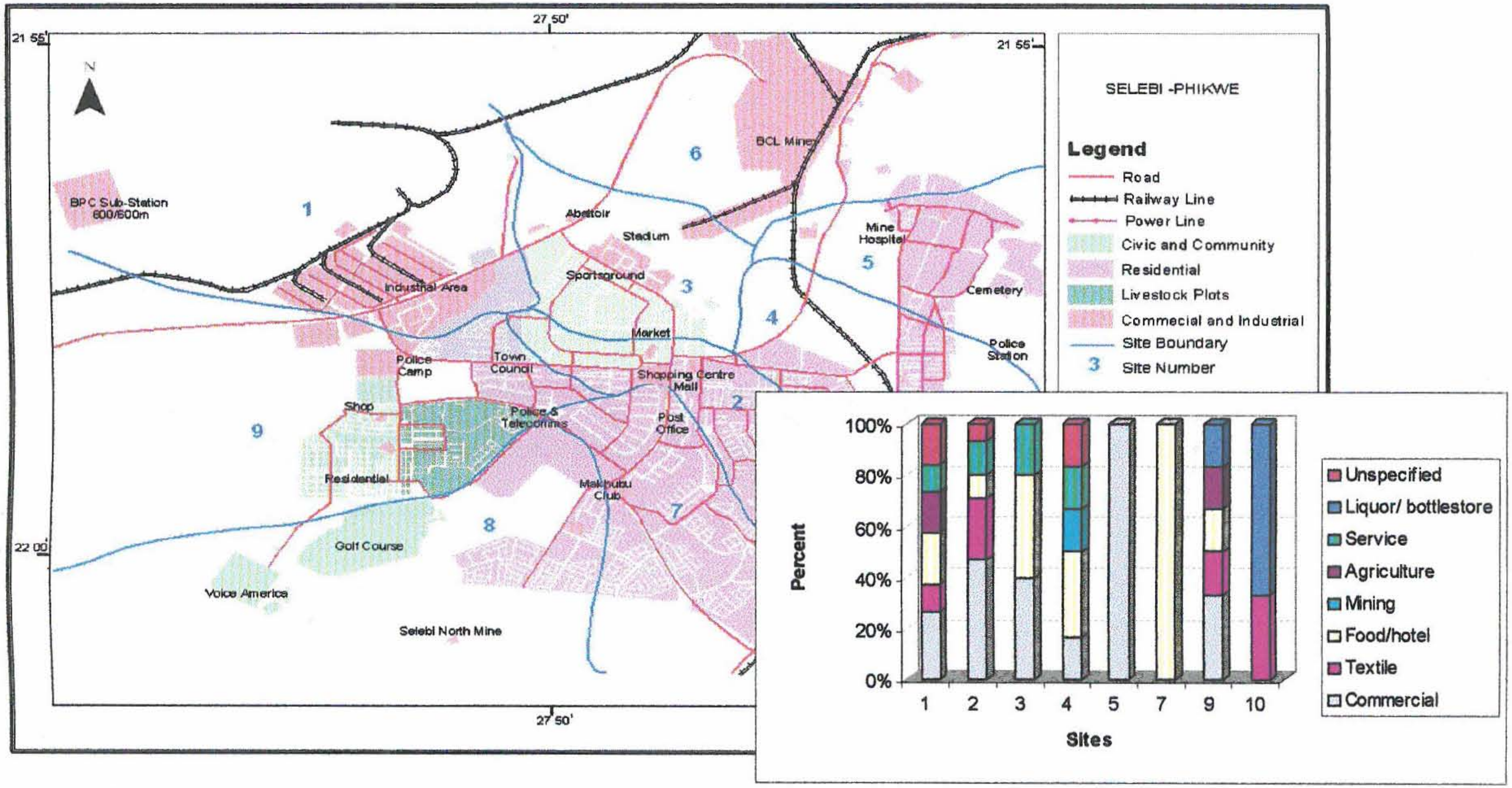

Figure 9.21: Percentge distribution of workers with persistent coughing according to study sites and type of enterprises

In previous studies conducted by Ekosse (2001) and Ekosse, Van den Heever, De Jager and Totolo (2003), it was established that heavy metals mostly associated with the exploitation of Ni-Cu ore at Selebi Phikwe are Zn, Cd, Ni, Cu, Fe, Cr, Se and Co. Zinc can cause vomiting, abdominal pain, nausea, dizziness, lack of muscular coordination, and renal failure (World Health Organisation, 1993). Cadmium is known to affect the renal, skeletal and respiratory systems (World Health Organisation, 1993; Alloway and Ayres, 1993). Excess Se may lead to gastrointestinal disturbances and nausea (Alloway and Ayres, 1993). Chromium can be carcinogenic and causes cancer of the respiratory organs (Alloway and Ayres, 1993). Cobalt also, is considered to be toxic (Alloway and Ayres, 1993), iron causes siderosis and Ni can be carcinogenic (World Health Organisation, 1993). Excess Cu leads to severe mucosal irritation and corrosion, capillary damage, hepatic and renal damage, gastrointestinal and nervous disturbances (World Health Organisation, 1993).

In a study conducted at Selebi Phikwe by Ekosse (2001), gases such as SO_2, CO, CO_2, NO_x and H_2S were mentioned as being deleterious to human health. Related chemical and mineralogical studies of PAM at the Selebi Phikwe area revealed that it consists of heavy metals (Ekosse, Van den Heever, De Jager and Totolo, 2004). Furthermore, phane worms which are contaminated with heavy metals are eaten by the residents of the Selebi Phikwe area.

Coughing, shortness of breath, headaches, and chest pains among other symptoms considered in this work could have been provoked by pollution resulting from mining and smelting of mineral ore bodies such as the Ni-Cu ore bodies at Selebi Phikwe, Botswana. The symptoms of these illnesses and diseases could be indicative of illnesses and diseases caused by mining effects. In this regard, environmental factors resulting from mining and smelting activities, among others, could very well have contributed to the negative human health status so far observed in Selebi Phikwe.

9.4 Conclusions

Frequent headaches, constant coughing, chest pains and regular bouts of influenza/common colds stand out distinctly in all the studies as the most common ailments inflicting the inhabitants of Selebi Phikwe. Respondents indicated that the respiratory tract-related health problems that are found in the study area were considered to be linked to the effects of air pollution caused by the emission of SO_2 from the mining and smelting activities. This gas, together with sulphate particulates, aggravates respiratory diseases, reduce the effective functioning of lungs, irritates the eyes and the respiratory tract, and may well be the cause of other health hazards (Asare, 1999; Mosweunyane, 2000).

In chapter eight of this document, we considered the lung functions of residents of the study area and related the results to their general health complaints, focusing on frequent headaches, regular bouts of influenza/common colds, chest pains and unusual shortness of breath. In this chapter we have pictorially depicted the three categories of respondents: residents, learners of educational institutions and workers of enterprises within the Selebi Phikwe area with he level to which they appear to be suffering from these ailments. It has been substantiated from the spatial presentation data in this chapter, that certain sites are more affected by the different ailments, sicknesses and diseases than others.

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Chapter Ten

An Integral Approach to Understanding the Human Health Status around the Selebi Phikwe Ni-Cu Mine Area

10.1 Introduction

Mining activities in the Selebi Phikwe area has been demonstrated to be affecting the biophysical environment (Ekosse, 2001; Ekosse, Van den Heever, and De Jager, 2003; Ekosse, Van den Heever, De Jager and Totolo, 2003; 2003a; 2003b). Other work carried out by Asare (1999), revealed the influence of mining of nickel-copper (Ni-Cu) on the socio-economy and environment of Selebi Phikwe. So far, no studies have been documented on the human health status of the inhabitants of this Ni-Cu mining environment, Selebi Phikwe, Botswana.

Inhabitants of environments of mining and heavy metals industries are generally exposed to a variety of health hazards particularly affecting their respiratory system; although there are many agents emanating from the mining and metal processing industries, particulate air matter (PAM) has been isolated as one of the principal provocative factors of respiratory tract complications (United States of America – Environmental Protection Agency, 1995). In Switzerland, the Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) was institutionalised in 1991, to examine associations between air pollution and respiratory health, taking into consideration certain factors such as urbanisation, air pollution, meteorological conditions and altitude of Swiss communities (Schindler, Künzli, Bongard, Leuenberger, Karrer, Rapp, Monn, and Ackermann-Liebrich, 2001).

Countries in Southern Africa such as Zambia and Zimbabwe have raised health concerns because of the mining of copper and other base metals (Ashton, Love, Mahachi and Dirks, 2001). Similar health concerns have been raised by inhabitants of the Selebi Phikwe area, Botswana (Asare, 1999; Ekosse, 2001). In this chapter, we attempt to integrate the results and discussions of the previous chapters of this document, especially those of chapters four, five, six, seven, eight and nine, with the primary objective of having a holistic view of the human health status in the Selebi Phikwe Ni-Cu mining area, Botswana.

10.2 Methods

Questionnaires on human health status of inhabitants of Selebi Phikwe study area were prepared for individuals, health service providers, educational institutions, and enterprises. Spirometry tests were performed on selected individuals. Details regarding the number of respondents for the different sets of questionnaires are given in Table 10.1. Figures 10.1, 10.2 and 10.3 show the maps of the Selebi Phikwe study area with the various sites where residents were interviewed, and where some of the educational institutions; and enterprises are located. Chapter three covers in a very detailed form the different methods and techniques which were employed in this study. Only a summary of the methods and techniques is presented here.

Table 10.1: Details of number of respondents for the different sets of questionnaires

No	Section	Number of questionnaires administered	Remarks
1.	Section one. Questionnaire for individuals	600	The study area was portioned into ten different sites with an almost equal population distribution per site; 60 respondents were chosen per site including the control site.
2.	Section two. Questionnaire for health service providers	7	There are eight health service providers within the whole study area including the control site. The BCL hospital authorities refused to participate. Consequently only seven respondents were obtained.
3.	Questionnaire for business and industrial enterprises	200	This number was chosen after reconnaissance visits. All the different types of enterprises at the ten different sites are statistically represented.
4.	Questionnaire for educational institutions	30	Includes all the educational institutions within the study area as well as the control site.
5.	Questionnaire completed by individuals who underwent spirometry tests	88	Selected individuals, which included all the different categories of residents within the study area.

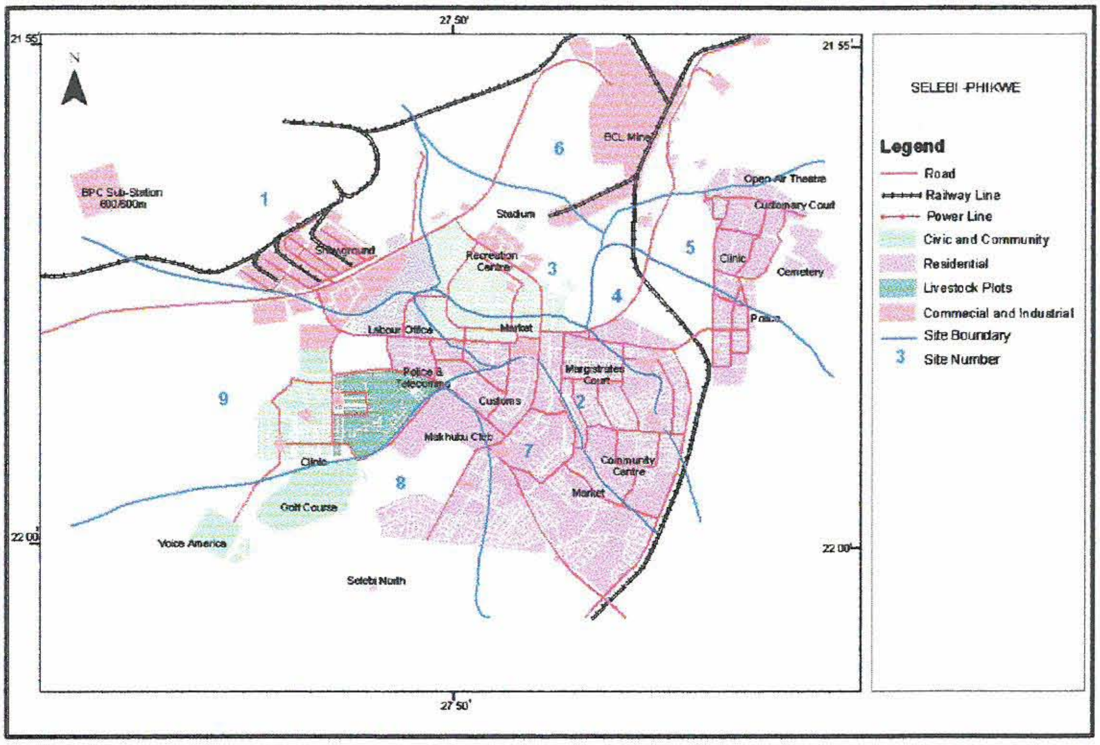

Figure 10.1: Map of Selebi Phikwe showing the different study areas from which residents were interviewed

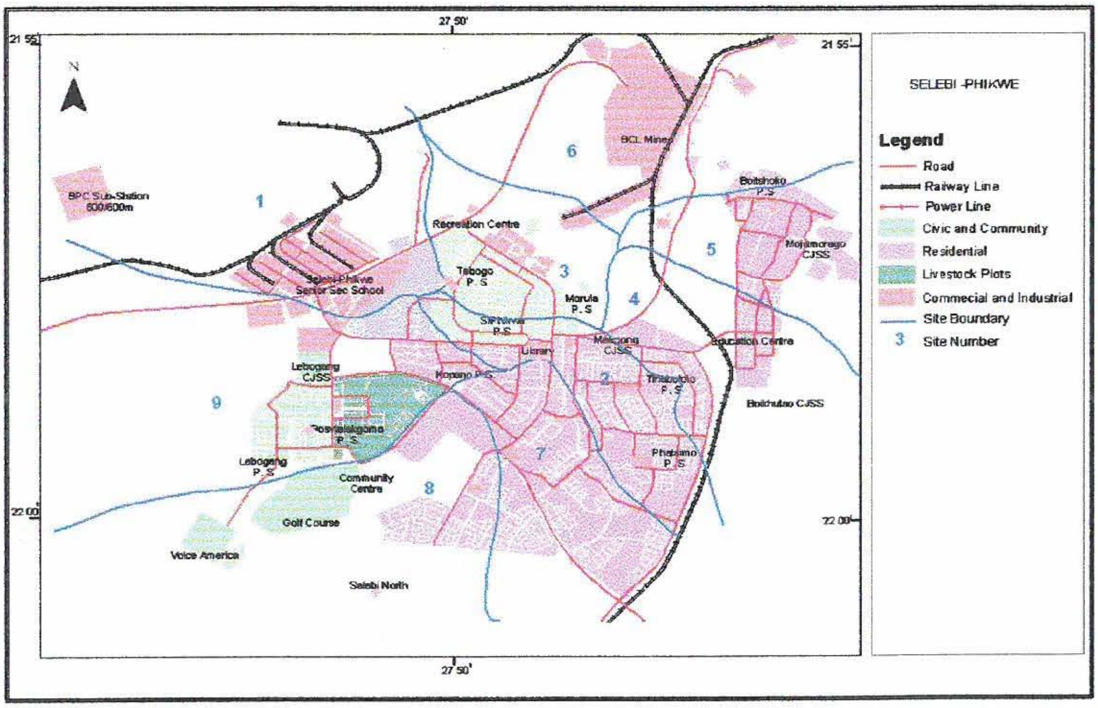

Figure 10.2: Map of Selebi Phikwe showing the different study areas where some of the educational institutions are located

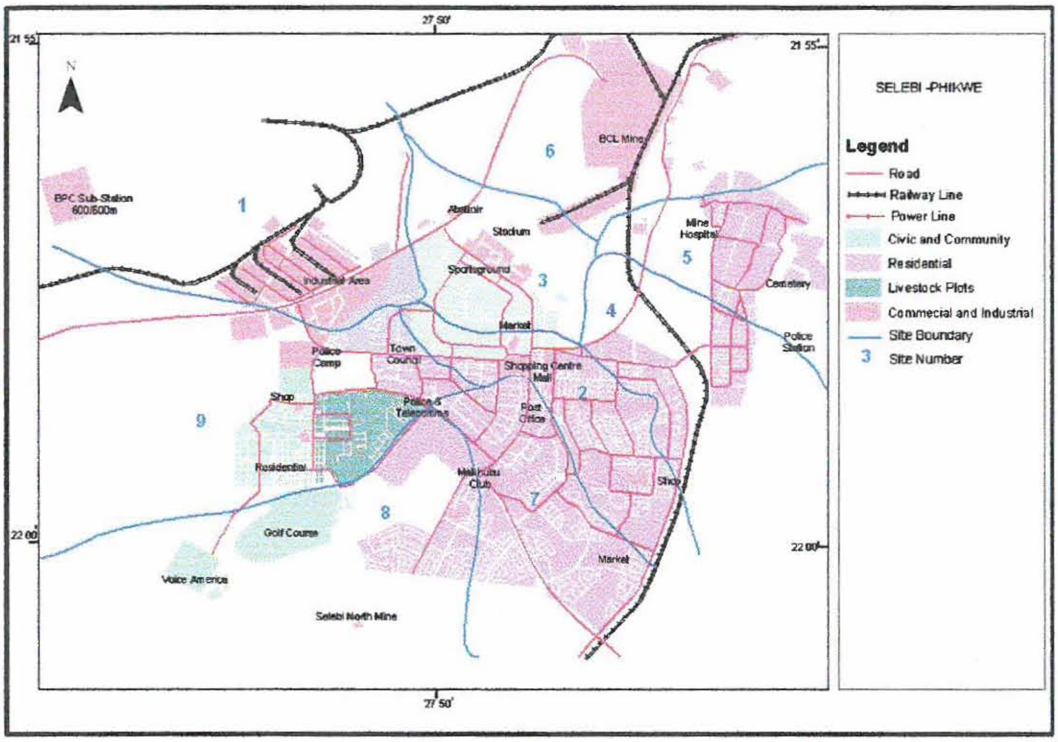

Figure 10.3: Map of Selebi Phikwe showing the different study areas where some of the enterprises are located

The first stage of the work was to collect primary data concerning the general health status of inhabitants in the Selebi Phikwe area and of inhabitants at a control site by means of structured interviews conducted with selected individuals, health service providers, enterprises and educational institutions. The information obtained was supplemented by spirometric testing of selected individuals. Furthermore, a literature search utilised both published and unpublished reports on health hazards as a result of exploitation of Ni-Cu.

Data was collected by means of five sets of questionnaires (Table 10.1), on the health status of individuals at the Selebi-Phikwe Cu-Ni mine area in Botswana (Appendices 4.1, 5.1, 6.1, 7.1 and 8.1). The field data obtained through the administration of questionnaires was coded, processed and analysed both qualitatively and quantitatively. Suitable software packages including SPSS, Version 11.0 (Statistical Package for Social Sciences Version, 2003), and Microsoft Excel (MS Excel) (Microsoft Office Excel, 2003) were utilised.

Results were also spatially presented using Geographical Information System (GIS) software packages. The main types of software used were: ArcGIS version 8.2, Microsoft Excel 2000, Microsoft Word 2000, and the operating system was Microsoft Windows XP (Microsoft Office Excel, 2003). Hard copies and digital data of the Selebi Phikwe area were acquired from the Departments of Urban, Regional and Town Planning, and Surveys and Lands of the Government of Botswana. Twenty different maps were displayed in Chapter nine which reflected demographic issues, complaints about personal health, and social and environmental concerns which were considered to be directly related to the mining activities within the Selebi Phikwe study area.

Selected data that was generated from the questionnaires and spirometry tests was considered to be related to the mining activities. The data (related to the mining activities) obtained in the different chapters cited in this section was collated and displayed in different tables and diagrams. The processed data was interpreted with the primary objective of portraying a holistic view of the human health status in the Selebi Phikwe Ni-Cu mining area, Botswana. The dynamics of the environment related to human health in Selebi Phikwe is discussed illustrated by means of figures and models.

10.3 Results, interpretation and discussions

10.3.1 General complaints about personal health and mortality

Apart from 71% of the health services and health service providers who reported that they had patients who complained of **general body weakness**, responses from individuals, educational institutions and enterprises indicated values which were < 50% for this complaint (Figure 10.4). However when considering the responses according to study sites, 53% of individuals and 100% health service providers in site 10 had complaints of general body weakness (Table 10.2). Respondents in site nine indicated that 50% of educational institutions, 100% of health services and health service providers and 50% enterprises reported that they had persons who complained of general body weakness.

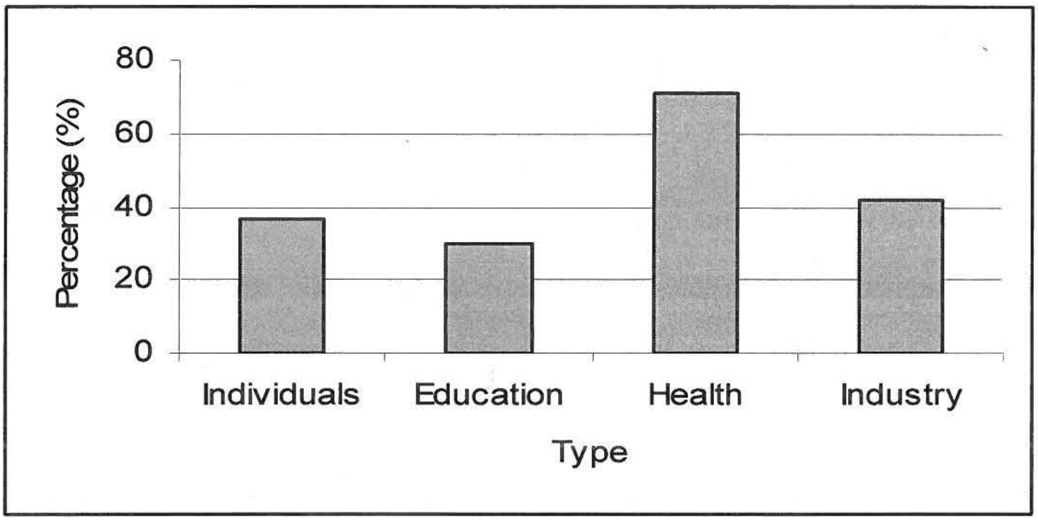

Figure 10.4: Overall percentages of individuals who complained of general body weakness and respondents at educational institutions, health service providers and enterprises who reported on complaints of general body weakness

Table 10.2: Details of individuals who complained of general body weakness and respondents at educational institutions, health service providers and enterprises who reported on complaints of general body weakness

Site	Individuals	Education	Health	Industry
One	43			62
Two	17		100	42
Three	38	50		53
Four	2	22	100	27
Five	51	100	0	25
Six	32	67	0	25
Seven	42	33		33
Eight	48	50		
Nine	42	50	100	50
Ten	53		100	47
Over all	**37**	**30**	**71**	**42**

There were reports of recent unexplained **loss of body weight** of persons within the study area. 86% of the health services and health service providers reported that they had patients who complained of recent unexplained loss of body weight, although none was from site 10. As shown in Figure 10.5, values < 50% for recent unexplained loss of body weight were obtained from individuals, educational institutions and enterprises. In considering the responses according to study sites, 53% of individuals and 100% of respondents health service providers in site nine had complaints of recent unexplained loss of body weight (Table 10.3).

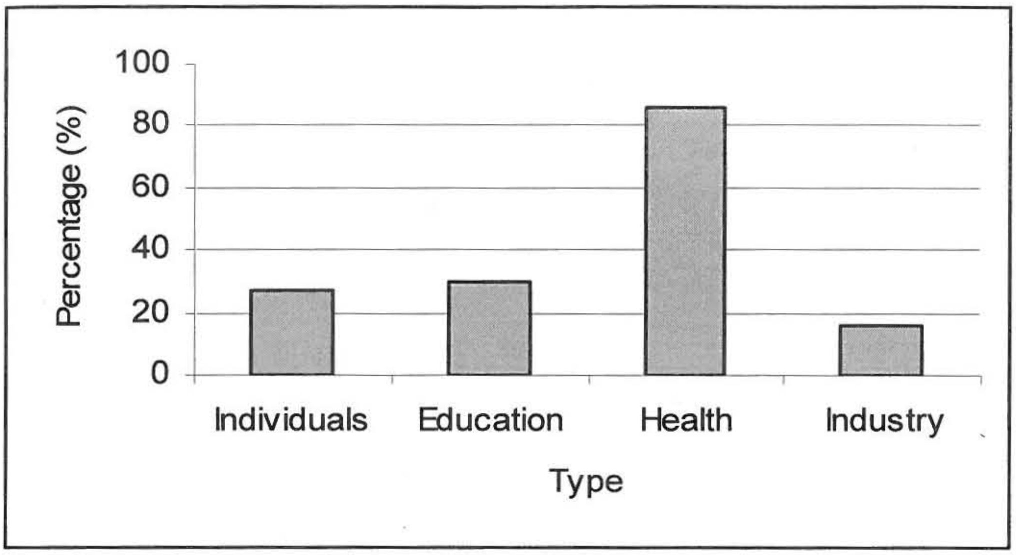

Figure 10.5: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of recent loss of body weight

Respondents in site ten indicated that only 16% of individuals and 7% of enterprises reported that they had persons who complained of recent unexplained loss of body weight. Values obtained for enterprise were < 50% for each of the study sites, and only site nine for individuals had a value > 50% (Table 10.3).

Table 10.3: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of recent loss of body weight according to study sites

Site	Individuals	Education	Health	Industry
One	37			33
Two	7		100	18
Three	15	50		13
Four	2	33	100	9
Five	40		100	
Six	35	67	100	13
Seven	44	67		
Eight	28	50		
Nine	53		100	13
Ten	16		0	7
Overall	**27**	**30**	**86**	**16**

Responses obtained from individuals, educational institutions, health services and health service providers, and enterprises indicated very high values which were > 50% for frequent complaints of **influenza/common cold** (Figure 10.6). The trend from the highest value of 86% to the lowest of 66% was as follows: health service providers > educational institutions > individuals > enterprises. The same trend, of very high values, was also obtained when considering the responses according to study sites. The values for sites four, five and nine for individuals, educational institutions, health services and health service providers, and enterprises were significantly very high (Table 10.4). Values for sites two and six were equally high. However, the values for individuals and enterprises at the control site (site ten) were very low, and there were no recordings for educational institutions and health service providers (Table 10.4).

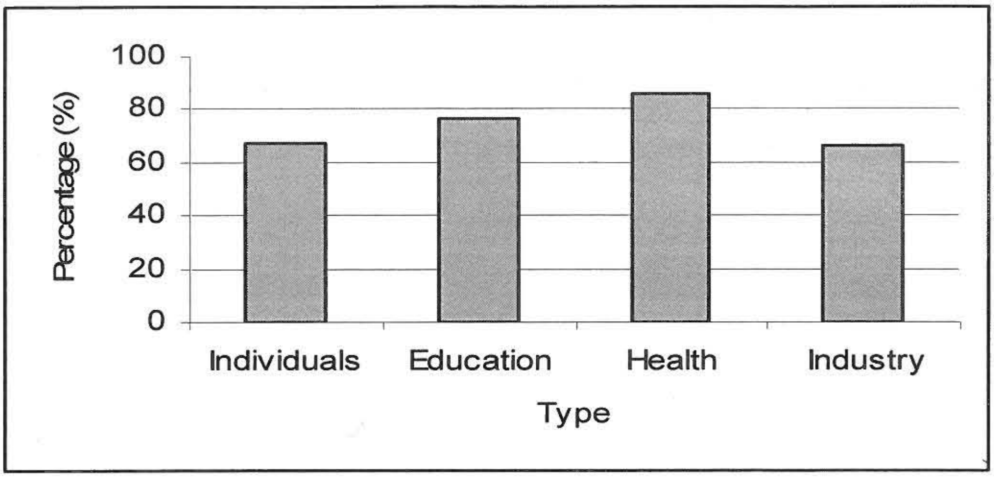

Figure 10.6: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent influenza/common colds

Table 10.4: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent influenza/common colds according to study sites

Site	Individuals	Education	Health	Industry
One	87	100		90
Two	28	60	100	68
Three	62	100		40
Four	85	89	100	100
Five	79	100	100	75
Six	60	100	100	25
Seven	73	67		67
Eight	72	50		57
Nine	81	100	100	100
Ten	47		0	27
Overall	**67**	**77**	**86**	**66**

Similar to influenza/common colds, very high values were also obtained for complaints of regular **headaches**; the values obtained for complaints of frequent headaches were higher than those obtained for influenza/common colds even though the trend from the highest value to the lowest was the same for both complaints. The values obtained were as follows: health service providers (100%), educational institutions (80%), individuals (77%) and enterprises (70%) (Figure 10.7). Similarly, the same trend of very high values was obtained when considering the responses according to study sites. The values for sites four, five, six and nine for individuals, educational institutions, health service providers, and enterprises were significantly very high (Table 10.5). It is important, however, values for complaints of headaches for the control site were also high.

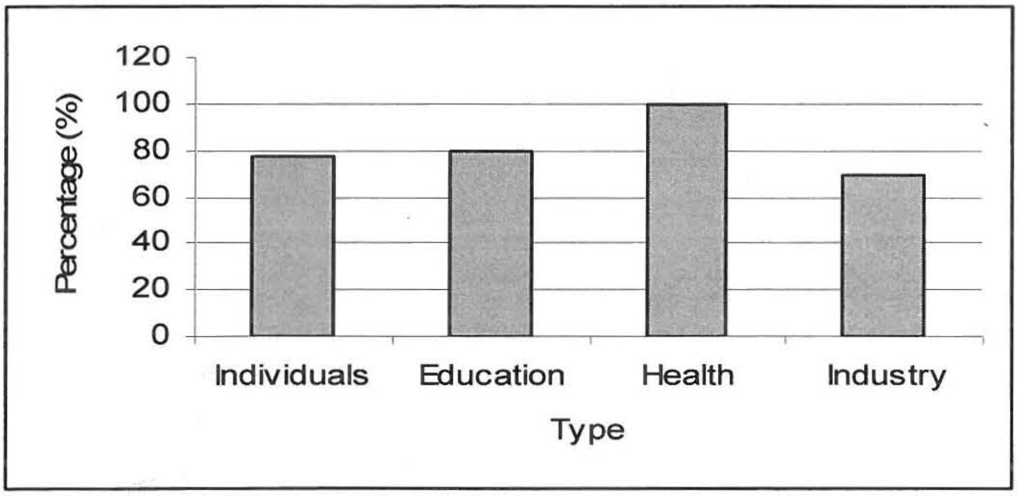

Figure 10.7: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent headaches

Table 10.5: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent headaches, according to study sites

Site	Individuals	Education	Health	Industry
One	93	100		95
Two	38	20	100	69
Three	69	100		40
Four	87	89	100	82
Five	77	100	100	100
Six	90	100	100	38
Seven	78	100		50
Eight	73	100		100
Nine	86	100	100	88
Ten	82	50	100	53
Overall	**77**	**80**	**100**	**70**

There were complaints of **shortness of breath** of persons within the study area. 86% of the health services and health service providers reported that they had patients who complained of shortness of breath. As shown in Figure 10.8, values < 50% for shortness of breath were obtained from individuals (24%), educational institutions (33%), enterprises (18%) and spirometry tests (6%). However, when considering the responses according to study sites, very high values were obtained for educational institutions and health service providers in sites five and six as depicted in Table 10.6.

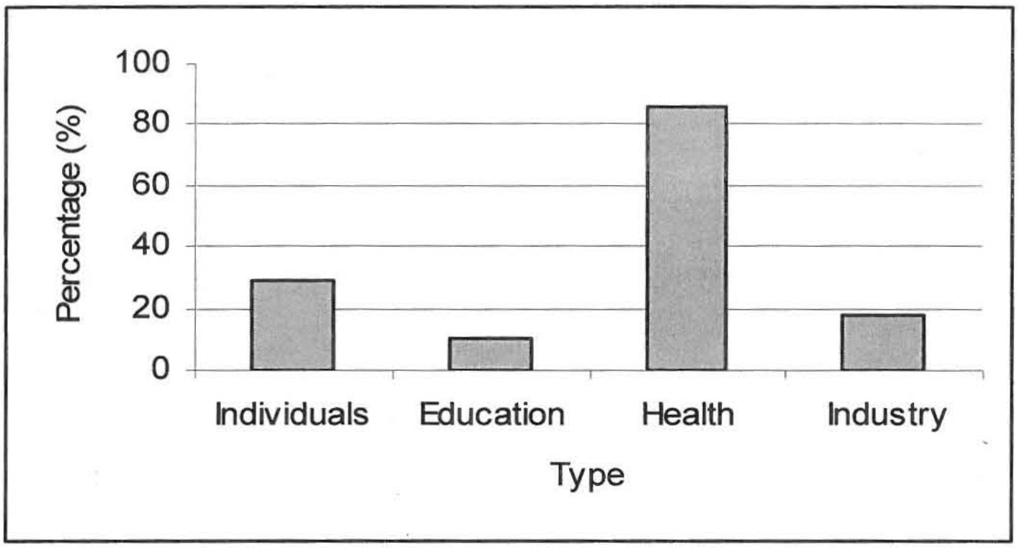

Figure 10.8: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of shortness of breath

Table 10.6: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of shortness of breath, according to study sites

Site	Individuals	Education	Health	Industry
One	48	100		52
Two	17	20	100	18
Three	20	100		13
Four	15	22	100	
Five	26	100	100	
Six	13	67	100	
Seven	24	0		17
Eight	18	50		
Nine	20		50	
Ten	35		100	20
Overall	**24**	**33**	**86**	**18**

86% of health service providers reported that they had patients who complained of **palpitations**. As shown in Figure 10.9, values < 50% for palpitations were obtained from individuals (29%), educational institutions (10%) and enterprises (14%). However, when considering the responses according to study sites, very high values were obtained for educational institutions and health service providers only in site five as shown in Table 10.7.

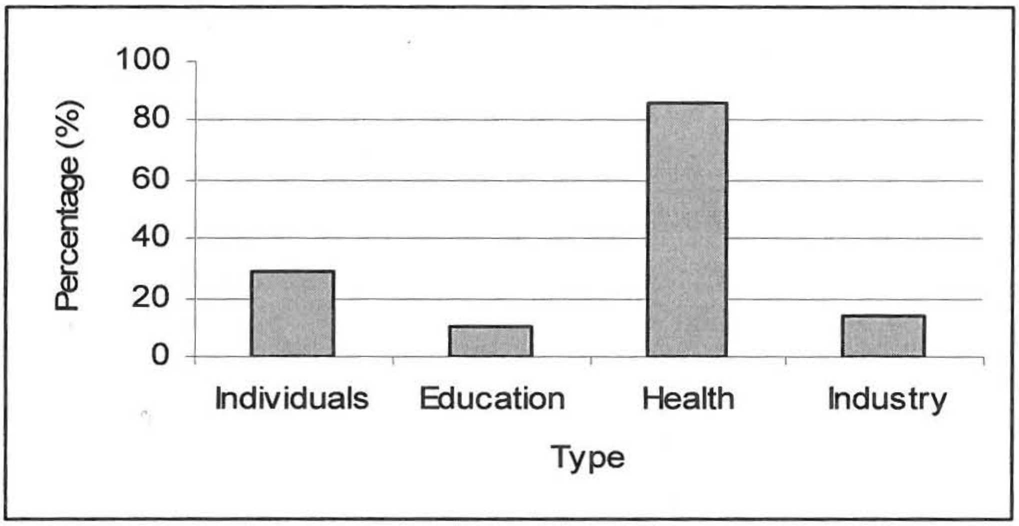

Figure 10.9: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of palpitations

Responses obtained from individuals, educational institutions, and enterprises indicated low values of < 50% each and very high values for health service providers (100%) for complaints of **pain in the lower abdomen** (Figure 10.10). The trend from the highest value of 100% to the lowest of 23% was as follows: health service providers > enterprises > individuals > educational

institutions. The values for site five for educational institutions, and health services and health service providers were significantly very high (Table 10.8).

Table 10.7: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of palpitations, according to study sites

Site	Individuals	Education	Health	Industry
One	35			24
Two	12		100	14
Three	21			27
Four	2	11	100	
Five	33	100	100	
Six	30	33	100	
Seven	42			17
Eight	48			
Nine	31		100	
Ten	39		0	20
Overall	**29**	**10**	**86**	**14**

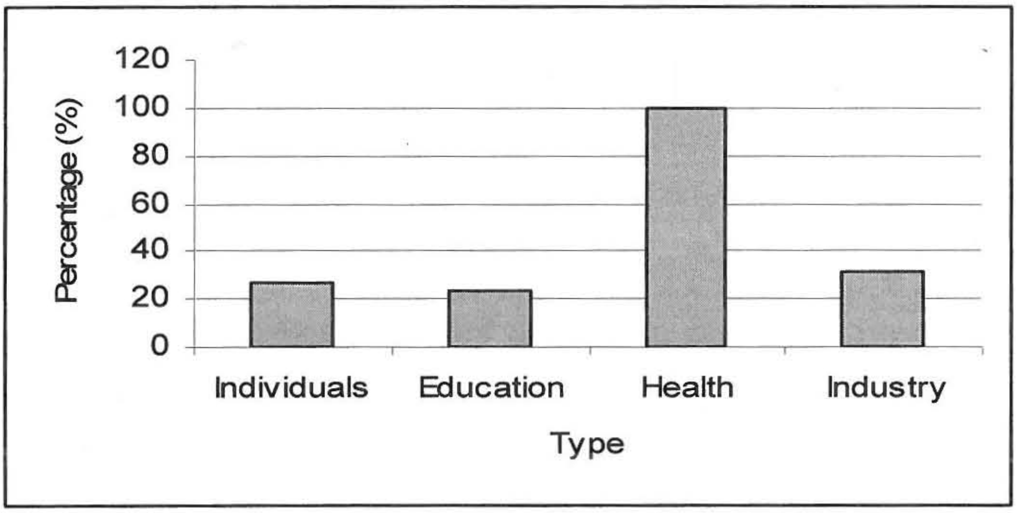

Figure 10.10: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of pains in the lower abdomen

Table 10.8: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of pains in the lower abdomen, according to study sites

Site	Individuals	Education	Health	Industry
One	25			43
Two	20	20	100	28
Three	16	50		40
Four	5	22	100	9
Five	37	100	100	
Six	35	33	100	25
Seven	37	33		33
Eight	18			29
Nine	46		100	63
Ten	37		100	33
Overall	**27**	**23**	**100**	**31**

In general, there were very few complaints of respondents in general experiencing **pain when urinating**. No case was reported by the educational institutions. While only 4% of enterprises indicated that they had workers who complained of experiencing pain when urinating, 9% of individuals experienced the pain. 100% of the health service providers reported that they had patients who complained of pain when urinating (Figure 10.11). There were indications from health service providers in all the sites where health services were available, that patients complained of pain when urinating as shown in Table 10.9. This complaint of pain when urinating was expected. In fact, people frequently visit health service providers because of symptoms of pain when urinating or a burning sensation occurring in their genital organs.

Similar to data on complaints of pain when urinating, are the responses for unusual **genital discharge** obtained from the study. Values obtained for complaints of unusual genital discharge for individuals (8%), educational institutions (3%) and businesses/industries (5%) were very low (Figure 10.12). However, 100% of the health service providers reported that they had patients who complained of unusual genital discharge (Figure 10.12). There were indications from health service providers in all the sites, where these services were available, that patients complained of unusual genital discharge as shown in Table 10.10. No trend could be established based on the results, however.

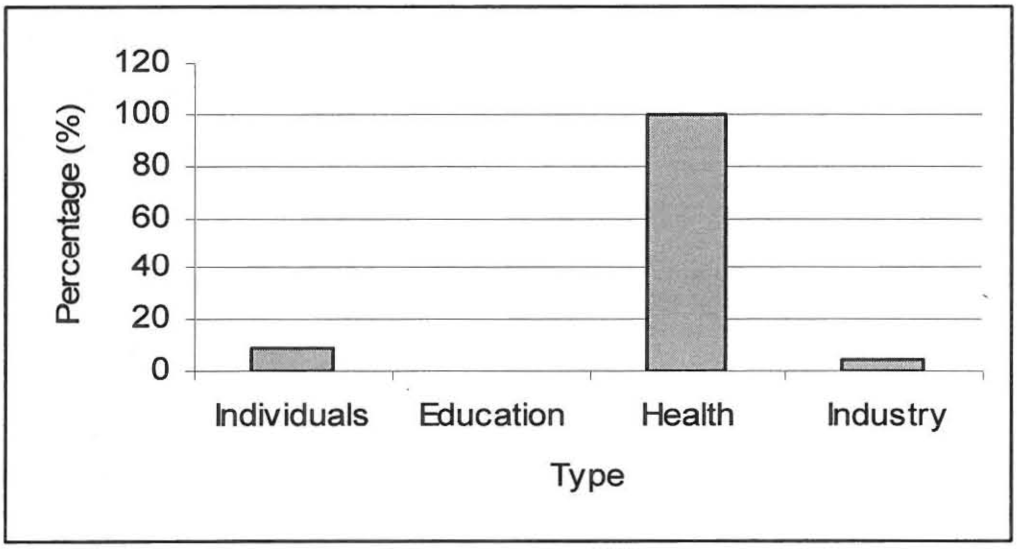

Figure 10.11: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of pain when urinating

Table 10.9: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of pain when urinating, according to study sites

Site	Individuals	Education	Health	Industry
One	15			14
Two	2		100	3
Three	8			7
Four	0		100	
Five	18		100	
Six	5		100	
Seven	12			
Eight	12			
Nine	14		100	
Ten	2		100	
Overall	**9**	**0**	**100**	**4**

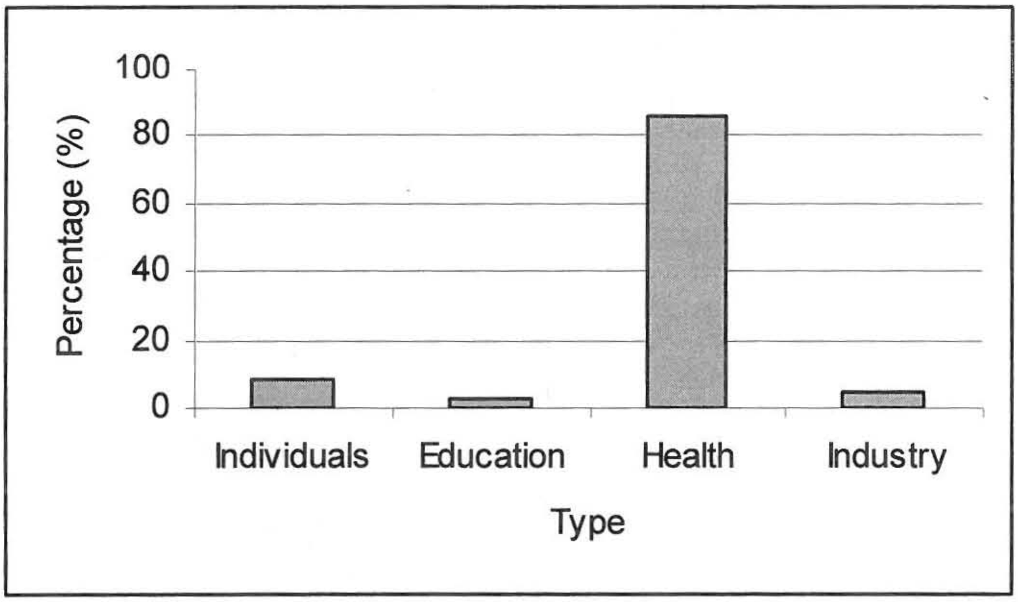

Figure 10.12: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of unusual genital discharge

Table 10.10: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of unusual genital discharge, according to study sites

Site	Individuals	Education	Health	Industry
One	10			14
Two	5		100	6
Three	2			
Four	0		100	
Five	18		100	
Six	3		100	
Seven	17	33		17
Eight	0			
Nine	10		100	
Ten	12		0	
Overall	**8**	**3**	**86**	**5**

There were complaints of frequent **nausea and vomiting** of persons within the study area. All of the health service providers reported that they had patients who complained of nausea/vomiting. As shown in Figure 10.13, values < 50% for frequent nausea and vomiting were obtained from individuals, educational institutions and enterprises. However, when considering the responses according to study sites, 100% of educational institutions and 100% of health service providers in site five had complaints of nausea/vomiting (Table 10.11). Values were > 50% for educational institutions and health service providers for sites three, five and six respectively, as reflected in Table 10.11. Respondents in site ten indicated that 42% of individuals and 100% of health service providers reported that they had persons who complained of frequent nausea and vomiting.

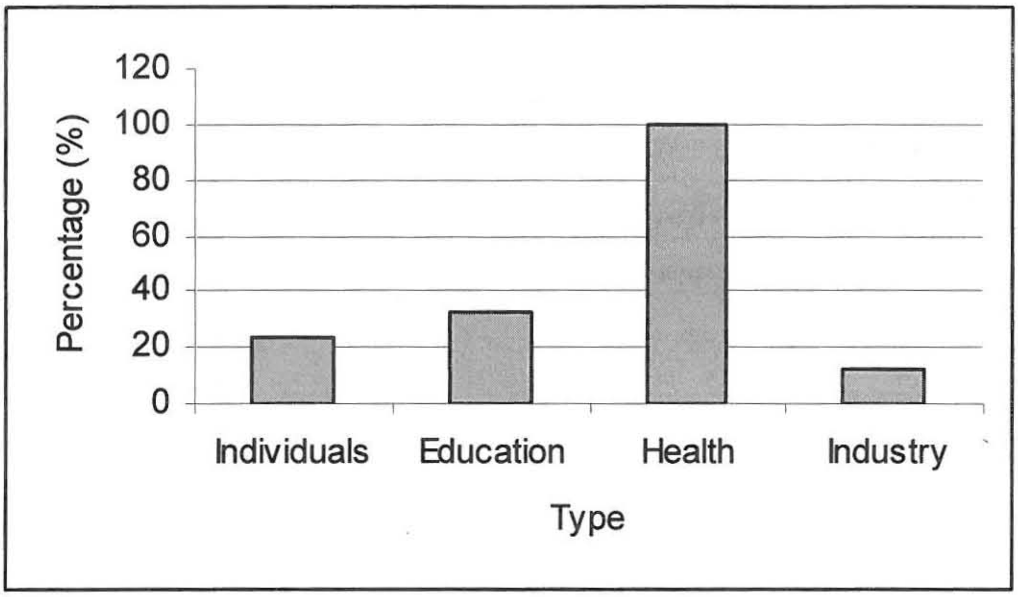

Figure 10.13: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of nausea and vomiting

Table 10.11: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of nausea and vomiting according to study sites

Site	Individuals	Education	Health	Industry
One	27			19
Two	10	40	100	13
Three	23	50		13
Four	17	22	100	18
Five	33	100	100	
Six	12	67	100	
Seven	31	67		
Eight	25			
Nine	17		100	25
Ten	42		100	
Overall	**23**	**33**	**100**	**12**

Values and trends for complaints of frequent **diarrhoea** are similar to those for nausea and vomiting. All of the health service providers reported that they had patients who complained of frequent diarrhoea. As shown in Figure 10.14, values < 50% for frequent diarrhoea were obtained from individuals (22 %), educational institutions (33%) and enterprises (12%).

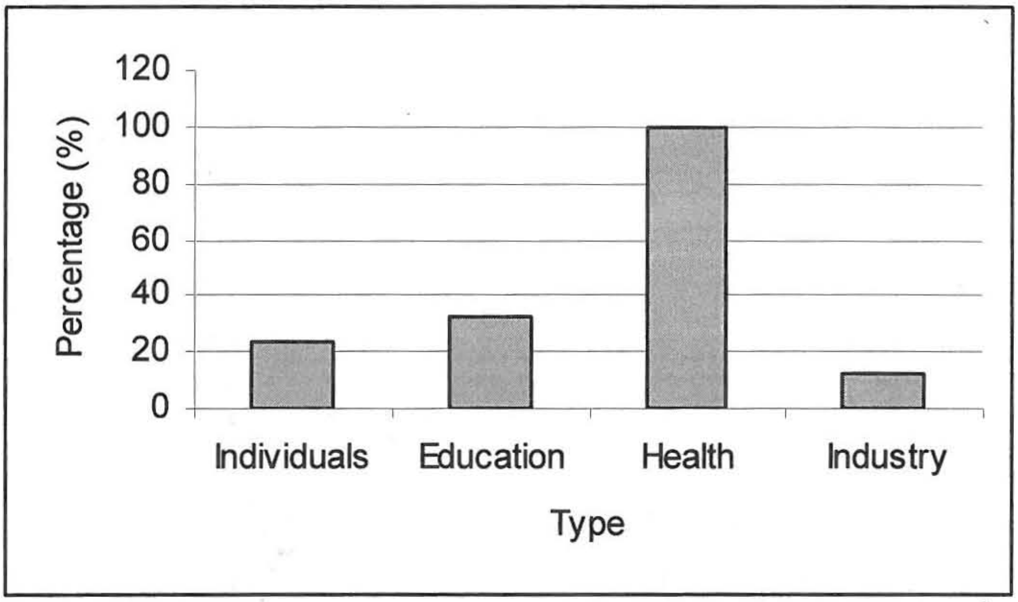

Figure 10.14: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent diarrhoea

However, when considering the responses according to study sites, very high values were obtained from educational institutions, and health services and health service providers in sites three, six and seven for complaints of frequent diarrhoea (Table 10.12). Respondents in site ten indicated that 35 % of individuals 100 % of health services and health service providers reported that they had persons who complained of frequent diarrhoea (Table 10.12).

Table 10.12: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent diarrhoea, according to study sites

Site	Individuals	Education	Health	Industry
One	35	100		33
Two	8	40	100	10
Three	11	50		7
Four	5	11	100	18
Five	18		100	
Six	25	67	100	
Seven	29	67		
Eight	17			
Nine	36	50	100	38
Ten	35		100	7
Overall	**22**	**33**	**100**	**12**

Values for complaints of frequent **constipation** were generally low except for health services and health service providers who all reported that they had patients who complained of frequent constipation. As shown in Figure 10.15, values < 50% for frequent constipation were obtained from individuals (18%), educational institutions (13%) and enterprises (10%). However, when considering the responses according to study sites, none of the sites indicated an unusual pattern of complaints of frequent constipation (Table 10.13). In site three, the educational institutions indicated that 50% of their learners complained of frequent diarrhoea.

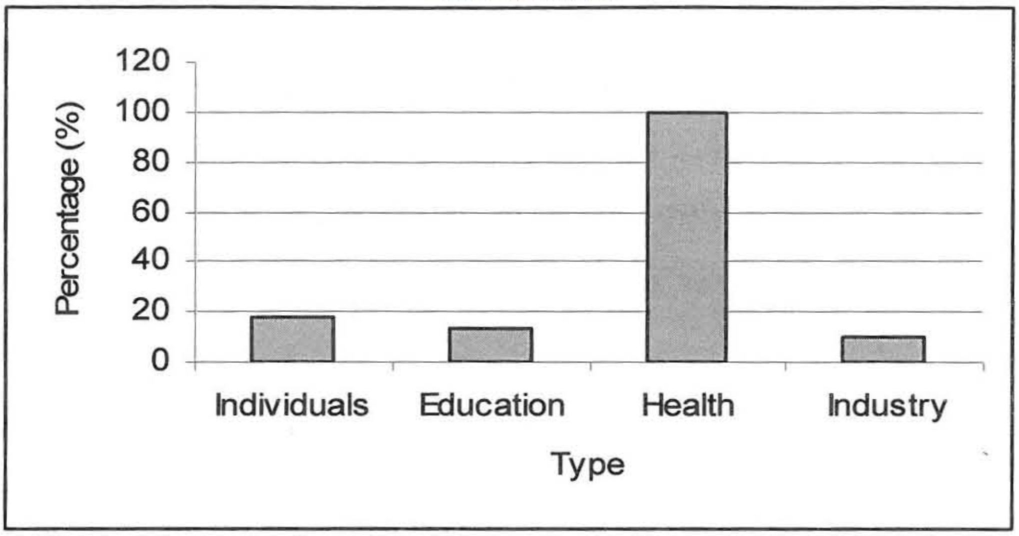

Figure 10.15: Overall percentages of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent constipation

Table 10.13: Details of individuals, respondents at educational institutions, health service providers and enterprises who complained of frequent constipation, according to study sites

Site	Individuals	Education	Health	Industry
One	30			24
Two	18		100	11
Three	10	50		7
Four	2	11	100	9
Five	18		100	
Six	28	33	100	
Seven	39	33		
Eight	2			
Nine	12		100	
Ten	19		100	7
Over all	**18**	**13**	**100**	**10**

There were complaints of persons **coughing** frequently within the study area. All of the health service providers and 70% of the educational institutions reported that they had patients and learners who complained of persistent coughing. As shown in Figure 10.16, values < 50% for inhabitants who complained of frequent coughing were obtained from individuals (49%), respondents at enterprises (45%) and those to whom spirometry tests were administered to (13%). Spirometry tests were administered to selected respondents living in Selebi Phikwe in order to determine the lung function status of residents within the study area. Considering the responses according to study sites, very high values were obtained for individuals, educational institutions, and health service providers in sites four, five, six, seven and nine as depicted in Table 10.14.

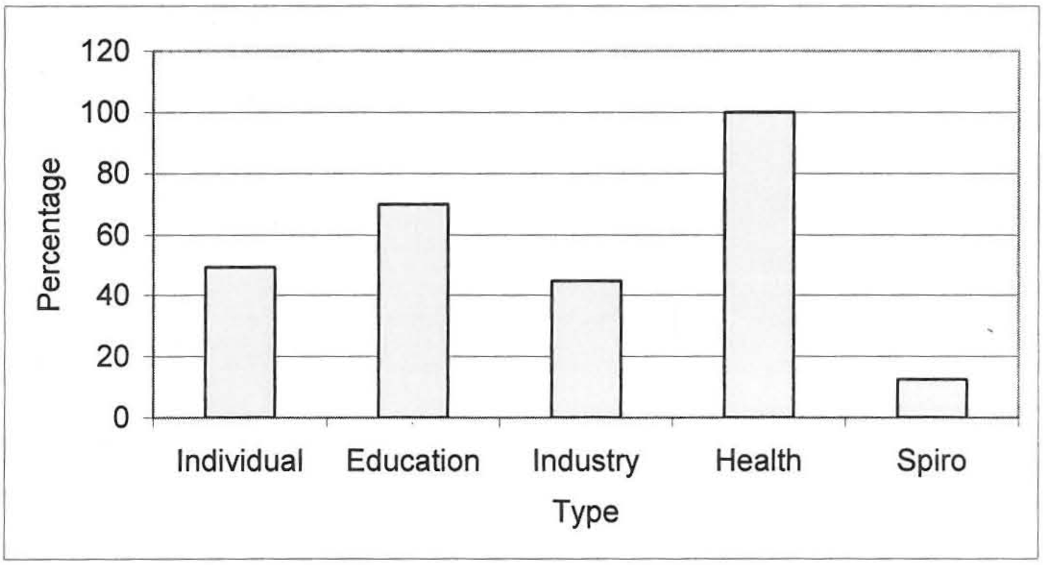

Figure 10.16: Overall percentages of individuals, respondents at educational institutions, enterprises, and health service providers who complained of persistent coughing as well as selected individuals to whom spirometry tests were administered who complained of persistent coughing

Table 10.14: Details of individuals, respondents at educational institutions, enterprises, and health service providers who complained of persistent coughing and selected individuals to whom spirometry tests were administered who complained of persistent coughing

Site	Individual	Education	Industry	Health	Spiro
One	75	100	90		25
Two	25	60	43	100	14
Three	31	100	33		9
Four	57	56	55	100	9
Five	67	100	50	100	10
Six	63	100		100	33
Seven	59	100	50		
Eight	17	50			22
Nine	63	100	75	100	
Ten	37		20	100	9
Overall	**49**	**70**	**45**	**100**	**13**

Values for complaints of **chest pain** were generally low except for the respondents at health service providers; these all reported that they had patients who complained of chest pains. As shown in Figure 10.17, values < 50% for chest pain were obtained from individuals (33%), educational institutions (27%), enterprises (40%) and spirometry tests (27 %). However, when considering the responses according to study sites, in site five the values were > 50% for all the categories of persons except for those undergoing spirometry tests (45%). Notably, 100% was recorded for educational institutions (Table 10.15).

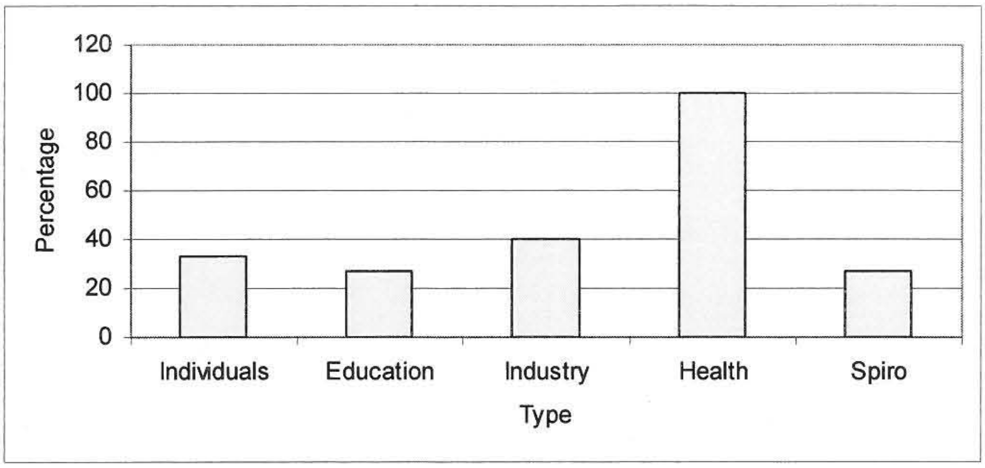

Figure 10.17: Overall percentages of individuals, respondents at educational institutions, enterprises, and health service providers who complained of chest pain as well as selected individuals to whom spirometry tests were administered to who complained of chest pain

Table 10.15: Details of individuals, respondents at educational institutions, enterprises, and health service providers who complained of chest pain as well as selected individuals to whom spirometry tests were administered to who complained of chest pain

Site	Individuals	Education	Industry	Health	Spiro
One	42		71		50
Two	8	20	38	100	57
Three	36	100	33		36
Four	30	22	27	100	45
Five	51	100	50	100	40
Six	22	33	25	100	33
Seven	36	33	17		17
Eight	25		43		
Nine	44		75	100	10
Ten	40		20	100	
Overall	**33**	**27**	**40**	**100**	**27**

Values obtained for complaints of unusual **spitting** for individuals (23%), respondents at educational institutions (17%) enterprises (6%), health service providers (29%) and selected individuals to whom spirometry tests were administered to (2%) were generally very low (Figure 10.18). There were indications from respondents of health service providers in sites two and six that patients complained of unusual spitting: this is shown in Table 10.10. More than 50% of the respondents at educational institutions in sites three, five and six had learners who complained of unusual spitting. However, no pattern could be established based on the results.

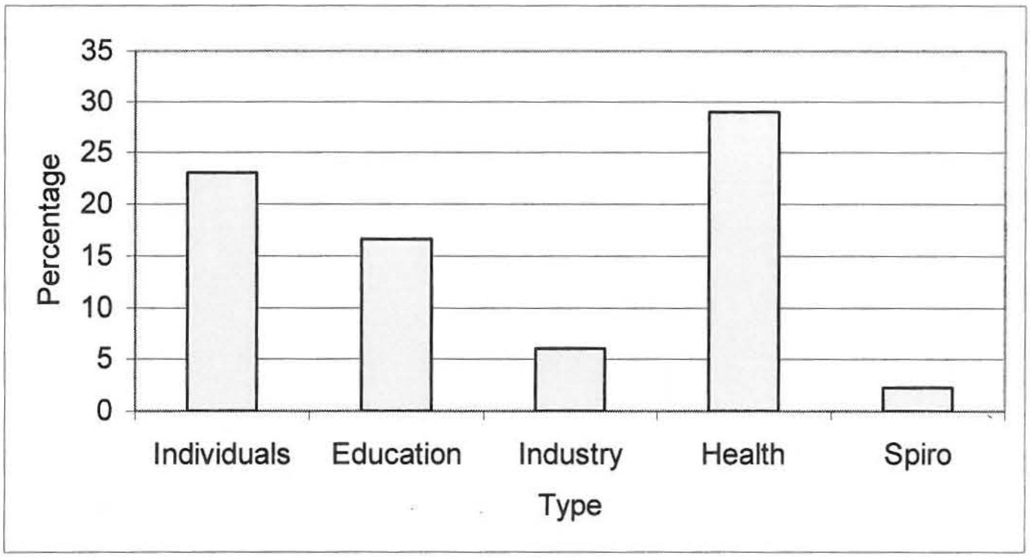

Figure 10.18: Overall percentages of individuals, respondents at educational institutions, enterprises, and health service providers who complained of unusual spitting, as well as selected individuals to whom spirometry tests were administered to who complained of unusual spitting

Table 10.16: Details of individuals, respondents at educational institutions, enterprises, and health service providers who complained of unusual spitting, as well as selected individuals to whom spirometry tests were administered to who complained of unusual spitting

Site	Individuals	Education	Industry	Health	Spiro
One	37		10		
Two	8		8	100	
Three	21	50			
Four	8	11			
Five	35	100	25		
Six	40	67		100	11
Seven	32		17		
Eight	2				
Nine	31				
Ten	18				9
Overall	**23**	**17**	**6**	**29**	**2**

A summary of six of the most common complaints as presented in Figure 10.19 reveal that headaches were the most frequent health complaints affecting all classes of residents in the Selebi Phikwe area. All the different classes of residents registered > 70% of the participants complaining of frequent headaches. This was followed by complaints of frequent influenza/common colds in which all the different classes of residents registered > 68%, and complaints of residents often coughing, the lowest class of which reflected 48% of its participants with this affliction (Figure 10.19). Complaints of chest pains were above 28%. While shortness of breath and unusual spitting complaints were few.

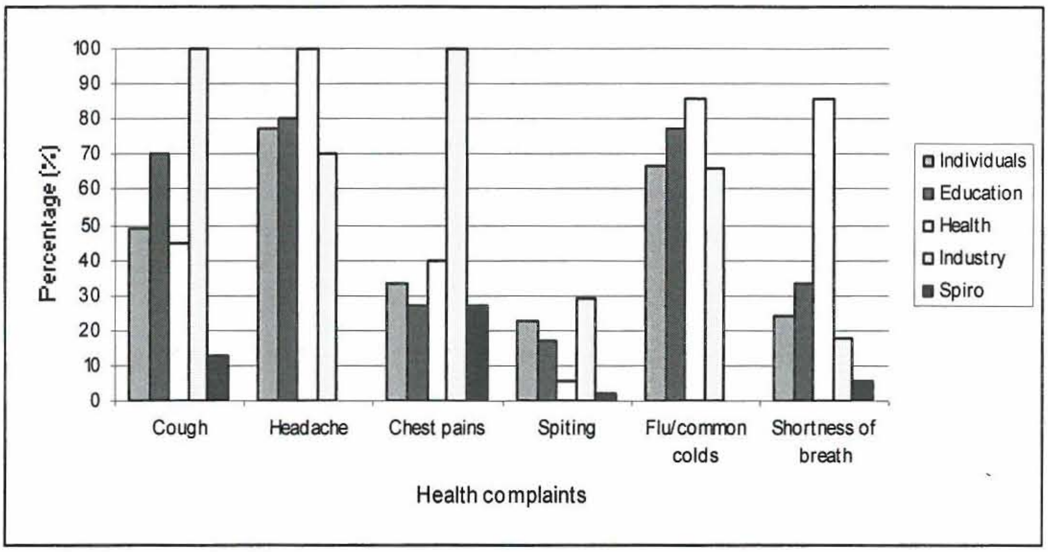

Figure 10.19: Overall percentages of individuals, respondents at educational institutions, enterprises, health service providers and spirometry tests who complained of frequent coughing, headaches, chest pains, influenza/common colds, unusual spitting, and shortness of breath

The results of this study indicate that the four most frequent health complaints at Selebi Phikwe were: frequent headaches, frequent influenza/common colds, persistent coughing, and frequent chest pains. These health complaints all manifest as symptoms of respiratory tract diseases of which pneumonia, asthma, emphysema, chronic bronchitis, chronic obstructive pulmonary disease (COPD) and lung cancer are the most common (The Human Respiratory System, 2003). Pneumonia is an infection of the alveoli and is caused by many kinds of bacteria and viruses. Tissue fluids accumulate in the alveoli reducing the surface area exposed to air. In asthma, periodic constriction of the bronchi and bronchioles makes it more difficult to breathe in and, more especially, out (Australian Lung Foundation, 2003). Airborne irritants such as chemical fumes and cigarette smoke, and airborne particles to which the patient is allergic can provoke attacks of asthma (National Heart, Lung and Blood Institute, 2003).

The immediate cause of emphysema seems to be the release of proteolytic enzymes as part of the inflammatory process that follows irritation of the lungs (Australian Lung Foundation, 2003). Any irritant reaching the bronchi and bronchioles thereby stimulating an increased secretion of mucous, causes chronic bronchitis. In chronic bronchitis the air passages become clogged with mucous, and this leads to a persistent cough especially if the individual indulges in cigarette smoking (Australian Lung Foundation, 2003).

Irritation of the lungs can lead to asthma, emphysema, and chronic bronchitis. In fact, many people develop two or three of these together. Lung cancer is the most common cancer and the most common cause of cancer deaths in U.S. males (National Heart, Lung and Blood Institute, 2003). Although in general more women develop breast cancer than lung cancer (The Human Respiratory System, 2003), since 1987 U.S. women have been dying in larger numbers from lung cancer than from breast cancer (The Human Respiratory System, 2003). This could be as a result of the smoking habit, as well as an increase in environmental pollution.

Previous studies of the aetiology of respiratory disease have suggested that individuals with limited respiratory capacity are at an increased risk for acquiring respiratory maladies such as chronic obstructive pulmonary disease

(COPD) due to PAM exposure (Avol, Gauderman, Tan, London and Peters, 2001). According to Feinleib, Rosenberg, Collins, Delozier, Pokras and Chevarly (1989), COPD affects more than 10% of the USA population over the age of 55. It is ranked as the fourth leading cause of death, although it does not become manifest early in life (Joost, Wilks, Cupples, Harmon, Shearman, Baldwin, O'Connor, Myers and Gottlieb, 2002). It should be pointed out that > 98% of the population living in the Selebi Phikwe area have access to health services (Asare, 1999). Discussions held with the Chief Medical Officer (2003) of Selebi Phikwe revealed that, in his opinion, illnesses, diseases and ailments in Selebi Phikwe were due to poor sanitation and hygiene, as well as poor living conditions. He felt that the respiratory tract diseases were so much higher than average for the country because of the SO_2 released into the atmosphere. However, no documents were available to substantiate his statements.

Mortality values at Selebi Phikwe were generally < 50% for the educational institutions, health service providers, and enterprises who reported cases of deaths. 43% of the educational institutions as well as 43% of the health service providers reported that they had patients who eventually passed away (Figure 10.20). As shown in Figure 10.20, 21% of the enterprises also reported cases of workers who had died. When considering the responses according to study sites, very high values were obtained for educational institutions and health service providers only in site five as shown in Table 10.17. No deaths were reported in site eight. More than 50% of the respondents at educational institutions at the different sites reported deaths.

Deaths were reported in sites (sites four, five and six) identified in previous studies (conducted by Ekosse *et al*., 2002, 2003, 2003a, 2003b), to contain higher contamination levels of heavy metals in the soils (Ekosse *et al*., 2003), *Imbrasia belina, Colophospermum mopane* (Ekosse, 2001), and particulate air matter (Ekosse *et al*., 2003). It was furthermore observed that the pungent smell of SO_2 and related gases and fumes was stronger and more intensified in those sites (sites four, five and six), than in the other study sites. These observations could be substantiated with further research that may include pathological examination.

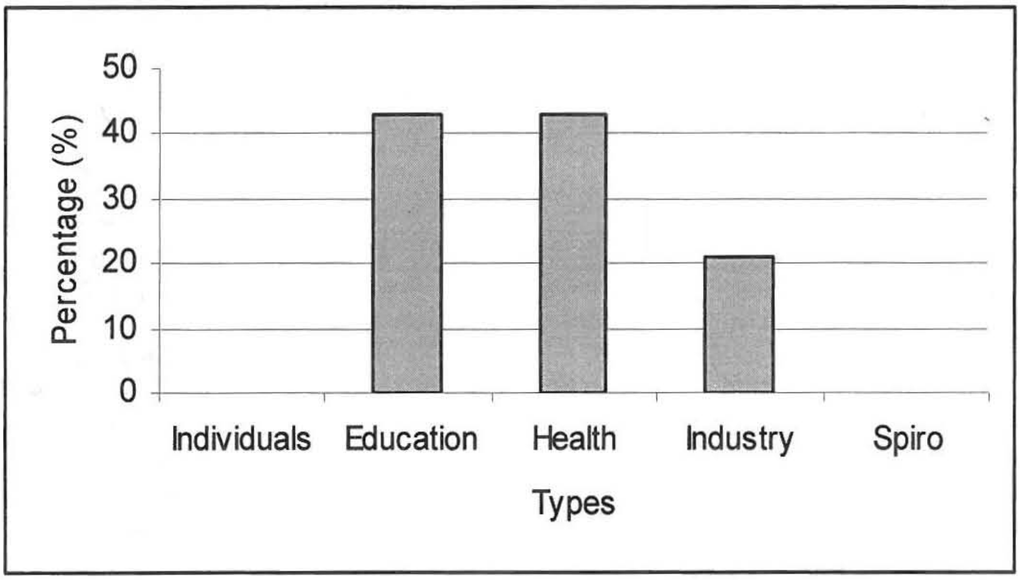

Figure 10.20: Overall percentages of educational institutions, enterprises and health service providers who reported deaths

Table 10.17: Details of educational institutions, enterprises and health service providers who reported deaths

Site	Education	Health	Industries
One	100		48
Two		100	21
Three	50		13
Four	56	0	18
Five	100	100	
Six	67	0	13
Seven	67		17
Eight			
Nine	50		
Ten		100	20
Overall	**43**	**43**	**21**

Not all the deaths reported in Selebi Phikwe can be attributed to mining activities. AIDS, malaria and tuberculosis are caused by bacterial and viral agents which are not associated with the mining activities in the area. Similarly, stroke is considered to be a stress related condition resulting from high blood pressure, and therefore it should be dissociated from causes of death in the mining activities in Selebi Phikwe. On the other hand, lung diseases, pneumonia, heart diseases and some cancers could be provoked by PAM, gaseous fumes, and heavy metals (Feinleib *et al.*, 1989; National Heart, Lung and Blood Institute, 2003; and Schindler *et al.*, 2001). These diseases have been identified to be the cause of some of the deaths which have occurred in the Selebi Phikwe area. In this regard, whereas several causes may exist for their manifestations, the mining activities could possibly have played a role.

10.3.2 Dynamics of the environment related to human health

The mining and processing of sulphide minerals at Selebi Phikwe is accompanied by mine waste. These wastes lead to the formation of different gas and PAM contents, deposition of tailings dump, and contamination of surrounding soils, vegetation and animals. It was demonstrated in a previous study carried out by Ekosse (2001), how the physico-chemical processes at Selebi Phikwe affect the immediate environmental constituents (Figure 10.21).

Fumes rich in sulphur, nitrous oxides (NO_x) and other associated gases were found to be deleterious to human life as well as to cattle and game (Prospero, 1999). The emissions of SO_2, CO, CO_2, and other gases from concentrator and smelter plants affect people, plants, wildlife, rocks and soils, buildings and landscape topography (Buseck and Posfai, 1999). Focusing on mining and smelting activities, a schematic flow diagram is provided to illustrate the influence of these activities on the immediate environment and on residents of the area. The details are presented in Figure 10.22.

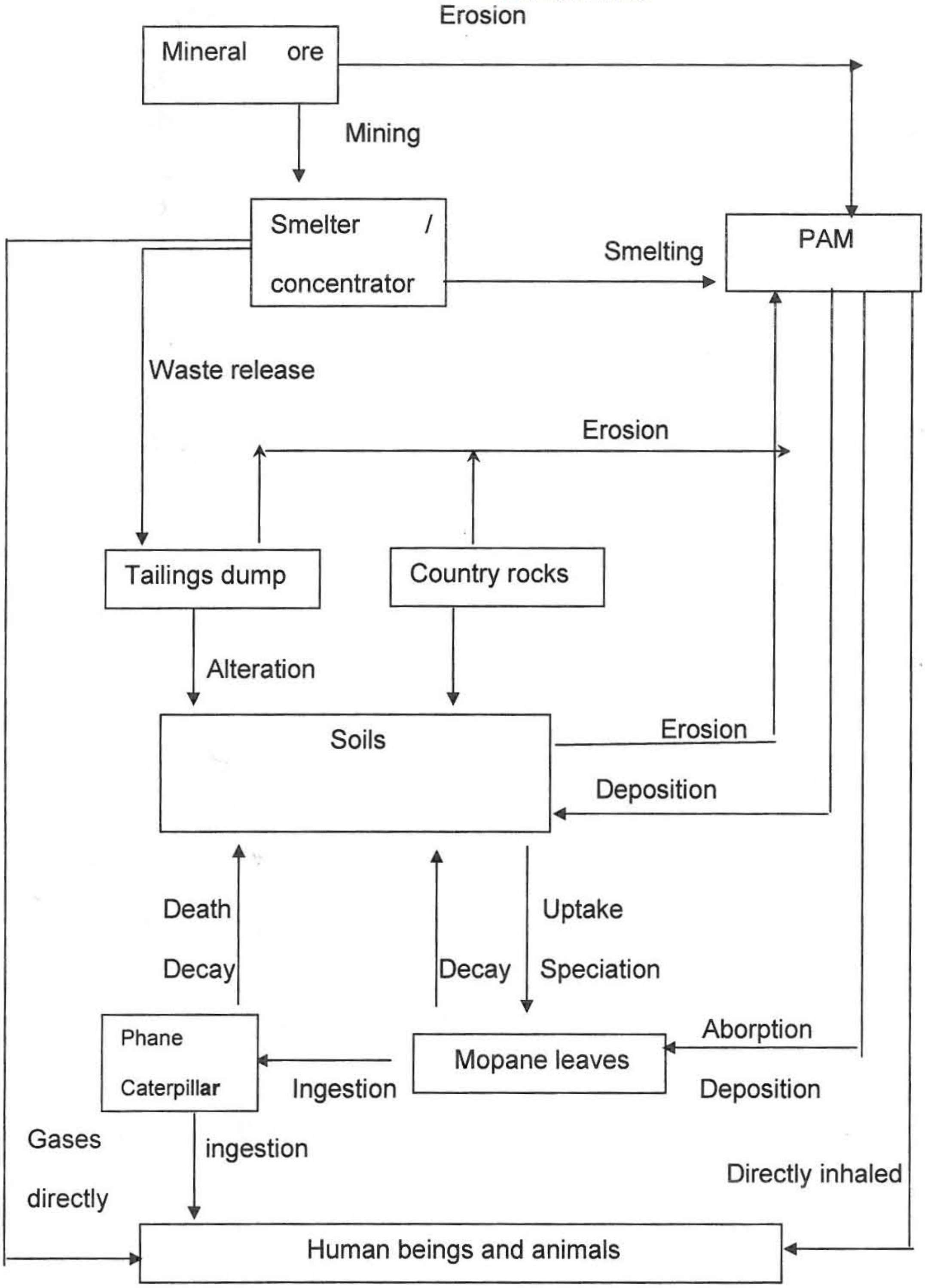

Figure 10.21: Schematic diagram showing physico-chemical processes and relationships of environmental constituents in the Selebi Phikwe study area.

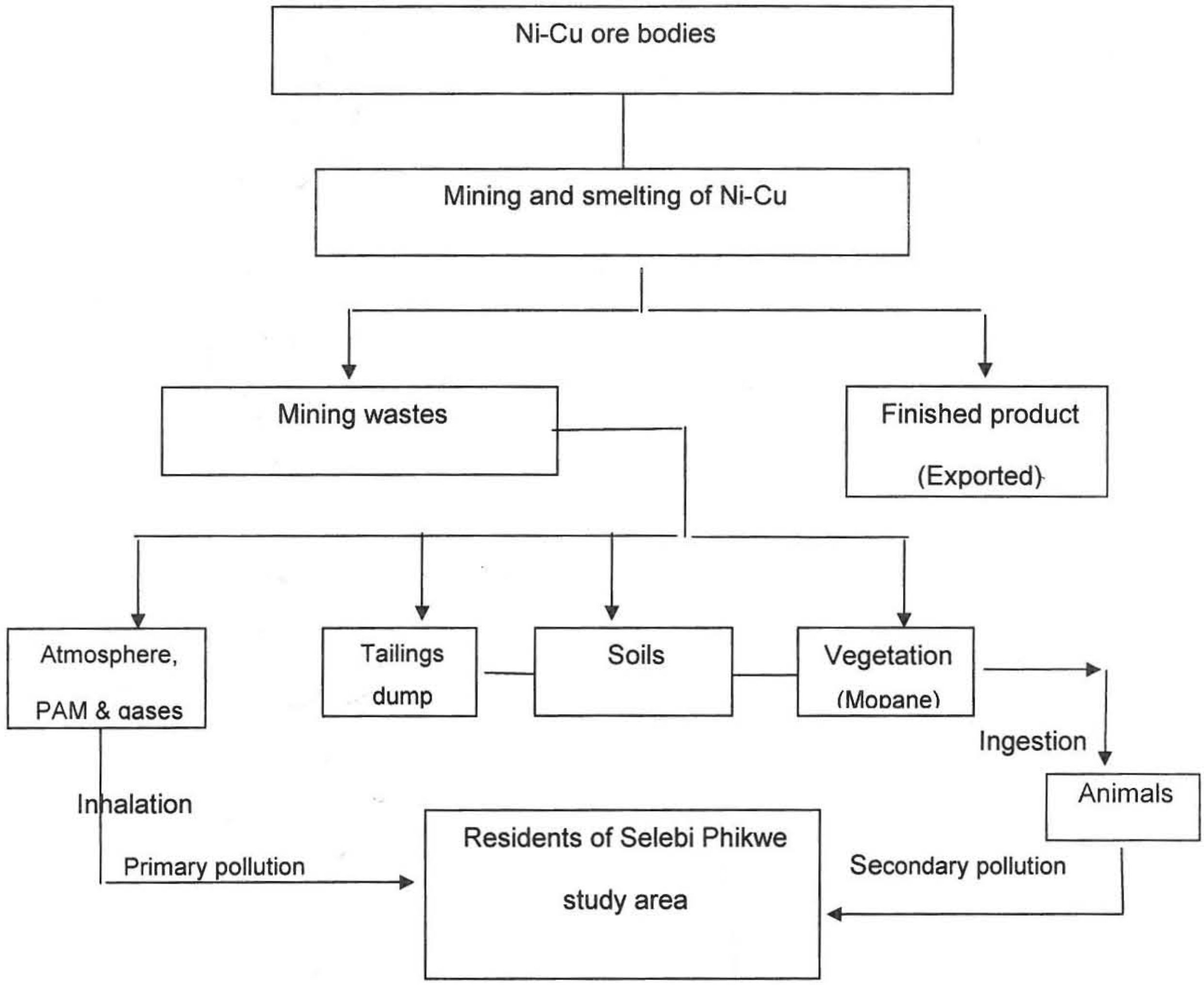

Figure 10.22: Schematic flow diagram depicting the influence of mining activities on the immediate environment and residents of the Selebi Phikwe study area

Mining wastes interact with the various components of the environment, thereby causing pollution. The various forms of primary and secondary pollution affect the residents. The findings of this study reported so far in this document, together with the relationship of the mining activities and other factors affecting human health of residents at the Selebi Phikwe area are summarised in Figure 10.23. In Figure 10.24, the schematic diagram of the human health status at Selebi Phikwe is provided based on the findings of this study.

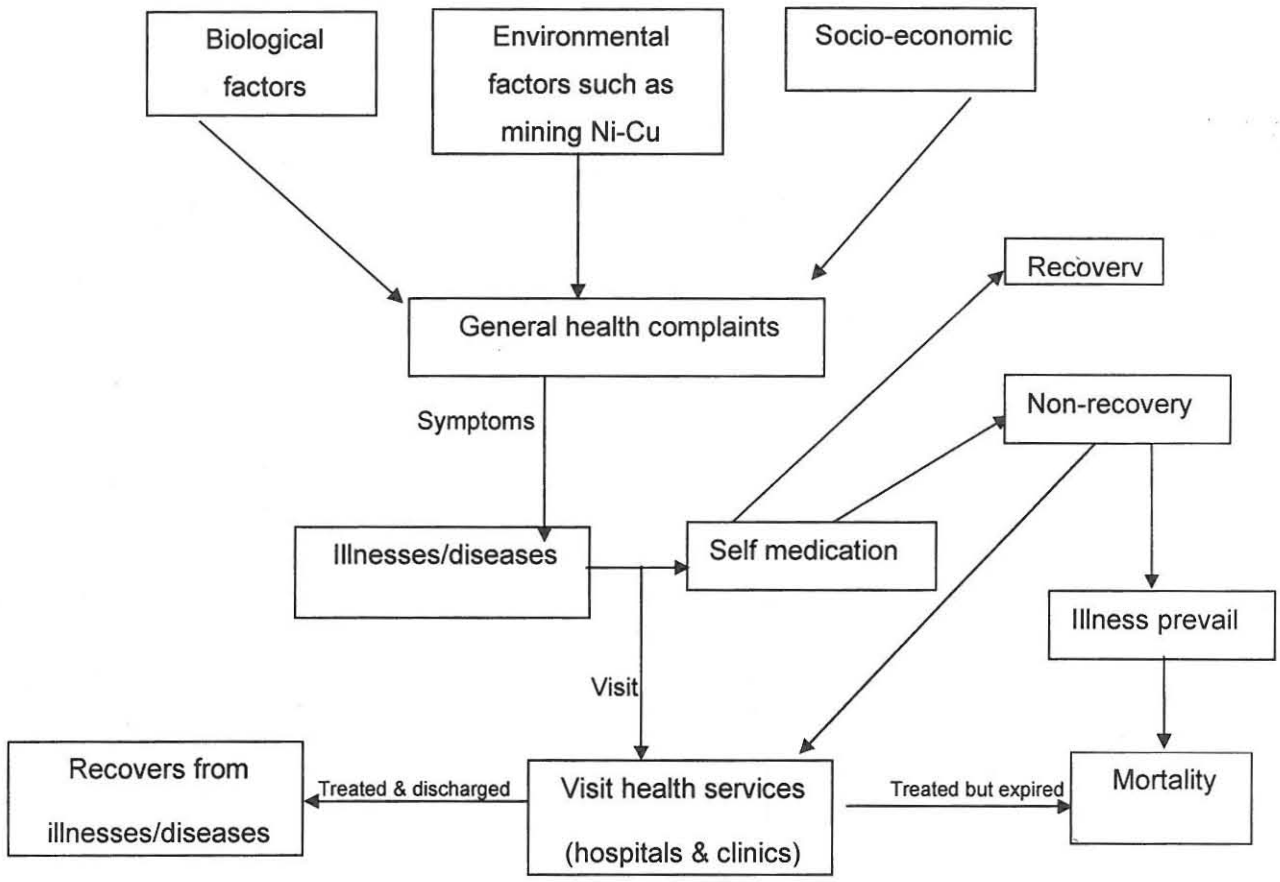

Figure 10.23: Schematic diagram of relationship of mining activities and human health status in the Selebi Phikwe study area

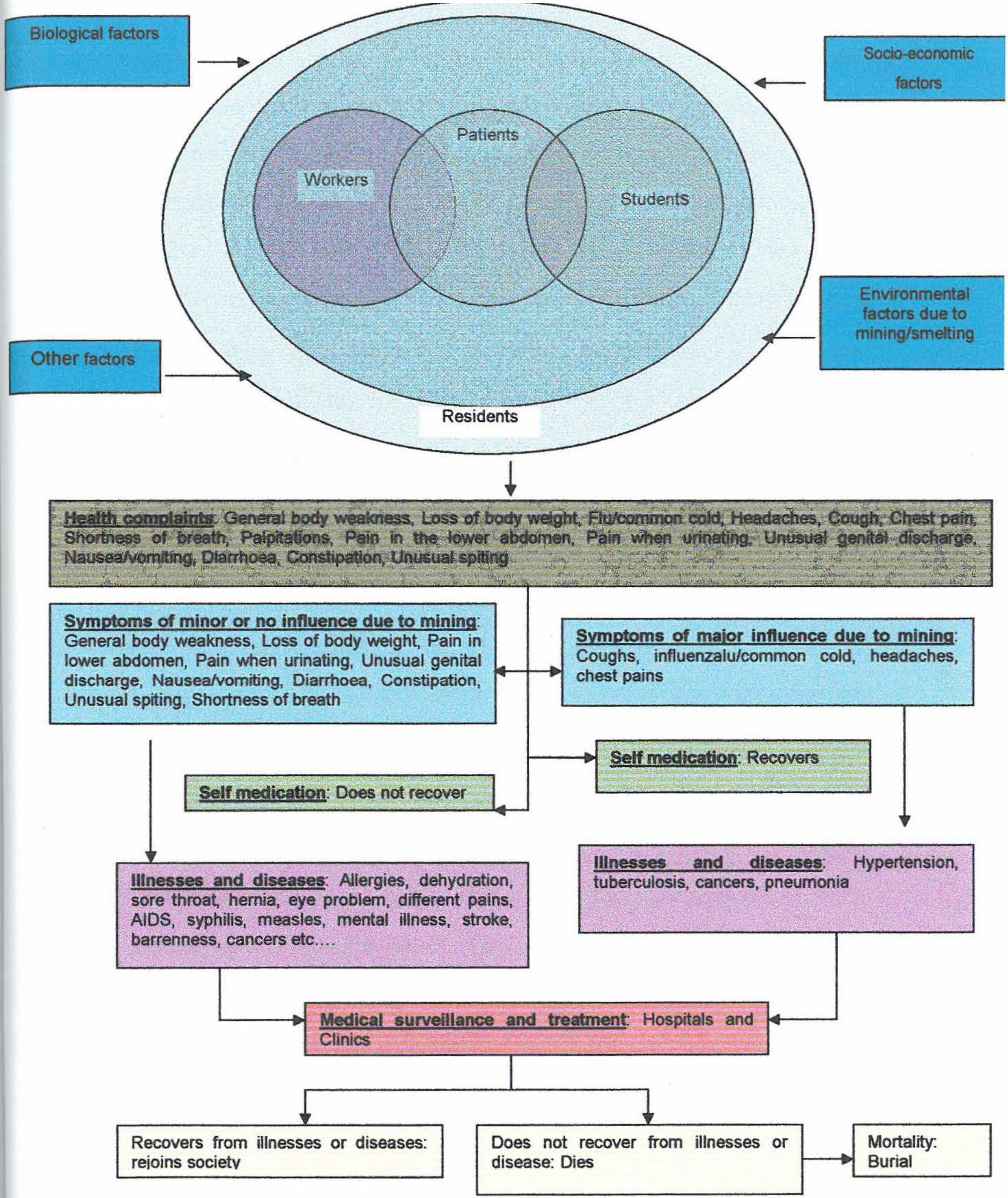

Figure 10.24: Schematic diagram of the human health status at the Selebi Phikwe study area

It can be deduced from Figure 10.24 that biological (including genetic), socio-economic, environmental (including noise, dust, fumes and gases) and other factors have a bearing on the health status of the residents at Selebi Phikwe. These factors influence the general health complaints of the different groups of residents. The health complaints are symptoms of various ailments. Frequent coughing, influenza/common cold, headaches and chest pains, being very common in Selebi Phikwe, sometimes forced some of the residents to apply self medication to relieve the symptoms. More often, however, they visit health service facilities where medical and para-medical services are professionally rendered. In some cases, the symptoms develop into any of the variety of illnesses and diseases which are treated by health service providers. Unfortunately not all cases of patients pull through, and some of the patients do not recover. These patients eventually pass away (Figure 10.24).

Cadmium (Cd) chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), nickel (Ni), selenium (Se) and zinc (Zn) were identified to be associated with the sulphides of Ni and Cu, and their ore minerals at Selebi Phikwe (Ekosse, 2001; Ekosse *et al.*, 2003). These metals may be the causes of some of the illnesses and diseases so far reported in this work. The health effects of Cd contamination in humans usually involve the kidneys and lungs (Langer, 1999). Cadmium is known to affect the renal, skeletal and respiratory systems, and causes itai-itai disease (Alloway and Ayres, 1993; WHO, 1993).

Chromium is carcinogenic and can cause cancer of the respiratory organs and chlorosis. Langer (1999) reported that workers who process ore rich in Cr have a tendency to develop lung cancer and and cancer of the main bronchus. Langer (1999) also mentioned Co to be the cause of what is known as 'hard metal disease".

Excessive intake of Cu by human beings leads to severe mucosal irritation and corrosion, capillary damage, hepatic and renal damage, gastrointestinal and nervous disturbances (WHO, 1993). Iron is known to cause siderosis and scarring of the lungs, depending on the quartz content, and experimental work conducted on ore miners in Newfoundland indicated that Fe is carcinogenic (Langer, 1999).

Nickel causes pneumoconiosis in workers exposed to it during mining and processing (Langer, 1999). A higher than normal rate of occurrences of lung cancer is common among miners of Ni found in hard rock areas. Workers at Ni concentration and smelter plants have been reported to suffer from very high incidences of lung and nasopharynx cancer. Studies have shown Ni to be carcinogenic in humans through intravenous, intramuscular and respiratory routes of infiltration. Nickel also causes dermatitis, eczema, vertigo and dyspnoea to exposed human populations (WHO, 1993).

Selenium causes pneumoconiosis, which may be the result of the associated gangue minerals within the ore body (Langer, 1999). Humans are exposed to the health hazards during ore processing. Langer (1999) reported that workers exposed to Se suffer from severe irritation of the nose and eyes, gastro-intestinal disorders, and dental caries.

Zinc causes shortness of breath, minor lung changes and pneumoconiosis (Langer, 1999) and can also cause vomiting, dehydration, electrolyte imbalance, abdominal pain, nausea, dizziness, lack of muscular coordination, and renal failure (WHO, 1993).

Illnesses and diseases, especially frequent coughing, influenza/common cold, headaches and chest pains reported so far could be provoked by the pollution caused by mining and smelting of mineral ore bodies such as the Ni-Cu ore bodies at Selebi Phikwe, Botswana. Symptoms of these ailments include the four most frequent health complaints of the residents of Selebi Phikwe: persistent coughing, frequent headaches, frequent bouts of influenza/common colds and rampant chest pains. Headaches could, however, also be symptomatic of high blood pressure, which could well be attributed to eating habits, as a great deal of roasted beef is consumed with plenty of non-iodated salt. Environmental factors resulting from mining and smelting activities, together with other factors, such as eating habits, could very well be contributory to the negative health effects occurring at Selebi Phikwe.

10.5 Conclusion

In this chapter we have integrated the results of questionnaires and structured interviews obtained on selected aspects of the health status of residents of the Selebi Phikwe Ni-Cu mine area, Botswana and presented models to demonstrate the possible relationships between the mining activities, environmental pollution and health status of the population. The responses were obtained from individuals, workers of business and industrial enterprises, learners of educational institutions, health service providers and spirometry tests. In this study, we have reported on an investigation which was conducted through the administration of questionnaires and structured interviews. Data was generated in areas related to demographical and biographical aspects, family history, general complaints about personal health, past medical history, past and present treatment and medication, and general profile of social and personal history. With the aid of SPSS software, attempts were made to interpret the findings.

Common ailments found in the area included asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headaches, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancers.

The study further revealed that the four most frequent health complaints of residents within the study area are frequent coughing, regular attacks of influenza/common colds, constant headaches, and regular chest pains. These symptoms have been associated with various illnesses and diseases such as hypertension, tuberculosis, cancers and pneumonia. A model has been postulated which summarises the interplay of biological, socio-economic, environmental and other factors bearing on the health status of the residents of Selebi Phikwe. It is evident that mining activities could be contributory to some of the negative health effects identified in this study.

More specifically, the findings of the study indicated that the respiratory tract-related health problems found in the study area are considered to be linked to the mining and smelting activities. The gas, together with sulphate particulates, aggravates respiratory diseases, reduces the effective functioning of lungs, and irritates the eyes and the respiratory tract (Asare, 1999). Previous studies revealed that sulphur dioxide, which is emitted from the roasting of the ore, particulate air matter, tailings dump, contaminated soils, contaminated *Colophospermum mopane* and *Imbrasia belina* were identified by Asare (1999), Ekosse (2001) and Ekosse *et al.* (2003) to be sources of pollution, which could possibly be affecting the health of individuals living within the Selebi Phikwe area.

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Chapter Eleven

Conclusions and Recommendations

11.1 Problem statement

The politically independent Botswana's premier large scale economic enterprise is the Selebi Phikwe Ni-Cu mine. Mining activities at Selebi Phikwe took off in 1973, and this mine has been operating for more than twenty years (Nkoma and Ekosse, 1999; 2000). At this mining site, there are underground mines from which Ni-Cu ore is being mined, as well as a concentrator/smelter plant for the processing of the ore to Ni-Cu matte. Unfortunately, possible negative impacts, such as environmental and human health hazards, were not adequately considered at the inception of the mining project (Bamangwato Concessions Limited, 1996; 1997).

Environmental risks associated with Ni-Cu mining at Selebi Phikwe include water and soil pollution from tailings and air pollution from smelters (Ekosse, 2001). No specific environmental impact assessment (EIA) studies were carried out prior to the inception of the minerals exploitation activities (Asare, 1999). Due to financial and technical problems, the Bamangwato Concessions Limited (BCL) could not compensate inhabitants who were displaced as a result of the exploitation exercise (Bamangwato Concessions Limited, 1996; 1997). This resulted in the simultaneous construction of mining facilities and the rapid growth of the township.

A symbiotic relationship ensued whereby the local population traded in livestock and dairy products, traditional alcoholic beverages and phane, and the mine recruited a strong labour force of about 5000 workers. Consequently, squatter camps, as well as urban settlements, sprang up (Asare, 1999; Ekosse, 2001). Fumes, gases, dust and noise emanating from mining and smelting activities were eminent in the environment (Ekosse, 2001), and the possibility that these environmental pollutants could have a direct bearing on the health of the inhabitants of the area is very real. It therefore became necessary to evaluate the possible influence of the mining activities on the general human health of the inhabitants of the area.

11.2 Response to queries

Information pertaining to the general health status of the inhabitants was obtained from the administration of questionnaires and structured questions, and the carrying out of spirometry tests.The spatial presentation of data related to the human health status within the study area elucidate the following responses to queries introduced in Chapter One.

- By means of questionnaires, information was generated from individuals of the population living at Selebi Phikwe.
- By means of questionnaires and structured questions directed to educational institutions, data was obtained and analysed regarding the health status of learners within the study area.

- By means of questionnaires and structured questions directed to business and industrial enterprises, data was obtained and analysed regarding the health status of workers within the study area.
- By means of questionnaires and structured questions directed to health service providers, data was obtained and analysed regarding the status of health services and health service providers in the study area. Questionnaires pertaining to health complaints of patients visiting the facilities were administered to generate information on the health status of the inhabitants of Selebi Phikwe.
- Spirometry tests were carried out on individuals in order to determine the functioning of their lungs. The results were then related to the health status of the individuals.
- With the aid of Geographical Information System (GIS) software, results obtained regarding individuals, educational institutions, enterprises, and spirometry tests were spatially presented.
- The findings were integrated in order to establish trends of health complaints and their spatial distribution and to relate these trends to the possible influence of environmental pollution as a result of Ni-Cu mining activities.

11.3 Conclusions

Exploitation of Ni-Cu ore bodies at Selebi Phikwe has been conducted for more than twenty years. In a separate study, it was demonstrated that the mining and smelting activities have a direct influence on the physical environment, affecting the soils, mopane vegetation, phane worm and the atmosphere (Ekosse, 2001; Ekosse, Chaoka, Alemaw, Van den Heever and De Jager, 2002; Ekosse, Van den Heever, De Jager and Totolo, 2003, 2003a; 2004; 2004a). In addition, atmospheric pollution due to release of mineral dust (Ekosse, 2001) and sulphur-rich gases, commonly detected by obnoxious smell, was demonstrated to be eminent at Selebi Phikwe (Department of Mines, 1998). It was thus suspected that the inhabitants of the area probably inhale polluted air (Asare, 1999). Inhabitants of the area generally complain that they are often infected with symptoms of diseases and these ailments are often related to pulmonary health complications (Ekosse *et. al.*, 2003). In this regard, this research aimed at establishing whether mining and smelting activities negatively affect the general health status of inhabitants in Selebi Phikwe, and at determining the status of health services available there.

By means of the study, an attempt was made to establish and verify the existing human health status at the Selebi Phikwe area. Furthermore, the pulmonary health status of the inhabitants of the Selebi Phikwe area was explored, with the intention of advancing possible solutions in the event that problems were identified. Several field visits were made to the study site for reconnaissance surveys, and also to administer questionnaires and lung function tests.

Common ailments, illnesses and diseases found in the study area included asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, coughing, constipation, diarrhoea, influenza/common cold, headaches, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancers. More significantly, the study further revealed that the four most frequent health complaints of residents within the study area are frequent coughing, regular attacks of influenza/common colds, constant headaches, and regular chest pains. A very high percentage of the population is affected in this regard. These four most frequent health complaints are symptoms which are associated with respiratory tract diseases. The inhabitants are of the opinion that these complaints are provoked by the mining and smelting activities; the main factors being dust, fumes, gases and noise.

Key social and economic problems in Selebi Phikwe coupled with low levels of education of the inhabitants have made it difficult for local communities to appropriately address health hazards affecting them. The efforts of the Government of Botswana in this venture are recognised. However, the general perception of the individuals living in the Selebi Phikwe area, as could be deduced from the questionnaires and structured interviews is that government authorities, local councils and the BCL have not adequately addressed the problem of air pollution. The health problems are perceived to be derivatives of air pollution in the environment.

11.4 Recommendations

The recommendations advanced in this study aim to address the problems as have been identified. The recommendations are thus advanced to the various groups, that is the individuals, learners of educational institutions, workers of enterprises and health service providers. Furthermore, recommendations are also advanced to the mining authorities and the different government authorities (Selebi Phikwe Town Council, Local Government, and the National Government). Some of the recommendations that were suggested in a previous study by Ekosse (2001) were found to be applicable in this work as well. Therefore, they have been incorporated with other recommendations based on the findings of the present study.

11.4.1 Residents

- The residents should avoid being outdoors as much as possible where the risk of exposure to contaminated air is fairly high.
- The residents of the Selebi Phikwe area should report to health authorities for regular check-ups of their health status. These visits should include a thorough examination of the cardio-pulmonary system, the circulatory system, and the urinary system.
- Residents considered to be frail in health should consider relocation to other township areas away from the sulphur-rich gases and fumes.
- Residents should be discouraged from buying drugs, such as penicillin, over the counter. They should rather be advised and encouraged to visit

heath service facilities where professional medical services and advice are rendered.

- Individuals who indulge in smoking and those often exposed to environmental tobacco smoke should make efforts to stop smoking or to avoid the smoke, especially if they often suffer from symptoms of respiratory tract diseases.
- The residents should be encouraged to maintain a balanced diet as much as possible, and to reduce the amount of alcohol consumed. They should also be encouraged to exercise regularly. These positive measures enhance breathing and improve the functioning of the lungs.

11.4.2 Educational Institutions

- Learners considered to be frail in health should seek schooling in other township areas away from the sulphur-rich gases and fumes. If possible, they should be moved completely out of the Selebi Phikwe area.
- Education authorities in association with health service providers should carry out health education programmes which focus on sanitation and hygiene for learners in educational institutions.
- Learners, especially those attending schools close to the mine, should report to health authorities for regular check-ups of their health status. The medical visits should include a thorough examination of the cardio-pulmonary system, the circulatory system, and the urinary system. Spirometry tests should be included in the medical examination.

- Learners affected with contagious sicknesses and diseases should not be allowed in school, but rather be advised to pursue medical help.

11.4.3 Business and industrial enterprises

- Managers and workers should apply all the necessary measures in reducing occupational hazards. Protective clothing and gear should be used at all times when carrying out their daily tasks.
- Workers should be encouraged to carry out good working practices at all times.
- Workers should not be exposed for very long periods to areas considered to be more hazardous.
- Risk-based medical examinations should be conducted annually.
- The workers should report to health authorities for regular check-ups of their health status. The medical visits should include examination of the cardio-pulmonary system, the circulatory system, and urinary system.
- Workers considered to be frail in health should seek employment in and relocation to other township areas away from the sulphur-rich gases and fumes.
- Education programmes on contaminants should be conducted annually.
- Environmental control measures should be implemented.
- An occupational exposure (Occupational Hygiene) programme should be compiled and implemented.
- Policy and procedures with regard to managing the contamination should be compiled and implemented.

11.4.4 Health services and health service providers

- Health services and health service providers should organise health education campaigns which focus on sanitation and information on environmental pollution due to the mining activities.
- Periodic medical check-ups should be conducted on the residents, and spirometry testing should be of primary importance.
- Whereas staffing of essential health services within the study area may appear adequate for the present population, there is a need for more specialised medical and para-medical personnel such as industrial nurses, industrial hygienists, occupation health specialists, and industrial psychologists, among others, who can better understand the health concerns of the residents. They would be better equipped and placed by virtue of their different specialisations to handle health matters in mining environments.
- Hospitals and clinics should expand to include monitoring beds for residents who regularly manifest symptoms symptome of illnesses and diseases discussed in this document.
- Quarantine units should be established in health facilities to curb the spread of contagious sicknesses and diseases.

11.4.5 Mining authorities

- Mining authorities should make stringent efforts to reduce the degree (time) of exposure of workers to hazardous materials such as SO_2 gas.

- Efforts should be made to institute resources to reduce situations considered to be deleterious to human health. These measures include wetting of the dust, better ventilation of the workstations, and using mask respirators that filter particles or chemicals.
- Educational programmes should be institutionalised for workers to inform and train them on relevant aspects related to Occupational Health and Safety.
- Mining authorities should ensure that workers are educated regarding personal hygiene, clean working areas, and consumption of beverages at designated areas. Keeping skin and especially the hands thoroughly clean before meals should be mandatory.
- Clothes used for work should always be kept separate from other clothes. Workers should have more than one set of work clothes and they should always keep them clean.
- Different forms of personal protective clothing and gear should be given to workers, adapted to their job requirements. The mining authorities should make sure that workers utilise their personal protective clothing as required.
- Secondary prevention measures such as medical monitoring of workers and environmental monitoring should be carried out regularly. Workers complaining of asthma, chronic obstructive pulmonary diseases and other respiratory tract ailments should not be exposed to high risk areas, and their medical situation should be evaluated more often than the other workers.

11.4.6 Government, Local Government and Town Council

- Government and related agencies as well as mine authorities should work as a team in monitoring pollution activities at Selebi Phikwe.
- The agencies should derive health monitoring programmes geared towards ensuring a quality lifestyle for sustainable development.
- In collaboration with health service providers, the government and related agencies as well as mine authorities should carry out active health education programmes which focus on sanitation, health and wellness of the inhabitants of the study area. This radical move will aid in abating a little of the frequency of occurrences of the illnesses and diseases.
- Applied research efforts on human and environmental health should be encouraged by authorising bodies.
- Expansion of Selebi Phikwe township should be regulated in such a way that the growing population is least exposed to atmospheric pollutants.
- Government authorities, local councils and the mining authorities should harness their resources in a combinatory effort in overcoming both environmental and health hazards in the study area.

11.5 Reflection of study

This study was developed from the outcome of previous studies which focused on perceptions on socio-economic and environmental impacts of exploiting Ni-Cu (Asare, 1999) and appraising the biophysical environment due to mining of Ni-Cu (Ekosse, 2001; Ekosse *et al.*, 2002; 2003; 2004), both at Selebi Phikwe. The study was executed within the conceptual framework of the fact that mining activities could possibly be having effects on the health status of the residents of the study area.

Several data gathering and analytical techniques have been utilised to arrive at the findings of this work. The data gathering techniques included the administration of questionnaires and structured questions to residents, and the carrying out of spirometry tests to selected individuals within the Selebi Phikwe area. Analytical techniques for data processing employed in the study included the use of Microsoft Excel and the statistical package for social sciences (SPSS) as well as ArcGIS software packages. Basically, the study has constructed a broad overview of the general human health status at Selebi Phikwe, and attempted to establish possible relationships to the on going mining activities.

The outcomes of this study indicated common ailments, illnesses and diseases such as asthma, bleeding tendencies, heart disease, high blood pressure, allergies, general body weakness, chest pain, cough, constipation, diarrhoea, influenza/common cold, headaches, loss of body weight, lower abdominal pain, nausea and vomiting, palpitations, shortness of breath, unusual spitting, genital discharge, and cancers to be occurring in the study area. Furthermore, the findings of the study revealed that the four most frequent health complaints of residents within the study area are frequent coughing, regular attacks of influenza/common colds, constant headaches, and regular chest pains, and a very high percentage of the population is affected. These four most frequent health complaints are symptoms which are associated with respiratory tract diseases. The inhabitants are of the opinion that these four most frequent health complaints are provoked by the mining and smelting activities; the main factors being dust, fumes, gases and noise. However, the study does not investigate pathways of these sicknesses and diseases among the inhabitants.

The study has broadly addressed the various health effects, and did not zoom in on any specific disease. In so doing, it became difficult to categorically determine the mining activities to be the main cause of the negative health effects in the study area. Other contributory factors emerged, such as the eating habits of the inhabitants. They consume plenty of non-iodated salt, and high levels of Na in the body is the main cause of high blood pressure. The symptomatic headaches of the inhabitants of the study area could be precursors to high blood pressure. They also consume a lot of coca cola that contains caffeine for increased heart rate. Coca cola and other cold drinks contain sugar in great quantities which lead to the feeling of general tiredness after their consumption.

The work was carried out within the time frame required for such a study. Administrative and other logistical problems which were encountered were easily overcome as the study progressed.

11.6 Future research

The suggestions for future research advanced in this section are based on the conclusions and recommendations, and reflections of this study. The following points for future research are suggested:

- It is anticipated that continued research should be applied in attempting to solve the Selebi Phikwe health problems.
- Future research should focus on in-depth studies of the symptoms, illnesses and diseases that have been identified in this study to be prevalent in the study area. These should include the four most frequent health complaints of residents within the study area, as have been mentioned.
- Ageing and specific diseases of residents should be further investigated. Findings of such a study could result in recommending relocation for the frail and the aged.
- Because there is a strong bearing on environmental health issues in the Selebi Phikwe area, research efforts should be directed towards understanding and advancing solutions to environmental health concerns.
- Respiratory health complications quite often have a bearing on the heart and the circulatory system. Investigations should be carried out which address health problems related to cardiological and circulatory systems of the inhabitants of the study area.

11.7 Concluding remarks

The work in the present study is divided into three sections: the first section includes Chapters One, Two and Three, the second section Chapters Four through Ten and the third section consists of Chapter Eleven. Chapters One, Two and Three dealt with the background to the study and the different methods and techniques which were used to carry out the research. Chapter Four focused on the health status of individuals residing within the Selebi Phikwe mine area, while Chapter Five investigated the health status of learners attending educational institutions, Chapter Six explores the health status of workers of business and industrial enterprises within the study area. The available health services and health status of patients within Selebi Phikwe area are reported in Chapter Seven. Chapter Eight reports on the use of the lung function test to further evaluate the health status of residents within the study area. In Chapter Nine, we applied Geographic Information System (GIS) techniques are applied, using the findings of the previous chapters, to attempt an understanding of the health status of residents within Selebi Phikwe area. Chapter Ten was an integrated approach combining data from the previous chapters, in understanding the human health status within the study area, and in Chapter Eleven the conclusions are given.

This study, which is summarised in Figure 11.1, has evaluated the health status of residents within the Selebi Phikwe Ni-Cu mine area, Botswana. It has advanced certain recommendations that may bring solutions to some of the existing human and environmental health problems. The findings of the study may serve as useful guidelines in interpreting the health status of the inhabitants Selebi Phikwe, and possibly similar mining/smelting settings around the world.

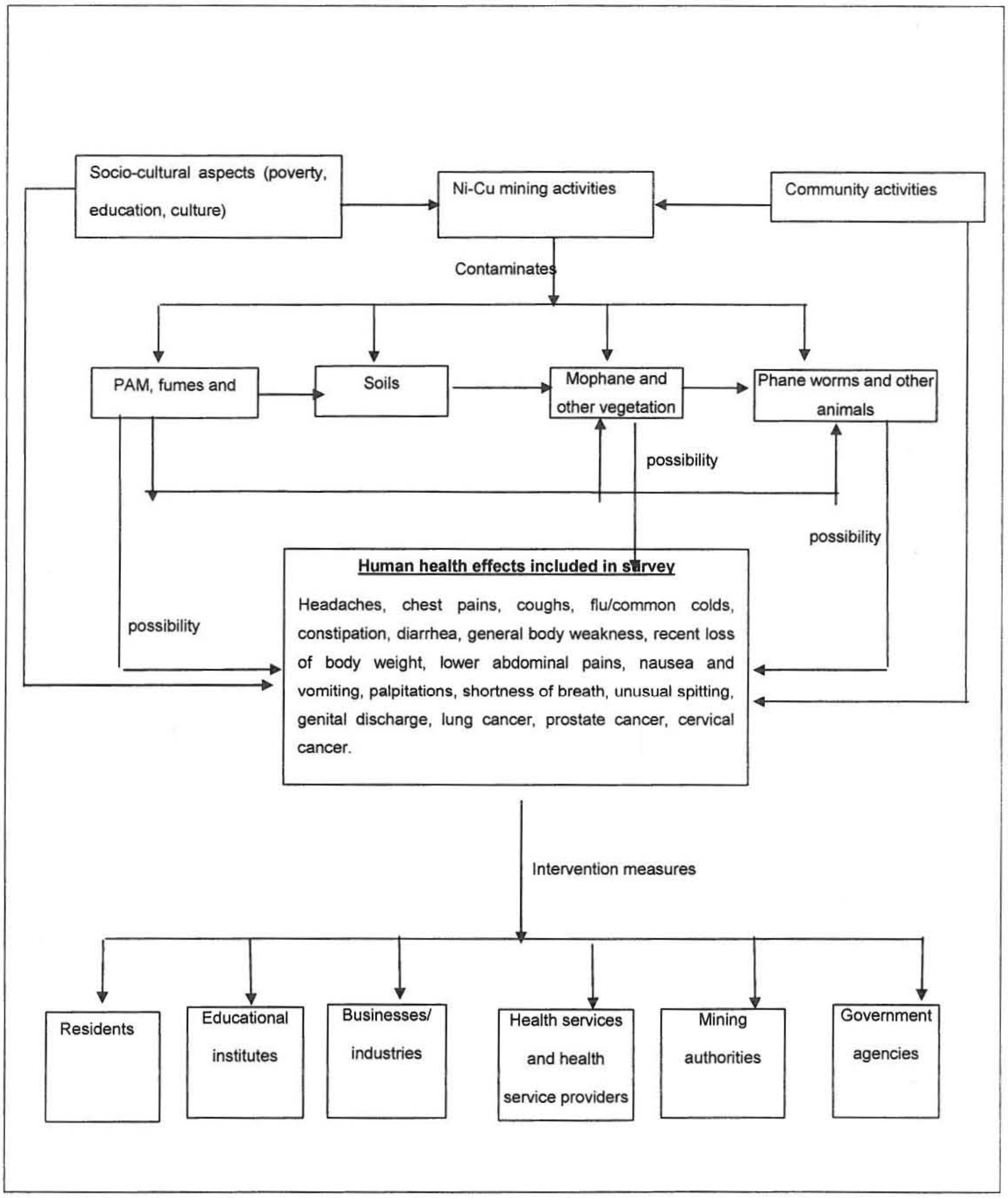

Figure 11.1: Schematic summary of human health study

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