

**The Respiratory Health Status of Adults
Who Spent Their Developing Years
in a Polluted Area in South Africa**

A Historical Cohort Study

By

Maria Aletta Oosthuizen

**SUBMITTED IN FULFILLMENT OF THE DEGREE
MASTERS OF MEDICAL SCIENCE**

**AT THE SCHOOL OF FAMILY & PUBLIC HEALTH
NELSON R MANDELA SCHOOL OF MEDICINE**

UNIVERSITY OF KWAZULU NATAL

2004

**SUPERVISOR: PROF C C JINABHAI
CO-SUPERVISOR: DR APS TERBLANCHE**

**“When you can’t breathe, nothing else matters”
(American Lung Association)**

DECLARATION

I declare that this dissertation is my own work. It is being submitted for the degree Masters of Medical Science at the Nelson R Mandela School of Medicine at the University of Natal. This work has not been submitted before for any other degree or examination at any other tertiary institution.



Maria Aletta Oosthuizen

Signed on the 14 day of October 2005 in Pretoria.

DEDICATION

Hierdie werk is opgedra ter herinnering aan my ouers.

PUBLICATIONS/PRESENTATIONS

Results from this study have been presented at the following conferences:

International Union of Air Pollution Prevention Associations (IUAPPA)'s
13th World Clean Air and Environmental Protection Congress
London, UK 22-27 August 2004, under the following title:

**Health status of adults exposed as children to air pollution in South Africa:
13 year interval follow-up study**

National Association for Clean Air (NACA)'s annual conference
Indaba Hotel, Johannesburg. 4-8 October 2004, under the following title:

**Prevalence of asthma in a group of young adults who spent their
developing years in the Vaal Triangle, South Africa.**

M A Oosthuizen*, C Jinabhai, APS Terblanche* and P Becker. *****

***CSIR, P O Box 395, Pretoria, South Africa **University of Natal ***MRC**

SUMMARY

The results of numerous studies show that polluted air may cause acute and chronic health effects (Abbey *et al.*, 1999; Garrison, 2001; Pope *et al.*, 2002). Children can be considered as a susceptible subgroup as far as air pollution is concerned (Bearer, 1995; Cohen Hubal *et al.*, 2000; Koenig and Mar, 2000). Studies on the effects of air pollution on the health of South African children have also clearly demonstrated adverse effects (Mathee and Von Schirnding, 2003; Nriagu *et al.* 1999; Terblanche, 1998). However, little is known about the respiratory health status of adults, who spent their developing years in areas where they were exposed to air pollution. It was therefore decided to conduct a study on adults who spent their developing years in a polluted area and of whom the respiratory health status as children is known.

The individuals chosen formed part of the Vaal Triangle Air Pollution Health Study (VAPS) conducted during the early nineties. The aim of VAPS was to study the exposure and effects of outdoor as well as indoor air pollution on the health of children (between the ages of 8 and 12), living in the Vaal Triangle. The area was and still is perceived as a polluted area because all main sources of ambient (outdoor) air pollution are represented in the Vaal Triangle. These include coal burning (from power stations, some industries and residential areas), industrial processes (including petrochemical and metallurgical industries) and motor vehicles.

The main findings of VAPS as far as air pollution is concerned, were that particulate matter concentrations were up to 2.5 times the US-EPA health standard. Concentrations of SO₂ were higher in winter than in summer but remained relatively low throughout the study period. Concentrations of NO_x remained below standards, while ozone concentrations occasionally (less than 1% of the time) exceeded standards (Terblanche, 1998).

Current air pollution monitoring results show that particulate matter remains a cause for concern in the Vaal Triangle, especially in domestic coal-burning areas. Source apportionment results showed that particulate matter from domestic fuel burning is still a problem but also that levels differ from area to area, even between two coal-burning residential areas. The current SO₂ concentrations in industrial areas and coal-burning residential areas may exceed guideline values. Ozone concentrations in the area did not change significantly since VAPS, which means that it may still occasionally exceed standards. The maximum hourly

average for ozone measured during 2003 did not exceed the SA 1-hour guideline of 120 ppb. Concentrations of NO₂ monitored after 1993 are still below guidelines (Reddy *et. al.*, 1996; Scorgie, *et. al.*, 2003; Sasol and Eskom, 2004).

A country such as South Africa that is less developed but having a developed aspect to it, has to cope with developed and developing world problems. These problems include the exposure of the population (often more vulnerable because of low socio-economic status) to pollutants, not only from domestic fuel burning but also from industries and motor vehicles. Over the past hundred years there was a definite transition in diseases globally, but also in South Africa. This transition was mostly from infectious diseases, of which many have been eliminated or reduced, to non-communicable diseases of which the risk factors are largely associated with lifestyle (WHO, 2002). Emerging infections such as HIV/AIDS and re-emerging infections (polio) together with existing diseases (TB and malaria) and the exposure to occupational and environmental pollution have had a “double burden” effect on the population of South Africa (Küstner, 1980; MRC, 2002).

The findings of this study confirmed the transition in health status. In general the study population in the current study had a higher prevalence of chronic diseases and a family history of chronic diseases as compared to the average for the South African population.

When considering the current top ten risks to health globally, the current study population has a higher prevalence than the average for the population of South Africa of at least the following five risks: high blood pressure, tobacco consumption, alcohol consumption, high cholesterol and overweight. These factors have mostly to do with lifestyle although hereditariness also plays a role.

As far as respiratory health effects are concerned, the prevalence of upper respiratory health effects found in the total population of the Vaal Triangle study was 65%, while 29% showed lower respiratory symptoms (Terblanche, 1998).

The current study conducted during 2003, investigated the respiratory health status of 184 respondents (response rate 46%) of self-administered questionnaires. These individuals participated during 1990 as ten-year-old children in VAPS and they have lived in the area for ten years or more. Sixty percent of the study population was female and 40% were male.

The majority (63%) of the population still resides in the Vaal Triangle. Thirty nine percent of the study population indicated that they still lived in the town where they were born.

In the current study the adulthood respiratory health status of all the individuals in the study population was compared to their childhood respiratory health status. The prevalence of upper (72%) and lower (24%) respiratory illnesses found in adulthood can be considered relatively high. A statistically significant increase in the prevalence of the upper respiratory illnesses (URI), sinusitis ($p < 0.001$) and hay fever ($p < 0.001$) as well as in the lower respiratory illnesses (LRI), pneumonia ($p = 0.008$) and asthma ($p = 0.034$) was found in the adult phase compared to childhood.

Through univariate statistical analysis, various risk factors associated with different upper and lower respiratory diseases were identified. Being allergic was the one factor statistically significant associated with most of the respiratory illnesses. Being occupationally exposed to dust or chemicals was a risk factor for some respiratory symptoms, while lifestyle factors such as smoking, living in a house where smoking is allowed and being overweight also had an influence. Another risk factor identified as being important, was people's perception on air pollution.

All risk factors with a crude odds ratio above 1.5 and/or a p-value below 0.299 were investigated using stepwise logistic regression.

The increase in upper and lower respiratory illnesses found within the study population over time is in line with findings from other cohort studies, even from countries with low air pollution, where an increase in respiratory symptoms was found with each follow-up assessment (Sears, et. al., 2003). This finding in itself is therefore not proving beyond doubt that adults who grew up in a polluted environment are unhealthy as far as their respiratory health status is concerned.

Fewer individuals (15% versus 17%) were absent from school, work or activities in 2003 as a result of lower respiratory ailments than in 1990 when they participated as ten-year-old children in VAPS. Only 2 of the individuals that had ever been hospitalised for respiratory ailments were hospitalised between the 1990 and 2003 surveys. Thus the severity of the illnesses was less.

Although the prevalence of URI as well as LRI in the study population can be considered to be high, no statistically significant difference in the prevalence of respiratory symptoms was observed for those (63%) who remained in the Vaal Triangle (which include the 39% who were born there) and those who have left the area for more than two years already, as well as between those who have left but visit the area >30 days per year and those who do not. This indicates that exposure to ambient air pollution alone cannot account for the increase in respiratory symptoms of the study population.

Having an allergy was the one statistically significant factor associated with all respiratory diseases, except pneumonia. A significant increase in the prevalence of allergies (a global problem) and possible severity of allergies was demonstrated in the current study. It is therefore possible that the increase in respiratory symptoms could have been from individuals with a family history of asthma, hay fever or eczema, which makes them more susceptible to respiratory ailments, as was found in a Swiss study (Braun-Fährlander, *et. al.*, 1997).

The influence of factors such as lifestyle and occupational exposure, as well as perceptions on air pollution exposure (as was found in the univariate analysis) can also not be ruled out.

In conclusion it can be said that although the prevalence of respiratory health symptoms in this selected group of adults, who spent their developing years in a polluted environment, is relatively high, ambient air pollution exposure cannot be considered the only cause since many other risk factors, including factors associated with genetic predisposition, occupation and lifestyle, were identified which indicates that respiratory illnesses are of multi-factorial etiology.

ACKNOWLEDGEMENTS

The help of the following individuals and institutions/organizations is acknowledged:

All the respondents from the study population

My supervisors, professor Jinabhai and doctor Terblanche

Dr Becker for his patience with the statistical analysis

Dr Greg Tosen and Mr Siven Naidoo for assistance in obtaining funding from ESKOM

Althea Adey for editing

Karin Harding for formatting of the document

Shirley McCormick for help with the graphs

Marthie Swart and Alta Hansen for data capturing and cleaning

My family, friends and colleagues for encouragement

My husband and children for patience

Sasol and Eskom for providing air pollution data.

FUNDING

This study was funded by CSIR (formerly known as Council for Scientific and Industrial Research), ESKOM (Electricity Supply Commission) and the National Association for Clean Air (NACA).

2.1.3.1	Swiss studies	21
2.1.3.2	New Zealand study	22
2.1.3.3	Studies in the United States	22
2.1.3.4	Studies in Germany.....	23
2.1.4	<i>Long term studies in South Africa</i>	24
2.1.4.1	The Vaal Triangle Air Pollution and health Study (VAPS).....	24
2.1.4.2	The Birth-to-ten study.....	25
2.1.4.3	A 2-year follow-up study on risk factors for the severity of Acute Respiratory Infection (ARI).....	26
2.2	HEALTH EFFECTS OF SOME CRITERIA POLLUTANTS	26
2.2.1	<i>Sulphur dioxide (SO₂)</i>	26
2.2.2	<i>Ozone (O₃)</i>	26
2.2.3	<i>Particulate Matter (PM)</i>	27
2.2.4	<i>Nitrogen dioxide (NO₂)</i>	27
2.3	ALLERGIC RESPIRATORY DISEASES AND AIR POLLUTION.....	27

CHAPTER THREE 30

3.0	AIR POLLUTION IN THE VAAL TRIANGLE FROM 1959.....	30
3.1	THE VAAL TRIANGLE AIR POLLUTION AND HEALTH STUDY (VAPS) 1990-1993 ...	31
3.1.1	<i>Air quality monitoring network during VAPS</i>	33
3.1.2	<i>Pollutants monitored</i>	34
3.1.3	<i>Air pollution in the Vaal Triangle during 1990</i>	35
3.1.4	<i>Air pollution in the Vaal Triangle during 1991</i>	36
3.1.5	<i>Air pollution in the Vaal Triangle during 1992</i>	37
3.1.6	<i>Personal Monitoring during VAPS</i>	37
3.1.7	<i>Main air pollution findings during the Vaal Triangle study</i>	38
3.2	AIR POLLUTION IN THE VAAL TRIANGLE AFTER 1993 (AFTER VAPS).	39
3.2.1	<i>Air quality monitoring results for Particulate Matter after 1993</i>	40
3.2.2	<i>Source apportionment results of PM₁₀ for the Vaal Triangle</i>	41
3.2.3	<i>Air quality monitoring results for sulphur dioxide after 1993</i>	45
3.2.4	<i>Air quality monitoring results for ozone after 1993</i>	46
3.2.5	<i>Air quality monitoring results for nitrogen dioxide after 1993</i>	46

CHAPTER FOUR 48

4.0	RISK TRANSITION ON DEVELOPING COUNTRIES	48
4.1	TRANSITION OF EPIDEMIOLOGY IN SOUTH AFRICA.....	54
4.1.1	<i>Active surveillance</i>	55
4.1.2	<i>Passive surveillance</i>	55
4.1.3	<i>Projects and field surveys</i>	56
4.1.4	<i>Training</i>	56

4.1.5	<i>Information</i>	56
4.1.6	<i>Co-ordination</i>	57
4.2	EPIDEMIOLOGICAL TRANSITION OF COMMUNICABLE DISEASES IN SOUTH AFRICA .	57
4.2.1	<i>Smallpox</i>	58
4.2.2	<i>Typhoid fever</i>	58
4.2.3	<i>Meningococcus</i>	58
4.2.4	<i>Polio</i>	58
4.2.5	<i>Tuberculosis (TB) and Human immunodeficiency virus (HIV)</i>	59
4.2.6	<i>Malaria</i>	60
4.2.7	<i>Measles</i>	61
4.2.8	<i>Cholera</i>	61
4.2	EPIDEMIOLOGICAL EMERGENCY SERVICE	63
4.3	RISK TRANSITION IN AIR POLLUTION.....	63
4.4	SUMMARY CHAPTER 4.....	64
 CHAPTER FIVE.....		66
5.0	METHODOLOGY.....	66
5.1	STUDY DESIGN	66
5.2	STUDY AREA	66
5.3	STUDY POPULATION	68
5.4	SAMPLING STRATEGY	69
5.5	DATA COLLECTION	71
5.6	DATA MANAGEMENT.....	72
5.6.1	<i>Quality of data</i>	72
5.6.2	<i>Missing data</i>	72
5.6.3	<i>Reliability of data</i>	72
5.6.4	<i>Validity of data</i>	72
5.7	STATISTICAL ANALYSIS	73
5.8	ETHICAL ASPECTS.....	73
5.9	LIMITATIONS OF THE STUDY.....	74
 CHAPTER SIX.....		75
6.0	RESULTS	75
6.1	DEMOGRAPHIC AND DESCRIPTIVE STATISTICS OF THE STUDY POPULATION	75
6.2	LIVING CONDITIONS OF THE STUDY POPULATION	76
6.2.1	<i>Houses</i>	77
6.2.2	<i>Water and energy sources</i>	77
6.2.3	<i>Indoor pollution sources</i>	79
6.3	LIFESTYLE OF THE STUDY POPULATION	80
6.3.1	<i>Hobbies</i>	80

6.3.2	<i>Sport</i>	80
6.3.3	<i>Eating and drinking habits</i>	81
6.3.4	<i>Smoking habits</i>	81
6.4	HEALTH STATUS OF THE STUDY POPULATION.....	82
6.4.1	<i>General health status</i>	82
6.4.2	<i>Prevalence of allergies</i>	83
6.4.3	<i>Prevalence of upper respiratory diseases</i>	85
6.4.4	<i>Prevalence of lower respiratory diseases</i>	86
6.4.5	<i>Statistical analysis of risk factors associated with URI and LRI in 2003</i> ..	89
6.4.5.1	Univariate risk factor analysis.....	89
6.4.5.1.1	Risk factors investigated.....	89
6.4.5.1.2	Risk factors that were statistically significant.....	89
6.4.5.1.3	Variables that showed elevated crude odds ratios.....	90
6.4.5.1.3.1	Upper respiratory illnesses (URIs).....	92
6.4.5.1.3.2	Lower respiratory illnesses (LRIs).....	93
6.4.5.2	Multivariate Analysis.....	96
6.4.5.2.1	Lower respiratory illnesses.....	96
6.4.5.2.2	Upper respiratory illnesses.....	97
6.5	OTHER HEALTH ISSUES.....	98
6.5.1	<i>Hospitalisations</i>	98
6.5.2	<i>Serious illnesses</i>	98
6.5.3	<i>Other disabilities</i>	98
6.5.4	<i>Non-communicable diseases</i>	99
6.5.5	<i>Family history</i>	99
6.6	EDUCATION AND SOCIAL STATUS OF THE STUDY POPULATION.....	100
6.7	PERSONAL PERCEPTIONS OF THE STUDY POPULATION.....	102
CHAPTER SEVEN		103
7.0	DISCUSSION.....	103
7.1	UPPER RESPIRATORY ILLNESSES.....	103
7.1.1	<i>Univariate analysis</i>	104
7.1.2	<i>Multivariate analysis</i>	106
7.2	LOWER RESPIRATORY ILLNESSES.....	106
7.2.1	<i>Pneumonia</i>	106
7.2.2	<i>Bronchitis</i>	107
7.2.3	<i>Asthma</i>	108
7.2.4	<i>Wheezing</i>	110
7.2.5	<i>Lung functions</i>	110
7.3	ANSWERS TO THE RESEARCH AND KEY QUESTIONS.....	111
7.3.1	<i>Answers to Key Questions</i>	111

CHAPTER EIGHT	114
8.0 CONCLUSIONS AND RECOMMENDATIONS	114
8.1 CONCLUSIONS	114
8.2 RECOMMENDATIONS.....	115
REFERENCES	117
APPENDIX A: LETTER OF CONSENT AND QUESTIONNAIRE USED IN THE STUDY	128
APPENDIX B: UPPER AND LOWER RESPIRATORY RISK FACTORS INVESTIGATED IN THE UNIVARIATE ANALYSIS	148

List of Figures

FIGURE 1.1: INTERACTION BETWEEN HUMAN ACTIVITIES AND THE PHYSICAL AND BIOLOGICAL ENVIRONMENT (WHO 1992).....	5
FIGURE 1.2: EXPOSURE PATHWAYS (SEXTON <i>ET.AL.</i> , 1992).....	7
FIGURE 3.1: ANNUAL AVERAGE CONCENTRATIONS OF TSP AND PM ₁₀ IN THE VAAL TRIANGLE 1992.....	39
FIGURE 3.2: MONTHLY MEAN PM ₁₀ CONCENTRATIONS AT LEITRIM IN THE VAAL TRIANGLE JAN 03-AUG 04.....	41
FIGURE 3.3: PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR VEREENIGING 1994-1995 (REDDY <i>ET. AL.</i> , 1996).....	42
FIGURE 3.4: PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR VANDERBIJLPARK 1994-1995 (REDDY <i>ET. AL.</i> , 1996).....	42
FIGURE 3.5: PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR SASOLBURG 1994-1995 (REDDY <i>ET. AL.</i> , 1996).....	43
FIGURE 3.6: PREDICTED PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR SEBOKENG (SCORGIE <i>ET. AL.</i> , 2003).....	44
FIGURE 3.7: PREDICTED PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR SHARPVILLE (SCORGIE <i>ET. AL.</i> , 2003).....	44
FIGURE 3.8: PREDICTED PM ₁₀ SOURCE APPORTIONMENT RESULTS FOR VANDERBIJLPARK (SCORGIE <i>ET. AL.</i> , 2003).....	45
FIGURE 4.1: MAIN CAUSES OF DEATH FOR DEVELOPED AND DEVELOPING COUNTRIES FOR 1997 (EATON, 2003).....	50
FIGURE 4.2: PROPORTION OF INDIVIDUALS UNDER 20 IN REHABILITATION CENTRES FOR SUBSTANCE ABUSE (1996-2001) (MRC 2002).....	52
FIGURE 4.3: MEASLES, MENINGOCOCCUS, POLIO, VIRAL HEPATITIS AND TYPHOID FEVER CASES IN SOUTH AFRICA; 1999 TO 2002.....	62
FIGURE 4.4: CHOLERA, MALARIA AND TB CASES IN SOUTH AFRICA; 1999 TO 2002.....	62
FIGURE 4.5: CHOLERA DISASTER MANAGEMENT STRUCTURE AND COMMUNICATION AND INFORMATION FLOW (DAAF, 2003).....	63

FIGURE 5.1: MAP OF THE STUDY AREA.	67
FIGURE 5.2: SELECTION PROCESS OF THE STUDY POPULATION.	70
FIGURE 6.1: DEMOGRAPHIC DISTRIBUTION OF THE STUDY POPULATION IN 1990.	76
FIGURE 6.2: DEMOGRAPHIC DISTRIBUTION OF THE STUDY POPULATION IN 2003.	76
FIGURE 6.3: SOURCES OF WATER AND SOURCES OF FUEL FOR COOKING IN 1990 AND 2003.	78
FIGURE 6.4: APPARATUS USED FOR SPACE HEATING IN 1990 AND 2003.	78
FIGURE 6.5: APPARATUS USED INSIDE HOUSES IN 1990 AND 2003.	79
FIGURE 6.6: PETS, SMOKING AND MOULD INSIDE HOUSES 1990 AND 2003.	80
FIGURE 6.7: AGE OF STUDY POPULATION AT ONSET OF SMOKING.	82
FIGURE 6.8: PREVALENCE OF ALLERGIES IN STUDY POPULATION FOR 1990 AND 2003.	84
FIGURE 6.9: STUDY POPULATION'S CONSUMPTION OF MEDICATION FOR ALLERGIES.	84
FIGURE 6.10: PREVALENCE OF UPPER RESPIRATORY SYMPTOMS IN STUDY POPULATION DURING 1990 AND 2003.	85
FIGURE 6.11: PREVALENCE OF LOWER RESPIRATORY SYMPTOMS IN STUDY POPULATION DURING 1990 AND 2004.	86
FIGURE 6.12: PERCENTAGE OF STUDY POPULATION EVER DIAGNOSED WITH ASTHMA.	87
FIGURE 6.13: MONTHLY PREVALENCE OF ASTHMA ATTACKS FOR 1990 AND 2003.	88
FIGURE 6.14: MONTHLY PREVALENCE OF ATTACKS OF WHEEZING WITHOUT A COLD FOR 1990 AND 2003.	89
FIGURE 6.15: RISK FACTORS FOR HAVING SINUSITIS, EARACHE AND HAY FEVER IDENTIFIED IN UNIVARIATE ANALYSIS.	93
FIGURE 6.16: RISK FACTORS FOR PNEUMONIA IDENTIFIED DURING UNIVARIATE ANALYSIS. ...	94
FIGURE 6.17: RISK FACTORS FOR BRONCHITIS IDENTIFIED IN UNIVARIATE ANALYSIS.	94
FIGURE 6.18: RISK FACTORS FOR ASTHMA IDENTIFIED IN UNIVARIATE ANALYSIS.	95

List of Tables

TABLE 6.1: STATISTICALLY SIGNIFICANT FACTORS ASSOCIATED WITH UPPER AND LOWER RESPIRATORY ILLNESSES.	90
TABLE 6.2: FACTORS FOR WHICH ELEVATED (≥ 1.5) CRUDE ODDS RATIOS (ORs) WERE FOUND IN THE UNIVARIATE ANALYSIS.	91
RESULTS FROM UNIVARIATE ANALYSIS OF UPPER AND LOWER RESPIRATORY RISK FACTORS INVESTIGATED.	149

GLOSSARY

ACS	The American Cancer Society
AIDS	Acquired Immune Deficiency Syndrome
AHSMOG	Adventist Health Study of Smog
Air pollution	Substances in air at concentration, durations and frequencies that adversely affect human health, human welfare or the environment (McGranahan and Murray, 2003)
APHEA	Air Pollution and Health: a European Approach
ARI	Acute Respiratory Infection
Atopic dermatitis	A type of immune-mediated (allergic) inflammatory skin disorder that results in itchy rash
CFR	Case Fatality Rate - usually expressed as the percentage of persons diagnosed as having a specified disease that die because of that illness within a given period (DAAF, 2003).
CVD	Cardio Vascular Disease
CO	Carbon monoxide
Confounding	Finding an association for the wrong reason
COPD	Chronic Obstructive Pulmonary Disease
DEAT	Department of Environmental Affairs and Tourism
DoH	Department of Health
Epidemiology	"the study of the distribution and determinants of health related conditions and events in populations, and the application of this study to the control of health problems" (Katzenellenbogen and Yach, 1991)

ETS	Environmental Tobacco Smoke
Ever-smoker	Individual who has at some stage smoked two or more cigarettes per day
Exposure	An event that occurs when there is contact at a boundary between a human and the environment with a contaminant of a specific concentration for an interval of time; the units are concentration multiplied by time (Ott, 1995).
F⁻	Fluoride ion
FEV₁	Forced Expiratory Volume in one second
HIV	Human Immunodeficiency Virus
HP	High Pressure
H₂S	Hydrogen Sulphide
IMR	Infant Mortality Rate - The number of deaths of children under one year of age per thousand live births
ISAAC	International Study of Asthma and Allergies in Childhood
m	meter
µg/m³	Micrograms per cubic meter
Mw	Mega watt
Never-smoker	An individual who has never smoked more than one cigarette per day
NHANES	National Health and Nutrition Examination Surveys
NH₃	Ammonia
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NMHC	Non-Methane Hydro Carbons

NO₂	Nitrogen dioxide
NO_x	Nitrogen oxides (NO + NO ₂)
OR	Odds Ratio
O₃	Ozone
PM	Particulate Matter or Particulates Small solid and liquid particles of various physical dimensions and chemical properties (McGranahan and Murray, 2003).
PM_{2.5}	Particulate Matter with a mean aerodynamic diameter of 2.5 micrometers or less
PM₁₀	Particulate Matter with a mean aerodynamic diameter of 10 micrometers or less
PEACE	Pollution Effects on Asthmatic Children in Europe
REL	Reference Exposure Level: A concentration at or below which no adverse health effects are anticipated.
RR	Relative Risk
SA	South Africa
SAPALDIA	Swiss Study on Air Pollution and Lung Diseases in Adults
SCARPOL	Swiss Study on Childhood Allergy and Respiratory Symptoms with Respect to Air Pollution
SES	Socio-Economic Status
SO₂	Sulphur dioxide
TB	Tuberculosis, caused by the bacteria <i>Mycobacterium tuberculosis</i>

Th 1	Th1 is a subset of helper-inducer T-lymphocytes that synthesise and secrete interleukin-2, gamma-interferon and interleukin-12. Due to their ability to kill antigen-presenting cells and their lymphokine-mediated effector activity, th1 cells are associated with vigorous delayed type hypersensitivity reactions.
Th2	Th 2 is a subset of helper-inducer T-lymphocytes which synthesise and secrete the interleukins il-4, il-5,il-6 and il-10. These cytokines influence B-cell development and antibody production as well as augmenting humoral responses.
TSP	Total Suspended Particulates
TCRS	Tucson Children's Respiratory Study
US-EPA	United States of America-Environmental Protection Agency
VAPS	Vaal Triangle Air Pollution Health Study.
VOCs	Volatile Organic Compounds
VT	Vaal Triangle- (Vanderbilpark, Sasolburg and Vereeniging).
WHO	World Health Organisation

CHAPTER ONE

1.0 Introduction

Environmental Health, according to the World Health Organisation (WHO) (1992) can be defined as “...those aspects of human health, including quality of life, that are determined by physical, biological, social and psychosocial factors in the environment”. Ambient air and specifically the quality of ambient air can therefore be considered as a factor that can determine the quality of an individual’s life. Figure 1.1 illustrates the interaction between human health and the environment.

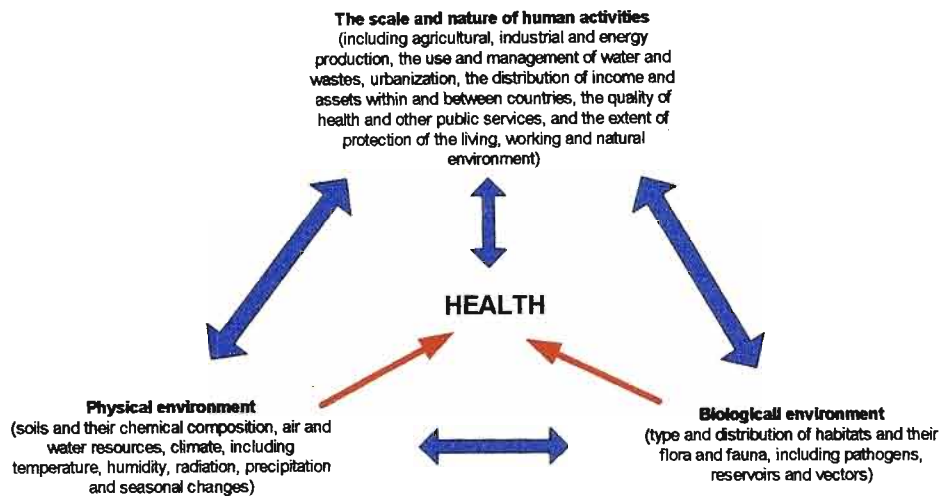


Figure 1.1: Interaction between human activities and the physical and biological environment (WHO 1992).

Ambient air is the atmospheric layer that envelops the earth and mainly consists of nitrogen and oxygen. Anything that disturbs the normal chemical balance of the air can therefore be considered pollution. Pollution is normally caused by man-made activities such as the burning of fossil fuels. According to the WHO, an estimated three million people die each year because of air pollution (WHO, 2000).

The average adult inhales about 13.25 m³ of air per day, whereas the ingestion of water in an adult is only about 2 litres per day (US-EPA, 1996). The quality of air is thus of utmost importance.

The South African constitution states, "Everyone has the right:

- ⇒ to an environment that is not harmful to their health or well-being; and
- ⇒ to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that:
 - ▶ prevent pollution and ecological degradation
 - ▶ promote conservation; and
 - ▶ secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development" (Republic of South Africa, 1996).

"Everyone", as stated in the constitution, will by implication include children. Children can be considered a sensitive population as far as air pollution is concerned, because of their different physiological and behavioural characteristics (Koenig and Mar, 2000; Landrigan, 1998).

In the light of the above, it is evident that exposure to pollution during childhood is an important aspect of air quality management. What the influence of this exposure will be in adulthood is not well known, especially not in the South African context.

1.1 Exposure

Exposure was defined in 1991 by the National Academy of Sciences (NAS) as "an event that occurs when there is contact at a boundary between a human and the environment with a contaminant of a specific concentration for an interval of time; the units are concentration multiplied by time" (Ott, 1995).

1.1.1 Exposure Pathways

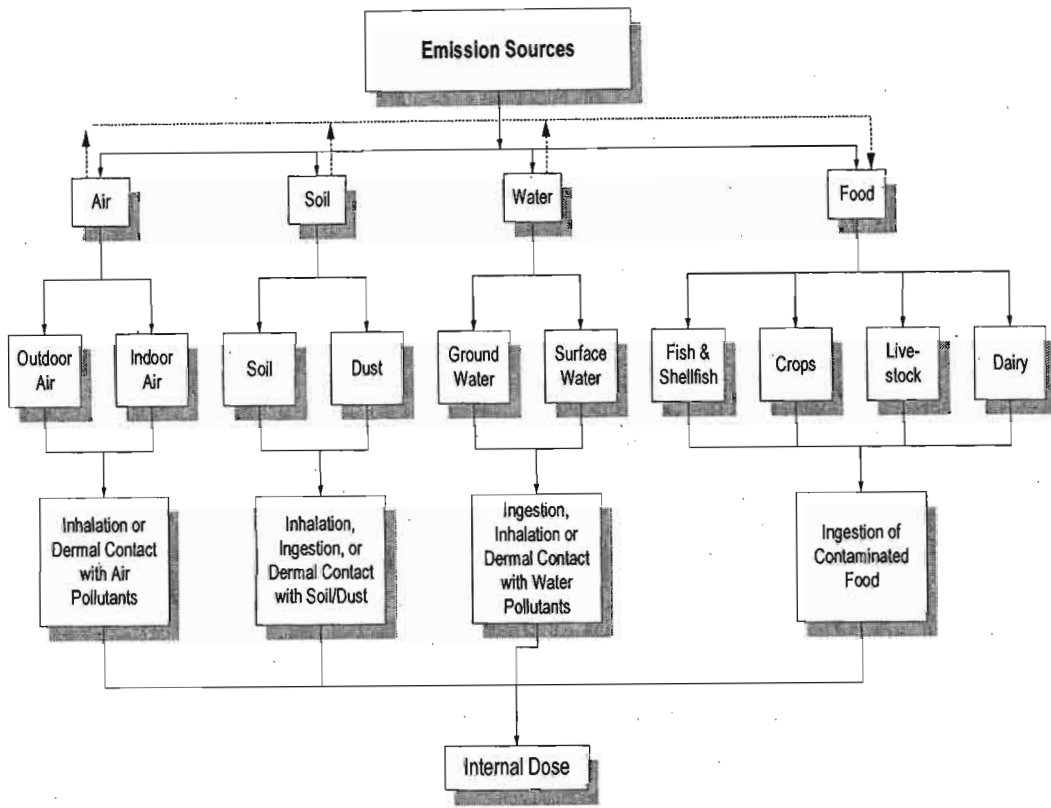


Figure 1.2: Exposure pathways (Sexton et al., 1992).

The different ways of “coming into contact” with a pollutant are often referred to as routes or pathways of exposure. From Figure 1.2 it is clear that there are several pathways of human exposure, namely inhalation, ingestion and dermal contact. Exposure can be direct or indirect. An example of direct exposure is when a pollutant present in air is inhaled and of indirect exposure, when contaminated food, grown in polluted soil, is ingested (Coombes, 2000).

Exposure directly relates to health effects, thus if there is no exposure, there is no risk to health. Health effects can therefore be prevented by the prevention of exposure but as this is not always possible in everyday life, exposure should be properly managed (Coombes, 2000).

Exposure is described by the following four basic characteristics (Sexton *et. al.*, 1992):

- ⇒ Route or pathway, which can be inhalation, ingestion and/ or dermal contact.
- ⇒ Magnitude, which is the concentration of the pollutant in the medium of concern, for example in air it is expressed as micrograms per cubic metre.
- ⇒ Duration, which is the time that the exposure lasts, for example hours, days or a lifetime.
- ⇒ Frequency, which describes how often exposure occurs, for example daily, monthly or seasonally.

When an individual is exposed to contaminated air, food, water and/or soil, one or all of these media may contribute to the total exposure of the individual through one or more of the pathways of ingestion, inhalation and dermal contact. In exposure assessment studies, the ideal is to determine total exposure by considering all media and all possible pathways of exposure (multimedia- multipathway exposure). This however is not always possible, due to costs and technical difficulties (Sexton *et. al.*, 1992)

1.1.2 Children and adolescent's exposure

Children require a higher rate of metabolism to maintain their body temperature as they have a larger surface-area-to-body-weight ratio than adults do and this results in rapid loss of body heat to the environment. This ratio for newborn infants is more than twice that for adults. The ratio decreases within the first year of life to about one-third, where it remains until about 17 years of age when it further decreases to the adult value (Cohen Hubal *et al.*, 2000).

Children have a high metabolism rate to maintain growth and development. They will therefore be in greater need for food and oxygen per kg bodyweight than adults, resulting in higher food consumption and breathing rate, with a subsequent relatively higher exposure to environmental contaminants including air pollutants. For example the breathing rate of an infant is about 40 breaths per minute compared with 15 breaths per minute for an adult (Koenig and Mar, 2000; Bearer 1995).

Developing organs in children go through growth and differentiation processes that can be affected by pollutants, which may then lead to different outcomes, such as, diminished lung volume. For example, the forced expiratory volume in one second (FEV₁), of children exposed to environmental smoke (ETS) was

found to be significantly slower than in children not exposed to ETS (Bearer, 1995). Children's alveolar surface area to body mass ratio is higher compared to that of adults, which means that children have a larger gas exchange area in their lungs (Koenig and Mar, 2000).

Children's behavioural patterns and their interaction with the environment have an influence on the magnitude of their exposure to pollutants (Bearer, 1995). Children are usually physically more active (resulting in a higher breathing rate) than adults, have more hand-mouth contact (resulting in a higher ingestion of, for example soil), and spend more time outdoors (resulting in a longer exposure time to outdoor pollutants). In warmer climates such as South Africa, children tend to play outside more often. Studies conducted in the Vaal Triangle showed that children spend up to 20% more time outdoors than in the United States of America (USA) (Opperman *et.al.*, 1991).

Maturation of the nervous, immune, endocrine and reproductive systems only occurs in adolescence (13-18 years). Adolescence is, after infancy, the second most rapid development period (Bruckner and Weil, 1999). Children and adolescents can therefore be considered as susceptible subgroups as far as air pollution is concerned.

1.1.3 Temporal and spatial patterns of exposure

Every individual is exposed to a soup of chemicals in the air on a daily basis. Exposure concentrations differ in different microenvironments such as indoors, outdoors and inside motor vehicles. The total exposure of an individual will therefore include the exposure in each of these microenvironments. To determine this total exposure, different methods such as the following can be used:

- ⇒ Biological measurements with the use of markers in human tissue, for example blood lead levels.
- ⇒ Micro environmental sampling, such as the use of passive samplers in, for example the office and residence.
- ⇒ Personal monitoring, using personal monitors worn by volunteers in each microenvironment.

The abovementioned "direct" measuring methods are however expensive and labour intensive and therefore not used on a large scale in epidemiological studies (Sexton *et. al.*, 1992).

“Indirect” methods are often used to determine exposure. These may include the following:

- ⇒ Fixed monitors in ambient air (area monitoring)
- ⇒ Models (mathematical simulations of reality)
- ⇒ Questionnaires
- ⇒ Telephonic Surveys
- ⇒ Fixed monitors in ambient air (area monitoring).

Data obtained from area monitoring will not reflect indoor exposure, with the result that the concentrations of pollutants of which the sources are indoors, could be underestimated and the concentrations of those of which the sources are outdoors, could be overestimated. For example, by using fireplaces, woodstoves or kerosene heaters, it is to be expected that pollutants such as sulphur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and particulate matter (PM) would be present in higher concentrations indoors than outdoors. In 1993, it was argued that, although power plants in the USA caused 25 times more pollution than cigarettes (if measured by tons of particulate matter emitted), environmental tobacco smoke, containing more than 4000 chemicals, contributed 50 times more to particulate matter exposure, because of emission in the breathing zone (Ott, 1995).

When no indoor sources of specific pollutants exist, indoor concentrations will depend on outdoor concentrations and factors such as ventilation rate, and the reactivity of the pollutant. Ozone for example is very reactive and the indoor concentration will therefore be expected to be lower than outdoors, as indoor surfaces react as cleaning agents for ozone, plus there are usually no sources of ozone indoors (Lippmann, 1992).

1.1.4 Models (mathematical simulations of reality)

Models can be used to determine estimates of human exposure (Sexton *et al.*, 1992). Atmospheric dispersion models for example, take emission rates of pollutants, meteorological conditions and topography into consideration. Exposure models take factors such as pollutant concentration, inhalation rate and body weight into consideration. Models may be validated by using monitored data.

1.1.5 Questionnaires

Questionnaires are often used in environmental epidemiological studies, because they are not an expensive method of obtaining exposure data of large populations.

A questionnaire can be defined as “a list of questions which are answered by the respondent, and which give indirect measures of the variables under investigation” (Katzenellenbogen and Joubert, 1997).

The advantages of a self-administered questionnaire are, apart from the fact that it is relatively cheap, that a wide geographical area can be covered and that interviewer variation can be excluded. Disadvantages are that the response rate is generally low and people might have difficulty in completing the questionnaire, which may lead to poor quality data (Katzenellenbogen and Joubert, 1997).

1.1.6 Telephonic Surveys

Telephonic surveys are also relatively cheap and can cover a wide geographical area but sampling can be biased, because people that are not listed in the telephone directory or do not have telephones will be excluded. The telephonic questionnaire may also lack information because it has to be short (Katzenellenbogen and Joubert, 1997).

1.2 Rationale behind the study

Millions of people are suffering from debilitating illnesses such as chronic obstructive pulmonary disease (COPD) and lung cancer, which can be attributed to air pollution. It is also estimated that about 30 – 40% of asthma cases and 20 – 30% of all respiratory diseases may be linked to air pollution in some populations. It is further estimated that about 3 million people die each year from illnesses resulting from exposure to air pollution, which represents about 5% of the total deaths worldwide (WHO, 2000).

In countries where energy carriers such as coal, wood and cow dung are still being used for cooking and heating, indoor air pollution increases the risk of acute respiratory infections; one of the leading causes of infant and child mortality in developing countries. In sub-Saharan Africa, the estimate of excess deaths due to such exposure is 300 000 – 500 000 every year (WHO, 2000).

Studies on the effects of air pollution on the health of South African children have clearly demonstrated adverse effects (Mathee and Von Schirnding, 2003; Nriagu *et. al.* 1999; Terblanche, 1998). However, little is known about the respiratory health status of adults, who spent their developing years in areas where they were exposed to air pollution.

Some longitudinal studies in other parts of the world have reported that, for example asthma in childhood has a good prognosis, whereas a recent study in Australia found that it actually depends on the severity of childhood symptoms; persistent asthma as a child continues into adult life with symptoms and reduced lung function. (Horak *et. al.*, 2003).

It was therefore decided to conduct a study on adults who spent their developing years in a polluted area and of whom the respiratory health status as a child is known. If the current respiratory health status of these individuals (now adults) can be determined, valuable information, currently not available for South Africa, will be obtained.

The situation and climate in South Africa is different from that in Europe and America and therefore may lead to new knowledge. The study is thus seen as a replication and not a mere duplication of research done elsewhere.

National authorities in policy making can use information obtained through epidemiological studies like this. An example is that with the new air pollution legislation, the responsible national authority will have to re-examine relevant scientific research data in the epidemiological field at 5-yearly intervals, in order to revise limit values in air pollution. Data specific to South Africa will be more relevant and valuable than data obtained from overseas studies.

It was decided to do a follow-up study on a specific group of individuals whose respiratory health status as children are known. These individuals formed part of the Vaal Triangle Air Pollution Health Study (VAPS) conducted during the early nineties. The aim of VAPS was to study the exposure and effects of outdoor as well as indoor air pollution on the health of children (between the ages of 8 and 12), living in the Vaal Triangle. Exposure was characterized through outdoor, indoor and personal monitoring of air pollutants, while questionnaires formed the basis of assessing the health status of the individuals.

The majority (65%) of participants in the VAPS suffered from upper respiratory diseases and 29% from lower respiratory diseases. In a cross sectional study, comparing children from the Vaal Triangle with children from

Klerksdorp, a less polluted area, it was found that children in the Vaal Triangle had a 134% higher risk of developing upper respiratory illnesses and a 203% higher risk of developing lower respiratory illnesses than the children in Klerksdorp (Terblanche, 1998).

1.3 Problem Statement

It is unknown whether children who grew up in polluted areas in South Africa are unhealthy adults as far as their respiratory health status is concerned.

1.4 Objectives of the study

The main objectives of the study are:

- ⇒ to determine whether exposure to air pollution during developing years has an influence on the respiratory health status as an adult,
- ⇒ to provide decision support to national authorities in revising air quality limit values (with new air pollution legislation, authorities will have to re-examine relevant scientific research data in the epidemiological field every 5 years for revision of air pollution limit values),
- ⇒ to evaluate the success of air quality management plans,
- ⇒ to draw a risk profile of adults who spent their developing years in a polluted area, and
- ⇒ to provide an infrastructure for various research projects.

1.5 Research Question

What is the respiratory health status of adults who spent their developing years in a polluted area in South Africa?

1.6 Key Questions

- ⇒ Is there a difference in the health status of adults who remained in the Vaal Triangle compared to those who left the area?
- ⇒ Is there an association between health status and years spent in the polluted area?
- ⇒ Does the occupation of the individual play a role in his/her health status?

- ⇒ Does the risk of having upper respiratory illness increase significantly with time spent in a polluted area during developing years?
- ⇒ Does the respiratory health status improve towards adulthood or does it stay the same (for those who remained in the area)?
- ⇒ What is the risk profile for respiratory diseases in adults who spent their developing years in a polluted area in South Africa?

1.7 Hypothesis

Null

Children who 'grew up' or spent their developing years in a polluted area in South Africa are not "unhealthy" adults as far as their respiratory health status is concerned.

Opposite

Children who 'grew up' or spent their developing years in a polluted area in South Africa are unhealthy adults as far as their respiratory health status is concerned.

CHAPTER TWO

2.0 Air Pollution and Health

As far back as 1285, an air pollution commission in London recommended the banning of coal burning in urban areas (Smith and Akhar, 2003). About 50 years ago (5 – 9 December 1952) severe air pollution in the form of a layer of smoke from coal burning (formed due to unfavourable meteorological conditions) caused a high mortality rate in London. This high mortality rate continued for a number of months after the episode. Recent evidence shows that, what was previously thought to be mortalities due to influenza during and after the episode, could not be possible, which leaves 12 000 unexplained and additional deaths (Brunekreef and Holgate, 2002; Davis *et al*, 2002).

The results of numerous studies show an association between polluted air and acute and chronic health effects. Impacts range from an increase in death rates in sensitive groups such as infants and the elderly, to chronic respiratory diseases, impaired development through to cancer (Lippmann, 2003, Davis *et al*, 2002). Observations in developing countries indicate that effects of air pollution on these nations may be greater because they are more vulnerable as a result of their nutritional status and lifestyle (Romieu and Hernandez-Avila, 2003).

Although ambient as well as indoor air contains complex mixtures of pollutants, most of the studies on health effects of air pollution have been on single pollutants because it is impossible to investigate exposure-response functions for all possible combinations under controlled conditions. Most studies are on acute responses, with the result that chronic exposure effects due to long term exposure to ambient concentrations of pollutants are still not clear (Murray and McGranahan, 2003).

2.1 Major air pollution and human health studies

2.1.1 Long-term mortality studies

2.1.1.1 The American Cancer Society (ACS) Cancer Prevention Study II

One United States cohort study (1982-1989) involving 552 138 individuals of at least 30 years old from 151 metropolitan areas (in 50 states), linked individual risk factors such as smoking habits, alcohol consumption, weight, occupational exposure and education to exposure of fine particulate matter

(PM) and sulphate in ambient air. Participants were drawn from the American Cancer Society (ACS)'s Cancer Prevention Study II. An association between fine PM and sulphate and mortality rates were found, which remained after adjustments had been made for the individual risk factors mentioned above.

Statistically significant associations were demonstrated between sulphates and all-cause, cardiopulmonary and lung cancer mortality, whereas the associations for fine PM and mortality were only statistically significant for the latter two causes (Pope *et. al.*, 1995).

2.1.1.2 The Six City Cohort Study

Another US cohort study involved 8111 adults (between 25 and 74 years) from six cities. Up until the time this study commenced, several short-term time-series studies (including one that involved three of the six cities) had already shown a strong association between particulate air pollution and cardiopulmonary mortality rates (Dockery *et. al.*, 1993).

The objective of the Six-city study was to evaluate long-term exposure. Survival analysis was conducted in 1993 with data from a 14 to 16 year follow-up (starting in 1974). It was found that as concentrations of fine PM increased, mortality rate also increased. Mortality was more strongly associated with fine PM and sulphate particles than with concentrations of total PM, sulphur dioxide (SO₂) or nitrogen dioxide (NO₂). After adjustments were made for risk factors such as smoking, age, sex, body mass index, occupational exposure and education, the correlation between fine PM and mortality remained. The correlation still remained even after hypertensive (high blood pressure) and diabetic individuals had been removed from the analysis. An additional finding from the Six-city study was the association between particulate air pollution and lung cancer mortality. Furthermore, it was shown that the relative risk of premature mortality for the most polluted city, Steubenville, versus the least polluted city Portage, was 1.26. The difference in concentrations of PM₁₀ between the two cities was 28.3 µg/m³ and for SO₂ 19.8 ppb (Dockery *et. al.*, 1993).

2.1.1.3 The Adventist Health Study of Smog (AHSMOG)

In a third cohort study in the US, the Adventist Health Study of Smog (AHSMOG), 6338 non-smoking Seventh-day Adventists were followed from 1977 to 1987. Contrary to the Six city and ACS studies, the AHSMOG study did not show positive associations between long-term concentrations of ambient particles and an increased risk of mortality. (Combined relative risks

(RR) observed for both sexes were 1.0 or slightly less). Mortality data from the AHSMOG study were updated through to 1992 and then reanalysed. Through the reanalysis, the following became evident: (Abbey *et. al.*, 1999).

An association between long-term PM₁₀ exposure, and

- ⇒ an increased risk of all-cause mortality in men
- ⇒ an increased risk of mortality with any indication of non-malignant respiratory causes in men and women (RR 1.18)
- ⇒ an increased risk of lung cancer mortality in men (RR 2.38).

An association between long-term ozone (O₃) exposure, and

- ⇒ an increased risk of lung cancer mortality in men (RR 4.19).

An association between long-term SO₂ exposure, and

- ⇒ an increased risk of lung cancer mortality in men and women (RR 2.99).

Reanalyses of studies

The Health Effects Institute in the US funded researchers to reanalyse the ACS and Six City studies, since critics felt that these studies lack sufficient control for confounders and co-pollutants. Different statistical methods (Poisson regression) were used in the reanalysis and factors such as climate, other pollutants and socio-economic factors were included. The findings of the reanalysis, published in a special report by Krewski *et. al.* (2000), largely confirmed the findings of the original studies (Brunekreef and Holgate, 2002). In addition, an association between mortality and SO₂ pollution was demonstrated and it was found that higher educational status was associated with a lower risk to air pollution exposure (Garrison, 2001).

Pope *et. al.* (2002) recently evaluated statistics on the ongoing ACS study's data. This time up to 1998. This means that the follow-up time was extended to more than 16 years with triple the number of deaths and yet the associations between mortality and air pollution remained. Data on risk factors however, dated back to the beginning of the study, which reduced the precision of control for risk factors and caused misclassification of exposure. Fine particulate matter was positively associated with all-cause, cardiopulmonary and lung cancer mortality. Positive association with the latter two remained even after controls for cigarette smoking, body mass index, diet and occupational exposure had been introduced. Each 10 µg/m³ increase in PM_{2.5} caused an increased risk in all-cause, cardiopulmonary, and lung cancer mortality of 4, 6 and 8% respectively. A positive association was also found between sulphate particles and mortality from all-cause, cardiopulmonary, lung cancer as well as all other causes. Coarse PM was not

consistently associated with mortality. Of the gaseous pollutants investigated, namely O₃, NO₂, CO and SO₂, only SO₂ was associated with elevated mortality risks. The concentrations at which these pollutants had the effects observed, were relatively low. For PM_{2.5}, the average was 17.7 µg/m³ and for SO₂ 6.7ppb (Pope *et. al.*, 2002).

2.1.2 Short-term mortality and hospital admission studies

Numerous short-term studies have been conducted on air pollution and health with emphasis on mortality and hospital admissions (Garrison, 2001).

2.1.2.1 The Air Pollution and Health: a European Approach (APHEA) studies

Initiated by the European Union Environment Programme, Air Pollution and Health: a European Approach (APHEA) I and II studies were conducted in Europe. APHEA initially investigated the effects of pollutants on mortality in 12 European Cities. Positive associations, especially in western European cities, were found between the concentrations of SO₂ and PM₁₀ and daily increases in mortality (Garrison, 2001).

APHEA II, a series of studies conducted in 29 European cities for 5 years during the middle to late nineties, involved 43 million people. Combined data from 21 of the cities showed a statistically significant increase of 0.6% in daily all-cause mortality for every 10 µg/m³ increase in PM₁₀ (Brunekreef and Holgate, 2002).

From the data of six of the European cities it was found that for every 50 µg/m³ increase in the maximum 1-hour ozone concentration, the daily mortality increased by 2.9% (Brunekreef and Holgate, 2002).

Eight cities' hospital admissions data over 3 to 9 years were studied. The total population involved was 38 million. Associations found were as follows: (Brunekreef and Holgate, 2002).

- ⇒ Admissions for chronic obstructive pulmonary disease (COPD) in those older than 65 years of age, increased by 1% for every 10 µg/m³ increase in PM₁₀.
- ⇒ Admissions for cardiovascular disease (CVD) increased by 0.5% for every 10 µg/m³ increase in PM₁₀.

2.1.2.2 The National Morbidity, Mortality, and Air Pollution Study (NMMAPS)

The Health Effects Institute in the US funded the National Morbidity, Mortality, and Air Pollution Study (NMMAPS) to determine the effects of air pollution, especially PM₁₀, in the 20 and 90 largest cities (1987-1994). Results of both studies indicated that for every 10 µg/m³ increase in PM₁₀ the day before death, an average increase of about 0.5% in overall mortality could be expected.

Effects of PM₁₀ concentrations on COPD in those older than 65 years of age were studied in 10 cities with a total population of 1 843 000. A 1.5% increase in COPD and a 1.1% increase in CVD hospital admissions were observed for every 10 µg/m³ increase in PM₁₀ (Brunekreef and Holgate, 2002).

However, subsequent to the finding that the use of the *gam* function in the S-Plus software caused an overestimation of the effect of PM on mortality (although without affecting statistical significance or co-pollutant adjustments), it was decided to re-analyse the data. As a result of the re-analyses, the national average increase in overall mortality for every 10 µg/m³ increase in PM₁₀, dropped from the 0.5% mentioned above to 0.21%. Although the quantitative estimates changed, the scientific findings did not. The association between PM₁₀ levels and daily mortality one day later remained. The shape of the dose-response curves did also not change when the two sets of analyses were compared. Furthermore, the association between mortality and PM₁₀ could not be ascribed to the pollutants NO₂, SO₂, CO or O₃ (Dominici *et. al.*, 2002)

2.1.2.3 The Pollution Effects on Asthmatic Children in Europe (PEACE) study

The Pollution Effects on Asthmatic Children in Europe (PEACE) study covered 28 regions in Europe. No associations could be demonstrated in this study between acute symptoms and lung functions on the one hand and PM and NO₂ on the other. Other similar small studies have however demonstrated such effects, which, according to Brunekreef and Holgate, show that panel studies might not be able to detect subtle effects (Brunekreef and Holgate, 2002).

In summary it can be said that short term studies had fairly consistent associations, suggesting that exposure to ambient air pollution is a risk factor for exacerbation of pre-existing cardiac and respiratory illnesses.

Much less is known about the health impacts of longer-term exposure, particularly on the development of cardiac or respiratory diseases. The results of studies that examined associations between long-term exposure and mortality are not entirely consistent. For example Pope *et. al.* (2002) found that after controlling for risk factors such as smoking, occupational exposure, body mass index and alcohol consumption, long-term exposure to PM_{2.5} was associated with increases in risks for all-cause, cardiopulmonary and lung cancer mortality. In contrast, Abbey (1999) found in re-analyses of the Adventist Health Study of Smog, associations of long-term exposure to PM and ozone with mortality due to diseases of the lung but not the cardiovascular system. These results could maybe because of factors such as life style. According to Hoek, *et. al.* (2002) cardiopulmonary mortality and chronic respiratory diseases are associated with traffic density close to an individual's residence.

Harvesting

Some scientists are of the opinion that the increase in mortality rate associated with an increase in air pollution levels is merely the advancement of death in individuals about to die from causes other than air pollution. This phenomenon is called "harvesting". However, investigations suggest that short-term studies could underestimate the numbers of early deaths. Professor Zeger and co-workers from Johns Hopkins University evaluated data from Philadelphia and found the opposite of the harvesting hypothesis. They found that when they remove the shortest-term fluctuations from their time series, the effects of pollutants increased rather than decreased (Garrison, 2001).

Dr. Schwartz from Harvard studied the same issue using data from Boston (from the NMMAPS study). In his findings, which he published in 2000, he mention that for pneumonia the statistical analyses showed that some deaths were brought forward a few days, correlating with the harvesting hypothesis. When longer time periods were examined they found that the estimates of effects increased, indicating that daily exposures are less harmful than cumulative exposures (Garrison, 2001).

2.1.3 Long-term morbidity studies

Most air pollution and health studies have focused on mortality, since mortality data are readily available and the effects are clear. For each death however, there might be numerous hospital admissions and visits to doctors. This is without taking into account the number of days absent from work or school or the use of medication being taken into consideration (Garrison, 2001).

Most of the cross-sectional epidemiological studies assume that exposure measured during the study also represents past exposure. In their review article on air pollution and health, Brunekreef and Holgate (2002) singled out a series of Swiss studies on morbidity from exposure to air pollution. According to them, these studies were carefully designed and conducted.

2.1.3.1 Swiss studies

The Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) conducted from 1991, studied lung functions and respiratory symptoms of 9651 adults (between 18 and 60 years) from eight communities in Switzerland. Spirometry, a bronchial challenge test with methacoline and allergy tests (skin prick, blood IgE and a fluoroenzyme immunoassay) were performed on participants. Pollutants monitored were SO₂, NO₂, O₃, TSP and PM₁₀. Relatively low concentrations of pollutants were measured. Annual average SO₂ concentrations ranged between 3 and 26 µg/m³ (SA and WHO guidelines 50 µg/m³) and annual average TSP concentrations between 15 and 53 µg/m³ (SA guideline 100 µg/m³). Annual average PM₁₀ concentrations ranged between 10 and 33 µg/m³ (SA guideline 60 µg/m³) and annual average NO₂ concentrations between 9 and 58 µg/m³ (SA guideline 90 µg/m³; WHO guideline 40 µg/m³). The concentrations of O₃ exceeded 160 µg/m³ between 0 and 35 hours/year in 8 of the areas and between 183 and 195 hours/year in the other two areas (WHO 8-hour average guideline 120 µg/m³) (Zemp, *et al.*, 1999; Martin, *et al.*, 1997).

The prevalence of wheezing without a cold in the SAPALDIA study was 8% (ranged between 5 and 12 % between never smokers and current smokers respectively), and phlegm 7% (ranged between 5 and 11 % between never smokers and current smokers respectively), (Zemp, *et al.*, 1999; Martin, *et al.*, 1997) The prevalence of asthma amongst participants was reported by Martin as 25.8% and amongst non-participants as 16%, while Zemp reported the **current** prevalence of asthma as 2% in current smokers, 3% in non- smokers and 4% in former smokers (average 3%).

Positive associations were found between annual average concentrations of PM₁₀ and TSP as well as NO₂ and the prevalence of respiratory symptoms such as chronic cough or phlegm production and breathlessness during day or night. No association was found with current asthma or wheezing without a cold. Lung functions in adults were found to be negatively effected when exposed to SO₂, NO₂ and PM₁₀. PM₁₀ showed the most consistent effect (Zemp, *et al.*, 1999; Ackermann-Liebrich, *et al.*, 1997).

Another Swiss study (the SCARPOL study) conducted in Switzerland during 1992/1993, involved 4470 schoolchildren between 10 and 15 years of age from 10 areas. Exposure concentrations were about the same as for the SAPALDIA study. The prevalence of ever having had asthma amongst this Swiss study population was between 5.1 and 10.6%. The prevalence of wheezing was between 3.7 and 9.1%, bronchitis between 5.7 and 26.9% and hay fever between 8.0 and 12.9% (Braun-Fährlander, *et. al.*, 1997).

Associations were again found between the pollutants SO₂, NO₂ and PM₁₀ and symptoms of bronchitis and chronic cough (not asthma or allergic symptoms and illnesses). Associations were again the strongest with PM₁₀, although concentrations were considered relatively low (between 10 and 33 µg/m³) (Braun-Fährlander, *et. al.*, 1997). It is believed that up to about 60% of asthma cases might be attributed to being allergic (Sporik and Platts-Mills, 2001; Holgate, 1997).

2.1.3.2 New Zealand study

In a New Zealand cohort study, about 1000 children borne in 1972/73 were repeatedly assessed from age 9 to 26. The prevalence of wheezing at age 9 was 22% and 27% at age 26, but the prevalence of ever wheezing at age 26 was 51% (in a UK cohort study, the prevalence of ever wheezing was 43% at age 33). Fifteen percent had wheezing that persisted from childhood to adulthood. The prevalence of asthma in the same study was 9% at 9 years of age and 21% at age 26. Thirty four percent of the study population were smoking at age 26. The prevalence of maternal and paternal asthma was 9% each. Risk factors identified for persistence or relapse of wheezing, were: early onset of wheezing, being allergic to house dust mite, airway hyper responsiveness, being female and being a smoker at the age of 21 years. Adult individuals with persistent wheezing and asthma had lower lung function since childhood (a phenomenon known as tracking). The lower lung function in those individuals was detected at each assessment (childhood, adolescence and adulthood), indicating that the impairment of lung function already occurred in early childhood, (before the first measurements at age 9) (Sears, *et. al.*, 2003).

2.1.3.3 Studies in the United States

The American Tucson Children's Respiratory Study (TCRS) that started in 1980 and followed 1246 individuals since birth is still ongoing and is assessing the interrelationship between a large number of risk factors, LRI during the first 3 years of life and the development of chronic lung disorders. The study

found that LRI is common early in life (rate of 46% during the first 5 years) and mostly attributable to a viral infection. It was further found that many behavioural and environmental risk factors were associated with LRI. For example children who were breast fed for at least one month, had a lower risk while children who attended day care centres or were exposed to passive tobacco smoke had a higher risk (Taussig, *et. al.*, 2003).

The results of the Tucson study show that reduced lung function in adults who suffered from respiratory illness in their childhood are not necessarily as a result of these illnesses but from pre-existing differences in lung functions. Infants who had at least one LRI in the first year of their life, already showed differences in tidal expiration compatible with small airways, even before the first LRI. A decline in lung function from infancy to 6 years of age was however demonstrated in children with persistent wheezing, possibly as a result of recurrent damage (Taussig, *et. al.*, 2003).

The study also confirmed the results of other studies, that infants (even healthy infants), can have relatively reactive airways. Wheezing in infants could thus be related to a family history of asthma and parental smoking and not swelling of the mucosa (Taussig, *et. al.*, 2003)

In a US study, involving children from 24 communities in the US and Canada, statistically significant associations were found between fine PM and their acidity, and lung function as well as an association with symptoms of bronchitis but again not with asthma (Brunekreef and Holgate, 2002).

Avol and co-workers found that the lung function growth rate of teenagers could be altered through a large change in air pollution exposure. Individuals who moved to areas with higher levels of PM₁₀ and NO₂ showed a decrease in lung function growth and visa versa. Exposure to tobacco smoke has been proved to be detrimental to lung function growth in children. However, the influence in adulthood is not known. It is possible that the growth rate is accelerated towards adulthood or that the growth period would be longer. On the other hand it is also possible that impaired lung function growth rate could have an effect in adulthood (Avol, *et. al.*, 2001).

2.1.3.4 Studies in Germany

A study was conducted in five German cities, where about 1000 new-borne infants were followed from 1990 to the age of seven years old. Repeated measurements of indoor allergen exposure and the presence of specific antibodies (IgE) to food and inhaled allergens were made. No association

was found between **exposure** to allergens **early in life** and the prevalence of asthma and wheeze at the age of 7 years old (Sporik and Platts-Mills, 2001). Taussig, *et al*, (2003) on the other hand found that events occurring early in life are important determinants of subsequent asthma

Sensitisation to indoor allergens (such as house dust mite, cats and cockroaches) is associated with asthma and wheeze. Exposure to allergens is a prerequisite to sensitisation but not necessarily early in life and the dose-response may differ. For house dust mite the dose-response is believed to be linear whereas for cat allergens it was found that children exposed to high concentrations of cat allergens, were less likely to be sensitised than those exposed to moderate concentrations. It must be noted however, that many children are sensitised to indoor allergens but do not have any symptoms (Sporik and Platts-Mills, 2001). The Tucson study found that IgE in umbilical cord blood was not associated with development of asthma at a later stage but that IgE in the blood at the end of the first year of life was associated with later persistent wheezing and asthma. The authors felt that this is suggesting that some event in the first year of life influences a child's tendency to respond in an allergic manner (Taussig, *et. al.*, 2003). Although IgE does not cross the placenta, some scientists are of the opinion that it can passively cross into the amniotic fluid, from where it can be swallowed by the fetus. Atopic conditions may therefore already start in utero (O'Hollaren, 2003)

2.1.4 Long term studies in South Africa

2.1.4.1 The Vaal Triangle Air Pollution and health Study (VAPS)

This study is described in detail in Chapter 3.

The main findings were that average concentrations of gaseous pollutants were occasionally exceeding standards but that total suspended particulate matter (TSP) in the air was 2.5 times the acceptable level. In some areas in townships, concentrations were 4-6 times the average for the region. The use of coal as the household energy source was found to be the single most significant risk factor for respiratory illnesses in children living in townships (Terblanche, 1998).

The highest personal exposure to particulate matter was from homes with smokers. Results indicated that sixty percent of participants were exposed to TSP levels above the US-EPA health standard at the time (Terblanche, 1998).

The majority (65%) of participants suffered from upper respiratory diseases and 29% from lower respiratory diseases. In a cross sectional study, comparing children from the Vaal Triangle with children from Klerksdorp, a less polluted area, it was found that children in the Vaal Triangle had a 134% higher risk of developing upper respiratory illnesses and a 203% higher risk of developing lower respiratory illnesses than the children in Klerksdorp (Terblanche, 1998).

2.1.4.2 The Birth-to-ten study

The birth-to-ten study (conducted by the Medical Research Council) that commenced in 1990, assessed the environmental, economic, psycho-social and biological determinants of health, development and well-being of 3275 children in Soweto from birth to ten years of age. To determine the influence of air pollution, a longitudinal sub study within the birth-to-ten study, involving 328 individuals from low and high lying suburbs in Soweto, were conducted. The caretakers of the children in the sub study completed questionnaires on a monthly basis over a period of one year. Information was obtained on housing factors, fuel usage and health status of the children involved. Ambient air monitoring as well as indoor air monitoring (in some of the houses) was performed. Although an average annual decrease of $12 \mu\text{g}/\text{m}^3$ in PM_{10} concentrations was demonstrated from 1992 to 1999, winter levels usually exceeded South African guideline values (Mathee and Von Schirnding, 2003).

It was reported that 54% of the children in the sub study experienced a high frequency of colds and chest illness since birth. Amongst the most frequently reported respiratory symptoms were: runny noses (53%) sneezing (38%) and a productive cough (28%). For symptoms diagnosed by a doctor (since birth), ear infection (8%), bronchitis (5%), pneumonia (4%) and allergies (4%) were the most frequent (Mathee and Von Schirnding, 2003).

The environmental factors identified as posing the biggest risks for respiratory symptoms in children of the sub study, were: (Mathee and Von Schirnding, 2003)

- ⇒ living in low lying (relatively more polluted) areas
- ⇒ living in homes with water damage or leaks
- ⇒ living in homes with pets or cockroaches

⇒ being in the kitchen during cooking.

2.1.4.3 A 2-year follow-up study on risk factors for the severity of Acute Respiratory Infection (ARI)

Wesley and Loening (1996) conducted a 2-year follow-up study involving children under the age of 3 years suffering from pneumonia and compared them with controls that suffered from upper respiratory infection only. The aim of the study was to determine risk factors for pneumonia. At entry to the study, more cases (21) than controls (12) had viral infections, but the prevalence of viral infection was not increased by the degree of crowding. There were no significant differences between cases and controls for overcrowding and nutritional status. Most of the cases (75%) as well as most of the controls (69%) came from houses where smoking was allowed and the use of domestic fuel was more or less the same for cases (19%) and controls (14%). During the follow-up it was found that subsequent ill health of children who had suffered from pneumonia was not necessarily greater than that of the controls.

2.2 Health effects of some criteria pollutants

Criteria pollutants are generally considered as those common pollutants for which most countries have guidelines or standards.

2.2.1 Sulphur dioxide (SO₂)

A review of studies on SO₂ show that children and individuals with asthma as well as the elderly can experience detrimental health effects such as bronchoconstriction and cardiovascular illnesses, even at concentrations below the current Californian EPA 1-hour Reference Exposure Level (REL) of 0,25 ppm (660 µg/m³). Symptoms experienced as a result of SO₂ exposure were found to be worse during mouth breathing, for example during exercise. Healthy subjects may show no significant decrease in pulmonary function even at 5 ppm (1300 µg/m³) (Koenig and Mar, 2000).

2.2.2 Ozone (O₃)

Children with asthma are more vulnerable to the effects of air pollution and those using maintenance medication are particularly more vulnerable. In a study in the United States it was found that an increase of 50 ppb in 1-hour ozone concentrations was associated with a 35% increase in the likelihood of wheeze and a 47% increase in chest tightness among asthmatic children on maintenance medication (even at concentrations below EPA standards). No

association was found among children not using maintenance medication for asthma (Gent *et al.*, 2003). Changes in lung capacity, flow resistance and epithelial permeability was found in humans following acute exposure to ozone and accelerated ageing was demonstrated following chronic exposure (Lippmann, 2003).

2.2.3 Particulate Matter (PM)

Statistically significant associations between concentrations of PM and mortality (cardiopulmonary and lung cancer) and morbidity (respiratory and cardiovascular) rates have been demonstrated in various studies (Lippmann, 2003). The WHO's view is that no safe level for PM does exist (Schwela, 2003).

2.2.4 Nitrogen dioxide (NO₂)

Studies showed that exposure to nitrogen dioxide increases susceptibility to respiratory infections. Nitrogen dioxide's adverse effects on the cellular and humoral immune system have been clearly demonstrated (Romieu and Hernandez-Avila, 2003).

2.3 Allergic respiratory diseases and air pollution

The prevalence of allergic (such as asthma, hay fever and atopic dermatitis) and autoimmune (such as diabetes mellitus type1 and multiple sclerosis) diseases has increased during the past three decades (Bach, 2002; Krämer, *et al.* 1999), while there was at the same time a decrease in the prevalence of infectious diseases, especially in developed countries (Bach, 2002).

The analyses of data from 18 825 adults who participated in the National Health and Nutrition Examination Survey (NHANES) III in the US, showed that low education level, female sex, current and past smoking status, pet ownership, hay-fever and obesity were risk factors significantly associated with asthma and wheezing (Arif, *et al.*, 2003).

The International Study of Asthma and Allergies in Childhood (ISAAC), involved 463 801 children (aged 13-14 years) from 56 countries. In this large study it was found that the prevalence of asthma differed between countries (from ~2-~35%) and even between cities (from ~2-~20%) in the same country. The highest prevalence was in Western countries with low air pollution, such as New Zealand, Australia, Canada and Ireland. Low prevalence of asthma was found in countries with high SO₂ and PM levels, such as China, India and

Russia. Intermediate prevalence of asthma was found in countries with high ozone levels, such as the USA. Although air pollution is not, according to these results, a major risk factor for asthma (Beasley, *et al.*, 1998), a cross-sectional study in France (as part of the ISAAC study) showed an association between asthmatic symptoms and ozone (Ramadour, *et al.*, 2000). It is believed that air pollution aggravates asthma in individuals and results from recent studies have shown that ozone may play a role in the onset of asthma (O'Neil, *et al.*, 2003).

Many asthmatics are sensitised to environmental allergens, which can precipitate bronchospasm. A study in the United States found that cat and dog antigens are present even in homes without these pets, although in much lower levels than in houses with one or more pets (Arbes *et al.*, 2004).

Epidemiological studies have indicated that the persistence of childhood asthma into adulthood depends amongst others on **early** (<3 years of age) **onset** and **severity** of symptoms (Horak, 2003; Sumer, 2004).

Kurukulaaratchy, *et al.*, (2003) investigated risk factors influencing the persistence of wheezing with an early (within first 4 years) onset, to the age of 10 years. A genetic tendency to be asthmatic and atopic, appeared to be a crucial factor. This finding confirmed what was found in another study on twins, namely that factors inherited dominated environmental influences in the development of asthma (Kurukulaaratchy, *et al.* 2003).

It was first believed that children exposed to less or no childhood infections would have less Th1 lymphocytes and would therefore develop an imbalance in their immune system between Th1 and Th2 lymphocytes, with a consequent tendency to allergy. Then it was found that Th1 mediated illnesses such as diabetes type 1, was also on the increase in the same areas of the world. Recently scientists have suggested that a reduction in regulatory T cells results in development of allergies. The cause of the reduction in regulatory T cells is however, not because children are not being exposed to pathogenic micro-organisms early in life, but the fact that they get less exposed to organisms such as *mycobacteria*, *lactobacilli* and helminth worms. These relatively benign organisms are believed to have stimulated the production of regulatory T cells in the body, so as to prevent the immune system from "overreacting" against them. In the absence of these organisms, less regulatory T cells are produced with a subsequent increase in allergies (Watts, 2004). The fact that treatment of atopic dermatitis with a mycobacterial extract and probiotics (live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance)

has been successful and those newborns from atopic women who have been taken *lactobacillus* while pregnant, have a lower incidence of atopic dermatitis, may confirm this (Bach, 2002). Already in 1997 Holgate mentioned that the overuse of antibiotics may alter intestinal bacterial flora and reduce mucosal Th1 responses (eg. preferential lactobacillus colonisation).

Studies also found that antibiotics in the first year of life increase the risk of allergic diseases in children with a genetic tendency to atopy (an allergy with strong family tendencies), possibly because it modifies intestinal flora, since it was found that the intestinal flora in newborns whom at a later age develop allergies and those in whom it does not, differs (Bach, 2002).

The Tucson study's findings are also consistent with the hypothesis of other researchers, that the current reduction in microbial load in most parts of the world has altered normal immune system development, especially the response to allergens, which underlies allergies. Children who were exposed to more children at home and in day care centres had lower IgE levels (Taussig, et. al., 2003) These results also confirm the findings of Krämer *et al.*, (1999) and Bach, (2002) that children from **small families** who entered nursery school before the age of 1 year had a lower prevalence of allergies than those who entered at an older age, while there was no association in children from large families.

Pollen and fungal spores are risk factors for the prevalence of hay fever as was found in the VAPS study. During 1991 high pollen and spore counts were registered because the rainfall during that year was high. The prevalence for hay-fever was also higher than for 1992, when a low rainfall and low counts of pollen and fungal spores were registered. This confirms what was found in the Swiss studies, namely that the prevalence of hay-fever was not associated with concentrations of PM, SO₂ and NO₂ (Braun-Fährlander, *et. al.*, 1997).

CHAPTER THREE

3.0 Air Pollution in the Vaal Triangle from 1959

Very little was done in the Vaal Triangle to combat air pollution during the period 1959 to 1970. There were no designated air pollution control officers. The only aspect of air pollution that was addressed at the time was excessive smoke emissions. This was done by health inspectors through the provision of information to make people aware of air pollution (Department of Health, 1990).

In 1970 a decision was taken by the council of Vanderbijlpark to address smoke emissions under The Atmospheric Pollution Prevention Act (Act number 45 of 1965) (Republic of South Africa, 1965). The first local regulations came into effect during 1973. These regulations were aimed at regulating fuel-burning apparatus that industries, hotels, dairies and dry cleaners were allowed to use. In the interim, approval was obtained from the minister to have some residential areas declared as smoke-free zones. The first came into effect on 28 July 1975 (Department of Health, 1990).

Since 22 July 1977, Section V of the Air Pollution Prevention Act, which focuses on the control of hazardous gasses emitted by diesel vehicles, came into force in the Vaal Triangle. The first full-time air pollution control officer was appointed during 1976. In the same year monitoring of smoke and sulphur dioxide commenced in the area and by 1981, five stations were in operation (Department of Health, 1990).

Smoke was measured in S/m³, which is the darkening ability that one cubic metre of air has on Whatman 42 filter paper with a diameter of 32 mm. Twenty S/m³ was considered acceptable at the time. Sulphur dioxide was measured in micrograms per cubic metre (µg/m³).

The average results of air pollution monitoring in Vanderbijlpark between 1977 and 1988 showed that concentrations of smoke and SO₂ remained more or less unchanged during the first 11 years of monitoring (Department of Health, 1990).

Currently all main sources of ambient (outdoor) air pollution are represented in the Vaal Triangle. These include coal burning (from power stations, some

industries and residential areas), industrial processes (such as petrochemical and metallurgical) and motor vehicles.

About a million people in the area are still using coal as energy carrier (Terblanche, 1998). The inefficient combustion of low-grade coal emits high levels of pollutants (such as SO₂, CO and PM) at ground level. Although domestic coal burning in the area most probably account for only a small percentage of emissions, the health impacts are potentially high, because of the low level (close to the ground) of emissions and the large populations that are exposed to these emissions.

In the Vaal Triangle, as in the rest of South Africa, individual motor vehicles dominate the transport system because of inadequate provision of public transport services. Furthermore, the current Atmospheric Pollution Prevention Act (Act number 45 of 1965) (Republic of South Africa, 1965), does not adequately control motor vehicle emissions. No procedures are in place for regular emissions testing and no emission standards for motor vehicles exist under this Act (De Kock *et. al.*, 1992).

The Atmospheric Pollution Prevention Act contains a list of processes that have the ability to cause air pollution and are therefore subject to operation under a permit system (De Kock *et. al.*, 1992). Industries have to comply with the emission concentrations stated in the permit. This procedure's aim is to control pollution at source. There are currently 55 scheduled industries in the Vaal Triangle (Van Graan, 2003).

Industries that are not considered as scheduled industries fall under the control of local authorities, whereas scheduled industries fall under the Department of Environmental Affairs and Tourism (DEAT).

3.1 The Vaal Triangle Air Pollution and Health Study (VAPS) 1990-1993

By 1990, a perception existed amongst the public that the air in the Vaal Triangle was highly polluted. Repeated complaints from the public eventually led to a meeting between the Department of Health, the Medical Research Council (MRC) and other role players. These role players were mainly from industries such as SASOL, ESKOM, ISCOR and EMSA. At this meeting it was decided to investigate the situation through an in-depth study funded by the mentioned Department and industries. At the time the study commenced (August 1990), with Dr Petro Terblanche from the MRC as leader, information on exposure to air pollution in South Africa, as well as on the health effects of the air pollution levels in South Africa, hardly existed. The results of only two

studies that investigated the prevalence of respiratory tract symptoms and lung function in children were known. These studies were conducted in Sasolburg (in the Free State) and the then Eastern Transvaal Highveld (now part of Mpumalanga) (Terblanche *et al*, 1992a).

In the Sasolburg study, children from Sasolburg (polluted area) were compared with children from Heilbron, Parys and Frankfort (all with negligible air pollution). Results from the questionnaire survey showed no significant differences in the incidence of respiratory diseases between the study and control areas. There was however a statistically significant difference in lung functions (forced expiratory volume in one second (FEV₁)) of boys in the two areas, with the boys from Sasol having lower FEV₁ than the boys from the other areas (Coetzee *et. al.*, 1986).

The Eastern Transvaal Highveld study conducted by Zwi *et al.*(1990) compared children from polluted highveld area with children in less polluted areas of the then eastern Transvaal as far as their respiratory health status was concerned. A slightly higher prevalence in respiratory symptoms, especially in chest illnesses (OR 1.88) was found in children from the highveld area. Contrary to the Sasol study, this study showed no significant difference in FEV₁ between the two groups (Zwi, *et. al.*, 1991).

The main aim of VAPS, which involved 14053 children, was to:

- ⇒ Determine concentrations of air pollution in the Vaal Triangle, so as to assess whether the air pollution control programme in South Africa was adequate to protect human health and
- ⇒ Determine whether these concentrations were detrimental to human health. Health effects of air pollution in the Vaal Triangle were to be studied in a multidisciplinary way (Terblanche, 1998 and Terblanche *et al*, 1992a).

In this study, data on human exposure to air pollution as well as on the respiratory health status of children living in the area were collected. The study set out as a multidisciplinary longitudinal study of children between the ages of 8 and 12 years of age. Children were chosen because they are considered more susceptible to air pollution as they are still developing physiologically. Another reason was to exclude the effect of smoking since it was highly unlikely at that time for children of this age to be smokers (Terblanche *et al*, 1992a).

The study had two main components, namely an exposure component that consisted of outdoor, indoor and personal monitoring of some criteria pollutants and a health effects component, where the respiratory health status of the participants was assessed. This was done using questionnaires, medical examinations, lung function tests, bio-chemical tests as well as immunological tests (Terblanche *et al*, 1992a). Eleven thousand nine hundred and sixteen (11916) questionnaires were distributed through forty-six primary schools. Eighty six percent of these were returned with more than seventy percent of the questions completed.

3.1.1 Air quality monitoring network during VAPS

At commencement of VAPS, an ambient air-monitoring network was designed for six monitoring stations. The sites were selected according to the following criteria (Terblanche, 1991):

- ⇒ Location of populations
- ⇒ Location of major sources of air pollution
- ⇒ Meteorological conditions
- ⇒ Topography of the area.

Based on the abovementioned criteria, the following sites were chosen:

1. Makalu (12 km south-west of Lethaba Power Station and 5 km south-east of Sasolburg). This was an existing station run by Eskom and it provided information for the southern border of the study area.
2. Sasolburg industrial area. This site was chosen to provide information on industrial pollution, as it was situated in the heart of Sasolburg's industrial area.
3. Sasolburg residential area; a site at Fonteine Primary School in the centre of town. This site was chosen to provide exposure data for the residents of Sasolburg
4. Vanderbijlpark residential area at Vanderbijlpark High School, an Afrikaans high school. This site was chosen to provide exposure data for the residents of the town of Vanderbijlpark.
5. Three Rivers Primary School; chosen to provide exposure data for the residents of Vereeniging.
6. Sharpeville, a station situated at Bedworthpark. This station was considered very important as it was situated downwind from Sharpeville and provided data on air pollution caused by domestic coal burning. It would therefore provide exposure data for residents of areas where coal is used as energy carrier for cooking and heating purposes.

The pollutants monitored at the aforementioned sites were chosen according to the following criteria (Terblanche, 1991):

- ⇒ A source inventory of major pollution sources in the area
- ⇒ Historical data and/or pilot monitoring studies done by Eskom
- ⇒ Criteria pollutants and standards used by the US-EPA at the time
- ⇒ Financial implications of monitoring of certain pollutants.

3.1.2 Pollutants monitored

Based on the mentioned criteria, the following pollutants were monitored:

- ⇒ sulphur dioxide (SO₂)
- ⇒ nitrogen oxides (NO_x)
- ⇒ carbon monoxide (CO)
- ⇒ non-methane hydrocarbons (NMHC)
- ⇒ hydrogen sulphide (H₂S) - in Sasolburg only
- ⇒ particulate matter with a diameter of < 2.5 µm (PM_{2.5})
- ⇒ total suspended particulate matter (TSP) - in Vanderbijlpark only
- ⇒ one year co-located sampling of TSP and PM₁₀ Vanderbijlpark and Sharpville to determine TSP/PM₁₀ ratio
- ⇒ ammonia (NH₃) – at the Sasol industrial site only
- ⇒ fluoride (F) – at the Sasol industrial site only
- ⇒ ozone (O₃) as secondary pollutant.

Wind speed and direction as well as temperature and humidity were also measured at the stations. Data were electronically logged on a continuous basis (every 30 seconds), and the hourly means calculated.

The stations were equipped with US-EPA approved instrumentation and regular calibrations were performed by the Department of Health. An auditing committee was convened to validate data.

A monitoring station for the determination of pollen and fungal spore counts was erected in Vanderbijlpark, at a station managed by The University of the Witwatersrand (Terblanche, 1991).

3.1.3 Air pollution in the Vaal Triangle during 1990

At the time of the 1990 progress report (February 1991), limited data were available, as the stations were, in terms of VAPS, in operation for less than a year.

The SO₂ and NO_x levels recorded were considered acceptable. The maximum hourly average for SO₂ was 94.3 ppb at Makalu and 1080 ppb at the Sasol industrial site. The SA guideline was 300 ppb at the time. (Currently South Africa has no hourly guideline for SO₂ but the 10 min. average guideline is 191 ppb (DEAT, 2001)). Guidelines in South Africa became more stringent as more information on health effects became available. This is comparable with practice in other countries. The current 10-minute guideline is because individuals sensitive to SO₂ (such as asthmatics), typically react within minutes. The maximum hourly averages recorded for NO_x were 122 ppb at Makalu and 400 ppb at Sasol industrial site. The SA hourly guideline at the time was, and still is, 800 ppb (DEAT, 1998). Maximum hourly ozone concentrations recorded at Makalu (50 ppb) and Sasol industrial site (170 ppb) were relatively high. The US-EPA standard as well as the South African guideline (both 120 ppb) was exceeded at the latter site. Concentrations increased from earlier in the year to November 1990. This was seen as an indication of the influence that increased sunlight has on ozone formation through photochemical reactions (Terblanche, 1991).

Recorded levels of ammonia and fluoride were, in the absence of specific guidelines at the time, considered to be relatively high (maxima of 1.16 ppm and 0.293 ppm respectively). The H₂S levels exceeded the odour threshold by a factor of 3 (maximum recorded was 0.4 ppm). A pilot study was conducted to determine the feasibility of CO monitoring in the Vaal Triangle area. Monitoring at three sites in Vanderbijlpark (a residential site, a site in the city centre and at a shopping centre) as well as at one site in Sharpeville, showed levels well below the then US-EPA standard. The steering committee of the Vaal Triangle Study subsequently decided that establishment of a R500 000 network to monitor CO was not feasible at the time (Terblanche, 1991).

The air pollution monitoring results for the limited period during 1990 already indicated potential problems, especially in terms of particulate matter (PM) (max TSP recorded was 284 µg/m³) and O₃ (maximum hourly average was 0.17 ppm) concentrations. The South African 24-hour TSP guideline was 350 µg/m³ at the time. Currently the South African guidelines for TSP and O₃ are 300 µg/m³ (24-hourly average) and 0.12 ppm (hourly average) respectively. The O₃ guideline was thus exceeded.

3.1.4 Air pollution in the Vaal Triangle during 1991

The 1991 progress report (Terblanche *et. al.*, 1992) focused on the stations at Makalu and Sharpeville and reported the following on the ambient (outdoor) pollution monitoring network:

On average the monthly means of the gaseous pollutants were higher for 1990 than 1991 at Makalu monitoring station. Atmospheric stability was seen as the most probable cause of this phenomenon. Sulphur dioxide, oxides of nitrogen, ozone and PM concentrations varied between the two sites. Levels of gaseous pollutants did not exceed US-EPA standards (Terblanche *et. al.*, 1992).

As far as particulate matter was concerned, concentrations recorded were significantly higher at Sharpeville than at Makalu. The reason was seen as the level at which particulate matter was emitted in the two areas. At the power station, emissions were through high stacks (thus emitted at a high level), whereas in Sharpeville emissions were from household coal burning, thus emitted at a low level. Monthly means of fine particulate matter at the Makalu site never exceeded $35 \mu\text{g}/\text{m}^3$. At Sharpeville, maximum concentrations measured exceeded $120 \mu\text{g}/\text{m}^3$ (Tosen and Rorich, 1992a).

The residential site at the Vanderbijlpark High School showed seasonal differences in TSP concentrations. Concentrations measured during winter exceeded SA guidelines and US-EPA standards. The South African 24-hour guideline of $350 \mu\text{g}/\text{m}^3$ at the time was exceeded once but the US-EPA Air Quality Standard of $260 \mu\text{g}/\text{m}^3$ was exceeded 5 times. Significantly lower concentrations of TSP were measured during summer. The reason for this was ascribed to the difference in meteorological conditions during the two seasons. Better atmospheric mixing and thus dilution is possible during unstable conditions during summer.

The first results of the bio-aerosol monitoring showed that both pollen and fungal spore counts frequently exceeded tolerance levels for sensitive (allergic) individuals. Pollen counts exceeded $260 \text{ grains}/\text{m}^3$ (guideline = $50 \text{ grains}/\text{m}^3$) during late winter to spring. Fungal spore counts remained high until end of May, with concentrations exceeding $16\,000/\text{m}^3$ (guideline = $3\,000/\text{m}^3$).

3.1.5 Air pollution in the Vaal Triangle during 1992

Health standards and/or guidelines for SO₂, NO₂ and O₃ were not exceeded at any of the ambient (outdoor) air monitoring stations during 1992 (Terblanche *et. al.*, 1993).

Total suspended particulate matter however was again a cause for concern. The two stations monitoring TSP (Vanderbijlpark and Meyerton) clearly showed differences in daily concentrations between winter and summer. The annual average for 1992 at Vanderbijlpark was 184 µg/m³ (US-EPA annual standard was 75 µg/m³). At the time of the Vaal Triangle study, a World Health Organization (WHO) 24-hour guideline for TSP of 180 µg/m³ was available. It was thus evident that the **annual** average of TSP in the Vaal Triangle was exceeding the WHO 24-hour guideline, indicating high 24-hour averages in the area throughout the year (Terblanche *et. al.*, 1993).

The pollen counts for 1992 were much lower than during 1991, because of the dry spring and summer experienced at the time. For example, the highest grass pollen counts measured during the 1991 season was 261 compared to the 28 grains/m³ of 1992 (Terblanche *et. al.*, 1993).

3.1.6 Personal Monitoring during VAPS

Personal monitoring of TSP was performed on 15 male and 16 female teenagers (median age 16 years) over an average period of 12 hours. None of these individuals lived in houses where coal or wood was used for cooking or heating purposes (Terblanche *et. al.* 1991a).

The median concentrations measured on a school day were 126 µg/m³, with a maximum of 248.4 µg/m³. On a Saturday, the median was found to be 168.3 µg/m³, with a maximum of 536.5 µg/m³ and on a holiday the median was 230.9 µg/m³ with a maximum of 628.7 µg/m³. Fifty one percent of the measurements exceeded the US-EPA 24-hour standard. It was found that children spent between 58 and 75% of their time indoors (Terblanche *et al* 1991a).

Cigarette smoking inside homes had an effect on exposure of the teenagers to TSP. Proximity of residences to sources of TSP had no statistical significant influence though. A study on personal TSP exposure in primary school children also found on average higher concentrations for a holiday than a normal school day (234 µg/m³ versus 196 µg/m³) (Terblanche, 1992).

In yet another sub study, fifteen children between 8 and 12 years of age were monitored for about 12 hours to determine their exposure to TSP. These children came from a township area where coal and wood were used for cooking and heating.

It was found that children living in homes where coal was used as the sole energy carrier were exposed to higher concentrations of TSP than children living in homes where electricity was used together with coal ($1363 \mu\text{g}/\text{m}^3$ versus $1168 \mu\text{g}/\text{m}^3$). Concentrations measured exceeded acceptable levels by a factor of 5 (Terblanche 1992).

In 99% of cases, the US-EPA 24-hour standard of $260 \mu\text{g}/\text{m}^3$ was exceeded and in 100% of cases the WHO guideline of $180 \mu\text{g}/\text{m}^3$ was exceeded. Measured concentrations were in the same range as those found in studies in other developing countries such as China ($2600 \mu\text{g}/\text{m}^3$) and Kenya ($1500 \mu\text{g}/\text{m}^3$) (Terblanche *et al* 1992b).

During the studies on personal exposure to TSP, in non-electrified and partially electrified townships, it was found that the main factors having an influence on exposure, were gender (boys higher than girls), season (winter higher than summer), day of the week (school days higher since the school was situated in a valley in a non-electrified area), electricity in homes (lower exposure on non-school days) and home type (higher exposure in informal dwellings) (Terblanche *et al* 1992b).

3.1.7 Main air pollution findings during the Vaal Triangle study

The main findings of the study as far as air pollution is concerned, were (Terblanche, 1998):

- ⇒ Air pollution during winter times was 2 to 4 times worse than during summer times.
- ⇒ The TSP levels remained high during the study period (1990 to 1993), especially during winter times. The 1992 annual average concentration of TSP at Vereeniging was $184 \mu\text{g}/\text{m}^3$, which was 2.5 times the US-EPA health standard of $75 \mu\text{g}/\text{m}^3$. In coal burning townships concentrations of TSP measured were 4 to 6 times the health standard (Fig. 3.1).
- ⇒ Sixty percent of the TSP in fact consisted of PM_{10} . The calculated average PM_{10} concentration was $70 \mu\text{g}/\text{m}^3$ while the US-EPA's standard was $50 \mu\text{g}/\text{m}^3$ (Fig. 3.1).
- ⇒ Concentrations of SO_2 were higher in winter than in summer but remained relatively low throughout the study period. Concentrations in residential

areas remained below standards, although standards were exceeded (less than 5% of the time) at the Sasol industrial site.

- ⇒ Concentrations of NO_x remained below standards.
- ⇒ Ozone concentrations occasionally (less than 1% of the time) exceeded standards.

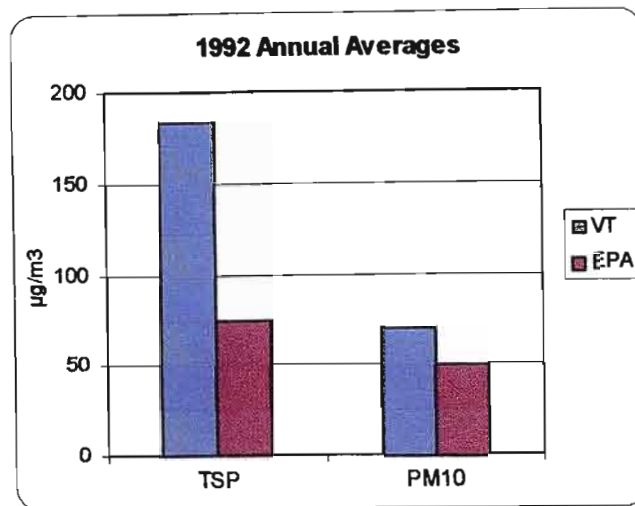


Figure 3.1: Annual average concentrations of TSP and PM_{10} in the Vaal Triangle 1992.

3.2 Air pollution in the Vaal Triangle after 1993 (after VAPS).

The VAPS came to an early end in 1993 when it was decided that adverse effects of air pollution in the area had been proven. The fate of the ambient monitoring stations was as follows:

- ⇒ Eskom's station at Makalu is still in operation but the one at Bedworthpark closed in 1995.
- ⇒ Sasol's industrial station is still in operation and monitors various pollutants but the residential station at Fonteine primary school was replaced by a station at Sasolburg Hospital. Both are still operational.
 - ▶ (Since VAPS, Sasol has also erected monitoring stations at Boiketlong and Leitrim, which are coal-burning residential areas and A. J. Jacobs a non-coal burning residential area).

⇒ The two stations financed by the then Department of Health, Vanderbijlpark High School and Three Rivers Primary School, closed when the study came to an end.

3.2.1 Air quality monitoring results for Particulate Matter after 1993

Particulate matter with a diameter smaller than 10 micron (PM₁₀) - 1994

PM₁₀ concentrations were monitored in the central business districts of Sasolburg, Vereeniging and Vanderbijlpark during April 1994 to April 1995 (Reddy *et. al.*, 1996). Relatively low concentrations were measured during the summer months but concentrations during the period late April to September were relatively high. The maximum monthly concentration (122 µg/m³) measured was at the Vereeniging station during June 1994. There is currently no monthly guideline for PM₁₀ to compare this concentration to. Annual averages were 69, 58 and 57 µg/m³ for Vereeniging, Vanderbijlpark and Sasolburg respectively (Reddy *et. al.*, 1996).

Annual averages of PM₁₀ for 1994 were more or less the same as the average of 70 µg/m³ calculated for the Vaal Triangle during VAPS (1990-1992). Compared with the US-EPA standard of 50 µg/m³ at the time, it was clear that PM₁₀ concentrations were still a cause for concern in 1994.

Particulate matter with a diameter smaller than 10 micron (PM₁₀) – 1994-2003

During the past decade, annual average PM₁₀ concentrations in residential areas with no domestic fuel burning, ranged between 60 and 70 µg/m³ (current SA guideline 60 µg/m³), with maximum 24-hour levels between 150 and 220 µg/m³ (current SA guideline 180 µg/m³) (Scorgie, *et.al.*, 2003). This means that levels of PM₁₀ in these specific residential areas have remained more or less the same for the past 12 years.

In areas of domestic fuel burning as well as in industrial and mining areas, annual average concentrations ranged between 80 and 100 µg/m³, with maximum 24-hour levels between 200 and 300 µg/m³ (Scorgie, *et.al.*, 2003). Guidelines were clearly exceeded in these areas.

About 12 to 13 years ago, annual average concentrations of total suspended particulate matter in **coal burning residential areas**, were in the order of 4 to 6 times the US-EPA health standard of 75 µg/m³ (Terblanche, 1998), thus ~400 µg/m³. Sixty percent of this was considered to be PM₁₀, thus ~240 µg/m³. If this figure is compared with the 80 to 100 µg/m³ mentioned above, then a downward trend over the past 12 to 13 years is evident in these

specific areas. It must be noted however that this concentration was calculated and not monitored.

Particulate matter with a diameter smaller than 10 micron (PM₁₀) – 2003-2004

The monthly averages for PM₁₀ during the period January 2003 to August 2004, at the Leitrim monitoring station, are depicted in Fig 3.2. This station is situated in a coal-burning residential area. The annual average for 2003, calculated from the monthly averages, was 126 µg/m³, which is double the current South African guideline of 60 µg/m³. These levels are in the same order of magnitude than those of domestic coal burning areas for the past decade reported by Scorgie, *et. al.* (2003). The highest monthly average (400 µg/m³) was for the month of June 2003. Concentrations for January to August 2004 were considerably lower, with the average for the first 8 months at 71 µg/m³. Particulate matter remains a cause for concern in the Vaal Triangle, especially in domestic coal-burning areas.

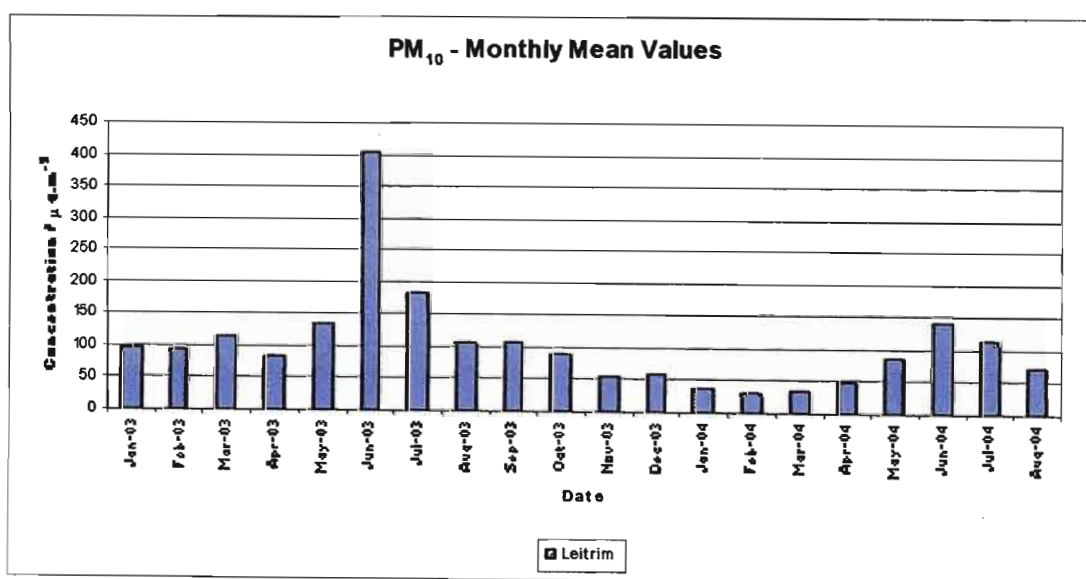


Figure 3.2: Monthly mean PM₁₀ concentrations at Leitrim in the Vaal Triangle Jan 03-Aug 04.

3.2.2 Source apportionment results of PM₁₀ for the Vaal Triangle

All major sources of air pollution in the Vaal Triangle were chemically characterised (Engelbrecht *et. al.*, 1993). The 1994/1995 source apportionment results for PM₁₀ are depicted in Figures 3.3 to 3.5. These results indicated that domestic coal burning was the biggest source of PM₁₀ in

the Vaal Triangle at the time (as mentioned, possibly due to the low level of emission).

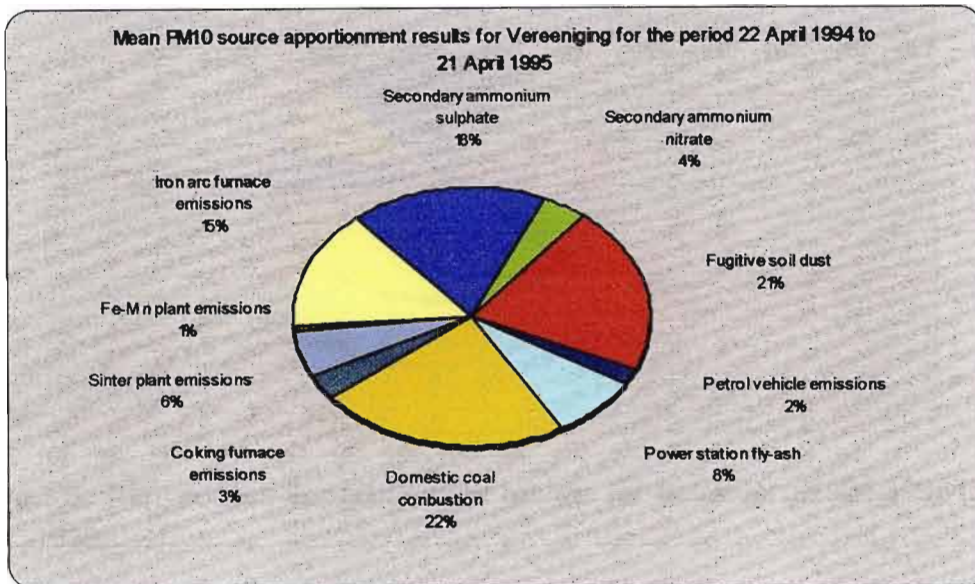


Figure 3.3: PM₁₀ source apportionment results for Vereeniging 1994-1995 (Reddy *et. al.*, 1996).

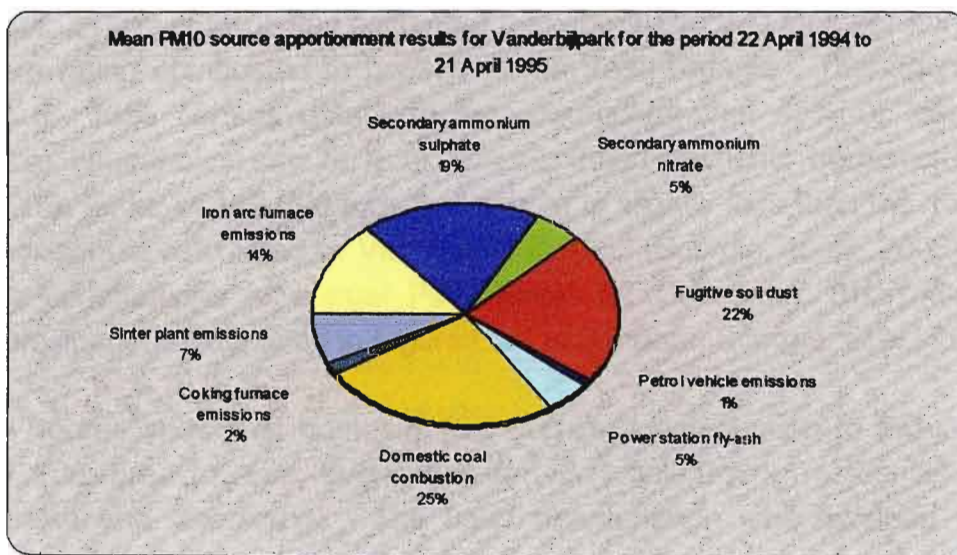


Figure 3.4: PM₁₀ source apportionment results for Vanderbijlpark 1994-1995 (Reddy *et. al.*, 1996).

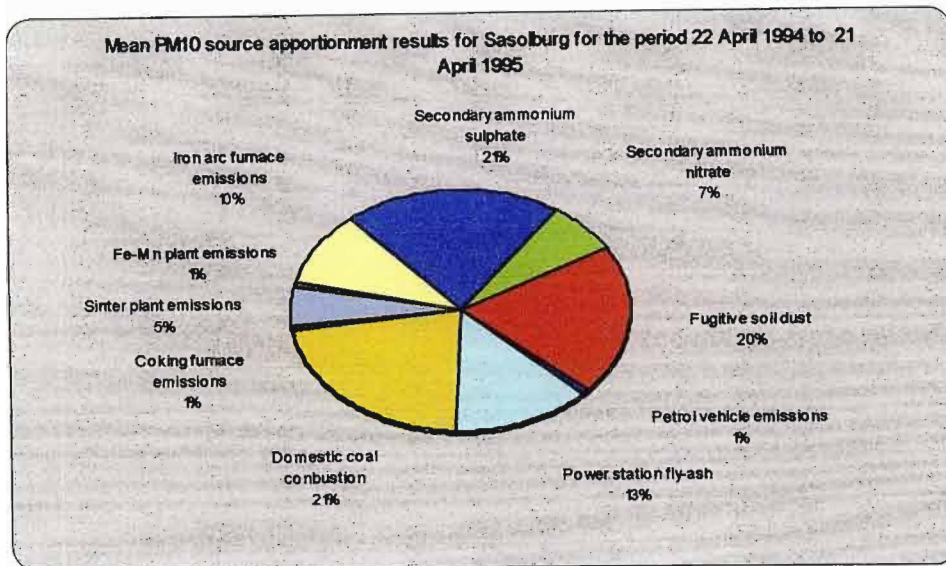


Figure 3.5: PM₁₀ source apportionment results for Sasolburg 1994-1995 (Reddy *et. al.*, 1996).

In 2003, Scorgie *et. al.* quantified source contributions to predicted PM₁₀ levels using more recent emissions data. Domestic fuel burning remains a problem, mainly due to rapid urbanization and the growth of informal settlements and the fact that about 45% of households with access to electricity continue to use coal. In this study it was estimated that about 140 200 tons per annum of coal are being combusted in houses in the Vaal Triangle. This figure was based on 1996 census data and the assumption that 45% of electrified township households and 88% of non-electrified township households use coal. The figure of 140 200 tons per annum is slightly less than the 145 146 tons per annum calculated by Van Nierop in 1993 (Scorgie, *et. al.*, 2003). The source contributions to annual PM₁₀ levels for Sebokeng, Sharpville and Vanderbijlpark, are depicted in Figures 3.6 to 3.8 (from Scorgie, *et. al.*, 2003).

These figures show that domestic fuel burning's contribution to PM₁₀ levels differs from area to area, even between two coal-burning residential areas (Sharpville and Sebokeng). The latter phenomenon was ascribed to the location of Sharpville, e.g. close to and downwind from industries (Scorgie *et. al.*, 2003).

It was found that despite the relatively high emissions from power generation, the predicted contribution to ground level PM₁₀ concentrations was below 0.2%. As mentioned previously, the reason for this is most probably the high (from stacks) level of emission.

The contribution from vehicles seems to be higher than for the previous study in 1993. A possible increase in the number of vehicles for the area could be the reason for this.

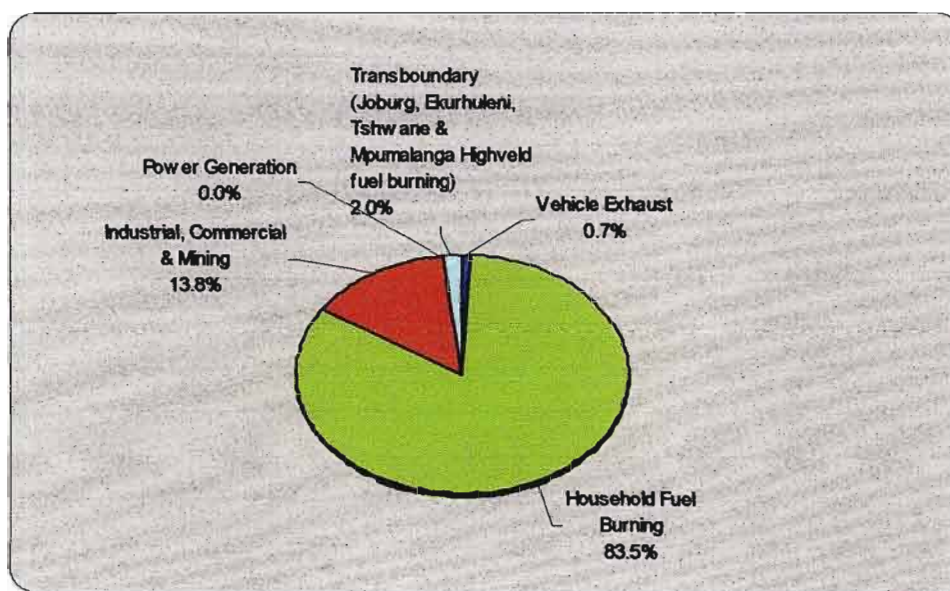


Figure 3.6: Predicted PM_{10} source apportionment results for Sebokeng (Scorgie *et. al.*, 2003).

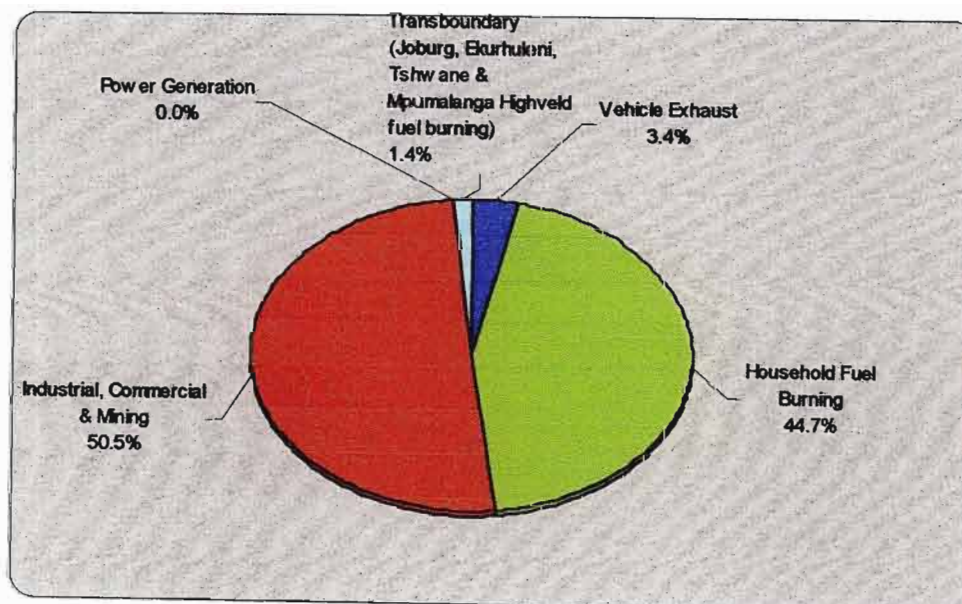


Figure 3.7: Predicted PM_{10} source apportionment results for Sharpville (Scorgie *et. al.*, 2003).

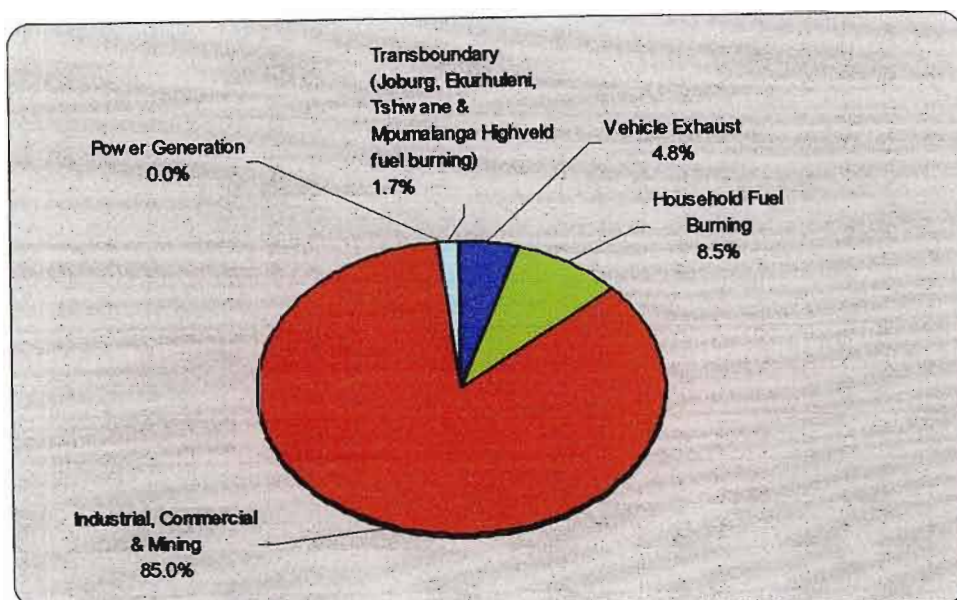


Figure 3.8: Predicted PM₁₀ source apportionment results for Vanderbijlpark (Scorgie *et. al.*, 2003).

3.2.3 Air quality monitoring results for sulphur dioxide after 1993

Sulphur dioxide concentrations- 1994-2003

As mentioned previously, concentrations of SO₂ during VAPS were higher in winter than in summer but remained relatively low throughout the study period, although standards were exceeded (less than 5% of the time) at the Sasol industrial site.

Between 1994 and 2003, **maximum** 24-hour average concentrations of SO₂ ranged between 180 and 850 µg/m³ in industrial and coal-burning areas (Scorgie *et.al.*, 2003). The SA 24-hour guideline (between 1994 and 2001) was 260 µg/m³ whereas the current SA and WHO guideline is 125 µg/m³. Annual average concentrations ranged between 40 and 80 µg/m³. The annual SO₂ guideline for SA was 78 µg/m³ but is currently 50 µg/m³. It is thus clear that concentrations in industrial and coal-burning areas could exceed guideline values.

Sulphur dioxide concentrations- 2003/2004

The annual average concentrations for 2003, monitored for the industrial and coal-burning residential sites, ranged between 7 ppb (18 µg/m³) and 29 ppb (76 µg/m³) and for non coal-burning residential sites, between 11 ppb (29 µg/m³) and 13 ppb (34 µg/m³) (Sasol and Eskom, 2004). Again it is clear that concentrations in industrial and coal-burning residential areas could exceed

guideline values. This is in line with the **predicted** annual levels of SO₂ for the Vaal Triangle (Scorgie et. al., 2003).

3.2.4 Air quality monitoring results for ozone after 1993

Maximum 1-hour ozone concentrations recorded during VAPS were relatively high (170 ppb), occasionally exceeding guideline values.

When considering the period after VAPS, hourly averages of ozone in the Vaal Triangle were available for one site only. Maximum hourly averages recorded at this industrial site between 1993 and 2003, ranged from 77 ppb (recorded in 1996) to 183 ppb (recorded in 2001). The maximum for 2003 was 107 ppb (Sasol and Eskom, 2004). The current SA 1-hour guideline is 120 ppb. According to these results, it can be concluded that the ozone concentrations in the area did not change significantly since VAPS.

The highest monthly average concentration for O₃ in an industrial area during the period January 2003 to August 2004 was 48 ppb, recorded during October 2003. The highest for a coal-burning residential area was 38 ppb, also recorded during October 2003 (Sasol and Eskom, 2004). There is currently no monthly guideline for ozone.

3.2.5 Air quality monitoring results for nitrogen dioxide after 1993

During VAPS (1990-1993) concentrations of nitrogen oxides (NO_x) (which includes nitrogen oxide and nitrogen dioxide), remained below standards (Terblanche, 1998).

The only data available on nitrogen oxides for the last decade were monthly averages of NO₂ for a coal-burning residential area (for 2003) and maximum hourly averages of NO₂ for an industrial site for the period 1993 to 2003.

The maximum monthly average monitored at the coal-burning residential area during 2003, was 16 ppb (recorded during July) and the lowest 4 ppb (recorded during September). The annual average for 2003, calculated from the monthly averages, was 9 ppb.

The maximum hourly averages for each year since 1993, ranged from 47 ppb (recorded during 2003) to 148 ppb (recorded during 1998) (Sasol and Eskom, 2004).

The current South African 1-hour and monthly average guidelines for NO₂ are 200 ppb and 80 ppb respectively (DEAT, 1998). Concentrations monitored after 1993 are thus still below guidelines.

CHAPTER FOUR

4.0 Risk Transition On Developing Countries

The WHO defines risk in their 2002 Annual Report as: "A probability of an adverse effect, or a **factor** that raises that probability."

The current top ten risks to health globally, are the following (WHO, 2002):

- ⇒ Underweight
- ⇒ Unsafe sex
- ⇒ High blood pressure
- ⇒ Tobacco consumption
- ⇒ Alcohol consumption
- ⇒ Unsafe water, sanitation and hygiene
- ⇒ Iron deficiency
- ⇒ Indoor smoke from solid fuel
- ⇒ High cholesterol
- ⇒ Obesity.

During the year 2000, 1.8 million underweight children died in Africa (WHO, 2002). An iron deficiency will also be associated with malnutrition. As far as the second risk factor, unsafe sex is concerned, the WHO 2002 Annual Report claims that 70% of the 40 million people infected with human immunodeficiency virus (HIV), are living in Africa, causing the current estimated life expectancy at birth to be 47 years in sub-Saharan Africa. The report further states that according to current estimate, more than 99% of the HIV infections in Africa in 2001 were due to unsafe sex.

Changes in lifestyle at work, where people sit in front of computers, and at home where they sit in front of the television, cause physical inactivity, which was found to be the cause of about 15% of some cancers, diabetes and heart disease (WHO, 2002). High cholesterol and obesity are generally also associated with lifestyle. The same is true for tobacco and alcohol consumption.

For risk number six, unsafe water and sanitation and hygiene, the situation in South Africa is that an estimated 35% of people lack basic sanitation services, while an estimated 15 % do not have access to safe drinking water. The Government has therefore developed policies and programmes to speed up service delivery (DWAF, 2003).

Indoor smoke from solid fuels (risk 8) is still a problem in South Africa, since a large proportion of the population still uses coal, wood, paraffin and or cow dung as household fuel. In 1999 these figures were 4993, 4497 and 3237 (in thousands of households) for cooking, heating and lighting respectively (Statistics South Africa, 2002). Air pollution, especially indoor air pollution is thus a fundamental problem and therefore an extra risk factor in the development of diseases. It is estimated that worldwide, air pollution is responsible for 600 000 premature deaths every year. Scientists from the WHO is of the opinion that there are striking similarities between the air pollution situation in London 50 years ago and that of developing countries (Gulland, 2002).

In 2003, the director general of the WHO, speaking at the World Health Day, in New Delhi, India, stated that although children under 5 years of age only comprise 10% of the world's population, they bear 40% of the global disease burden. About 2 million children die each year from acute respiratory infections, the number one killer of children, followed by diarrhea diseases (1.3 million) and malaria (1million) (Dyer, 2003).

Some risks have been reduced or eliminated, especially infectious diseases for which vaccines are available. For example, infectious diseases such as smallpox, measles and whooping cough have been eliminated or reduced in South Africa. There are infectious diseases, such as cholera and tuberculosis, however, which are still present in low and middle-income countries (including South Africa) and mainly associated with poverty (WHO, 2002).

Changes in lifestyle such as consumption patterns of food and alcohol and inactivity, brought about new risks. This situation is called "risk transition". These "new" risks are amongst others, high blood pressure, high blood cholesterol and obesity (WHO, 2002). Risk factors for circulatory diseases, such as myocardial infarction, are uncontrolled hypertension, obesity, tobacco smoking, blood lipids, stress and a lack of exercise (Küstner, 1980). In the US it was found that during the time between two National Health and Nutrition Examination Surveys (NHANES) (conducted between 1988-1994 and 1999-2000) average blood pressure in US children and adolescents rose significantly. It was further found that the increase was at least partly attributable to an increase in the prevalence of individuals who are overweight (Falkner, 2004).

Figure 4.1 compare the main causes of death in developing and developed countries for 1997.

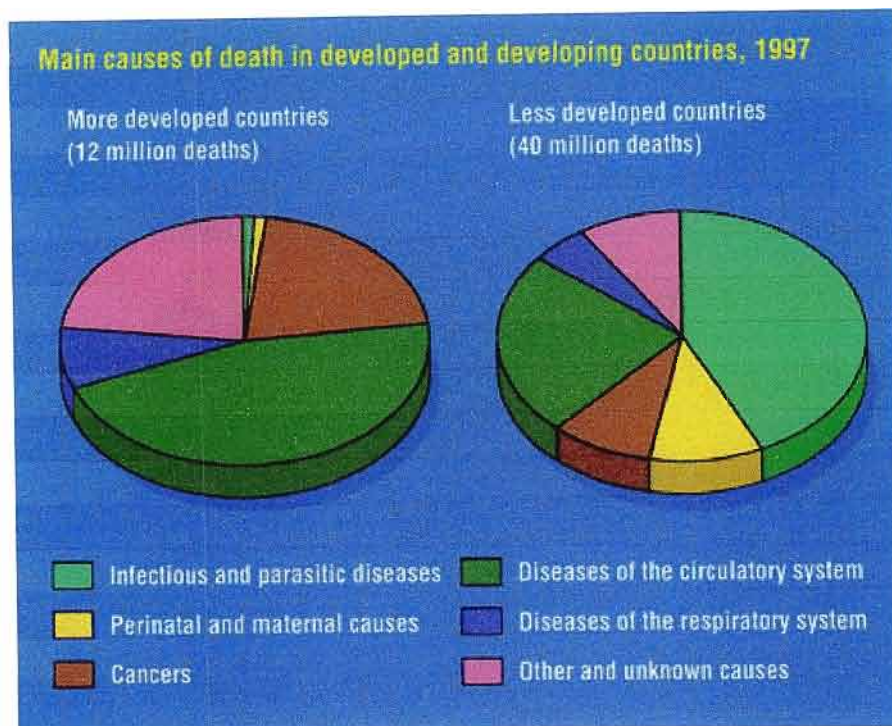


Figure 4.1: Main causes of death for developed and developing countries for 1997 (Eaton, 2003).

From Figure 4.1 it is evident that there is a transition in mortality risk from mainly infectious diseases, perinatal and maternal causes in less developed countries to diseases of the circulatory system and an increase in cancer in more developed countries.

The abovementioned emerging risks are usually associated with an affluent lifestyle, but the problem is that the incidence of these risks is currently rising in developing countries as well. It is estimated that non-communicable diseases are responsible for about 60% of deaths worldwide (WHO, 2002). In 2000 non-communicable diseases already accounted for 37% of deaths in South Africa (communicable (other than HIV/AIDS), maternal, perinatal and nutritional accounted for 21% of deaths) (Bradshaw, *et. al.*, 2003).

Low and middle-income countries still suffering from “old” diseases such as infections and underweight (because of malnutrition), now also have to deal with the rise in diseases such as diabetes, heart disease, stroke and cancer. These countries are therefore suffering the “double burden” of disease (WHO, 2002).

In South Africa the mortality profile for 2000 in fact shows a quadruple burden of disease, since HIV/AIDS, chronic diseases, poverty-related conditions and injuries all contributed substantially. The leading causes of death were, after HIV/AIDS, which contributed 30%, cardiovascular diseases that contributed 17%, infectious diseases (10%), malignant neoplasms (8%) and injuries 12% (Bradshaw, *et. al.*, 2003).

The incidence of heart attacks and strokes is on the increase in the developing regions of Africa. This transition from the rheumatic and nutritional heart diseases towards arteriosclerotic diseases is mainly because of a change in lifestyle. Urbanisation, stress, increased living standards and the 'Western' diet - all contribute to this (MRC, 2002).

It is expected that the global figure for diabetes will reach 300 million within the next 25 years. Although the developed world is most affected, the disease is also increasing in developing countries and the risk factors include a lack of exercise and a poor diet (also risk factors for obesity). In South Africa it was found that as rural black communities migrate to urban areas, the incidence of diabetes (type 2; maturity onset) increased (MRC, 2002). Unlike HIV and smoking, the precautionary measures for diabetes cannot be taken by a single action such as practicing of safe sex or stopping smoking (Watts, 2003).

Another risk on the increase in both developed and developing countries is cancer. It is estimated by the WHO that cancer rates worldwide will double by 2020. Again, unhealthy lifestyles and smoking are seen as the main causes, with the increase in the number of elderly people as a contributing factor (Eaton, 2003). The incidence of liver cancer in low and middle-income countries is high, with more than half of the cases in China but sub-Saharan Africa has also got a high incidence. It is estimated that persistent hepatitis B infection plays a role in 50% and hepatitis C in 25% of cases. There is currently no vaccine for hepatitis C and the initial high cost of hepatitis B vaccine is probably the reason why its use worldwide is still low (Hall and Wild, 2003). South Africa had 212 cases of hepatitis B in 2002, with a case fatality rate (CFR) of 2.8 (Department of Health, 2003). The most recent (1995) data on the lifetime risk of cancer in South Africa shows that it ranges from 1 in 3 for white males and 1 in 4 for white females, to 1 in 6 for Asian males and 1 in 11 for black females (Sitas *et. al.*, 1998).

Studies show that although the more affluent areas of South Africa were further ahead in the epidemiological transition, the poor areas also suffer a substantial burden of premature death due to chronic diseases such as

stroke, chronic obstructive lung diseases, asthma, epilepsy, oesophageal cancer and cervical cancer (MRC, 2002).

Other lifestyle factors, such as alcohol consumption (responsible for 20 – 30% of the world's oesophageal cancers, liver diseases, epilepsy, motor vehicle accidents, homicides and other injuries) and tobacco use are also on the rise in developing countries (WHO, 2002). Alcohol remains the dominant substance of abuse in South Africa (SA Yearbook, 2004).

In Gauteng, 80% of all patients admitted to substance abuse rehabilitation centres during the first half of 2000 were male, and 83% were white, 27% black/African, 7% Coloured and 4% Asian. The overall mean age was 35 years, although the mean age of patients treated for alcohol abuse is much higher (42 years) than for the other drugs (20-29 years). Patients using cannabis or Ecstasy had the lowest mean age (20 years and 21 years, respectively). The mean age of heroin patients was 23. In 60% of patients the primary substance of abuse was alcohol. Apart from alcohol, the most common primary substances of abuse were cannabis alone (19%), cocaine/crack (11%), cannabis/Mandrax (2%), over-the-counter or prescription medicines (3%), and heroin (3%), (Plüddemann, 2001).

Fig 4.2 depicts the proportion of individuals under 20 in substance abuse rehabilitation centres in South Africa during the period 1996 to 2001.

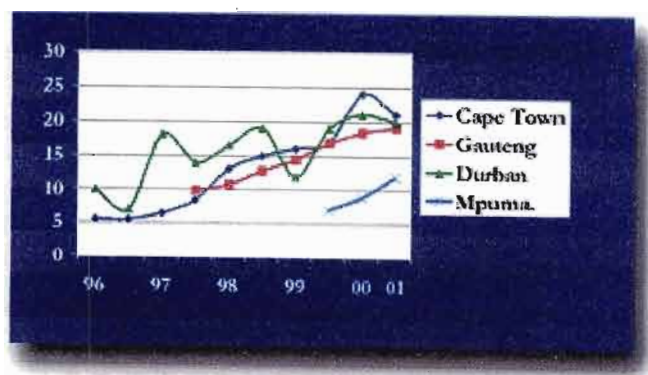


Figure 4.2: Proportion of individuals under 20 in rehabilitation centres for substance abuse (1996-2001) (MRC 2002).

Many individuals believe that government, through different interventions, should reduce risks that they as individuals do not have any control over. Interventions is defined as "any health actions – any promoting, preventive, curative or rehabilitative activity where the primary intent is to improve health"

(WHO, 2002). South African national authorities have intervened in many cases, for example in progressive legislation as far as environmental tobacco smoke is concerned. The Tobacco Products Control Act (Act number 83 of 1993), as amended by the Tobacco Products Control Amendment Act (Act number 12 of 1999) (Republic of South Africa, 1999), makes provision for the regulation of the sale, advertising and promotion of tobacco products, the prescription of maximum yields of tar and nicotine and where smoking of tobacco products in public places is permissible. However, it is also the responsibility of every individual to live a healthy lifestyle.

The results of the mentioned interventions are encouraging. Adult smoking dropped from 34% in 1996 to 24% in 1998 (S A Yearbook, 2004). A survey conducted by the Medical Research Council (MRC) in 2002 among high school leavers, showed that school going teenagers were less likely to smoke than they had been in 1999. The percentage of teenagers interviewed who had ever smoked, dropped from 47% in 1999 to 38% in 2002 and that of frequent smokers (who had smoked on at least 20 days in the 30 days preceding the interview) dropped from 10.1% in 1999 to 5.8% in 2002. The use of cannabis (dagga) and mandrax (methaqualone) alone or in combination (white pipes) continues to be high in South Africa (SA Yearbook, 2004).

In a WHO report it was mentioned that chronic disease, which can be defined as: "health problems that persist over time and require some degree of health care management" will be the world's leading cause of disability by 2020. The report states that the prevalence of chronic conditions is on the increase and although mostly preventable or at least manageable through behavioral changes, primary health care in developing countries is not sufficiently equipped to deal with the situation (Whelan, 2002).

The WHO 2002 Annual Report warns that countries now need to adopt control policies in order to improve global health and lower the burden of disease.

In the light of the above, it was decided to include questions in the questionnaire that will attempt to obtain information on the lifestyle and consumption habits of the study population. Results could be used to help national authorities to make informed decisions based on scientific evidence in risk reduction policies.

4.1 Transition of epidemiology in South Africa

The word "epidemiology" is derived from: (Küstner, 1980)

- ⇒ epi- down, on or upon
- ⇒ -demos- the people
- ⇒ -logy- study, knowledge.

Epidemiology was already defined in 1883 by A. Hirsch as "a picture of the occurrence, the distribution and the types of the diseases of mankind, in distinct epochs of time and at various points of the earth's surface; and render an account of the relations of those diseases to the external conditions" (Küstner, 1980).

A more modern definition is that epidemiology is "the study of the distribution and determinants of health related conditions and events in populations, and the application of this study to the control of health problems" (Katzenellenbogen and Yach, 1991)

Epidemiology can be: (Küstner, 1980)

- ⇒ descriptive- describes health and disease patterns and trends
- ⇒ analytical- analyse the described variables
- ⇒ experimental- introduces variables into study and control groups and observes trends.

Although vaccination against smallpox already became compulsory in 1893 and tuberculosis became notifiable in 1919, it was only in 1977 that the then Department of Health (DoH), decided to establish a division of epidemiology in South Africa. In order to reach this goal, Dr Küstner was sent to the Centre for Disease Control (CDC) in Atlanta, to receive formal training in epidemiology. It was envisaged that such a division would provide an advisory service aimed at preventing, containing and controlling preventable and other medical conditions in South Africa. The service was to include the development and maintenance of a Surveillance Programme.

Surveillance is a facet of epidemiology and consists of the following steps: (Küstner, 1980)

- ⇒ consolidation or collation of data
- ⇒ analyses of data
- ⇒ dissemination of data- to those to whom it is important to know

⇒ taking of action- in the decision making process.

The status quo of epidemiological services in South Africa in 1977, revealed that there were several fields where very little was done in terms of epidemiological input. These were:

- ⇒ Active surveillance
- ⇒ Passive surveillance
- ⇒ Projects and field surveys
- ⇒ Training
- ⇒ Information
- ⇒ Co-ordination.

4.1.1 Active surveillance

Co-ordinated active surveillance was only performed in the field of malaria, bilharzia and tuberculosis (Küstner, 1980).

4.1.2 Passive surveillance

In the late seventies, it was clear from publications in the South African Medical Journal that numerous researchers in South Africa worked in the field of passive surveillance on subjects such as death profiles, cancer rates and accidents. The Department of Health however, only covered the field of certain notifiable diseases and death statistics. The latter was periodically released by the Department of Statistics. The purpose of a notifiable system is to monitor the trends of certain diseases and to control them (Küstner, 1980).

The notifiable diseases database, known as the "notifiable disease file" came into operation in South Africa towards the end of 1971. It was based on specifications set by Dr L W Osburn, the then epidemiologist at the Department of Health. This was not the first list of 'notifiable' diseases, since smallpox could already be considered a 'notifiable disease' in the eighteenth century when households were obliged to report cases of smallpox to the "burgher surgeon". It was only in 1919 after the Anglo Boer War (1899 – 1902) and the influenza epidemic (1918 – 1919) that smallpox was declared a notifiable disease throughout the country, under the Public Health Act (Act number 36 of 1919) (Küstner, 1980).

Currently 44 distinct medical conditions are considered notifiable under the Health Act (Act number 63 of 1977) in South Africa. The first health professional or

facility with whom the patient with a notifiable disease presents has to notify the relevant authority. Statistics on the notifiable diseases in South Africa are still released periodically (Department of Health, 2003).

4.1.3 Projects and field surveys

There was a lack of suitable manpower in the seventies, which was the main reason for the very limited involvement in epidemiological projects, programmes and field surveys (Küstner, 1980). The time and costs involved in epidemiological surveys remain a problem in South Africa. Human Health Risk Assessments, another linkage method between exposure and health effects, is a much faster and cheaper option and often used, especially in Environmental Impact assessments.

4.1.4 Training

Training in practical epidemiology in South Africa in the late seventies, early eighties was virtually non-existing and in the medical, nursing and para-medical fields, training was dealt with in passing. This lack of training resulted in no available supervision for field workers (Küstner, 1980). Today Universities with medical schools do present courses in epidemiology.

4.1.5 Information

The only epidemiological information released by the Department of Health in the seventies, was about certain notifiable diseases. The South African Institute for Medical Research was far more involved in epidemiological field service than the Department of Health, especially as far as cholera outbreaks and West Nile Fever control were concerned (Küstner, 1980).

Globally, epidemiological interest has of late focused more on chronic diseases as opposed to the previous focus on diseases known for their potential to cause an epidemic. The reason for this shift in focus is because of better control of infectious diseases, especially in developed countries.

Infant mortality rate in South Africa

Infant mortality rate (IMR) (determined as the number of deaths of children under one year of age per thousand live births) is often used to determine the health status of a population. In South Africa the IMR under certain population groups is not reliable because not all births get registered and not all deaths are notified. For 1970, the IMR in South Africa amongst Whites, Coloureds, Asians and Africans were 21.6, 132.6, 36.4 and 149.7

respectively. The last figure was estimated. This gives an average of 85.0 for the country. In 1975 the average was 64.8 for the country. IMR for Asians at that stage was lower than for other Asian countries such as India (122 in 1971) and Burma (56 in 1974). The estimated IMR for Africans was higher than for some other African countries at the time, such as Mozambique (26 in 1973) and Angola (24 in 1972) but lower than others, for example Lesotho (114 in 1973) and Liberia (159 in 1971) (Küstner, 1980).

The South African Demographic and Health Survey (SADHS, 1998) (the most recent for which results are available) found the IMR in South Africa for the ten years preceding the survey, to be 45.4, (thus a significant decrease from 85 in 1970). For the African population it was 47.0, (38.7 and 53.6 for urban and non-urban Africans respectively), 18.8 for Coloureds and 11.4 for Whites. The last was based on 250 to 500 cases. The sample of Asian births was too small to determine a reliable infant mortality rate.

4.1.6 Co-ordination

There was no co-ordination of epidemiological services in South Africa in the seventies. Although it was felt that the Department of Health should not **control** such services as it could stifle enthusiasm and initiative, the need for such a **co-ordinating** authority was emphasised.

The absence of co-ordination in epidemiological services resulted in limited publications and a lack of knowledge of other studies and projects.

At the same time the absence of co-ordination led to very little liaison between the Department of Health and academic and research bodies. The only liaison at the time was with research organisations through funding (Küstner, 1980)

The current situation is not much different

4.2 Epidemiological transition of communicable diseases in South Africa

The communicable diseases that were and still are some of the main role players in the epidemiological history of South Africa are discussed below. Figures 4.3 and 4.4 show the trend in these diseases since 1999.

4.2.1 Smallpox

The success story of smallpox demonstrates the value of surveillance. The first documented epidemic of smallpox in South Africa occurred in 1713, when the crew of a ship from India introduced the disease. Vaccination against smallpox in South Africa became compulsory on 14 September 1893. The WHO launched an intensified smallpox eradication programme in 1966, resulting in a downward trend in observed cases since 1967 (Küstner, 1980). During 1971, ten cases and one death were reported. The last confirmed case of smallpox in South Africa were two black men from a farm in the district of Delmas in 1971, although the National Institute of Virology in 1972 had the name of a person from Rietfontein who tested positive but the origin of this record could not be explained as no confirmation of the case could be obtained from either the Rietfontein Hospital or any other hospital, clinic or regional office. The very last known case worldwide was in Ethiopia in 1976 (Küstner, 1980).

4.2.2 Typhoid fever

In 1979, it was clear that typhoid fever showed a negligible decline as the number of cases stayed more or less the same for 50 years (The number of cases in 1920 was between 4000 and 5000 and in 1970 it was still between these two figures) (Küstner, 1980). During 1994, 820 typhoid cases and 15 deaths were reported (CFR 1.8) and during 2002, 162 cases and 5 deaths (CFR 3.1). There was thus a considerable decrease in the number of cases since 1970 but the CFR increased (Department of Health, 2003).

4.2.3 Meningococcus

Meningococcus was first declared a notifiable disease in South Africa in terms of section 18 of Act number 36 of 1919. By 1979 it occupied 5th position on the list (Küstner, 1980) and in 2002 6th position on the list of notifiable diseases (Department of Health, 2003).

4.2.4 Polio

Polio remains a major problem in Africa. Although the last confirmed case in South Africa occurred in 1989, the country remains at risk of the disease from neighboring countries. On 30 May 2003, the Minister of Health launched the countdown to a polio-free South Africa as part of a global initiative to raise awareness about efforts to eradicate polio by 31 December 2005 (SA Yearbook, 2004).

According to the South African Yearbook (2003/4), the most common communicable diseases currently in South Africa are TB, malaria, measles and sexually transmitted diseases.

4.2.5 Tuberculosis (TB) and Human immunodeficiency virus (HIV)

In 1979 TB control was already for some decades top of the list in South Africa of number of cases and cost of controlling the disease. The mortality rate from tuberculosis in South Africa decreased from about 70 per 100 000 of the population around 1953, when the intensification of active case findings commenced, to less than 30 around 1955. All forms of tuberculosis are notifiable since the Public Health Act of 1919 (Act number 36 of 1919) (Küstner, 1980).

In the seventies, the population of South Africa's profile was typical of that of a developing country, with a substantial number (+50%) of the population being **under** 15 years of age. Calculated from the 2001 census data, this percentage is currently 22%, with 7% of the population older than 60 years of age. In a developed community, contribution from children to notifiable diseases is less than that from older people (Küstner, 1980).

In the seventies it was found that in South Africa, less children and more adults were being diagnosed with TB, thus a **transition pattern** from that of a developing to that of a developed community. Pooled data from 1971 to 1977 showed that children under the age of 15 years contributed about 30% of all TB notifications (Küstner, 1980).

In 1977, <3% of all TB notifications came from the White and Asian populations, thus at that stage it was clear that what happened in these two populations as far as TB is concerned would not have had a great influence on the total picture (Küstner, 1980).

TB is still top of the list of cases of notifiable diseases in South Africa:

- ⇒ In 1945, 3470 cases and 536 deaths (CFR 15.0) were reported out of a population of 11.8 million
- ⇒ In 1955 this figure was 3997 cases with 104 deaths (CFR 2.6) out of a population of 14.9 million
- ⇒ In 1965 there were 4916 cases and 17 deaths (CFR 0.3) out of a population of 19.0 million

- ⇒ In 1975 3796 cases and 87 deaths out of a population of 25.0 million (CFR 2.3) were reported (Küstner, 1980)
- ⇒ During 1994 80 609 cases and 2408 deaths (CFR 2.9) were reported (Küstner, 1995)
- ⇒ During the year 2000, a total of 92 646 cases of TB and 4410 deaths were reported, thus a case fatality rate (CFR) of 4.8
- ⇒ The most recent data for one year are for 2002 when 89 423 cases and 3553 deaths (CFR 4.0) were reported (Department of Health, 2003).

South Africa remains one of the 22 high-burden TB countries, even though free testing is available at public clinics countrywide (SA Yearbook, 2004). When the Human Immunodeficiency Virus (HIV) emerged, pulmonary tuberculosis, caused by *Mycobacterium tuberculosis*, increased. Moreover, multi-drug resistant TB as well as rare forms of TB have become more prevalent. As a consequence HIV and TB are on the rise in developing countries, e.g. Africa, Asia and South America. It is estimated that 40% of TB patients in South Africa are infected with HIV (Department of Health, 2000b).

The Department of Health has implemented the Directly Observed Treatment Strategy (DOTS), advocated by the International Union against TB and the WHO. The focus is on curing infectious patients at the first attempt, by ensuring that they are identified, then supported and monitored to ensure that they take their tablets. A subsequent survey showed that 80% of patients completed their treatment under this direct observation programme (MRC, 2002). The National TB Control Programme aims to achieve the following specific targets by 2005:

- ⇒ a cure rate of between 80 and 85% among smear-positive TB cases
- ⇒ decreasing the treatment interruption rate to less than 10%
- ⇒ detecting 70% of estimated new smear positive TB cases (SA Yearbook, 2004).

4.2.6 Malaria

About 90% of worldwide malaria deaths occur in Africa south of the Sahara, because the most effective vector, which is also the most difficult to control, *Anopheles gambiae*, is the most widespread in Africa. One million people (mostly women and children under 5 years) die annually in Africa as a result of malaria. Two percent of children who do recover from cerebral malaria suffer from some form of brain damage. Malaria mortality in children under 5 in southern and eastern Africa almost doubled over the period 1990 to 1998 when compared with 1982-1989 data (WHO, 2003).

In South Africa, malaria is endemic in the low-altitude areas of Limpopo, Mpumalanga and northeastern KwaZulu-Natal. The highest-risk area is a strip of about 100 km along the Zimbabwe, Mozambique and Swaziland border. The disease should therefore be viewed as a regional rather than a country-specific problem (SA Yearbook, 2004).

The number of malaria cases and related deaths in South Africa started to rise from approximately 27 000 cases and 160 deaths (CFR 0.60), in the mid-1990s, peaking at 62 000 cases and 420 deaths (CFR 0.70) in 2000. To deal with the problem, the Department of Health took drastic measures in addressing the issue, including changing the drugs and insecticides used, as well as massive education and awareness campaigns within the affected communities. As a result of these actions, the number of malaria cases dropped by 59% in 2001 and a further 42% in 2002. The malaria deaths in 2001 declined by 74% and a further 21% in 2002 compared with the 2000 malaria season. South Africa is one of the signatories to the Abuja Declaration, committing itself to reducing malaria morbidity and mortality by 50% by 2010 (SA Yearbook, 2004).

4.2.7 Measles

Measles became a notifiable medical condition in 1980. The highest number of cases for the period 1980 to 1999 was recorded in 1992, namely 22 798 cases. There has generally been a decline in case fatality rates over time. Although the number of cases reported in 1987 is almost equal to the number reported in 1992, the case fatality rates (CFRs) are different (2% in 1987 compared with 0.23% in 1992). The highest case fatality rate (3.01%) was recorded in 1983 (Department of Health, 2000). Measles decreased dramatically to 37 cases and no deaths in 2000, a direct result of the Measles Elimination Strategy (SA Yearbook, 2004). In 2002, 30 cases and no deaths were reported (Department of Health, 2003).

4.2.8 Cholera

Cholera is an endemic disease in Asia. By the end of the 19th century it was thought that cholera no longer pose a global health threat, but it re-emerged in Africa and Latin America and has remained ever since (Department of Health, 2000a). Cholera became a notifiable disease in 1965 but the first known case in South Africa was in 1980 (DWAF, 2003). During the 20 years from 1980 to 2000 a total of 30645 cholera cases were reported in South Africa. The highest was 13900 cases for 1982. For the period August 2000 to July 2001, 106389 cases with a CFR of 0.22 were reported and 18224 cases with a CFR

of 0.67 during August 2001 to July 2002. For the first six months of 2003, 3774 cases with a CFR of 1.06 were reported (Department of Health, 2000a). It is evident from these statistics that cholera is still a huge problem in South Africa.

Africa accounted for 94% of global cholera cases during the 2001 outbreak. South Africa accounted for 58% of the cases in that year (DWAF, 2003).

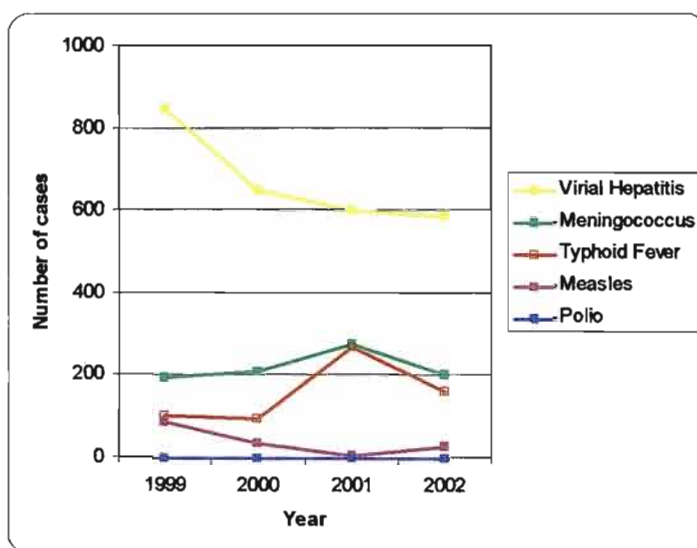


Figure 4.3: Measles, meningococcus, polio, viral hepatitis and typhoid fever cases in South Africa; 1999 to 2002.

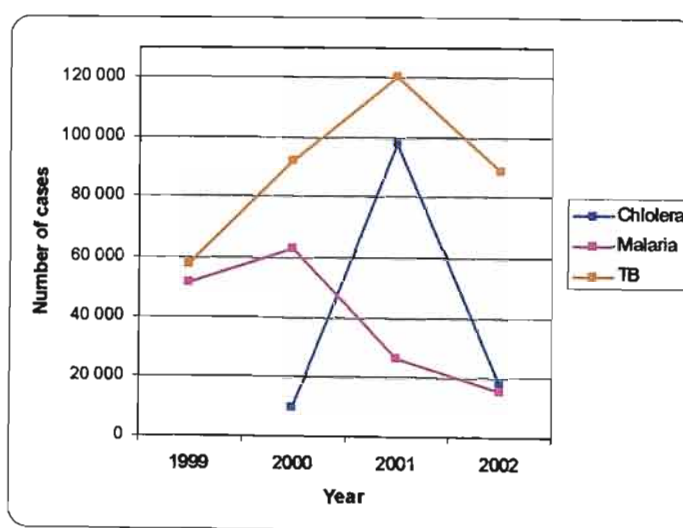


Figure 4.4: Cholera, malaria and TB cases in South Africa; 1999 to 2002.

4.2 Epidemiological Emergency Service

No epidemiological emergency service existed in the late seventies, despite the fact that there had been occasions that called for prompt action (Küstner, 1980). As far as cholera is concerned, it was agreed during the 2001 outbreak to activate National and Provincial management structures to deal with an outbreak (DWAF, 2003). This management structure and the communication process involved is depicted in Fig 4.5.

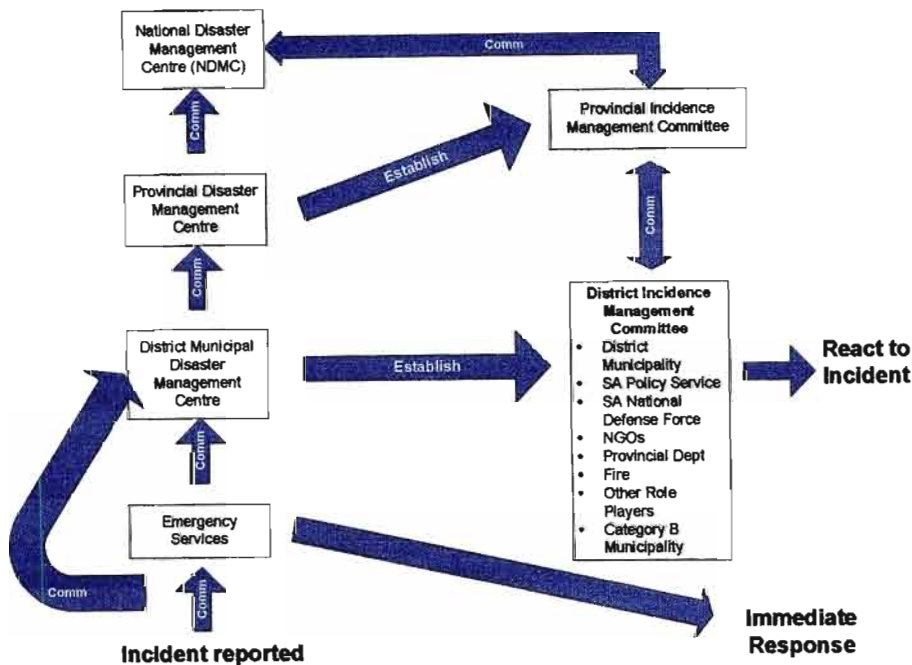


Figure 4.5: Cholera disaster management structure and communication and information flow (DWAF, 2003).

4.3 Risk Transition in Air Pollution

Another form of risk transition is the trend in environmental risks such as air pollution, which during economic development move from household level to community level to regional and then global level, with some overlapping at each level. In developing countries, environmental risks in poor communities mostly relate to poor quality of water, food and air at household level. Technological development causes these households to then also be exposed to risks at community level. For example if chimneys are installed, the spatial distribution of air pollution from domestic fuel burning increases to community level (with some overlapping of household/community) (Smith and Akhar, 2003).

When development moves towards urbanisation and industrialisation, communities would be exposed to air pollution from motor vehicles and industries, with some community/regional overlapping. The pollutants in the air thus change from those emitted by traditional fossil fuel burning to an increase in fine particulate matter (PM) and photochemical pollutants such as ozone (Brunekreef and Holgate, 2002). The next step would be regional/global overlapping when for example fine PM stays aloft long enough to travel between countries around the world (Smith and Akhar, 2003).

Occupants of large cities in developing countries are therefore exposed to both "traditional" and "modern" pollutants. This change in composition of air pollution may in turn change the toxicity potential of ambient air (Brunekreef and Holgate, 2002). In cities in India for example it was found that mean PM₁₀ concentrations were more than six times the mean (of about 30 µg/m³) found in cities in the US (Smith and Akhar, 2003).

It is estimated that worldwide 1.5 billion people currently live in polluted urban areas and that about 40% of all children in the world live in polluted cities in developing countries. It is further projected that by 2025, 65% of the world's population will live in cities (O'Neill et. al., 2003).

4.4 Summary Chapter 4

A country such as South Africa, that is less developed but that does have a developed aspect to it, has to cope with developed world as well as developing world problems. Over the past hundred years there was a definite transition in diseases globally, but also in South Africa. The epidemiology transition in South Africa was mostly from infectious diseases, of which many have been eliminated (such as smallpox) or reduced (such as meningococcus), to non-communicable diseases (such as cancer, diabetes and heart disease), of which the risk factors are, according to the WHO (2002) largely associated with lifestyle.

According to the South African Yearbook (2003/4), the most common communicable diseases currently in South Africa are TB, malaria, measles and sexually transmitted diseases.

From studies it is evident that there is a transition in mortality risk from mainly infectious diseases, perinatal and maternal causes in less developed countries to diseases of the circulatory system and an increase in cancer in more developed countries (Eaton, 2003). In South Africa the mortality profile

for 2000 in fact shows a quadruple burden of disease, since HIV/AIDS, chronic diseases, poverty-related conditions and injuries all contributed substantially. The leading causes of death were, after HIV/AIDS, which contributed 30%, cardiovascular diseases that contributed 17%, infectious diseases (10%), malignant neoplasms (8%) and injuries 12% (Bradshaw, *et. al.*, 2003).

The transition from infectious diseases to non-communicable diseases is mainly because of a change in lifestyle, with urbanisation, stress, increased living standards and the 'Western' diet - all contributing (MRC, 2002). The WHO (2002) warns that countries need to adopt control policies in order to improve global health and lower the burden of disease.

Another form of risk transition is the trend in environmental risks such as air pollution, which during economic development move from household level to community level to regional and then global level, with some overlapping at each level. Occupants of large cities in developing countries are therefore exposed to both "traditional" and "modern" pollutants. This change in composition of air pollution may in turn change the toxicity potential of ambient air (Brunekreef and Holgate, 2002).

CHAPTER FIVE

5.0 Methodology

5.1 Study design

The study is designed as an historical (retrospective) cohort study, also known as a follow-up study. A predetermined group of individuals identified from the VAPS study were followed using historical records. All the available questionnaires of the participating children that were in grade 5 (standard 3) and between 10 and 11 years old when the Vaal Triangle study commenced in 1990, were used to specify the study population. At this age, children normally do not yet smoke actively and they are still developing physiologically. The outcome (respiratory health status) was determined in the present and subsequently compared to the same individual's childhood respiratory health status (13 years ago).

The respiratory health status and the risk profile were characterised with self-administered questionnaires that were posted to individuals. The questionnaire served to collect data on demographics, socio-economic status, crowding, house characteristics, and sources of indoor pollution, smoking habits, respiratory health, allergies and perceptions on air pollution. Data on physical activity, dietary intake, and alcohol use were also collected. Afrikaans and English questionnaires were distributed according to the individual's choice.

The existing outdoor monitoring network in the area currently consists of stations managed by Eskom, Iskor and Sasol. Available data from this network were used to determine current air pollution concentrations for the area.

5.2 Study area

Historically known as the Vaal Triangle, the area extends from Randvaal in the north to Sasolburg in the southwest and Deneysville in the east, including the towns of Evaton, Sebokeng, Sharpville, Boipatong, Bophelong, Zamdela, Vereeniging, Vanderbijlpark, Sasolburg and Meyerton. The area is 3600 km² in size (Terblanche, 1998).

Currently the study area refers to District Councils 20 (Northern Free State) and 42 (Sedibeng), including the following District Municipalities:

- ⇒ GT 421 Emfuleni
- ⇒ GT 422 Midvaal
- ⇒ GT 423 Lesedi
- ⇒ FS 204 Metsimaholo.

The study area (Fig.5.1) houses several sources of air pollution, including heavy industries, refineries, a 3600 Mw power station, motor vehicles as well as an estimated 14 000 thousand households still utilising coal as an energy carrier (Scorgie, *et.al.*, 2003). Industrial development in the area already began as early as 1877 when coal reserves were discovered (Terblanche, 1998).

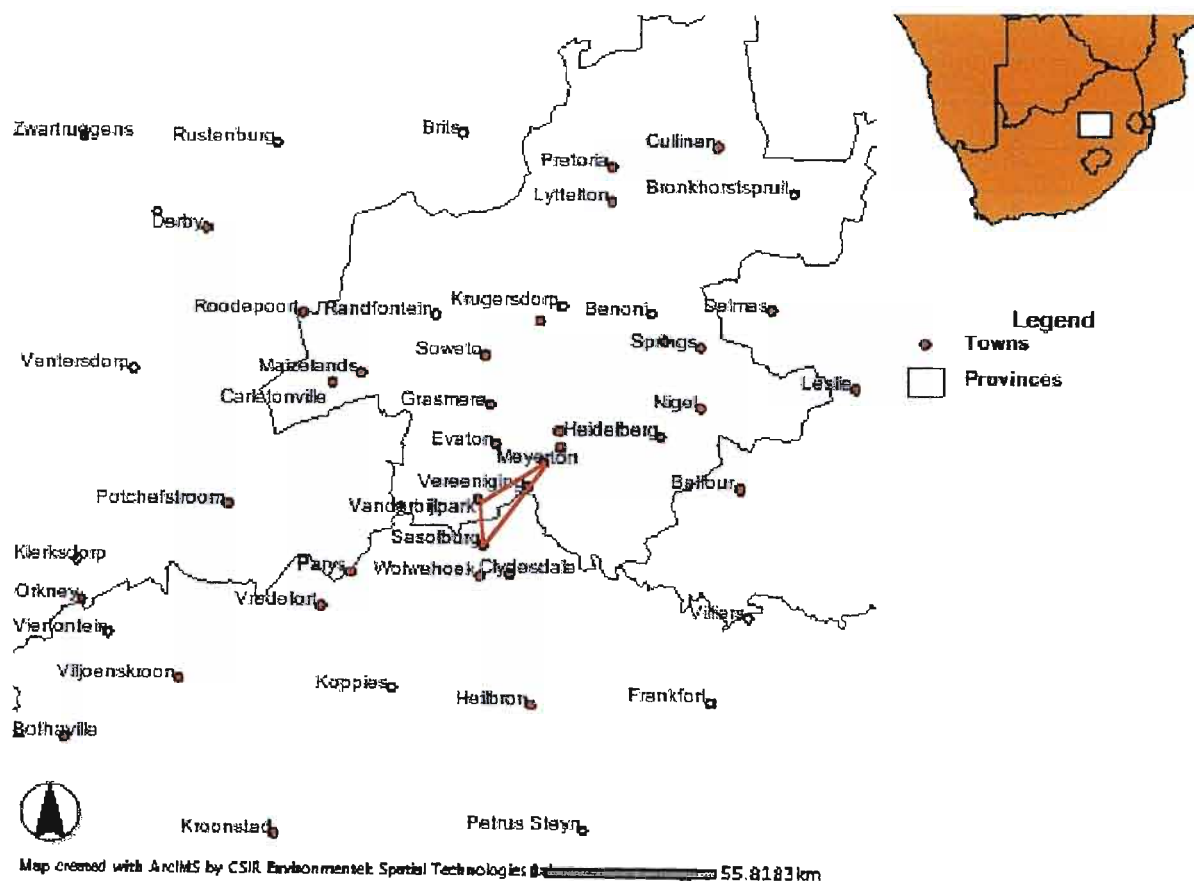


Figure 5.1: Map of the study area.

Climatology of the study area

The Vaal Triangle lies about 1500m above sea level within the Vaal River basin. The prevailing wind direction is north to northwest in summer and west

to southwest in winter. Topographically induced drainage flows on clear weather nights are easterly to south-easterly (Tosen *et. al.*, 1992).

Mean wind conditions in the area are dominated by the latitudinal position of the high- pressure (HP) system. This HP system is weakly developed in summer and displaces towards the southeast by the tropical low-pressure trough over the western interior. This situation then results in northerly airflow conditions (Tosen *et. al.*, 1992).

From April, the HP system strengthens; causing the summer northerly winds to change to westerly, while increasing in strength between April and September (Tosen *et. al.*, 1992).

Subsidence of the air (associated with an HP system) produces adiabatic warming, resulting in drying of the atmosphere as well as an increase in atmospheric stability. Most important though, is that conditions highly conducive to the formation of inversions (surface as well as elevated) are present as a result. Anticyclonic conditions dominate in the area between May and October (Tosen *et. al.*, 1992).

During winter, nocturnal surface inversions occur some 80% of the time, with a mean strength of 5°C and a mean depth of 300 m. During the day, heating and turbulence from below cause the stable boundary layer to develop. The mixing layer reaches a depth of about 1000 m in winter and about 3000 m in summer. The seasonal variation in depth of the mixing layer, together with the atmospheric stability, has a huge influence on the pollution dispersion potential of the area, and therefore on the ground level concentrations of pollutants (Tosen *et. al.*, 1992).

5.3 Study population

The original study population of 1686 young adults, consisted of individuals who participated as children in the VAPS study of 1990.

All the available questionnaires of the participating children that were in grade 5 (standard 3) and between 10 and 11 years old when the Vaal Triangle study commenced in 1990, were used to specify the study population. At this age, children normally do not yet smoke actively and they are still developing physiologically.

"Reliable" (1991) demographic information for the 1686 individuals was used to obtain the final study population.

5.4 Sampling strategy

Sampling is used to study a subgroup of a population, while being able to generalise to the whole population. A large sample size will give reliable results although an unnecessarily large sample is a waste and may not be practically feasible. If the sample is too small, results might not be conclusive or useful (Joubert and Katzenellenbogen, 1997).

In this study, calculation of a sample size is not relevant since it is a follow-up study, which means that there is no control over the study population.

The ideal would be to send questionnaires to all individuals for whom addresses for 1991 were available (1686), so as to aim for a 100% sample. However, this was not possible due to budget constraints and the possibility that people have left the area due to known retrenchments over the past 13 years.

It was therefore decided to first conduct a pilot study in which every 17th individual (10% sample) on the list was contacted by phone, to determine the success rate of tracking down the original population.

While conducting the pilot study, it was found that some individuals did not supply telephone numbers on the original questionnaires, supposedly because they either did not have a telephone or did not want to be contacted. Others apparently moved out of the area as the number now either belonged to somebody else or the ringing tone indicated that the number no longer existed.

In the case of Vereeniging, most numbers changed completely instead of only obtaining an extra number as in the case of the other towns. In these cases, the numbers were traced using the latest telephone directory and the available surname and street address.

As a result of the low (33%) success rate, it was finally decided to phone every individual on the list (1686), so as to aim for the best sample size possible.

Eighty-three of the 1686 individuals did not provide a telephone number on the original questionnaire, and therefore could not be located. A further 456 no longer lived in the same residence and could not be located. Five hundred and ninety five telephone numbers no longer existed and these individuals could also not be located. Despite several attempts, both during the day and

during evening, there was no reply at 117 of the numbers. A total of 435 of the original study population had now been located. Six of these had died of unnatural causes, 23 were working overseas without a permanent address and two individuals refused to participate in the study. Questionnaires were subsequently sent to the remaining 404 individuals. This constitutes 23.96% of the original 1686 individuals on the list. The final selection of the study population as described above is depicted in Fig. 5.2.

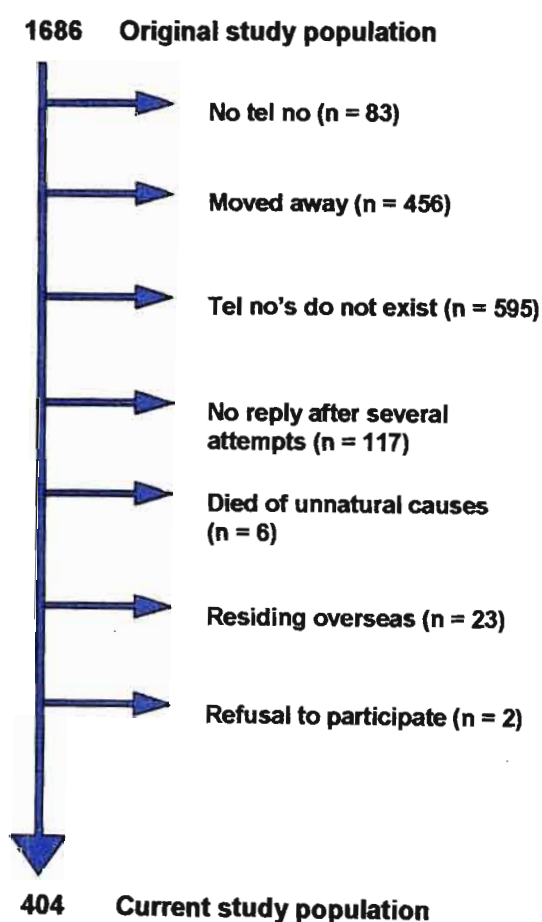


Figure 5.2: Selection process of the study population.

The University Ethics Committee approved the study on 9 September 2003. Questionnaires were sent to 404 individuals by 25 September 2003. By end October 2003, 101 completed questionnaires (25%) were received and by end November 2003 one hundred and forty five (36%). At the beginning of December 2003 it was decided to again telephone those individuals who had not yet responded. Two percent (7/404) said that they did return the questionnaires but those were never received. Three percent (13/404) moved overseas in the mean time, two percent (9/404) moved and could not be located, while the telephone numbers of another 2% (10/404) no longer exist

and despite several attempts, there was no reply at 3 (1%) of the remaining numbers. Ten percent (42/404) did not receive their questionnaires and it was decided to resend and give them time until middle January 2004 to respond. By 16 February 2004, 184 (46%) of the questionnaires had been returned. A total of 10% (39/404) of questionnaires had been returned after individuals were reminded to do so. A decision was made that this sample size was sufficient to proceed with the study.

5.5 Data Collection

Data can be collected by one of the following:

- ⇒ Monitoring or measurements using instrumentation
- ⇒ Questioning by an interviewer or the individual can fill out a questionnaire
- ⇒ Using records, for example clinical records
- ⇒ Observation by another human being.

This study made use of self-administered questionnaires. The questionnaire used was based on several other questionnaires used in epidemiological studies on respiratory diseases. These are the ATS-DLD-78-A questionnaire, used for respondents of 13 or more years of age (Ferris, 1978), the Canadian Air Quality and Health Study questionnaire (NHW/HPB-190-03040), the Harvard School of Public Health's Children's Health Study Questionnaire (NHW/HPB-190-03210) and the Vaal Triangle Air Pollution and Health Study questionnaire. All of these questionnaires have been extensively tested and reviewed by a large body of experts. An example of the questionnaire used is attached as Appendix A.

Steps taken in compiling the questionnaire:

- ⇒ The variables, based on the study objectives, were listed.
- ⇒ It was decided to use a mix of open –ended and closed questions but to keep to closed questions as far as possible.
- ⇒ Layout and design was kept simple to make it legible and save on costs.

Pilot Study

- ⇒ A pilot study ran on the questionnaires aimed to improve its quality.
- ⇒ The questionnaires were tested against a group similar to the target population, and 12 individuals participated in the pilot study.
- ⇒ Notes were taken on anything that was not clear in the questionnaire.
- ⇒ Respondents were asked about how the questionnaire made him/her feels and how they felt about questions asked in that way.
- ⇒ The necessary changes to the questionnaires were then made.

5.6 Data Management

Analysis of data by computer is not only the most accurate way but also the quickest. Two independent data encoders did double entry of questionnaires into the computer. Data entry checks were used to determine the percentage error. Data capturing was done using Epi Info. A bio-statistician was consulted during sample selection and again during data analysis. Data were analysed using Stata Release 8.0, statistical software. Stata is extremely powerful in its survey and epidemiological commands.

5.6.1 Quality of data

The most reliable information was ensured through self-administered questionnaires. The principal investigator coded questionnaires received, where after two independent data encoders conducted double data entry.

5.6.2 Missing data

Fields not completed in questionnaires were treated as missing in the data analyses.

5.6.3 Reliability of data

Administering the questionnaire in the participant's preferred language enhanced reliability of data

5.6.4 Validity of data

This study made use of self-administered questionnaires. The questionnaire used was based on several other questionnaires used in epidemiological studies on respiratory diseases. These are the ATS-DLD-78-A questionnaire, used for respondents of 13 or more years of age (Ferris, 1978), the Canadian Air Quality and Health Study questionnaire (NHW/HPB-190-03040), the Harvard School of Public Health's Children's Health Study Questionnaire (NHW/HPB-190-03210) and the Vaal Triangle Air Pollution and Health Study questionnaire. All of these questionnaires have been extensively tested and reviewed by a large body of experts.

5.7 Statistical analysis

The data collected by questionnaire are categorical (nominal/ordinal) in nature and were summarised by means of frequencies, percentages and cross-tabulations. At a univariate level the data from 1990 were compared with that of 2003 by employing McNemer's test for symmetry, while for 2003 outcome variables (upper respiratory and lower respiratory variables) were tested for association with demographic/risk/environmental factors using Pearson's chi-square test or, when applicable, Fisher's exact test. The crude (unadjusted) odd ratios (ORs) along with their 95% confidence intervals were also found. Following the within 2003 analyses demographic/risk/environmental factors "significant" at a 0.20 level of significance, were studied in a multivariate data analysis using logistic regression.

5.8 Ethical Aspects

The Nuremberg trials highlighted abuses suffered by prisoners at the hands of Nazi doctors during World War II. This led to the Nuremberg Code of 1947 and the Declaration of Helsinki, which was adopted by the World Medical Association in 1964. Voluntary informed consent is now considered a requirement and independent ethical reviews of studies further ensure that research is ethically sound (IJsselmuiden, 1997). In this study the following ethical steps were taken:

- ⇒ Only competent adults were included.
- ⇒ Participants were informed as to:
 - ▶ The purpose of the study
 - ▶ How the participant will be treated
 - ▶ The potential risks the participant may face.
- ⇒ Participation in the study was on a voluntary basis.
- ⇒ Care was taken that participants understood the information questionnaires were available in more than one language).
- ⇒ Written informed consent was asked from voluntary participants (Appendix A).
- ⇒ Measures were taken to ensure that individuals couldn't be identified from study results.
- ⇒ The study is seen as a replication and not a mere duplication of research done elsewhere.
- ⇒ Absolute independence between researcher and sponsorship for the study was ensured. Sponsors had no role in the study design, data collection and interpretation or in the writing of the report.

⇒ Information gained in the study will not only be published in peer-reviewed journals but feedback will also be given to communities and relevant government departments.

Ethical approval

The Higher Degrees Committee as well as the Research Ethics Committee of the Nelson R Mandela School of Medicine at the University of Natal approved the study (H 104/03).

5.9 Limitations of the study

Possible limitations of the study sample could be that only volunteers whose parent's addresses were unchanged since 1990 could be contacted. Since the 1990 participants could not all be located, sample size was limited, e.g. 404 of the 1686 individuals were located and 184 of these responded.

The ideal would have been to send questionnaires to all individuals for whom demographic data for 1991 were available (1686), to aim for a 100% sample. However, this was not possible due to relocation during the past 13 years of the parents of potential participants.

Only those individuals whose parents remained either at the same street address in the Vaal Triangle or had the same telephone number could be contacted via telephone.

In this study there was no control over the sample size. The original sample of 1990-91 became the sample space for the current study and the study sample now constitutes responders only, which brings about its own limitations, for example the relatively small study population caused some estimated confidence intervals to be wide.

Disadvantages of a postal questionnaire are that they will be completed by untrained individuals, therefore questions have to be very clear and well laid out, the response rate is generally low, it is difficult to assess who completed a postal questionnaire, and individuals may experience difficulty in completing the questionnaire, resulting in poor quality data.

When comparing 1990 data to 2003 data it is possible that marginally significant results could have yielded a different result in a bigger follow-up sample.

CHAPTER SIX

6.0 Results

The results of the study will be divided into sections as follows:

- ⇒ Demographic and descriptive statistics of the study population
- ⇒ Living conditions of the study population
- ⇒ Lifestyle of the study population
- ⇒ Health status of the study population
 - ▶ *General health status*
 - ▶ *Prevalence of allergies*
 - ▶ *Prevalence of upper respiratory diseases*
 - ▶ *Prevalence of lower respiratory diseases*
 - ▶ *Other*
- ⇒ Education and social status of the study population
- ⇒ Personal perceptions of the study population

6.1 Demographic and descriptive statistics of the study population

One hundred and eighty four individuals responded by sending their completed questionnaires back. Sixty percent (110/184) of the study population were female and 40% (74/184) were male. Afrikaans is the home language of 89% (163/184) of the study population, English that of 10% (19/184) and 1% (2/184) reported their home language as "other", of whom one individual specified it as German.

Figures 6.1 and 6.2 show the demographic distribution of the study population in 1990 and 2003 respectively. It is evident from these figures that the majority (63%) of the population still resides in the Vaal Triangle. Thirty nine percent (71/184) of the study population indicated that they still lived in the town where they were borne.

Fig 6.2 further shows that the majority of the individuals, who have left the Vaal Triangle to reside elsewhere, settled in Pretoria (30%) and

Johannesburg (15%). Of those who had left the area, 98% still visit the Vaal Triangle. Most (69%) of them visit for 30 days or more per year.

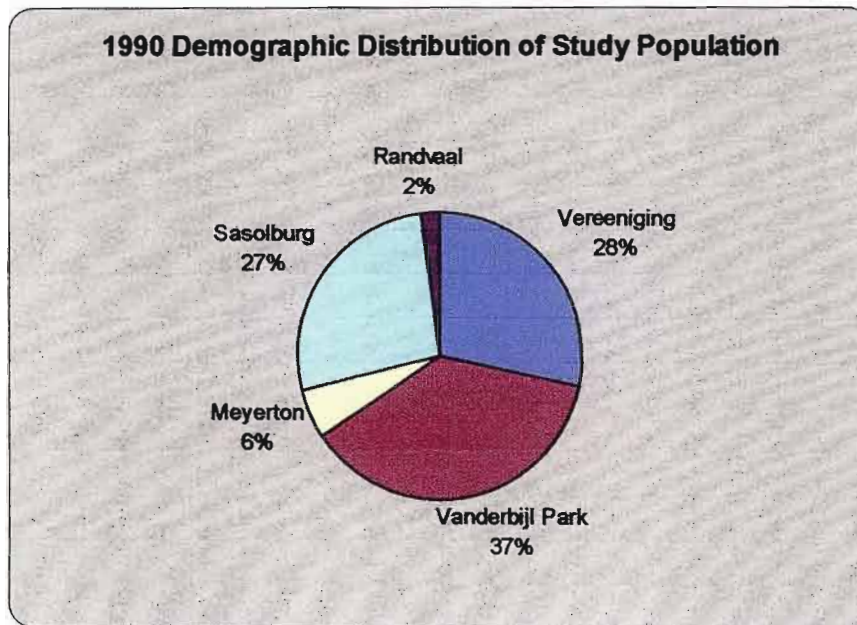


Figure 6.1: Demographic distribution of the study population in 1990.

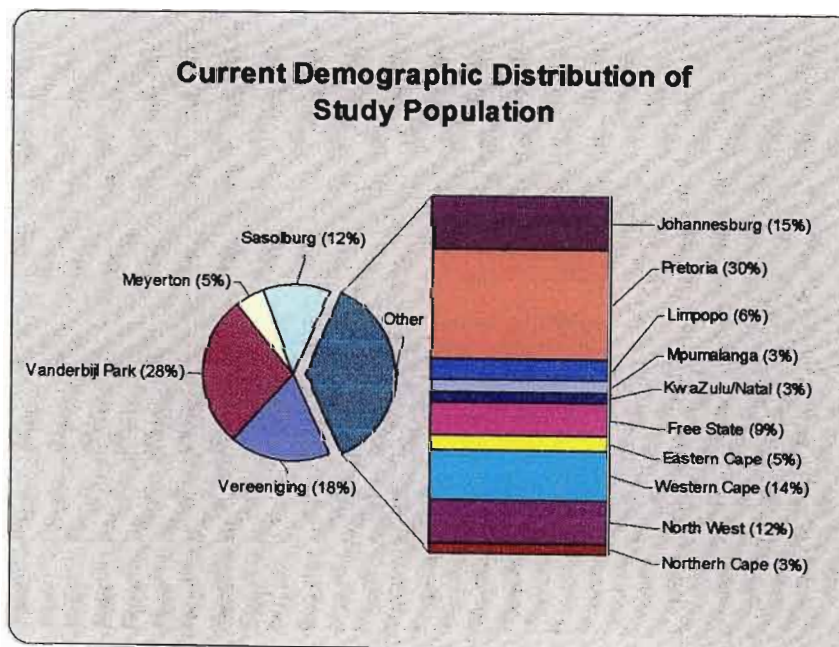


Figure 6.2: Demographic distribution of the study population in 2003.

6.2 Living conditions of the study population

6.2.1 Houses

Sixty nine percent of respondents (121/175) indicated that they live in single-family houses not attached to other houses while 13% (23/175) live in flats. Most (75% (136/181)) of the individuals live in a residence with 3 or more bedrooms. In 1990, 95% (172/181) lived in single-family houses and only 0.5% (1/181) lived in a flat. The reason for this phenomenon is most probably that in 1990 the children were living with their parents while now as young adults, they have begun to start living on their own and usually the first step is to move into a flat. None of the respondents live in informal or pre-fabricated houses.

People inside houses are considered to be exposed to more or less the same pollutant concentrations as is in ambient air since 91% (167/184) of respondents indicated that they open windows and doors on a regular basis and 67% (124/184) on a daily basis, even during winter months.

6.2.2 Water and energy sources

It is evident from figure 6.3 that the majority (93% or 170/182) of the respondents rely on municipal water for domestic use, which decreases the risk for water-borne diseases. This figure shows no change compared with the 1990 data, where 92% of households used municipal water. Seventeen percent have access to private borehole water as well, which in most cases could be considered safer than surface water. Figure 6.3 further shows that electricity is used by 97% (176/182) of the households for cooking purposes, which again represents a no change compared with 1990 data (when 179/184 or 97% used electricity for cooking).

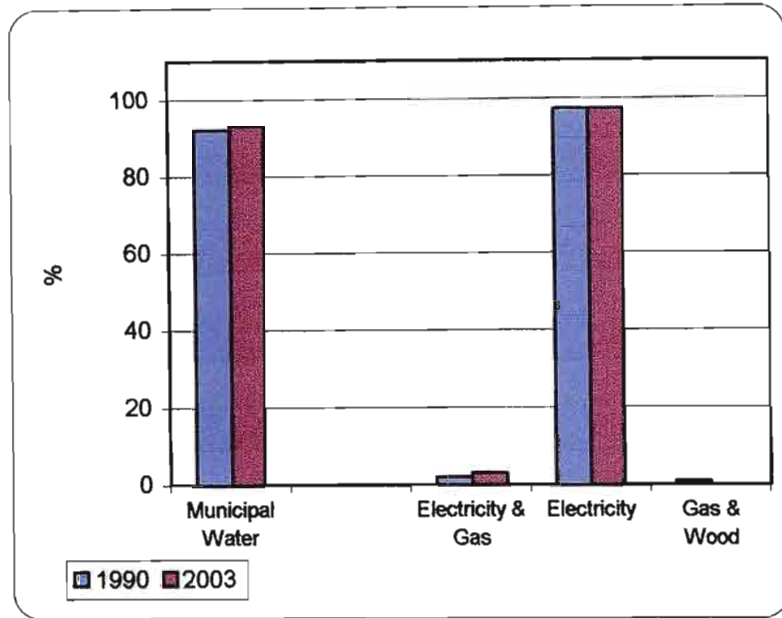


Figure 6.3: Sources of water and sources of fuel for cooking in 1990 and 2003.

Figure 6.4 shows that there was a marked difference in the choice of apparatus used for space heating. In 1990, many (46%) households used asbestos heaters as they were considered a cost-effective heating mechanism. In 2003 only 10% (17/171) of respondents indicated that they used asbestos heaters. Possible reasons for this phenomenon could be that people are more aware of the dangers of asbestos exposure. In addition, asbestos heaters are no longer sold in South Africa. The preferred choice of apparatus for space heating in 2003 was electric heaters (56%), followed by gas heaters (13%).

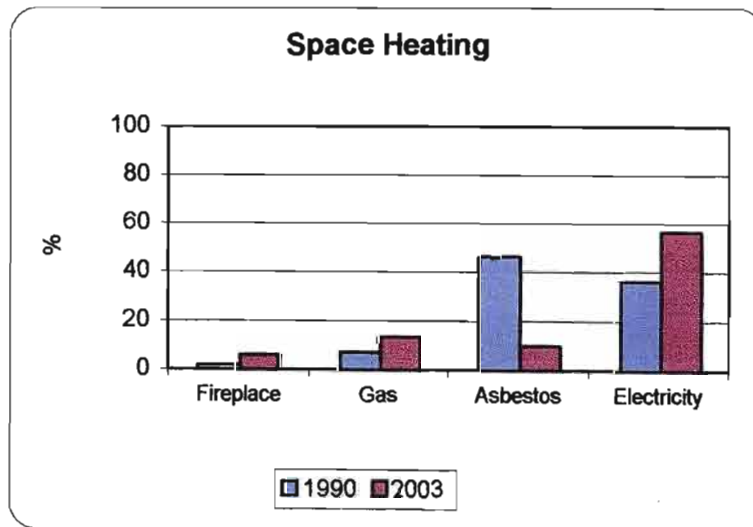


Figure 6.4: Apparatus used for space heating in 1990 and 2003.

Figure 6.5 shows that fewer people were using humidifiers and air cleaners in 2003 than in 1990. In the early nineties, many, as a way of decreasing indoor air pollution, perceived air cleaners to be the solution. At the same time humidifiers were also in fashion and many believed they had a positive effect on respiratory diseases. One of the reasons for the increase in the use of air conditioners in 2003 compared with 1990 (from 2% to 6%) could be that respondents now live in areas where, because of climatic conditions, air conditioners are essential, for example Northern Cape and KwaZulu Natal.

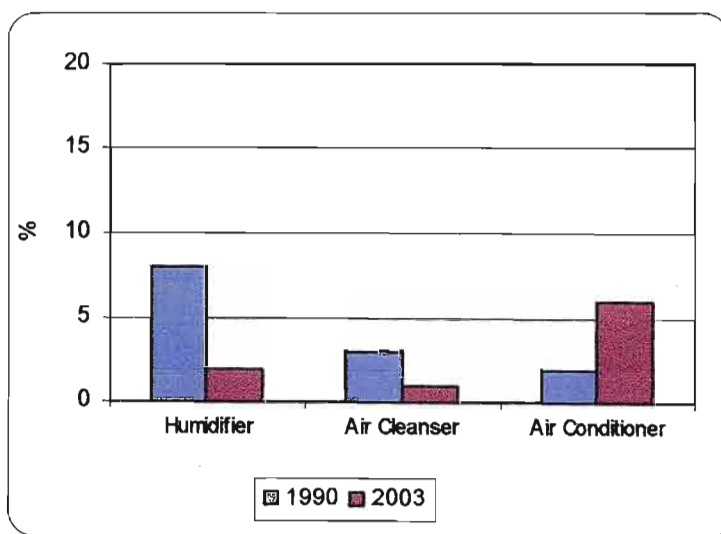


Figure 6.5: Apparatus used inside houses in 1990 and 2003.

6.23 Indoor pollution sources

Seventy percent (113/161) of respondents live in houses where pets are allowed inside. This is an increase compared to the 66% (119/181) of 1990, although not statistically significant ($p=0.216$) (Figure 6.6). Dogs are the most popular pet, with 82% (122/149) of respondents having a dog as a pet. The second most popular pets are cats (45%), followed by birds (43%).

Also shown in Figure 6.6 are the percentage households with mould growing inside the house. During the 1990 survey this figure was 14% (23/170) but in 2003 it increased to 34% (58/170), which is a statistically significant increase ($p<0.001$). It is believed that this increase is due to the increased popularity of showers. Showers usually have a mould problem. In 1990, 10% of respondents reported having mould growing inside showers and 2% elsewhere in the house. In 2003, 29% of respondents reported having mould

growing inside showers and 7% elsewhere in the house. The extent of the mould growth is not known as no questions were asked in this regard.

Another factor that could have an effect on indoor air pollution (besides pets and mould inside the house) is tobacco smoking. From Figure 6.6 it is evident that there was a decrease, although not statistically significant ($p=0.096$), in smoking inside houses from 1990, when 40% of households reported having smokers who smoke inside the house to 2003 when 33% of the households reported having individuals in the household who smoke inside the house.

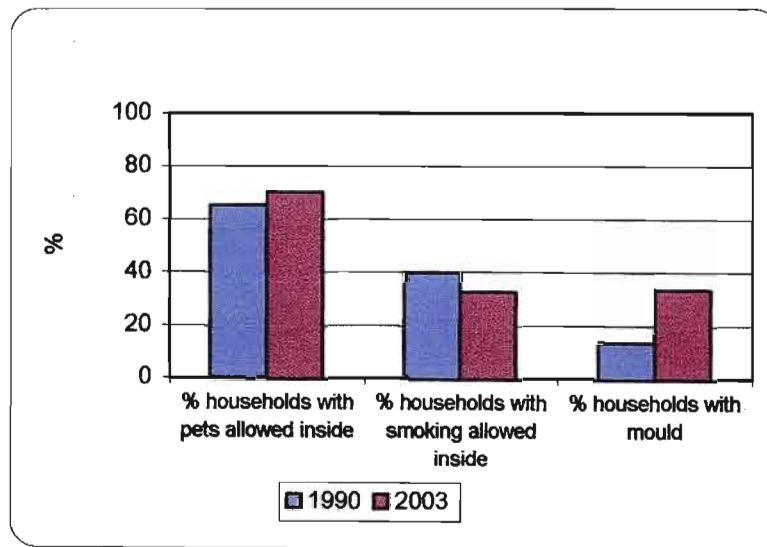


Figure 6.6: Pets, smoking and mould inside houses 1990 and 2003.

6.3 Lifestyle of the study population

6.3.1 Hobbies

Only 38% of respondents exercise any form of hobby. The most popular hobbies were painting (10%), woodwork (8.4%) and working on cars (mechanical/electrical) (8.33%).

6.3.2 Sport

As far as general activities are concerned, walking was found to be the most popular, with 56% (92/165) of respondents participating in this form of exercise, followed by exercising with weights (31% or 53/170), swimming (25% or 41/161), jogging (23% or 38/162) and aerobics (17% or 27/158). Group sport such as soccer, rugby and netball are played by 9% (14/160) of respondents. Amongst those respondents (34) who indicated that they

respondents. Amongst those respondents (34) who indicated that they participate in "other" forms of exercise or sport, cycling was the most popular (35%) followed by squash or tennis (18%) and then golf (12%).

Dancing, rowing, yoga and mountaineering were under the less common forms of exercise, where only 1 or at the most 2 individuals each perform these forms of exercise.

6.3.3 Eating and drinking habits

Chicken and/or fish are more popular than red meat, with 97% (176/182) of respondents having chicken on a regular (at least once a week) basis, while 88% (160/181) have red meat on a regular basis. Processed food is less popular, with 44% (78/177) of respondents having this on a regular basis. Fruit (84% or 153/182) and vegetables (93% or 172/184) are eaten on a regular basis by most of the respondents.

As far as fried food is concerned, it is evident that 97% (178/184) of respondents use oil to fry food. Of these, 10% (17/178) do so on a daily basis, 45% (80/178) on a weekly basis and another 45% (81/178) only occasionally. Sunflower oil is the preferred choice (66% or 88/134) for frying of food, while 31% (41/134) used olive oil. The rest use butter or margarine.

Sixty seven percent (123/184) of respondents consumed alcohol. The majority (85% or 109/128) of them less than seven drinks per week. The 1998 prevalence of alcohol consumption in South Africa amongst men between 15 and 24 years of age was 23% and amongst women for the same age group, 9% (thus 16% on average for both sex groups) (SADHS, 1998). The prevalence of alcohol consumption amongst the study population is thus higher than the average for South Africa when considering the same age group.

6.3.4 Smoking habits

Twenty seven percent (46/168) of respondents are currently smoking, while 12% (20/168) have stopped smoking and 61% (102/168) have never smoked. The 1998 prevalence of smoking in South Africa amongst men between 15 and 24 years of age was 24% and amongst women for the same age group, 6% (thus 15% on average for both sex groups) (SADHS, 1998). The prevalence of smoking amongst the study population is thus higher than the average for South Africa when considering the same age group.

Figure 6.7 depicts the age of the study population at onset of smoking. Only one individual reported starting at ten years old. There are 4 clear peaks; one at age 14 (at high school entry), one at 16 (grade 10), one at 18 (school leaving age) and one at 21 (coming of age).

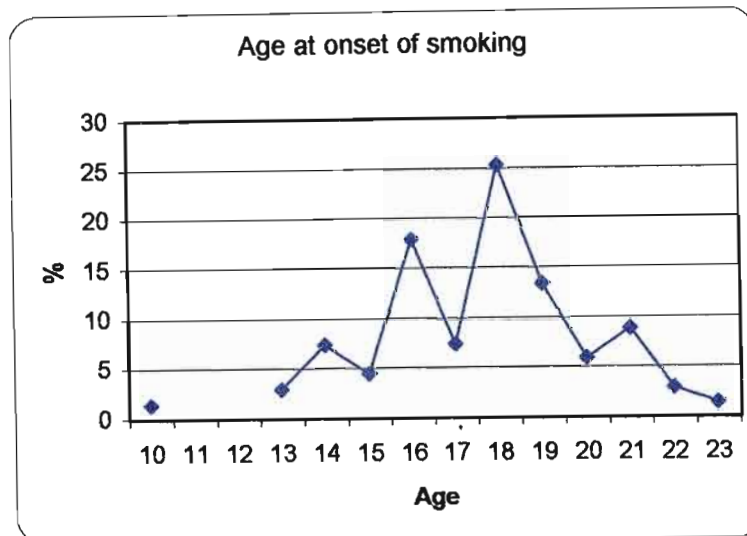


Figure 6.7: Age of study population at onset of smoking.

6.4 Health status of the study population

6.4.1 General health status

Forty four percent (81/183) of respondents felt that their health status compared excellently with others of the same age group, 55% (100/183) felt theirs compared well, while 1% (2/183) felt that they have a poor health status compared to others of the same age group. During the 1990 survey, 61% (113/184) of the parents felt that their children's health compared excellently with others of the same age group, while 39% (71/184) felt theirs compared well.

Only 6% (10/161) of respondents were absent from work or activities for one or more days during the **2 weeks** preceding completion of the questionnaire (6 of them for one day only). In 1990, 8% (14/161) were absent for one or more days preceding completion of the questionnaire; 10 of them for one day only.

Sixty six percent (100/179) of respondents were absent from their work or activities during the **12 months (year)** preceding completion of the

questionnaire. Eighty one percent of these were absent for 1–5 days only. (During the 1990 survey, 48% (88/184) were absent for one or more days, 95% of them for 1-5 days) If it is assumed that most people work 5 days a week and 50 weeks a year (2 weeks normally taken as leave) it adds to 250 days per year. Should an individual be absent for 5 of these days (2% of the time), it is considerably less than the 40 days per year (120 days in a three year cycle) sick leave that most workers are allowed by law.

The main reasons for absenteeism in 2003 were given as flu (44% or 52/119), followed by lower respiratory diseases (15%) such as bronchitis, pneumonia and asthma. Gastro-intestinal disorders accounted for 12% (14/119) of the absenteeism rate. Eight percent were absent as a result of sinusitis and the rest were absent due to illnesses that varied from migraine (3%), surgery (3%), accidents (1%) and kidney stones (0,8%) to hangovers (0,8%).

The reasons for absenteeism during 1990 followed the same trend, with flu (44% or 39/89), lower respiratory infections (17% 15/89) and gastro-intestinal disorders (12% or 11/89) mentioned as the main ailments.

6.4.2 Prevalence of allergies

Figure 6.8 shows that as far as allergies are concerned, 63% (112/178) of respondents indicated that they do not have any allergies. Twelve percent (22/178) of allergic individuals diagnosed their own allergies, while the allergies of 24% (43/178) were diagnosed by a doctor and one individual was not sure who had diagnosed his/her allergy. The prevalence of allergies amongst the study population in 2003 was thus 37% (66/178).

During the 1990 survey 5% (10/182) of respondents indicated that their children's allergies were self-diagnosed (by parents) and 22% (40/182) indicated that the diagnosis was made by a physician (Fig. 6.8). Seven percent (12/182) of the respondents were not sure whether their children were allergic to something or not. The "diagnosed" prevalence of allergies in 1990 was thus 27% (50/182).

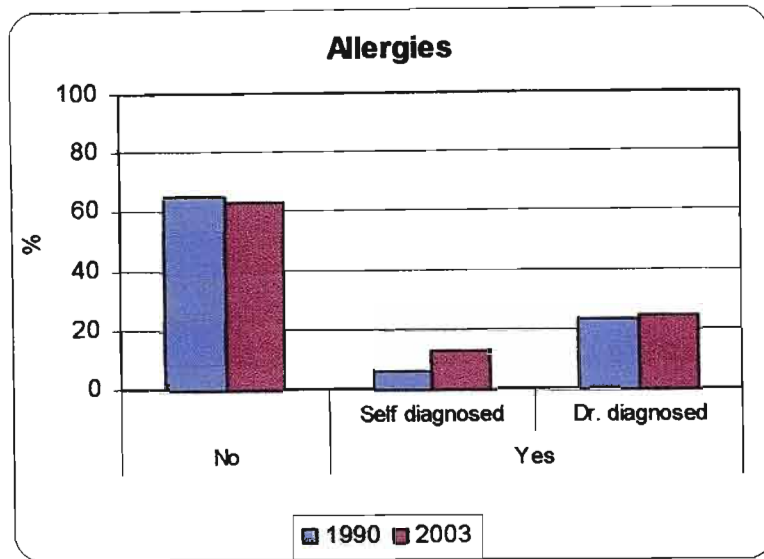


Figure 6.8: Prevalence of allergies in study population for 1990 and 2003.

When the same individuals for 1990 and 2003 are compared as far as their consumption of medication for allergies are concerned, it is evident that although a smaller number of those individuals (33% versus 42%) currently take medication for their allergies, more (17% versus 11%) are now taking it on a daily basis (Fig. 6.9).

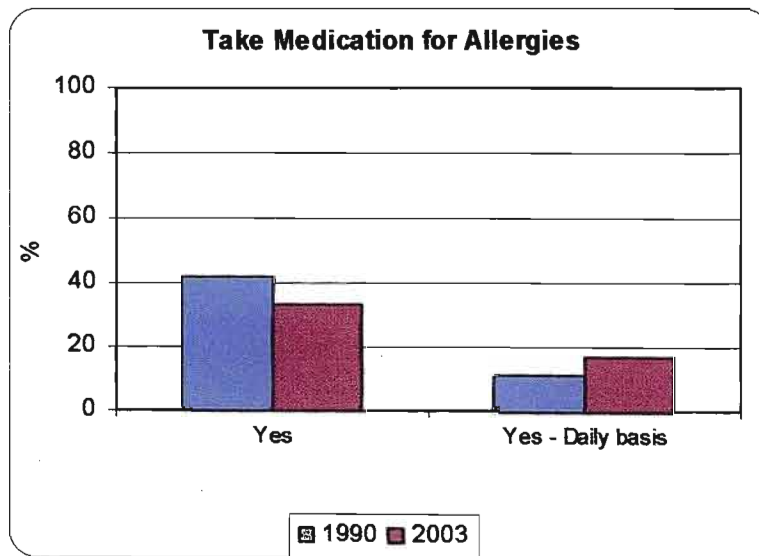


Figure 6.9: Study population's consumption of medication for allergies.

6.4.3 Prevalence of upper respiratory diseases

In this study, the current (adulthood) upper respiratory health status of all individuals in the study population was compared to that in their childhood.

Figure 6.10 depicts the prevalence of upper respiratory illness in the study population for 1990 and 2003. The prevalence of upper respiratory illness (URI) was determined by a “yes” answer to either of the questions on having had sinusitis, hay fever or earache during the year preceding the survey. Seventy two percent (124/173) of respondents answered “yes” to either of the aforementioned questions. The prevalence of URI during the 2003 survey was therefore 72%. Fifty nine percent (104/177) of respondents had sinusitis during the year preceding the 2003 survey, while 48% (86/178) had hay fever and 36% (62/174) earache. When comparing these results with those from 1990, the following became evident: The prevalence of URI as compared to 72% in 2003, was 68%. Forty percent (68/172) had sinusitis ($p < 0.001$), 27% (46/173) had hay fever ($p = 0.001$) and 37% (62/169) earache ($p = 0.811$).

A runny nose was considered to be an indication of an allergic reaction and therefore not included as an indicator of upper respiratory infection. There was however an increase (76 versus 69%) in the prevalence of “runny nose” compared with 1990 data ($p = 0.112$).

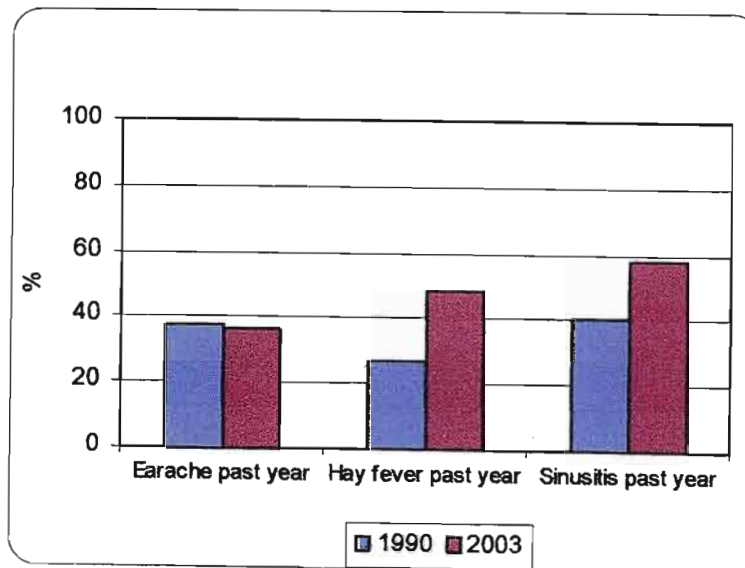


Figure 6.10: Prevalence of upper respiratory symptoms in study population during 1990 and 2003.

Seventy percent (125/179) of respondents answered positive to the question of **ever** having had sinusitis, compared to 43% (75/177) in 1990. Sixty percent (104/174) ever had earache compared to 54% (96/178) in 1990 and 59% (105/178) had hay fever compared to the 28% (50/176) in 1990. It must be noted however that these individuals are now 13 years older and the possibility of having had one of the aforementioned would have therefore increased.

6.4.4 Prevalence of lower respiratory diseases

In this study the adulthood (2003) lower respiratory health status of all the individuals in the study population was compared to their childhood (1990) lower respiratory health status.

Figure 6.11 depicts the prevalence of lower respiratory illness in the study population for 1990 and 2003. Should the prevalence of lower respiratory illness (LRI) be determined by a “yes” answer to either having had bronchitis, pneumonia or asthma during the past year, then the current prevalence of LRI is 24 %, since 24% (41/169) of respondents answered “yes” to either of the aforementioned questions. During the 1990 survey, this figure was 19% (32/169). Eighteen percent (32/174) of respondents had bronchitis during the year preceding the 2003 survey. During the 1990 survey, this figure was 14% (25/178) ($p = 0.343$). Four percent (7/172) had pneumonia (compared to the 0% of 1990) ($p = 0.008$). Eight percent (13/173) had asthma compared to the 4% (8/179) of 1990 ($p = 0.034$).

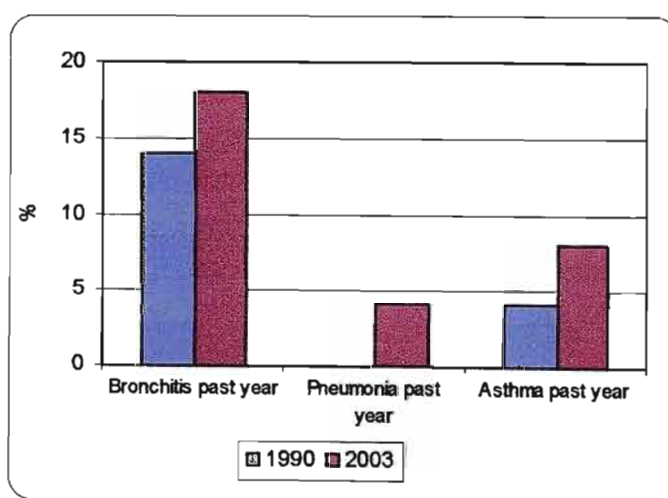


Figure 6.11: Prevalence of lower respiratory symptoms in study population during 1990 and 2004.

On the question whether they have **ever** had bronchitis, 46% (82/178) of respondents answered positively, compared to 33% (58/176) in 1990. Nineteen percent (33/172) ever had pneumonia compared to 7% (12/176) in 1990 and 7% (12/167) chronic bronchitis, compared to 3% (5/176) in 1990. Again it must be noted that these individuals are now 13 years older and the possibility of having had one of the aforementioned would have therefore increased.

Asthma

The percentage of the study population **ever** diagnosed (by a doctor) with asthma is depicted in Figure 6.12

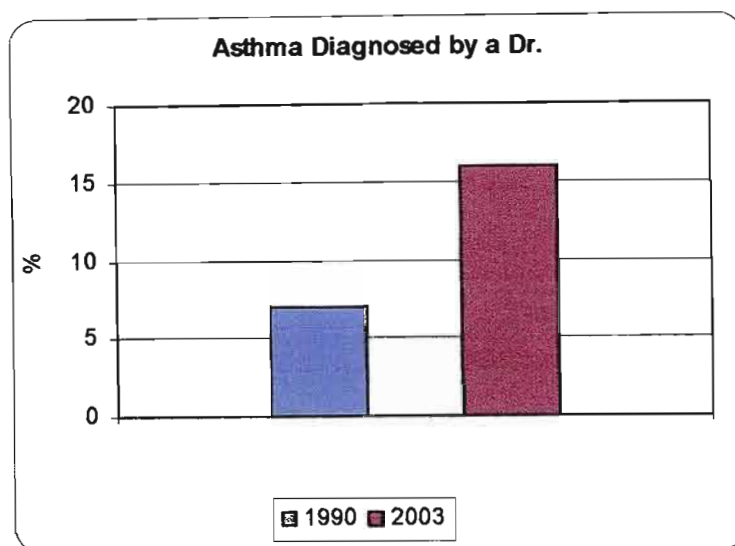


Figure 6.12: Percentage of study population ever diagnosed with asthma.

It is evident from Fig.6.12 that during the 1990 survey, the parents indicated that 7% (12/181) of the study population had been diagnosed with asthma at some stage in their lives of 10 years. At that stage (1990), eight individuals were still suffering from asthma and all but one (88%) was taking medication for the condition. The prevalence of asthma amongst the study population in 1990 was thus 4% (8/181).

During the 2003 survey 16 % (29/181) of respondents indicated that they had been diagnosed with asthma at some stage in their lives. Of these, 45% (13/29) indicated that they were diagnosed before 10 years of age, 10% (3/29) cannot remember when they were diagnosed and another 45% (13/29) were diagnosed after the age of ten years old. (The Tucson study found an annual increase in the prevalence of asthma until the age of 16 (Taussig, *et. al.*, 2003). Twenty five percent (4/16) of individuals who have at least one parent

who has been diagnosed with asthma, have already been diagnosed with asthma themselves by the age of 10 years old and were, at the age of 23 still suffering from asthma.

Fifty two percent (15/29) of those ever being diagnosed, still suffer from asthma. The current prevalence of asthma in the study population is therefore 8% (15/181). The prevalence of asthma in the South African adult (age 15+) population is 7% for men and 9% for women, thus an average of 8% (SADHS, 1998). Two respondents were unsure whether they still get asthma or not but 16 individuals responded to the question on the frequency of attacks.

Of the respondents who have indicated that they still suffer from asthma, 31% (5/16) indicated they have attacks on a weekly basis, 13% (2/16) on a monthly basis and 56% (9/16) only occasionally. Seventy three percent of asthma sufferers (11/15) took medication for the condition (compared to the 88% in 1990). Considering all respondents, then only 0.6% (11/181) was on asthma medication during the 2003 survey. This figure is lower than the average of 1.8% for the South African adult population (SADHS, 1998).

Figure 6.13 shows that the prevalence of asthma attacks amongst asthmatics during the 1990 survey was highest during the months, June to September, with a peak of 50% in August. The 2003 survey shows that the prevalence of attacks increases from April/May already and stays relatively high until October. From May to September the prevalence of attacks remains between 65 and 70%.

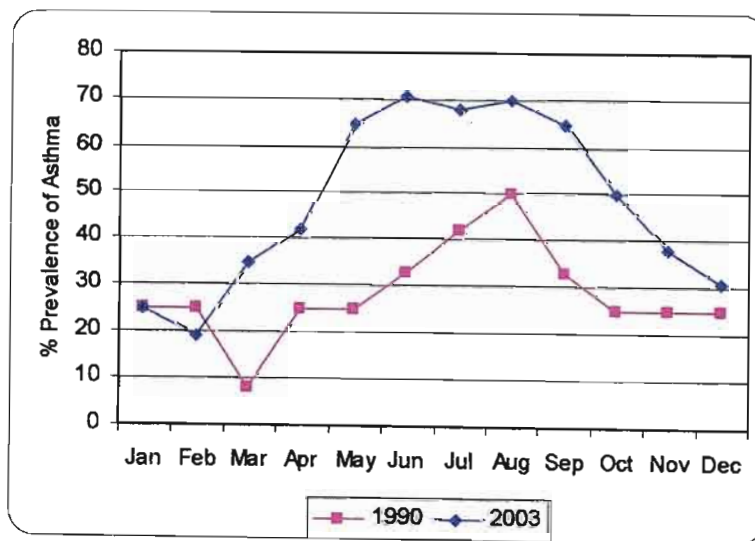


Figure 6.13: Monthly prevalence of asthma attacks for 1990 and 2003.

Figure 6.14 shows that the monthly prevalence of having a wheezy chest without a cold, follows more or less the same pattern as asthma attacks.

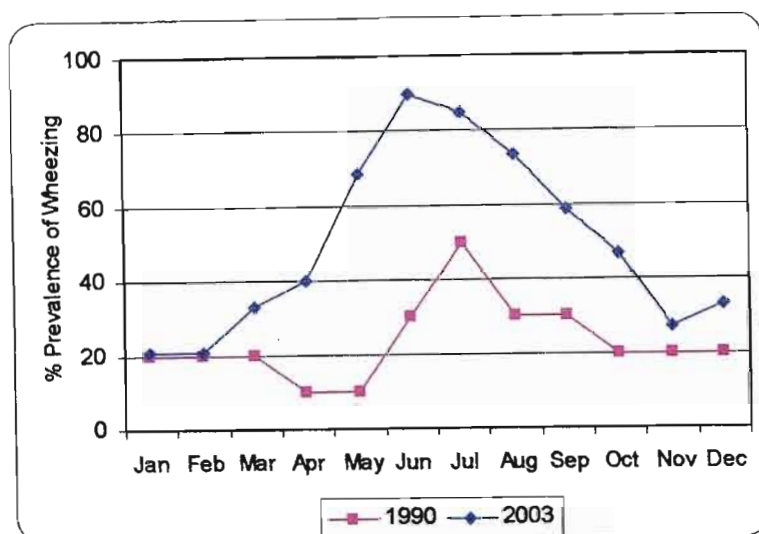


Figure 6.14: Monthly prevalence of attacks of wheezing without a cold for 1990 and 2003.

6.4.5 Statistical analysis of risk factors associated with URI and LRI in 2003

6.4.5.1 Univariate risk factor analysis

6.4.5.1.1 Risk factors investigated

All upper and lower respiratory risk factors investigated in the univariate analysis are summarised in Appendix B. The exposed category (in brackets) was considered relative to the reference category, for example for sex, male was exposure and female reference.

6.4.5.1.2 Risk factors that were statistically significant

The factors which reached significance ($0 < p \leq 0.05$) on a 95% confidence level in the univariate analysis, are summarised in Table 6.1. The “exposed” category for each variable is given in brackets. These factors are also graphically depicted in the spider graphs (Figures 6.15 to 6.18). The numbers in the spider graphs represent the crude odds ratios.

Table 6.1: Statistically significant factors associated with upper and lower respiratory illnesses.

UPPER RESPIRATORY ILLNESSES					
Risk Factor	Cases	Controls	Crude OR	95% c i of OR	P value
Sinusitis					
Allergy (being allergic)	45/102	19/70	2.119	1.051; 4.341	0.026
Hay fever					
Allergy (being allergic)	47/86	18/87	4.619	2.253; 9.601	<0.001
Earache, hay fever and sinusitis					
Allergy (being allergic)	21/36	41/133	3.141	1.377; 7.221	0.003
LOWER RESPIRATORY ILLNESSES					
Risk Factor	Cases	Controls	Crude OR	95% c i of OR	P value
Pneumonia					
Alcohol>7*	3/5	14/115	10.821	1.098; 135.274	0.020
Bronchitis					
Sex (male)	6/32	64/142	0.281	0.089; 0.759	0.009
Allergy (being allergic)	19/30	42/138	3.948	1.608; 9.968	0.001
Asthma					
Allergy (being allergic)	11/13	52/155	10.894	2.224; 103.267	<0.001

* Consuming more than 7 drinks per week.

It is evident from Table 6.1 that having an allergy is statistically significant when associated with upper respiratory illnesses such as earache, sinusitis and hay fever as well as with lower respiratory illnesses such as bronchitis and asthma. It is believed that up to about 60% of asthma cases might be attributed to being allergic (Sporik and Platts-Mills, 2001; Holgate, 1997).

Pneumonia was associated with the consumption of more than 7 drinks per week. It is envisaged however; that during logistic regression, a confounding factor (possibly smoking), will emerge for this phenomenon.

Being male was found to be protective of bronchitis ($p=0.009$).

6.4.5.1.3 Variables that showed elevated crude odds ratios

Although not statistically significant, elevated (≥ 1.5) crude odds ratios (OR) were found for some factors associated with URI and LRI (see Table 6.2). The "exposed" category for each variable is given in brackets. These

variables are also graphically depicted in Figures 6.15 to 6.18. The numbers in the spider graphs represent the crude odds ratios.

Table 6.2: Factors for which elevated (≥ 1.5) crude odds ratios (ORs) were found in the univariate analysis.

UPPER RESPIRATORY ILLNESSES					
Risk Factor	Cases	Controls	Crude OR	95% c i of OR	P value
Earache					
Ever- smoker	25/56	36/103	1.500	0.73; 3.07	0.216
Sinusitis					
Weight (overweight)	36/104	17/71	1.681	0.814; 3.548	0.180
Hay fever					
Working (with chemicals).	17/86	12/92	1.642	0.683; 4.042	0.310
Perception (AP VT. Serious)	78/86	78/92	1.750	0.640; 5.088	0.261
Perception (AP in area serious)	9/38	7/41	1.507	0.434; 5.387	0.578
Earache, hay fever and sinusitis					
Ever- smoker	15/32	46/127	1.553	0.653; 3.648	0.497
Perception (AP VT. Serious)	34/36	119/138	2.714	0.601; 25.084	0.254
Mould in the house	15/34	42/131	1.672	0.713; 3.858	0.187

Table 6.2 (cont)

LOWER RESPIRATORY ILLNESSES					
Risk Factor	Cases	Controls	Crude OR	95% c i of OR	P value
Pneumonia					
Sex (male)	5/7	64/165	3.945	0.618; 42.256	0.118
Ever- smoker	4/6	56/151	3.392	0.465; 38.323	0.074
Smoking in house	4/7	51/165	2.981	0.482; 20.938	0.212
Weight (overweight)	3/7	48/163	1.796	0.252; 11.019	0.430
Working (in dusty env.)	2/7	20/163	2.860	0.254; 18.802	0.225
Working (with chemicals.)	2/7	24/165	2.350	0.210; 15.296	0.286
Perception (AP in area serious)	1/3	15/72	1.900	0.030; 38.459	0.519
Bronchitis					
Smoking in house	13/32	44/142	1.523	0.630; 3.584	0.304
Weight (overweight)	14/32	37/140	2.165	0.895; 5.124	0.084
Perception (AP in area serious)	3/11	13/65	1.500	0.224; 7.424	0.690
Asthma					
Live (outside VT)	8/13	60/160	2.666	0.726; 10.791	0.103
Ever- smoker	7/11	54/146	2.980	0.714; 14.439	0.154
Alcohol >7	3/9	15/113	3.266	0.472; 17.179	0.128
Working (with chem.)	3/13	24/160	1.700	0.279; 7.250	0.430

LOWER RESPIRATORY ILLNESSES					
Risk Factor	Cases	Controls	Crude OR	95% c I of OR	P value
Weight (overweight)	6/13	45/158	2.152	0.561; 7.905	0.211
Mould in the house	5/10	52/154	1.961	0.428; 8.899	0.296

* Consuming more than 7 drinks per week.

APVT Air pollution in the Vaal Triangle

6.4.5.1.3.1 Upper respiratory illnesses (URIs)

As far as URI are concerned, Table 6.2 shows that although statistically not significant, the risk of contracting earache is 1.5 times higher for 'ever-smokers' (individuals who have at some stage smoked two or more cigarettes per day) than for 'never-smokers' (never smoked more than one cigarette per day). Individuals who are overweight have a 1.7 times higher risk of having sinusitis than individuals who are either underweight or have normal weight.

Having worked in an environment where they have been exposed to chemicals for more than a year increases an individual's risk of suffering from hay fever by 1.6 times. Other risks associated with hay fever, are having the perception that the air pollution problem in the Vaal Triangle is serious (OR=1.8), the same is true for having the perception that air pollution is a serious problem in the area (outside the VT) where the individual currently lives (OR=1.5).

Three factors are associated with having all three URIs, namely earache, hay fever **and** sinusitis. These are: being an 'ever-smoker' (OR=1.6), having the perception that air pollution in the Vaal Triangle is of a serious nature (OR=2.7) and mould growth inside the house (OR=1.7).

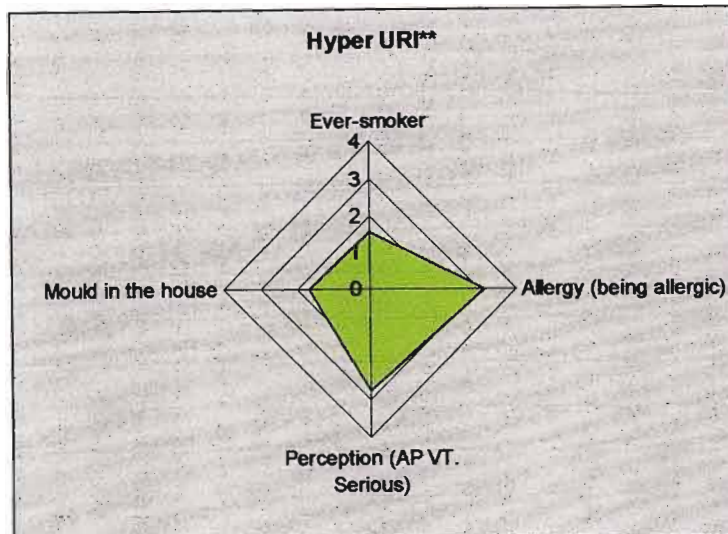


Figure 6.15: Risk factors for having sinusitis, earache and hay fever identified in univariate analysis.

6.4.5.1.3.2 Lower respiratory illnesses (LRIs)

Pneumonia

Again referring to Table 6.2 it is evident that the risk of contracting pneumonia is 4 times higher for a man than for a woman. The risk for an ever-smoker is 3.4 times higher and for an individual living in a house where people are smoking, 3 times higher.

An overweight person has a 1.8 times higher risk for contracting pneumonia, one that has worked in a dusty environment for at least a year has a 3 times higher risk, and one who was exposed to chemicals in the working environment for at least a year, a 2.4 times higher risk. An individual having the perception that the air pollution in the area outside the Vaal Triangle (where he or she resides) is serious has a 1.9 times higher risk of contracting pneumonia. The risk of contracting pneumonia was 10.8 times higher for an individual consuming more than 7 drinks per week. It is envisaged however; that during logistic regression, a confounding factor (possibly smoking), will emerge for this phenomenon.

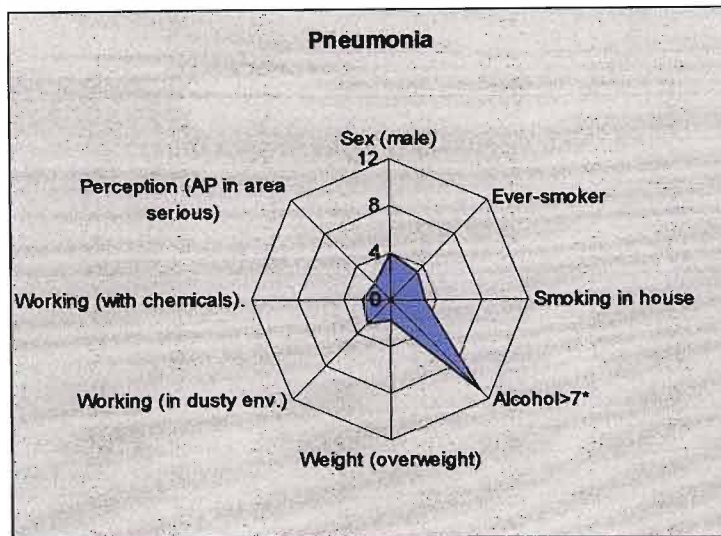


Figure 6.16: Risk factors for pneumonia identified during univariate analysis.

Bronchitis

Three risk factors were found to be associated with bronchitis. These are: being overweight (2.2 times higher risk), living in a house where people smoke (1.5 times higher risk) and having the perception that the air pollution in the area (outside the Vaal Triangle) where they live is serious (1.5 times higher risk).

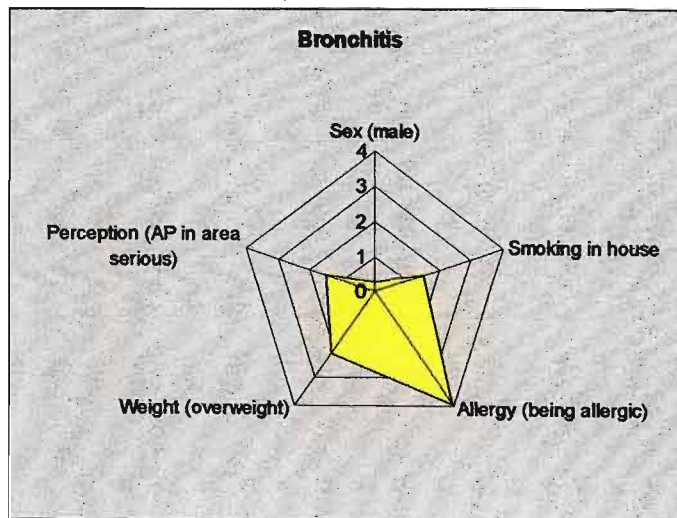


Figure 6.17: Risk factors for bronchitis identified in univariate analysis.

Asthma

For asthma, five risk factors were identified on the grounds of an elevated OR. The risk factor with the highest risk (3.3 times) was the habit of consuming

more than 7 drinks per week. As mentioned before, it is believed that a confounder such as smoking might play a role in this finding and the issue will be addressed through logistic regressions.

Being an ever-smoker was associated with a three times higher risk, being overweight with a 2.2 times higher risk (confirms the Tucson study's finding of an association between overweight and asthma as well as the finding by Huovinen *et al.* (2003) that there is an association between obesity and adult onset of asthma), and working for more than a year in an environment exposed to chemicals, with a 1.7 times higher risk. Having mould growing inside the house was associated with a 1.9 times higher risk for asthma.

An unexpected risk factor found to be associated with asthma was living outside the Vaal Triangle (2.7 times higher risk). It is however possible those individuals with asthma have left the Vaal Triangle.

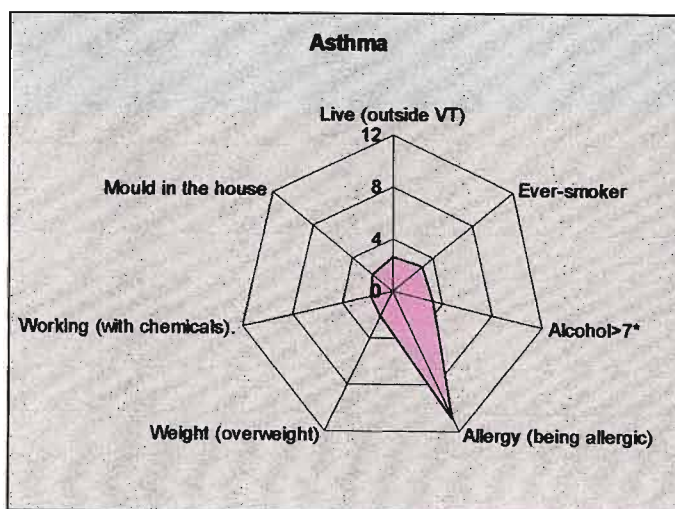


Figure 6.18: Risk factors for asthma identified in univariate analysis.

Summary of univariate analysis

In summary; the adulthood respiratory health status of the individuals was compared to their childhood respiratory health status. A statistically significant increase in the prevalence of the upper respiratory illnesses, sinusitis ($p < 0.001$) and hay fever ($p < 0.001$) as well as in the lower respiratory illnesses, pneumonia ($p = 0.008$) and asthma ($p = 0.034$) was found.

Univariate analysis performed on the data identified preliminary risk factors. Being allergic was the one statistically significant factor associated with all respiratory illnesses, except pneumonia.

6.4.5.2 Multivariate Analysis

6.4.5.2.1 Lower respiratory illnesses

In stepwise logistic regression, the following risk factors were identified for pneumonia:

- ⇒ Living in a house where smoking is allowed: adjusted OR 10.74 95% confidence interval 1.06 to 108.00.
- ⇒ Consuming more than 7 drinks per week: adjusted OR 11.76 95% confidence interval 1.61 to 85.90.

The relatively small study population caused a wide confidence interval.

When being an ever-smoker is brought in with consuming more than 7 drinks per week, the OR of consuming more than 7 drinks per week decreases from 10.82 to 8.43. Being an ever-smoker thus **seems** to have **some** influence but the large adjusted OR of 8.43 indicates that factors brought about by drinking that have been overlooked may play a role. It is believed that other lifestyle factors may play a role. For example, that these individuals do not follow a balanced diet which might have an influence on their immune system and make them more vulnerable to infections.

For bronchitis the following risk factors were identified in stepwise logistic regression:

- ⇒ Being male was found to be **protective**
 - ▶ adjusted OR 0.28 (0.096; 0.823) ($p = 0.02$)
- ⇒ Having an allergy
 - ▶ adjusted OR 3.78 (1.54; 9.27) ($p = 0.004$)
- ⇒ Suffering from sinusitis
 - ▶ adjusted OR 4.20 (1.33; 13.23) ($p = 0.014$)

The risk factors identified through stepwise logistic regression for asthma was:

- ⇒ Having an allergy
 - ▶ adjusted OR 10.89 (2.32; 50.97) ($p=0.002$).

⇒ Being an ever-smoker was found to be a **risk factor** but not a confounding factor

▶ adjusted OR 4.25 (0.99; 18.14) ($p = 0.05$)

Mould in the house was found to be a confounding factor for having an allergy, since the OR for having an allergy decreased from 10.89 to 7.43 when "mould in the house" was taken into account.

6.4.5.2.2 Upper respiratory illnesses

In stepwise logistic regression, the following risk factors were identified for sinusitis:

⇒ Being allergic

▶ adjusted OR 2.3 (1.13; 4.74) $p = 0.022$

⇒ Living outside the Vaal Triangle was found to be slightly protective

▶ adjusted OR 0.71 (0.48; 1.04) $p = 0.07$ marginally significant

⇒ Being overweight. Adjusted OR 2.17 (1.03; 4.61) $p = 0.04$

For earache the only risk factor identified in stepwise logistic regression was:

⇒ Having sinusitis

▶ adjusted OR – 6.68 (3.09; 14.48).

Being an ever-smoker and working with chemicals; were identified as risk factors during univariate analysis. However, these did not show up as significant risk factors during stepwise logistic regression.

For hay fever, only one factor was identified through stepwise logistic regression, namely:

⇒ Having an allergy

▶ adjusted OR 8.73 (2.72; 26.04) $p = <0.001$

Although identified as risk factors during univariate analysis, working with chemicals, and considering air pollution in the Vaal Triangle and in the area where they currently reside as serious, did not feature as risk factors during stepwise logistic analysis.

Although a large number of potential confounders were evaluated, the possibility of confounding by unmeasured variables cannot be ruled out.

6.5 Other health issues

6.5.1 Hospitalisations

Seven percent (12/184) of respondents have **ever** been hospitalised for respiratory ailments. Eighty three percent (10/12) of these already by the year 1990, thus by the time they reached 10 years of age. Only 2 of the 12 respondents (17%) that had ever been hospitalised for respiratory ailments were hospitalised between the 1990 and 2003 surveys. Fifty percent were hospitalized once, 33% twice and 2 respondents (17%) more than twice.

The main respiratory ailments that respondents were hospitalised for were bronchitis 30% (3/10), asthma 30% (3/10), pneumonia 20% (2/10), croup 10% (1/10) and a combination of bronchitis and asthma 10% (1/10), thus all lower respiratory infections.

6.5.2 Serious illnesses

Sixteen percent (29/176) of respondents answered positive to the question as to whether they experienced a serious illness or injury during the year preceding the 2003 survey, which kept them at home and/or prevented them from participating in any activities. The main types of illnesses or injuries were gastro-intestinal 18% (5/28), influenza 14% (4/28) and surgery 11% (3/28). Lower respiratory illness caused 7% (3/29) of respondents to stay at home and/or not to participate in activities. Other reasons given were: infections 7% (2/28), migraine 4% (1/28), acid reflux 4% (1/28) and hypernatremia (abnormal high sodium concentration in blood plasma) 4% (1/28).

When the same question was asked in 1990, the reason given by 95 % (67/175) of respondents (parents) was respiratory illness. The other 5% was made up of children's diseases, influenza, injuries, surgery and gastro-intestinal disorder.

6.5.3 Other disabilities

On the question if they have ever had a learning disability, 12% (22/177) of respondents answered positive. In 1990, this figure was 8% (13/168). Seven percent (13/176) ever experienced hyperactivity (5% or 8/168 in 1990), and 6% (1/176) liver infection (hepatitis) (0% in 1990). Sixteen percent (28/177) experienced gastro-intestinal disorders (5% or 8/168 in 1990).

6.5.4 Non-communicable diseases

None of the respondents had ever been diagnosed with cancer (same as in 1990). The average for the South African population in the same age group (15-24 years of age) is 0.0 (SADHS,1998). Eleven percent (19/178) has had high blood pressure. This is much higher than the figure for South Africa. The prevalence of high blood pressure (hypertension) amongst individuals between 15 and 24 years of age in the South African population is 0.2% for men and 3.8% for women (average 2%) (SADHS,1998). Ten percent (18/176) of respondents has had high cholesterol. The prevalence of hiperlipidaemia amongst individuals between 15 and 24 years of age in the South African population is 0.2% for men and 0.5% for women (average 3.5%) (SADHS,1998).

Eighteen percent (32/176) painful joints (gout/ arthritis). A review of publications on recent studies in different parts of the world, found an increase in the prevalence and severity of gout, with a simultaneous decrease in age at onset of disease. (Twenty five percent of patients in a Chinese study started before age 30). It is believed that dietary habits play a major role (Pascual and Pedraz, 2004). One percent (2/173) of the respondents is diabetic. The prevalence of diabetes for the South African population between 15 and 24 years of age is 0.1% for men and 0.5% for women (average 0.3%) (SADHS, 1998). The prevalence of type 2 diabetes has increased worldwide and even children are now at risk. Overweight and a lack of exercise are risk factors (Rizvi, 2004), which again refers to lifestyle.

Thirty one percent (56/182) of respondents consider themselves to be overweight, 3% (5/182) under weight and 65% (118/182) to be of normal weight. The remainder of the respondents was not sure whether they are over or underweight. According to the 1998 South African demographic and health study, 20% of women and 8% of men (average 14%) between 15 and 24 years of age are overweight (according to WHO standards). It was found that white South African women are already overweight while still considering themselves to be of normal weight (SADHS, 1998). The results indicate that the prevalence of being overweight was higher for the respondents than for the average South African between 15 and 24 years of age.

6.5.5 Family history

Looking at the family history of the respondents, it became clear that the majority of them (66% or 117/177) have at least one immediate family member who suffers from high blood pressure. The prevalence of family

history of hypertension for the South African population between 15 and 24 years of age is 25% (SADHS, 1998). Eighteen percent (31/169) have at least one immediate family member who has had a stroke, while the average for the South African population between 15 and 24 years of age is 3% (SADHS, 1998). Thirty five percent (61/172) have an immediate family member who has had either a heart attack, or angina or chest pain (while exercising). The prevalence for family history of ischemic heart disease for the population in SA between 15 and 24 years of age, is 9% (SADHS, 1998).

In 29% (28/98) of cases the heart attack, angina or chest pain experienced by the immediate family member was before the age of fifty.

In general the study population in the current study had a higher prevalence of chronic diseases and a family history of chronic diseases than the average for the South African population, considering the same age group.

When considering the current top ten risks (according to the WHO (2002), (section 4.0)) to health globally, then the current study population has a higher prevalence than the average for the population of South Africa of at least the following five: high blood pressure, tobacco consumption, alcohol consumption, high cholesterol and overweight.

6.6 Education and social status of the study population

As far as education is concerned, it is evident that most (98% or 179/183) of the respondents have at least completed grade 12. Thirty six percent (66/179) have a degree or diploma and 18% (33/179) a postgraduate qualification. The percentage of whites in South Africa (amongst those aged 20 years and older) having at least grade 12, is 41% and the percentage with a higher qualification than grade 12 is 30% (Statistics South Africa, 2001).

When the current work status of respondents was analysed, it was found that 78% (143/184) of them are employed on a full time basis and 6% (11/184) on a part-time basis while 3% (6/184) are self-employed. Eight percent (14/184) of respondents are students while 3% (6/184) are unemployed. Five out of a total of 184 respondents marked 'other' for the question on employment status but did not specify what this meant.

In order to obtain specific information on occupations, participants were asked to specify their job or occupation as well as the type of business or industry they work for and the number of years they have been working there. Occupation was coded according to certain categories. One to ten (1-10)

included professionals, management, executive and administrative occupations. Eleven to eighteen (11-18) included sales, clerical, technical and service occupations. Nineteen to twenty three (19 – 23) included farmers, artisans and apprentices. Twenty-four to twenty six (24 – 26) mainly represented individuals in the mining and production sector; while those classified under numbers 29 and 30 were economically inactive. Housewives, students and the unemployed will fall in this category.

Fifty five percent (96/174) of respondents fell in the "professional" category, 26% (45/174) in the sales, clerical, technical and service category and 7% (13/174) in the farmers, artisans and apprentices category. Four percent (7/174) were production workers while the rest (8%) were economically inactive (housewives, students or unemployed).

Most (72% or 119/165) of the respondents work in commercial buildings such as offices and shopping centres. Twenty eight percent (48/170) of the respondents have been working at the same place for more than 5 years, 38% (65/170) for 2 to 5 years and 34% (57/170) for less than 2 years.

Fourteen percent (26/182) of the respondents have worked in a dusty environment for more than a year, while 17% (31/184) have worked in an environment where they were or still are exposed to chemicals in the air. The types of dust ranged from grain dust, wood dust and mine dust to dust created by activities in a panel beating shop. Chemicals included acid fumes, welding fumes, solvents and cleaning agents.

Socio-economic status (SES) was not included as a confounding factor in this study because the SES of these young adults is considered to be the same as that of their parents, in other words, their SES as children. During the VAPS study (when they were children), the parent's SES had no significant effect on results (Özkaynak *et.al.*, 1994), possibly because there was not much difference in the SES of the parents.

In addition, no significant difference in the prevalence of respiratory diseases between the towns of Vereeniging, Vanderbijlpark, Meyerton and Sasolburg could be demonstrated during VAPS (Özkaynak *et.al.*, 1994). Therefore, for the purpose of this study, these areas were treated as one area (the Vaal Triangle).

6.7 Personal perceptions of the study population

It is possible that current research of air pollution and health cannot provide a complete picture, since people's perceptions of the risks involved are not always addressed. It has been proven that people's perception of air pollution could have an influence on their respiratory symptoms (Hunter, *et. al.*, 2003).

Questions asked on individual's perception of factor(s) influencing their respiratory health status, revealed that 53% are under the impression that industries have an influence, 28% think domestic fuel use and 27% cigarette smoke, while 16% are of the opinion that motor vehicle exhaust fumes are influencing their respiratory health status. Eleven percent thinks climate has an influence and 6% each blames it on lifestyle and grass and pollen. Other factors mentioned were veld fires (2%), viruses (3%), genes (2%), dust (<1%) and the area where they reside (<1%).

Eighty eight percent (161/184) of respondents currently perceive air pollution in the Vaal Triangle as serious, while 5% (10/184) do not feel it is critical and the rest does not really know whether it is serious or not. Twenty percent (16/80) of individuals who live elsewhere (outside the Vaal Triangle) consider air pollution in the area where they currently reside as serious.

Sixty percent of respondents mention industry as the main source of pollution; while 21% blame it on motor vehicles, 14% on domestic fuel burning and 5% on cigarette smoking.

Fifty eight percent (105/182) of respondents were aware of unusual odours in their neighbourhood, 62% for the past 10 years or more. Forty four percent (55/124) of respondents feel that the odours in their neighbourhood have an adverse effect on their health and 28%(20/72) think that this happens to a great extent, while 43% (31/72) think it fairly affects their health, 4% (3/172) think the effect is very little, while 25% (18/72) do not know if the odours are affecting their health or not.

CHAPTER SEVEN

7.0 Discussion

The aim of this cohort study, performed on a selected group of adults, 23 years of age, was to determine the respiratory health status of adults who had spent their developing years in a polluted area of South Africa. The study population's respiratory health status as children of 10 years old is known, since they participated in the Vaal Triangle Air Pollution and health Study (VAPS) conducted between 1990 and 1993. Indicators used in the study were self-reported symptoms and reported diagnosis through the use of self-administered questionnaires. The questionnaire was based on other respiratory health questionnaires extensively tested and reviewed by a large body of experts. In 1990 questionnaires were completed by the parents.

Fewer individuals were absent from school, work or activities in 2003 as a result of respiratory ailments than in 1990 (15 versus 17%). Seven percent (12/184) of respondents had been hospitalised for respiratory ailments. Eighty three percent (10/12) of these already by the year 1990, thus by the time they reached 10 years of age. Only 2 of the individuals that had been hospitalised for respiratory ailments were hospitalised between the 1990 and 2003 surveys.

The prevalence of allergies however, has increased by 10% (from 27% to 37%) since 1990. It seems as if the severity of allergies in at least some individuals has also increased, since more individuals took medication for allergies on a daily basis in 2003 compared with 1990 (although a smaller number were taking medication than in 1990). It is well known that the prevalence of allergic and autoimmune diseases has increased during the past three decades (Bach, 2002; Krämer, *et. al.*, 1999).

7.1 Upper respiratory illnesses

The adulthood upper respiratory health status of the individuals was compared to their childhood upper respiratory health status. A 4% increase (from 68 to 72%) in the prevalence of URI was observed. The increase was statistically significant for the upper respiratory illnesses, sinusitis ($p = <0.001$) and hay fever ($p = <0.001$) but not earache.

7.1.1 Univariate analysis

In view of the general interpretation of various studies, that note should be taken of a p-value of ≤ 0.25 because "a more traditional level (such as 0.05) often fails to identify variables known to be important" (Hosmer and Lemeshow, 1989), it was decided to take a generous approach and consider all variables for which a p-value ≤ 0.299 and/or a crude odds ratio of ≥ 1.5 were found as risk factors for further investigation.

The only variable, which reached significance ($0 < p \leq 0.05$) on a 95% confidence level in the univariate analysis for sinusitis, hay fever as well as for having sinusitis, hay fever and earache, was: having an allergy.

Hay fever is considered an allergic disease (Bach, 2002; Krämer, *et. al.* 1999). Pollen and fungal spores are risk factors for the prevalence of hay fever as was found in the VAPS study (Özkaynak *et.al.*, 1994). This confirms what was found in the Swiss studies, namely that the prevalence of hay fever was not associated with concentrations of PM, SO₂ and NO₂ (Braun-Fährlander, *et. al.*, 1997; Martin, *et. al.*, 1997).

For earache the only risk factor was having been an ever smoker (OR 1.5). Numerous studies have found associations between passive and active tobacco smoking and detrimental effects on respiratory health (Taussig, *et. al.*, 2003, Radon, *et. al.*, 2002, Burr, *et. al.*, 1999 and Özkaynak *et.al.*, 1994).

VAPS results showed that living in a house where indoor smoking was allowed, was associated with increased odds of children developing respiratory illnesses (Özkaynak *et.al.*, 1994). These results confirmed what was found by Radon, *et. al.*, (2002) in a German study, which involved 1890 adults. In this (German) study it was found that being exposed to passive tobacco smoke for more than 8 hours per day increased the risk of chronic bronchitis (OR 3.07), asthma (OR 2.06) and wheezing (OR 2.12). Ehrlich and co-workers (2004) determined predictors of chronic bronchitis in South African adults and found smoking, amongst others, to be a risk factor. Also in other studies passive and active smoking were found to be important causes of respiratory symptoms in adolescence (Burr, *et. al.*, 1999) and having been an ever smoker was found to be a risk factor for asthma in adults (Hunter, *et. al.*, 2003).

For sinusitis, the only risk factor found was being overweight (OR 1.7). Overweight had been associated with respiratory diseases especially asthma as was found in epidemiological studies (Taussig, *et al.*, 2003; Arif, *et al.*,

2003). Thirty one percent of the current study population considered themselves overweight.

The risk factors for hay fever were:

- ⇒ having worked in an environment where they have been exposed to chemicals for more than a year (OR 1.6),
- ⇒ having the perception that the air pollution problem in the Vaal Triangle is serious (OR 1.8) and
- ⇒ the perception that air pollution is a serious problem in the area (outside the VT) where the individual currently lives (OR 1.5).

Three factors were associated with having all three URIs, namely earache, hay fever and sinusitis. These were:

- ⇒ having been an 'ever-smoker'(OR 1.6),
- ⇒ mould growth inside the house (OR 1.7) and again,
- ⇒ having the perception that air pollution in the Vaal Triangle is of a serious nature (OR 2.7).

During VAPS, higher odds of illness were found to be associated with the indoor presence of mould. This finding was consistent with previous research in many communities in the US and Canada (Özkaynak *et.al.*, 1994). In the current study, univariate analysis show that having mould growing inside the house was associated with a 1.9 times higher risk for asthma and a 1.7 times higher risk for having all three upper respiratory illnesses, namely earache, hay fever and sinusitis.

It has been proven that people's perception of air pollution could have an influence on their respiratory symptoms (Hunter, *et. al.*, 2003). It is therefore possible that current research of air pollution and health cannot provide a complete picture, since people's perceptions of the risks involved are not always addressed.

During VAPS higher prevalence of illnesses amongst children was reported by parents who perceived air pollution as a serious problem (Özkaynak *et.al.*, 1994). In the current study most respondents (88%) answered affirmatively to the question whether air pollution in the Vaal Triangle is considered serious and 53% of all respondents perceive emissions from industries to have an influence on their respiratory health.

7.1.2 Multivariate analysis

Variables for which elevated (≥ 1.5) odds ratios (ORs) and/or a p-value below 0.299 were found in the univariate analysis, were further evaluated in multivariate analysis.

Stepwise logistic regression showed that the only risk factor identified for earache, was having sinusitis while the risk factors identified for sinusitis, were: being allergic and being overweight.

Through stepwise logistic regression it was shown that living outside the Vaal Triangle was a marginally significant ($p = 0.07$) protection against sinusitis. This phenomenon cannot, without doubt, be associated with a possible decrease in exposure to chemical air pollution, since risk factors for having sinusitis are: having an allergy and being overweight, which in turn reflects on genetic predisposition, exposure to allergens and lifestyle.

7.2 Lower respiratory illnesses

The adulthood lower respiratory health status of the individuals was compared to their childhood lower respiratory health status. A 5% increase in the prevalence of LRI (from 19% to 24%) was observed. The increase was statistically significant for the lower respiratory illnesses pneumonia ($p = 0.008$) and asthma ($p = 0.034$) but not bronchitis.

7.2.1 Pneumonia

The prevalence of pneumonia in the current study was 4% (7/172), compared to the 0% of 1990 ($p = 0.008$). This is the same as the prevalence found in the Soweto birth-to-ten study (Mathee and Von Schirnding, 2003).

The only variable, which reached significance ($0 < p \leq 0.05$) on a 95% confidence level in the univariate analysis for pneumonia, was the consumption of more than 7 drinks per week. When stepwise logistic regression was applied, the same risk factor once again showed an elevated adjusted OR of 11.76. Since it was believed that tobacco smoke was a confounding factor, having been an ever smoker was brought in with consuming more than 7 drinks per week. The OR of consuming more than 7 drinks per week decreased from 10.82 to 8.43. Having been an ever-smoker thus **seems** to have **some** influence but the large adjusted OR of 8.43 indicates that factors brought about by drinking that have been overlooked may play a role. It is believed that other lifestyle factors may play a role. For

example, that these individuals do not follow a balanced diet which might have an influence on their immune system and make them more vulnerable to infections.

A second risk factor for pneumonia, identified through stepwise logistic regression, was living in a house where smoking is allowed (adjusted OR 10.74). Confidence in both these as risk factors for pneumonia is however not very high because of a wide interval.

Risk factors for pneumonia identified through univariate analysis that did not show up during logistic regression, were:

- ⇒ being male,
- ⇒ being overweight,
- ⇒ being occupationally exposed to dust and chemicals for more than a year and
- ⇒ having the perception that air pollution in the area of residence is serious.

The current study failed to identify specific risk factor(s) for pneumonia.

7.2.2 Bronchitis

Eighteen percent of respondents in the current study had bronchitis during the year preceding the 2003 survey. During the 1990 survey, this figure was 14%. The prevalence of bronchitis amongst children in the SCARPOL study (in Switzerland where air pollution is less of a problem) was between 6 and 27% (Braun-Fährlander, *et. al.*, 1997) and 5% in the Soweto birth-to-ten study (where air pollution is a huge problem)(Mathee and Von Schirnding, 2003).

Risk factors that reached significance ($0 < p \leq 0.05$) on a 95% confidence level in the univariate analysis for bronchitis were:

- ⇒ having an allergy and
- ⇒ being female.

A possible explanation for the latter risk factor is a potential difference in life style between men and women. Women might be less exposed to tobacco smoke.

The same two factors featured as risk factors in stepwise logistic regression, while an additional factor, suffering from sinusitis, showed up. Having

sinusitis was also identified as a risk factor for earache during logistic regression.

None of the bronchitis risk factors associated with lifestyle (smoking in the house and being overweight) and perceptions (having the perception that you live in a polluted environment), which showed elevated crude ORs, featured as risk factors in stepwise logistic regression.

These results are in line with what was found by Ehrlich and co-workers (2004) when they determined predictors of chronic bronchitis in the South African adult population. They found that smoking, obesity, underweight, occupational exposure (especially in men) and domestic fuel use (especially in women) featured as risk factors in univariate analysis but that obesity and underweight were not significant in the multivariate analysis. They also found that more women than men suffered from chronic bronchitis and that a history of TB was a strong predictor.

The fact that an URI, in this case sinusitis, is a risk factor for a LRI, in this case bronchitis (in the current study), might be an indication that the respiratory system is reacting as a unit and should therefore be seen as a unit instead of the usual grouping of respiratory illnesses into upper and lower.

In some epidemiological studies, associations were found between bronchitis and frequency of fog, as well as between bronchitis and the pollutants NO₂ and PM₁₀ (Brunekreef and Holgate, 2002; Braun-Fährlander, *et. al.*, 1997).

7.2.3 Asthma

In this study a statistically significant increase ($p = 0.034$) in the prevalence of asthma for 2003 (8% or 13/173) compared with 1990 (4% or 8/179) was evident. In a New Zealand cohort study the prevalence of asthma in the same population was 9% at 9 years of age and 21% at age 26, thus higher than for the current study, although New Zealand is considered less polluted than the Vaal Triangle and South Africa at large. The prevalence of asthma in the white South African adult (age 15+) population is 7% for men and 9% for women, thus an average of 8% (SADHS, 1998).

The prevalence of asthma differs between countries and even between cities in the same country. The highest prevalence was found in countries with low air pollution, and the lowest prevalence in countries with high levels of pollution. Intermediate prevalence of asthma was found in countries with high ozone levels (Beasley, *et. al.*, 1998).

Large well-designed epidemiological studies failed to show an association between NO₂, PM₁₀ and asthma (Brunekreef and Holgate, 2002; Zemp, et al., 1999; Ackermann-Liebrich, et al., 1997). However, some recent studies found that O₃ might play a role in the onset and aggravation of asthma (O'Neil, et al., 2003; Ramadour, et al., 2000).

Several risk factors have been identified for asthma in as many studies. Risk factors for asthma identified in the current study, using logistic regression were:

- ⇒ having been an ever-smoker and
- ⇒ having an allergy.

Also evident from the current study is the fact that statistically significant (p=0.02) more individuals with asthma have at least one parent who suffers from asthma as well.

Twenty five percent (4/16) of individuals in the current study who have at least one parent who has been diagnosed with asthma, have been diagnosed with asthma themselves, already by the age of 10 years old and these individuals are still suffering from asthma. It seems thus that if at least one of an individual's parents is suffering from asthma and that individual is prone to get asthma it would happen before the age of 10 years old and will most probably continue into adult life. This confirms what was found in the Tucson study, namely that children with maternal asthma were more likely to have asthma and most children who will develop atopic asthma have their first symptoms during the first 6 years of life (Taussig, et al., 2003; Holgate, 1997).

Asthma is considered an allergic disease and it is believed that up to about 60% of asthma cases might be attributed to being allergic. Sensitisation for asthma does not necessarily have to be early in life though (Sporik and Platts-Mills, 2001; Holgate, 1997).

Persistence of childhood asthma

Epidemiological studies have indicated that the persistence of childhood asthma into adulthood depends amongst others on **early** (<3 years of age) **onset** and **severity** of symptoms (Horak, 2003; Sumer, 2004). These indications were largely confirmed in the current study.

It was found that 5 of the 6 individuals, who were diagnosed with asthma before the age of 3, still had asthma attacks during the year preceding the

2003 survey, while only 2 of the 6 individuals who were diagnosed between 4 and 10 years old still have asthma.

As far as severity is concerned, it was found in this study that of the 6 individuals hospitalised for asthma as children, 4 still have asthma. It was further found that of the 6 individuals who were on asthma medication during the 1990 survey, 4 were still on medication during the 2003 survey (3 of the hospitalised children plus one extra). However, according to the classification of severity of asthma (Lalloo, *et. al.* 2000), the current severity of asthma amongst the study population can be described as mild intermittent.

Kurukulaaratchy, *et. al.*, (2003) investigated risk factors influencing the persistence of wheezing with an early (within first 4 years) onset, to the age of 10 years. A genetic tendency to be asthmatic and atopic, appeared to be a crucial factor. This finding confirmed what was found in another study on twins, namely that factors inherited dominated environmental influences in the development of asthma (Kurukulaaratchy, *et. al.* 2003).

Findings from the Swiss studies were that children with a family history of asthma, hay fever or eczema, had higher rates of respiratory and especially allergic symptoms than those without, which makes them a susceptible subgroup (Braun-Fährlander, *et. al.*, 1997).

7.2.4 Wheezing

In the current study, the prevalence of wheezing without a cold was 8%, which is the same as was found in the SAPALDIA study and considerably lower than what was found in the New Zealand study. Both these studies were conducted in countries with low air pollution levels. The majority (10/15 or 67%) of individuals in the current study reporting wheezing without a cold, were asthmatics. This confirms what was found in the Tucson study, namely that wheezing without a cold could be used as a marker in an asthma predictive index (Taussig, *et. al.* 2003).

7.2.5 Lung functions

The New Zealand study by Sears and co-workers suggested that impaired lung functions found in adults with respiratory diseases already occurred in early childhood (Sears *et. al.*, 2003). This finding was confirmed by the Tucson study, which demonstrated impaired lung function in infants even before their first LRI (Taussig, *et. al.*, 2003).

7.3 Answers to the research and key questions

In order to determine whether children who spent their developing years in a polluted area in South Africa are unhealthy adults as far as their respiratory health status is concerned, it would be necessary to compare their respiratory health status to that of other adults who spent their developing years in a less polluted area in South Africa, preferably an area with similar climatic and socioeconomic conditions.

Due to capacity and cost constraints, such a cross-sectional study could not be performed and it was decided to compare the study population's respiratory health status to their own health status as children (which is known), the average for South Africa and to the average found in other studies conducted in less polluted areas.

The respiratory illnesses, hay fever and asthma, have increased significantly since childhood but on the other hand so did the prevalence of most allergic and autoimmune diseases worldwide. The prevalence of hay fever in 1990 (when the study population were children), did not differ from other surveys conducted during the same time on children in less polluted areas (Braun-Fährlander, *et. al.*, 1997; Martin, *et. al.*, 1997). The prevalence of asthma in the current study did not exceed the average for the South African white adult population. Hay fever and asthma are considered allergic diseases (Bach, 2002; Krämer, *et. al.* 1999) and studies found no associations with concentrations of PM, SO₂ and NO₂ (Braun-Fährlander, *et. al.*, 1997; Martin, *et. al.*, 1997). In the current study, being allergic was the one statistically significant factor associated with all respiratory illnesses except pneumonia.

The prevalence of bronchitis (18%) in the current study was in the same order as the prevalence found in less polluted areas such as Switzerland (6-26%) and parts of the US (14%).

7.3.1 Answers to Key Questions

Is there a difference in the health status of adults who remained in the Vaal Triangle compared to those who left the area?

Univariate analysis found no statistically significant differences in any of the upper or lower respiratory health symptoms of individuals living in the Vaal Triangle compared with those who have left the area for more than two years already. For asthma, a higher risk (crude OR 2.7; p=0.103) for living outside the Vaal Triangle was observed. It is however possible that asthmatics have left the area. Stepwise logistic regression revealed only one factor, namely that living outside

the Vaal Triangle was a marginally significant ($p = 0.07$) protection against sinusitis. Risk factors for suffering from sinusitis (being allergic and being overweight) were associated with genetic predisposition and life style.

Is there an association between health status and years spent in the polluted area?

Due to small numbers, the only way was to distinguish between the health status of those individuals who remained in the area and those who have left, as well as between those who have left but who visit the area for more than 30 days per year and those who do not. No significant differences in upper or lower respiratory health symptoms could be observed between the aforementioned groupings. The risk for sinusitis was borderline.

Does the occupation of the individual play a role in his/her health status?

Working for more than a year in an environment exposed to chemicals and/or dust, increased the risk for pneumonia, asthma and hay fever in univariate analysis but not in stepwise logistic regression.

Does the risk of having upper respiratory illness increase significant with time spent in a polluted area during developing years?

As mentioned above, due to low numbers, the only groups that could be studied, were those individuals who remained in the area and those who have left as well as those who have left but visiting the area for >30 days per year as opposed to those who have left but do not visit the area for 30 days or more per year. There was no significant difference in the prevalence of URI of those who remained in the Vaal Triangle (63%), (which include the 39% who were born there) and those who have left the area at some stage, as well as no significant difference in respiratory symptoms between those visiting the area for >30 days per year as opposed to those who do not.

Although numbers were small, asthma was used in an attempt to prove a difference between the groups. No significant difference ($p= 0.365$) was observed for the prevalence of asthma between those individuals who have always been living in the Vaal Triangle compared to those who had left the area between 4 and 10 years ago (results not shown).

Does the respiratory health status improve towards adulthood or does it stay the same (for those who remained in the area)?

The prevalence of most respiratory symptoms within the total study population has increased since childhood with no statistical significant difference between those who remained in the area and those who have left.

What is the risk profile for respiratory diseases in adults who spent their developing years in a polluted area in South Africa?

The risk profile for respiratory diseases is graphically depicted in Figures 6.15 to 6.18. Having an allergy, was the one factor statistically significant associated with all respiratory symptoms except pneumonia. Risk factors related to lifestyle, such as smoking and being overweight formed part of the risk profile. According to the risk factors identified during univariate analysis, the individual with the highest risk would be an overweight allergic individual, who is either currently smoking or had been smoking at some stage, who is exposed to chemicals in the workplace and who has a perception that he or she lives in a polluted area.

CHAPTER EIGHT

8.0 Conclusions and Recommendations

8.1 Conclusions

The increase over time, in upper and lower respiratory illnesses found within the study population is in line with findings from other cohort studies, even from countries with low air pollution, where an increase in respiratory symptoms was found with each follow-up assessment (Sears, *et. al.*, 2003). This finding in itself is therefore not proving beyond doubt that adults who grew up in a polluted environment are unhealthy as far as their respiratory health status is concerned. In contrast, as mentioned earlier, fewer individuals (15% versus 17%) were absent from school, work or activities in 2003 as a result of lower respiratory ailments than in 1990 when they participated as ten-year-old children in VAPS. Only 2 of the individuals that had ever been hospitalised for respiratory ailments were hospitalised between the 1990 and 2003 surveys. Thus the severity of the illnesses was less.

The current study referenced numerous studies that found human respiratory health to be negatively affected by chemical and biological air pollution. However, many studies identified risk factors other than air pollution, to be associated with respiratory health. Examples are: factors relating to lifestyle and atopy.

The fact that no statistically significant difference in the prevalence of respiratory symptoms was observed for those (63%) who remained in the Vaal Triangle, (which include the 39% who were born there) and those who have left the area at some stage, as well as between those who have left but visit the area >30 days per year and those who do not, shows that exposure to ambient air pollution alone cannot account for the increase in respiratory symptoms.

Having an allergy was the one statistically significant factor associated with all respiratory diseases, except pneumonia. A significant increase in the prevalence of allergies (a global problem) and possible severity of allergies was demonstrated in the current study. It is therefore possible that the increase in respiratory symptoms could have been from individuals with a family history of asthma, hay fever or eczema, which makes them more

susceptible, similar to what was found in a Swiss study (Braun-Fährlander, *et al.*, 1997).

The influence that factors such as lifestyle and occupational exposure as well as perceptions on air pollution (as was found in the univariate analysis) have on respiratory symptoms can also not be discarded.

The fact that the same risk factors for respiratory symptoms were identified to be important in this study compared to studies from other countries, including first world countries, indicates that the data from this study could be compared with the data from first world countries to determine prevalences of respiratory symptoms.

In conclusion it can be said that although the prevalence of respiratory health symptoms in this selected group of adults, who spent their developing years in a polluted environment, is relatively high, ambient air pollution exposure cannot be considered the only cause since many other risk factors, including factors associated with genetic predisposition, occupation and lifestyle were identified, which indicates that respiratory illnesses are of multi factorial etiology.

8.2 Recommendations

It is recommended to do a follow-up on the same study population to determine whether respiratory symptoms will increase even more or if a plateau will be reached. Such a study may also indicate whether the effect of exposure to air pollution during childhood might really only become evident much later in life.

Several studies have found that populations with a lower socio-economic status have a lower prevalence of immunological diseases such as allergies and diabetes 1 (Bach, 2002). Long-term exposure to air pollution, might therefore not be a causal factor for the development of asthma and respiratory allergies.

More research addressing vulnerability is therefore needed to understand not only the role of poverty and associated malnutrition, ill health and access to health care, but also the role of rapidly changing lifestyles, diets, and over nutrition among the middle class, in mediating the relationship between air pollution and health.

Indicators other than respiratory illnesses should be investigated to determine the effect of air pollution on the human body, since allergies, genetic predisposition life style and even perception have such a major influence on respiratory diseases.

The role of genetic factors in the persistence of respiratory diseases into adult life should be investigated.

The need for primary health care facilities to cope with chronic diseases should be pro-actively investigated.

This study confirms what was found during the SADHS of 1998, namely that smoking, living in a house where smoking is allowed, being overweight and being occupationally exposed to air pollution (dust and chemicals) are risk factors that should be reduced in order to have a beneficial influence on the prevalence of respiratory symptoms.

REFERENCES

- Abbey, D.E., Nishino, N., McDonell, W.F., Burchette, R.J., Knutsen, S.F., Beeson, W.L. and Yang, J.X. 1999. Long-Term Inhalable Particles and Other Air Pollutants Related to Mortality in Nonsmokers. *American Journal of Respiratory and Critical Care Medicine* 159: 373-382.
- Ackermann-Lieblich, U., Leuenberger, P., Schwartz, J., Schindler, C., Monn, C., Bolognini, G., Bongard, J. P., Brändli, O., Domenighetti, G., Elsasser, S., Grize, L., Karrer, W., Keller, R., Keller-Wossidlo, H., Künzli, N., Martin, B.W., Medici, T. C., Perruchoud, A. P., Schöni, M. H., Tschopp, J. M., Villiger, B., Wüthrich, B., Zellweger, J. P., Zemp, E. and the Study on Air Pollution And Lung Diseases In Adults (SAPALDIA) Team. 1997. Lung Function and Long Term Exposure to Air Pollutants in Switzerland. *American Journal of Respiratory and Critical Care Medicine* 155: 122-29.
- Arbes, S.J., Cohn, R.D., Yin, M., Muilenberg, M.L., Friedman, W. and Zeldin, D.C. 2004. Dog Allergen (Can f 1) and Cat Allergen (Fel d 1) in US Homes: Results from the National Survey of Lead and Allergens in Housing. *Journal of Allergy and Clinical Immunology* 114(1).
- Arif, A.A., Delcos, G.L., Lee, E.S., Tortolero, S.R. and Whitehead, L.W. 2003. Prevalence and Risk Factors of Asthma and Wheezing among US Adults: an Analysis of the NHANES III Data. *European Respiratory Journal* 21: 827-33.
- Avol, E.L., Gauderman, W.J., Tan, S.M., London, S.J. and Peters, J.M. 2001. Respiratory Effects of Relocating to Areas of Differing Air Pollution Levels. *American Journal of Respiratory and Critical Care Medicine* 164(11): 2067-72.
- Bach, J. 2002. The effect of infections on Susceptibility to Autoimmune and Allergic Diseases. *The New England Journal of Medicine* 347:911-20.
- Bearer, C.F. 1995. How are Children Different from Adults? *Environmental Health Perspectives* 103 (6): 7-12.
- Beasley, R., Von Mutius, E. and Pearce, N. 1998. Worldwide Variation in Prevalence of Symptoms of Asthma, Allergic Rhinoconjunctivitis, and Atopic Eczema: ISAAC. *The Lancet* 351: 1225-32.
- Bradshaw, D., Groenewald, P. Laubcher, R., Nannan, N., Nojilana, B., Norman, R., Pieterse, D. and Schneider, M. 2003. Initial Burden of Disease Estimates for South Africa, 2000. *South African Medical Research Council Report* ISBN 1-919809-64-3.

- Braun-Fährlander, C., Vuille, J.C., Sennhauser, F.H., Neu, U., Künzle, T., Grise, L., Gassner, M., Minder, C., Schindler, C., Varonier, H.S., Wührich, B and the SCARPOL team. 1997. Respiratory Health and Long-term Exposure to Air Pollutants in Swiss Schoolchildren. *American Journal of Respiratory and Critical Care Medicine* 155:1042-49.
- Bruckner, J.V. and Weil, W.B. 1999. Biological Factors Which May Influence an Older Child's or Adolescent's Responses to Toxic Chemicals. *Regulatory Toxicology and Pharmacology* 29: 158-64.
- Brunekreef, B. and Holgate, S.T. 2002. Air Pollution and Health. *The Lancet* 360:1233-42.
- Burr, M.L., Anderson, H.R., Austin, J.B., Harkins, L.S., Kaur, B., Strachan, D.P. and Warner, J.O. 1999. Respiratory Symptoms and Home Environment in Children: A National Survey. *Thorax* 54: 27-32.
- Coetzee, A.M., Smith, F.C.A., Van der Merwe, C.A., Dreyer, R.J. 1986. Die Invloed van Lugbesoedeling op Gesondheid in die Sasolburg-gebied. *Suid Afrikaanse Mediese Tydskrif* 70:339-43.
- Cohen Hubal, E.A., Sheldon, L.S., Burke, J.M., McCurdy, T.R., Berry, M.R., Rigas, M.L. 2000. Children's Exposure Assessment: A Review of Facts Influencing Children's Exposure and the Data Available to Characterise and Assess that Exposure. *Environmental Health Perspectives* 108(6): 475-586.
- Coombs, M. (ed.). 2000. *Medical and Environmental Surveillance Guidelines*. ISBN 1-919 727-14-0: 14-16.
- Davis, D.L., Bell, M.L. and Fletcher, T. 2002. A Look Back at the London Smog of 1952 and the Half Century Since. *Environmental Health Perspectives* 110(12): A734-75.
- De Kock R.G., Terblanche P. and Annegarn H.J. 1992. Air Pollution Health Research in South Africa: Yesterday and Today. *9th World Clean Air Congress Montreal Canada 30 August – 4 September 1992*.
- Department of Environmental Affairs and Tourism (DEAT). 1998. *Maximum Allowable Concentrations for the More Common Pollutants: South African Limits*. Document ESM16/0159/0694.

- Department of Environmental Affairs and Tourism (DEAT). 2001. Adoption of Revised Guidelines for Sulphur Dioxide in terms of the Atmospheric Pollution Prevention Act of 1965. *Government Gazette no 1387*.
- Department of Health (DoH). 1990. Information Brochure written by the Department for the Vaal Triangle Air Pollution and Health study. No number or author given.
- Department of Health (DoH). 2003. Notifiable Medical Conditions [Online] Available <http://www.doh.gov.za/facts/index.html> [28 October 2003].
- Department of Health (DoH). 2000. Statistical Notes. 2(19) [Online] Available <http://www.doh.gov.za/facts/stats-notes/2000/stat19-00.html> [25 May 2004].
- Department of Health (DoH). 2000a. Statistical Notes. 2(14) [Online] Available <http://www.doh.gov.za/facts/index.html> [25 May 2004].
- Department of Health (DoH). 2000b. Statistical Notes. 2(18) [Online] Available <http://www.doh.gov.za/facts/index.html> [25 May 2004].
- Department of Health (DoH). 2003. Notification System in a Nutshell. [Online] Available http://www.doh.gov.za/docs/misc/epi_comment/notify.html [6 May 2003].
- Department of Water Affairs and Forestry (DWAf). 2003. Review of Cholera Interventions Strategies in KwaZulu-Natal South Africa. *DWAf Report prepared by CSIR and HSRC*.
- Dockery, D.W., Pope, C.A. III, Xu, X., Spengler, J.D., Ware, J.H., Fay, M.E., Ferris, B.G.(jr). and Speizer, F.E. 1993. An Association between Air Pollution and Mortality in Six U. S. Cities. *New England Journal of Medicine*. 329: 1753-59.
- Dominici, F., McDermott, A., Daniels, M., Zeger, S.L. and Samet, J.M. 2002. A Report to The Health Effects Institute: Reanalyses of the NMMAPS Database [Online] Available <http://www.biostat.jhsph.edu/~fdominic/HEI/nmmaps.html>.
- Dyer, O. 2003. Environmental Hazards Kill Five Million Children a Year. *British Medical Journal* 326(7393): 782.
- Eaton, L. 2003. World Cancer Rates Set to Double by 2020. *British Medical Journal* 326(7392): 728a.

- Ehrlich, R.I., White, N., Norman, R., Laubcher, R., Steyn, K., Lombard, C. and Bradshaw, D. 2004. Predictors of chronic bronchitis in South Africa. *International Journal of Tuberculosis and Lung Disease* 8(3): 369-76.
- Engelbrecht, J.P., Reddy, V.S., Swanepoel, L., Mostert, J.C., Stuckenberg, B., De Beer, H and Jones-Watson, E.A. 1993. The Establishment of Chemical Source Profiles and their Application to the Apportionment of Aerosols in the Vaal Triangle. *Mintek Communication C2023M*.
- Falkner, B. 2004. New US Guidelines for Hypertension in Children and Adolescents National High Blood Pressure Education Program (NHBPEP) Working Group on High Blood Pressure in Children and Adolescents. *American Society of Hypertension 19th Annual Scientific Meeting*. [Online] Available <http://www.medscape.com/viewarticle/479474> [24 June 2004].
- Ferris B.G. 1978. Epidemiology Standardization Project: *Contract No 1-HR-5-3028. Report HR-53028-F. Division of Lung Diseases, National Heart, Lung and Blood Institute, USA*.
- Garrison, J.R. 2001. Selected Key studies on Particulate Matter and health: 1997-2001. *American Lung Association* [Online] Available <http://www.lungusa.org> [February 2004].
- Gent, J.F., Triche, E.W., Holford, T.R., Belanger, K., Bracken, M.B., Beckett, W.S., and Leaderer, B.P. 2003. Association of Low- Level Ozone and Fine Particles With Respiratory Symptoms in Children With Asthma. *Journal of the American Medical Association* 290(14): 1859-67
- Gulland, A. 2002. Air Pollution Responsible for 600 000 Premature Deaths Worldwide. *British Medical Journal* 325(7377): 1380c.
- Hall, A.J. and Wild, C.P. 2003. Liver Cancer in Low and Middle Income Countries. *British Medical Journal* 326(7397): 994.
- Hoek, G., Brunekreef, B., Goldbohm, S., Fischer, P. and Van der Brandt, P.A. 2002. Association between Mortality and Indicators of Traffic-Related Air Pollution in The Netherlands: A Cohort Study. *The Lancet* 360: 1203-09.
- Holgate, T. 1997. The Cellular and Mediator Basis of Asthma in Relation to Natural History. *The Lancet* 350(II): 5-9.
- Horak, E., Lanigan, A., Roberts, M., Welsh, L., Wilson, J., Carlin, J.B., Olinsky, A., and Robertson, C.F. 2003. Longitudinal Study of Childhood Wheezy Bronchitis and Asthma: Outcome at Age 42. *British Medical Journal* 326(7386): 422-23.

- Hosmer, D.W.(Jr) and Lemeshow, S. 1989. *Applied Logistic Regression*. John Wiley & Sons, New York. ISBN 0-471-61553-6: 86.
- Hunter, P.R., Davies, M.A., Hill, K., Whittaker, M. and Sufi, F. 2003. The Prevalence of Self-Reported Symptoms of Respiratory Disease and Community Belief about the Severity of Pollution from Various Sources. *International Journal of Environmental Health Research*. 13(3): 227-38.
- Huovinen, E., Kaprio, J. and Koskenvuo, M. 2003. Factors Associated to Lifestyle and Risk of Adult Onset Asthma. *Respiratory Medicine* 97(3): 273-80.
- Ijsselmuiden, C. 1997. Ethical Aspects of Epidemiology Research (In Katzenellenbogen, J.M., Joubert, G. and Abdool Karim, S.S., (eds.). *Epidemiology: a Manual for South Africa*). ISBN 0-19-571308-7: 25-34.
- Joubert, G. and Katzenellenbogen, J.M. 1997. Study Design and Sampling (In Katzenellenbogen, J.M., Joubert, G. and Abdool Karim, S.S., (eds.). *Epidemiology: a Manual for South Africa*). ISBN 0-19-571308-7: 69-70; 80-81.
- Katzenellenbogen, J.M. and Yach, D. 1991. Introduction (In Katzenellenbogen, J.M., Joubert, G. and Yach, D. *Introductory Manual for Epidemiology in Southern Africa*). ISBN 1 874826 05 6: 3.
- Katzenellenbogen, J.M. and Joubert, G. 1997. Data Collection and Measurement (In Katzenellenbogen, J.M., Joubert, G. and Abdool Karim, S.S., (eds.). *Epidemiology: a Manual for South Africa*). ISBN 0-19-571308-7: 82-94.
- Koenig, J.Q., and Mar, J.F. 2000. Sulphur dioxide: Evaluation of Current California Air Quality Standards with Respect to Protection of Children. [Online] Available: www.arb.ca.gov/ch/ceh/aqstandards/oehhaso2.contractorreport091200.pdf. [6 March 2003].
- Krämer, U., Heinrich, J., Wjst, M. and Wichmann, H.E. 1999. Age of Entry to Day Nursery and Allergy in Later Childhood. *The Lancet* 353(9151): 450-54.
- Kurukulaaratchy, R.J., Matthews, S., Holgate, S.T. and Arshad, S.H. 2003. Predicting Persistent Disease among Children who Wheeze during Early Life. *European Respiratory Journal* 22: 767-71.
- Küstner, H.G.V. 1995. *Epidemiological Comments* 22(1): 18.
- Küstner, H.G.V. 1980. *Surveillance as it Pertains to Community Health in the Republic of South Africa*. MD Thesis, University of Pretoria, South Africa: 1,53,77, 100,101,110,300,301.

- Laloo, U.G., Bateman, E.D., Feldman, C., Bardin, P.G., Plit, M., Irusen, E.M. and O'Brien, J. 2000. Guideline for the Management of Chronic Asthma in Adults - 2000 update. *South African Medical Journal* 90(5): 540-52.
- Landrigan, P.J., Carlson, J.E., Bearer, C.F., Cranmer, J.F., Bullard, R.D., Etzel, R.A., Groopman, J., McClachlan, J.A., Perera, F.P., Keigart, J.R., Robinson, L., Schell, L. and Sur, W.A. 1998. Children's Health and the Environment: A new Agenda for Prevention Research. *Environmental Health Perspectives*: 106(3): 1-14.
- Lippmann, M. 1992. Ozone (*In* Lippmann, M. (ed.). *Environmental Toxicants: Human Exposures and Their Health Effects*). Van Nostrand Reinhold, New York. ISBN 0-442-00549-0: 465.
- Lippmann, M. 2003. Air Pollution and Health- Studies in the Americas and Europe (*In* McGranahan, and Murray, F. (eds). *Air pollution & Health in Rapidly Developing Countries*). Earthscan, London. ISBN:185383985:37,38,41.
- Martin, B.W., Ackermann-Liebrich, U., Leuenberger, P., Künzli, N., Zemp Stutz, E., Keller, R., Zellweger J.P., Wüthrich, B., Monn, C., Blaser, K., Bolognini, G., Bongard, J.P., Brändli, O., Braun, P., Defila, C., Domenighetti, G., Grize, L., Karrer, W., Keller-Wossidlo, H., Medici, T.C., Peeters, A., Perruchoud, A.P., Schindler, C., Elsasser, S., Schoeni, M.H., Schwartz, J., Solari, G., Tschopp, J-M., Villiger, B., 1997. SAPALDIA: Methods and participation in the cross-sectional part of the Swiss Study on Air Pollution and Lung Disease In Adults *Sozial-und Präventivmedizin*. 42: 67-84.
- Mathee, A. and Von Schirnding, Y. 2003. Air Quality and Health in Greater Johannesburg (*In* McGranahan, G. and Murray, F (eds). *Air pollution & Health in Rapidly Developing Countries*). Earthscan, London. ISBN 185383985: 209,210,211.
- Medical Research Council (MRC) 2001/2002 *Annual Report*. [Online] Available <http://www.mrc.ac.za/annualreport/annual.html> [6 May 2003].
- Murray, F. and McGranahan, G. 2003. Air pollution and Health in Developing Countries - the Context (*In* McGranahan, G. and Murray, F (eds). *Air pollution & Health in Rapidly Developing Countries*) Earthscan, London. ISBN 185383985: 2,6,9.

- Nriagu, J., Robins, T., Gary, L., Liggans, G., Davila, R., Supuwood, K., Harvey, C., Jinabhai, C. and Naidoo R. 1999. Prevalence of Asthma and Respiratory Symptoms in South-central Durban, South Africa. *European Journal of Epidemiology*: 15: 747-55.
- O'Hollaren, M.T. 2003. The Development and Prevention of Allergic Disease. *Highlights of the American College of Allergy, Asthma & Immunology 2003 Annual Meeting* [Online] Available <http://www.medscape.com/viewarticle/468786> [1 March 2004].
- O'Neill, M.S., Jerrett, M., Kawachi, I., Levy, J.I., Cohen, A.J., Gouveia, N., Wikinson, P., Fletcher, T., Cifuentes, L. and Schwartz, J. 2003. Health, Wealth, and Air Pollution: Advancing Theory and Methods. *Environmental Health Perspectives* 111(16): 1861-70.
- Opperman, L., Terblanche, A.P.S., Nel, C.M.E., Nyikos, H. 1991. Personal Monitoring of total suspended particulate matter in the Vaal Triangle. *Proceedings of NACA Conference: Air Pollution and the Environment, Durban, South Africa*.
- Ott, W.R. 1995. Human Exposure Assessment: The Birth of a New Science. *Journal of Exposure Analysis and Environmental Epidemiology* 5(4): 449-72.
- Özkaynak, H., Xue, J and Spengler, J.D. 1994. Analysis of Health and Pollution Data Collected from Transvaal, South Africa (Phase II and III). Report prepared for the VAPS study (unpublished).
- Pascual, E and Pedraz, T. 2004. Gout *Current Opinion in Rheumatology*. [Online] Available <http://www.medscape.com/viewarticle/475056?src=mp> [27 May 2004].
- Plüddemann, A. 2001. The South African Community Epidemiology Network on Drug Use - SACENDU (Phase 8) - A Gauteng Focus. *Urban Health and Development Bulletin* 40(1). [Online] Available <http://www.mrc.ac.za/urbanbulletin/march2001/sacendu.htm> [6 May 2003].
- Pope C.A. III, Thun, M.J., Namboodiri, M.M., Douglas, W., Dockery, D.W., Evans, J.S., Speizer, F.E. and Heath, C.W.(jr). 1995. Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U. S. Adults. *American Journal of Respiratory and Critical Care Medicine*. 151: 669-74.
- Pope C. A. III, Burnett, R.T., Thun, M. J., Calle, E.E., Krewski, D., Ito, K. and Thurston, G. D. 2002. Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution *Journal of the American Medical Association* 287: 1132-41.

- Radon, K., Büsching, K., Heinrich, J., Wichmann, H.E., Jörres, R.A., Magnussen, H. and Nowak, D. 2002. Passive Smoking Exposure A Risk Factor for Chronic Bronchitis and Asthma in Adults? *Chest* 122: 1086-90.
- Ramadour, M., Burel, C., Lanteaume, A., Vervloet, D., Charpin, D., Brisse, F. and Dutau, H. 2000. Prevalence of Asthma and Rhinitis in relation to Long-term Exposure to Gaseous Air Pollutants. *Allergy* 55: 1163-69.
- Reddy, V.S., Engelbrecht, J.P., Swanepoel, L. and Mostert, J.C. 1996. Airborne Particulate Matter Monitoring and Source Apportionment in the Urban Areas of the Vaal Triangle, Olifantsfontein, Nelspruit and Randburg. *27th Annual Clean Air Conference Badplaas*, 20-22 November 1996.
- Republic of South Africa, 1965. *The Atmospheric Pollution Prevention Act (Act number 45 of 1965)*. Government Printer Pretoria.
- Republic of South Africa, 1996. *Constitution of the Republic of South Africa (Act number 108 of 1996)* Government Printer Cape Town.
- Republic of South Africa, 1999. *Tobacco Products Control Amendment Act (Act number 12 of 1999)* Government Printer Pretoria.
- Rizvi, A.A. 2004. Type 2 Diabetes: Epidemiologic Trends, Evolving Pathogenic Concepts, and Recent Changes in Therapeutic Approach. *Southern Medical Journal* 97(11): 1079-87. [Online] Available <http://www.medscape.com/viewarticle/494580?src=mp> [16 December 2004].
- Romieu, I. and Hernandez-Avila, M. 2003. Air Pollution and Health in Developing Countries: A Review of Epidemiological Evidence. (In McGranahan, G. and Murray, F. (eds). *Air pollution & Health in Rapidly Developing Countries*). Earthscan, London. ISBN 185383985: 49, 58.
- Sasol and Eskom. 2004. Air Quality Monitoring Data from Stations in the Vaal Triangle (unpublished).
- Schwela, D. 2003. Local Ambient Air Quality Management (In McGranahan, G. and Murray, F (eds) *Air pollution & Health in Rapidly Developing Countries*). Earthscan, London. ISBN185383985: 70.
- Scorgie, Y., Kneen, M.A., Annegarn, H.J. and Burger, L.W. 2003. Air Pollution in the Vaal Triangle- Quantifying Source Contributions and Identifying Cost-effective Solutions. *Proceedings of the National Conference of the National Association for Clean Air (NACA), Vanderbijlpark*, October 2003.

- Sears, M.R., Greene, J.M., Willan, A.R., Wiecek, E.M., Taylor, D.R., Flannery, E.M., Cowan, J.O., Herbison, G.P., Silva, P.A. and Poulton, R. 2003. A Longitudinal, Population-based, Cohort Study of Childhood Asthma followed to Adulthood. *New England Journal of Medicine* 349(15): 1414-22.
- Sexton, K., Selevan, S.G., Wagener, D.K., Lybarger, J.A. 1992. Estimating Human Exposure to Environmental Pollutants: Availability and Utility of Existing Databases. *Archives of Environmental Health*: 47(6): 398-407.
- Sitas, F., Madhoo, J. and Wessie, J. 1998. Incidence of Histologically Diagnosed Cancer in South Africa, 1993-1995. *National Cancer Registry S.A Institute for Medical Research*.
- Smith, K.R. and Akhar, S. 2003. Health-Damaging Air Pollution: A Matter of Scale (In McGranahan, G. and Murray, F (eds). *Air pollution & Health in Rapidly Developing Countries*). Earthscan, London. ISBN 185383985: 21, 25, 30.
- South Africa Yearbook 2003/2004. [Online] Available <http://www.gcis.gov.za/docs/publications/yearbook.htm>: 389-95 [13 May 2004]
- South African Demographic and Health Survey (SADHS). 1998. ISBN 0-621-31456-X: xii, 169, 171,172,196,197,201,212,213,223,227,231,234,239,241,245,247. [Online] Available <http://www.doh.gov.za/search/index.html> [28 October 2003].
- Statistics South Africa 2001. *Census in Brief*. Report no:03-02-03.
- Statistics South Africa 2002. *Stats in Brief 2002*. ISBN 0-621-32899-5: 67.
- Sporik, R. and Platts-Mills, T.A.E. 2001. Allergen Exposure and the Development of Asthma. *Thorax* 56(2): ii58-ii63.
- Sumer, T. 2004. Outgrowing Childhood Asthma. *Medscape Allergy and Clinical Immunology*(2). [Online] Available http://www.medscape.com/viewarticle/482720_print [22 July 2004].
- Taussig, L.M., Wright, A.L., Holberg, C.J., Halonen, M., Morgan, W.J. and Martinez, F.D. 2003. Tucson Children's Respiratory Study: 1980 to Present. *Journal of Allergy and Clinical Immunology* 111(4): 661-75.
- Terblanche P. 1991 Vaal Triangle Air Pollution Health Study Progress Report 1990. *Report number 7/90*.
- Terblanche A.P.S, Smit H.E. and Uys L. 1991a. Personal Monitoring of Total Suspended Particulates in South Africa. *Presentation at the 84th Annual Meeting of the Air and Waste Management Association*. 16 – 21 June 1991.

- Terblanche P., Opperman L. and Nel R. 1992. Vaal Triangle Air Pollution Health Study Progress Report 1991. *Report number 10/91*.
- Terblanche A.P.S., Opperman L., Nel C.M.E., Reinach S.G., Tosen G. and Cadman A. 1992a. Preliminary Results of Exposure Measurement and Health Effects of the Vaal Triangle Air Pollution Health Study. *South African Medical Journal*. 81: 550–56.
- Terblanche P., Nel R., Opperman L. and Nyikos H. 1992b. Exposure to Air Pollution from Transitional Domestic Fuels in a South African Population. *Presented at the Fourth Annual Meeting of the International Society for Environmental Epidemiology and the International Society of Exposure Analysis*. Cuernavaca, Morelos, Mexico, 26 – 29 August 1992.
- Terblanche P., Opperman L. and Nel R. 1993: Vaal Triangle Air Pollution Health Study Progress Report 1992. *Report number 11/92*.
- Terblanche, P. 1998. Vaal Triangle Air Pollution Health Study: Bibliography, Summary of Key Findings and Recommendations. ISBN 1-874826-89-7.
- Tosen, G. R., Terblanche, A.P.S., Uys, L. and Turner, C.R. 1992. Design and Operation of an Ambient Air Pollution Monitoring Network in the Vaal Triangle Air Pollution Health Study. *The Clean Air Journal* 18(6): 10.
- Tosen G and Rorich R. 1992a. Observed Variations in Outdoor Gaseous and Particulate Concentrations for 1990/91 in the Vaal Triangle Region. *National NACA Conference* 8 – 10 November 1992 – Vaal Triangle.
- US-EPA. 1996. Inhalation (*In Exposures Factors Handbook Volume I-General Factors*): 3-20, 5-13. EPA/600/8-89/043.
- Van Graan J. 2003. Air Pollution Control Officer DEAT. Personal communication, April 2003.
- Watts, G. 2003 Huge Numbers Must Change Lifestyle to Prevent Epidemic of Diabetes. *British Medical Journal* 327(7428): 1365a.
- Watts, G. 2004. The Defence of Dirt. *British Medical Journal* 328(7450): 1226.
- Wesley, A.G. and Loening, W.E. 1996. Assessment and 2-year Follow-up of some Factors associated with Severity of Respiratory Infections in Early Childhood. *South African Medical Journal* 86(4): 365-8.

Whelan, J. 2002. WHO Calls for Countries to Shift from Acute to Chronic Care. *British Medical Journal* 324(7348): 1237.

World Health Organisation (WHO). 1992. *Our Planet Our Health; Report of the WHO Commission on Health and Environment*. ISBN 92 4 156 148 3.

World Health Organisation (WHO). 2000. Air Pollution Fact Sheet no 187. [Online] Available: <http://222.who.int/inf/inf-fs/en/fact187.html> [6 March 2003].

World Health Organisation (WHO). 2002. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. [Online] Available: <http://www.who.int/whr/2002/en/> [16 April 2003].

World Health Organisation (WHO) 2003 Africa Malaria Report [Online] Available <http://www.rbm.who.int/amd2003/amr2003/ch1.htm> [10 May 2004].

Zemp, E., Elsasser, S., Schindler, C., Künzli, N., Perruchoud, A.P., Domenighetti, G., Medici, T., Ackermann-Liebrich, U., Leuenberger, P., Monn, C., Bolognini, G., Bongard, J.P., Brändli, O., Karrer, W., Keller, R., Schöni, M.H., Tschopp, J.-M., Villiger, B., Zellweger J.P. 1999. Long-term Ambient Air Pollution and Respiratory Symptoms in Adults (SAPALDIA study). *American Journal of Respiratory and Critical Care Medicine*. 159: 1257-66.

Zwi, S., Goldman, H.I., Kallenbach, J.M., Davies, J.C.A., Becklake, M.R. and Reinach, S.G. 1991. Respiratory Health Status of Children in the Eastern Transvaal Highveld. *The Clean Air Journal* 8(3); 11-21.

APPENDIX A: LETTER OF CONSENT AND QUESTIONNAIRE USED IN THE STUDY

Letter of Consent

Dear Participant,

The University of Natal, in collaboration with CSIR and other organisations, is currently conducting a study on air pollution and associated health effects. The study will contribute towards an M Med Sci degree at the University of Natal.

One of the aims of the study is to provide decision support to national authorities in revising air pollution standards for South Africa. Questionnaires are being distributed to a population of individuals who participated in a similar study in 1990, of whom you are one. The information provided by participants is therefore of the utmost importance for the success of the study.

Information is needed regarding your health status, your occupation and the home you live in as well as on your current life style and activities. There are no potential risks to participants as all information will be treated as confidential and will be used for research purposes only. Only overall results will be reported and no reference will be made to any individual's information. Participation in the current study is voluntary.

If you are willing to participate in this study, please sign this form and send it back in the enclosed envelope, together with the completed questionnaire.

Kind regards,

Rietha Oosthuizen.

I hereby declare that I am aware of what the study is about and grant permission that the information provided by me in the questionnaire may be used for research purposes.

Signature (participant)

Please print name and surname

For further information, please contact:

Mrs M A Oosthuizen

Environmentek – CSIR

P O Box 395

Pretoria

0001

e-mail: roosthui@csir.co.za

Tel no: (012) 841 2035

Fax no: (012) 841 2689

**QUESTIONNAIRE
RESPIRATORY HEALTH STUDY
2003**

Thank you for your willingness to participate in this study. You were chosen from a group of Grade fives (Std 3s) of 1990 who participated in a similar study, known as the Vaal Triangle Air Pollution Health Study (VAPS). The aim of the current survey is to study the potential health effects associated with air pollution. Chronic health effects associated with modern life style will also be considered. Your co-operation is of the utmost importance in the success of the study.

In order for us to better understand the health effects, it will be necessary that we obtain information regarding your health status, as well as that of members of your household. We would also need to have information about your house or apartment in order to take indoor air quality into consideration, as well as about your current life style, to study modern chronic diseases.

This study is conducted by the University of Natal and CSIR in collaboration with other organisations and has been approved by an ethics committee.

ALL INFORMATION OBTAINED THROUGH THE STUDY WILL BE KEPT CONFIDENTIAL AND WILL BE USED FOR RESEARCH PURPOSES ONLY.

There is a possibility that the results of the study may lead to further research that would require follow-up with some of the participants.

Once you have received the questionnaire, please complete it as soon as possible and return it to us in the enclosed envelope. A lucky draw will be held where three completed questionnaires will be drawn from those received. These individuals will each receive a prize.

Please note: The questionnaire is printed on both sides

Instructions

Although this questionnaire seems bulky, it should not take longer than 30 minutes to complete. Please note that the questions have been printed on both sides of the pages. Mark your answers where a choice is given, for example:

What is your gender?

- | | |
|-----------|-------------------------------------|
| a) Male | <input type="checkbox"/> |
| b) Female | <input checked="" type="checkbox"/> |

Where a word or figure is required, please answer in the given space(s), for example:

How old are you?

Year Months

If you experience any difficulties in completing the questionnaire, please phone the following person:

Riëtha Oosthuizen

Office no: 012 841 2035 Cell no: 084 652 9132

YOUR PERSONAL (RESPONDENT) INFORMATION (Demographic)

1. What is your gender?

- a) Male 1
b) Female 2

2. What is your date of birth?

YEAR: MONTH: DAY:

3. What is your home language?

- a) Afrikaans 1 e) Zulu 5
b) English 2 f) Swazi 6
c) Sotho 3 g) Other 7
d) Xhosa 4

4. How long have you been living in this town (where you now reside most of the time)?

- a) Since birth 1 d) 4 – 5 years 4
b) Less than 2 years 2 e) 5 – 10 years 5
c) 2 – 4 years 3 f) More than 10 years 6

5. Where did you live before living in this town?

6. How long were you living there?

- a) Since birth 1 d) 4 – 5 years 4
b) Less than 2 years 2 e) 5 – 10 years 5
c) 2 – 4 years 3 f) More than 10 years 6

7. If you do not live in the Vaal Triangle anymore, do you still visit the area?

- a) Yes 1
b) No 2

8. If yes, how many days per year do you spend there?

--	--	--

THE FOLLOWING QUESTIONS PERTAIN TO YOUR CURRENT RESIDENCE

9. Which of the following best describes your home?

- | | |
|--|---|
| a) A single family house, not attached to other houses | 1 |
| b) A single family house, attached to other houses | 2 |
| c) A flat | 3 |
| d) Pre-fabricated home (asbestos/wood) | 4 |
| e) A hostel | 5 |
| f) Other (define) | 6 |

10. a) How many rooms are there in the home? (Don't count bathroom and toilet)

b) How many of these are bedrooms?

11. From where is the water in the home obtained? (Mark Yes or No for each one)

- | | | |
|-----------------------|-----|----|
| a) Municipality | Yes | No |
| b) Private borehole | Yes | No |
| c) Community borehole | Yes | No |

d) Other (Specify) _____

12. Do you use any of the following heating systems? (Mark Yes or No for each one)

- | | | |
|-----------------------------|-----|----|
| a) Wood / coal stove | Yes | No |
| b) Fireplace | Yes | No |
| c) Gas heater | Yes | No |
| d) Asbestos heater | Yes | No |
| e) Portable electric heater | Yes | No |

f) Other (Specify) _____

13. If you do have a portable **gas heater** in your home, how often do you use it during the winter?

- | | |
|--------------------------------|---|
| a) About every day | 1 |
| b) 2 to 3 times a <u>week</u> | 2 |
| c) 2 to 3 times a <u>month</u> | 3 |
| d) Seldom | 4 |
| e) Never | 5 |

14. If you do have a **coal stove** in your home, how often do you use it during the winter?

- | | |
|--------------------------------|---|
| a) About every day | 1 |
| b) 2 to 3 times a <u>week</u> | 2 |
| c) 2 to 3 times a <u>month</u> | 3 |
| d) Seldom | 4 |
| e) Never | 5 |

15. If you do have a **fireplace** in your home, how often do you use it during the winter?

- | | |
|--------------------------------|---|
| a) About every day | 1 |
| b) 2 to 3 times a <u>week</u> | 2 |
| c) 2 to 3 times a <u>month</u> | 3 |
| d) Seldom | 4 |
| e) Never | 5 |

16. What fuel do you **mostly** use for cooking? (Mark only one)

- | | |
|------------------------|---|
| a) Electricity | 1 |
| b) Wood | 2 |
| c) Gas | 3 |
| d) Electricity and gas | 4 |

e) Other (Specify) _____

17. Do you use any of the following equipment in your home? (Mark Yes or No for each one)

- | | | |
|-------------------------|-----|----|
| a) Humidifier | Yes | No |
| b) Air scrubber/cleaner | Yes | No |
| c) Air conditioner | Yes | No |

18. If yes (question 17), how often did you use this equipment the past summer?

- a) About every day

1

- b) 2 to 3 times a week

2

- c) 2 to 3 times a month

3

- d) Seldom

4

- e) Never

5

19. Where did you use the equipment specified in question 17?

- a) All the rooms

1

- b) Living room

2

- c) Bedroom(s)

3

- d) Other (Specify) _____

20. Do you open windows or doors to circulate fresh air into your home during the winter months?

- a) Yes

1

- b) No

2

21. How often did you open windows and doors during the previous winter?

- a) About every day

1

- b) 2 to 3 times a week

2

- c) 2 to 3 times a month

3

- d) Seldom

4

22. Have you ever had problems with leakages, flooding or water damage in your home?

- a) Yes

1

- b) No

2

23. Have you ever had mold or mildew growing on any surface inside your present home? (e.g. on walls, wallpaper, carpets, ceilings, shower, curtains, etc.)

- a) In the shower area (curtain, around bath)

Yes	No
-----	----
- b) In other areas in the home

Yes	No
-----	----
- c) Unknown

Yes	No
-----	----

24. Which of the following pets do you have? (Mark more than one if necessary)

- | | | | | | |
|--------------|-----|----|------------------|-----|----|
| a) None | Yes | No | e) Mice | Yes | No |
| b) Dog(s) | Yes | No | f) Bird(s)/Doves | Yes | No |
| c) Rabbit(s) | Yes | No | g) Guinea pig(2) | Yes | No |
| d) Cat(s) | Yes | No | | | |

h) Other (Specify)

25. Are any of these animals allowed in the home?

- | | |
|--------|---|
| a) Yes | 1 |
| b) No | 2 |

26. Is the home in which you live used on a regular basis by anyone in your household for the following hobbies or crafts? (By regular we mean at least once a week or at least 50 hours per year). (Mark more than one if necessary)

- | | | |
|---------------------------------------|-----|----|
| a) Pottery and ceramics | Yes | No |
| b) Painting (Oil)/spray painting | Yes | No |
| c) Dyes and fibers /fabrics | Yes | No |
| d) Jewelry and enameling | Yes | No |
| e) Metal work | Yes | No |
| f) Automotive (mechanical/electrical) | Yes | No |
| g) Stained glass soldering | Yes | No |
| h) Photography (Darkroom use only) | Yes | No |
| i) Print making | Yes | No |
| j) Furniture stripping | Yes | No |
| k) Wood working | Yes | No |
| l) Silk screening | Yes | No |

m) Other, (Specify) _____

INFORMATION ON SMOKING HABITS

27. Have you ever smoked more than one cigarette per day?

- | | |
|-------------------------------------|---|
| a) Yes (two or more cigarettes/day) | 1 |
| b) No (one or less cigarette/day) | 2 |

28. If yes,

- | | | | | |
|---------------------------|--------|---|-------|---|
| a) Do you currently smoke | a) Yes | 1 | b) No | 2 |
|---------------------------|--------|---|-------|---|

- b) How old were you when you started smoking? _____
 c) How many cigarettes do you smoke per day? _____
 d) If you have quit smoking, how old were you when you quitted?

29. Is there currently anyone who smokes cigarettes, cigars or pipe on a regular basis (daily) in the home where you live?

- | | |
|--------------------------------|---|
| a) No | 1 |
| b) Yes, mother/female guardian | 2 |
| c) Yes, father/male guardian | 3 |
| d) Yes, both parents/guardians | 4 |
| e) Yes, husband/wife | 5 |
- f) Yes, other (specify) _____

30. How many **cigarettes** in total are smoked in the home each day?

- | | | | |
|------------|---|-----------------|---|
| a) None | 1 | d) 21 – 40 | 4 |
| b) 1 – 10 | 2 | e) 41 – 60 | 5 |
| c) 11 – 20 | 3 | f) More than 60 | 6 |

31. How many **cigars** in total are smoked in the home each day?

- | | | | |
|----------|---|-----------------|---|
| a) None | 1 | c) 6 – 10 | 3 |
| b) 1 – 5 | 2 | d) More than 10 | 4 |

32. How many times in total is a **pipe** smoked in the home each day?

- | | | | |
|----------|---|-----------------|---|
| a) None | 1 | c) 6 – 10 | 3 |
| b) 1 – 5 | 2 | d) More than 10 | 4 |

e) Other substances (specify)

GENERAL ACTIVITIES AND LIFESTYLE

33. Do you participate in any of the following activities twice or more per week (Mark Yes or No for each one)

a) One or more of the following: soccer, rugby, hockey, netball	Yes	No
b) Aerobics	Yes	No
c) Exercise with weights	Yes	No
d) Jogging	Yes	No
e) Walking	Yes	No
f) Swimming	Yes	No

h) Other (Specify) _____

EATING HABITS

34. Which of the following do you eat on a regular (at least weekly) basis?

a) Chicken/Fish	Yes	No
b) Red meat	Yes	No
c) Processed food (e.g. polony, meat pies)	Yes	No
d) Vegetables	Yes	No
e) Fruit	Yes	No

35. How often do you eat food fried in oil or fat?

a) Daily	1	b) Weekly	3
c) Seldom	2	d) Never	4

Specify type of oil

36. Do you currently consume any form of alcohol?

a) Yes	1
b) No	2

37. If yes, how many drinks on average do you consume per week? (One glass of wine, one beer or one tot of spirits is considered as one drink)

- a) Less than 7

1

- b) 8 – 14

2

- c) 15 – 21

3

- d) More than 21

4

THE FOLLOWING QUESTIONS CONCERN YOUR HEALTH

38. How would you describe your health compared to that of others of the same age group?

- a) Excellent

1

- b) Good

2

- c) Poor

3

39. Do you have any allergies?

- a) No - **go to question 42**

1

- b) Yes, self diagnosed

2

- c) Yes, diagnosed by a doctor

3

- d) Other

4

40. How often do you take medication for the allergy?

- a) Never

1

- b) Daily

2

- c) 2 x a week

3

- d) 3 x a week

4

- e) Do not know

5

f) Other (Specify) _____

41. What are you allergic to? (Mark each applicable one)

a) Things I eat
Specify: _____

b) Things I inhale
Specify: _____

c) Skin contact
Specify: _____

d) Medication, e.g. Aspirin
Specify: _____

e) Other
Specify: _____

Yes	No
Yes	No
Yes	No
Yes	No

42. How many **days** over the last **2 weeks** have you been absent from work/studies because of illness?

--	--

43. During the **past 12 months**, how many **days** have you been absent from work/study due to illness?

- | | | | |
|-----------|---|-----------------|---|
| a) None | 1 | d) 11 – 15 | 4 |
| b) 1 – 5 | 2 | e) 16 – 20 | 5 |
| c) 6 – 10 | 3 | f) More than 20 | 6 |

44. Due mostly to which illness?
Specify _____

45. Have you ever had any of the following illnesses? (Mark No or Yes for every illness)

a) Bronchitis	Yes	No
b) Pneumonia	Yes	No
c) Earache	Yes	No
d) Hay fever	Yes	No
e) Chronic bronchitis	Yes	No
f) Sinus trouble	Yes	No
g) Rhinitis	Yes	No
h) Running nose	Yes	No

46. How do you predominantly breathe?

a) Through the mouth

1

b) Through the nose

2

Explain

47. When you have a cold, does it normally go to your chest?

a) Yes

1

b) No

2

ASTHMA

48. Has your doctor ever said that you have asthma?

a) Yes

1

b) No

2

If NO, go to question 54.

49. At what age did your asthma start?

a) 0 – 1 years

1

e) 8 – 9 years

5

b) 2 – 3 years

2

f) 10 years and older

6

c) 4 – 5 years

3

g) Unknown

7

d) 6 – 7 years

4

50. a) Do you still have asthma?

a) Yes

1

b) No

2

c) Not sure

3

b) If yes, how frequent

Weekly

1

Monthly

2

Occasionally

3

51. Do you currently take medicine or get treatment for asthma?

- a) Yes

1

b) No

2

52. If you no longer have asthma, at what age did you last have asthma?

- a) 0 - 1 years

1

 e) 8 - 9 years

5

b) 2 - 3 years

2

 f) 10 years and older

6

c) 4 - 5 years

3

 g) Unknown

7

d) 6 - 7 years

4

53. Which months of the year do you have asthma? (Mark each applicable one)

- | | | | | | | | |
|-------------|--|-----|----|--------------|--|-----|----|
| a) January | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | g) July | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |
| b) February | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | h) August | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |
| c) March | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | i) September | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |
| d) April | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | j) October | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |
| e) May | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | k) November | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |
| f) June | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No | l) December | <table border="1"><tr><td>Yes</td><td>No</td></tr></table> | Yes | No |
| Yes | No | | | | | | |
| Yes | No | | | | | | |

CHEST COUGH

54. Do you cough when you wake up in the morning? (Mark one)

- a) No - **go to question 56**

1

b) Yes, the previous 3 months

2

c) Yes, longer than the previous 3 months

3

d) Yes, the previous year

4

e) Yes, longer than the previous year

5

55. When do you cough mostly? (Mark one)

- a) During the day

1

b) During the night

2

c) During the day and the night

3

d) Only when I wake up/go to bed

4

PHLEGM

56. Do you usually have phlegm on the chest? (Mark one)

- a) No - **go to question 58**

1

- b) Yes, with colds

2

- c) Yes, without colds

3

- d) Yes, with and without colds

4

f) Other, Specify _____

57. If "Yes", has this phlegm been present for longer than 3 months of the year?

- a) No

1

- b) Yes, previous year

2

- c) Yes, previous and other years

3

WHEEZE OF THE CHEST

58. Does your chest sound wheezy or whistling when you inhale?

- a) Yes

1

- b) No

2

If NO, go to question 66.

59. Does this wheeze of the chest occur with colds?

- a) No

1

- b) Yes, previous year

2

- c) Yes, previous and other years

3

60. Does this occasionally happen other than with colds?

- a) No

1

- b) Yes, previous year

2

- c) Yes, previous and other years

3

61. When does your chest wheeze mostly, when you **don't** have a cold?

- a) During the day

1

- b) During the night

2

- c) During the day and the night

3

62. During which month(s) of the year do you usually have an episode of wheezing? (Mark each applicable one)

a) January	Yes	No	h) August	Yes	No
b) February	Yes	No	i) September	Yes	No
c) March	Yes	No	j) October	Yes	No
d) April	Yes	No	k) November	Yes	No
e) May	Yes	No	l) December	Yes	No
f) June	Yes	No	m) Unknown	Yes	No
g) July	Yes	No			

63. Have you had attacks of shortness of breath when your chest wheezes?

a) No	1
b) Yes, previous year	2
c) Yes, previous and other years	3

64. Do you ever get attacks of wheezing during or after you have been exercising?

a) Yes	1
b) No	2

65. Have you ever taken any medication for these attacks?

a) Yes	1
b) No	2

66. Have you ever been hospitalized for respiratory ailments?

a) Yes	1
b) No	2

If yes, please provide the following information:

- c) How many times? _____
- d) If possible, specify month and year of **each** admittance:
- i) _____
- ii) _____
- iii) _____
- iv) _____
- v) _____
- vi) _____
- e) List reasons for admittance:
-

OTHER ILLNESSES AND CONDITIONS

67. Are you currently using any medication prescribed by a doctor?

- a) Yes

1

 b) No

2

If yes, please specify _____

68. Within the past **year**, have you had any of the following? (Mark Yes or No for each one)

- | | | |
|-----------------|-----|----|
| a) Bronchitis | Yes | No |
| b) Pneumonia | Yes | No |
| c) Running nose | Yes | No |
| d) Earache | Yes | No |
| e) Hay fever | Yes | No |
| f) Sinusitis | Yes | No |
| g) Asthma | Yes | No |

69. Have you had any other major illnesses or accidents that kept you home or prevented you from participating in any activities during the past year?

- a) Yes

1

 b) No

2

If yes, please specify _____

70. Have you **ever** had any of the following? (Mark Yes or No for each one)

- | | | |
|------------------------------------|-----|----|
| a) Learning disability | Yes | No |
| b) Hyperactivity | Yes | No |
| c) Hepatitis | Yes | No |
| d) Cancer | Yes | No |
| e) Gastro-intestinal diseases | Yes | No |
| f) Heart disease | Yes | No |
| g) High blood pressure | Yes | No |
| h) Stroke | Yes | No |
| i) High cholesterol | Yes | No |
| j) Diabetes | Yes | No |
| k) Painful joints (arthritis/gout) | Yes | No |

71. During the past **12 months** how often have you been bothered by any of the following?

- a) Eye problems _____ times
- b) Nose problems _____ times
- c) Ear problems _____ times
- d) Throat problems _____ times
- e) Chest/lung problems _____ times
- f) Skin problems _____ times
- g) Stomach/abdomen problems _____ times

72. Has anyone in your immediate family ever had any of the following? (Mark Yes or No for each one)

- a) High blood pressure
- b) Stroke
- c) Heart attack/angina/chest pain while exercising
- d) If yes in c above, was it before age 50?

Yes	No
Yes	No
Yes	No
Yes	No

73. Do you consider yourself as?

- a) Overweight

1

- b) Underweight

2

- c) Normal weight

3

- d) Unknown

4

INFORMATION ON OCCUPATION

74. How many years of schooling or other education have you completed?

- a) Did not complete std. 8 (Grade 10)

1

- b) Completed std. 8 (Grade 10)

2

- c) Completed std. 10 (Grade 12)

3

- d) Completed Degree Diploma

4

- e) Completed Post-graduate qualifications

5

75. What is your current employment status?

- a) Employed full time

1

- b) Employed part time

2

- c) Self-employed

3

- d) Student

4

- e) Unemployed

5

- f) Other

6

76. What is your current occupation or job?

a) Job or occupation (please be specific)

b) Type of business or industry

c) Number of years worked at this job

77. Have you ever worked in a dusty environment for more than a year?

a) Yes 1

b) No 2

c) If yes, please specify

78. Have you ever been exposed to gases and/or chemicals in the work place?

a) Yes 1

b) No 2

c) If yes, please specify

PERSONAL VIEWS

79. In your opinion, what factor(s) has the biggest influence on your respiratory health status?

80. Do you perceive the air pollution in the Vaal Triangle as serious?

a) Yes 1 c) Not critical 3

b) No 2 d) Unknown 4

81. If you do not live in the Vaal Triangle any more, do you perceive air pollution levels in the area where you currently live as serious?

a) Yes 1 c) Not critical 3

b) No 2 d) Unknown 4

82. What do you consider the most important source of air pollution in your area?
(Mark one)

- a) Motor vehicles

1

- b) Industries and mines

2

- c) Cigarette smoke

3

- d) Open fires (from areas without electricity)

4

e) Other (Specify) _____

83. Have you noticed unusual odours in your neighbourhood?

- a) Yes

1

- b) No

2

84. If "Yes" for how long have you noticed these odours? (Complete only one)

- a)

--	--

 Years
- b)

--	--

 Months
- c)

--	--

 Days

85. Do you feel that these odours are affecting your health?

- a) Yes

1

- b) No

2

- c) Unknown

3

86. If "Yes" how severely do you feel these odours are affecting your health?

- a) A great deal

1

- b) Fairly

2

- c) Very little

3

- d) Unknown

4

THANK YOU!

Once you have completed the questionnaire, please return it to us in the enclosed envelope.

APPENDIX B: UPPER AND LOWER RESPIRATORY RISK FACTORS INVESTIGATED IN THE UNIVARIATE ANALYSIS

Results from univariate analysis of upper and lower respiratory risk factors investigated.

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Lower Respiratory Illnesses (LRI)						
Pneumonia	Sex (male)	5/7	64/165	3.945	0.618; 42.256	0.118
	Live (outside VT)	2/7	65/165	0.615	0.057; 3.906	0.740
	Visit>30 days	0/2	40/66	0	0; 1.317	0.166
	Pets in house	4/7	102/143	0.535	0.086; 3.835	0.419
	Mould shower and pets	6/7	121/148	1.338	0.152; 63.824	0.311
	Ever-smoker	4/6	56/151	3.392	0.465; 38.323	0.074
	Smoking in house	4/7	51/165	2.980	0.482; 20.938	0.212
	Alcohol>7*	3/5	14/115	10.821	1.098; 135.274	0.02
	Allergy (being allergic)	2/7	59/160	0.684	0.063; 4.353	1.00
	Weight (overweight)	3/7	48/163	1.796	0.252; 11.019	0.430
	Working (in dusty env.)	2/7	20/163	2.860	0.254; 18.802	0.225
	Working (with chemicals).	2/7	24/165	2.350	0.210; 15.296	0.286
	Perception (AP VT. Serious)	6/7	145/165	0.827	0.092; 39.900	1.00
	Perception (AP in area serious)	1/3	15/72	1.900	0.030; 38.459	0.519
	Mould in the house	2/7	55/157	0.741	0.686; 4.72	0.725

Outcome variable	Risk Factor (Exposure) ^{***}	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Lower Respiratory Illnesses (LRI)						
Bronchitis	Sex (male)	6/32	64/142	0.281	0.089; 0.759	0.009
	Live (outside VT)	11/32	57/142	0.781	0.315; 1.853	0.364
	Visit>30 days	5/10	35/59	0.686	0.141; 3.352	0.732
	Pets in house	17/27	89/125	0.687	0.267; 1.854	0.489
	Mould shower and pets	21/26	106/130	0.950	0.306; 3.555	0.334
	Ever-smoker	11/28	50/131	1.048	0.408; 2.599	0.953
	Smoking in house	13/32	44/142	1.523	0.630; 3.584	0.304
	Alcohol>7*	3/21	14/101	1.035	0.173; 4.288	1.00
	Allergy (being allergic)	19/30	42/138	3.948	1.608; 9.968	0.001
	Weight (overweight)	14/32	37/140	2.165	0.895; 5.124	0.084
	Working (in dusty env.)	3/32	20/140	0.620	0.110; 2.316	0.575
	Working (with chemicals).	3/32	24/142	0.508	0.092; 1.861	0.419
	Perception (AP VT. Serious)	29/32	124/142	1.403	0.371; 7.911	0.769
	Perception (AP in area serious)	3/11	13/65	1.500	0.224; 7.424	0.690
Mould in the house	7/30	50/135	0.517	0.175; 1.365	0.153	

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Lower Respiratory Illnesses (LRI)						
Asthma	Sex (male)	3/13	66/160	0.427	0.073; 1.752	0.248
	Live (outside VT)	8/13	60/160	2.666	0.726; 10.791	0.103
	Visit>30 days	4/9	36/61	0.555	0.100; 2.890	0.483
	Pets in the house	6/11	101/140	0.463	0.111; 2.047	0.299
	Mould shower and pets	10/12	118/144	1.101	0.215; 10.924	0.485
	Ever-smoker	7/11	54/146	2.981	0.714; 14.439	0.154
	Smoking in house	2/13	54/160	0.356	0.037; 1.731	0.227
	Alcohol>7*	3/9	15/113	3.266	0.472; 17.179	0.128
	Allergy (being allergic)	11/13	52/155	10.894	2.224; 103.267	<0.001
	Weight (overweight)	6/13	45/158	2.152	0.561; 7.905	0.211
	Working (in dusty env.)	2/13	21/137	1.186	0.119; 6.029	0.688
	Working (with chemicals).	3/13	24/160	1.700	0.279; 7.250	0.430
	Perception (AP VT. Serious)	13/13	139/160	--ND-	0.494; --ND	0.372
	Perception (AP in area serious)	2/9	14/68	1.102	0.100; 6.708	1.000
	Mould in the house	5/10	52/154	1.961	0.428; 8.899	0.296

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Upper Respiratory Illnesses (URI)						
Earache	Sex (male)	23/62	48/112	0.786	0.394; 1.555	0.521
	Live (outside VT)	20/62	47/112	0.658	0.323; 1.321	0.450
	Visit>30 days	12/20	28/49	1.125	0.346; 3.783	1.0
	Pets in house	41/56	67/96	1.18	0.537; 2.671	0.713
	Mould shower and pets	47/58	82/99	0.885	0.356; 2.282	0.896
	Ever-smoker	25/56	36/103	1.500	0.73; 3.07	0.216
	Smoking in house	20/62	36/112	1.005	0.486; 2.047	1.00
	Alcohol>7*	5/45	13/75	0.596	0.154; 1.96	0.435
	Allergy (being allergic)	25/60	37/109	1.389	0.688; 2.790	0.323
	Weight (overweight)	19/62	33/110	1.031	0.491; 2.130	1.000
	Working (in dusty env.)	5/61	18/111	0.461	0.127; 1.388	0.165
	Working (with chemicals)	8/62	21/112	0.641	0.229; 1.642	0.398
	Perception (AP VT. Serious)	56/62	97/112	1.443	0.492; 4.796	0.628
	Perception (AP in area serious)	4/23	12/53	0.719	0.149; 2.809	0.763
Mould in the house	18/58	39/107	0.784	0.371; 1.628	0.485	

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Upper Respiratory Illnesses (URI)						
Sinusitis	Sex (male)	38/104	34/73	0.660	0.343; 1.271	0.214
	Live (outside VT)	35/104	34/73	0.581	0.301; 1.126	0.159
	Visit>30 days	21/33	21/38	1.416	0.492; 4.118	0.629
	Pets in the house	68/93	42/61	1.230	0.565; 2.648	0.588
	Mould shower and pets	79/95	52/64	1.139	0.452; 2.805	0.948
	Ever-smoker	38/95	26/67	1.05	0.528; 2.101	0.244
	Smoking in house	31/104	27/73	0.723	0.365; 1.435	0.333
	Alcohol>7*	12/74	6/49	1.387	0.438; 4.854	0.611
	Allergy (being allergic)	45/102	19/70	2.119	1.051; 4.341	0.026
	Weight (overweight)	36/104	17/71	1.681	0.814; 3.548	0.180
	Working (in dusty env.)	14/103	10/72	0.975	0.375; 2.625	1.000
	Working (with chemicals).	17/104	12/73	0.993	0.412; 2.456	1.000
	Perception (AP VT. Serious)	91/104	64/73	0.984	0.348; 2.659	1.000
	Perception (AP in area serious)	8/38	8/40	1.066	0.305; 3.723	1.000
	Mould in the house	33/99	24/68	0.916	0.456; 1.853	0.792

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Upper Respiratory Illnesses (URI)						
Hay fever	Sex (male)	33/86	39/92	0.846	0.444; 1.609	0.648
	Live (outside VT	35/86	35/92	1.117	0.585; 2.132	0.867
	Visit>30 days	22/37	20/35	1.10	0.388; 3.115	1.0
	Pets in the house	53/75	58/80	0.913	0.428; 1.950	0.859
	Mould shower and pets	65/78	67/82	1.119	0.456; 2.77	0.902
	Ever-smoker	33/77	31/85	1.306	0.662; 2.579	0.646
	Smoking in house	25/86	33/92	0.732	0.370; 1.442	0.343
	Alcohol>7*	9/61	9/63	1.038	0.336; 3.210	1.00
	Allergy (being allergic)	47/86	18/87	4.619	2.253; 9.601	<0.001
	Weight (overweight)	26/85	27/91	1.044	0.520; 2.092	1.000
	Working (in dusty env.).	14/86	11/90	1.396	0.547; 3.631	0.519
	Working (with chemicals)	17/86	12/92	1.642	0.683; 4.042	0.310
	Perception (AP VT. Serious)	78/86	78/92	1.750	0.640; 5.088	0.261
	Perception (AP in area serious)	9/38	7/41	1.507	0.434; 5.387	0.578
	Mould in the house	31/81	26/86	1.430	0.716; 2.863	0.27

Outcome variable	Risk Factor (Exposure)***	Cases	Controls	Crude OR	95% confidence interval of OR	p-value of Fisher exact
Upper Respiratory Illnesses (URI)						
Hyper URI**	Sex (male)	17/36	54/138	1.391	0.618; 3.104	0.447
	Live (outside VT)	13/36	54/138	0.879	0.375; 1.994	0.963
	Visit > 30 days	6/13	34/56	0.554	0.135; 2.234	0.367
	Pets in house	22/31	86/121	0.994	0.391; 2.706	1.0
	Mould shower and pets	28/33	101/124	1.275	0.420; 4.678	0.795
	Ever-smoker	15/32	46/127	1.553	0.653; 3.648	0.497
	Smoke					
	Smoking in house	9/36	47/138	0.645	0.246; 1.562	0.325
	Alcohol > 7*	4/25	14/95	1.102	0.239; 4.016	1.00
	Allergy (being allergic)	21/36	41/133	3.141	1.377; 7.221	0.003
	Weight (overweight)	12/36	40/136	1.200	0.495; 2.784	0.685
	Working (in dusty env.)	2/36	21/136	0.322	0.035; 1.437	0.169
	Working (with chemicals)	6/36	23/138	1.000	0.305; 2.831	1.000
	Perception (AP VT. Serious)	34/36	119/138	2.714	0.601; 25.084	0.254
	Perception (AP in area serious)	3/14	13/62	1.027	0.161; 4.740	1.000
Mould in the house	15/34	42/131	1.672	0.713; 3.858	0.187	

* Consuming more than 7 drinks per week.

** Having sinusitis, earache and hay fever

*** Exposure category considered relative to reference category, e.g. for sex, male was exposure and female reference.

ND Not determined - 0 in calculation

Figures in bold indicate significant factors that will be investigated through logistic regression