A SURVEY OF THE RESPIRATORY HEALTH STATUS OF 10-YEAR-OLD CHILDREN IN THE VAAL TRIANGLE PRIORITY AREA IN 1990 AND IN 2010

A cross-sectional inter-comparative study

by

ANTONY JINO MUNDACKAL

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SUPERVISOR: DR J WICHMANN
CO-SUPERVISOR: DR CY WRIGHT

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DECLARATION

I, AJ Mundackal, hereby declare that this dissertation which I hereby submit for the degree Masters in Community Health at the School of Health Systems and Public Health at the University of Pretoria is my own work and has not previously been submitted by me for any other degree or examination at any other tertiary institution.

_____

Antony Jino Mundackal

Signed on the _____ day of _____ in _____

DEDICATION

This work is dedicated to my parents and family who supported me a great deal.

PUBLICATIONS/PRESENTATIONS

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

National Association for Clean Air (NACA) 12-14 October 2011

The Vaal Triangle Multi-stakeholder meeting and medical forum in 2010, 2011, 2012, and 2013.

The study design and methodology were published in:

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ABSTRACT

Background: The Vaal Triangle is an area generally associated with a number of harmful determinants of health since it houses diverse industrial processes and industrial development in South Africa, hence being categorised as an outdoor air pollution priority area in 2006.

Method: A cross-sectional inter-comparative study to the 1990 Vaal Triangle Air Pollution and Health Study (VAPS) was conducted in 2010. The main objectives of this study were to measure the prevalence of upper and lower respiratory illnesses of 10-year-old children in 2010 and compare those findings to the 1990 study, and lastly to identify risk and protective factors for respiratory illnesses in 1990 and in 2010. In addition, the association between exposure factors (risk and protective factors) that are sources of indoor air pollution and factors related to diet and household living conditions and their associations with upper and lower respiratory health illnesses in 1990 and 2010 was determined.

Results and Discussion: The prevalence of the respiratory health outcomes in the 1990 study and 2010 study cannot be compared directly since a 1-year prevalence was determined in 1990 and a 6-month prevalence in 2010. Throughout the dissertation this should be kept in mind. The change in prevalence of a respiratory health outcome observed in 1990 and in 2010 is just an indication of the possible change. The 1990 1-year prevalence and the 2-week 2010 prevalence of asthma were the same in the two study populations (i.e. 12%). The 6-month prevalence of sinusitis, bronchitis and pneumonia in 2010 was lower when compared to the yearly prevalence of these illnesses in the 1990 study. On completion of the multivariate analyses, in 1990 study, the use of a gas heater acted as a risk factor for pneumonia (a lower respiratory illness), with a odds ratio of 3.67 (1.15-11.71) and a p-value of 0.03, whilst environmental tobacco smoke within the household was protective of hay fever and sinusitis (upper respiratory illnesses). In the 2010 study, the consumption of chicken and/or fish and fruit at least three times a week was protective of bronchitis (with odds ratios of 0.23 and 0.26 respectively).

Conclusion and Recommendations: It is not certain whether the change in the respiratory health status of 10-year-olds living in the Vaal Triangle is real as the prevalence of health outcomes in the two studies cannot be compared directly to one another due to the differences in prevalence time periods in the two studies.

Nevertheless, a statistically significant change was observed in the prevalence of sinusitis, earache, bronchitis, and pneumonia between the two study populations. It is imperative to have a study protocol; this ensures all levels of measure are consistent in both studies and leads to a dataset of high quality. There is also a need for more analytical epidemiological studies (i.e. cohort, time-series, case-crossover and panel studies) to be done in South Africa, addressing indoor and outdoor air pollution and respiratory health.

SAMEVATTING

Agtergrond: Die Vaaldriehoek is ‘n area wat gewoonlik verbind word met bepaalde faktore wat ‘n negatiewe uitwerking op gesondheid mag hê, omdat verskeie van die industriële prosesse en industriële ontwikkelings in Suid Afrika hier geleë is. Gevolglik is die area in 2006 as ‘n prioriteitsarea in terme van buitenshuiselugbesoedeling geklassifiseer.

Metode: ‘n Momentopname studie is in 2010 gedoen met die doel om hierdie studie met die “Vaal triangle Air Pollution and health Study (VAPS)” van 1990 te vergelyk. Die hoofoogmerke van die studie was om die voorkoms van boonste- en onderstelugwegsiektes in 10-jaar oue kinders in 2010 te bepaal en met die van 1990 te vergelyk, om risikofaktore te identifiseer wat hierdie siektes bevorder asook om beskermdefaktore te identifiseer wat die siektes teenwerk, en om uiteindelik voorstelle vir verdere navorsing te maak. Verder is die verband tussen blootstellingsfaktore (beide risiko- en beskermendefaktore) soos bronne van binnenshuiselugbesoedeling, diet en lewensomstandighede en lugwegsiektes bepaal vir 1990 en 2010.

Resultate en bespreking: Die voorkoms van lugwegsiektes in 2010 kon nie direk met die van 1990 vergelyk word nie, omdat die voorkoms in 1990 oor ‘n tydperk van een jaar bepaal is en in 2010 oor ses maande. Hierdie feit moet deurgaans in gedagte gehou word. Die verandering in voorkoms van ‘n lugwegsiekte in 1990 in vergeleke met 2010 is dus slegs ‘n aanduiding van ‘n moontlike verandering. Die voorkoms van 12% oor een jaar vir asma in die 1990 studie, was dieselfde as die voorkoms bepaal oor ses maande in 2010. Die voorkoms van sinusitis, bronchitis en longontsteking bepaal oor ses maande in 2010 was laer as die voorkoms vir dieselfde siektes gemeet oor een jaar in 1990.

Na ‘n meerveranderlikevariansie ontleding van die data is die gebruik van ‘n gasverwarmer uitgewys as ‘n risikofaktor in 1990 vir die onderstelugwegsiekte, longontsteking, met ‘n kansverhouding van 3.67 (1.15 – 11.71) en ‘n p-waarde van 0.03, teryl tabakrook in die huis ‘n beskermende factor was in die geval van hooikoors en sinusitis (beide boonstelugwegsiektes). In die 2010 studie was die inname van hoender en of vis en vrugte ten minste driekeer per week, ‘n beskermende faktor teen bronchitis, met ‘n respektiewelike kansverhouding van 0.23 en 0.26.

Gevolgtrekking en aanbevelings: Die verandering wat waargeneem is in die respiratoriese gesondheidstoestand van 10-jaar oue kinders in die Vaaldriehoek, kan nie bevestig word nie, omdat die voorkoms in die twee studies nie direk vergelyk kan word nie, as gevolg van die verskil in tydperk van waarneming. Daar is egter ‘n statisties betekenisvolle verskil waargeneem in die voorkoms van sinusitis, oorpyn, bronchitis en longontsteking tussen die twee studies. Dit is van uiterste belang om ‘n studieplan te hê, want dit verseker dat bepalings konsekwent toegepas word om ‘n databasis van hoë gehalte daar te stel. Daar is ‘n behoefte aan meer analitiese epidemiologiese studies (soos kohort-, tydreeks-, en paneelstudies asook oorkruis-gevallestudies) in Suid Afrika om binnenshuise-, asook buitenshuise-lugbesoedeling en lugwegsiektes aan te spreek.

LIST OF ABBREVIATIONS

ACS	American Cancer Society
AHSMOG	Adventist Health Study of Smog
APHEA	Air Pollution and Health: a European Approach
AQI	Air Quality Index
AQMP	Air Quality Management Plan
ARI	Acute Respiratory Infection/Illness
ATSDR	Agency for Toxic Substances and Disease Registry
C EPA	Californian Environmental Protection Agency
CI	Confidence Interval
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Disease
CSIR	Council for Scientific and Industrial Research
CVD	Cardiovascular Disease
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DoH	Department of Health

EC	European Commission
EEA	European Environment Agency
EIP	Environmental Implementation Plan
EMP	Environmental Management Plan
HRA	Health Risk Assessment
HPA	Highveld Priority Area
IDP	Integrated Development Plan
LRI	Lower Respiratory Infection/Illness
NAAQS	National Ambient Air Quality Standard
NEMAQA	National Environmental Management: Air Quality Act
NIEHS	National Institute of Environmental Health Sciences
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
O_3	Ozone
OR	Odds Ratio
Pb	Lead
PEACE	Pollution Effects on Asthmatic Children in Europe

PM	Particulate matter
$PM_{2.5}$	Particulate Matter with a mean aerodynamic diameter of 2.5 micrometers or less
PM_{10}	Particulate Matter with a mean aerodynamic diameter of 10 micrometers or less
REC	Research Ethics Committee
RfC	Reference concentration
RfD	Reference dose
RSA	Republic of South Africa
SAAQIS	South African Air Quality Information System
SAPALDIA	Swiss Study on Air Pollution and Lung Diseases in Adults
SHSPH	School of Health Systems and Public Health
SO_x	Sulphur oxides
SO_2	Sulphur dioxide
TSP	Total suspended particulate
UFP	Ultrafine particles
UP	University of Pretoria
URI	Upper Respiratory Infection/Illness

USA	United States of America
USA AQS	United States of America Air Quality Standard
US EPA	United States Environmental Protection Agency
VAPS	Vaal Triangle Air Pollution and Health Study
VOC	Volatile Organic compounds
VTAPA	Vaal Triangle Airshed Priority Area
WHO	World Health Organization

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CHAPTER ONE – BACKGROUND AND MOTIVATION OF THE STUDY

1.1. INTRODUCTION

This chapter describes the background and motivation/focus of the study and defines the problem statement and study objectives. Finally, it concludes with an outline of the structure of this dissertation.

1.2. BACKGROUND

There is a perception amongst some members of the public that the indoor air pollution and respiratory health status of children in the Vaal Triangle has not improved during the past 20 years. Therefore, it is imperative to find out the current respiratory health status since the 1990 Vaal Triangle Air Pollution and Health Study (VAPS).

The Vaal Triangle, in the central interior of South Africa, is an area generally associated with a number of harmful determinants of health, since it encompasses a variety of industrial processes and industrial development in South Africa [1].

There are numerous epidemiological studies which link air pollution with human health outcomes, especially to respiratory health [1-5]. This study site is appropriate to determine respiratory health outcomes since the Vaal Triangle, which is situated between the Gauteng and Free State provinces of South Africa, was categorised as an air pollution priority area due to the elevated levels of pollutant concentrations within the area. Air pollution epidemiological studies in South Africa have been documented in the review by Wichmann and Voyi in 2005 [6]. A few more studies have been conducted in South Africa in the meantime [7-13].

Respiratory health is not only influenced by air pollution but rather a wide array of factors. However, the main risk factor of interest in this dissertation is air pollution and specifically indoor air pollution (since indoor air pollution source data were collected in the 2010 study). Outdoor air pollution sources are also important risk

factors to respiratory health, but the focus of this study will be specifically on indoor air pollution since outdoor air pollution sources were not measured in the study.

In the late 1980s, perceptions existed that air pollution in the Vaal Triangle was increasing exponentially. Several role players and stakeholders came together raising concerns and this instigated the VAPS in 1990. The main aims of this study were, firstly, to determine concentrations of air pollution in the Vaal Triangle, thereby assessing the adequacy of the air pollution control programme in South Africa. Secondly, to determine whether the concentrations of the pollutants were injurious to human health, by focusing on the health impacts of air pollution [6,14].

Earlier studies conducted in the Vaal Triangle demonstrated that children spent up to 20% more time outdoors than, for example, children in the United States of America (USA) [6], indicating that air pollution at urban background levels (i.e. ambient levels) are important when determining exposure of South African children to air pollution. The main findings of the VAPS were: Air pollution during winter times was 2 to 4 times worse than during summer times; acceptable total suspended particulate (TSP) levels were exceeded throughout the study period, whereas spikes in SO_2 were evident during winter months. Other criteria pollutants such as ozone (O_3) and nitrogen oxides (NO_x) were within permissible limits. [6]

In 1993, the VAPS came to a premature end; since the set out objectives had been achieved, the main findings of the VAPS were: the gaseous pollutants and total suspended particulate matter were above standards and the use of coal was the most important risk factor for respiratory illnesses. Additionally, 65% of the population suffered from upper respiratory illnesses (URIs) and 29% from lower respiratory illnesses (LRIs) [3].

Throughout the mid to late 1990's, when particulate matter (PM) was investigated, it was of interest to the surrounding mines, industries and areas, when domestic fuel burning was increasing. PM was monitored during the VAPS in 1990, and again in 2003 and 2004 with the aid of permanently installed monitoring stations. It was evident that levels of PM of less than 10 μm (PM_{10}) were higher than the United States of America Air Quality Standards (USA AQS), especially in areas where domestic fuel burning was a norm. [1,14]

The presence of various sources of air pollution in the Vaal Triangle resulted in exceedances of the National Ambient Air Quality Standards of South Africa (NAAQS), thereby justifying the need for the area to be declared the first priority area (in terms of air quality) by the Minister of Environmental Affairs and Tourism on 26 of April 2006, under the National Environmental Management: Air Quality Act (Act 39 of 2004).

South Africa has three outdoor air pollution priority areas: the Highveld priority area (HPA), the Waterberg priority area and the Vaal Triangle Airshed priority area (VTAPA). The latter air pollution priority area is of interest in the current project.

1.3. FOCUS OF THIS DISSERTATION

The objective of this study was to ascertain whether a change, if any, in respiratory health status, in addition to identifying risk factors that are proxies for indoor air pollution and other possible risk factors related to diet and household living conditions, when compared to the VAPS, has occurred among school children living in the Vaal Triangle in 2010. The monthly outdoor PM_{10} concentration of the 2010 study are also compared to NAAQS and World Health Organisation (WHO) guidelines, but was not an objective of the study, rather added value to the interpretation of the results.

The output of this research project will provide potentially useful information on the current respiratory health status of children in the Vaal Triangle (2010), which is presently not known, and will determine any changes since the baseline study in 1990. The results of this study have been presented to the Department of Environmental Affairs (DEA) and Department of Health (DoH). It may add insight to studies related to indoor air pollution and possible risk factors related to diet and living conditions.

1.4. PROBLEM STATEMENT

The change, if any, in the respiratory health status of children living in the Vaal Triangle in 2010, compared to the respiratory health status of children who participated in the 1990 VAPS, is not known.

1.5. OBJECTIVES

The main objectives of the study were:

- to measure the prevalence of upper and lower respiratory health illnesses of 10-year olds in the Vaal Triangle priority area(VTAPA) in 2010
- to identify risk and protective factors, if any, for upper and lower respiratory tract illnesses;
- to compare the prevalence of upper and lower respiratory health illnesses in 10-year olds in the VTAPA in the 1990 and 2010 study populations and
- to provide recommendations for other related projects and future studies.

1.6. STRUCTURE OF THIS DISSERTATION

The dissertation is structured according to six chapters as described below:

Chapter 1 – Background and motivation for the study: This chapter describes the background and motivation/focus of the study and defines the problem statement and study objectives. Finally, it concludes with an outline of the structure of this dissertation.

Chapter 2 - Foundation and research problem: In this chapter, the epidemiological foundation and research problem is established, focusing on epidemiology study design, air pollution and its link with human health. Upper and lower respiratory

health illnesses and health risk assessment will be discussed. The concepts of air quality indexes, air quality standards and air quality management plans will also be addressed.

Chapter 3 - Research design and methodology: This chapter concentrates on the research design and methodology of this cross-sectional study. The reason why this method is appropriate for this specific study is provided; thereafter the research procedures conducted during the study are explained and justified. The ethical considerations applicable to the study are also documented.

Chapter 4 - Results: This chapter describes the sample population, i.e. the demographics and descriptive statistics, living conditions, respiratory health status, and the personal perceptions of the study population. The unadjusted and adjusted associations between risk/protective factors and respiratory health outcomes will be presented.

Chapter 5 – Discussion: This chapter will highlight the important findings and interpret these in relation to the study objectives as well as the literature. The causality of the multivariate regression results will be addressed. The strengths and shortcomings of the study will be discussed.

Chapter 6 - Conclusions and recommendations: The final chapter summarises the conclusions of the research outcomes and research problem. Additionally the recommendations are discussed with the need for further recommended research also being documented.

CHAPTER TWO – FOUNDATION AND RESEARCH PROBLEM

2.1. INTRODUCTION

In this chapter, the epidemiological foundation and research problem will be established focusing on an epidemiologic study design, air pollution and its link with human health. Air pollution is the main risk factor of interest, and in this study specifically indoor air pollution sources. Upper and lower respiratory health illnesses and health risk assessment will be discussed. The concepts of air quality indexes, air quality standards and air quality management plans will also be discussed.

2.2. RESPIRATORY ILLNESSES IN CHILDREN

The respiratory system is differentiated into the upper and lower respiratory tracts. The upper respiratory tract consists of airways from the nostrils to the vocal cords in the larynx and also is inclusive of the paranasal sinuses and middle ear. The lower respiratory tract consists of the airways of the trachea, bronchi, bronchioles and the alveoli (refer to Fig. 2 on page 9) [15].

Likewise, respiratory illnesses can be differentiated into upper respiratory tract illnesses (URIs) and lower respiratory tract illnesses (LRIs), and these are collectively known as respiratory illnesses (ARIs) [15].

URIs include: earache, hay fever and sinusitis. LRIs include: bronchitis, pneumonia, asthma and wheezing.

2.3. AIR POLLUTION

2.3.1. Definition

Air pollution can be defined as the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere [4,16].

2.3.2. Criteria Air Pollutants

In most countries, standards and guidelines for “criteria pollutants” have been developed; these pollutants are globally the most widespread. For South Africa (refer to Table 5), these pollutants are SO_2, NO_2 (nitrogen dioxide), carbon monoxide (CO), O_3, benzene, lead (Pb) and PM [7,17,18].

2.3.3. Sources of air pollution

Air pollution is caused by both natural as well as human activities. Natural causes of air pollution can be volcanic eruptions, wind erosion, veld fires and pollen dispersal whereas those attributed to human activities mostly entail the burning of fossil fuels [16].

Data were collected on sources of indoor air pollution in the 1990 and 2010 studies: the heating systems used in the household, the fuels used for cooking in the household, whether windows are open or closed in the household for purposes of air circulation within the household, the presence of mould or mildew in the household, and the prevalence of environmental tobacco smoke exposure in the household.

SO_2 originates from industrial and commercial fuel-burning processes. NO_2 is derived primarily from vehicle emissions, fossil fuel and biomass (e.g. coal, wood, straw, animal dung) burning. CO is formed through the incomplete combustion of carbon fuels. O_3 is a secondary pollutant formed through complex chemical processes under the presence of ultraviolet light [4,17].

Benzene is classified as a volatile organic compound (VOC) and is generated through industrial processes and vehicle emissions. Pb is found in leaded petrol additives and also in paint [19]. PM is derived from industrial, commercial and household fuel combustion (wood, coal, fire) as well as vehicle emissions [4,17].

2.3.4. Particulate matter physical and chemical properties

Total suspended particulate (TSP) can be categorised into four different fractions, namely: Ultrafine particles (UFP) (particles with an aerodynamic diameter smaller than 100nm), $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than or equal to 2.5µm), PM_{10} and particulates with an aerodynamic diameter greater than 10µm and up to 0.01µm [20].

Figure 1 illustrates the different fractions of PM with the area of deposition within the respiratory tract depicted in Figure 2 (refer to page 22). PM can be deposited in the human respiratory system either at the upper or lower respiratory tract depending on the physical and chemical properties of it.

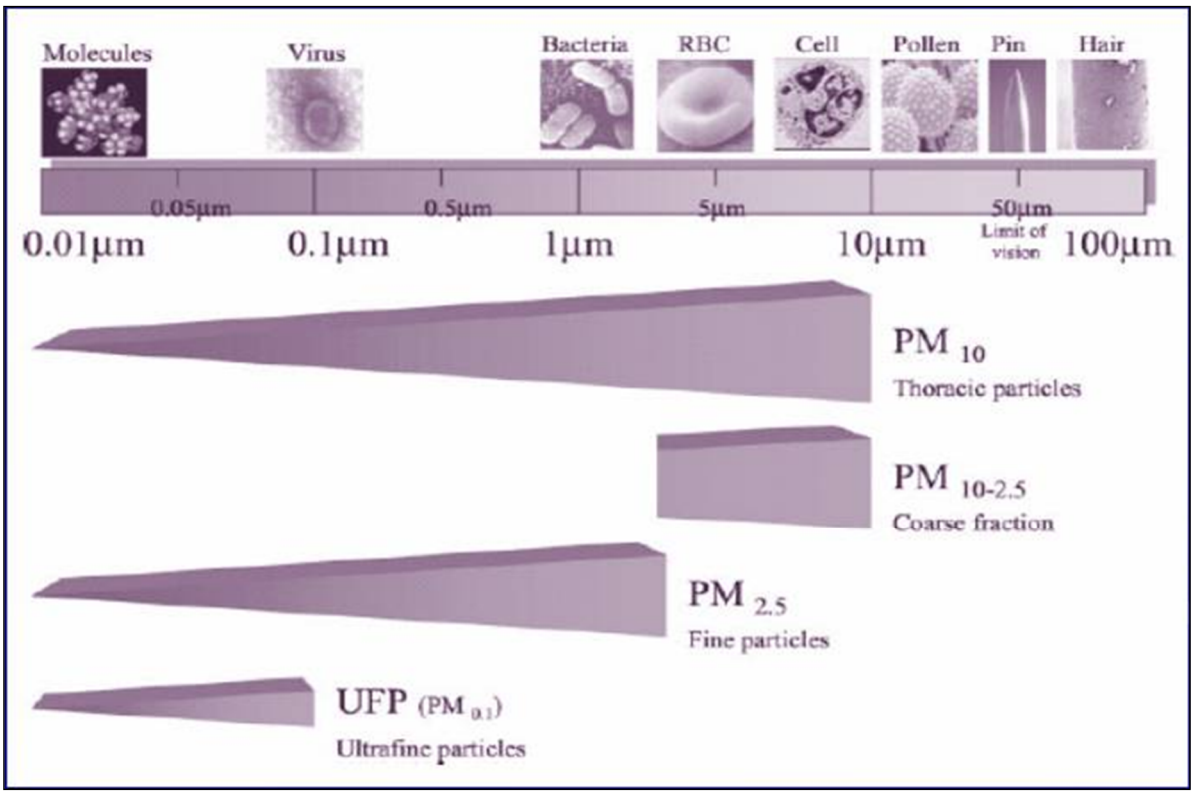

FIGURE 1: **PM DEPICTED IN DIFFERENT FRACTIONS [21].**

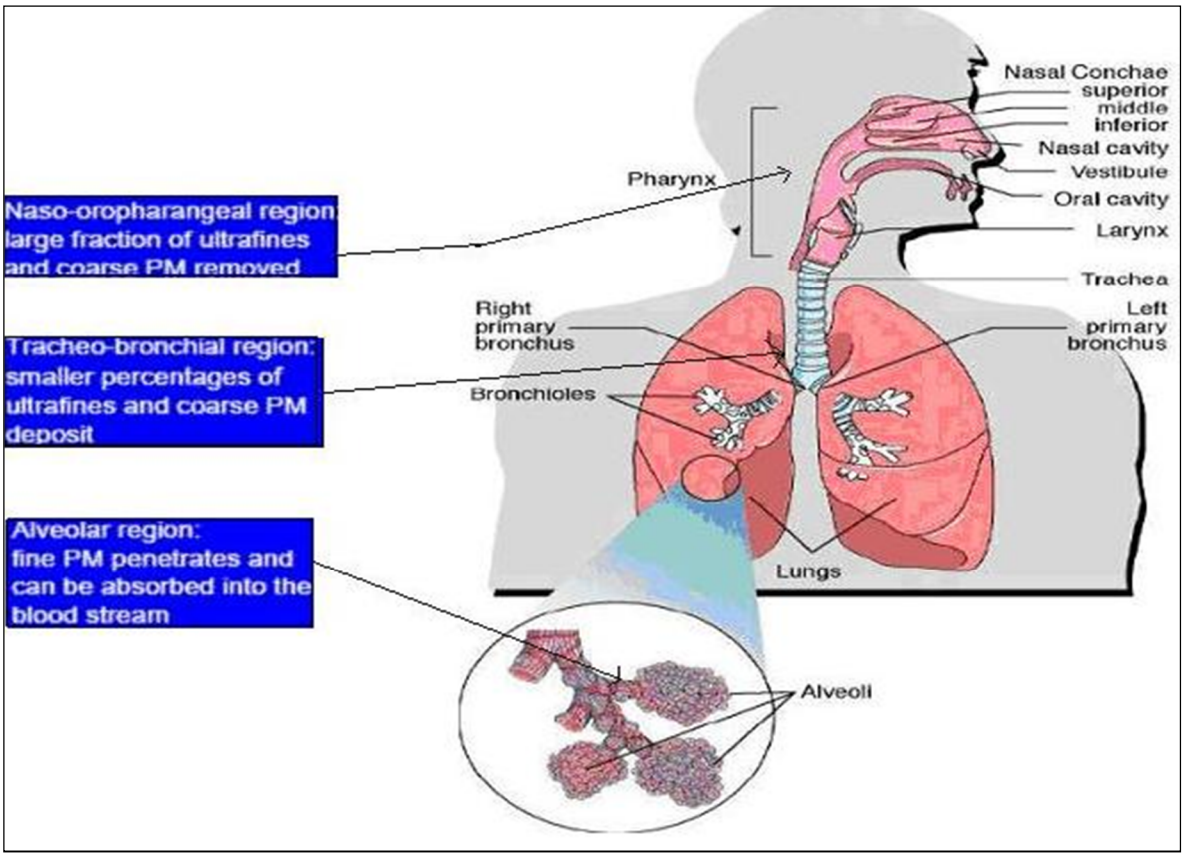

FIGURE 2: DEPOSITION OF PM IN THE RESPIRATORY SYSTEM [21].

The physical properties of PM include particle size and shape, with the shape being that of liquid droplets, regular or irregular shaped crystals and aggregates in odd shapes. The chemical composition of PM also varies from being dilute water solutions of acids or salts, organic liquids, dust, unburned carbon and toxic metals [22].

2.3.5. Exposure

The different ways in which one comes into contact with a pollutant can be described as the pathways or routes of exposure. Upon exposure to contaminated air, food, water, and/or soil, a single one of or combination of these media may possibly contribute to the entire exposure of the individual by means of ingestion, inhalation, dermal contact or a combination thereof. In exposure assessment studies, the ideal approach is to determine total exposure by considering all media (air, water, and soil) and all possible pathways of exposure [3].

Exposure is described by the following four basic characteristics: [3]

- Route or pathway
- Magnitude
- Duration and
- Frequency

The route or pathway of exposure can be: inhalation, ingestion and/or dermal whereas the magnitude of exposure refers to the concentration of the contaminant in the medium of concern. The duration of exposure pertains to the time that the exposure lasts and the frequency of exposure is related to how often the exposure occurs [3]. The quantity of any given pollutant that enters the human body is often termed the dose. The dose is dependent upon the duration and intensity of the exposure and how much the body absorbs [23].

Exposure can occur simultaneously from numerous sources and through several routes. An example of multiple pathways of exposure when considering lead exposure is: air pollution from traffic and industrial emissions, tobacco smoking, food, drinking water, other industrially produced commodities and soil. Hence, exposure assessment necessitates understanding and attaining detailed information about the geographical distribution of the pollutants of concern. In addition, the sequential variations in pollution levels and the course of exposure need to be documented [23-25].

People are exposed to different pollutants simultaneously. Exposure to these may occur at different locations (e.g. in the workplace and/or at home) and at different times. The various exposure pathways are seen in Figure 3 below.

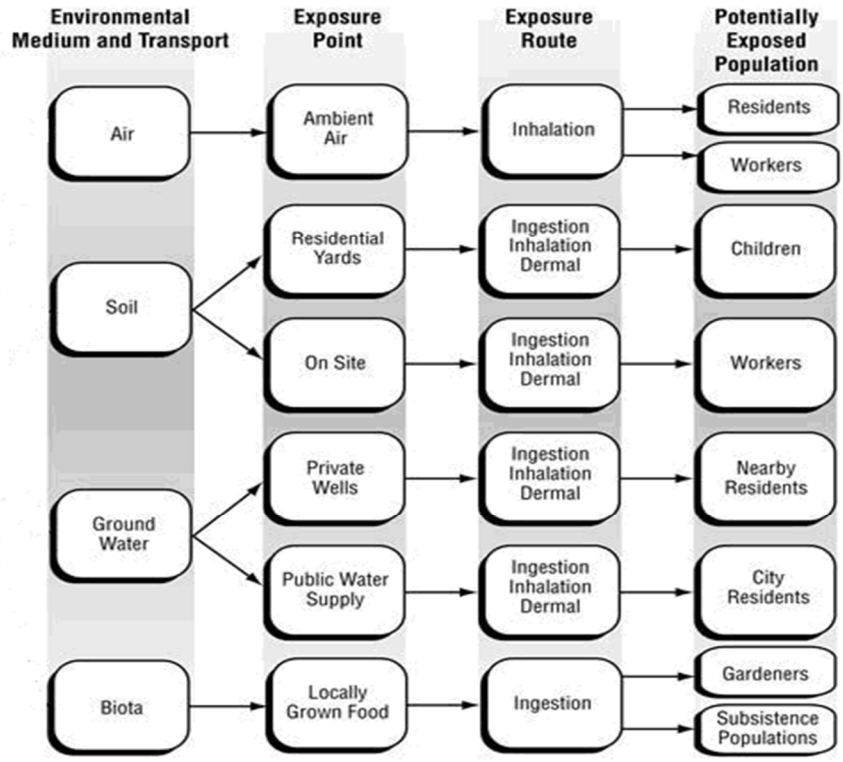

FIGURE 3: EXPOSURE PATHWAYS IN THE SURROUNDING ENVIRONMENT [23].

The exposure pathway with respect to air pollution as per Figure 1 is as follows: Air being the medium of transport, with the exposure point being ambient air, and the exposure route being predominantly inhalation. The potentially exposed population consists of residents (the elderly, mothers, and children) and workers.

A model for air pollution and human health depicts the various sources from which one may be exposed to air pollution (Figure 4). The locations of air pollution are similar to those of PM as discussed by Polichetti and colleagues [26]. There are numerous sources to PM, i.e. industrial output, transportation sources, sources arising from ones house, tobacco smoke, climatic sources, geographical location sources, and those through human activities.

FIGURE 4: THEORETICAL FRAMEWORK OF PARTICULATE MATTER SOURCES [26].

Understanding human exposure to air pollution is not an easy task to undertake. Many epidemiological studies make use of exposure proxies for indoor and outdoor air pollution; this allows further assessment of the burden of disease attributable to respective sources of air pollution [1,4].

It is imperative to know how and where people are exposed to air pollution. These criteria are critical in the identification of individuals who are susceptible to the health impacts of air pollution in addition to the reduction of that risk. Human exposure models that quantify exposure to air pollution are important decision-making tools for the United States Environmental Protection Agency (US EPA), air quality managers and risk assessors [27].

These models are utilised to understand how exposure variances are brought about between people, i.e. children vs. adults, as well as over time. Although air quality monitoring can provide actual current data, limitations arise in that the data are of a specific location and precise time. Exposure models on the other hand can provide predicted exposure in varying conditions. Conditions such as lower air pollutant concentrations attributed to emission reductions or increased time frequency in the presence of high pollutant concentrations can be predicted via these models [27].

2.4. LINKING AIR POLLUTION EXPOSURE TO HUMAN HEALTH

2.4.1. Epidemiology

Epidemiology can be defined as the study of the distribution and determinants of health-related states or events (including disease), and the application of this study to the control of diseases and other health problems, by means of utilising investigations, surveillance, descriptive and analytical studies [28].

There exist several epidemiological study designs which can be conducted in order to determine the distribution and determinants of health problems. Some types of epidemiological studies are: cohort, case-control, cross-sectional and ecological studies [28]. These studies, with their respective characteristics, strengths and limitations are seen in Table 1.

Epidemiological studies usually gather information and analyse data from a real life situation or scenario whilst a toxicological study makes use of laboratory experiments to identify dose-response relationships. Toxicological studies have many shortcomings, i.e. problems arise in extrapolation from high to low dose, interspecies comparisons, exposure route comparisons and the interactions between multiple toxins cannot be quantified [28].

Table 1: Epidemiological study designs with their strengths and limitations [28].

Type of Study	Characteristics	Strengths	Limitations
Cohort	Examines multiple health effects of an exposure; subjects are defined according to their exposure levels; followed for disease occurrence.	Optimal for short induction periods; and can look at multiple outcomes.	Requires large populations; more expensive; Time consuming; and not suitable for rare exposures.
Case-control	Examines multiple exposures in relation to a disease; Subjects are defined as cases and controls, and exposure histories are compared.	Cheaper; convenient; Suitable for rare outcomes (long induction periods); and can evaluate multiple exposures.	Does not estimate risk directly; Recall bias; and difficult to study rare exposures.
Cross-sectional	Examines relationship between exposure and disease prevalence in a defined population at a single point in time.	Can study entire populations or representative samples and provide estimates of prevalence of all factors measured.	Selection bias; misclassification; not good for rare exposures or diseases; and temporal ambiguity.
Ecological	Examines relationship between exposure and disease with population -level rather than individual-level data.	Focuses on group comparison; and Biological inferences can be made.	Limitations in causal inference; Misclassification; and temporal ambiguity.

2.4.2. Health Risk Assessment

A health risk assessment (HRA) can be defined as a formal, step-by-step, scientific process for quantifying health risks to residents (elderly, mothers, children), workers, and recreationalists by incorporating standardised tools, formats, and scientifically accepted assumptions made by experienced toxicologists [29].

A typical HRA has four steps [29]:

- ⇨ Data collection (hazard identification);
- ⇨ Exposure assessment;
- ⇨ Toxicity assessment (dose-response); and

⇨ Risk characterisation.

Data collection (hazard identification) is a step whereby information on the exposure potential, data on site history, the contaminant type and distribution thereof is attained [29]. Here possible health outcomes that could result from exposure in all species are documented. Some of the exacerbated health effects may be: headaches, acute and chronic diseases, cancerous and non-cancerous effects.

An integral process in this step is the identification of studies and other complementing literature that provide precise information on a specific pollutant's structure-activity relationship and the end result with respect to health effects. Studies may include various exposure pathways and routes, with extrapolations done for inter and intra-species variations incorporated [30].

The second step, exposure assessment, documents the duration, routes and pathways of exposure. Information from epidemiological findings and results are used in this step of an HRA [29]. Determination of the duration and the magnitude of the exposure to a specific pollutant or chemical are done. The frequency of exposure and the routes and pathways of the exposure are determined.

All of this information is pooled with additional factors such as breathing rates, water consumption, and time-activity patterns thereby estimating chemical intake [30]. The pathways of exposure are usually: air, water and soil. The routes of exposure are: inhalation, ingestion and dermal absorption. In terms of exposure, further biological samples may be taken such as hair, urine, and blood samples.

The third step of toxicity or dose-response assessment entails the potential of the contaminant to cause health effects in humans and the degree thereof [29]. This step entails determining the amount of the chemical substance needed to exhibit health effects. Different levels of exposure to a chemical can impact the likelihood and severity of health effects. Exposure levels are diverse for numerous cancer-causing chemicals than others with different end-points in terms of health. [30].

Finally, the last step of risk characterisation entails the integration of the previous steps to highlight the human health risks if no action is taken [29]. The available information from all the above-mentioned steps is used by scientists and toxicologists to convey the resultant health effects that may affect the exposed population or population of interest. The final output in terms of the health effects is differentiated into cancer and non-cancer health effects [30].

The dose-response relationships (i.e. odds ratios, relative risks and other effect measures) obtained in epidemiological and toxicological studies are applied in setting air quality guidelines/standards and also in HRA (i.e. for RfC (reference concentration) and RfD (reference dose) values in the last step of HRA).

2.5. HEALTH EFFECTS OF AIR POLLUTION

2.5.1. Current evidence

Exposure to ambient air pollution has been related to a number of different health outcomes, starting from short-lived changes in the respiratory tract and impaired pulmonary function, continuing to restricted activity/reduced performance, emergency room visits and hospital admissions and to mortality [6,14].

There is sufficient evidence that air pollution is detrimental to human respiratory health in both developed and developing countries [31]. It is essential to do more research to ascertain the health effects of exposure to air pollution. Results from one region cannot be extrapolated to another, due to geographical landscape, temperature and climate variations, thereby making it important to conduct studies in South Africa itself. Ambient air pollutants, especially fine and ultra-fine particulates, have an adverse effect on human health, on the basis of their ability to penetrate deep into the lungs and in some instances dissolve into the bloodstream [4,14].

Several health outcomes are exacerbated with exposure to criteria air pollutants. SO_2 health impacts are: the aggravation of existing respiratory conditions in addition to respiratory irritation [17,18]. NO_2 personal exposure may cause individuals to be more susceptible to respiratory infections [17,18]. CO hampers oxygen delivery to

body tissues and cells [17,18]. O_3 is known to cause lung tissue damage and affects the immune system [17,18]. Benzene is known as a human carcinogen [17]. Pb is known to affect the central nervous system, kidneys and reproductive system [17].

The characteristic health effects exacerbated by PM are related to the cardiovascular and respiratory systems, with damage extent dependant not only on concentration and duration of exposure but also on particle size and chemical composition [17]. The majority of existing studies on particulates and their association with human health outcomes have utilised TSP and PM_{10} for the measurement of PM exposure [6].

These health outcomes comprise respiratory or allergic illness, heart disease, cancer, adverse pregnancy and birth outcomes and lowering of male fertility [4,14]. The health effects can be particularly harmful for sensitive groups, namely children, senior citizens, and people with existing diseases such as asthma, cardiovascular and lung diseases that make them susceptible to exacerbated health effects [4,14,26].

Exposure to air pollution considerably increases both morbidity and mortality in the general population [32,33]. Research carried out by the National Institute of Environmental Health Sciences (NIEHS) has shown that long-term exposure to air pollutants increases the risk of respiratory illnesses such as allergies, asthma, chronic obstructive pulmonary disease, and lung cancer [34]. There are certain groups of individuals partially susceptible and sensitive to the health effects of air pollution, i.e. children, older people and people with pre-existing diseases, and these sensitivities could be on the basis of carrying certain genetic traits as well [35,66].

Several groups within the population have potentially higher vulnerability to the effects of exposure to air pollutants, namely: those who become more susceptible as a result of environmental or social factors or personal behaviour and those who are simply exposed to extraordinarily large amounts of air pollutants [1,4,26].

Studies have been conducted mainly in the USA and Europe whereby real or modelled levels of specific air pollutants have been directly linked to the effects on human health, i.e. exposure-response relationships have been determined and these

can be used in health risk assessment studies and in burden of disease estimations (Table 2) [6,14].

Table 2: List of a few air pollution and health studies around the world and their major findings.

Name of the study [year conducted and location]	Length of exposure [type of study]	Major findings
The American Cancer Society (ACS) Cancer Prevention Study II [1982-1989: USA]	Long-term mortality study [cohort study]	Associations between PM, sulphate and mortality* were found [37].
The Six City Cohort Study [1993: USA]	Long-term mortality study [cohort study]	Associations between PM, sulphate and mortality* were found [34].
The Adventist Health Study of Smog (AHSMOG) [1977-1987: USA]	Long-term mortality study [cohort study]	Associations between PM_{10}, SO_2, O_3 and mortality* in men and women [38].
The Air Pollution and Health: a European Approach (APHEA) studies [1995-1999: Europe]	Short-term mortality and hospital admission study [time-series study]	Associations between O_3 and mortality*; increase in chronic obstructive cardiopulmonary (COPD) and cardio vascular disease (CVD) admissions for people older than 65 years with increases in PM_{10} [39].
The National Morbidity, Mortality, and Air Pollution Study (NMMAPS) [1987-1994: USA]	Short-term mortality and hospital admission study [time-series study]	A 1.5% increase in COPD and a 1.1% increase in CVD; hospital admissions were observed for every 10 $\mu g/m^3$ increase in PM_{10} [40].
The Pollution Effects on Asthmatic Children in Europe (PEACE) study [1993/1994: Europe]	Short-term mortality and hospital admission study [panel study]	No clear relation could be established between PM_{10}, SO_2, black carbon, NO_2 and respiratory health [41].
The European Study of Cohorts for Air Pollution Effects (ESCAPE) project [2013]	Cohort studies	Associations between lung cancer and PM_{10} were found. No associations were between lung cancer and nitrogen oxides' concentration [42].

Note: mortality* in the studies refer to both all-cause mortality and respiratory disease mortality.

2.5.2. Children's susceptibility to air pollution

When investigating the health effects exacerbated by exposure to hazardous agents, children represent the largest subpopulation more susceptible than adults to detrimental health outcomes of air pollution [43]. Experimental studies involving children's health have revealed that air contaminants aggravate airway pathology by inducing inflammation [44,45].

Children are susceptible to the adverse effects of air pollution due to a number of traits that they carry. Numerous factors play a role in a child's susceptibility to air pollution [43]. Factors such as socio-economic conditions, demographics of certain populations and lifestyle can be detrimental to upper and lower respiratory health outcomes.

A child can be susceptible to air pollution effects due to differences in physiology, metabolism, growth and development, time-activity patterns and different prevalence rates of acute and chronic diseases [43].

Table 3: Factors relating to a child's susceptibility to the effects of air pollution [43].

Factors	Characteristics
Physiology	Breathe more per unit body weight than adults; and have smaller airways and lungs.
Metabolism	Have different rates of toxification and detoxification.
Lung growth and development	Vulnerable due to on-going development of airways and alveoli; vulnerability due to immature host defence mechanisms.
Time-activity patterns	Time spent outdoors more than adults; Increased ventilation with play and exercise.
Acute disease	High rates of acute respiratory disease.
Chronic disease	High prevalence of asthma and other diseases.

Children require a superior rate of metabolism to sustain their body temperature as they comprise a larger surface-area-to-body-weight ratio than adults do, resulting in rapid body heat loss to the surrounding environment [45]. Children thereby have a greater need for food and oxygen per kg body weight than adults, bringing about higher food consumption and breathing rates. These attributes result in a relative higher exposure to environmental contaminants such as air pollutants [46].

Children's behavioural patterns and their interaction with the environment have an influence on the magnitude of their exposure to air pollutants. They are physically more active than adults, have more hand-mouth contact and spend more times outdoors. These attributes bring about a high breathing rate, increased ingestion and a longer exposure time to outdoor pollutants among children compared to adults [14,45,46]. Hence, children are a susceptible subpopulation with respect to air pollution as depicted in Table 3 above.

Examination of outdoor air pollutants link air pollution with an amplified frequency and severity of upper and lower respiratory symptoms in children [3]. There is also substantiation for possible interactions between exposure to air pollution and infections, and that reducing air pollution could improve children's health [14].

Infants and children inhale and retain larger amounts of air pollutants per unit of body weight than adults, with the air intake of a resting toddler being twice that of an adult. In addition, infants' immature lungs may contribute to a limited metabolic capacity to protect against severe contaminant agent exposures [43].

2.5.3. South African studies

A review by Wichmann and Voyi (2005) summarised 14 epidemiological studies that focused on air pollution [6]. Some of these studies included were the following: the VAPS [1-3,6] and Birth-to-ten study [47] that both commenced in 1990 (both focussed on children), a 2-year follow up study on risk factors for the severity of Acute Respiratory Infection (ARI) in 1996 [48], the historical cohort study of the respiratory health status of adults who spent their developing years in a polluted area in South Africa in 2003 [3].

Wichmann and Voyi (2005) concluded that the vast majority of South African studies were fraud with limitations and that none established exposure-response relationships for the criteria pollutants.

In the mean time more studies have been conducted in the country. These include a study of vulnerabilities of South African communities to air pollution in 2004 [49], indoor air pollution and child respiratory health conducted by Barnes et al. in 2009 [50], the International Study of Asthma and Allergies in Childhood (ISAAC) studies in Cape Town and Polokwane [51-53], the secondary data analyses of the 1998 South African Demographic and Health Survey data [54], the South Durban Health Study (SDHS) conducted by Naidoo et al., in 2007 [55] and the Cape Town petrochemical refinery study carried out by White et al., in 2009 [56] and Wichmann and Voyi (2012) [57]. The latter study was the very first in the country to establish exposure-response relationships for PM_{10}, NO_2 and SO_2 in Cape Town [57].

These South African studies with their major findings are highlighted in Table 4 below. The 1990 VAPS, which served as the comparative study to the current study, was a longitudinal study and incorporated children aged 8-12 years. The main aim of the study was to evaluate indoor and outdoor air pollution levels and health outcomes. Widespread information was attained for indoor, outdoor and personal exposures to air pollution [1]. Preliminary results of the 1990 VAPS indicated that the quantity of PM to which one was exposed was higher than the US EPA standard. [1].

Table 4: Some air pollution and health studies done in South Africa.

Name of the study [year conducted and location]	**Length of exposure [type of study]**	**Major findings / key results**
1990 VAPS [3,6]	Multi-disciplinary, longitudinal study	Average gaseous pollutants concentrations were occasionally exceeding standards but total suspended particulate (TSP) in the air was 2.5 times the

		acceptable level.
The Birth-to-ten study [47]	Longitudinal birth cohort study	54% of the children in the sub study experienced a high frequency of colds and chest illness since birth.
A 2-year follow-up study on risk factors for the severity of Acute Respiratory Infection (ARI) [48]	Case-control study	Subsequent ill health of children who had suffered from pneumonia was not necessarily greater than that of the controls.
A study of the respiratory health status of adults who spent their developing years in a polluted area in South Africa in 2003 [3]	Historical cohort study	The prevalence of respiratory health symptoms in this population was high.
South Durban Health Study (SDHS) [55]	Multi-disciplinary, longitudinal study	Ambient concentrations of NO_2, NO, PM_{10}, and SO_2 were strongly and significantly associated with decrements in lung function among children with persistent asthma
Cape Town petrochemical refinery study [56]	Cross-sectional study	An increased prevalence of asthma symptoms among children in the area as a result of the refinery emissions
Ambient Air Pollution Exposure and	Case-crossover study	In the warm period, PM_{10} was significantly associated with

respiratory, cardiovascular and cerebrovascular Mortality in Cape Town [57]		respiratory and cardiovascular mortality. NO2 had significant associations with cerebrovascular, respiratory and cardiovascular mortality, whilst SO2 was associated with cardiovascular mortality.

All the above-mentioned studies have found key linkages between air pollution and a detrimental effect on human health [14,47,55-57], although direct measurement of air pollution was not done, proxies were used. The only study that linked real air pollution measurements to mortality was that of Wichmann and Voyi (2012) [57]. The key health outcomes for certain studies were: a high incidence of colds, flu and chest illnesses such as pneumonia and bronchitis.

In a South African context, all epidemiological studies carried out highlighted several risk factors which in turn led to specific health outcomes. Some of the risk factors for respiratory illnesses that stood out in the 1990 VAPS were: the presence of mould in the house and an increased prevalence of earache and the use of a gas or asbestos heater were linked to a higher prevalence of sinusitis [1-3]. Household heating is what is relevant here and the resultant increased prevalence of sinusitis. The use of household heaters increases the prevalence of sinusitis irrespective of it being a gas or asbestos heater, i.e. the material of the heater or the type is not of concern.

In the study conducted by Barnes and colleagues in 2009, the use of polluting fuels in households with children, compared to those reliant on electricity, increased the risk of acute lower respiratory infections, which was seen in the households using fuels such as paraffin and wood for cooking and heating purposes [50].

2.6. AIR POLLUTION MANAGEMENT

2.6.1. Air quality guidelines and standards

Urban air pollution has adversely affected the health of individuals in cities of both developed and developing countries. The health and wellbeing of an individual in the developing world is influenced by factors such as population growth, industrialisation and increased vehicle use [58]. These settings, in conjunction with individuals' lifestyles and living environments, have turned out to be the foremost interacting factors that are influencing health and wellbeing [58].

The escalating level of air pollution in some countries threatens public health and as a result, those countries have begun to introduce and enforce air quality regulations and/or standards. Moreover, there exists an ever-increasing interest in understanding the impact of these regulations. The inadequate coverage of air pollution screening confines our ability to gauge the direct impact of these regulations. Air pollution estimates in periods before and after the implementation of the regulations are critical to assess the impact. [4].

In most countries, standards and guidelines for pollutants have been developed [59] and air pollutants are classified into specific categories. In South Africa and globally, the term 'criteria pollutants' is used for those pollutants which cause damaging health effects. These pollutants are SO_2, NO_2, CO, O_3, benzene; Pb and PM [16], as mentioned in Section 2.3.2, 2.3.3 and Table 5.

These standards are predominantly applied with specific time frames since the health impacts attributed to pollutants originate over multiple exposure times such as 10 minutes, 1 hour, 8 hours, 24 hours, and 1 year [60,61]. In South Africa, National Ambient Air Quality Standards (NAAQS) exist for these criteria pollutants and are shown in Table 5 below. CO concentrations have not been included in Table 5 below since the WHO guideline does not incorporate CO in their "common air pollutants". [50].NAAQS are important tools to implement as part of an air quality management programme defined in an air quality management plan, as discussed in the following section.

Table 5: South African NAAQS for SO_2, NO_2, PM_{10} and O_3 [61].

Pollutant	Averaging period	Concentration	Frequency of Exceedance	Compliance Date

SO_2	10 minutes	500µg/m^3	526	Immediate
	1 hour	350µg/m^3	88	Immediate
	24 hours	125µg/m^3	4	Immediate
	1 year	50µg/m^3	0	Immediate
CO	1 hour	30µg/m^3	88	Immediate
	8 hour (calculated on 1 hourly averages)	10µg/m^3	11	Immediate
NO_2	1 hour	200µg/m^3	88	Immediate
	1 year	40µg/m^3	0	Immediate
PM_{10}	24 hours	120µg/m^3	4	Immediate – 31 December 2014
	24 hours	75µg/m^3	4	1 January 2015
	1 year	50µg/m^3	0	Immediate – 31 December 2014
	1 year	40µg/m^3	0	1 January 2015
$PM_{2.5}$	24 hours	65µg/m^3	0	Immediate – 31 December 2015
	1 year	25µg/m^3	0	Immediate – 31 December 2015
O_3	8 hours (running)	120µg/m^3	11	Immediate

The WHO has set air quality guidelines for four common air pollutants, namely: SO_2, NO_2, PM_{10} and O_3. These guidelines are seen in Table 6 below. The WHO air quality guidelines are for purposes of worldwide use but have been developed to support actions thereby achieving air quality that leads to protection of public health in various contexts [62].

Table 6: WHO air quality guidelines for SO_2, NO_2, PM_{10} and O_3 [62].

Pollutant	Averaging period	Concentration

SO_2	10 minutes (mean)	500µg/m^3
	24 hours (mean)	20µg/m^3
NO_2	1 hour (mean)	200µg/m^3
	1 year	40µg/m^3
PM_{10}	24 hours	50µg/m^3
	1 year	20µg/m^3
$PM_{2.5}$	24 hours	25µg/m^3
	1 year	10µg/m^3
O_3	8-hours (mean)	100µg/m^3

The NAAQS varies from the WHO, since the national standards vary from one country to another, and take into account political, social, economic factors and other technological and health risk criteria. Furthermore the level of development and the national capability in air quality management also are essential factors in determining a guideline/standard in terms of air quality in a country [62].

2.6.2. Air Quality Management Plans

Air quality management is essentially the minimisation, management and prevention of air pollution, thereby aiming to improve areas which have deteriorating air quality and sustain good air quality throughout the area [63]. An Air Quality Management Plan (AQMP) refers to a documented plan to certify that air quality in a specific area is in conformity with the National Environmental Management: Air Quality Act, Act 39 of 2004 (NEMAQA) [64]. The plan must delineate all activities to be undertaken to

plan, assess, characterise, mitigate, implement, monitor and review the air quality within the specific area.

The AQMP ensures the constitutional right of the public to air that is not harmful to their health or wellbeing. Furthermore, NEMAQA declares that each National and Provincial Department, responsible for the preparation of an Environmental Implementation Plan (EIP) or an Environmental Management Plan (EMP) should include an AQMP [64]. In addition, each Municipality must include an AQMP in its Integrated Development Plan (IDP). Industries that release emissions which may have a significant impact on ambient air quality, should also prepare an AQMP as part of their EMP [64].

During the 1990 VAPS, air quality management and control was based on stack emission standards for PM, which did not account for ambient levels if multiple sources were present in a specific area [1]. During the follow-up study in 2003 conducted by Oosthuizen et al [3], it was further evident that an effective AQMP was needed to curb the pollution levels in the area. The Vaal Triangle was declared as a priority area in 2006, with an AQMP being developed thereafter.

In South Africa, an AQMP has been put in place in the Highveld priority area and the VTAPA. An AQMP was developed for the VTAPA in 2007 and 2008. The primary aim of the VTAPA AQMP was to develop a plan that ensured, once implemented, that air quality in the area was brought into sustainable compliance with ambient air quality objectives and within agreed timeframes [63].

The VTAPA AQMP was based on scientific data obtained from the baseline characterisation studies and all sources of emissions were identified and quantified with dispersion modelling. This was conducted to determine the status quo of air quality within the Vaal Triangle. This measure of assessment was carried out for the following criteria pollutants: PM_{10}, SO_2 and NO_2 [63].

AQMPs focus on determining the air pollutant concentrations and likely effects which in turn assist in the formulation of control strategies and necessary monitoring and evaluation. This occurs in accordance with appropriate legislation and enforcement in terms of the sources, emissions, transport and transformation of these air pollutants as depicted in Figure 5 below.

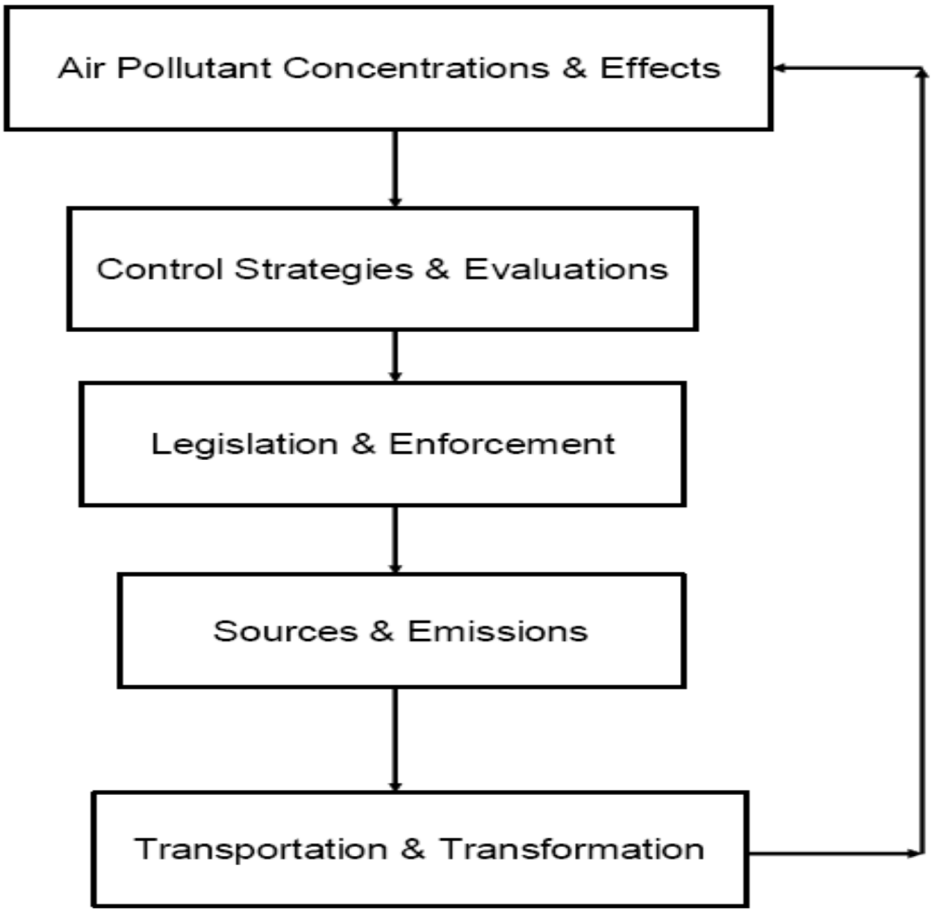

FIGURE 5: COMPONENTS OF AN AQMP [64].

The planning process of an AQMP is extensive and starts with finding out the status quo; the gaps present; setting up a vision and objectives; development of implementation plans; monitoring and evaluation; and review. Public participation is an integral key throughout the formulation of an AQMP. The development of a Baseline Air Quality Status Quo Report through a public participation process, including municipalities, industry and the public, is essential to formulating a high quality AQMP as illustrated in Figure 6 below.

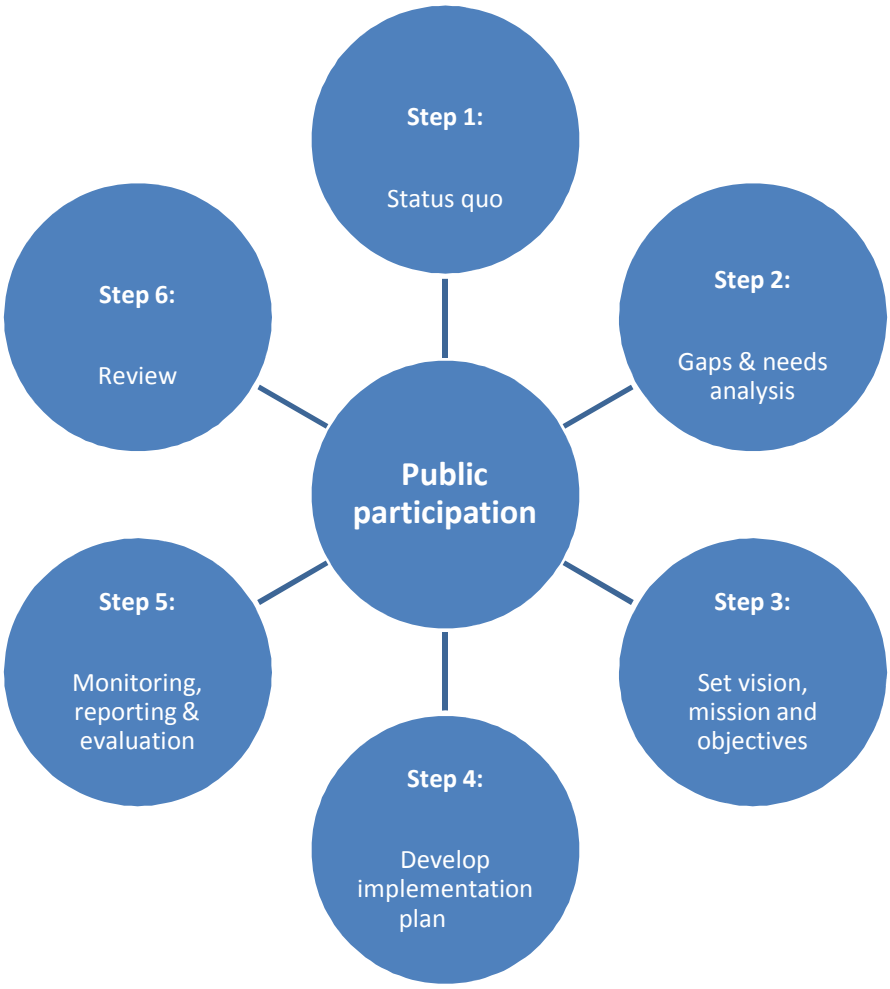

FIGURE 6: PLANNING PROCESS OF AN AQMP [65].

2.6.3. Air quality indexes (AQI)

Since the surrounding air quality is ever-changing, for the assessment of the air quality that one is breathing, an air quality index (AQI) or other similar means can be incorporated. Although an AQI has not been implemented in South Africa, this tool used in conjunction with air quality management plans (AQMP) could provide valuable information in understanding air pollution and its effects, thereby being valuable in a South African setting such as the Vaal Triangle.

The United States Environmental Protection Agency (US EPA) has developed an AQI (Table 6), which serves to endow the public with timely and easy-to-understand information on local air quality and whether air pollution levels are harmful to health. The AQI tells the public how clean the air is and whether or not there is a concern for

human health and whether or not to stay indoors. It focuses primarily on health effects that can happen after acute or chronic exposure to contaminated air [59]. A typical AQI has several bands designated by different colours which in turn signify the levels of health concern attributed to a specific pollutant. The action to protect one's health is dependent upon the AQI value for a specific pollutant as seen in Table 7 below.

Table 7: Classification of the AQI-redrawn [66].

Air Quality Index values	Levels of Health concern	Colours
0-50	Good	Green
51-100	Moderate	Orange
101-150	Unhealthy for sensitive groups	Yellow
151-200	Unhealthy	Red
201-300	Very unhealthy	Purple
301-500	Hazardous	Maroon

The AQI has been formulated for several pollutants of concern, i.e. CO, SO_2, and PM thereby allowing an individual to undertake specific actions to protect them as seen in Table 8. These indexes can be critical in ensuring that air pollution can be controlled to a certain extent. Furthermore individuals will have an idea of what pollutants aggravate their health and at which concentrations or values there are detrimental to health.

Table 8: AQI values for pollutants of concern [66].

Pollutant of Concern	AQI value	Actions to protect your health
	Good (0-50)	None
	Moderate (51-100)	None
	Unhealthy for sensitive groups	People with heart disease, such as angina, should reduce heavy exertion and

CO	(101-150)	avoid sources of CO, such as heavy traffic.
	Unhealthy (151-200)	People with heart disease, such as angina, should reduce moderate exertion and avoid sources of CO, such as heavy traffic.
	Very unhealthy (201-300)	People with heart disease, such as angina, should void exertion and sources of CO, such as heavy traffic.
SO_2	Good (0-50)	None
	Moderate (51-100)	None
	Unhealthy for sensitive groups (101-150)	People with asthma should consider reducing exertion outdoors.
	Unhealthy (151-200)	Children, asthmatics, and people with heart or lung disease should reduce exertion outdoors.
	Very unhealthy (201-300)	Children, asthmatics, and people with heart or lung disease should avoid outdoor exertion. Everyone else should reduce exertion outdoors.
PM	Good (0-50)	None
	Moderate (51-100)	Unusually sensitive people should consider reducing prolonged or heavy exertion.
	Unhealthy for sensitive groups (101-150)	The following groups should reduce prolonged or heavy outdoor exertion: People with heart or lung disease and children and older adults. Everyone else should limit prolonged or heavy exertion.
	Unhealthy (151-200)	The following groups should avoid all physical outdoors: People with heart or lung disease and children and older adults. Everyone else should avoid prolonged or heavy exertion.
	Very unhealthy (201-300)	The following groups should remain indoors and keep activity levels low: People with heart or lung disease and children and older adults. Everyone else should avoid all physical activity outdoors.

The implementation of an AQMP and an AQI in a specific country or priority area can lead to a decrease in air pollution levels.

When conducting a cross-sectional study, as for this dissertation, the methodology incorporated is critical in attaining the study objectives. The methodology of the 2010 study follows in chapter three.

CHAPTER THREE – RESEARCH DESIGN AND METHODOLOGY

3.1. INTRODUCTION

This chapter concentrates on the research design and methodology of this cross-sectional study. The reason why this method is appropriate for this specific study is provided; thereafter the research procedures conducted during the study are explained and justified. The ethical considerations applicable to the study are also documented.

3.2. METHODOLOGY

3.2.1. Study Design

The study was designed as a cross-sectional study to compare the current respiratory health status of 10-year-old children, with children of the same age from the VAPS conducted in 1990. As many as possible of the original parameters from the VAPS, such as the age of the child, area of the school, were duplicated in the 2010 study.

3.2.2. Study setting

The study setting for the VAPS was the 3600 km^2 area, previously known as the Vaal Triangle, which refers to the area between Randvaal in the north, Sasolburg in the southwest and Deneysville in the east, and includes the towns of Evaton, Sebokeng, Sharpeville, Boipatong, Bophelong, Zamdela, Vereeniging, Vanderbijlpark, Sasolburg and Meyerton [1-2]. Of interest in this study though are the three towns of Vereeniging, Vanderbijlpark and Sasolburg (Figure 7), since these are the three towns from which the comparative population was randomly selected. In the 1990 VAPS, the Vaal Triangle included the Local Municipalities of:

- Emfuleni;
- Midvaal;
- Lesedi; and
- Metsimaholo

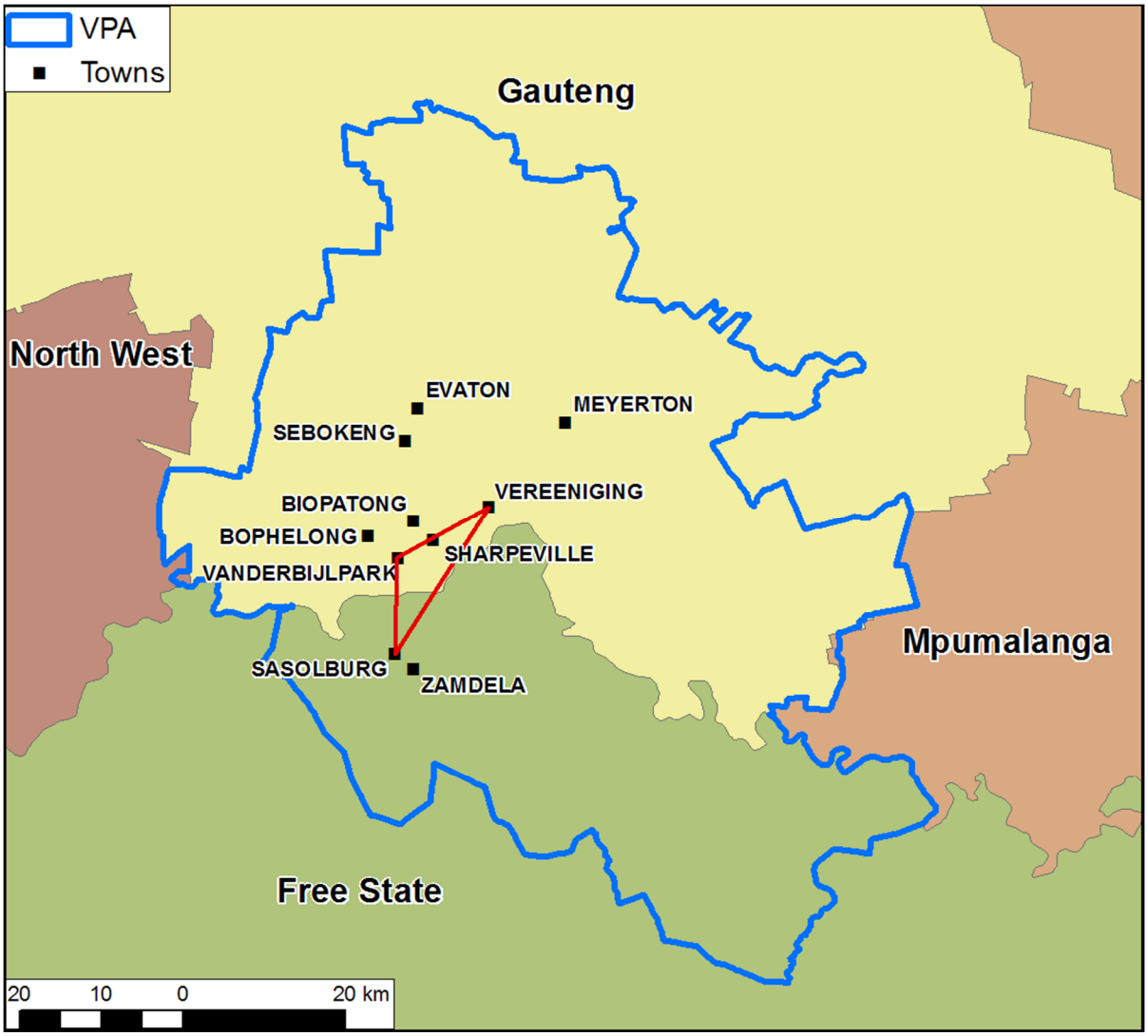

FIGURE 7: THE VAAL TRIANGLE AREA CONSTITUTED BY SASOLBURG, VEREENIGING AND SASOLBURG-REDRAWN.

The Vaal Triangle was declared as an Airshed priority area (Figure 8) in 2006 by the Minister of Environmental Affairs and Tourism and now constitutes the areas of the Gauteng and Free State provinces enclosed currently in an area of approximately 4,960 km², with the major areas being:

- City of Johannesburg;
- Emfuleni Municipality;
- Midvaal Municipality; and
- Metsimaholo Municipality

FIGURE 8: THE VAAL TRIANGLE AIRSHED PRIORITY AREA [67].

3.2.3. Study population

Two schools from each of the following towns: Sasolburg, Vereeniging and Vanderbijlpark were selected and served as the study comparative population. The study population comprised 10-year old children from the six schools in the Vaal Triangle, including three schools surveyed in the VAPS of 1990. The focus was on children 10 years of age, because at this age children normally do not yet smoke actively and they are still developing physiologically (at an age of 12 children are more vulnerable). Furthermore, the selected age group was consistent with the VAPS study, which looked at 8-12 year old children.

An enquiry revealed that there were about 100 ten-year-olds per school. The budget did not allow for all children between 9 and 11 to be included, as this number could theoretically be thrice the envisaged 600 to 1000 participants. All children of 10 years old (including disabled/handicapped children) in each of the six schools were included.

3.2.4. Sampling method

Six schools from the area were selected with the aid of two biostatisticians (Dr. Das and Dr. Becker) who were involved in the selection process. Three of these schools were those that participated in the VAPS, while the other three were randomly selected from government schools with more or less the same number of learners in each of the three towns.

3.2.5. Sampling size

All children of 10 years of age in the six schools selected comprised the study population; an approximate sample of 600 school children was used in the study. There was no intention of taking a random sample from the study population as the whole population were surveyed. The minimum sample size calculated was 333

children. However, the sample was envisaged to be between 600 and 1000 children (about 100 ten-year-olds per school) but all 10-year-olds in a selected school were included.

3.2.6. Pilot study

A pilot study was conducted in the Gauteng province during August in 2010, to test the questionnaires with the aim of improving its quality. The questionnaires were tested against groups similar to the target population (parents/guardians/ caregivers were handed out questionnaires), and 30 individuals for each language spoken, including English, Afrikaans and Sesotho, participated in the pilot study. Notes were taken about items that were not clear or mis-interpreted in the questionnaire.

A decision was taken on the merits and flaws of open-ended questions. Respondents were asked about how the questionnaire made them feel and how they felt about questions asked in a particular way.

Furthermore, gaps and problem areas with respect to context, syntax and the readability were identified and improved upon. The necessary changes to the questionnaires were made and thereafter questionnaires were printed.

3.3. RESEARCH PROCEDURES

The study commenced by acquiring ethical clearance from both the Council for Scientific and Industrial Research (CSIR) (REC number: 03/2010) as well as the University of Pretoria (UP) Ethics Committees (REC number: S136/2010) - (refer to Appendix D). The envisaged sample size needed to be calculated to conform to ethical committee requirements.

With the aid of two biostatisticians, using a response rate of 30% and a confidence level of 90% the minimum required sample size of the study was approximately 333 children, as seen in the formula below:

$$N = \frac{\frac{4\pi (1-\pi)}{(\text{margin of error})^2}}{\frac{\text{Response rate}}{100}}$$

Where π = 0.5 (for this study, π is not known, therefore it was assumed to be 0.5, as this value allows for the largest possible sample size, as advised by the biostatistician),

Margin of error = 0.1 (90% Confidence level),

Response rate = 30%,

N (sample size) = 333.3 (recurring)

Since the study was planned to be undertaken in schools situated in the Free State and Gauteng provinces, permission was obtained from the Departments of Education in the respective provinces. A total of six schools were selected in the Vaal Triangle, from the towns of Vereeniging, Sebokeng, Vanderbijlpark, Bophelong, Sasolburg and Zamdela with the aid of two biostatisticians.

Each principal was contacted telephonically during August 2010, to explain the need for the study, the expected study outcomes and their schools role in the study. The physical location of each school was conveyed telephonically by the principal and GPS coordinates were obtained from Google Earth. The principals of each school concurred with specific dates when questionnaires would be handed out to all 10-year-old children, with the parent/guardian/caregiver filling them in and retrieval planned 2 weeks thereafter.

The approximate number of 10-year-old children in each school was computed from the telephonic communication with the principal, in addition to the language preferences of the children. Upon arrival at each school during September 2010, the principals were given copies of the ethical clearance letters obtained from the CSIR and University of Pretoria as well as a written consent form to complete to obtain

consent from the school to partake in the study. All 10-year old children were identified with the aid of the teachers, whereby all children born in 2000 (January-December) were deemed to be the study population. A total of 800 questionnaires were distributed amongst the six schools during September 2010.

3.3.1. Measurement tool

A structured questionnaire served to collect data on demographics, socio-economic status, house characteristics as well as child health status. This questionnaire was based on several other questionnaires used in epidemiological studies on respiratory diseases [2].

The questionnaire utilised in this study was based on five other questionnaires used in epidemiological studies on respiratory diseases (Appendix A). The questionnaire used in these studies were: the ATS-DLD-78-A questionnaire; 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); the 1990 VAPS questionnaire, and the study on the respiratory health status of adults spending their developing years in a polluted area in South Africa conducted in 2003 by Oosthuizen and colleagues [1-3].

The 1990 VAPS questionnaire comprised of a total of a 102 questions. From this questionnaire, all questions pertaining to: the parent's level of education, the parent's employment status, family income, use of equipment inside the house, hobbies, smoking habits, time spent outdoors, chest illnesses, birth weight of the children, and odours in the surrounding environment were discarded, resulting in 42 questions that were used in the 2010 questionnaire.

Four questions were added to the 42 questions (i.e. total of 46 questions in the 2010 questionnaire), i.e. a question on the child's diet, the way in which the child breathes mostly, whether the child has been hospitalised for any respiratory illness, and whether any medication was prescribed by the doctor, which eventually resulted in 46 questions. For the 2010 study, this concise questionnaire was used to answer the specific research question and achieve the set out objectives. Thereby from the

VAPS questionnaire there were 42 identical questions in the 2010 questionnaire with the addition of 4 more questions.

There were also differences encountered in the prevalence of illnesses. The prevalence of the respiratory diseases used in the 1990 VAPS was one year, and in the 2010 study it was six months. It was decided to ask about the 6-month prevalence in the 2010 study and not the 1-year prevalence as in the 1990 study because of the issue of recall bias, however, this turned out to be a major limitation in the study design, as will be addressed in Chapters 4,5 and 6.

The first seven questions in the questionnaire deal with child's demographics, i.e. gender, home language, date of birth, current residence, the of residence, time spent in the current town, and where the child resided previously.

The section that follows pertains to the child's home and consists of thirteen questions. These questions provided information on risk factors that are sources of indoor air pollution and other possible risk factors related to diet and household living conditions: description of the type of home the child resides in, the number of bedrooms, the number of people in the home (these questions elicit information pertaining to exposure assessment), the source of water used in the home (if the water that is consumed, is contaminated, the children could get diarrhoea and other water-related illnesses which compromise their immune system and make them more vulnerable to respiratory diseases), heating systems used in the home, use of electrical appliances, the presence of a fireplace, fuels used for cooking, ventilation within the household, the presence of mould, having pets within the home and smoking within the household. Having pets within the household has shown to have a protective effect on illnesses such as asthma [68].

This is followed by a single question on eating habits, whereby information is gathered on the regularity of eating chicken, fish, processed food, fruits, and vegetables. Dietary intake as an exposure factor has been associated with respiratory disease outcomes in a study conducted by Matooane and colleagues in 2011 [69].

The next section in the questionnaire relates to the child's health and differentiates various health outcomes such as allergies, asthma, chest cough, phlegm, wheezing

and other illnesses. Here the child's current health status is ascertained by the use of nominal and ordinal questions related to lower and upper respiratory health outcomes.

The last section in the questionnaire, comprising of two questions, requests the personal opinion or view of the parent/guardian/caregiver of the child, with respect to air pollution in the study area and the source thereof, i.e. motor vehicles, industries and mines, cigarette smoke, and open fires.

The questionnaires were translated into English, Afrikaans and Sesotho and piloted as discussed in section 3.2.6. There were 200 English, 200 Afrikaans and 400 Sesotho questionnaires printed. Administering the questionnaire in the participant's preferred language should enhance the reliability of data. Validation of the entire database was conducted on final output tables to verify quality and consistency.

3.3.2. Data capturing and questionnaire retrieval

The collection of questionnaires ended during October in 2010, which was then followed by the data capturing, which commenced during November 2010 and was completed during March in 2011.

The VAPS questionnaire was reviewed by the selection of certain questions that were applicable to the current study and also since those questions were comparable to the current study. The VAPS data included the raw data captured from the questionnaires, i.e. double entered data and descriptive statistics.

The VAPS data had to be re-entered and analysed since the original electronic data set and analyses were lost in the 1990s. The VAPS questionnaires, which were in storage, were checked to locate all the 10-year-old children's questionnaires. Each school that formed part of the VAPS in 1990 had been assigned a unique code and a database of these codes was used to determine the schools involved in the VAPS. This in turn assisted in determining the exact schools involved during the VAPS in addition to ascertaining the study population.

A delay was encountered during the questionnaire retrieval process. Two weeks was planned, however, 4 to 6 weeks was required for the retrieval of questionnaires. This was caused by a teachers' strike in 2010, three weeks prior to the school term coming to a close. The resultant school holidays together with the strike ensured that schools were closed and questionnaires could only be retrieved a month later.

3.3.3. Data management and analyses

All returned questionnaires were scrutinised thoroughly for completeness from November 2010 to March 2011 and differentiated so as to ascertain the response rate. The 2010 questionnaire data were then entered in tandem with the VAPS data into EpiData (version 3.1), whereby all the questions were denoted by numerical values as per the questionnaire and unique names was assigned to each variable. Checks were incorporated to ensure continuous monitoring of the entries. Data coding was checked by two individual double enters, who also carried out the double entry of the entire data set. All errors were rectified and the database was perused through scrutiny to ensure the elimination of consistency errors.

Following the double entry of the questionnaire data, the final output was transferred into STATA (version 10) whereby dependant variables were re-coded into binary variables. The binary variables were coded with the outcome being either "yes" or "no" and thereafter ordered and sorted. Univariate analysis was then computed with frequency tables being the output, thereby identifying significant associations between outcome and exposure variables.

As mentioned in Chapter 2, respiratory illnesses can be categorised into upper and lower respiratory tract illnesses. In both the 1990 and 2010 studies, upper respiratory illnesses (URIs) comprised of earache, hay fever and sinusitis, whereas lower respiratory illnesses (LRIs) comprised of asthma, bronchitis and pneumonia. For clarity, asthma refers ever being diagnosed with asthma by a medical doctor and not to asthma attacks or asthma symptoms, e.g. wheezing.

The data collected in the questionnaire were 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 2010, while the 2010 outcome variables (asthma, bronchitis, pneumonia, earache, hay fever and sinusitis) were tested for association with demographic, risk and environmental factors using crude odds ratios (OR), confidence intervals (CI) and Fisher's exact tests.

The crude OR with CI and the p-values are calculated for instances where the exposure factor had an answer of "yes" in the questionnaire. The reference groups were those participants that answered "no" in the questionnaire. The OR is a relative measure of association, describing how much more likely it is that someone who is exposed to the factor under investigation will develop the outcome as compared to someone who is not exposed [70]. In other words, OR quantifies the relationship between an exposure and health outcome.

An OR of 1 signifies that the health outcome is equally likely to occur in both the exposed and reference groups. An OR greater than 1 implies that the health outcome is more likely to occur in the exposed group. An OR of less than 1 means that the health outcome is less likely to occur in the exposed group [70]. The crude OR is the unadjusted OR and one that is not adjusted for confounding. ORs may be adjusted for confounding factors by means of logistic regression, i.e. adjusted OR [71,72].

The Fisher's exact is used when two nominal variables are present. It is more accurate than the chi-square or G-test of independence when the resultant count is less than five [70]. The 95% CI means that there is a 95% degree of confidence that the population odds ratio will lie between the limit values of the 95% CI. The p-value is a probability, with a value ranging from zero to one. It is the probability calculated which signifies that the results acquired in the study could have occurred by chance [71,72].

The OR along with the 95% CI and the p-value will determine the statistical associations [71,72]. In the univariate analyses, an OR of greater than 1.20 and less than 0.80 in tandem with a p-value less than 0.20 were used as initial cut-off points for significance, thereby ensuring the majority of exposure variables (including confounders) were taken to the next stage of regression analyses as recommended by the biostatistician.

All variables deemed significant in the univariate analyses were included for multivariate analyses, whereby their associations with the six health outcomes (asthma, bronchitis, pneumonia, earache, hay fever and sinusitis) were investigated during forward and backward stepwise regression analyses.

At the multivariate level, variables were deemed significant if the p-value was less than or equal to 0.05.

3.3.4. Quality control and validity of questionnaires

This study employed questionnaires, administered to the teachers which were completed by the parent/guardian/caregiver of the child. The questionnaire served to amass data on demographics, socio-economic status, house characteristics, smoking habits, respiratory health, allergies, sources of air pollution and the overall health status of the children. Quality control and quality assurance systems were put in place, including quality control of questionnaire content as discussed in section 3.3.3.

Double entry of questionnaire data was done using a computer, whilst incorporating data entry checks to determine the percentage error. Data entry accuracy was ensured by having the principal investigator; in tandem with another data enter coding all of the questionnaires received. Thereafter two independent data encoders conducted double data entry. Fields not completed in questionnaires were treated as missing in the data analyses.

3.4. ETHICAL CONSIDERATIONS

The study commenced with prior ethics approval from both the University of Pretoria's Faculty of Health Sciences as well as the CSIR Research Ethics Committees (REC).

In this study the following steps were taken; participants were informed about:

- The purpose of the study;
- How the participant will be treated; and
- The potential risks, if any, the participant may face

On the consent form, the purpose of the study and the way in which the participant will be treated were explained in detail. This study did not have any potential risks that participants faced. Specific attention was paid to ascertain whether the voluntary participants understood the information (questionnaires were available in more than one language, i.e. English, Afrikaans and Sesotho). Furthermore, written informed consent was asked from the participants and this formed the cover page of the questionnaire.

Measures were put in place to ensure the confidentiality of the participants so they could not be identified from the study results through the implementation of unique identifier codes. All personal information was secured and locked in a filing cabinet, only accessible to the principal researcher.

This study was not a duplication of research but generated new knowledge. The study was thus seen as a replication and not a mere duplication of research done elsewhere (no real pollution measurements were linked with health outcomes; just sources of indoor air pollution and other possible confounding factors are the outputs of the study).

Absolute independence between researcher and sponsorship for the study was ensured. The participation in the study was on a voluntary basis. Information gained in the study is planned to be published in a peer-reviewed journal, with feedback also planned to be given to relevant government departments as well as stakeholders involved, in the form of an informal article and a poster.

CHAPTER FOUR - RESULTS

4.1. INTRODUCTION

This chapter describes the sample population, i.e. the demographics and descriptive statistics, living conditions, respiratory health status, and the personal perceptions of the study population. The results from the univariate and multivariate analyses will be presented.

4.2. FINAL SAMPLE SIZE

The final sample size that resulted from the distribution of 800 questionnaires was 420. The acquired sample size of 420 is greater than the envisaged size of 333 children as per the sample size calculations.

A total of 648 questionnaires were retrieved after a month from all six schools; this tallied up to a return rate of 81.00%. From the 648 questionnaires obtained, each one was scrutinised and ensured that they were filled in correctly. Questionnaires where questions pertaining to prevalence of health outcomes and possible risk factors were completed in full were isolated with the remainder discarded(more than 80% of the questionnaire was incomplete, specifically questions answering the objectives of the study), resulting in 420 questionnaires, and leading to a response rate of 52.50% (420/800) as seen in Figure 9.

The reason for discarding questionnaires where questions pertaining to prevalence of health outcomes and possible risk factors were not completed in full was to ensure that a small cell frequency did not result in the analyses, since these outputs would affect the association between a health outcome and an exposure variable, bringing about issues of exposure misclassification and selection bias.

On comparison of participants to non-participants in the study, the questionnaires retrieved served as an indicator of the number of participants in the study. Out of a total of 800 questionnaires, 648 questionnaires were retrieved, of these 648

questionnaires, 420 questionnaires were useable and formed the 2010 study population, the 228 questionnaires that were discarded were those questionnaires that could not be used in the study.

The discarded questionnaires were perused to get an idea of the demographic profile and the demographics were the same as those of the 420 questionnaires incorporated in the 2010 study. Of the 228 unusable questionnaires, 126 questionnaires were girls (55.26%) and the remaining 102 were boys (44.74%) which are consistent with the final sample population, whereby 55.24% of the study population were girls and 44.76% boys. Nevertheless, it is not possible to say if the distribution of health outcomes, risk and protective factors were the same for the discarded and included questionnaires.

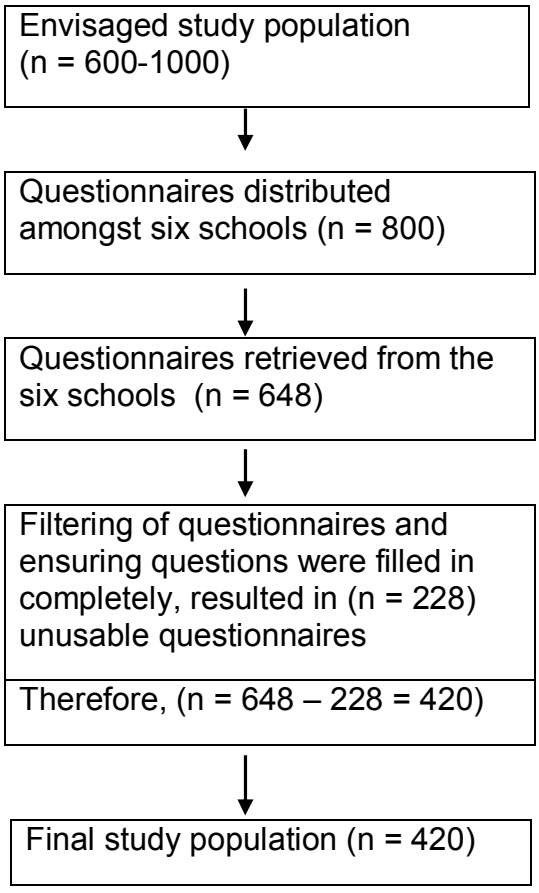

FIGURE 9: SELECTION PROCESS AND FINAL STUDY POPULATION.

4.3. DEMOGRAPHICS AND LIVING CONDITIONS OF THE STUDY PARTICIPANTS

A total of 420 children comprised the study population of the 2010 study as compared to the 271 (these children were selected from the 11000 children that participated in the VAPS of 1990, by selecting all the 10-year-olds) children in the 1990 VAPS. The study population in 1990 comprised 42.44% females (115/271), 57.20% males (155/271) and one missing value (0.37%) whereas in the 2010 study 55.24% (232/420) of the study population comprised girls and 44.76% (188/420) were boys as seen in Table 9.

When considering the child's primary linguistic group, in the 1990 study, 77.86% of the children spoke Afrikaans and the remaining 22.14% of the children spoke English. In 2010, however, several linguistic groups were present, i.e. Sotho (55.64%), Afrikaans (15.83%), English (11.51%), Zulu (9.35%), Xhosa (3.84%), Swazi (0.24%) and other languages (3.60%) which were Venda, Pedi, Tswana and Tsonga as seen in Table 9.

The geographical distribution of the study populations both in 1990 and 2010 are as follows: In 1990; 37.27% of the children lived in Vereeniging compared to 15.00% in 2010; 29.52% of the children lived in Vanderbijlpark compared to 25.48% in 2010 and lastly 33.21% of children lived in Sasolburg in 1990, compared to 15.95% in 2010. In addition, in the 2010 study, 42.86% of the study population came from other towns like Sharpeville, Zamdela, Sebokeng and Evaton as seen in Table 9.

The length of stay of the study population in their respective towns were broken down into the following parameters: since birth, < 2 years, 2 - 4 years, 5 – 10 years and lastly unknown. In 1990 19.93% of 10-year olds were residing in their respective towns since birth as compared to the 69.05% in 2010; 23.24% were residing in their respective towns for < 2 years in 1990 as compared to 4.29% in 2010; 21.77% children resided for 2 – 4 years in their respective towns in 1990 as compared to 7.62% in 2010; 34.32% of children resided in their respective towns for 5 – 10 years as compared to 18.81% in 2010; lastly the length of stay in a town was deemed to be unknown by 0.74% of the population in 1990 as compared to o.24% in the 2010 study as seen in Table 9.

With respect to the town that the child lived in before residing in the current town, on inspection of the frequency of various towns resided in, the majority of the study population seemed to be staying within the Vaal Triangle itself or its surrounds, in towns such as: Sasolburg, Vereeniging, Vanderbijlpark, Evaton, Sebokeng, and Sharpeville. There were some instances where the study population resided in another province such the Western Cape before relocating to Gauteng and the Free State where the Vaal Triangle is situated.

With respect to the length of stay of the child in the previous town, the results obtained for this particular question were not used in the results since there were numerous blanks and missing values, thereby being insufficient to yield a meaningful result. Respondents mentioned that recall bias was a problem when answering this question.

In 1990, 92.59% (250/270) of the study population lived in single unattached households, 3.70% (10/270) in single attached houses and the remainder in prefabricated houses or flats. In 2010, 77.97% (315/404) of respondents lived in single unattached households, 9.16% (37/404) in single attached houses, 6.68% (27/404) in flats and the remainder 6.19% (25/404) in prefabricated homes as illustrated in Table 9.

On review of the number of bedrooms in the household, in 1990, 93.36% of households had three or four bedrooms, whereas in 2010, the households ranged from one to as large as four bedrooms in the main, i.e. 39.52% of the bedrooms ranged between one and two bedrooms and 55.71% ranged between three to four bedroom houses in 2010.

With regard to the number of people in the household, in 1990, three to four people were seen in the main per household as signified by 93.36% of the total households. In 2010 however, 48.10% of the households constituted of three to four people and 49.29% constituted five people or more in the household.

The source of water to each household was asked separately, with the following sources documented: municipal, private borehole, community borehole and other sources. In 1990, 94.46% of the population had municipal water as a source of water

and this is similar in 2010 where 95.71% of the study population also had municipal water as a source of water.

With respect to the other sources of water, private and community boreholes were less in frequency, i.e. 9.23% of people having private boreholes and none (0.00%) having community boreholes in 1990, whereas in 2010, 1.90% had private boreholes and 0.48% of the study population had community boreholes. In terms of other sources of water, in 1990, 0.37% of the population had another source of water whereas in 2010 no other sources of water were documented due to a 100.00% of blanks obtained from the questionnaire for that question as evident in Table 9.

With respect to the type of heating system present in each household in both studies; the use of wood/coal stove, fireplace, and gas/paraffin heater seems to be higher in the 2010 study as compared to the 1990 study. Furthermore it is seen that the use of an asbestos heater as a means of heating has diminished when comparing the 2010 study to that of 1990, i.e. 33.58% in 1990 as opposed to 8.33% in the 2010 study as depicted in Table 9.

Looking at the fuels used for purposes of cooking in 1990 and in 2010, electricity is the main fuel present in both studies, i.e. 97.42% in 1990 comparable to 93.33% in the 2010 study. In 1990, a combination of electricity and gas was documented whereas in 2010 this was not seen for fuels used in cooking. Other fuels that came to the fore in the 2010 study were: paraffin, wood and coal as evident in Table 9.

When considering the air circulation within the homes, even in the winter months, a slight decrease between 1990 and 2010 was evident. In 1990, 96.67% (261/270) of the respondents opened their windows for interior air circulation compared to 82.01% (342/417) of respondents in 2010 as seen in Table 9.

Looking at the presence of mould in the household, in 1990, 14.76% of the population had mould in the house, with 83.76% not having any mould, whereas in 2010, 23.57% of respondents had mould in their homes and 73.33% did not have any form of mould or mildew in their home.

With regard to having any pets and whether they were allowed into the homes, quite distinct variations are seen, in 1990, 90.04% of households had pets and of those,

61.62% of them allowed the pets into their homes, in 2010 however, only 40.00% of households had pets and of those 24.52% of them allowed the pets into their homes.

With respect to an individual smoking within the household on almost a daily basis; in 1990, 57.20% of the population had individuals who smoked a cigarette within the household. On comparison with the 2010 study, a decline is seen, since the proportion of cigarette smokers within the household was 22.14%.

Table 9: Descriptive statistics of the demographics and living conditions of the 1990 and 2010 study populations.

Characteristic	**1990 Sample distribution n (%)**	**2010 Sample distribution n (%)**
Sex of child		
Boys	155 (57.20)	188 (44.76)
Girls	115 (42.44)	232 (55.24)
Missing	1 (0.37)	
Linguistic groups		
Afrikaans	211 (77.86)	66 (15.71)
English	60 (22.14)	48 (11.43)
Sotho	-	232 (55.24)
Zulu	-	39 (9.29)
Xhosa	-	16 (3.81)
Swazi	-	1 (0.24)
Other	-	15 (3.57)
Missing	-	3 (0.71)
Geographic distribution of study populations		
Vereeniging	101 (37.27)	63 (15.00)
Vanderbijlpark	80 (29.52)	107 (25.48)
Sasolburg	90 (33.21)	67 (15.95)

Missing	-	180 (42.86)
Other	-	3 (0.71)
Child's length of stay in current town		
Since birth	54 (19.93)	290 (69.05)
< 2 years	63 (23.24)	18 (4.29)
2 – 4 years	59 (21.77)	32 (7.62)
5 – 10 years	93 (34.32)	79 (18.81)
> 10 years	2 (0.74)	1 (0.24)
Type of home		
Single, not attached	250 (92.59)	315 (77.97)
Single, attached	10 (3.70)	37 (9.16)
Flat	8 (2.96)	27 (6.68)
Pre-fabricated	1 (0.37)	25 (6.19)
Other	1 (0.37)	0 (0)
Number of bedrooms in the house		
1 – 2	4 (1.48)	166 (39.52)
3 – 4	253 (93.36)	234 (55.71)
≥ 5	13 (4.80)	15 (3.57)
Missing	1 (0.37)	5 (1.19)
Number of people living in the house		
1 – 2	29 (1.48)	8 (1.90)
3 – 4	188 (93.36)	202 (48.10)
≥ 5	53 (4.80)	207 (49.29)
Missing	1 (0.37)	3 (0.71)
Water source (each source of water being asked as a separate question)		
Municipality (Yes)	256 (94.46)	402 (95.71)
Municipality (No)	15 (5.54)	6 (1.43)
Missing	-	12 (2.86)

Private borehole (Yes)	25 (9.23)	8 (1.90)
Private borehole (No)	246 (90.77)	122 (29.05)
Missing	-	290 (69.05)
Community borehole (Yes)	0 (0.00)	2 (0.48)
Community borehole (No)	271 (100.00)	124 (29.52)
Missing	-	294 (70.00)
Other (Yes)	1 (0.37)	-
Other (No)	270 (99.63)	-
Missing	-	420 (100.00)
Type of heating system (each type of heating system owned is asked as a separate question)		
Wood/coal stove (Yes)	4 (1.48)	60 (14.29)
Wood/coal stove (No)	258 (95.20)	176 (41.90)
Missing	9 (3.32)	184 (43.81)
Fireplace (Yes)	13 (4.79)	34 (8.10)
Fireplace (No)	249 (91.88)	166 (39.52)
Missing	9 (3.32)	220 (52.38)
Gas/paraffin heater (Yes)	28 (10.33)	102 (24.29)
Gas/paraffin heater (No)	234 (86.35)	124 (29.52)
Missing	9 (3.32)	194 (46.19)
Asbestos heater (Yes)	91 (33.58)	35 (8.33)
Asbestos heater (No)	171 (63.10)	171 (40.71)
Missing	9 (3.32)	214 (50.95)
Fuel used for cooking		
Electricity	264 (97.42)	392 (93.33)
Gas	1 (0.37)	14 (3.33)
Electricity and Gas	6 (2.21)	-
Paraffin	0 (0)	4 (0.95)
Wood	0 (0)	3 (0.71)

Coal	0 (0)	2 (0.48)
Other	0 (0)	0 (0)
Missing	-	5 (1.19)
Opening of windows (air circulation)		
Yes	261 (96.67)	342 (82.01)
No	9 (3.33)	75 (17.99)
Missing	1 (0.37)	3 (0.71)
Mould in the home		
Yes	40 (14.76)	99 (23.57)
No	227 (83.76)	308 (73.33)
Unknown	2 (0.74)	-
Missing	2 (0.74)	13 (3.10)
Does the household have any pets?		
Yes	244 (90.04)	168 (40.00)
No	26 (9.59)	251 (59.76)
Missing	1 (0.37)	1 (0.24)
Are the pets allowed inside the house?		
Yes	167 (61.62)	103 (24.52)
No	77 (28.41)	312 (74.29)
Missing	27 (9.96)	5 (1.19)
Smoking inside the house almost every day?		
Yes	155 (57.20)	93 (22.14)
No	115 (42.43)	320 (76.19)
Missing	1 (0.37)	7 (1.67)

4.4. HEALTH STATUS OF STUDY PARTICIPANTS

In 1990, 89.67% (243/271) of the children were not absent from school in the last two weeks whereas in 2010 this decreased to 62.38% (262/420), thereby showing that more children were absent from school in the past 2 weeks in the 2010 study. In 1990, when looking at the number of times the child missed school in the past year due to illnesses, 56.83% (154/271) of children had missed school 1 to 10 times, and this is similar to that in 2010, i.e. 55.48% (233/420).

Of all the illnesses that caused the absenteeism, influenza seemed to be one of the common illnesses in the 1990 and 2010 study; the frequency was relatively the same in both studies, i.e. 25.32% (39/154) in 1990 and 25.27% (46/182) in 2010, when excluding all the missing values/blanks in the questionnaire.

As mentioned in Chapter 3, the 1-year prevalence of health outcomes in the 1990 study cannot be compared directly to the 6-month prevalence of the 2010 study. Throughout the dissertation this should be kept in mind. The change in the prevalence of a respiratory health outcome from 1990 to 2010 is just an indication of the possible change.

Table 10 list the prevalence of the six main health outcomes: bronchitis, pneumonia, earache, hay fever, sinusitis and asthma. The missing values/blanks were excluded in the calculation of the prevalence of each health outcome.

Table 10: Descriptive statistics of children's health in the 1990 and 2010 study populations.

Characteristic	**1990 Sample distribution** **n (%)**	**2010 Sample distribution** **n (%)**
Absenteeism		
Not absent	243 (89.67)	262 (62.38)
1 – 9 days	27 (9.96)	61 (14.52)
≥ 10 days	1 (0.37)	1 (0.24)
Missing	-	96 (22.86)

Number of times missing school in the past year		
None	106 (39.11)	168 (40.00)
1 – 10 times	154 (56.83)	233 (55.48)
≥ 11 times	6 (2.21)	6 (1.43)
Missing	5 (1.85)	13 (3.09)
Disease/illness prevalence (asked separately)		
Bronchitis	82 (38.86)	43 (13.65)
Pneumonia	19 (10.50)	5 (1.71)
Earache	127 (57.47)	25 (8.22)
Hay fever	51 (26.29)	93 (27.27)
Sinusitis	94 (44.34)	112 (34.36)
Asthma	33 (12.41)	50 (12.05)

With regard to the prevalence of childhood allergies in 1990 and 2010, allergies amongst children seem to have decreased in 2010 as compared to those in 1990 as depicted in Figure 10.

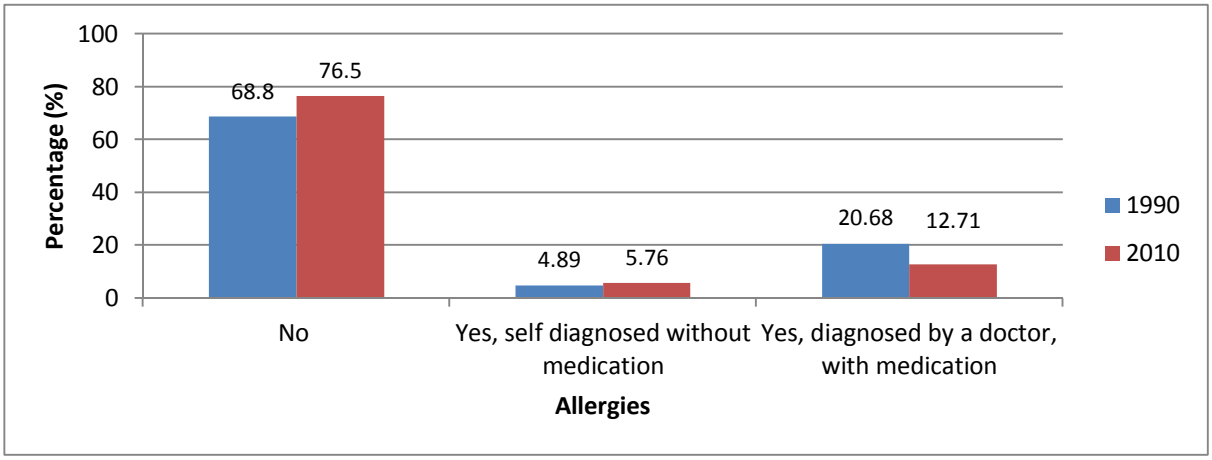

Figure 10: Comparison of children's allergies in 1990 (1-year prevalence) and 2010 (6-month prevalence).

Table 11: Comparison of the prevalence of URIs and LRIs in the 1990 (1-year) and 2010 (6-month) study.

Respiratory Illnesses	1990 (1 year) %	2010 (6 month) %
URIs	65.90	23.92
LRIS	28.90	6.09

In the 1990 study, the 1-year prevalence of URIs and LRIs was 65.90% and 28.90%, respectively [1]. In the 2010 study, the 6-month prevalence of URIs and LRIs was 23.92% and 6.09%, respectively (Table 11).

The prevalence of URIs was determined by a "yes" answer to either of the questions: have had sinusitis, hay fever, and earache in the past year for 1990 and in the past 6 months for the 2010 study. The 1-year and 6-month prevalence for these URIs illustrated in Figure 11.

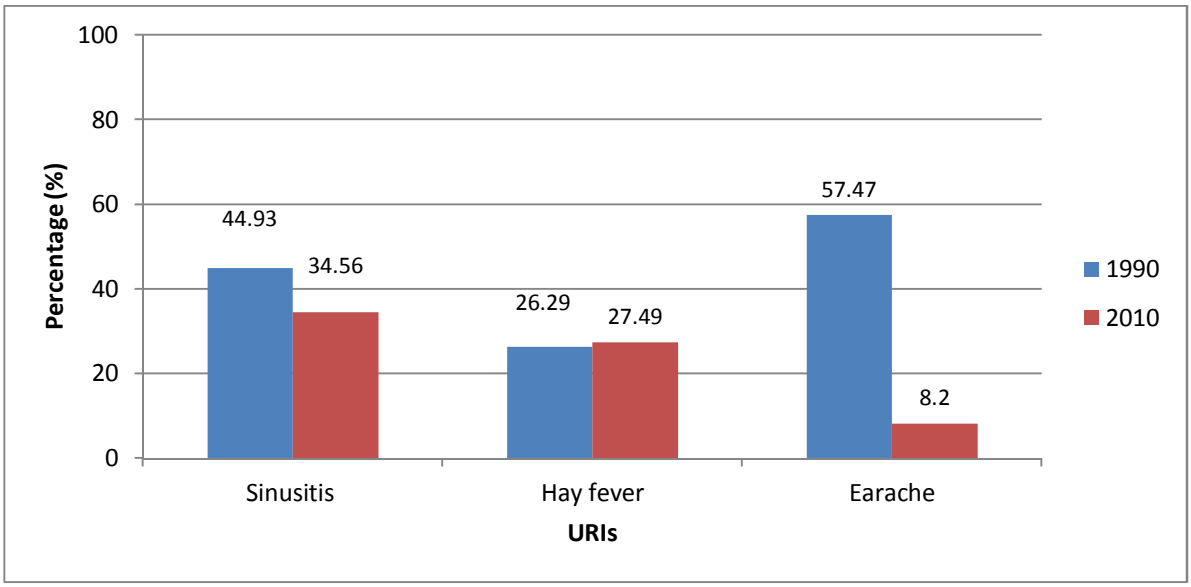

FIGURE 11: COMPARISON OF THE 1-YEAR PREVALENCE OF URIS IN 1990 AND THE 6-MONTH PREVALENCE IN 2010.

The prevalence of LRIs was determined by a "yes" answer to either of the questions: having had bronchitis, pneumonia, and asthma and wheezing over the past year for

the 1990 study and over the past 6 months for the 2010 study. The 1-year and 6-month prevalence for these LRIs are illustrated in the Figure 12.

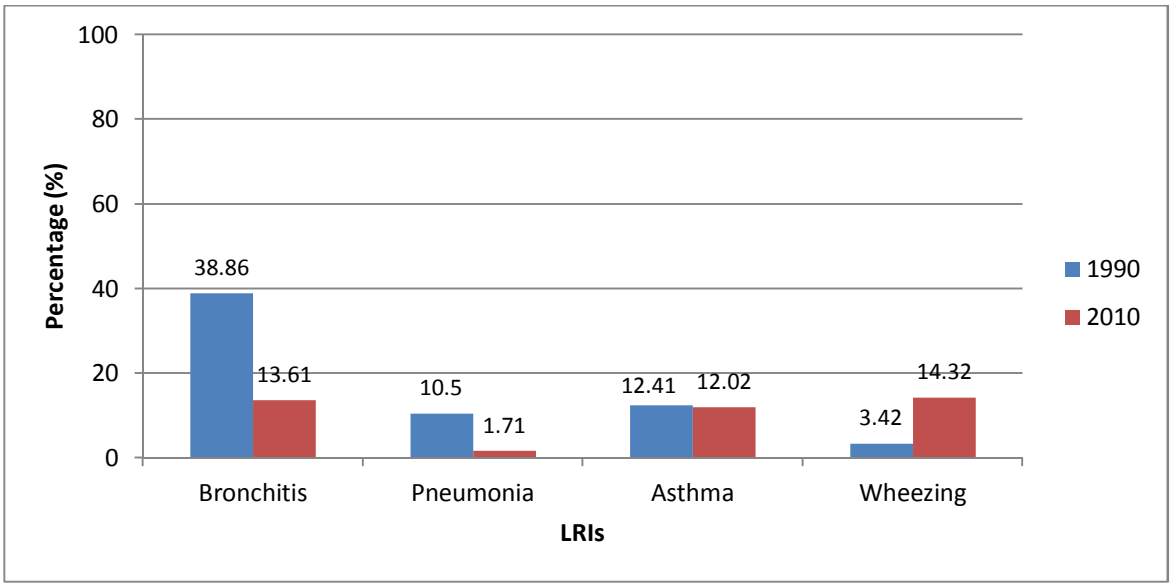

FIGURE 12: COMPARISON OF THE 1-YEAR PREVALENCE OF LRIS IN 1990 AND THE 6-MONTH PREVALENCE IN2010.

4.5. OUTDOOR AIR POLLUTION – PM_{10}

In the 1990 study, TSP was of concern, in that elevated levels were prevalent in the study area [1,2]. The Department of Health (DoH) guideline at that time, 350µg/m^3 for a 24-hour period, was exceeded once during the VAPS project, whilst the United States of America Air Quality Standards (USA AQS) of 260µg/m^3 was exceeded five times [1]. All other criteria pollutants were within the USA AQS [1].

As mentioned previously, the 2010 study focused in on the towns of Vereeniging, Vanderbijlpark and Sasolburg. The monitoring stations of PM_{10} is in close proximity to the 2010 study setting, i.e. located at Sebokeng, Sharpeville, Three Rivers and Zamdela. PM_{10} monthly monitoring data for 2010 are depicted in Figure 13. Sebokeng had missing data and hence could not be depicted for the entire year, whereas in Zamdela, the monitoring station was non-functional thereby not yielding any data that could be depicted graphically.

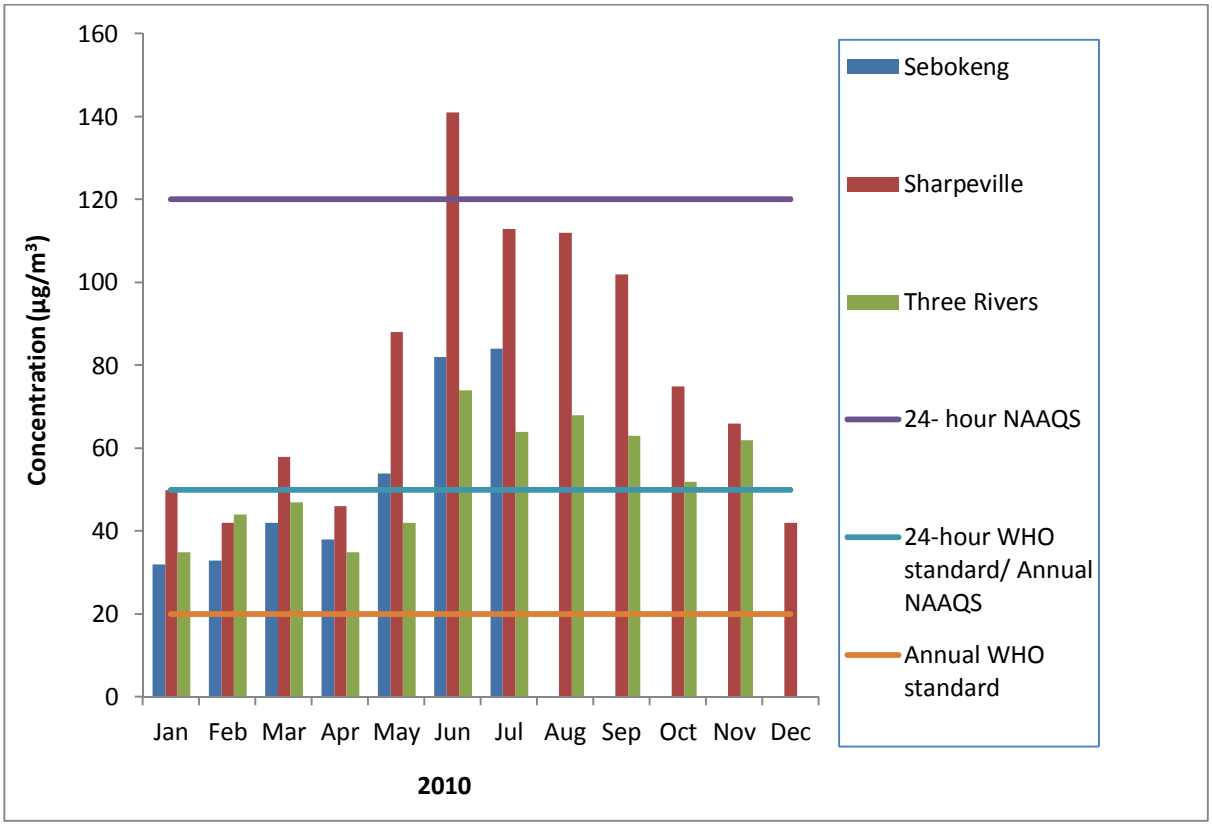

FIGURE 13: MONTHLY AVERAGES OF PM_{10} FOR JANUARY – DEC 2010.

In the winter months, a clear increase in PM_{10} levels is seen, where the three towns exceed the 1-year NAAQS standard of 50µg/m^3 (Figure 13). PM_{10} starts peaking in May through till August and September. This trend was seen in the study conducted by Oosthuizen and colleagues in 2003 [14].

The focus of the study is to determine the respiratory health status in terms of the association found between the exposure factors and the respiratory health outcomes. Air quality data usage and linking that to the respiratory health outcomes was not an objective or aim of the study, it just serves as a comparison to the 1990 study results.

4.6. PERCEPTIONS OF AIR POLLUTION

Table 12 illustrates all 10-year-old children's health status as perceived by parents/guardians/caregivers in 1990 and in 2010. In 1990, 51.29% (139/271) of parents/guardians/caregivers deemed their children's health as being excellent; 46.86% (127/271) considered it to be good and 1.48% (4/271) thought it was poor when compared to children of the same age group. In the 2010 study, however, 56.90% (239/420) parents/guardians/caregivers thought their children's health to be better than children of the same age group; 41.43% (174/420) thought it to be the same as children from a similar age group and 0.95% (4/420) deemed their child's health to be worse than that of children of the same age.

Table 12: Perception of children's health status in 1990 and in 2010 as deemed by parents/guardians/caregivers.

1990		2010	
	n (%)		**n (%)**
Excellent	139 (51.29)	**Better**	239 (56.90)
Good	127 (46.86)	**The same**	174 (41.43)
Poor	4 (1.48)	**Worse**	4 (0.95)

On review of the perceptions of parents on whether the air pollution in the Vaal Triangle is a serious problem or not, it is evident that in 1990, 74.54% of the study population perceived that the pollution in the area was serious and this has increased in the 2010 study whereby 83.33% of the population perceived the air pollution in the Vaal Triangle as being a problem. Furthermore in 1990, 16.24% of the population deemed the air pollution in the area as being not critical.

The major sources of air pollution in the Vaal Triangle as perceived by the parents of the study population were categorised into the following: motor vehicles, industries and mines, cigarette smoke, and open fires. In 1990 the major source of air pollution was industries and mines followed by open fires having values of 77.12% and 16.24% respectively. In 2010, however, in addition to industries and mines (60.95%)

and open fires (18.10%), motor vehicles (14.52%) also was deemed to be a major source of air pollution with cigarette smoke (0.37% in 1990 and 5.00% in 2010) having a minimal weighting as seen below in Table 13.

Table 13: Descriptive statistics of the perceptions of parents in the 1990 and 2010 study populations.

Characteristic	1990 Sample distribution n (%)	2010 Sample distribution n (%)
Perception of air pollution in the Vaal Triangle (being serious or not)		
Yes	202 (74.54)	350 (83.33)
No	6 (2.21)	53 (12.62)
Not critical	44 (16.24)	-
Unknown	13 (4.80)	-
Missing	6 (2.21)	17 (4.05)
Perceived major source of air pollution in Vaal Triangle		
Motor vehicles	12 (4.43)	61 (14.52)
Industries and mines	209 (77.12)	256 (60.95)
Cigarette smoke	1 (0.37)	21 (5.00)
Open fires	44 (16.24)	76 (18.10)
Missing	5 (1.84)	6 (1.43)

4.7. STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN ALL BINARY VARIABLES IN THE 1990 AND 2010 STUDIES.

All of the binary variables in the 1990 and 2010 studies were compared to see if there is a statistically significant difference between the two studies. Those differences that had a p-value of <0.05 (i.e. statistically significant) are listed in Table 14.

Table 14: Statistically significant differences between all binary variables in the 1990 and 2010 studies.

	Variable (1990 and 2010)	p-value
Risk factors*		
	Use of municipal water (water source) in the house	<0.001
	Fireplace in the house	<0.001
	Asbestos heater in the house	<0.001
	Opening windows for air circulation	<0.001
	Pets in the house	<0.001
Health outcomes**		
	Allergy	<0.001
	Bronchitis	<0.001
	Pneumonia	<0.001
	Earache	<0.001
	Sinusitis	0.02
	Cough	<0.001
	Phlegm	<0.001
	Wheeze	<0.001
	Running nose (1 year)	<0.001
	Earache (1 year)	<0.001
	Hyperactivity	<0.001
	Gastro-intestinal diseases	<0.001
	Asthma	<0.001

*All based on past year
**1990 based on past year and 2010 (all schools) on past 6 months
Note: This table aims to show the statistically significant difference between the binary variables in the two studies. Each variable and exposure factor are run, on completion of the univariate analyses and the actual difference in terms of odds ratios with the direction are given at the multivariate level (the reference group were the 1990 study population).

In terms of the risk/protective factors, only a few are different in the two studies, i.e. some indoor air pollution sources, opening windows and having a pet. For all the respiratory health outcomes there were tendencies of statistically significant differences as the prevalence of 1990 cannot be compared to 2010(Table 13). Allergies and wheezing had a lower 1-year prevalence in 1990 when compared to the 6-month prevalence of 2010 (Figure 12). The 6-month prevalence of bronchitis, pneumonia, earache and sinusitis was lower in 2010 than the 1-year prevalence in 1990 (Tables 10 and 14, Figures 11 and 12). The 6-month prevalence of hay fever in 2010 was significantly higher than the 1-year prevalence in 1990 (Tables 10 and 14, Figure 11).

The prevalence of the URIs and LRIs are shown in Tables 15 and 16. In the 2010 study, a 2-week prevalence in addition to 6-month prevalence was used, whereas in 1990 a 1-year prevalence was used.

Table 15: Prevalence of respiratory health status in the 1990 and 2010 (all schools) study populations.

Respiratory Illnesses	1990 1-year %	2010 (All six schools) 2-week %	p – value	2010 (All six schools) 6-month %	p-value
Lower respiratory illnesses					
Bronchitis	38.86	13.61	<0.001	13.41	<0.001
Pneumonia	10.50	1.71	<0.001	0.94	<0.001
Asthma	12.41	12.02	<0.001	4.32	<0.001
Upper respiratory illnesses					
Sinusitis	44.34	34.56	<0.001	33.33	<0.001
Hay fever	26.29	27.49	0.930*	26.90	0.980*
Earache	57.47	8.20	<0.001	11.52	<0.001

Note: The p-value shows a statistically significant difference between the 1990 1-year and 2010 (all six schools) 2-week prevalence of the study populations. This was discussed with the biostatistician, and thereafter computed and depicted as such (the reference group were the 1990 study population).

The 1990 study population is compared to all the schools in the 2010 study (2-week and 6 month prevalence) as depicted in Table 15. The 1990 study population are also compared to the 2010 ‘white’ schools and ‘township’ schools (6-month prevalence) as depicted in Table 16 below.

Table 16: Prevalence of respiratory health status in the 1990 and 2010 (3 schools) study populations.

Respiratory Illnesses	1990 1-year %	2010 (3 'white' schools) 6-month %	p – value	2010 (3 'township' schools) 6-month %	p – value
Lower respiratory illnesses					
Bronchitis	38.86	20.40	<0.001	19.72	<0.001
Pneumonia	10.50	0.90	0.001	0.96	<0.001
Asthma	12.41	0.90	0.389*	6.32	0.002
Upper respiratory illnesses					
Sinusitis	44.34	42.04	0.497*	16.84	0.631*
Hay fever	26.29	26.67	0.950*	27.27	0.990*
Earache	57.47	10.75	<0.001	12.71	<0.001

Note: The p-value shows a statistically significant difference between the 1990 1-year and 2010 ('white' schools) 6-month prevalence of the study populations. This was discussed with the biostatistician, and thereafter computed and depicted as such (the reference group were the 1990 study population).

* Indicates that this was not statistically significant, i.e. a p-value greater than 0.05.

4.8. ASSOCIATION BETWEEN POTENTIAL RISK OR PROTECTIVE FACTORS AND HEALTH OUTCOMES

4.8.1. Univariate analyses

These results that follow are those specifically in relation to the upper (bronchitis, pneumonia, asthma) and lower (earache, sinusitis, hay fever) respiratory health outcomes. All URI and LRI risk and protective factors investigated in the uni- and multivariate analyses are summarised in Table C1 and C2 (Appendix C). These tables include all the variables and exposure factors obtained through the questionnaire with respect to the URIs and LRIs. Those exposure factors that were

statistically significantly associated with any of the six URIs and LRIs in the univariate regression analyses are highlighted in bold.

Table 17 (1990 study) and Table 18 (2010 study) summarise those exposure factors that were statistically significantly associated with any of the six URIs and LRIs in the univariate regression analyses. The following indoor air pollution sources had a significant association in the 1990 study (univariate cut-off significance level): the use of a coal stove, the use of a gas heater, the use of an asbestos heater, smoking within the house, and opening windows in the house for air circulation.

Table 17: Statistically significant risk and protective factors for respiratory illnesses in 1990.

Illness	Risk factor (exposure factor)	Crude OR (CI)	p-value
Lower respiratory illnesses			
Bronchitis	**Using a coal stove**	0.21 (0.021-2.03)	0.18
	Opening windows within the house	4.77 (0.49-46.67)	0.18
Pneumonia	**Using a gas heater**	3.67 (1.15-11.71)	0.03
	Using an asbestos heater	0.46 (0.15-1.45)	0.19
Asthma	**Smoking within the house**	0.61 (0.29-1.28)	0.19
	Using a gas heater	0.25 (0.032-1.88)	0.18
	Using an asbestos heater	1.98 (0.93-4.22)	0.08
Upper respiratory illnesses			
Earache	**Having pets in the house**	0.64 (0.34-1.19)	0.16
Hay fever	**Using a private borehole**	2.23 (0.84-5.91)	0.11
	Smoking within the house	0.53 (0.29-0.99)	0.05
Sinusitis	**Having pets in the house**	0.65 (0.36-1.21)	0.17
	Smoking within the house	0.56 (0.32-0.98)	0.04
	Using a gas heater	2.54 (0.97-6.65)	0.06
	Using an asbestos heater	1.55 (0.88-2.74)	0.13

During the univariate analyses, it was evident that in certain instances an extremely high OR coupled with a wide CI was encountered. This could be attributed to the low number of responses obtained for specific questions. A common risk or protective factor encountered was the use of municipal water as a source of water, the majority of the population uses municipal water since it is readily available amongst the study population. This is reflected by the 98.53% of people who use municipal water (refer to Table 9).

In the 2010 study, the following indoor air pollution sources were considered to be statistically significant (univariate cut-off significance level of 0.20 and an odds ratio of less than 0.60 and greater than 1.60): opening of windows for circulation, using a wood or coal stove, smoking within the house, using an asbestos heater, using a gas and or paraffin heater, having mould within the house, and making use of a fireplace.

Table 18: Statistically significant risk and protective factors for respiratory illnesses in 2010.

Illness	Risk factor (exposure factor)	Crude OR (CI)	p-value
Lower respiratory illnesses			
Bronchitis	**Opening windows within the house**	0.58 (0.26-1.31)	0.19
	Having pets in the house	0.49 (0.21-1.15)	0.10
	Eating chicken and/or fish	0.24 (0.08-0.71)	0.01
	Eating red meat	1.84 (0.76-4.45)	0.17
	Eating fruit	0.33 (0.12-0.86)	0.02
Pneumonia	**Using municipality water**	0.06 (0.01-0.63)	0.02
	Using a private borehole	16.00 (0.90-283.63)	0.06
Asthma	**Having pets in the house**	2.46 (1.33-4.55)	<0.001
	Using a wood or coal stove	0.13 (0.03-0.56)	0.01
	Smoking within the house	1.72 (0.90-3.29)	0.10
	Eating chicken and/or fish	0.36 (0.12-1.06)	0.06

	Eating red meat	1.84 (0.89-3.79)	0.10
	Eating vegetables	0.44 (0.18-1.11)	0.08
Wheezing	**Eating red meat**	0.31 (0.16-0.59)	<0.001
	Eating processed food	2.75 (1.27-5.94)	0.01
	Smoking within the house	1.71 (0.93-3.16)	0.09
	Using an asbestos heater	2.04 (0.73-5.65)	0.17
	Opening windows within the house	0.17 (0.09-0.32)	<0.001
Upper respiratory illnesses			
Earache	**Using a wood or coal stove**	8.41 (2.32-30.49)	<0.001
	Using a gas or paraffin heater	3.87 (1.00-15.09)	0.05
	Having mould within the house	2.37 (0.98-5.75)	0.06
	Using a private borehole	5.24 (0.48-57.09)	0.17
Hay fever	**Using a fireplace**	1.97 (0.86-4.51)	0.11
	Opening windows within the house	0.41 (0.23-0.73)	<0.001
	Having pets in the house	0.58 (0.32-1.04)	0.07
	Using a gas or paraffin heater	1.83 (0.96-3.47)	0.07
	Eating fruit	2.11 (0.70-6.37)	0.18
	Eating red meat	0.67 (0.38-1.17)	0.16
	Eating processed food	1.78 (0.99-3.20)	0.05
Sinusitis	**Eating vegetables**	0.47 (0.21-1.04)	0.06
	Eating chicken and/or fish	0.32 (0.11-0.92)	0.03
	Using a wood or coal stove	0.39 (0.17-0.90)	0.03

With respect to bronchitis, children who ate chicken and/or fish two to three times a week were 76% less likely to get bronchitis as compared to children who did not eat chicken and/or fish. Children in houses where gas and/or paraffin heaters were used were nearly twice more likely to get hay fever as compared to children in households where gas and/or paraffin heaters were not used.

The risk and protective factors for LRIs (combined earache, sinusitis and hay fever) for the 2010 study were: using a wood or coal stove, using municipal water, using a private borehole, using an asbestos heater, smoking within the house, opening windows within the house, having pets within the house, eating chicken and/or fish, vegetables, fruit, and processed food (2-3 times a week).

The risk and protective factors for URIs (combined asthma, pneumonia and bronchitis) for the 2010 study were: using a wood or coal stove, using a gas or paraffin heater, having mould within the house, using a private borehole, using a fireplace, opening windows within the house, having pets within the house, eating chicken and/or fish, red meat, vegetables, fruit, and processed food (at least 2-3 times a week).

4.8.2. Multivariate analyses

The results for the multivariate regression analyses are reported in Table 19 (1990) and Table 20 (2010), respectively.

Table 19: Stepwise multivariate logistic regression results for LRIs AND URIs in 1990.

Disease/Outcome	Risk factor (exposure factor)	Adjusted OR with CI	p-value
Lower respiratory illnesses			
***Pneumonia**	Using a gas heater	3.67 (1.15-11.71)	0.03
Upper respiratory illnesses			
****Hay fever**	Smoking within the house	0.51 (0.27-0.98)	0.04
*****Sinusitis**	Smoking within the house	0.54 (0.30-0.94)	0.03

Note: In the univariate analyses, the use of a gas heater was the only risk factor for pneumonia, hence multivariate analyses was not performed on this health outcome.
* For pneumonia, the use of an asbestos heater was also included in the multivariate model
** For hay fever, the use of a private borehole was also included in the multivariate model
*** For sinusitis, the use of a gas heater, an asbestos heater and having pets in the house were other factors run in the multivariate model.

With regard to pneumonia, children in households where a gas heater was used were nearly four times more likely to get pneumonia as opposed to children in

households where gas heaters were not used. Smoking within the house had a protective effect on a child getting hay fever or sinusitis, as the odds of acquiring these illness almost halved in houses were smoking within the house was prevalent as opposed to houses where no smoking was seen.

On completion of the multivariate analyses, the following indoor air pollution sources were statistically significant with pneumonia, hay fever and sinusitis for the 1990 study: the use of a gas heater, and smoking within the house.

Table 20: Stepwise multivariate logistic regression results for LRIs AND URIs in 2010.

Disease/Outcome	Risk factor (exposure factor)	Adjusted OR with CI	p-value
LRIs			
***Bronchitis**	Eating chicken and/or fish	0.23 (0.07-0.75)	0.02
	Eating fruit	0.26 (0.09-0.78)	0.02

Note: None of the upper respiratory illness risk factors were significant on the basis of their OR, large confidence interval and p-value, therefore not included in the table above.
* For bronchitis, other factors that were run in the multivariate model included: having pets in the house, opening windows within the house for air circulation and the consumption of red meat at least two to three times a week.

In the 2010 study, with respect to bronchitis, eating chicken and/or fish and fruits 2-3 times a week had a significant protective effect on a child getting bronchitis. On completion of the multivariate analyses, none of the indoor air pollution sources were statistically significant.

The analyses described above were looking at all the three 1990 ‘white’ schools and comparing them to the six schools in 2010 which comprise of the three 1990 ‘white’ schools and three other ‘township schools’ as depicted in Table 15. It was decided to compute multivariate analyses on the ‘white’ schools only in both the 1990 and 2010 studies.

The ‘white’ schools were compared to one another with regard to exposure factors (risk and protective factors) that were statistically significant and the associated respiratory illness.

Table 21: Stepwise multivariate logistic regression results for LRIs and URIs in 2010 ('white schools – same as those used in the 1990 study').

Disease/Outcome	Risk factor (exposure factor)	Adjusted OR with CI	p-value
URIs			
***Hay fever**	Smoking in the house	0.50 (0.27-0.96)	0.03
LRIs			
****Bronchitis**	Eating chicken and/or fish	0.26 (0.09-0.65)	0.02
	Eating fruit	0.28 (0.08-0.68)	0.02

*For hay fever, other factors that were run in the multivariate model included: using a fireplace, opening windows in the house for air circulation, having pets in the house, using a gas or paraffin heater, eating red meat, fruit, and processed food at least two to three times a week

** For bronchitis, other factors that were run in the multivariate model included: having pets in the house, opening windows within the house for air circulation and the consumption of red meat at least two to three times a week.

On review of Table 21 above, it is evident that in the 'white' schools in the 2010 study population, a similar trend was seen as the entire 2010 study population, whereby the consumption of chicken and/or fish and fruit was protective of bronchitis. Smoking was now also significantly associated with hay fever, albeit as a protective factor.

CHAPTER FIVE - DISCUSSION

5.1. INTRODUCTION

One of the four objectives of this cross-sectional study was to determine the change, if any, in the respiratory health status of 10-year-old children in the Vaal Triangle in 1990 and 2010. The respiratory health of the children was assessed by means of a questionnaire in which critical questions on URIs and LRIs were documented. The study design used for the 2010 study ensured that a representative sample could be studied and provided estimates of prevalence of all factors measured (indoor air pollution sources and respiratory health outcomes).

Descriptive statistics were derived from the questionnaire responses, followed by univariate and multivariate analyses. This chapter will highlight the important findings and interpret these in relation to the four study objectives as well as the literature. A discussion on the results will be done and the biological plausibility of certain associations will be mentioned. The strengths and limitations of the study will be discussed.

5.2. REVIEW OF MAIN FINDINGS

The study limitations of both cross-sectional studies will be addressed in Section 5.3. Differences in the study design of the two studies should be considered when the descriptive statistics and multivariate regression results are compared in the 1990 and 2010 studies.

The first difference in the study design of the two studies is that of the study populations. The demographic profile in the 1990 study population was different from that of the 2010 study population. The 1990 study incorporated all former ‘model C’ schools (i.e. white population) whereas the 2010 study consisted of both former

'model C' schools and 'township' schools (i.e. mostly non-white population). The 2010 study population were combined in the statistical analyses and were further stratified according to socio-economic status and analysed. The geographical location of the study population was the same in both studies.

South Africa has a population of approximately 48 million people, with a sex ratio of 1.01 males/females in an under-15 age category [73]. The linguistic languages that are dominant are Zulu (23.82%), Xhosa (17.64%), Afrikaans (13.35%), Sepedi (9.39%) and English (8.20%) [73]. In the 1990 study, the study population comprised entirely of English and Afrikaans speakers, since only English and Afrikaans medium schools participated in the study. In 2010 though, the study population was representative of a true South African population for the geographical area, since there were English, Afrikaans and Sotho medium schools that participated.

The second study design issue is that 1-year prevalences were used in the 1990 study and 2-week and 6-month prevalences were used in the 2010 study. It was done to reduce the effect of recall bias since a 1-year prevalence is a long time frame. These different prevalences are a defining limitation to compare respiratory health status the two studies. This should be taken in to account when evaluating and understanding the statistically significant differences between the two studies.

Allergies had lower 1-year prevalences in 1990 when compared to the 6-month prevalences of 2010. The 6-month prevalence of the URIs (combined earache, sinusitis and hay fever) and LRIs (combined pneumonia, bronchitis and asthma) in 2010 was lower than the 1-year prevalence in 1990. Wheezing had a higher 6-month prevalence in 2010 when compared to the 1-year prevalence in 1990. The 6-month prevalences of the URIs (earache and sinusitis) were lower in 2010 than the 1-year prevalences in 1990.

The 6-month prevalences of the LRIs (bronchitis and pneumonia) were also lower in 2010 than the 1-year prevalences in 1990. The 6-month prevalence of hay fever in 2010 was significantly higher than the 1-year prevalence in 1990. The 1-year prevalence of asthma in 1990 was the same as the 2-week prevalence in 2010 (i.e. 12% with a p-value of < 0.001, thereby being statistically significant).

Looking at the 2010 “township” schools, there is a marked decrease in the 6-month prevalence of asthma in 2010 when compared to the 1-year prevalence in 1990. This finding is consistent with the findings of Matooane et al in 2011 [69], whereby asthma prevalence was less in townships as compared to other areas (where the ‘white’ schools are situated).

Studies done in Maputo and Mozambique on children aged 13-14 years found an asthma prevalence of 13% [74]. In a study conducted by Ehrlich and colleagues in South Africa, looking at children between the ages of 7 and 8, the prevalence of the reported asthma was 10.8% [75]. Burr and colleagues conducted a comparative study on childhood asthma in four countries, namely: New Zealand, Wales, South Africa and Sweden, the history of asthma was reported to be 11.5% in South Africa [76].

In the ISAAC study in Cape Town, an asthma prevalence of 13.3 % was found [77]. In a study conducted by Obihara *et al* in Cape Town (2005) amongst 6-14 year-old children; the prevalence of asthma was 12.3% [77]. From all the above-mentioned studies it is clearly seen that the prevalence of asthma ranges between 10 to 14 %. The 1-year 1990 (12.41%), and 2-week 2010 (12.02%) prevalence of asthma was found to be similar to the one found by Obihara *et al* in Cape Town, through their cross-sectional questionnaire, a similar measurement tool as incorporated in the 1990 and 2010 studies.

On comparison of the living conditions of the study populations in 1990 and in 2010, the majority of the study population lived in single, unattached houses, although a declining trend is observed in 2010 when compared to 1990. Comparing the water sources in both studies; municipal water is used predominantly. This is consistent with the census of 2011 whereby the major water source was municipal or piped water [78].

The use of private boreholes has decreased marginally with the use of community boreholes increasing slightly. Although not much emphasis should be placed on the unadjusted association observed between borehole water use and some of the respiratory health illnesses, it is worthwhile to mention a possible biological plausible

reason. Studies done by Isa *et al* (2013) found that the presence of chromium in borehole water increased the toxicity in the body and may lead to respiratory disorders [79]. Okpaka *et al*, on examination of borehole water identified the Penicillum species which is known to cause allergy, asthma and respiratory problems [80].

Wood and coal stove usage for cooking purposes have increased marginally from 1990 to 2010, whilst the use of a fireplace and a gas/paraffin heater for household heating has increased considerably. The use of an asbestos heater has reduced in 2010 when compared to 1990. It is important to note that the fact that an asbestos heater is a household heater is what one should consider. Exposure misclassification does not affect the illness, since the use of a household heater is what is being looked at and not the type of heater or the constituent material of the heater. In this dissertation, the health effects emanating from the use of asbestos heaters itself are not of concern and were not dealt with in this dissertation.

On evaluation of absenteeism in the last two weeks, between the two studies, an increase was evident in the number of days absent from school in the 2010 study. This is a possible indicator of the degree in which the child is affected by an illness. Children in the 2010 study, living in the Vaal Triangle seemed to have a lower prevalence of allergies as compared to those in 1990, self-diagnosis without the aid of medication seems to have increased marginally and diagnosis of allergies by doctors has almost halved in 2010.

Another study objective was to identify risk/protective factors of URIs and LRIs. With respect to the personal perception as to whether the air pollution in the Vaal Triangle was critical or not; an increased number of people in 2010 deemed air pollution in the Vaal Triangle as critical, as opposed to those in the 1990 study. In 2010, the public's perception of air pollution was assessed by posing whether air pollution in the area was critical or not, whereas back in 1990, numerous perceptions were documented, i.e. not critical, unknown. These findings are consistent with the community and other stakeholders' perceptions of the respiratory health of individuals not improving since the 1990 study, and this is what gave rise to this study.

The perceived sources of air pollution documented in 1990 and in 2010 seemed to have changed marginally. The principal contributors to air pollution in 1990 were deemed to be industries/mines and open fires whereas in 2010, industries/ mines were still categorised as major pollutant source in addition to open fires and motor vehicle pollution. Ozcan (2012) found that in both developed and rapidly developing or industrial areas, major air pollution has typically originated from industrial activities and also form high levels of smoke, SO_2 and the combustion of fossil fuels for domestic, industrial purposes and traffic [81]. The 1990 study findings were consistent with the air quality within the area, i.e. all criteria pollutant concentrations conforming to the USA AQS, with the exception of TSP [1,2].

The PM_{10} concentrations are elevated during the winter months in 2010, which is consistent with what Klejnowski *et al* (2011) found in Poland where the PM_{10} levels were elevated during the winter months when compared to summer [82]. In a study conducted by Pey *et al* (2013), the seasonal trend of PM_{10} was studied in the Mediterranean Basin over eleven years and PM_{10} peaked throughout the year with some peaks seen in winter, although major peaks were seen in summer and spring [83].

In the 2010 study, peaks were encountered from May till September; these may be due to domestic fuel burning during the winter months. These peaks are observed in the monitoring stations that are in the towns of Sebokeng, Sharpeville and Three Rivers. On completion of the 1990 study, exceedances in PM_{10} were found with all other criteria pollutant concentrations being deemed within US AQS standards [1].

During January to April 2010 and December 2010 the PM_{10} levels were generally below the 1-year NAAQS. The implication of the findings suggest that the implementation of the Vaal Triangle as a priority area in April 2006 may have led to lower PM_{10} levels, although the trend between 2006 and 2010 was not investigated in this study.

Due to urbanisation and industrialisation, communities are exposed to air pollution from numerous sources, the pollutants in the air transform themselves from normal fossil fuel burning constituents to constituents in PM and other pollutants such as O_3

[17], this could explain the elevated levels of PM in 1990 and in 2010 (the elevated PM_{10} levels in winter are proportional to the low levels of O_3 as compared to spring or summer where O_3 levels are higher).

In the 1990 study, the use of a gas heater was the only significant risk factor for pneumonia, i.e. no other statistically significant factors were found after completion of the multivariate models. The US EPA describes NO_2 as the main pollutant emitted from gas heaters and stoves and the health effects include: pulmonary edema, lung injury, bronchitis, pneumonia, and an increased risk of other respiratory infections [84]. In the 2010 study, it was found that a quarter of the study population used gas heaters, however, no association was observed between gas heater usage and any respiratory illness outcomes.

In the 1990 study, exposure to environmental tobacco smoke at home was a significant protective factor for hay fever and sinusitis, after adjusting for other confounders. A possible reason for these biological implausible results may be that environmental tobacco smoke at home is associated with other unmeasured confounding variables, which in turn act as protective factors for hay fever and sinusitis [85]. Nevertheless, in a study conducted by Austin and Russell (1997), exposure to second-hand smoke decreased the risk of hay fever [86]. When comparing the same schools in both studies, smoking within the household was once again found to have a protective effect on hay fever, which is consistent with the findings of Austin and Russell [86].

Looking at the association between smoking within the house and sinusitis, secondary data analyses from the Third National Health and Nutrition Examination Survey in 1988-1994, the prevalence of acute, recurrent and chronic sinusitis was seen in smokers, whereas exposure to second-hand smoke was not found to increase the risk of an individual getting sinusitis [87]. In the 1990 study, smoking within the house had a protective effect on sinusitis, although similar studies have not been documented, smoking has neither been associated as a risk or protective factor for an individual's likelihood of getting sinusitis [87]. The possible explanation of this could be that there is a less likely chance of smoking being present in houses where children have respiratory illnesses (i.e. reverse causation).

In the 2010 study, none of the indoor air pollution sources were significantly associated with earache, sinusitis, hay fever, pneumonia, bronchitis or asthma. Eating chicken, fish or fruit at least two to three times a week had a protective association with bronchitis. The dietary intake of polyunsaturated fatty acids and omega-6 fatty acids reduced the risk of COPD and asthma as seen in a study done by Hirayama *et al* (2010) [88]. Associations have been documented between the intake of fish and fruit and indicators of asthma and COPD as studied by Smith (2001) [89].

McKeever *et al* (2010) did a study on the patterns of dietary intake in relation to respiratory disease and a more traditional diet, i.e. a high intake of meat and potatoes associated with a lower forced expiratory volume, whereas a more cosmopolitan diet was associated with an increased risk of getting wheezing and asthma [90]. However associations with bronchitis have not been found in all these studies. The above-mentioned associations were linked to asthma, wheezing and COPD.

The temporal relationship between dietary intake and respiratory health outcomes is critical in determining causality as most associations between diet and respiratory health outcomes are drawn from cross-sectional studies. Information though is thus limited as to whether dietary intake is truly involved in the development of certain respiratory health outcomes. Data on induction time or reversibility of the potential effect of diet on these health outcomes seems to be scarce and need to be sought [91].

5.3. LIMITATIONS

In the 1990 and 2010 studies, children's respiratory health status and the exposure (risk/protective) factors were assessed at the same point in time. This is an inherent limitation of all cross-sectional studies. A cross-sectional study design cannot

distinguish whether the exposure risk/protective factors preceded that of the health outcome.

In this study design, there arises an issue of low exposed or unexposed controls. Since no source variable of ambient air pollution was included in the questionnaires of both studies, inferences could not have been made about the effect of ambient air pollution on the children's respiratory health. If a source of ambient air pollution was present, it could have served to model the respiratory health outcomes. This study is rather reliant on data derived from self-reporting questionnaires between two surveys on the basis of reflecting changes in respiratory illness.

The questionnaire used in the study comprised questions which had skips and stem and branch questions. The structure of the questions affected the responses of the study participants, since branch and stem questions may have led to numerous missing values. These discrepancies led to problems arising during the data coding and analysis stages; thereby the repeatability of this study may be in question. The respondents tended to proceed to the secondary question although a skip was employed; this brought about contradictory results.

The 2010 study was done to identify the respiratory health of children in a snap-shot in time and was once-off, which compared 1990 children to those in 2010. Conducting the study in another year (e.g. 2012 or 2013) could result in different findings.

Recall bias and issues arising from variations in questionnaire interpretation were evident in the questionnaire since the prevalence of particular health outcomes were asked in 2-weeks, 6-month and yearly time frames. This led to respondents answering only one of the questions pertaining to prevalence and skipping the other. This compounded the problem of low cell frequencies and these in turn affected results during the multivariate analyses. Self-reported prevalences are being measured in both studies and this only gives an idea of the actual prevalence, and may be subject to measurement error.

The study sample was randomly selected with the aid of a biostatistician. In both the 1990 and 2010 studies, all 10-year-old children formed the population of interest.

Through random selection, selection bias is partially accounted for, although measurement error and selection bias are still present in the study population selected.

Exposure misclassification and disease misclassification may have had an effect on the eventual health outcomes, since the term “allergies” may be perceived to the parents as inclusive of asthma and other health outcomes therefore misclassification of the disease may occur.

In terms of the prevalences of health outcomes, 1-year prevalences in the 1990 study and a 2-week and 6-month prevalences in 2010 study were used. This resulted in different prevalence periods and should be taken into account when interpreting the prevalences of the respiratory illnesses. The self-reporting questionnaire also furthermore led to under-reporting and over-reporting of certain respiratory health outcomes, i.e. recall bias, since 6-month and yearly prevalences may be difficult to remember.

When examining respiratory health and air pollution effects, the demographics of an area are critical. These factors require information ranging from socio-economic status to household characteristics. Furthermore, respiratory health and the resultant air pollution end-points are determined by the exposure variables which can be either protective or act as a risk for an individual acquiring a particular health outcome[92].

It is also important to keep in mind that in both the 1990 and 2010 study, real air pollution measurements were not linked to health outcomes. Finally, none of the sources of indoor air pollution were associated with any of the respiratory health outcomes in the 2010 study.

5.4. ADVANTAGES OF THE STUDY

In terms of the prevalence, statistical associations and linkages between exposure factors and health outcomes with specific reference to respiratory health outcomes the results obtained from the questionnaire are similar to those in the 2003 study by Oosthuizen *et al* (2003), and in a similar study conducted in the Highveld priority area in 2010 by Albers (2011) [3,92].

Furthermore this study incorporated an adequate sample size and the methodology used in the study was sound, except the decision to use a 6-month prevalence in the 2010 study. This self-reported questionnaire was one that was used in several other studies in addition to Oosthuizen *et al* and Albers [3,92].

CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1. INTRODUCTION

This final chapter summarises the conclusions of the research outcomes and research problem. The recommendations are discussed with the need for recommended research being documented.

6.2. CONCLUSIONS ON RESEARCH PROBLEM AND OUTCOMES

Research question: The change, if any, in the respiratory health status of children living in the Vaal Triangle in 2010, compared to the respiratory health status of children who participated in the 1990 VAPS, is not known.

Changes in the respiratory health status (URIs and LRIs) have been found, on the basis of the findings obtained from this inter-comparative cross-sectional study. With respect to the overall self-reported prevalences of some respiratory illnesses derived from the questionnaire, a statistically significant difference in certain respiratory (but not all) diseases among 10-year-old children in the two study populations were evident. This serves as an idea of the actual prevalence and may be subject to measurement error. It is important to keep in mind that a 1-year prevalence in the 1990 VAPS was compared to a 6-month prevalence in the 2010 study.

Objectives:
Measure the current (2010) respiratory health status of 10-year olds in the Vaal Triangle Airshed priority area:

The respiratory health status of 10-year-old children in the VTAPA in 2010 was determined on the basis of the prevalences of URIs and LRIs obtained from data extracted from self-reported questionnaires used in the 2010 study. Results showed

that there seems to be a statistically significant difference in the respiratory health status of 10-year-old children living in the Vaal Triangle in 2010 when compared to those in 1990.

Allergies had lower 1-year prevalences in 1990 when compared to the 6-month prevalences of 2010. The 6-month prevalence of the URIs (combined earache, sinusitis and hay fever) and LRIs (combined pneumonia, bronchitis and asthma) in 2010 was lower than the 1-year prevalence in 1990. Wheezing had a higher 6-month prevalence in 2010 when compared to the 1-year prevalence in 1990. The 6-month prevalences of the URIs (earache and sinusitis) were lower in 2010 than the 1-year prevalences in 1990.

The 6-month prevalences of the LRIs (bronchitis and pneumonia) were also lower in 2010 than the 1-year prevalences in 1990. The 6-month prevalence of hay fever in 2010 was significantly higher than the 1-year prevalence in 1990. The 1-year prevalence of asthma in 1990 was the same as the 2-week prevalence in 2010 (i.e. 12% with a p-value of < 0.001, thereby being statistically significant). Looking at the 2010 “township” schools, there is a marked decrease in the 6-month prevalence of asthma in 2010 when compared to the 1-year prevalence in 1990.

Identify risk factors for upper and lower respiratory health outcomes:

Risk factors and protective factors have been identified for LRIs and URIs in 1990 and in 2010.

In the 1990 study, on completion of the multivariate analyses, the use of a gas heater was identified as a risk factor for an individual acquiring pneumonia, whilst smoking within the household was protective of hay fever and sinusitis.

In the 2010 study, on completion of the multivariate analyses, the consumption of chicken and/or fish and fruit at least two to three times a week was identified as a protective factor for an individual acquiring bronchitis.

Compare the current (2010) respiratory health status of 10-year olds in the Vaal Triangle Airshed priority area to that found in the VAPS (1990) study:

The respiratory health statuses of 10-year-old children in the VAPS in 1990 and in 2010 study have been calculated on the basis of the statistically significant differences in the prevalence of both LRIs and URIs.

With respect to the overall respiratory health status of 10-year-olds in the Vaal Triangle, a change is evident in certain respiratory illnesses. On comparison of the yearly prevalences in 1990 to the 6-month prevalences of 2010, the URIs, sinusitis, and earache have decreased in the 2010 study when compared to the 1990 study. Hay fever prevalence increased in 2010 (6-month prevalence) when compared to the yearly prevalence of it in 1990. When comparing LRIs, asthma prevalence in the 1990 and 2010 study was found to be the same (yearly prevalence in 1990 and a 2-week prevalence in 2010). The 6-month prevalences of bronchitis and pneumonia in 2010 were less than the yearly prevalences in 1990. Lastly the 6-month wheezing prevalence in the 2010 study was almost four times higher than the 1990 yearly prevalence.

6.3. RECOMMENDATIONS FOR FURTHER RESEARCH

A bigger study with a representative sample of children in various age groups and other susceptible populations, for e.g. the elderly, could be utilised in future to evaluate whether the exacerbated respiratory symptoms and diseases will increase even more or if a plateau will be reached. Furthermore a study of this nature will enhance the reliability of the study findings. It may also allow for considering whether the effects of exposure to air pollution during childhood might really only become evident much later in life by conducting a long-term cohort study.

Air pollution exposure for long periods may not be a causative agent in one acquiring upper and lower respiratory diseases and other health outcomes. Research studies

addressing vulnerability to air pollution need to be carried out; thereby ensuring the causality of specific disease outcomes and limiting the role of confounders in the final health outcome (what results thereafter is an issue of residual confounding). Another possible factor that needs to be investigated is an individual's genetic susceptibility to air pollution and being prone to specific URIs and LRIs.

An essential component of all studies is data handling and the storage thereof. In this study delays were brought about due to ineffective storage of the 1990 VAPS data. Hence it is of utmost importance to store data effectively, with backups done readily on each stage of data analysis and write-up. An effective and novel solution that ensures the safety of the data is by means of remotely backing up files on a daily basis. This ensures data are readily available even after decades of publication of the results, as encountered in this study whereby a comparison was done after a time frame of two decades.

Remote backup ensures that the data files are protected from technical, natural and other mishaps. The files are encrypted, transmitted and stored in an encrypted format in mirrored data centers. Each dataset is given a specific personal encryption key and fast and efficient data transfers are ensured by redundant fiber optic bandwidths [93].

On extraction of information from questionnaires into statistical software, coding of variables is essential and in a comparative study of this nature, consistency is imperative in ensuring data of high quality. The way in which data of this nature is documented and stored is crucial, with respect to the data and results needed for possible comparative studies in future.

Another critical aspect is the measurement tool of the study, i.e. questionnaires; they should be based on other studies and be reviewed by experts so as to ensure a high degree of reliability and validity.

As evident from the protective factors that arose from the 2010 study, the consumption of chicken and/or fish, fruits and vegetables can aid in minimising the risk of an individual getting respiratory illnesses. Food programmes with diets rich in

these foods could be incorporated in school canteen menus in areas where respiratory illnesses, emanating from air pollution are on the rise.

More advanced epidemiological studies need to be done in South Africa, e.g. time-series, case-crossover and panel studies (i.e. focus on 24-hour real measured air pollutants on acute 24-hour health outcomes) and also cohort studies (link long-term exposure to the development of new disease cases, not just the prevalence of existing disease cases).

It is imperative to have a consistent and similar study protocol when doing a comparative study; this ensures all measurements are consistent in both studies and is more likely to lead to a dataset of high quality. This is imperative when comparing data originating from two self-reporting questionnaires.

Lastly, closer collaboration is needed with DoH, DEA and research groups that focus on air pollution and health effects.

6.4. FINAL CONCLUSIONS

This dissertation provides the results of a cross-sectional study undertaken in the Vaal Triangle priority area, focusing on the respiratory health status of 10-year-old children between the studies conducted in 1990 and in 2010. A change in the respiratory health status of 10-year-old children in 1990 and 2010 was found for some health outcomes.

After the multivariate analyses was computed, a very few factors were statistically significantly associated with the respiratory health outcomes. Asthma prevalence remained the same in both the studies, whilst the prevalence of sinusitis, bronchitis and pneumonia decreased in 2010 when compared to the 1990 study. The risk factors for LRIs in the 1990 study were the use of a gas heater; the only URI protective factor was smoking within the household. In the 2010 study, there were no risk factors and only protective factors emanated after the multivariate analyses for

LRIs and these were the consumption of chicken and/or fish and fruits at least three times a week. Possible recommendations and insights to future studies have been made, thereby helping in the priority area management.

There are numerous methodological difficulties that arise when using a self-reporting questionnaire as a measurement tool. These include bias and misclassification, on the basis of using a self-reporting questionnaire. Comparing the data that emanates from two self-reporting questionnaires is challenging in that all parameters and levels of measure should be consistent in both study populations to acquire data of high quality. It is imperative that a study protocol is used and can be a measure of ensuring consistency between the two study populations.

The questionnaire must be better tested in pilot studies, thereby reducing skips and other areas where missing data comes about.

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APPENDIX A

Letter of consent and questionnaire used in the 2010 study

PARTICIPANT'S INFORMATION LEAFLET & INFORMED CONSENT FORM
TITLE OF STUDY: Human Health Risk Assessment: Vaal Triangle priority area.

1) THE NATURE AND PURPOSE OF THIS STUDY

The CSIR in collaboration with the University of Pretoria is currently doing a study focusing on air pollution and the respiratory health status of 10-year old children in the Vaal Triangle Airshed priority area. The main objective of the study is to compare the current respiratory health status of 10-year olds in the Vaal Triangle Airshed priority area to the respiratory health status of those who participated in the Vaal Triangle Air Pollution and Health Study (VAPS) done in 1990. The results will indicate the trend in the health status of children over the past 20 years and provide decision support to national authorities in managing air quality and human health.

2) EXPLANATION OF PROCEDURES TO BE FOLLOWED

You as the parent or guardian of a ten year old child are asked to complete this questionnaire. The information provided by you is very important for the success of the study. Information will be collected about the child's health, the home the child lives in, the life style and activities of the child and your personal views. Completion of the questionnaire may take about 20 minutes.

3) RISK INVOLVED

There is no risk involved to you or the child as all the information obtained in this study will be treated as confidential by the researchers.

4) POSSIBLE BENEFITS OF THIS STUDY

There will be no immediate direct benefit to participants as the benefit will be indirectly through improved management of human health and the environment.

5) HAS THE TRIAL RECEIVED ETHICAL APPROVAL?

This study was approved by the ethics committees of the CSIR and the University of Pretoria and consent was given by the Department of Education to the child's school to administer the questionnaires.

6) INFORMATION

If you have any questions concerning this study, please contact:
Dr Caradee Wright tel: 012 8413092
Ms R Oosthuizen tel: 012 841 2035 cell: 084 652 9132

7) CONFIDENTIALITY

All records obtained whilst in this study will be regarded as confidential. Results will be published or presented in such a fashion that participant's information remains unidentifiable.

8) CONSENT TO PARTICIPATE IN THIS STUDY

I have read in a language that I understand the above information before signing this consent form. I understand that I am being asked to take part in a research study and that I may at any time withdraw from this study or refuse to answer a question. I hereby volunteer to take part in this study.

Note:
The implication of completing the questionnaire is that informed consent has been obtained from you. Thus any information derived from you (which will be known to the researchers only) may be used for e.g. publication, by the investigators. As all information or data are anonymous, you should understand that you will not be able to recall your consent, as your information will not be traceable.

Parent or Guardian signature …… Date .....

Witness …… Date ……

QUESTIONNAIRE TO ASSESS THE RESPIRATORY HEALTH STATUS OF CHILDREN IN THE VAAL TRIANGLE AIRSHED PRIORITY AREA

Introduction:
The CSIR, in collaboration with the University of Pretoria, is doing research on the respiratory health status of 10 year old children in the Vaal Triangle. In order to do so, we need to get information about a number of things, including the child's living conditions.

Once we get enough information on exposure and health status, we will be able to determine what actions could be taken to improve the health status of children should that be necessary. Examples of actions include looking at ways of decreasing their exposure to air pollution which will help to reduce the health effects from this pollution.

Who should give information?
The parent or guardian of the child should complete the questionnaire about the child.

Confidentiality:
Your answers will be used for research purposes only and will not be given to anyone else.

Questionnaire no	
Personal details of parent/guardian	
1.1. Village/town	
1.3. Tel number	
1.4 Date completed	

CHILD's PERSONAL INFORMATION (Demographics)

1. What is the child's gender?

   a) Male ☐
   b) Female ☐

2. What is the child's date of birth?

   YEAR: ☐☐☐☐ MONTH: ☐☐ DAY: ☐☐

3. What is the child's home language?

   a) Afrikaans ☐ e) Zulu ☐
   b) English ☐ f) Swazi ☐
   c) Sotho ☐ g) Other ☐
   d) Xhosa ☐

4. In which town does the child live?

   VEREENIGING ☐ VANDERBIJLPARK ☐ SASOLBURG ☐
   ZAMDELA ☐ LEKOA ☐ EVATON ☐
   SHARPVILLE ☐ OTHER ☐

5. How long has the child been living in this town (where he/she now lives most of the time)?

   a) Since birth ☐ d 5 – 10 years ☐
   b) Less than 2 years ☐ e) More than 10 years ☐
   c) 2 – 4 years ☐

6. In what town did the child live before living in this town?

   _____

7. How long did the child live in the previous town?

   a) Since birth ☐ d) 5 – 10 years ☐
   b) Less than 2 years ☐ e) More than 10 years ☐
   c) 2 – 4 years ☐

THE FOLLOWING QUESTIONS RELATE TO THE HOME WHERE THE CHILD LIVES

8. Which of the following best describes the child's home?

a) A single family brick house, not attached to any other house
b) A single family brick house, attached to another house (or houses)
c) A flat
d) Pre-fabricated home (zinc/wood/clay)

9. How many bedrooms or sleeping areas are there in this home?

10. How many people live in this home?

11. From where do you get the water used in the child's home? (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. Are any of the following heating systems used in the child's home? (Mark Yes or No for each one)

a) Wood/coal stove/konka?	Yes	No
b) Fireplace	Yes	No
c) Gas or paraffin heater	Yes	No
d) Asbestos heater	Yes	No

13. If there is a portable gas heater (can be carried around) in the child's home, how often is it used during the winter?

a) About every day	
b) 2 to 3 times a week	
c) 2 to 3 times a month	
d) Seldom	
e) Never	

14. If there is a coal stove/konka in the child's home, how often is it used during the winter?

a) About every day ☐
b) 2 to 3 times a week ☐
c) 2 to 3 times a month ☐
d) Seldom ☐
e) Never ☐

15. If there is a fireplace in the child's home, how often is it used during the winter?

a) About every day ☐
b) 2 to 3 times a week ☐
c) 2 to 3 times a month ☐
d) Seldom ☐
e) Never ☐

16. What fuel is mostly used for cooking? (Mark only one)

a) Electricity ☐
b) Gas ☐
c) Paraffin ☐
d) Wood ☐
e) Coal ☐

17. Are windows or doors opened often to circulate fresh air into the child's home during the winter months?

a) Yes ☐
b) No ☐

18. Is there mould or mildew (usually black or brown spots) growing on any damp or moist surface inside the child's home (these can be.on walls, wallpaper, carpets, ceilings, shower, curtains, etc.)?

Yes	No

19 a) Does household where the child lives or stays in most of the time have any pets?

a) Yes ☐
b) No ☐

b) Are any animals allowed inside the home?

a) Yes ☐
b) No ☐

20. Does smoking (cigarettes, cigars or pipe) happen on a regular basis (almost every day) inside the home where the child lives?

a) Yes ☐
b) No ☐

EATING HABITS

21. Which of the following does the child eat regularly (at least three times a week)? Mark Yes or No for each one)

a)	Chicken or 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

THE FOLLOWING QUESTIONS ARE ABOUT THE CHILD's HEALTH

22. How would you describe the child's health compared to the health of other children of the same age group?

a) Better ☐
b) The same ☐
c) Worse ☐

23. Does the child have any allergies?

a) No ☐
b) Yes, and the child is not using any medication ☐
c) Yes, and the child is using medication bought at pharmacy (chemist) ☐
c) Yes, and the child is using medication prescribed by a doctor ☐

24. During the last 2 weeks, how many **days** did child not go to school because he/she was sick?

☐☐ days

25. During the past 12 months, how many **days** did the child not go to school because he or she was sick?

a)	0 days	☐	c)	21-30 days	☐
b)	1-10 days	☐	d)	>30 days	☐
c)	11-20 days	☐			

26. If absent from school during the past 12 months, please specify which illness mostly caused this absence

_____

27. Has the child had any of the following conditions during the past 2 weeks? (Mark No or Yes for every illness)

a) Bronchitis	Yes	No	Symptoms: cough with headache, no or mild fever, chills, sometimes chest pains and shortness of breath..
b) Pneumonia	Yes	No	Symptoms: high fever , cough, difficulty breathing, wheezing, chills, chest pain, green/yellow sputum
c) Earache	Yes	No	
d) Hay fever	Yes	No	Symptoms: sneezing, itchy and watery eyes, runny nose and a burning throat
e) Sinus problems	Yes	No	

28. How does the child mostly/usually breathe?

a) Through the mouth ☐ b) Through the nose ☐

ASTHMA

29. Has a doctor ever said/told you that the child has asthma?

a)	Yes	☐
b)	No	☐

If the answer was NO, go to question 34.

30. How old was the child when asthma was diagnosed by the doctor?

a)	0 – 1 years	☐	e)	8 – 9 years	☐
b)	2 – 3 years	☐	f)	10 years and older	☐
c)	4 – 5 years	☐	g)	Do not know	☐
d)	6 – 7 years	☐			

31. a) Does the child still have asthma attacks?

a)	Yes	☐
b)	No	☐
c)	Not sure	☐

If the answer was NO, go to question 34.

b) If the answer is "**yes**", or "**not sure**" how often does the child have asthma attacks?

Weekly	☐
Monthly	☐
Occasionally	☐
During exercise or play	☐

32. Does the child take asthma medication or get treatment for asthma at the moment?

a)	Yes	☐
b)	No	☐

33. Which months of the year does the child have asthma attacks more often? (Mark No or Yes for each one)

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

CHEST COUGH (COUGH THAT COMES FROM THE CHEST)

34. Does the child cough most mornings when he/she wakes up? (Mark one)

a) No **(go to question 36)**	☐
b) Yes, has been coughing during the previous 3 months	☐
c) Yes, has been coughing for longer than the previous 3 months	☐

35. When does the child cough mostly? (Mark one)

☐

a) During the day ☐
b) During the night ☐
c) During the day and the night ☐
d) Only when waking up or going to bed ☐

PHLEGM (phlegm on the chest is thick, sticky substance that causes coughing)

36. Does the child usually have phlegm on the chest? (Mark one)

a) No **(go to question 38)** ☐
b) Yes, when he/she has a cold ☐
c) Yes, with and without having a cold ☐

37 If "Yes", is this phlegm usually present for longer than 3 months continuously or non-stop?

a) Yes ☐
b) No ☐

WHEEZE OF THE CHEST (whistling sound of the chest)

38. Does the child's chest sound wheezy or make a whistling sound when he/she exhales/breathes out?

a) Yes ☐
b) No ☐

If NO, go to question 40.

39. When the child does **not** have a cold, when does the wheezing mostly happen?

a) Never ☐
b) During the day ☐
c) During the night ☐
d) During the day and the night ☐

40. Has the child ever been hospitalised for respiratory illnesses?

a) Yes ☐
b) No ☐

If yes, please provide the following information:

c) How many times has the child been admitted to hospital for respiratory illnesses? _____

d) If possible, indicate month and year of each time the child was admitted to hospital:

i) month _____ year _____
ii) month _____ year _____
iii) month _____ year_____
iv) month _____ year _____
v) month _____ year _____

e) What respiratory illnesses was the child admitted for?

_____
_____
_____

OTHER ILLNESSES AND CONDITIONS

41. At the moment is the child using any medication prescribed by a doctor?

a) Yes ☐
b) No ☐

If yes, please indicate what medication: _____

42. During the **past 6 months**, has the child had any of the following conditions? (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

43. Has the child **ever** had any of the following conditions? (Mark Yes or No for each one)

a)	Learning problems	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)	Sugar Diabetes	Yes	No
k)	Painful joints (arthritis/gout)	Yes	No

Symptoms: moving at all times, find it more difficult to sit still than other children

Hepatitis is a liver disease

Stomach problems, runny tummy

44. How much does the child weigh?

a) < 30 kg ☐
b) 31-40 kg ☐
c) > 45 kg ☐

PERSONAL VIEWS / YOUR OPINION

45. Do you think the air pollution in the Vaal Triangle is a problem?

a) Yes ☐
b) No ☐

46. What do you think is the most important source / cause of air pollution in your area? (Mark **one**)

a) Motor vehicles ☐
b) Industries and mines ☐
c) Cigarette smoke ☐
d) Open fires (from areas without electricity) ☐

THANK YOU!

Once the questionnaire has been filled in, please return it to the child's teacher in a sealed envelope (provided).

APPENDIX B

1990 VAPS QUESTIONNAIRE

QUESTIONNAIRE

MEDICAL RESEARCH COUNCIL

VAAL TRIANGLE AIR POLLUTION HEALTH STUDY

Dear parent / guardian

Your child's school is participating in an extensive program to study the potential respiratory health effects associated with the air quality in your area. This study is being conducted by the Medical Research Council in coordination with various Universities, the Department of Health and your City Councils. The approval of the Director of Education is also given to the study.

In order to better understand the effects of the air that your child breathes on his/her health it is necessary for us to obtain information on the health status of some members of your household, yourself, your partner and the child who brought this questionnaire home. We also need to know something about the house you live in to understand more about the indoor air quality. The main part of this questionnaire concerns the child who brought this questionnaire home.

We would appreciate your co-operation in completing this questionnaire. Your participation in this environmental health research project will assist us in ensuring a healthy environment for all South-Africans. We would like to encourage the parent/ guardian who is most familiar with the health of the child who brought this questionnaire home, to fill in the questionnaire.

ALL INFORMATION OBTAINED IN 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. You have a right to the results of this research project concerning your childs health.

Once you have completed the questionnaire, please have your child who brought this questionnaire home, return it to his/her teacher.

Thank you for your co-operation.

PLEASE NOTE: THE QUESTIONNAIRE IS PRINTED ON BOTH SIDES

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

Although this questionnaire seems bulky, it will take you just between 20 - 30 minutes to complete. (Please note that questions are printed on each side of the page). Encircle you answer where a choice is given, for example:

What is the sex of the child?
(a) Male
(b) Female

When a word or figure is required you must write the answer in the given space, for example:

How old is your child? 9

Year 09 Months 11

We would like to encourage the parent/guardian who is most familiar with the child's health to fill out the questionnaire.

If you have any questions or problems relating to this questionnaire, you can phone one of the following persons:

Dr Petro Terblanche	(W) (012) - 324-1680 x 231	
	(H) (012) - 344-5791	
Miss Louise Uys	(W) (012) - 324-1680 x 235	
Miss Tercia Smit	(W) (012) - 324-1680 x 239	

Please complete: Details of the child who brought this questionnaire home (One character per block).

OFFICE USE
Chart nr. 1

SURNAME:

NAME:

ADDRESS:

POSTAL CODE:

Chart nr. 2

TEL NR: CODE: NR.

TOWN: (Encircle the correct one)
VEREENIGING, VANDERBIJLPARK, MEYERTON,
(SASOLBURG) RANDVAAL, LEKOA, EVATON, SHARPEVILLE

4

QUESTION. NR:

DATE ON WHICH THIS QUESTIONNAIRE IS COMPLETED:

YEAR: 1990 MONTH: 10 DAY: 31

901031

Office use

Chart nr. 3

Question nr.

CHILD'S PERSONAL INFORMATION:

1. What is the sex of the child?
   a) Female (b) Male

2. What is the child's date of birth?
   Year 1980 Month NOV. Day 07

3. What is the child's original linguistic group?
   a) Afrikaans e) Zulu
   (b) English f) Swazi
   c) Sotho g) Other
   d) Xhosa

4. How long has this child been living in this town where you now live?
   a) Since birth d) 4 - 5 years
   (b) Less than 2 years e) More than 5 years
   (c) 2 - 4 years f) Unknown

5. Where did the child live before living in this town?
   _____

6. How long has this child been living in this present residence?
   a) Since birth d) 4 - 5 years
   (b) Less than 2 years e) More than 5 years
   c) 2 - 4 years f) Unknown

THE FOLLOWING QUESTIONS CONCERNS THE PERSON WHO IS COMPLETING THIS QUESTIONNAIRE

7. What is your relationship to this child?
   (a) Biological mother
   b) Biological father
   c) Female guardian
   d) Male guardian
   e) Other (Specify) _____

Office use

8. What is the marital status of the childs biological parents?
   a) Never married
   (b) Married
   c) Widow/widower
   d) Separated/Divorced
   e) Other (Specify)_____ [2]

THE FOLLOWING QUESTIONS CONCERNS THE MOTHER/ FEMALE GUARDIAN WHO IS PART OF THE HOUSEHOLD

9. How many years of schooling or other education did the mother/female guardian complete?
   a) Did not complete st. 8
   b) Complete st. 8
   c) Complete st. 10
   d) Degree or Diploma [5]
   (e) Post-graduate qualifications

10. What is the current employment status of the mother/female guardian?
   a) Employed full time
   b) Employed part time
   c) Self-employed
   (d) Housewife
   e) Retired
   f) Unemployed
   g) Other [4]
   h) Unknown

11. What is the current occupation or job of the mother/female guardian?
   a) Job or occupation
   _____
   b) Type of business or industry
   _____ [27]
   c) Number of years worked at job
   _____

THE FOLLOWING QUESTIONS CONCERNS THE FATHER/ MALE GUARDIAN WHO IS PART OF THE HOUSEHOLD

12. How many years of schooling or other education did the father/male guardian complete?
   a) Did not complete st. 8
   b) Complete st. 8
   c) Complete st. 10
   d) Degree or Diploma
   (e) Post-graduate qualifications [5]

Office use

13. What is the current employment status the father/male guardian?

(a) Employed full time
b) Employed part time
c) Self-employed
d) Retired
e) Unemployed
f) Other

[1]

14. What is the current occupation or job of the father/male guardian?

a) Job or occupation

Engineering. chemical.

b) Type of business or industry

c) Number of years worked at this job

[01]

15. In which of the following ranges did your total family income fall for the last year? (Include all income before taxes and deductions - sum of both breadwinners)

a) Less than R7 000
b) Between R7 000 and R12 000
c) Between R12 001 and R18 000
d) Between R18 001 and R24 000
e) Between R24 001 and R36 000
f) Between R36 001 and R48 000
(g) More than R48 000

[7]

CURRENT HOUSEHOLD MEMBERS

16. Counting yourself, how many people of 10 years and older live in the house together with the child? (Include the child if he/she is 10 years or older than 10 years).

2

[0]
[02]

17. How many people under 10 years live in the house together with the child? (Include the child if he/she is younger than 10 years).

2

[02]

Office us

ANSWER THE FOLLOWING QUESTIONS REGARDING THE RESIDENCE OF THIS CHILD

18. Which of the following best describe your home?
   a) A single family house, not attached to other houses
   b) A single family house, attached to other houses
   c) A flat
   d) Pre-fabricated home (asbestos/wood)
   e) Other

   [1]

19. How many rooms are there in your home?
   (Don't count bathroom and toilet)
   7

   [07]

20. How many bedrooms are there in the home?

   3

   [03]

21. Where is the water in the home obtained from?
   (Mark each one applicable)
   a) Municipality
   b) Private borehole
   c) Community borehole
   d) Other (Specify) _____

   [1] [2] [1] [1]

22. Do you use any of the following heating systems?
   (Mark each one applicable)
   a) Wood stove
   b) Coal stove
   c) Fireplace
   d) Gas heater
   e) Asbestos heater
   f) Portable electric heater
   g) Other (Specify) _____
   h) None - go to question 26

   [1] [1] [1] [1] [1] [2] [1] [1]

23. Do you have a portable gas heater in your home and how often do you use it during the winter?
   a) No, do not have a gas heater
   b) Yes, about every day
   c) Yes, 2 to 3 times a week
   d) Yes, 2 to 3 times a month
   e) Yes, seldom
   f) Yes, never

   [1]

Office use

24. Do you have a coal stove in your home and how often do you use it during the winter?
   a) No, do not have a coalstove
   b) Yes, about every day
   c) Yes, 2 to 3 times a week
   d) Yes, 2 to 3 times a month
   e) Yes, seldom [4]
   f) Yes, never

25. Do you have a fireplace in your home and how often do you use it during the winter?
   a) No, do not have a fireplace
   b) Yes, about every day
   c) Yes, 2 to 3 times a week
   d) Yes, 2 to 3 times a month
   e) Yes, seldom [3]
   f) Yes, never

26. What fuel do you use mostly for cooking? (Encircle only one)
   a) Electricity
   b) Wood
   c) Gas
   d) Electricity and gas [1]
   e) Other (Specify) _____

Chart nr. 3 4
Question nr.

27. Do you use any of the following equipment in your home? (Mark each one applicable)
   a) Humidifier [1]
   b) Airscrubber/cleaner [1]
   c) Airconditioning [1]
   d) Do not use any of the above mentioned [2]
      - go to question 30

28. If yes (question 27), how often did you use this equipment the previous summer?
   a) About every day
   b) 2 to 3 times a week
   c) 2 to 3 times a month
   d) Seldom [ ]
   e) Never

Office use

29. Where did you use the equipment specified in question 27?
a) All the rooms
b) Livingroom
c) Bedroom(s)
d) Other (Specify) _____ ☐

30. Do you open windows or doors to circulate fresh air into your home during the winter months?
a) No - go to question 32
(b) Yes 2

31. How often did you do this during the past winter?
(a) About every day
b) 2 to 3 times a week
c) 2 to 3 times a month
d) Seldom 1

32. Have you ever had problems with leakage, flooding or water damage in your home?
(a) No b) Yes 1

33. Have you ever had mold or mildew growing on any surface inside your present home? (for example on walls, wallpaper, carpets ceilings, shower, curtains, etc.)
(a) No
b) Yes, in the shower area (curtain, around bath)
c) Yes, in other areas in the home
d) Unknown 1

34. Which of the following pets do you have? (Encircle more than one if necessary)
a) None e) Mice
(b) Dog(s) f) Bird(s)/Doves 2 1
c) Rabbit(s) g) Guinea pig(s) 1 1
d) Cat(s) h) Other _____ 1 1

35. Are any of these animals allowed in the home?
(a) No b) Yes 1

Office use

36. 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). (Encircle more than one if necessary)

a) Pottery and ceramics
b) Painting (Oil)
c) Dyes and fibers /fabrics
d) Jewelry and enamelling
e) Metal work
f) Automotive (mechanical/electrical)
g) Stained glass soldering
h) Photography (Darkroom use only)
i) Print making
j) Furniture stripping
k) Wood working
l) Silk screening
m) None
n) Other, (Specify) _____

[1][1][1][1][1][1][1][1][1][1][1][2][1]

THE FOLLOWING QUESTIONS CONCERN THE BIOLOGICAL PARENTS OF THE CHILD

37. Has a doctor ever said the biological father of this child has any of the following: chronic bronchitis, emphysema or chronic obstructive lung disease?

(a) No c) Unknown
b) Yes

[1]

38. Has a doctor ever said the biological father of this child had asthma?

(a) No c) Unknown
b) Yes

[1]

39. Has a doctor ever said the biological mother of this child has any of the following: chronic bronchitis, emphysema or chronic obstructive lung disease?

(a) No c) Unknown
b) Yes

[1]

40. Has a doctor ever said the biological mother of this child had asthma?

(a) No c) Unknown
b) Yes

[1]

Office use

INFORMATION ABOUT SMOKING HABITS

41. Did the child's mother smoke while she was pregnant with this child?
   a) No, she did not smoke
   b) Yes, the first 3 months
   c) Yes, the middle 3 months
   d) Yes, the last 3 months
   e) Yes, the first 6 months
   f) Yes, the whole pregnancy
   g) Unknown [1]

42. During which of the following periods from the child's birth until he/she turned 6 years old, did the mother/female guardian smoke?

   a) No, did not smoke
   b) Since birth until 2 years old
   c) Since 2 - 6 years
   d) Since the child's birth until 6 years old
   e) Unknown [1]

43. During which of the following periods from the child's birth until he/she turned 6 years, did any other smokers live in the home?
   a) Never
   b) Before the child's birth
   c) Since birth until 2 years old
   d) Since 2 - 6 years
   e) Before the child's birth until 6 years old
   f) Unknown [1]

44. Who else, except the mother, has smoked in the home before and six years after the birth of the child?
   a) Father
   b) Male guardian
   c) No one
   d) Unknown
   e) Other, Specify _____ [03]

45. Is there currently any one who smokes cigarettes, cigares or pipe on a regular basis (daily) in the home where this child lives? Office use

a) No
b) Yes, mother/female guardian
c) Yes, father/male guardian
d) Yes, both parents/guardians
e) Yes, other

[1]

46. How many cigarettes in total are smoked in the child's home each day?

a) None
b) 1 - 9
c) 10 - 19
d) 20 - 29
e) 30 - 39
f) 40 - 59
g) 60 - 79
h) 80 or more

[1]

47. How many cigars in total are smoked in the child's home each day?

a) None
b) 1 - 5
c) 6 - 10
d) More than 10

[1]

48. How many times in total are a pipe smoked in the child's home each day?

a) None
b) 1 - 5
c) 6 - 10
d) More than 10

[1]

ACTIVITIES

49. Approximately how much time within the last year did the child spend away from home, outside the town where he/she currently stays?

a) Less than 1 week
b) 1 - 2 weeks
c) 2 - 4 weeks
d) 4 - 6 weeks
e) 6 - 8 weeks
f) More then 8 weeks
g) Unknown
h) None

[2]

50. Where did the child spend most of this time referred to in question 49? Name the city or district.

Durban

[07]

51. Approximately how many hours per day did your child spend outside the home this past summer holiday?

a) Less than 1 hour per day
b) 1 - 2 hours per day
c) 3 - 4 hours per day
d) 5 or more hours per day
e) Unknown

[4]

Office u

52. Approximately how many hours per day did your child spend outside the home this past winter holiday?
a) Less than 1 hour per day
b) 1 - 2 hours per day
c) 3 - 4 hours per day
d) 5 or more hours per day
e) Unknown

[3]

53. How many hours on a school day do your child spend outside?
a) Less than 1 hour per day
b) 1 - 2 hours per day
c) 3 - 4 hours per day
d) 5 or more hours per day
e) Unknown

[4]

THE FOLLOWING QUESTIONS CONCERNS THE CHILD'S HEALTH

4 Chart nr Question

54. How would you describe your child's health compared to other children of the same age group?
a) Excellent
b) Good
c) Poor

[1]

55. Does this child have any allergies?
a) No - go to question 58
b) Yes, self diagnosed
c) Yes, diagnosed by a doctor
d) Unknown

[1]

56. How ofen does the child take medication for the allergy?
a) None
b) Daily
c) 2 x week
d) 3 x week
e) Other (Specify)_____

[2]

Office use

57. For what is the child allergic to? (Encircle)

a) Things he/she eats?
Specify: _____ ☐☐

b) Things he/she inhales?
Specify: _____ ☐☐

c) Skin contact?
Specify: _____ ☐☐

d) Medication, eg. aspirine?
Specify: _____ ☐☐

e) Other?
Specify: _____ ☐☐

f) Unknown ☐☐

58. How many days of school has this child missed over the last 2 weeks, because of illness?

(a) None
b) 1
c) 2
d) 3
e) 4
f) 5
g) 6
h) 7
i) 8
j) 9
k) 10 or more

01

59. During the past 12 months, how many times has this child missed school because of illness?

a) None
(b) 1 to 5
c) 6 to 10
d) 11 to 20
e) 21 - 30
f) more than 30

2

60. Due mostly to which illness?
Specify operation. / apendix.

05

61. Has this child ever had any of the following illnesses? (Encircle No or Yes for every illness)

a) Bronchitis	~~No~~	Yes	1
b) Pneumonia	No	Yes	1
c) Earache	No	Yes	1
d) Croup	No	Yes	1
e) Hay fever	No	Yes	1
f) Chronic bronchitis	No	Yes	1
g) Sinus trouble	No	Yes	1
h) Rhinitis	No	Yes	1

Office use

62. Did this child have a severe chest illness for example: pneumonia or chest cold before the age of two years?
a) No - go to question 64
b) Yes
c) Unknown

63. Did the child have more than one such illness?
a) No
b) Yes
c) Unknown

64. Did this child have a severe chest illness for example: pneumonia or chest cold after the age of two years?
a) No - go to question 67
b) Yes
c) Unknown

65. Did the child have more than one such illness?
a) No
b) Yes
c) Unknown

66. What was the doctor's diagnoses?

67. In the past year, has this child had a chest illness that kept him/her at home for three or more days in bed?
a) No - go to question 70
b) Yes
c) Unknown

68. Did the child have more than one such illness?
a) No
b) Yes
c) Unknown

69. Did the child see a doctor for such illness?
a) No
b) Yes, what was the diagnoses? He had a flu.

70. Has a doctor ever said that this child has a heart disease?
a) No
b) Yes
c) Unknown

Office use

71. After the child's birth was he/she kept in the hospital after the mother went home?
a) No
b) Yes
c) Unknown

72. What was the child's weight at birth?
a) Under 3 pounds / under 1,5 kg
b) 3 - 5 pounds / 1,5 kg - 2,3 kg
c) More than 5 pounds/more than 2,3 kg
d) Unknown

ASTHMA

73. Has your doctor ever said that this child has asthma?
a) No - go to question 79
b) Yes
c) Unknown

74. At what age did the child's asthma begin?
a) 0 - 1 years
b) 2 - 3 years
c) 4 - 5 years
d) 6 - 7 years
e) 8 - 9 years
f) 10 years and older
g) Unknown

75. Does the child still have asthma?
a) No
b) Yes

76. Does the child currently take medicine or treatment for asthma?
a) No
b) Yes

77. If the child no longer has asthma, at what age did the child last had asthma?
a) 0 - 1 years
b) 2 - 3 years
c) 4 - 5 years
d) 6 - 7 years
e) 8 - 9 years
f) 10 years and older
g) Unknown

78. Which months of the year is the child's asthma the worst? (Mark every one that is applicable)

Office use

a) January
b) February
c) March
d) April
e) May
f) June
g) July
h) August
i) September
j) October
k) November
l) December
m) Unknown

Chart nr.
Question n

CHEST COUGH

79. Does this child cough when he/ she wakes up in the morning?

a) No - go to question 81
b) Yes, the previous 3 months
c) Yes, longer than the previous 3 months
d) Yes, the previous year
e) Yes, longer than the previous year

80. When does the child cough mostly?

a) During the day
b) During the night
c) During the day and the night
d) When he/she wakes up/go to bed only

PHLEGM

81. Does this child usually have phlegm on the chest?

a) No - go to question 83
b) Yes, with colds
c) Yes, without colds
d) Yes, with and without colds
e) Unknown
f) Other, Specify _____

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

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

Office use

WHEEZE OF THE CHEST

83. Does the child's chest sound wheezy or whistling when he/she inhales?
   a) No - go to question 90
   b) Yes
   c) Unknown

84. Does this wheeze of the chest occur with colds and when?
   a) No
   b) Yes, previous year
   c) Yes, previous and other years

85. Does this occasionally happen other than with colds and when?
   a) No
   b) Yes, previous year
   c) Yes, previous and other years

86. When does the child's chest wheeze mostly, when he/she <u>don't</u> have a cold?
   a) During the day
   b) During the night
   c) During the day and the night

87. During which month(s) of the year does the child usually have an episode of wheezing?
   a) January
   b) February
   c) March
   d) April
   e) May
   f) June
   g) July
   h) August
   i) September
   j) October
   k) November
   l) December
   m) Unknown

88. Has this child ever had attacks of shortness of breath when his/her chest wheezes?
   a) No
   b) Yes, previous year
   c) Yes, previous and other years

89. Does this child ever get attacks of wheezing after he/she has been playing hard or exercising?
   a) No
   b) Yes
   c) Unknown

OTHER ILLNESSES

Office use

90. Within the past year, has this child had any of the following? (Encircle No or Yes for each one)

a) Bronchitis	No	Yes	
b) Pneumonia	No	Yes	
c) Running nose	No	Yes	2
d) Earache	No	Yes	
e) Hay fever	No	Yes	
f) Sinusitis	No	Yes	
g) Asthma	No	Yes	
h) Rhinitis	No	Yes	

91. Did the child have any allergy test during the previous year?

a) No b) Yes — 1

92. In the past year has this child had any other major illness or accident that kept him/her home or prevented him/her to participate in any school activities?

a) No
b) Yes, specify

_____ 01

93. Has the child ever had any of the following? (Encircle No or Yes for each one)

a) Learning disability	No	Yes
b) Hyperactivity	No	Yes
c) Mental retardation	No	Yes
d) Hepatitis	No	Yes
e) Cancer	No	Yes
f) Gastro-intestinal diseases	No	Yes

Chart nr. 6 7
Question nr.

94. During the past 12 months how often has this child been bothered by any of the following? (Document number)

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

Office use

PERSONAL VIEWS

95. Do you consider the air pollution in the Vaal Triangle as serious?
a) No
(b) Yes
c) Not critical
d) Unknown
[2]

96. What do you consider the most important source of air pollution in your area?
a) Motorvehicles
(b) Industries and mines
c) Cigarette smoke
d) Open fires (black townships)
e) Other (Specify) _____
[1] [2] [1] [4] [7]

97. Have you noticed unusual odors in your neighborhood?
(a) No
b) Yes
[1]

98. If "Yes" fill in for how long have you noticed the odors? (Document number)
a) [ ][ ] Years
b) [ ][ ] Months
c) [ ][ ] Days
[ ][ ][ ][ ][ ][ ]

99. Do you feel these odors affect the health of this child?
a) No
b) Yes
c) Unknown
[ ]

100. If "Yes" how severely do you feel these odors affect the health of this child?
a) A great deal
b) Fairly
c) Very little
d) Unknown
[ ]

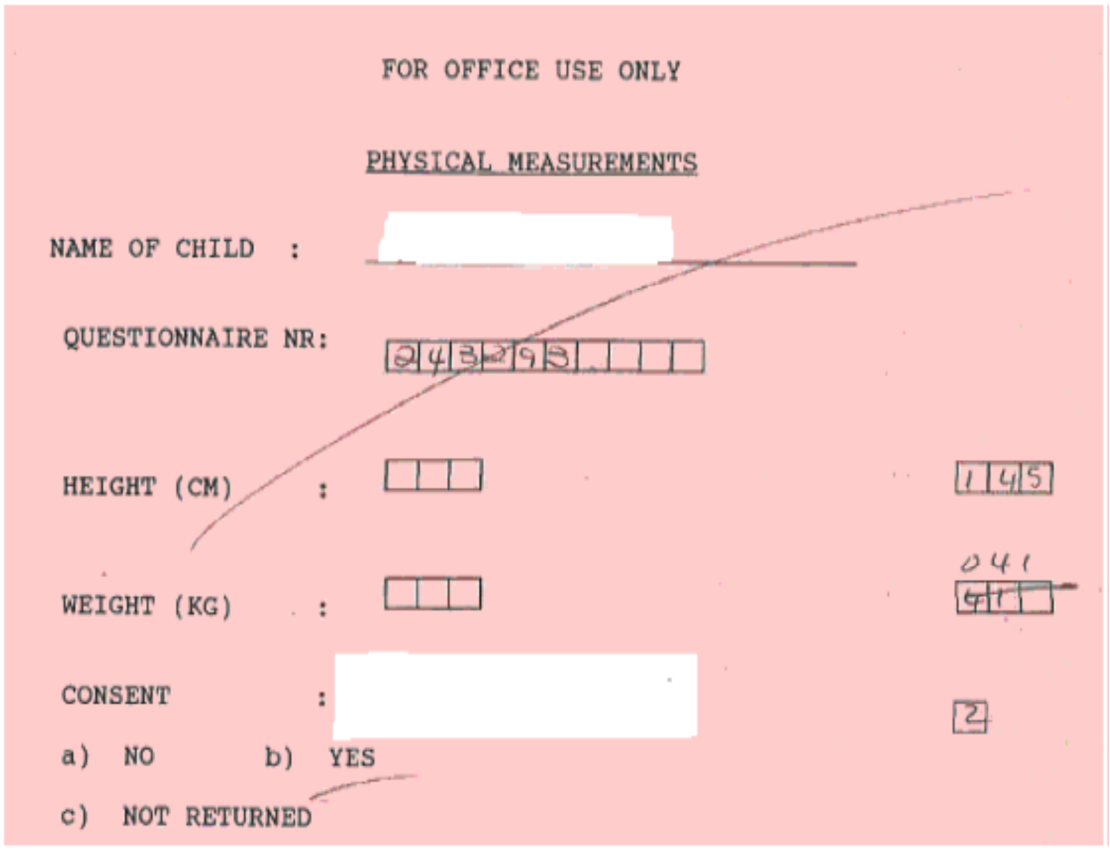
101. Do you feel these odors affect your health?
a) No
b) Yes
c) Unknown
[ ]

102. If "Yes" how severely do you feel these odors affect your health?
a) A great deal
b) Fairly
c) Very little
d) Unknown
[ ]

THANK YOU!

Once you have completed the questionnaire, please have the child who brought this questionnaire home, return it to his/her teacher.

September 1990



FOR OFFICE USE ONLY

PHYSICAL MEASUREMENTS

NAME OF CHILD :

QUESTIONNAIRE NR: 2 4 3 2 9 3

HEIGHT (CM) : 1 4 5

WEIGHT (KG) : 041

CONSENT : 2

a) NO b) YES

c) NOT RETURNED

APPENDIX C

UNIVARIATE RESULTS FOR THE 1990 AND 2010 STUDIES

Table C1: Univariate analyses-Odds ratio with confidence intervals and p value for LRIs and URIs in the 1990 study.

Disease / Outcome	Risk factor (exposure factor)	Crude OR (CI)	p-value
LRIs			
Bronchitis	Using municipality water	0.52 (0.17-1.61)	0.26
	Using a private borehole	1.51 (0.63-3.60)	0.35
	Using a coal stove	4.77 (0.49-46.67)	0.18
	Using a fireplace	0.88 (0.25-3.09)	0.84
	Using a gas heater	0.81 (0.31-2.14)	0.68
	Using an asbestos heater	1.27 (0.71-2.25)	0.42
	Using an electric heater	0.88 (0.48-1.61)	0.68
	Opening windows within the house	0.21 (0.021-2.03)	0.18
	Having mould within the house	1.49 (0.70-3.19)	0.30
	Having pets in the house	0.68 (0.36-1.28)	0.23
	Smoking within the house	0.72 (0.41-1.26)	0.25
Pneumonia	Using a private borehole	1.71 (0.45-6.51)	0.43
	Using a fireplace	0.92 (0.11-7.69)	0.94
	Using a gas heater	3.67 (1.15-11.71)	0.03
	Using an asbestos heater	0.46 (0.15-1.45)	0.19
	Using an electric heater	1.03 (0.39-2.77	0.95
	Having mould within the house	0.66 (0.14-3.05)	0.60
	Having pets in the house	1.04 (0.35-3.10)	0.94
	Smoking within the house	0.73 (0.28-1.90)	0.52
	Using municipality water	0.84 (0.18-3.94)	0.83
	Using a private borehole	1.39 (0.45-4.34)	0.57
	Using a coal stove	3.75 (0.33-42.62)	0.29

Asthma	Using a fireplace	0.60 (0.075-4.76)	0.63
	Using a gas heater	0.25 (0.032-1.88)	0.18
	Using an asbestos heater	1.98 (0.93-4.22)	0.08
	Using an electric heater	1.05 (0.47-2.34)	0.91
	Having mould within the house	0.74 (0.25-2.23)	0.59
	Having pets in the house	1.45 (0.59-3.57)	0.42
	Smoking within the house	0.61 (0.29-1.28)	0.19
URIs			
Earache	Using municipality water	1.66 (0.49-5.62)	0.41
	Using a private borehole	0.58 (0.23-1.45)	0.24
	Using a coal stove	0.74 (0.10-5.38)	0.77
	Using a fireplace	0.89 (0.26-3.02)	0.86
	Using a gas heater	0.58 (0.23-1.47)	0.25
	Using an asbestos heater	1.11 (0.63-1.97)	0.72
	Using an electric heater	0.84 (0.47-1.49)	0.55
	Window	0.68 (0.12-3.77)	0.66
	Having mould within the house	1.57 (0.74-3.33)	0.24
	Having pets in the house	0.64 (0.34-1.19)	0.16
	Smoking within the house	1.02 (0.59-1.76)	0.94
Hay fever	Using municipality water	0.60 (0.17-2.16)	0.44
	Using a private borehole	2.23 (0.84-5.91)	0.11
	Using a fireplace	0.31 (0.038-2.51)	0.27
	Using a gas heater	1.40 (0.50-3.90)	0.53
	Using an asbestos heater	1.24 (0.64-2.43)	0.52
	Using an electric heater	0.79 (0.39-1.61)	0.52
	Having mould within the house	0.90 (0.36-2.27)	0.83
	Having pets in the house	0.64 (0.32-1.28)	0.21
	Smoking within the house	0.51 (0.27-0.98)	0.04
	Using municipality	0.79 (0.24-2.52)	0.69

Sinusitis	water		
	Using a private borehole	1.77 (0.71-4.41)	0.22
	Using a fireplace	1.53 (0.45-5.20)	0.49
	Using a gas heater	2.54 (0.97-6.65)	0.06
	Using an asbestos heater	1.55 (0.88-2.74)	0.13
	Using an electric heater	0.94 (0.53-1.69)	0.84
	Window	0.40 (0.035-4.44)	0.45
	Having mould within the house	1.21 (0.57-2.55)	0.62
	Having pets in the house	0.65 (0.36-1.21)	0.17
	Smoking within the house	0.56 (0.32-0.98)	0.04

Table C2: Univariate analyses-Odds ratio with confidence intervals and p value for LRIs and URIs in the 2010 study.

Illness	Risk factor (exposure factor)	Crude OR (CI)	p-value
LRIs			
Bronchitis	Using municipality water	0.64 (0.07-5.88)	0.69
	Using a private borehole	1.88 (0.35-10.11)	0.46
	Using a community borehole	5.39 (0.32-90.14)	0.24
	Using a fireplace	0.72 (0.20-2.60)	0.62
	Using an asbestos heater	0.84 (0.23-3.04)	0.79
	Opening windows within the house	0.58 (0.26-1.31)	0.19
	Having mould within the house	0.94 (0.43-2.08)	0.88
	Having pets in the house	0.49 (0.21-1.15)	0.10
	Using a wood or coal stove	1.39 (0.54-3.53)	0.50
	Using a gas or paraffin heater	1.41 (0.64-3.06)	0.39
	Smoking within the house	0.55 (0.22-1.37)	0.20
	Eating chicken and/or fish	0.24 (0.08-0.71)	0.01
	Eating red meat	1.84 (0.76-4.45)	0.17
	Eating processed food	1.34 (0.61-2.93)	0.46
	Eating vegetables	0.79 (0.25-2.43)	0.68
	Eating fruit	0.33 (0.12-0.86)	0.02
Pneumonia	**Using municipality water**	0.06 (0.01-0.63)	0.02
	Using a private borehole	16.00 (0.90-283.63)	0.06
	Using a fireplace	1.38 (0.15-12.80)	0.78
	Using an asbestos heater	1.44 (0.16-13.42)	0.75
	Having mould within the house	1.17 (0.12-11.47)	0.68
	Having pets in the house	0.63 (0.07-5.75)	0.68
	Using a wood or coal stove	1.18 (0.13-10.91)	0.88

	Using a gas or paraffin heater	0.35 (0.04-3.21)	0.36
	Smoking within the house	0.89 (0.10-8.12)	0.92
	Eating chicken and/or fish	0.26 (0.03-2.43)	0.24
	Eating red meat	0.46 (0.06-3.33)	0.44
	Eating processed food	0.24 (0.02-2.30)	0.21
	Eating vegetables	0.43 (0.05-4.00)	0.46
	Eating fruit	0.31 (0.03-3.06)	0.31
Asthma	Using a private borehole	0.50 (0.06-4.22)	0.52
	Using a fireplace	1.34 (0.55-3.25)	0.52
	Using an asbestos heater	0.93 (0.36-2.44)	0.89
	Opening windows within the house	1.01 (0.47-2.18)	0.98
	Having mould within the house	0.75 (0.36-1.57)	0.45
	Having pets in the house	2.46 (1.33-4.55)	0.00
	Using a wood or coal stove	0.13 (0.03-0.56)	0.01
	Using a gas or paraffin heater	1.08 (0.56-2.11)	0.81
	Smoking within the house	1.72 (0.90-3.29)	0.10
	Eating chicken and/or fish	0.36 (0.12-1.06)	0.06
	Eating red meat	1.84 (0.89-3.79)	0.10
	Eating processed food	0.67 (0.35-1.28)	0.22
	Eating vegetables	0.44 (0.18-1.11)	0.08
	Eating fruit	0.74 (0.26-2.06)	0.56
	Using a private borehole	1.20 (0.14-10.52)	0.87
	Using a fireplace	1.05 (0.33-3.32)	0.93
	Using an asbestos heater	2.04 (0.73-5.65)	0.17
	Opening windows within the house	0.17 (0.09-0.32)	0.00
	Having mould within the house	0.87 (0.45-1.70)	0.69
	Having pets in the house	1.01 (0.54-1.91)	0.97
	Using a wood or	0.87 (0.33-2.27)	0.77

Wheeze	coal stove		
	Using a gas or paraffin heater	1.28 (0.57-2.91)	0.55
	Smoking within the house	1.71 (0.93-3.16)	0.09
	Eating chicken and/or fish	0.88 (0.24-3.14)	0.84
	Eating red meat	0.31 (0.16-0.59)	0.00
	Eating processed food	2.75 (1.27-5.94)	0.01
	Eating vegetables	1.09 (0.36-3.29)	0.87
	Eating fruit	1.11 (0.37-3.37)	0.85
URIs			
Earache	Using municipality water	0.35 (0.04-3.30)	0.36
	Using a private borehole	5.24 (0.48-57.09)	0.17
	Using a fireplace	1.12 (0.13-10.00)	0.92
	Using an asbestos heater	2.26 (0.42-12.28)	0.35
	Opening windows within the house	1.24 (0.35-4.33)	0.74
	Having mould within the house	2.37 (0.98-5.75)	0.06
	Having pets in the house	0.50 (0.16-1.49)	0.21
	Using a wood or coal stove	8.41 (2.32-30.49)	0.00
	Using a gas or paraffin heater	3.87 (1.00-15.09)	0.05
	Smoking within the house	0.49 (0.14-1.71)	0.27
	Eating chicken and/or fish	0.49 (0.10-2.34)	0.37
	Eating red meat	0.63 (0.19-2.04)	0.44
	Eating processed food	0.94 (0.32-2.80)	0.91
	Eating vegetables	0.44 (0.12-1.64)	0.22
	Eating fruit	1.47 (0.18-11.69)	0.72
	Using municipality water	1.49 (0.16-13.51)	0.72
	Using a private borehole	1.20 (0.23-6.31)	0.83
	Using a fireplace	1.97 (0.86-4.51)	0.11
	Using an asbestos heater	0.73 (0.26-2.04)	0.54

Hay fever	**Opening windows within the house**	0.41 (0.23-0.73)	0.00
	Having mould within the house	1.43 (0.82-2.48)	0.21
	Having pets in the house	0.58 (0.32-1.04)	0.07
	Using a wood or coal stove	1.49 (0.70-3.14)	0.30
	Using a gas or paraffin heater	1.83 (0.96-3.47)	0.07
	Smoking within the house	1.05 (0.59-1.87)	0.87
	Eating chicken and/or fish	0.83 (0.30-2.30)	0.73
	Eating red meat	0.67 (0.38-1.17)	0.16
	Eating processed food	1.78 (0.99-3.20)	0.05
	Eating vegetables	0.78 (0.32-1.87)	0.58
	Eating fruit	2.11 (0.70-6.37)	0.18
Sinusitis	Using municipality water	2.19 (0.24-19.79)	0.49
	Using a private borehole	0.47 (0.09-2.42)	0.37
	Using a fireplace	0.84 (0.38-1.88)	0.68
	Using an asbestos heater	0.70 (0.31-1.58)	0.40
	Opening windows within the house	0.71 (0.38-1.35)	0.30
	Having mould within the house	1.22 (0.70-2.11)	0.48
	Having pets in the house	0.95 (0.56-1.60)	0.85
	Using a wood or coal stove	0.39 (0.17-0.90)	0.03
	Using a gas or paraffin heater	1.46 (0.82-2.57)	0.20
	Smoking within the house	0.74 (0.42-1.31)	0.30
	Eating chicken and/or fish	0.32 (0.11-0.92)	0.03
	Eating red meat	0.77 (0.44-1.33)	0.35
	Eating processed food	1.23 (0.73-2.10)	0.44
	Eating vegetables	0.47 (0.21-1.04)	0.06
	Eating fruit	0.82 (0.35-1.92)	0.64

APPENDIX D

CSIR AND UNIVERSITY OF PRETORIA ETHICS APPROVAL LETTERS

CSIR RESEARCH ETHICS COMMITTEE

PO Box 395 Pretoria 0001 South Africa
Tel: +27 12 841 3275
Fax: +27 12 349 2476
Email: cmathabe@csir.co.za

20 July 2010

Dear Rietha Oosthuizen

Approval of Protocol: **HUMAN HEALTH RISK ASSESSMENT VAAL TRAINGLE:**

The respiratory Health Status of 10-year old children exposed to air pollution in the Vaal Triangle priority area.

This is to confirm that your Protocol reviewed by the CSIR REC has been approved. The clearance number of this research project is 03/2010.

This approval is granted under the condition that:

1. The researcher remains within the procedures and protocols indicated in the proposal, as well as the additions made to the procedures and protocols as indicated in the responses submitted to the questions of the REC, particularly in terms of any undertakings made and guarantees given.
2. The researcher notes that her research may have to be submitted again for ethical clearance if there is substantial departure from the existing proposal.
3. The researcher remains within the parameters of any applicable national legislation, institutional guidelines and scientific standards relevant to the specific field of research.
4. This approval is valid for one year from the date of this letter.
5. The researcher submit a short report to the REC on completion of the research in which it is indicated (i) that the research has been completed; (ii) if any new or unexpected ethical issues emerged during the course of the study; and if so, (iii) how these ethical issues were addressed.

We wish you all of the best with your research project.

Kind regards

Prof Johan Hattingh
(CSIR REC Chair)

Dr Christina Mathabe
(CSIR REC Secretariat)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

28/07/2010

Number	:	**S136/2010**
Title	:	A survey of the respiratory health status of 10 year old children exposed to air pollution in the Vaal Triangle priority area
Investigator	:	A J Mundackal, School of Health Systems and Public Health, University of Pretoria (SUPERVISORS: Prof APS Terblanche / Dr C Y Wright)
Sponsor	:	**CSIR**
Study Degree:		**MSc (Community Health)**

This Student Protocol was approved by the Faculty of Health Sciences Research Ethics Committee, University of Pretoria on 27/07/2010. The approval is valid for a period of 3 years.

Prof M J Bester	BSc (Chemistry and Biochemistry); BSc (Hons)(Biochemistry); MSc(Biochemistry); PhD (Medical Biochemistry)
Prof R Delport	(female)BA et Scien, B Curationis (Hons) (Intensive care Nursing), M Sc (Physiology), PhD (Medicine), M Ed Computer Assisted Education
Prof V.O.L. Karusseit	MBChB; MFGP (SA); MMed (Chir); FCS (SA)
Prof J A Ker	MBChB; MMed(Int); MD – Vice-Dean (ex officio)
Dr M L Likibi	MBChB; Med.Adviser (Gauteng Dept.of Health)
Dr MP Mathebula	Deputy CEO: Steve Biko Academic Hospital
Prof T S Marcus	(Female) BSc (LSE), PhD (University of Lodz, Poland)
Prof A Nienaber	(Female) BA (Hons) (Wits); LLB (Pretoria); LLM (Pretoria); LLD (Pretoria); PhD; Diploma in Datametrics (UNISA)
Prof L M Ntlhe	MBChB(Natal); FCS(SA)
Mrs M C Nzeku	(Female) BSc(NUL); MSc Biochem(UCL,UK)
Snr Sr J. Phatoli	(Female) BCur (Et.Al); BTech Oncology
Dr R Reynders	MBChB (Pret), FCPaed (CMSA) MRCPCH (Lon) Cert Med. Onc (CMSA)
Dr T Rossouw	(Female) MBChB.(cum laude); M.Phil (Applied Ethics) (cum laude), MPH (Biostatistics and Epidemiology (cum laude), D.Phil
Mr Y Sikweyiya	MPH (Umea University Umea, Sweden); Master Level Fellowship (Research Ethics) (Pretoria and UKZN); Post Grad. Diploma in Health Promotion (Unitra); BSc in Health Promotion (Unitra)
Dr L Schoeman	(Female) BPharm (NWU); BAHons (Psychology)(UP); PhD (UKZN); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) - MBChB; MMed (Int); MPharMed.
Prof T J P Swart	BChD, MSc (Odont), MChD (Oral Path), PGCHE
Prof G van Biljon	(female)FCP (Paed)SA
Prof C W van Staden	**Chairperson** - MBChB; MMed (Psych); MD; FCPsych; FTCL; UPLM; Dept of Psychiatry

Student Ethics Sub-Committee

Prof R S K Apatu	MBChB (Legon,UG); PhD (Cantab); PGDip International Research Ethics (UCT)
Dr A M Bergh	(female) BA (RAU); BA (Hons) (Linguistics) (Stell); BA (Hons) (German) (UNISA); BEd (Pretoria); PhD (Pretoria); SED (Stell)
Mrs N Briers	(female) BSc (Stell); BSc Hons (Pretoria); MSc (Pretoria); DHETP (Pretoria)
Dr S I Cronje	BA (Pretoria); BD (Pretoria); DD (Pretoria)
Prof M M Ehlers	(female) BSc (Agric) Microbiology (Pret); BSc (Agric) Hons Microbiology (Pret); MSc (Agric) Microbiology (Pret); PhD Microbiology (Pret); Post Doctoral Fellow (Pret)
Prof D Millard	(female) B.lur (Pretoria); LLB (Pretoria); LLM (Pretoria); AIPSA Diploma in Insolvency Law (Pretoria); LLD (UJ)
Dr S A S Olorunju	BSc (Hons). Stats (Ahmadu Bello University –Nigeria); MSc (Applied Statistics (UKC United Kingdom); PhD (Ahmadu Bello University – Nigeria)
Dr L Schoeman	CHAIRPERSON: (female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) MBChB; M.Med (Int); MPhar.Med

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD; Dip. International Research Ethics
CHAIRPERSON of the Faculty of Health Sciences Student Research Ethics Committee, University of Pretoria

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
VICE-CHAIR of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

☎ 012 354 1677 🖷 0866516047 deepeka.behari@up.ac.za http://www.healthethics-up.co.za
✉ P O Box 667, Pretoria, 0001 31 Bophelo Road, HW Snyman South Building, Level 2, Room 2.33, Gezina, Pretoria

APPENDIX E

DEPARTMENT OF EDUCATION-APPROVAL LETTERS TO CONDUCT STUDY IN RESPECTIVE PROVINCES

education
Department of Education
FREE STATE PROVINCE

Enquiries : Mr M.B. Monnane
Reference no. :

Tel. : 051 – 404 8420
Fax. : 051 – 404 8117

OFFICE OF THE DDG: DISTRICT MANAGEMENT

Attention: Rietha Oosthuizen
Senior Scientist

PERMISSION TO UNDERTAKE A STUDY TO DETERMINE THE RESPIRATORY HEALTH STATUS.

Kindly be informed that the Free State Department of Education grants you permission to undertake a study to determine the respiratory health status of a 10-year old Children in schools in the Vaal Triangle Area as requested.

The Department of Education also gives permission for your office to contact Principals of affected schools for any arrangements that need to be done.

Hope you find this in order.

SR Malope
Mr SR Malope
HOD: Education
Date: 02/06/2010

Private Bag X20565, Bloemfontein, 9300
Free State Provincial Government Building, 19th Floor, Cnr Markgraaf and Elizabeth Streets, Bloemfontein
Tel: (051) 404 8420 Fax: (051) 404 8117

www.fsdoe.fs.gov.za

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Enquiries: Nomvula Ubisi (011)3550488

Date:	20 May 2010
Name of Researcher:	Mundackal Antony
Address of Researcher:	12 Eileen Street
	Kilner Park
	Pretoria
Telephone Number:	0128413056/0834448346
Fax Number:	0128412689
Research Topic:	The Respiratory Health Status of 10-year Old Children Exposed to Air Pollution in the Vaal Triangle Priority Area
Number and type of schools:	6 Primary Schools
District/s/HO	Sedibeng East and West

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. ***The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.***
2. ***The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.***
3. ***A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.***

Office of the Chief Director: Information and Knowledge Management
Room 501, 111 Commissioner Street, Johannesburg, 2000 P.O.Box 7710, Johannesburg, 2000
Tel: (011) 355-0809 Fax: (011) 355-0734

APPENDIX F

References for articles emanating from Masters' and bigger CSIR study:

Published articles and informal articles:

National Air Quality Office News (NAQO News). 2010. Article on South African Air Quality Information System (SAAQIS) website: Air pollution in the Vaal Triangle, October-December edition.

Mundackal AJ, Wright CY and Oosthuizen MA. 2011 Change in lower respiratory diseases amongst 10-year-old children in the Vaal Triangle over the last two decades. *Peer-reviewed article and presentation,* Port Elizabeth, October.

Draft articles:

Oosthuizen MA, Mundackal AJ, Wright CY, John J. 2013. Is air quality improving? Results of a study on the upper respiratory health among 10-year-old schoolchildren at three schools in the Vaal Triangle: 20 years after the Vaal air pollution study.

Mundackal AJ, Wichmann J, Wright CY and Oosthuizen MA. 2013. Results on the upper respiratory diseases amongst 10-year-old children in the Vaal Triangle in 1990 and in 2010.

Mundackal AJ, Wichmann J, Wright CY and Oosthuizen MA. 2013. A cross-sectional survey on the respiratory health status of 10-year-olds in the Vaal Triangle.

APPENDIX G

Initially Professor Petro Terblanche was my main supervisor (from 01/01/2010 till 30/06/2010). Due to her taking up a new position as the Group Executive: Research and Development in the Nuclear Energy Corporation of South Africa (NECSA), Professor Petro Terblanche had to step down as my main supervisor.

Dr Janine Wichmann kindly accepted to be my main supervisor as of 10 November 2010 to completion. Hence, Dr Janine Wichmann was only involved in the write up of this dissertation and not in the planning of this study or in the fieldwork thereof.