UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Tel no 2078660
Tel (W) 012 841 4189
epos jjohn@csir.co.za

LEAD EXPOSURE OF CHILDREN ATTENDING PRE-SCHOOL FACILITIES IN CERTAIN GEOGRAPHICAL AREAS OF PRETORIA, IN RELATION TO THEIR ACTIVITY PATTERNS

A CROSS-SECTIONAL STUDY

by

JUANETTE JOHN

SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE
MASTERS OF SCIENCE IN COMMUNITY HEALTH
IN THE SCHOOL OF HEALTH SYSTEMS AND PUBLIC HEALTH

FACULTY OF HEALTH SCIENCES

AT THE

UNIVERSITY OF PRETORIA

SUPERVISOR: Prof C IJsselmuiden
CO-SUPERVISOR: Prof K Voyi

DATE: 12 June 2003

S126/2001

SUMMARY

Objectives

- To estimate the exposure to lead of 5-year old children attending pre-school facilities in two different socio-economic areas, Pretoria East and Soshanguve in Pretoria, using existing exposure measurement tools, activity patterns and pollutant concentrations in air and soil;
- To determine the influence of external factors on the inhalation exposure of children to lead particles in air.

Population and methods

Design: Cross-sectional.

Setting: Pre-school facilities in Soshanguve, representing a lower socio-economic area, and in Pretoria East, representing a higher socio-economic area, during winter (July 2001).

Participants: Thirty pre-schools in Soshanguve (random sample) and 24 in Pretoria East (known pre-schools in the selected area), involving a total of 216 five-year old children; 120 from Soshanguve and 96 from Pretoria East.

Main outcome measures: Exposure to lead in air, lead concentrations in surface soil and dust, risk factors associated with inhalation exposure to lead particles.

Main measurement methods: Questionnaires, time-activity diaries, lead concentrations in air, soil and surface dust, statistical analyses.

Results: Environmental lead levels, especially in air, were generally low. No significant difference in estimates of indoor lead inhalation exposure was found between pre-schools in the two areas. Estimates of outdoor inhalation exposure were significantly lower in Soshanguve, as measured both by total inhalation exposure on the survey day and by traffic counts. The average surface dust lead loadings on window sills, and objects such as book cases, were significantly higher in Soshanguve. Average soil lead concentrations, including concentrations in sandpits and playground areas, were also significantly higher in Soshanguve.

Multivariate analysis indicated that **mean log exposure** to lead (assessing inhalation exposure - not differentiating by area) was associated with a variety of factors. For intervention purposes, five of these factors were selected as being the most important, on the basis of statistical testing. The variables of most practical importance were:

- monthly fees paid at the school
- sloping of the street on which the pre-school was located
- traffic volume
- number of children/m^2 outdoors, and
- surface area (m^2)/child indoors

Inhalation lead exposure was positively associated with the first two and inversely associated with the last three variables.

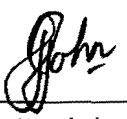
Conclusions and Recommendations: Recommended factors to be considered when planning future pre-schools include the following:

- Proximity of the site to busy roads and other sources of lead. Traffic volumes on these roads should be monitored in advance.
- Facilities should not be built on sites close to steeply sloping roads.
- Cleaning procedures used at a pre-school should not use appliances that disperse dust so-as to minimize exposure to resuspended lead.
- Reduce time spent outdoors if the facility is close to sources of pollution.

As the scope of the study did not include quantification of the measures mentioned above, further research is recommended. This study did not sufficiently address the impact of activity patterns on exposure of children in a South African setting as compared to standardised exposure equations developed by the USEPA, warranting the need for further research in this field.

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree Masters of Science in Community Health at the University of Pretoria. It has not been submitted before for any other degree or examination at any other Technikon or University.



Juanette John

Signed on the 12th day of June 2003 in Pretoria

ACKNOWLEDGEMENTS

I would like to express my sincere thanks the following people and Institutions for their inputs into the thesis:

First and foremost, I would like to thank my Creator for strength to persevere throughout this process.

Mr Brent Christenssen from the US Embassy for his assistance in obtaining additional funding.

The National Safety Council, through the US Environmental Protection Agency for partial funding of the study.

Dr Petro Terblanche for providing invaluable insights at the outset of the research.

Dr Elsie Calitz (VVOS) for providing useful contacts.

Ms Thembi Mphokeng (Church Action in Need) for useful inputs at the outset of the study.

All pre-school facilities that gave inputs during the planning and pilot phase.

Environmental Science Services and the National Centre for Occupational Health for the use of their instruments.

Mr Joe Davidson from Transportek for the use of their traffic counters.

Ms Annemieke van Middelkoop for her useful inputs with regard the study design.

Prof Margo Schwab from Johns Hopkins University for invaluable inputs during the study design and approach of the study.

Dr Jonathan Levin for his patience in assisting me with statistical analyses.

Dr Zeleke Worku for assistance with statistics.

A special thanks to all my colleagues at work for their invaluable assistance and inputs at various stages:
Ms Riëtha Oosthuizen, especially for her help during the field work but also for review.
Ms Shirley McCormick, especially for preparation of filters before and after the field work.
Mr Nico Henning for acting as mentor and reviewer.
Ms Thabisa Mbugwana for spending long hours in the laboratory.
Mr Eddie Erasmus for his assistance in the laboratory.
Ms Yvonne Hong and Liz Muller for useful inputs during the review process.
Ms Annette van Zyl, Ms Karin Harding and Ms Helen de Beer for editorial assistance during the study.

My supervisors, professors Kuku Voyi and Carel IJsselmuiden for their guidance throughout the research.

The Environmental Health officers at Acacia City Council for sacrificing their time to assist in selection of the pre-school facilities.

Mr Fred Molelekwa and Mr Braam Aucamp from Technikon Northern Gauteng for allowing their students to take part in this study and for providing assistance with transport.

The students at the Technikon Gauteng North for taking part in this study.

All the staff and children at the pre-schools for their willingness to take part in the study.

Patricia Mangaladzi and Marlene Westmore for assistance with data capturing and cleaning.

Pat Brown and Johan van der Waals for assistance with matters relating to the capturing of geographic coordinates.

Althea Adey and Elize Webb for valuable editorial inputs into the study and Liz Wolfaardt for excellent support.

My husband, Alan, for his patience and encouragement during this whole period.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Absorption

The process of active or passive transport of a substance, across biological membranes or other barriers, into an organism [1].

Acute exposure

A single exposure to a toxic substance that results in severe biological harm or death.

Air particulates

Airborne particulates include windblown dust, emissions from industrial processes, smoke from the burning of wood and coal, and motor vehicle or non-road engine exhausts.

Air pollutant

A potentially harmful agent occurring in the air usually as a result of human activities [1].

Ambient air

Any unconfined portion of the atmosphere: open or outdoor air.

Background level

In toxic substances monitoring, the average presence of a substance in the environment.

Biomarkers

A measure of a chemical, cellular, immunologic, genetic, or physiologic signal or biologic event or state in biological media, including in tissue, cells or fluids.

BTech in Environmental Health

Bachelors degree in Technology consisting of a year of study after completing a national diploma in Environmental Health at a South African Technikon.

Chronic effect

An adverse effect on a human, animal or vegetation in which symptoms recur frequently or develop slowly over a long period of time.

Cyclone

A cyclone is a device used to separate coarse and fine suspended particles

Developmental disorders/effects

Adverse effects such as altered growth, structural abnormality, functional deficiency, or death observed in a developing organism.

Dose

The amount of a substance to which a person is exposed, often expressed in relation to body weight.

Dose-response

The process of characterising the relationship between the dose of an agent administered or received and the incidence of an adverse health effect in exposed populations [1].

Emission

Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Environmental fate

The destiny of a chemical or biological pollutant after release into the environment, involving temporal and spatial considerations of transport, transfer, storage and transformation.

Environmental Tobacco Smoke (ETS)

'Second hand smoke'; tobacco smoke inhaled by someone in proximity to a smoker.

Exposure

Contact with a chemical by swallowing, by breathing, or by direct contact such as through the skin or eyes. Exposure may be short term (acute) or long term (chronic).

Exposure assessment

Identifying the pathways by which toxicants may reach individuals, estimating how much of a chemical an individual is likely to be exposed to, and estimating the number of individuals likely to be exposed.

Exposure variable

A variable estimating inhalation exposure to lead, created in this study. This variable incorporated data on time-activity patterns and lead concentrations in air. Lead concentrations in soil and dust were measured as proxies for ingestion exposure.

FEV_1

A measure of the maximum amount of air during a forced vital capacity determination that can be expelled in 1 second.

Hazard

A source of risk that produces risk only if an exposure pathway exists, and if exposures create the possibility of adverse consequences.

Hazard identification

Determining if a chemical can cause adverse health effects in humans and what those affects might be.

Hazardous substance

Any material that poses a threat to human health and/or the environment. Typical hazardous substances are toxic, corrosive, ignitable, explosive, or chemically reactive.

Heavy metals

Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead; can damage living things at low concentrations and tend to accumulate in the food chain.

High risk community

A community located within the vicinity of numerous sites or facilities or other potential sources of environmental exposure/health hazards that may provide high levels of exposure to contaminants or pollutants.

Indicator/proxy

In biology, an organism, species, or community whose characteristics show the presence of specific environmental conditions.

Indoor air

The air inside a habitable structure or means of transportation.

Indoor air pollution

Chemical, physical, or biological contaminants in indoor air.

Ingestion

Swallowing, such as eating or drinking, during which chemicals can get inside the body.

Inhalation

Exposure may occur from inhaling or breathing in contaminants because they can be deposited in the lungs, taken into the blood, or both.

Lead (Pb)

A heavy metal that is hazardous to health if breathed or swallowed.

Mean exposure

Mean inhalation exposure of 5-year olds attending 6 hours and more, determined in this study. If all four children at a pre-school were eligible for inclusion, the mean exposure consists of the

average of four observations. If only one child was eligible for inclusion, the mean exposure consists of the exposure of the one child.

Mean log exposure

Log transformed variable of mean exposure, assessing inhalation exposure to lead (see mean exposure)

Mbawula

A container with holes at the bottom used for cooking and heating purposes

Micro-environment

A physical three-dimensional space with a well-characterised, relatively homogenous pollutant concentration level over a specified period of time.

Monitoring

Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

NIOSH

National Institute of Occupational Health and Safety

Particulate Matter

Collective term used to describe small solid and liquid particles that are present in the atmosphere over relatively brief to extended periods of time.

PM_{10} and $PM_{2.5}$: Particulate matter with an aerodynamic diameter of less than 10 and 2.5 µm respectively.

Respirable suspended particulate matter (RSP)

This is the respirable fraction of airborne particulates based on the internationally accepted 'Johannesburg Curve' for size distribution, ie particle aerodynamic diameter of less than 7.0 micron (ie PM_7) [2]. This terminology is used instead of PM_{10} (particulate matter with

diameter less than 10 µm) as the cyclones used in the study have a cut-off point of 7 µm.

Total suspended particulate matter (TSP)

This refers to all airborne particulates as collected by a personal gravimetric sampler without particle size selection [1].

Typical winter day

A sunny day where the day temperatures average 16 ± 4 °C [3]. in Pretoria.

USEPA

United States Environmental Protection Agency