Epidemiological and Clinical Status of South African Primary School Children: Investing in the Future

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Declaration

This research represents original work by the author and has not been submitted in any form to any other university. The protocols for all the research in this thesis were written by the author. All fieldwork was conducted by field-workers under the supervision of the author. Data collation, checking and analysis were undertaken by the author.

Where use has been made of the work of others, it has been duly acknowledged.

Champak C Jinabhai

Dedication

This work is dedicated to my mother and my wife.

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List of Publications and Scientific Presentations Emanating from this Doctoral Research Programme

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2. Jinabhai CC, Taylor M, Coutsoudis A, Coovadia HM, Tomkins A, Sullivan KR. Epidemiology of helminth infections: implications for parasite control programmes in South Africa. *Public Health & Nutrition*, 2001. (Accepted – in press).

3. Jinabhai CC, Taylor M, Coutsoudis A, Coovadia HM, Tomkins A, Sullivan KR. A randomized controlled trial of the effect of anthelminthic treatment and micronutrient fortification on the health status and school performance of rural primary school children, 2001. (*Annals of Tropical Paediatrics, Dec 2001*).

4. Taylor M, Jinabhai CC, Couper I, Kleinschmidt I, Jogessar V. The effect of different anthelminthic treatment regimens combined with iron supplementation on the nutritional status of schoolchildren in KwaZulu-Natal, South Africa: a randomized controlled trial. *Trans R Soc Trop Med and Hyg,* 2001: **95**(2), 211-216.

5. Nriagu JO, Jinabhai CC, Naidoo R, Coutsoudis A. Atmospheric lead pollution in KwaZulu-Natal, South Africa. *Sci. Total Environ,* 1996: **191**,69-76.

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7. Jinabhai CC, Taylor M, Mkhize N, Pillay B, Rangongo F, Sullivan KR. A cognitive and scholastic test battery for rural South African children.(Paper under review).

B. Other Reports, publications and contributions emanating directly from the doctoral research

1. Thurnham DI, McCabe D, Northrop-Clewes CA, Adelekan DA, Christian P, Dirren H, Jinabhai CC, Nestel P, Paracha N, Trumbo P, Harris S, Coutsoudis A, Dary O, Filteau S, Labadarios D, Mburu A, Rosales F. *The*

use of acute phase proteins to interpret vitamin A status. A meta-analysis of data collected in apparently – healthy pre-school children and its wider applicability to other neonatal, child and maternal groups. Report submitted to the International Life Sciences Institute (ILSI), Washington, DC. 2000. (Reviewed).

2. Taylor M, Jinabhai CC, Dladla N, Rangongo MF. Developing a health promotion programme for HIV and AIDS control amongst rural school pupils in KwaZulu-Natal. 1998. Department of Community Health, University of Natal.

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5. Taylor M, Morar N, Memela D, Nzimakwe D. A situational analysis of school health services in KwaZulu-Natal. 1996. Department of Community Health, University of Natal.

6. Health Systems Trust. Making a difference to school children's health: An evaluation of School Health Services in KwaZulu-Natal, South Africa. 1998.(Reviewed).

7. Jinabhai CC, Morar N. Assessment of recipient organisations utilization of the National Nutritional and Social Development Programme (NNSDP) funds in KwaZulu-Natal. 1995. Department of Community Health, University of Natal. Report submitted to the Health Systems Trust (Reviewed).

C. Other research dissertations/degrees related to the research programme

1. Taylor M. Control of helminth infections, 2000 - a health education strategy for rural South African school pupils. PhD dissertation submitted to the Faculty of Medicine, University of Natal, 2000.

2. Nzimakwe D. A health education model for schools in region F of KwaZulu-Natal.D.Litt *et* Phil 2000. dissertation submitted to the University of Zululand.

3. D Memela. A cross-sectional evaluation of health inspection as a component of school health services in KwaZulu-Natal. 1999. Submitted in partial fulfilment of the requirements for the degree of Master of Medical

Science (M. Med Sc.) in the Department of Community Health, University of Natal, Durban.

4. O'Rielly SM. Relationship between blood lead and micronutrient, hematological, anthropometric and cognitive outcomes. 1999. M Sc. Dissertation, submitted to the School of Public Health, University of Michigan, 1999. (Co-supervisor: Prof CC Jinabhai)

D. Presentations at Scientific Meetings emanating from this thesis

1. Jinabhai CC, Taylor M, Coutsoudis A, Coovadia HM, Tomkins AM, Sullivan KR. The effect of anthelminthic treatment and micronutrient fortification on health status and school performance of rural primary school children: a randomized controlled trial. XX International Vitamin A Consultative Group (IVACG) Meeting, Hanoi; 12-15 February 2001.

2. Jinabhai CC, Taylor M, Coovadia HM, Tomkins AM, Sullivan KR. The effect of anthelminthic treatment and micronutrient supplementation on health and cognitive development of rural primary school children in KwaZulu-Natal, South Africa: A randomized controlled trial workshop on human helminth infections - future research foci. Lusaka, 5-9 March 2001.
3. Jinabhai CC, Coutsoudis A, Taylor M, Coovadia HM, Tomkins A, Sullivan K. The effect of anthelminthic treatment and micronutrient supplementation on

health status of rural school children in KwaZulu-Natal. *From Lab to Land, Nutrition Conference*, Durban, 18-20 August 2000.

4. Taylor M, Coovadia HM, Kvalsvig JD, Jinabhai CC. Health education for helminth control amongst rural KwaZulu-Natal pupils. *From Lab to Land, Nutrition Conference*, Durban, 18-20 August 2000.

5. Taylor M, Naidoo K, Jinabhai CC, Bailey M. Promoting community health in a rural area of KwaZulu-Natal: linking community health workers, NGO, Department of Health, University of Natal. Epidemiological Society of South Africa: *Poverty and Inequity: The Challenges for Public Health in South Africa*, East London, 24-25 February, 2000.

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7. James S, Reddy P, Jinabhai CC, Taylor M. The perceptions, attitudes, knowledge and sexual practices with regard to sexually transmitted diseases (STDs) amongst secondary school learners in KwaZulu-Natal, South Africa: Epidemiological Society of South Africa: *Poverty and Inequity: The Challenges for Public Health in South Africa*, East London, 24-25 February 2000.

8. Mburu ASW, Coutsoudis A, Jinabhai CC, Taylor M, Northrop-Clewes CA, Thurnham DI. Vitamin A and micronutrient supplementation and deworming interventions in school children: effects on intestinal permeability. XIX IVACG Meeting, Durban, 8-11 March 1999.

9. Taylor M, Jinabhai CC, Couper I, Kleinschmidt I. Identifying appropriate anthelminthic treatment and iron supplementation regimens for rural South African primary school children. International Anaemia Consultative Group (INACG) Meeting, Durban, 8-11 March 1999.

10. Jinabhai CC, Coutsoudis A, Taylor M, Coovadia HM, Tomkins A, Sullivan K. Anthropometric, micronutrient, cognitive, scholastic and parasitic status of African primary school children in rural South Africa. INACG Meeting, Durban, February 1999.

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12. Taylor M, Jinabhai CC, Dladla AN, Rangongo MF. Use of the Precede / Proceed Model for HIV / AIDS prevention strategies amongst rural primary school pupils in KwaZulu-Natal. 16th Epidemiology Society of South Africa (ESSA) Conference 1998.

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17. Taylor M, Jinabhai CC, Morar N, Memela Nzimakwe D. Improving the health of school children: role of school health services: KwaZulu-Natal. 18th African Health Sciences Congress, Cape Town 14-17 April 1997.

18. Taylor M, Coovadia HM, Kvalsvig JD, Reddy P, Jinabhai CC. Risk factors for helminth infections amongst rural KwaZulu-Natal primary pupils. 18th African Health Sciences Congress, Cape Town, 14-17 April 1997.

19. Taylor M, Jinabhai CC. Education, health and the school environment. health promoting schools in South Africa: Challenges for the 21st century. Cape Town. 18-19 January 1996.

E. Peer Reviewed Publications related to (but not directly from) the doctoral research

Taylor M, Jinabhai CC, Dladla NA, Rangongo MF, Connolly C. HIV/AIDS health education for rural KwaZulu-Natal primary school pupils. *S Afr J Epid Inf*, 2000;15(4),100-107.

Taylor M, Coovadia HM, Kvalsvig JD, Jinabhai CC, Reddy P. Helminth control as an entry point for health promoting schools in KwaZulu-Natal. *S Afr Med J* 1999; 89(3),273-279.

Contents

List of Abbreviations

ACC / SCN	Administrative Co-ordinating Committee / Sub-Committee on Nutrition
ANC	African National Congress
BMI	Body Mass Index
CBO	Community-based Organisation
DOE	Department of Education
DOH	Department of Health
GMT	Young Group Mathematics Test
HAZ	Height for Age Z-score
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
HPS	Health Promoting Schools
IOTF	International Obesity Task Force
ISHI	International School Health Initiative
KZN	KwaZulu-Natal
NCHS	National Centre for Health Statistics
OBE	Outcomes Based Education
PCD	Partnership for Child Development
PCP	Parasite Control Programme
PSNP	Primary School Nutrition Programme
RAVLT	Rey Auditory Verbal Learning Test
RCT	Randomised Controlled Trial
RDP	Reconstruction and Development Programme

SAVACG	South African Vitamin A Consultative Group
SDMT	Symbol Digit Modalities Test
SHS	School Health Services
WAZ	Weight for Age Z-score
WFP	World Food Programmes
WHO	World Health Organisation

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Executive Summary

The physical, psychological and social development of school children has been neglected - partly because they were seen as healthy "survivors" of the ravages of childhood illnesses, and partly because of the way in which health services are organized (such as the traditional under-five maternal and child health (MCH) services and the curative PHC clinic services). From the age of five years children undergo rapid and profound bio-psycho-social development, to emerge in adolescence as the next generation of leaders and workers. Securing their future growth and development is vital for any society to be economically and socially productive.

A substantial body of national and intemational literature has recognised the detrimental impact of helminthic infections and micronutrient deficiencies on the physical and psychological health and development of school children; which requires appropriate nutritional interventions. Concern has been expressed that these adverse biological, physical and social deprivations have a cumulative impact on several dimensions of children's growth. Most important, apart from stunting physical growth, is the inhibition of educational development of school children. Recent evidence strongly suggests a powerful interaction between physical and psychosocial growth and development of children. Inhibition of either component of a child's well-being has adverse implications. Conversely, investments in the physical and psychological development of children are likely to

generate substantial health and educational benefits and are a worthy investment to secure a healthy future generation.

In summary, there are a number of reasons for, and benefits of, investing in school- based health and nutrition interventions. They are likely to improve learning at school and enhance educational outcomes; create new opportunities to meet unfulfilled needs; redress inequity; build on investments in early child development and promote and protect youth and adolescent development. Health and nutrition interventions such as school feeding programmes, micronutrient supplementation and deworming aim to improve primary outcomes of macro and micro-nutrient deficiencies, parasitic and cognitive status; as well as secondary outcomes of developing integrated comprehensive school health policies and programmes. This rationale served as the conceptual framework for this study. This theoretical framework views improvements of the health, nutritional, cognitive and scholastic development status of school children as the primary focus of policies, strategies and programmes in the health and education sector. This focus constitutes the central core of this thesis. Optimum social development requires investments in both the health and educational development of school children, so as to maximise the synergies inherent in each sector and to operationalise national and international strategies and programmes.

As part of the larger RCT study a comprehensive nutritional, health and psychological profile of rural school children was established through a community-based cross-sectional study. Eleven schools were randomly selected from the Vulamehlo Magisterial District in southern KwaZulu-Natal (KZN). Within each school, all Standard 1 pupils, aged between 8 – 10 years, were selected giving a final study sample of 579 children. Some of the observed prevalence's were stunting (7.3%), wasting (0.7%), anaemia (16.5%) (as measured by haemoglobin below 12 g/dl), vitamin A deficiency (34.7%) (as measured by serum retinol below 20 μg/dl) and serum ferritin below 12ng/ml (28.1%). This study established that micronutrient deficiency, parasitic infestations and stunting remain significant public health problems among school-aged children in South Africa. Combining micronutrient supplementation and deworming are likely to produce significant health and educational gains.

To determine the impact of single and combined interventions (anthelminthic treatment and micronutrient supplements) on nutritional status and scholastic and cognitive performance of school children, a double-blind randomised placebo controlled trial was undertaken among 579 children 8-10 years of age. There was a significant treatment effect of vitamin A on serum retinol ($P<0.01$), and the suggestion of an additive effect between vitamin A fortification and deworming. Vitamin A and iron fortification also produced a significant treatment effect on transferrin saturation ($P<0.05$). Among the dewormed group, anthelminthic treatment produced a significant decrease in the prevalence of helminthic infections ($P<0.02$), but with no significant between-group treatment effect ($P>0.40$). Scholastic and cognitive scores and anthropometric indicators were no different among the treated or the untreated children. Fortified biscuits improved micronutrient status among rural primary school children; vitamin A combined with deworming had a greater impact on micronutrient status than vitamin A fortification on its own; while anthelminthic treatment produced a significant reduction in the overall prevalence of parasite infection.

The prevalence's of *Ascaris lumbricoides, Trichuris trichiura* and *Schistosoma haematobium* declined significantly sixteen weeks post-treatment. The levels of both prevalence and intensity in the untreated group remained constant. The cure rates over the first two weeks of the study were 94.4% for *Ascaris lumbricoides,* 40% for *Trichuris trichiura*, and 72.2% for *Schistosoma haematobium.* The benefits of targeted school-based treatment in reducing the prevalence and intensity of infection supports the South African government's focus of using school-based interventions as part of an integrated parasite control programme. These strategies and programmes were found to be consistent with the recommendations of WHO and UNICEF.

The nutritional transition facing developing and middle-income countries also has important implications for preventive strategies to control chronic degenerative diseases (Popkin B, 1994; WHO 1998; Monyeki KD, 1999). This descriptive study, comparing BMI data of school children over three time periods, found a rising prevalence of overweight and obesity among South African school children. Obesity as a public health problem requires to be addressed from a population or community perspective for its prevention and management.

Environmental risk factors such as exposure to atmospheric pollution remain significant hazards for children. Lead poisoning is a significant, preventable risk factor affecting cognitive and scholastic development among children. The prevalence of elevated blood lead (PbB) levels in rural and semi-urban areas of

KwaZulu-Natal (KZN) as well as the risk factors for elevation of PbB among children in informal settlements were examined. This study investigated over 1200 rural and urban children in two age groups: 3-5 and 8-10 years old. Average PbB level in peri-urban Besters, an informal settlement in the Durban metropolitan region, was 10 μg/dl with 5% of the children showing PbB level of greater than 25 μg/dl. By comparison, average PbB value in Vulamehlo, a rural area located 90-120 km from Durban, was 3.8 μg/dl and 2% of the children's PbB levels were greater than 10 μg/dl.

Since the cognitive and scholastic performance of school children was a primary outcome measure in this study, it was important to explore other factors that influenced this variable. The performance scores of all four tests in the battery, among the cohort of a thousand rural and urban children, were in the lower range. The educational deficit identified in this test battery clearly indicates the impact of the inferior "Bantu" educational system that African children have experienced in South Africa.

Aspects of the School Health Services that were investigated in this descriptive study included the services provided and their distribution; assessment of health inspection; health education and referral processes undertaken by the School Health Teams; perceptions of managers, providers and recipients of the service; as well as the costs of the provision of the service in KwaZulu-Natal. In KwaZulu-Natal, there were School Health Teams in all the 8 health and education regions in the province. In total, there were 95 teams in the province, consisting of nearly 300 staff members. The School Health Teams were involved in a wide range of activities - 74% of all teams were involved in health inspection and 80% were involved in health education. The total annual cost of delivering School Health Services in the province in 1995 was estimated to be approximately R8 750 000. Given the rise of HIV and AIDS in the province, School Health Services need to play a central role not only in prevention, but also in assisting with the acceptance of HIV-positive children within schools. It is recommended that the current and future draft SHS policy guidelines be approved by the relevant authorities for immediate implementation. Districts should consider developing "Health Promoting Schools", with School Health Teams being a central resource.

This thesis has explored several aspects of the epidemiological profile of school children in rural and urban settings in KwaZulu-Natal. It has established that school children are exposed to a range of risk factors ranging from nutritional deficits, parasitic infections, atmospheric lead poisoning and a rising prevalence of overweight. All of these risk factors may compromise their physical, psychological and social development. A number of health interventions have been identified, which have the potential to address these problems. Such investments are essential to secure the health of future generations.

Chapter 1: Introduction

1.1 Motivation for focusing on school-aged children

The health, educational and social development of school-aged children has become a major focus of national and international attention due to the success of child survival strategies; increasing emphasis on (primary) school education; availability of cost-effective deworming and supplementation programmes; and the implementation of comprehensive school feeding programmes (Bot *et al,* 2000; WHO,1997; del Ross *et al,* 1996; PCD, 2000). Although UNICEF has estimated that over 95% of the world's children survive beyond the age of 5 years, a significant burden of ill health and disease, including poor nutrition and intestinal parasitic diseases, continues to compromise the children's development, school attendance and growth (PCD, 2000). The global Partnership for Child Development (PCD) regards school health and nutrition programmes as an essential sequel and complement to early child development programmes (Dolan, 2000). It notes that these short-term interventions should ideally be accompanied by appropriate health and nutrition information, education and communication (IEC).

During this period of rapid physical growth and social development, it is essential to establish optimum conditions for their full potential to be nurtured to secure a healthy future generation. Health-promoting behavioural characteristics can be inculcated during this critical period of transition. The devastation wrought by the HIV/AIDS pandemic, especially in Africa, makes it imperative to advocate for behavioural changes among increasingly younger age cohorts, including primary school children

(Taylor *et al*, 2000). Of the estimated 33.6 million people infected worldwide with human immunodeficiency virus and Acquired Immunodeficiency Syndrome (HIV/ AIDS), half are under the age of 25, and in some countries up to 20% of children between the ages of 10 – 14 years is HIV positive (PCD, 2000).

While school-aged children suffer significant morbidity from nutritional, parasitic and behavioural disorders, the interactions among these different risk factors and their impact on growth and development is poorly understood. It is necessary to establish the epidemiological profile of this age cohort to optimise the potential gains from the cost-effective, comprehensive school-based interventions that are now available (World Bank 1993). The Health Promoting Schools (HPS) strategy advocated by a nurnber of national and international agencies recognises the considerable potential for health promotion, behaviour changes, multi-sectoral and community participation among school children (WHO, 1997).

The size and shape of the (primary) education sector, the demographic profile of school-aged children as a proportion of total population, and the infrastructure in South African schools offers considerable potential for health interventions. According to the Annual Report of the KwaZulu-Natal Department of Health (1998), there were 1.05 million (12%) children between 5-9 years, and 1.06 million (12.2%) between 10-15 years: over 24% of the total population of 8.4 million people in KwaZulu-Natal are school-aged children. A review of the infrastructure at schools in South Africa found that nationally more than half (52%) of the schools were without electricity, 24% had no water, 12% no toilets and 61% no telephones;

while in KwaZulu-Natal 57% had no electricity, 24% had no water, 10% had no toilets, 66% had no telephones and 82% had no library facilities (Education Foundation, 1996). The key demographic and socio-economic indicators in KwaZulu-Natal province show high levels of poverty, under-development and a youthful rural population (Table 1.1). This brief overview of the circumstances in public schools and at the community levels suggests that a significant proportion of the population, especially school children, is exposed to environments that constitute serious risks to public health. Neglect of a quarter of the population at a critical stage of their development, through poor environmental and community circumstances, is unacceptable. There is an urgent need to investigate the health status of this important age group and to identify appropriate interventions.

Table 1.1: Comparison of demographic and socio-economic indicators in KwaZulu-Natal & South Africa (National)

	KWAZULU-NATAL	NATIONAL
Area square km	92 100	1 219 090
Population density	91.4	33.3
Population	8 417 021	40 583 573
%Population	20.7	100.0
Rural as % population	56.9	46.3
African as % population	81.7	76.7
% population < 5 years old	11.5	10.9
Poverty rates	53.0	53.0
% population over 20 years with no schooling	22.9	19.3
% population over 20 years with matric or higher	20.7	22.6
% women over 20 years with no schooling	25.2	21.1
% economically active population unemployed	39.1	33.9
% households living in 2 or less rooms	29.6	32.6
% households living in 1 or less rooms	15.6	17.2
% using electricity for cooking	46.1	47.4
% with water tap in house	39.8	44.7
% with water tap in house or yard	48.7	61.4
% with flush or chemical toilet	42.0	50.5
Disabled as % of population	6.0	6.5

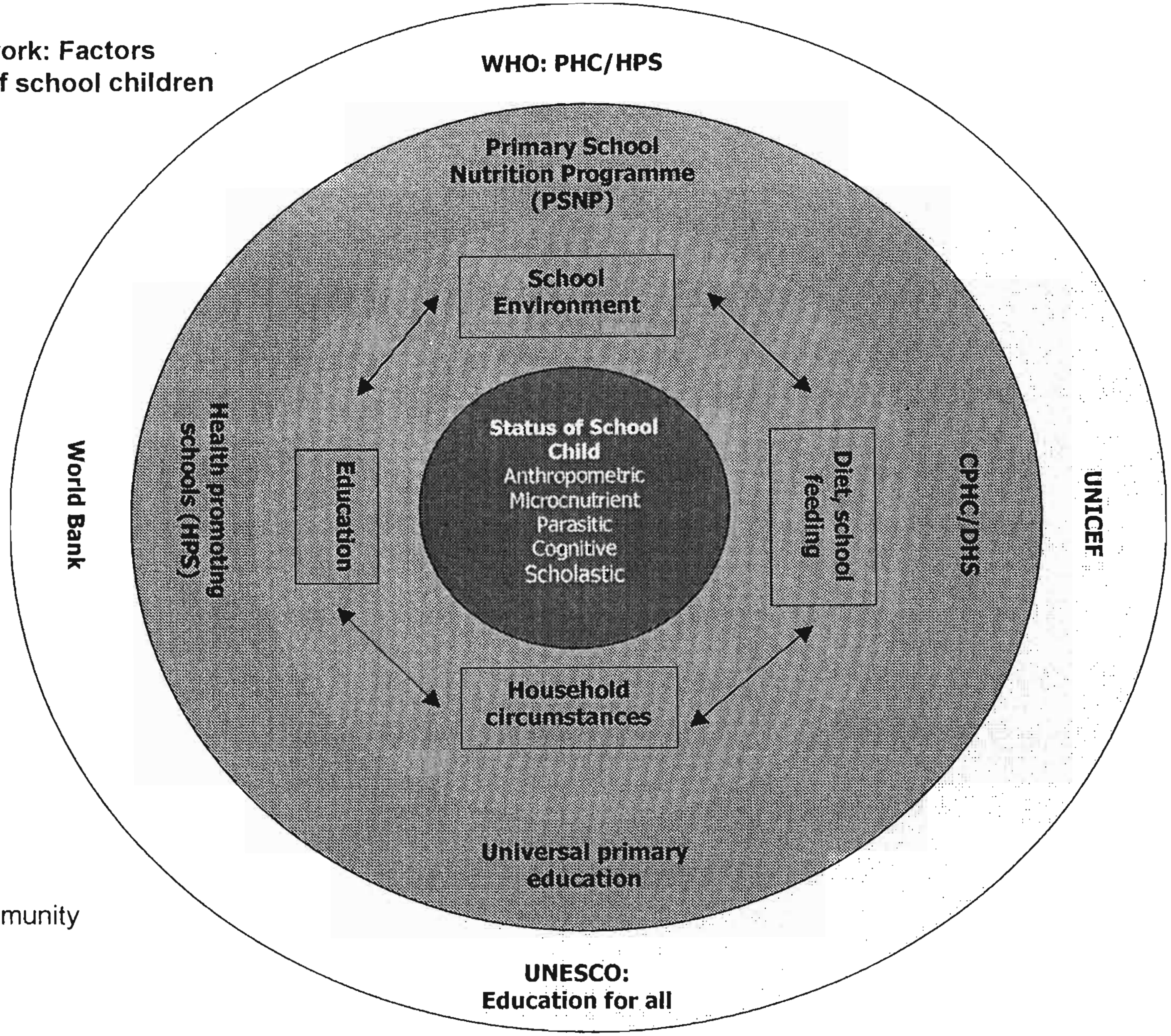
Sources: Statistics South Africa. *The people of South Africa, Population census 1996: Census in brief.* Pretoria: Statistics South Africa, 1998. Poverty Rate data from Reconstruction and Development Programme. *Key indicators of poverty in South Africa*. Pretoria RDP, 1995.

In summary there are a number of reasons for, and benefits of, investing in school-based health and nutrition interventions. They are likely to improve learning at school and enhance educational outcomes, create new opportunities to meet unfulfilled needs, redress inequity, build on investments in early child development and promote and protect youth and adolescent development. Many of these interventions have been identified as cost-effective investments in health and education (del Rosso, 1996). Health and nutrition interventions such as school feeding programmes, micronutrient supplementation and deworming aim to improve primary outcomes of macro and micronutrient deficiencies; parasitic and cognitive status; as well as secondary outcomes of developing integrated, comprehensive school health policies and programmes. This rationale served as the conceptual framework for this study (Table 1.2). This theoretical framework views improvement of the health, nutritional, cognitive and scholastic development status of school children as the primary focus of polices, strategies and programmes in the health and education sector. This focus constitutes the central core of this thesis. These multi-factorial interventions cascade through several levels – local (school and community based), provincial, national and global (WHO, UNICEF, UNESCO, PCD, World Bank) (Fig.1). Optimum social development requires investments in both the health and educational development of school children so as to maximise the synergies inherent in each sector; and to operationalise national and international strategies and programmes.

Table 1. 2
Framework for school-based health and education policies, programmes and strategies

LEVEL	INTERVENTION
School Based: Primary School Child	Selective, cost effective interventions. School feeding, micro-nutrient supplementation, deworming, health promotion, counseling
Local: District, School and Community	Integrated programme implementation, assessment, monitoring and evaluation though school health services (SHS)
National/Provincial National Health Bill: NHS, DHS, PHC, integrated School Health Services Integrated nutrition policy: INP, public health nutrition Education: increased educability Health promoting schools strategy HIV/AIDS prevention, care and control	Legislation, policies, planning and programme development
Global: WHO, UNICEF, UNESCO, WORLD BANK National Health Service (NHS) - PHC, DHS, health for all - Cost effective interventions/ evidence based medicine Multiple, synergistic interventions e.g. - deworming and anthelminthic treatment - health and education - nurses (PHC) and teachers (education) sectors - schools as sites for community development - (health) promotion, care, treatment and rehabilitation Health promoting schools (deworming and micronutrient, life skills, HIV/AIDS) Education for all - UNESCO, National Dept of Education	Policies and Strategies

Figure 1: Conceptual Framework: Factors influencing health of school children



Coding:

- Individual/clinical
- Local: School, district, community
- Provincial/National
- Global

1.2 Epidemiological rationale for health interventions

It is not clear whether or not the disease burden among school-aged children in South Africa (SA) is similar to the profile identified among pre-school children (SAVACG, 1994). While macro and micronutrient deficits, parasitic infections (helminths, malaria and schistosomiasis) and poor school performance continue to stunt children's growth and development, the extent to which it compromises the health and well-being of future generations is poorly understood. Likewise, the emergence of these old and new epidemics has challenged national health systems to improve their performance (WHO, 2000). District based primary health care (PHC) programmes and school health services have important contributions to make in this regard. Considerable opportunities exist for synergistic health and educational gains to be made from a combined approach, targeting school-aged children (PCD, 2000). The government's health policies and programmes have identified children and women as priority groups for social services resource allocations, while the shift towards comprehensive PHC services greatly facilitates integrated health and development programmes targeting school children (Department of Health, Annual Report 1999).

The focus on school-aged children is global. Many countries and international agencies have developed school-based programmes to examine the global burden of nutritional, parasitic and behavioral deficits; the interactions between macro and micro-nutrient and parasitic diseases; and impact of malnutrition and parasitic diseases on nutritional, parasitic and cognitive development (WHO 1997, World Bank 2000, PCD 2000). The integration of micronutrient supplementation into school feeding programmes is part of a wider strategy of Health Promoting

Schools (HPS) through the School Health Services (SHS). This review of national and international experiences examines the current status of research and the epidemiological rationale for the research hypothesis, and lays the basis for consideration of the lessons for South Africa, and other developing countries, in the final chapter.

Dolan *et al* (2000) in a global review for the Working Group on the Nutrition of School age Children, at a Sub-Committee for Nutrition (ACC/SCN) meeting, identified the main nutritional problems facing school-age children as stunting, underweight and micronutrient deficiencies (anaemia, iodine and vitamin A); while the main diseases were helminth infections, malaria, diarrhoea, tuberculosis and respiratory infections. The review noted that countries undergoing a nutritional transition also faced the increasing problems of overweight and obesity. Although Dolan *et al* (2000) estimated that 79% of a total of 625 million children of primary school age are in school, those who do not enrol for school are more likely to be sick, with higher levels of stunting and morbidity. They estimated that approximately 11% of the global burden of disease is suffered by children of school age. This would justify the need for joint international and national action promoting a package of school-based interventions, evolved from examples of best practise, to address their poor health and nutritional status (Dolan, 2000).

Helminthic infections and micronutrient deficiencies are both associated with intellectual and physical impairment during childhood (Dolan, 2000). The precise pathways for these interactions and their individual and synergistic contribution to these impairments are unknown. Current preventive and therapeutic regimens for anthelminthiasis, anaemia and vitamin A deficiency are inadequate for several reasons: Firstly, they are usually single interventions, not sensitive to the synergistic effects of other variables; secondly, the potentiating and inhibitory capacity of multiple factors to achieve maximum impact is poorly understood and often neglected. Recommendations that certain therapies such as vitamin A supplementation and deworming should be part of a basic package of health services and incorporated into supplementary feeding programmes have major policy and fiscal implications for the efficient use of health resources if their therapeutic efficacy under local conditions has not been demonstrated (World Bank 1993, Dolan 2000). Concem has been expressed that nutritional requirements for children in developing countries have concentrated too long on dietary protein and energy (Editorial, 1990). This is especially relevant to South Africa where the major problem in children is stunting and not wasting; the former is unresponsive to food supplements alone (Child Health Unit (CHU), 1997).

While vitamin A and iron deficiency and helminthic infections individually have been identified as having a significant impact on the physical growth, nutritional status and cognitive and behavioural functions of infants and children, the synergistic inter-action of tackling all three elements and their cumulative effects on child health is unclear (Del Rosso 1997; Voster *et al*, 1997; Beaton *et al*, 1993; WHO, 1983). While many of these studies have indicated the value of selectively tackling each of these problems individually, the cumulative benefits specifically on nutritional status and cognitive and behavioural functions of children through multiple interventions requires further elucidation. Over the last decade micronutrient supplementation of iron, iodine and vitamin A have demonstrated substantial reductions in morbidity and mortality among children (Coutsoudis *et al*, 1994; Tomkins *et al*, 1989; World Bank 1993). If we are to further increase child survival and ensure that programmes are effective and sustainable at community level, new strategies - focussing on improving both micro-nutrient and parasite status - are required.

1.2.1 Vitamin A deficiency and impact of supplementation

Studies in Indonesia, India, Guatemala, Thailand and South Africa have shown an association between vitamin A deficiency and increased morbidity and mortality in children (Sommer 1993, Rahmathula 1990, Meija 1982,1988, Bloem 1989, Coutsoudis 1991). Sommer (1993) reports that the relationship between vitamin A deficiency and increased childhood mortality is now widely accepted, as vitamin A impacts on susceptibility to infection (Coutsoudis *et al*, 1991) and mortality (Sommer 1992). Underwood has reviewed the literature on the impact of vitamin A on morbidity and mortality reduction (including several meta-analyses of vitamin A supplementation) and recommends that, despite contradictory results from the Haiti study, vitamin A supplementation is still highly recommended (Mahalanabis 1979).

Beaton (1993) reviewed 29 vitamin A supplementation trials for WHO and found no study conducted in populations with bio-chemical evidence of vitamin A depletion, but without clinical manifestations of deficiency. Hence they could not comment on the impact of vitamin A supplementation programmes in areas with bio-chemical depletion but no clinical signs. The XV International Vitamin A Consultative Group (IVACG, 1993) recognised the impact of vitamin A in reducing child morbidity and mortality and called for co-ordinated efforts to prevent vitamin A, iron and iodine deficiencies through joint team approaches. Hunger and micronutrient deficiencies adversely affect the learning capacity, school attendance and general well being of children (Levinger, 1992). Several intervention studies have shown that vitamin A supplementation markedly reduces these risks to such an extent that the World Bank Report (1993) "Investing in Health " recommended that an essential health package should include school health programmes to treat worm infections and micro-nutrient deficiencies, and to provide health education.

The South African Vitamin A Consultative Group (SAVACG, 1994; Coutsoudis *et al,* 1994) has reported a deficiency of vitamin A below 20 microgram/dl as a public health problem among pre-school children. The prevalence among the school-aged children in South Africa is unknown. Tomkins and Hussey (1989), in a review of the relationship between vitamin A, immunity and infection, concluded that the findings of all the epidemiological studies are not yet sufficient to confirm that children living in areas with adequate vitamin A intake should be given vitamin A as an immune-support stimulant during infection. Their recommendations, supported by Beaton (1993), are that further studies are required for the evaluation of the effect of vitamin A for routine prophylaxis or clinical management in communities where vitamin A status is marginal.

1.2.2 Impact of iron supplementation

Iron deficiency is the most prevalent form of malnutrition: over 1.3 billion people are affected, with a major impact on morbidity (including reduced growth among children), increased susceptibility to infections and, when severe, on mortality (Gillespie 1991). In children iron deficiency is associated with apathy, inactivity and significant loss of cognitive abilities; this situation persists although the interventions required for prevention and treatment are available, effective and inexpensive. In addition, the improvement in certain behavioural tests in children because of iron therapy suggests that iron deficiency anaemia is causally associated with behaviour deficits (Haas 1989). Soewondo *et al* (1989) reported that iron deficiency has an adverse effect on selective cognitive processes amongst pre-school children in Indonesia. Pollitt *et al* (1989), in an investigation amongst 9-11 year old Thai children, found evidence of a positive association between iron status, I.Q., and a language school achievement test.

While field trials have shown iron supplementation to be effective in raising haemoglobin levels in targeted groups, when scaled up to district or country level, many programmes have had a relatively limited impact - mainly due to lack of supplies and service delivery. Liu *et al* (1993) in China and Walter *et al* (1993) in Chile have demonstrated the nutritional efficacy of biscuits fortified with iron in reducing iron deficiency. The Administrative Co-ordinating Committee/Sub-Committee on Nutrition Statement (ACC/SCN) on the Control of Iron Deficiency has recommended food fortification, dietary modification and parasitic disease control (Gillespie 1989). Locally, over 21 % of pre-school children in a study in KwaZulu-Natal were found to be anaemic (Coutsoudis *et al,* 1994).

1.2.3 Impact of parasitic infections & deworming on health

Helminth infections contribute to the development and persistence of malnutrition and diminished growth, while improved physical fitness (Stephenson *et al*, 1993, Thein Hlaing, 1989) and cognition (Boivin 1993) was observed after treatment. Parasitic infections with Giardia and Ascaris result in malabsorption of water-miscible vitamin A. Mahalanabis *et al (*1989) noted a marked impairment of vitamin A absorption in children treated with a water miscible vitamin A supplement in all cases where children were infected with *Giardia lamblia* and *Ascaris lumbricoides,* in children with giardiasis only; and in some children with ascariasis infection only. We wish to investigate if treatment of helminth infections in primary school children will affect the amount of vitamin A absorbed from their diet.

While helminthic diseases (schistosomiasis, hookworms, Ascaris, tapeworms) are not a major cause of mortality in developing countries, they cause florid morbidity resulting in severe anaemia and stunted physical and mental development in children (Muller, 1994). The importance of targeting school-aged children for anthelminthic treatment is emphasised by Bundy *et al* (1988) since the intensity of gastro-intestinal helminth infection has a convex relationship with host age - rising among school children. Hall (1992) suggests that treatment of the school-age population is likely to lower transmission rates within the community. Stephenson *et al* (1993) showed that treatment with a single dose of albendazole improved the growth of Kenyan school children with hookworm, *Trichuris trichiura* and *Ascaris lumbricoides* infection. Solomons (1993) notes that intestinal pathogens cause a nutritional drain, which is only partially compensated by increased intake of food, while Boivin *et al* (1993) reported that children successfully treated for chronic intestinal parasites demonstrated significant improvements in short-term spatial memory.

In a rural hospital in KwaZulu-Natal, Bradley (1994) found the prevalence of helminthic infections to be 38% for ascariasis; 22% for *Trichuris trichiura;* 12% with double infections; 9% with *Taenia spp;* and 2% with both Taenia and Ascaris. They compare this with previously reported prevalence rates for Ascaris: 70% at the Red Cross War Memorial Children's Hospital, 80% at King Edward Hospital, and 96% in Tygerberg, Cape.

1.2.4 Interactions between health interventions & scholastic and cognitive development

Kvalsvig (1994) investigated the cognitive effects of intestinal and schistosomal infections on primary school pupils in KwaZulu-Natal (1991) and showed that parasitic infections combine with nutritional deficits to impair the efficiency of cognitive processes. In a study of pre-school children, Kvalsvig and Connolly (1994) report a positive effect on children's behaviour after treatment for parasitic infections.

Pollit (1990) has established the benefits of controlling parasitic infections to enhance education performance especially among school children. Pollitt (1984) has found that short term hunger (e.g. lack of breakfast) has adverse effects on emotional behaviour, scholastic achievement, arithmetic, reading ability and physical work output and suggests that attentiveness and classroom behaviour which impacts on learning is influenced by supplementary feeding in the face of chronic underfeeding.

This has been supported by Leslie's (1990) identification of the negative consequences of chronic protein-energy malnutrition, iron-deficiency anaemia, iodine deficiency and intestinal helminth infection on school performance and enrolment. Both these studies have prompted UNESCO to develop and recommend a School Nutrition and Health Service (Leslie, 1990). Cost benefit analyses by Jamison and Leslie (1990) suggest that carefully targeted investments in child health and nutrition are likely to provide high yield investments for educational outcome. This is especially important for South Africa, as universal primary education has been identified as a national priority to redress the inequities of under-development; thus providing expanded opportunities for integrating health and nutrition interventions in the education sector. UNESCO has recommended measuring school enrolment, attendance, repetition (failures) and drop-outs in schools to provide quantitative assessments; while tests of school performance (language, mathematics), cognitive performance, general achievement and alertness will provide qualitative measures to asses the impact of health and nutrition interventions in the education sector (UNESCO, 1989).

Connolly and Kvalsvig (1993) suggest that a general effect of parasitic infection would be to limit the energy sources available to infected individuals - thus reducing their capacity for physical and mental work - with potential effects on motivation, emotional state, patterns for social interaction and further consequences for cognitive efficiency and behaviour. They suggest that these effects may be reversible with treatment. It is important to establish the impact of mass chemotherapy for parasite control in altering marginal vitamin A status - as recommended by Hall (1992) and Bradley (1994).

Levinger (1992) defines a child's Active Learning Capacity (ALC) as " a child's propensity and ability to interact with and take optimal advantage of the full complement of resources offered by any formal or informal learning environment". Included in the factors affecting a child's ALC are nutritional and health factors, socio-economic status and home and school environments; all of which serve as confounding factors in any investigation. She identifies five major health and nutrition problems as especially suitable for intervention strategies. These are protein-energy malnutrition, micronutrient deficiencies (especially iron, iodine and vitamin A), helminth infection, hearing and sight impairment, and temporary hunger.

Grantham-McGregor (1993) has highlighted the methodological issues and problems in assessing the effects of nutrition on mental development in Jamaica; the difficulties of achieving reliable and valid measurements of mental development and behaviour in Third World children; and the confounding and interacting effects of social background. While she identifies a number of problems that have to be overcome for designing intervention studies - inappropriate study design, lack of randomisation, self selection of samples, controlling for practise effects and absence of placebo groups - she concludes, on the basis of her Jamaican work, that it is possible to measure the impact of poor nutrition on development.

Burger (1993) presents the essential criteria for valid tests of causality and provides a detailed account of experimental study designs, criteria for ensuring internal and external validity, and the plausibility of testing the effects of nutrient deficiencies on behavioural performance. She stresses that good public health policy and programmes require sound scientific observations. She concludes that there is little scientific evidence for the deleterious effects of mild to moderate micronutrient deficiencies, especially on behavioural development, to undertake or forego public health policy or actions. This position may not be valid in developing country contexts where these deficiencies co-exist with other diseases (diarrhoea, tuberculosis, HIV/ AIDS) and socio-economic, environmental and other deprivations. Connolly and Grantham-McGregor (1993), in supporting Burger's plea for a scientific basis for sound public health policies in nutrition programmes, recommend that the most powerful design for such investigations is the double-blind randomised treatment trial, with pre-and post tests to establish causal links between nutritional variables and psychological consequence and to control for poor social circumstances.

1.2.5 Combining micronutrient interventions

Studies in Thailand, Indonesia and Guatemala have shown a relationship between iron and vitamin A supplementation (Sommer, 1993, Meija 1988, Bloem 1989). Bloem (1989) in Thailand showed significant differences for retinol, retinol-binding protein, serum iron (Fe) and percent saturation between supplemented and controlled groups after 2 months, although these differences were not sustained after 4 months. Meija *et al* (1982) showed that after 6 months of vitamin A fortification, indices of iron status had improved, while the work of Muhilal *et al* (1988) in Indonesia supported these findings. Studies suggesting that a lack of vitamin A may lead to mild anaemia characterised by low serum Fe have been supported by epidemiological evidence, while nutritional interventions with vitamin A demonstrated a positive effect on iron nutrition (Meija 1988). These studies suggest that vitamin A deficiency impairs the utilisation of iron and that improving vitamin A nutrition may improve iron status.

1.3 Rationale & potential for School-Based Interventions

This section explores the potential that exists for transferring the scientific benefits from health interventions aimed at school children to cascade at different levels of the health and educations sectors (Table 1.2). The primary focus of this thesis was to obtain the best evidence from scientific studies of micronutrient supplementation and deworming programmes so that it can inform policies, strategies and programmes at local, national and global levels. This evidence-based partnership is important in the allocation of resources. The constrained socio-demographic and developmental status of KwaZulu-Natal, reflected in Table 1.1, raises issues of equity, relevance and cost effectiveness of interventions - especially in resource constrained environments.

1.3.1 School health policies & programmes: PSNP, SHS, HPS

Apart from the obvious gains of improving the nutritional and health status of children, a central objective of the South African government's Reconstruction and Development Programme (RDP, 1994) is to enhance the educability of school children by promoting health interventions through the education sector. Measuring both sets of outcome measures - health and educational benefits - would provide an objective assessment of the impact and the economic and political sustainability of the government's Primary School Nutrition Programme (PSNP), and contribute to the further development of School Health Services (SHS) and the Health Promoting Schools (HPS) strategy.

The PSNP was launched in 1994 as a Presidential Lead Project of the RDP with a total annual budget of R 496 million. Its specific aims were: improving health and education by enhancing active learning capacity and school attendance; micronutrient supplementation and deworming; health education; and supporting broader development goals to combat poverty (CHU, 1997). The principles underlying the PSNP included community involvement, a holistic approach – linking school nutrition activities to improvements in the quality of education; multi-sectoral and interdisciplinary interventions involving several government departments; and financial sustainability.

The PSNP's intervention of school feeding, micronutrient supplementation and deworming to improve scholastic achievement and nutritional status is consistent with international recommendations. This requires base line prevalence data to assess which therapeutic regimens are likely to achieve maximum impact. In addition, it is important to establish the efficiency and synergism of multiple interventions and to target these interventions, especially since the benefits of (school) feeding programmes have not been consistent (CHU, 1997). A National Nutrition Commission (1994) had recommended a phased strategy for tackling these multiple problems. Approximately 50% of the 3.8 million South African primary school children were estimated to be in need of nutritional support in 1994.

1.3.2 Role and contribution of School Health Services (SHS) as part of the DHS

One area in which existing global evidence based strategies have successfully emerged is in the formulation of the HPS strategy. Here the availability of sound epidemiological data about the health and social problems of school children, coupled with cost-effective micro-nutrient and anthelminthic interventions with demonstrated positive impacts on growth and development, created conditions for a world wide Partnership for Child Development (PCD) between scientists, policy makers and international agencies (PCD, 2000). The HPS strategy allows for the potential integration of programmes such as PSNP, the National Oral Health Survey, the Parasite Control Programme, HIV/AIDS education, Life Skills and the National Plan of Action for Children. The components of a comprehensive SHS usually include health inspection; health education; environmental health, including water and sanitation; nutritional services; the treatment of common diseases such as helminth infections; and growth monitoring. The WHO rationale and conceptual framework for SHS provision is based on evidence of substantial health savings made through the SHS.

Promoting health through schools has been an important goal of WHO, UNICEF, UNESCO and other international organizations since the 1950s. The WHO (1997) expert committee made recommendations for a comprehensive school health programme directed at prevention, where possible, or treatment by efficient referral of children with common health problems. It also noted that there was a need to develop policies, legislation and guidelines at country level in order to ensure the identification, allocation, mobilization and co-ordination of resources at all levels of health care to support school health. Research conducted by the World Bank, WHO, UNICEF and other organizations concluded that interventions in schools - to provide supplementary food and specific nutrients; to give drugs to prevent or treat infections; to screen for hearing, vision, dental, psychological and other problems - can prove to be very high yielding investments.

1.3.3 The education sector in South Africa: Maximizing the potential impact of health interventions

The actual impact of health interventions being investigated in this study will be influenced by the quality of the education sector in South Africa (SA) and its potential capacity to integrate these interventions. This review is based on the Education Foundation Report (2000), which has provided a comprehensive overview of the entire education sector, including the policy and legislative context. The National Education Policy Act stipulates the rights of every person to a basic education and equal access to education; while the SA schools Act established a single, non racial education system, and made schooling compulsory for all children between the ages of 7 – 15. The policy framework recommended the introduction of Curriculum 2005, focused on Outcomes Based Education (OBE) with up to eight learning areas, including health education. To cope with the infrastructural backlogs, the RDP funded a National School Building Programme to build over 10,000 classrooms by 1999; and the Culture of Learning and Teaching (COLT) Programme to improve school buildings and the quality of learning (Education Foundation, 2000). A central goal of the RDP strategy was to complement these initiatives with those from the health and other sectors, such as the Primary School Feeding Programme (PSNP), so as to maximize these investments and to explore synergies.

An important indicator of the significance of involving the education sector and the magnitude of the impact that health interventions could make is the proportion of the population that constitutes the school-aged population between 7 – 18 years. In KwaZulu-Natal there were 2,342,760 children (28%) in this age cohort - just over a quarter of the total provincial population - while 35.5% of children of a total population of 8.4 million are under the age of 15 years. KwaZulu-Natal also had the largest number of learners enrolled in schools: 2.7 million or 23% of the national total. The total provincial education department budget for 1999 was R7.2 billion, with a per capita expenditure of R 2 426 in 1999, rising from an expenditure of R 1 979 in 1995. In summary, a review of the size of the education sector indicates that school-aged children are a significant proportion of the population and that substantial investments both in financial and other resources are being made in this sector. This suggests that the potential for maximizing synergistic improvements in both health and educational outcomes is considerable, and that the education sector offers considerable opportunities to reach a large and important section of the SA population.

1.3.4 Review of global policies, programmes and partnerships in school health

As scientific evidence of the benefits of single and multiple interventions (focussing on the health problems of school children) have accumulated, there has been a concomitant increase in the number of school-based health policies and programmes to utilise the gains from these findings. At a global level the experiences of WHO, UNICEF, UNESCO and the World Bank are forging effective partnerships to impact on the health and nutrition of school children and to promote school-based programmes (Del Rosso, 1996, Dolan 2000, PCD 2000).

In 1996 the World Health Organisation (WHO) launched the Global School Health Initiative (GSHI) to increase the number of Health Promoting Schools (HPS), defined as a school that 'constantly strengthens its capacity as a healthy setting for living, learning and working'. It has four strategies:

- building capacity to advocate for improved school health programmes;
- mobilising resources for developing HPS;
- strengthening capacity at national and international levels;
- research to improve school health programmes.

The purpose of this initiative is to harness existing resources at country, community and school levels to assist governments to advocate for increased funds for HPS, influence policy through advocacy and ensure long term sustainability of the initiative. Its Task Force for Healthy School Children has produced a number of guidelines, action plans and documents that address important programme and technical issues in HPS (PCD, 2000). Of The 22 WHO divisions relevant to the school health strategy, eight are represented on the Task Force, while all seven WHO regional offices are involved at different levels.

UNICEF's Child Friendly Schools stresses a rights-based, child-friendly educational system and schools characterised as ' healthy for children, effective with children, protective of children and involved with families, communities and children'. The four components of its school-based interventions include: school policies to protect the rights of children; skills-based health education and life skills training; water, sanitation and hygiene promotion; and specific medical and nutrition interventions (including deworming, micronutrient supplementation and malaria treatment). UNICEF's programme works within the framework of the 1989 UN Convention of the Rights of the Child, the 1990 World Summit for Children and the 1990 World Conference on "Education for All" (PCD, 2000).

Four programme principles have been identified to support these interventions:

i) strengthening partnerships and linkages between schools, communities and parents, and between health, education and other sectors;

ii) capacity-building and training;

iii) sustainability for long-term programmes;

iv) children's participation to identify needs, and for implementation.

UNESCO was one of the first UN agencies to begin sector work on school health and nutrition - emanating from the World Declaration on Education for All in 1990 - providing a comprehensive approach to school health; providing safe and supportive environments for the development of teaching and learning; and providing technical support for the World Food Programmes (WFP) School Feeding Programmes (PCD 2000).

The World Bank's International School Health Initiative (ISHI) seeks to improve the quality of health and nutrition programmes by providing access to expert advice based on good practice; developing practical tool kits for implementation; dissemination of quality information through the internet; building partnerships with governments and NGO's; and including school health components into World Bank projects. It recognises the need to build on the investments in early child development and to lay a sound foundation for appropriate social behaviour in adolescence as part of its Human Development strategy. The core group of cost-effective components that make up *Focussing Resources on Effective School Health (FRESH)* – launched at a World Education Forum (2000) - include:

- health related policies in schools – including policies for health education;
- provision of safe water and sanitation facilities;
- skills-based health education which focuses on the knowledge, attitude, values and life skills needed to make health related decisions;
- school-based health and nutrition services (Dolan, 2000).

FRESH is an inter-agency initiative (including WHO, UNICEF, UNESCO and the World Bank) to identify best practices from field programmes and increase the number of countries and regions to implement school components of child-friendly school reforms as starting points to which other appropriate interventions may be added (PCD 2000).

The Partnership for Child Developmentt (PCD) was established in 1992 to undertake operation's research on school health programmes. It provides research and technical support in some 50 countries and has a Scientific Coordinating Center at the Center for the Epidemiology of Infectious Diseases (CEID), University of Oxford (PCD 2000). The PCD has developed core programmes in five partner countries (Ghana, Tanzania, India, Indonesia and Vietnam), providing a core package of anthelminthic treatment, micronutrient supplementation and participatory health education. A major survey of donor and agency support of school-based health and nutrition programmes undertaken by the PCD in 1998, and updated in April 2000, has identified a large number of bilateral, multi-lateral, governmental and NGO initiatives, programmes and agencies involved in this field and collaborating at various levels (PCD, 2000).

Chapter 2: Research hypothesis, Scope of the research study and Objectives

The primary research hypothesis was that a combination of deworming and micronutrient supplementation amongst school children was likely to produce a synergistic effect on nutritional and health status, greater than that produced by single selective health intervention alone. Beginning with a clinical and epidemiological investigation of the health and nutritional problems faced by school children, a community-based randomized controlled trial (RCT) evaluated the impact of anthelminthic treatment alone, or anthelminthic treatment combined with micro-nutrient supplements (iron and vitamin A) on the following indicators of health of school children: anthropometric indices, micronutrient status, prevalence and intensity of infections and scholastic and cognitive functions. The primary end-points were improvements in the micronutrient and the cognitive and scholastic status of school children.

The examination of the impact of these selected health interventions on rural school children generated a number of additional research questions that were explored in a further series of research studies. Studies of smaller groups of urban school children provided a rural/urban comparison and validated some of the findings from the main rural study. The endemic nature of geohelminths and schistosomiasis in many parts of South Africa required a deeper analysis of the epidemiology and efficacy of different treatment regimens for the development of effective control strategies. While infestations with these parasites have a low mortality, the associated morbidity has increasingly been linked to cognitive and scholastic impairment (Kvalsvig, 1991).

Recognising that health interventions such as micronutrient supplementation and deworming are not the only factors that influence the health and development of school children, we explored one dimension of the health transition: specifically the changes in the nutrition status occurring in this age cohort. Changes in the prevalence of under nutrition (wasting and stunting) and over nutrition (overweight and obesity) have important implications for the prevention and control of diseases in adulthood (Cole T *et al*, 1999). Rapid socio-political changes, urbanisation and the shift towards westem lifestyles have influenced this nutritional transition, and this in turn has important implications for the provision and re-orientation of health policies, programmes and services for school children and adolescents (May J *et al* 2000, NDOH, 1999).

Intellectual, cognitive and scholastic performance are important measurable outcomes of both investments in health and educational resources, as well as strategic objectives of broader human and social developmental programmes. In this study, cognitive and scholastic test scores of school children were investigated primarily to measure the post-intervention impact of the health interventions in the RCT. Kvalsvig (1991) investigated the cognitive effects of intestinal and schistosomal infections on primary school pupils in KwaZulu-Natal and showed that parasitic infections combine with nutritional deficits to impair the efficiency of cognitive processes. In a study of preschool children, Kvalsvig and Connolly (1994) report a positive effect on children's behaviour after treatment for parasitic infections.

In developing the study design for both the assessment of the nutritional transition and the cognitive test scores, methodological issues were required to be addressed. Internationally acceptable standards, norms and cut off points existed to define normal and abnormal levels for variables such as stunting, wasting, anaemia, iron and vitamin A deficiency and parasitaemia. However, for overweight and obesity using Body Mass Index (BMI) and for cognitive and scholastic test scores, no clearly defined nationally acceptable cut-off points exist. Defining BMI cut-off points required the application of the International Obesity Task Force's (IOTF) recommended cut-off points, and the LMS method of Cole *et al* (2000) for establishing the prevalence of overweight and obesity. With respect to assessing, interpreting and analysing cognitive and scholastic performance we developed a test battery, in consultation with clinical psychologists, to measure a wide range of psychological functions.

An important objective was to make recommendations to policy makers, programme managers and communities to integrate these findings into existing and future polices and programmes. Nationally and internationally many governments, UN and NGO agencies and donors have been struggling to develop programmes that are integrated among different sectors (health, education, water and sanitation, poverty alleviation) and comprehensive (combining curative care, health promotion and rehabilitation) (World Bank, 2000 FRESH). In South Africa we have several initiatives that would benefit from improved co-ordination: in the Department of Health we have the Primary School Nutrition Programme (PSNP) (which included a national deworming component) and the Health Promoting Schools strategy and guidelines for integrating School Health Services (SHS) into the PHC based District Health Services (DHS) (Department of Health, Annual Report 1999); from the Department of Education we have the universal primary Education for All strategy linked to Outcomes Based Education (OBE); and from the Department of Water Affairs and Environment, the Water for All policy. The Reconstruction and Development

Programme (RDP) of the government provided a conceptual and strategic framework for an integrated development programme (RDP, 1995). Increasingly it is becoming clear to governments and communities that health policies and programmes based on evidence are more likely to optimally utilise scarce public sector resources, be sustainable at community and political levels and generate significant health gains. Many governments, including the South African Department of Health, have acknowledged the World Health Organisation's (WHO, 2000) concerns about the limited performance of health systems. They have committed themselves to both improving health systems performance and to base policies and programmes on best evidence. The challenge is to identify priority health problems affecting the nation's children and to provide a sound scientific and policy rationale for interventions.

2.1 Purpose

The main purpose of this study was to determine the extent to which anthelminthic treatment alone or anthelminthic treatment combined with micronutrient supplements improves nutritional status, physical health and scholastic and cognitive functions of primary school-aged children in KwaZulu-Natal. A related purpose was to explore the potential of integrating this evidence into school-based health and education policies, services and interventions.

2.2 Specific objectives

- Assess the nutritional and health status of primary school children
- Measure the impact of combining micronutrient supplementation and

deworming on their nutritional and health status

- Investigate the prevalence and intensity of geohelminthic and Schistosoma infections among rural primary school pupils
- Compare the extent of changes in the nutritional status of school children, with specific reference to changes in the prevalence of overweight and obesity
- Develop a battery of cognitive and scholastic tests, for application at school level, to measure the impact of the health interventions on the performance of school children
- Assess the potential for the School Health Services (SHS) in KwaZulu-Natal to implement an integrated nutrition programme
- Make recommendations to district, provincial and national government departments, communities and development agencies - based on these results - for improved health and education policies, programmes and services.

2.3 Structure of the thesis

The thesis is presented in eleven chapters. The first chapter outlines the epidemiological justification for the study and the motivation for the focus on school-aged children. A literature review covers the main components of the study with regard to the interaction between micronutrient supplementation and deworming and its impact on the four main outcome measures, namely anthropometric, micronutrient and parasitic status and cognitive indicators. It also provides background information, both South African and international, and outlines the policy and planning perspectives of the South African government's

Departments of Health and Education with regard to improving the health and well being of school-aged children. It relates the value of the evidence base provided by this study for the main programmes and services dealing with school children - namely the Primary School Nutrition Programme (PSNP), the School Health Services (SHS) and the universal Primary Education Strategy, which are briefly summarised. Chapter two covers the research hypothesis, scope of the research study and the objectives. Chapter three covers the methodological aspects, study design, sites and subjects.

The rest of the seven chapters present the research findings. A cross-sectional epidemiological study of the health status of primary school children in South Africa (Chapter 4) and the results of a community-based randomized controlled trial (RCT) to assess the synergistic impact of combining micronutrient supplementation and deworming on nutritional (macro and micro) and cognitive / scholastic status (Chapter 5). Both of these studies were undertaken in the primary rural Vulamehlo study site. Subsequent chapters cover the impact of deworming on parasite status (Chapter 6); the changes in the prevalence in overweight and obesity (the nutritional transition) specifically in BMI; the implications for the emergence of chronic diseases (Chapter 7); the cognitive and scholastic status of school children (Chapter 8); and the impact of environmental influences, especially exposure to lead poisoning (Chapter 9). An evaluation of School Health Services (SHS) in KwaZulu-Natal (KZN) considers the potential for implementing the health interventions (micronutrient supplementation and deworming) through SHS (Chapter 10).

Chapter 11 covers the integration of the micronutrient and deworming interventions into existing school health services, policies and programmes and conclusions and recommendations for the promotion and protection of the health of school children as a significant investment for the future.

Chapter 3: Overview of study design, subjects and methods

3.1 Introduction

The main intervention consisted of a randomised controlled trial (RCT) in the primary study site, the rural Vulamehlo district. For comparative purposes, subjects from three other urban sites were also investigated as nested cross-sectional descriptive studies. All the studies were undertaken during 1995 and 1996. This chapter provides a general overview in the primary rural study site of the following aspects: the RCT study design; sample selection, size, inclusion and exclusion criteria for the subjects; the clinical and health interventions among the six different study groups; and the collection, administration, analysis and interpretation of the anthropometric, micro-nutrient, parasitic and cognitive and scholastic data. Descriptions of all these aspects of the methods with respect to the other urban study sites are also provided in each of the relevant chapters. Where relevant, important methodological issues such as the development of the cognitive and scholastic test battery in a "psychological laboratory" will be described and discussed in greater detail in the respective chapters. Fig. 2 provides an overview of the study objectives, methods and subjects, outcome measures and study sites. Where secondary data sources have been used, this is clearly indicated. Bio-medical methods were used to measure some of the quantitative variables, while different psychosocial techniques (such as focus group discussions, key informant interviews and semi-structured questionnaires) were used to collect qualitative data for the different studies that are listed in Table 3.1.

3.2 Study design in the primary rural site

A double blind randomised placebo controlled trial using a factorial study design was used. The first part of the study was a community-based, cross sectional prevalence study of the anthropometric, micronutrient, parasitic, and cognitive / scholastic status of the primary school children. This constituted the pre-intervention data set for the prospective study and the post-intervention analysis of the intervention and control arms of the study. The treatment and placebo groups were randomly allocated within each class. The advantage of this study design was that pupils from the different study groups had exposure to the same quality of teaching and the same level of stimulation, which is a serious confounder when measuring scholastic progress and cognitive development. Comparison of outcome measures after random allocation to two groups removes the effects of unknown sources of bias and ensures validity (Beaglehole R., 1993).

The intervention consisted of micronutrient supplementation in the form of two fortified biscuits given daily during the study period. Biscuits were distributed daily for the five days of the school week for a total of 16 weeks. A single dose of albendazole (400 mg) for geohelminths and praziquantel (40 mg/kg) for schistosomiasis, or of placebo, was given once at the beginning of the study by health professionals. Distribution and consumption of biscuits took place under close supervision of local community members ("school mothers") who were trained for the task. The researchers undertook weekly checks to monitor the distribution and adherence to protocol. Each "school mother" completed a weekly register of each child per class enrolled in the study, noted absent children (and the reasons for absenteeism), the number of biscuits given, and any side effects, complaints or other problems. All the pupils in grade 3 who were excluded from the study on the exclusion criteria received placebo biscuits to reduce any feelings of discrimination and the possibility of exchanging of biscuits among subjects.

3.2.1 Selection of Study site

Vulamehlo Magisterial District, a rural area in southern KwaZulu-Natal (see Appendix 1, Map), was selected for the study as it was similar to other rural areas in this province. It was one of the districts where the government's school feeding programme had not been initiated. Its socio-economic and demographic characteristics were similar to the KwaZulu-Natal provincial profile presented in Table 1.1. The illiteracy rate was 40.1% and the income of 47.0% of households was below the basic household level (Data Research Africa, 1992). It was a well-established community, close to Durban, and relatively free of the political violence endemic in KwaZulu-Natal during this period. A non-governmental community-based organisation (CBO), the Siyabona Community Centre, assisted with mobilising community support for the study and provided logistical support for the fieldwork. (See Appendix 2, Photographs)

The first phase of community consultation involved several steps. Firstly, we identified all the schools in the Vulamehlo Magisterial District, allowing us to develop a sampling frame for the random selection of eleven schools. Prior authorization to undertake the study had been obtained from both the Departments of Health and Education. These letters of authorization were presented at meetings held with the Circuit Inspectors and School Principals in this magisterial district to share the aims and objectives of the study; the requirements of the research team from the schools; anticipated teacher and pupil involvement; and logistical preparations. Once this level of permission had been obtained we began the process of consultation and consent from the community. Both the School Education Committee and the Tribal Authorities were consulted, and authorization obtained. With the permission and support of both the education and community leaders, individual letters of consent were given to each pupil to obtain parental consent for their children to participate.

Since we anticipated that any school children identified with health problems would be referred for treatment, the school health nurses, PHC nurses in the local Jolivet and Dududu Clinics, the matron and chief medical superintendent at the regional Prince Mshiyeni Hospital, and the private general practioners were briefed and their involvement sought. The nurses and other health professionals in the public and private sector provided support by advising parents and pupils to participate in the study and by managing pupils referred to them. They were all briefed about the study, consent and authorization was obtained, and their involvement sought - especially during the intervention phase. An important objective of this community involvement was to ensure that unwanted interventions did not occur and that the controlled nature of the study was maintained for its duration.

3.3 Subjects: Selection of schools, samples and study groups

3.3.1 Sample size calculation

Statistical support was obtained from the Bio-statistics division of the Medical Research Council (MRC), Durban and from the epidemiologist from the Institute of Child Health, University College, London. A single outcome of response was selected and a statistical formula was applied to establish the sample size, so as to ensure sufficient power in the calculation to detect a statistically significant result. Choosing one of the Fe status parameters viz. haemoglobin, a sample size of 100 per group was estimated (total for 6 groups was 600) based on the following assumptions: ability to detect an increase in haemoglobin of 0.5 g/dL with 90% power at the 5% significance level, and to allow for a drop out of 25% (Pocock, 1983). The formulae used to estimate sample size was as follows:

$$N = \frac{2\,@^2 * f(a,b)}{(d)^2}$$

Where u1 = anticipated mean untreated response for one of the variables

u2 = clinically relevant increase in this response

d = u1 - u2

@ = standard deviation

Alpha (a) = $p < 0.05$ (the level of chi square significance test used for detecting a treatment difference). Alpha (a) commonly called the type I error, is the probability of detecting a "significant difference" when the treatments are equally effective (i.e. it represents the risk of a false-positive result).

Beta (b) = 0.95 (power or degree of certainty to detect a difference)

Beta (b) commonly called type II error, is the probability of not detecting a significant difference when there really is a difference (i.e. it represents the risk of a false-negative result).

f = is a factor derived from a standard table of values based on the alpha and beta values.

Where accurate figures did not exist for the means before (u1) and after (u2) and for the standard deviations, estimates were used in this formula. The above formula provided the scientific requirements for statistical calculations of sample size. This was balanced by consideration of clinical significance and availability of resources.

3.3.2 Selection of Schools & Grade 3 Subjects

Eleven schools were randomly selected from a list of the 72 primary schools in the Vulamehlo Magisterial District in rural southern KwaZulu-Natal (sampling rate approximated 15%). These were all government-run schools. Within each school all the classes with Grade 3 pupils between 8 - 10 years of age were selected, giving a representative sample of approximately 800 children at the beginning of the study. At different stages of the study the actual sample size for analytical purposes varied due to dropouts in the study pre- and post-intervention and ability to obtain or collect the required blood, urine or stool samples.

Grade 3 pupils were chosen as they had the benefit of at least two years of schooling to enable measurement of concentration and learning skills. Beyond 10 years of age, pubertal changes impact on growth (Dalman, 1990, Pollitt, 1990). In KwaZulu-Natal there is a high attendance rate among primary schools, with 89.2% of the children attending (Education Foundation (1996), Department of Statistics (1999)). Since this was a school-based study, we were partly constrained by the length of the school terms available for the study period. The longest term period available was between the third and fourth terms (between July and December): a period of 16-18 weeks, hence the selection of those scholastic and cognitive test measures most likely to reflect changes within this time period. This constraint also limited our ability to undertake longer-term follow up to measure the impact on certain variables.

3.3.3 Study inclusion and exclusion criteria

The inclusion criteria were that the children had to be between 8 years 1 month and 9 years 11 months of age (i.e. between 8.0 and 9.99 years). All the children in these schools were African.

Exclusion criteria

1. Physically and mentally handicapped children.
2. Children who attended less than 50% of the classes during the study.
3. Parental refusal for the child to participate.
4. Participation in any other fortified feeding programme, immediately preceding the study.
5. Children who, during the course of the study, received any food supplements or treatment outside of the study context.

6. Children with no accurate age records, not formally registered in the school (i.e. awaiting registration or temporarily registered).

All the children that fulfilled the criteria for inclusion were identified from the school register, randomly allocated to a placebo or intervention group and a database established in respect of each child and school.

3.3.4 Study groups and interventions

The total sample was subdivided into 6 homogeneous samples (in terms of age and sex). A "treatment group" was then randomly allocated to each sample to create the following groups:

- Group 1: Deworming and fortified biscuits with combination of micronutrients (vitamin A, iron)
- Group 2: Deworming and vitamin A biscuits
- Group 3: Deworming and placebo biscuit (no micronutrients)
- Group 4: Biscuit with combination of micronutrients and no deworming
- Group 5: Biscuit with vitamin A and no deworming
- Group 6: Placebo biscuit and no deworming.

Dewormed groups were 1, 2, and 3, while the non-dewormed (placebo treatment) groups were 4, 5 and 6.

Each child received 2 x 20 g biscuits containing either a) vitamin A (group 2 and 5), b) combination of micronutrients (group 1 and 4), or c) no micronutrients - placebo (group 3 and 6). The 2 biscuits given daily to groups 2 and 5 supplied 100% of the RDA of vitamin A. The biscuits supplied to groups 1 and 4 contained the following combination of micronutrients:

B vitamins (B6) (25% RDA), Vitamin A (50% RDA), Iron in the form of FeEDTA (50% RDA), Calcium (25%), Zinc (25%). With respect to quality assurance SASKO, the food company that supplied the biscuits that were manufactured by an independent bakery, analysed a random sample of biscuits to ensure strict compliance with the specifications.

3.4 Methods of data collection and analysis

3.4.1 Cross sectional studies and randomised controlled trial (RCT)

Outcome measurements for randomised controlled trial (RCT)

1. Anthropometric status - weight, height, BMI and knee heel, actual values and Z scores calculated
2. Micronutrient status - Vitamin A (serum retinol) and iron – (Hb, haematocrit, serum ferritin), percent transferrin saturation
3. Parasitic prevalence and intensity – geohelminths and schistosomiasis
4. Scholastic and cognitive test performance.

These were measured at baseline and 16 weeks post-start of the intervention. The specific variables and the criteria for normal and abnormal cut-off points are indicated in Table 3.1.

Table 3.1: Criteria for Assessing Health Status parameters

VARIABLES	DEFICIENT	BORDERLINE	NORMAL	EXCESS
ANTHROPOMETRY Wt for Age (WAZ) Ht for Age (HAZ) Wt for Ht (WHZ) Body Mass Index (BMI)	=< -2 SD Z scores for all parameters	< -1 SD	-1 to +1 SD	= > +2 SD
MICRONUTRIENT Serum Vitamin A Haemoglobin Serum Ferritin	< 10 μg / dL < 11 g /dl -	≥10 <20μg / dL < 12 g /dl < 12 ng/ ml	≥ 20 μg /dL > 12 g /dl > 12 ng / ml	- - -
BLOOD LEAD LEVEL				> 10 μG/DL
PARASITES Geohelminth sp Schistosoma sp	Prevalence – percent of children with single & multiple parasites Intensity – eggs per cover slip, as light, medium & heavy			
COGNITIVE / SCHOLASTIC PERFORMANCE	Test scores were compared to international and local norms.			

3.4.1.1 Anthropometric measures

Children were weighed without shoes and jerseys using a Masskot electronic scale, and trained field assistants measured height using a stadiometer. The same measurement protocols were used for all subjects. The measurements taken were the subjects' height (cm) and weight (kg); while body mass index (BMI), weight for age Z-score (WAZ) and height for age Z-score (HAZ) were computed. The reference population used in calculating the WAZ and HAZ scores was that given by the National Centre for Health Statistics (NCHS) (Hamhill *et al*, 1979). Z-scores were also calculated for BMI, using the method described by Cole *et al* (1990). BMI Z-scores for children are relatively untried but, as with all anthropometric centiles and standard normal deviates, they can be used to identify children who are unusually fat or thin on the basis of a single statistical measurement. In addition, a knemometer was used to measure the distance between knee and ankle to determine if this measure would provide a more sensitive measure of children's short-term growth. Standard errors of measurement and standard deviations of differences had to fall within internationally acceptable limits to ensure accuracy and reliability.

3.4.1.2 Parasite status

Stool and urine samples were collected from children at mid-morning. The stool samples were fixed in 10% formalin. For the stool analysis, two aliquots were measured from the stool sample and analysed separately using the standard formol ether method (Visser & Pitchford, 1972, Ritchie, 1948). The stool investigation determined the prevalence of infection of *Ascaris lumbricoides, Trichuris trichiura, Taenia spp*, *Hymenolepsis nana, Schistosoma mansoni,* and *Giardia lamblia*. An aliquot of the urine samples were analysed for *Schistosoma haematobium* using a helminth filter. Parasite status was measured in terms of prevalence and intensity. The intensity of stool parasites was quantified as light, medium and heavy approximately corresponding to the following eggs per cover slip field –

- *A. lumbricoides:* light (<20), moderate (21 -75) and heavy (>75)
- *T.trichiura:* light (<20), moderate (21-50) and heavy (>50)
- Hookworm sp*:* light (<10), moderate (11-20) and heavy (>20).
- *Schistosoma spp*: was quantified as light or heavy

(Parasitology Laboratory, Medical Research Council, Durban).

3.4.1.3 Micronutrients: Iron and vitamin A status

Micronutrient status was assessed in terms of serum retinol (vitamin A), serum ferritin, haemoglobin and percent transferrin saturation. Nutritional status was also assessed in terms of serum albumin levels. Collection and processing of blood samples was undertaken, as described below.

Half a millilitre (0.5) of blood was collected by qualified medical personnel (in a vacuum tube containing EDTA as an anti-coagulant) by venipuncture to determine haemoglobin and haematocrit. An additional 4.5ml blood was collected in a plain tube, protected from light to prevent photodestruction of vitamin A, and allowed to clot. After separation of serum, it was divided into three aliquots and stored at -20 degrees C. Serum analysis included serum iron, serum ferritin and percent transferrin saturation and vitamin A (serum retinol). The method used for laboratory analysis of iron included haemoglobin and haematocrit using a Coulter Model STKS; serum ferritin and serum transferrin using the Cobas Integra reagent systemimmunoturbidimetric method (percent transferrin saturation was calculated); serum iron using the Cobas Integra reagent system; and the guanidine/ferrozinc method. All tests of iron status were conducted in the routine haematology and chemistry laboratories of King Edward Hospital.

An aliquot of the serum was used to measure vitamin A in the Analytical Unit of University of Natal. The method used was reverse phase High Pressure Liquid Chromatography (HPLC).

3.4.1.4 Scholastic and cognitive test battery

The following test battery was developed in consultation with clinical psychologists with experience in working with African children in KwaZulu-Natal.
At baseline all children completed the Raven Coloured Progressive Matrices (CPM), a non-verbal test of intellectual development designed for use in children, considered a culture-fair test and which can be administered to groups.

The following three tests were undertaken pre- and post-intervention

- Rey Auditory Verbal Learning Test (RAVLT) (Andersen SJ, 1994). A modified version was used to test cognitive functions such as auditory and intellectual functions and immediate memory span and attention. The test was modified for use in a group setting: five presentations of a fifteen-word list were read, followed by a sixth recall trial and a recognition test of all the words. Pupils recorded all the words that they could remember (Anderson, 1994).

- Young Group Mathematics Test (GMT) (Young D, 1980). This timed group test of academic achievement consisted of two parts: the oral section where pupils responded to oral questions and recorded the responses, and the computational section involving additions and subtractions.
- Symbol Digit Modalities Test (SDMT) (Smith A, 1982). This screening test measured three dimensions of memory - visual, auditory and spatial; psychomotor speed, sustained attention (concentration) and gave an overall indication of cerebral processing efficiency to detect leaming difficulties in children.

The criteria for choosing this battery of tests was that these were likely to detect changes in behaviour within the time duration of the study; they could be used as group tests; they were relatively robust and easy to use under the difficult circumstances found in rural schools; and they measured several dimensions of scholastic and cognitive functions to give a well rounded battery of tests.

All the tests were standardised, administered at the same time in the morning for all the children, in the same order, using a bound colour-coded answer book to facilitate the smooth flow of the testing procedures. The tests were administered in Zulu by a team of clinically trained researchers under the supervision of a clinical psychologist. All the field-workers were rigorously trained in both the theory and practice of these tests and underwent several pilot training sessions before the actual testing in the schools.

3.4.2 Treatment of helminth infections

After the baseline measurements described above had been performed, pupils in groups 1, 2 and 3 were treated for geohelminths infections using a single dose of albendazole 400mg plus praziquantel 40mg/kg for schistosomiasis. Pupils in the other three groups (namely groups 4, 5 and 6) received placebos. At the end of the study all the children with infections or any other clinical problems were referred for treatment. Two weeks after anthelminthic treatment, stool and urine samples were collected from a sub-sample of the pupils and analysed as previously described, in order to determine the efficacy of treatment.

3.4.3 Implementation of micronutrient intervention

Immediately after the initial treatment of the helminth infections, the micronutrient intervention was started. Each pupil received a daily allocation of two biscuits each day of the school week. The "school mother" monitored the intake, and the research team visited each school weekly to check compliance with the protocols.

3.4.4 Post-intervention measurements

After 16 weeks the anthropometric, parasite, micronutrient and cognitive measures were taken again as previously described. The cognitive tests post-intervention used the same format but different examples. At the end of the study all infected pupils received treatment for geohelminths infections, schistosomiasis and anaemia.

3.4.5 Data analysis & Reporting of studies

The data was entered using Epi-Info 6.04 and analysed using SPSS 9.0. Independent two-sample and paired t-tests were performed together with one-way analysis of variance (ANOVA) and general factorial ANOVA tests. Duncan's multiple range test was used. Chi-squared tests were also used, and where appropriate, Fisher's exact test. Significance was taken in all tests as $P<0.05$.

3.4.6 Evaluation of School Health Services (SHS)

Both quantitative and qualitative methods were used to measure the availability, coverage and quality of SHS; the attitudes and perceptions of pupils, parents and teachers to the role and contributions of the SHS; and the views of the School Health Nurses and the teams on the current and future functioning of SHS.

Focus group discussions, key informant interviews and a structured questionnaire were used to collect the quantitative and qualitative data, which was analysed thematically and then entered onto spreadsheets.

With respect to the quantitative study, a situation analysis of the entire SHS throughout the KwaZulu-Natal province was undertaken through a structured questionnaire administered to all staff members of the SHS. A random sample of schools – pupils, parents and teachers – in Region B (the Midlands region) were selected for the more in-depth investigation of the perceptions and the roles and contributions of the SHS to protect and promote the health of school children.

Policy analysis and review of legislative, strategic and programme documents provided background material to contextualise the current and future roles of the SHS.

3.5 Ethical approval

The Ethics Committee, Faculty of Medicine, University of Natal, approved the protocol, while written informed consent was obtained from each parent, and authorisation given by the school teachers and the local tribal authority. A briefing of education and school committees, parents, teachers and local tribal authorities took place and ensured compliance with the above criteria.

3.6 Limitations of the study

With respect to the cross sectional studies and the RCT, the research team undertook independent random spot-checks on a routine basis to monitor the feeding programme and detect any deviations. Rigorous training of all interviewers controlled inter-interviewer variability, while intra-observer variation was reduced by quality control by the researcher.

The study design for the RCT, where the children were randomised and allocated to one of six study groups, precluded the prior screening for parasite status of the study samples. Assessment of parasite status occurred after the intervention commenced. As a result, the distribution of children who had parasite infestations among the six study groups was uneven. All six intervention groups had a mixed pattern of children – some were infected and others not. At the analytical level, the numbers of children and the sample size of parasite-positive children were not large enough to provide sufficient statistical power for sub-group analysis.

The time period for the intervention, 16 weeks, was not of a sufficiently long duration to measure changes in certain variables such as the Ravens CPM test for intelligence or anthropometric status. The study was constrained by the fact that the longest school term was limited to 16 weeks. This constraint also precluded the measurement of variables beyond this time period.

Limitations of resources and field conditions meant that not all the specimens – stool, urine, and blood – could be collected both pre- and post-intervention. The poor school environments meant that the scope of the study had to be restricted to its specific objectives. These resource constraints were compounded by the difficulties experienced in collecting specimens from small children. Again, at the analytical level, only subjects with both pre- and post-measures were included for the RCT investigations; while for the cross sectional studies, it was possible to investigate and analyse a larger sample of children. Since the primary objective of the RCT was to measure the changes in the prevalence in the parasite status among children to assess the impact of the deworming intervention, the intensity of infection was restricted to measuring the eggs per cover slip rather than the eggs per gram (epg) method (which is much more expensive).

The lack of nationally acceptable, standardised battery of tests to assess cognitive and scholastic performance necessitated the development of our own test battery to specifically measure the pre- and post-impact of the health interventions.

3.7 Study design in urban sites

Cross sectional, descriptive prevalence studies were undertaken in three urban sites – Umlazi, Besters and Manor Gardens – to provide comparative data for the main rural study. These urban studies provided two data sources – blood lead levels and psychological test score comparisons. The same study protocols and researchers were used to collect data at these sites. The sampling consisted of both random and convenience samples, and these are described in detail in the respective chapters, with a motivation for both the sample size and sampling frames used.

3.7.1 Secondary data sources

In the investigation of changes in nutritional status in our studies, comparisons were also made with two other secondary data sets drawn from the National Schools Survey (1994) by the Department of Health of 92,000 primary school children and the KwaZulu-Natal Income Dynamics Study (KIDS) (1998). The objectives, study design, sampling of subjects and analysis of data in studies are described in greater detail in the relevant chapters.

3.8 Summary

As indicated in the introduction, data from subjects in the rural Vulamehlo study site were the primary data source for analysis of the RCT component of the research. Data from subjects in other urban study sites were also collected for comparative purposes. This relates to the anthropometric data which examined the nutritional transition between rural and urban children, and among different data sets collected over different time periods. With respect to the cognitive and scholastic data, again the test scores of the rural children were compared with those of urban children. Each of the different components of the study that are described in the subsequent chapters will be complemented with a more detailed description of the specific method appropriate to that particular component or study subjects and sites.

An innovative feature of this thesis was the judicious application of both bio-medical and psychosocial methods to examine quantitative and qualitative variables so as to provide a composite analysis of the epidemiological status of school children. The breadth and depth of the (health) challenges confronting school children necessitated the use of a broader range of methodological tools to investigate and analyse these problems.

Fig. 2: Overview of Study Objectives, Methods & Subjects, Outcome measures & Sites

CHAP	OBJECTIVES	STUDY DESIGN	SAMPLING	SAMPLE SIZE (3,4)	MEASUREMENT VARIABLES	STUDY SITE(2)
4	Health status of primary school children	Cross sectional, prevalence	Random	800	Baseline: Anthropometry Micronutrient Status Parasite infections Cog. & scholastic scores	Vulamehlo Primary schools
5	Effect of anthelminthic Rx + micronutrient supplementation	Community based Randomised Controlled Trial (RCT)	Stratified random 11 Schools	579	Anthropometric status Micro-nut. Status Parasite infections Cog. & scholastic scores	Vulamehlo Schools
6	Investigate nutrition changes in prevalence of overweight & obesity	Cross sectional- urban rural comparison. Retrospective time trend analysis.	Random & convenience National school survey (1)	Vulamehlo - 800 Provincial- 4240 National – 23828 KIDS(5) - 515	Weight for age (WAZ) Height for age (HAZ) Body mass index (BMI)	Prov. schools - KZN Vulamehlo, Umlazi, Besters, Manor Gardens
7	Epidemiology of parasitic infections	Cross sectional	Random	600	Prevalence & intensity of infections	Vulamehlo
8	Assessment of cognitive & scholastic status	Cross cultural, urban rural comparison Cross sectional	Random	1000	Test scores: Ravens CPM, Rey AVLT, SDMT, GMT	Vulamehlo, Umlazi, Besters, Manor Gardens
9	Prevalence of Blood lead	Cross sectional	Random	Vulamehlo 800 Besters 452	Blood lead levels	Vulamahelo[2] Besters schools
10	Evaluation of School Health Services (SHS)	Quantitative & Qualitative survey Cross sectional	Entire KZN prov. Random	All Prov. School Health teams Region B schools	Qualitative: Perceptions, attitudes Quantitative: Size of SHS	KwaZulu-Natal province

Notes: **(1) Secondary data source - National & Provincial Schools Survey, Dept. of Health, 1994 & KIDS 1998.**
(2) Vulamehlo was the only rural site; all the others – Umlazi, Besters & Manor Gardens were urban sites.
(3) All the subjects sampled were primary school children, in the age range 8.0 to 10 years.
(4) Sample size variations – field and resource constraints limited collection of specimens from all children
(5) Secondary data - KIDS Study – KwaZulu-Natal Income Dynamics Study, 1993 –1998.

Chapter 4: A health and nutritional profile of rural school children in KwaZulu-Natal, South Africa

4.1 Introduction

This community based cross-sectional study was undertaken to measure anthropometric indices, micronutrient status, and prevalence of parasite infections in rural South African primary school children as the first pre-intervention phase of the RCT. A number of major nutritional, deworming and educational programmes have been targeted at primary school children to improve their health status, enhance their scholastic performance and promote health in schools (del Rosso *et al*, 1997). As previously indicated, helminthic infections and micronutrient deficiencies have been found to be associated with intellectual and physical impairment during childhood and school age (CHU, 1997). The prevalence of these public health problems among school children in South Africa, its persistence beyond pre-school age, and cost-effective strategies for its control and prevention are poorly understood (Beaton *et al*, 1993; Vorster *et al*, 1997). The recommendation that vitamin A supplementation and deworming should be part of a basic package of health services and incorporated into supplementary feeding programmes (World Bank, 1993) has major policy and fiscal implications for the efficient use of health resources, and therapeutic efficacy under local conditions needs to be established. This is especially relevant in South Africa and other countries where the major problem in children is stunting and not wasting; the former being unresponsive to food supplements alone (Vorster *et al*, 1997). Micronutrient supplementation (iron, iodine and vitamin A), which has demonstrated substantial improvements in morbidity and mortality among young children (Beaton *et* *al*, 1993; McGuire *et al,* 1993), may be of value in addressing similar deficits among school children. The objective of this study was to measure the following indicators of health of school children: anthropometric indices; micronutrient status; and prevalence of parasite infections in rural KwaZulu-Natal (KZN), to guide nutrition interventions as part of a comprehensive health and nutrition programme.

4.2 Methods

In Chapter 3, a detailed description of the methods has been given, and in this section, we have summarised the key features. This was a community-based, cross sectional prevalence study of primary school children undertaken in 1995, among 11 schools. Their anthropometric, micronutrient, parasite and cognitive status were measured as previously described in Chapter 3.

4.3 Results

4.3.1 Socio-demographic profile

A total of 579 children were included for analysis. The mean age of boys in this study was 108.5 months (SD 6.9) and for girls 107.9 months (SD 6.5). The study consisted of 261 boys and 318 girls, divided equally into the two age groups of 96-107 and 108-120 months (Table 4.1).

Table 4.1: Age and gender distribution – number and percentage (%).

Age (months)	Gender		Total
	Male	Female	
96 – 107	115 (19.9)	152 (27.9)	267 (47.8)
108 – 120	146 (25.2)	166 (27.0)	312 (52.2)
Total	261 (45.1)	318 (54.9)	579

When analysed separately there was no significant difference between the boys and girls for anthropometric, nutritional and micro-nutritional measures (including Z-scores and BMI), nor for parasite prevalence. There was no gender difference observed whatsoever even when considering variable cut-off levels for haemoglobin, serum ferritin and vitamin A. The results, therefore, are grouped for gender and only aggregate data are presented.

4.3.1.1 Micronutrient status

Normal levels were obtained for the majority of micronutrient variables. However, the low percentage transferrin saturation (mean 16.3, SD 8.2) may suggest sub-clinical iron depletion, but this is not reflected in the haemogoblin levels or in the ferritin levels (Table 4.2).

Table 4.2: Anthropometric and micronutrient status.

	Mean	N	SD	95% CI	
				Lower	Upper
Anthropometric status					
Height (cm)	127.73	520	5.87	127.23	128.23
Weight (kg)	26.99	517	3.75	26.63	27.27
BMI (kg/m^2)	16.49	516	1.63	16.34	16.63
Height for Age Z-score	-0.73	520	0.94	-0.81	-0.65
Weight for Age Z-score	-0.40	517	0.76	-0.47	-0.34
BMI for Age Z-score	-0.13	516	0.64	-0.16	-0.10
Micronutrient status					
Serum retinol (μg/dL)	24.04	300	10.48	22.85	25.22
Serum Ferritin (ng/ml)	30.94	178	18.34	28.24	33.63
Haematocrit (%)	37.62	426	3.43	37.30	37.95
Haemoglobin (g/dl)	12.82	426	1.10	12.72	12.93
Serum Iron (mmol/l)	12.56	469	5.97	12.01	13.10
Transferrin Saturation (%)	16.34	468	8.18	15.60	17.08
Albumin (g/l)	46.31	471	4.12	45.94	46.68

4.3.1.2 Parasite burden

The prevalence of roundworm infection was 27.3% in this study (Table 4.3); whipworm 53.9%; hookworm 3.3%; urinary bilharzia 24.5%; intestinal bilharzia 1.2%; and *Giardia lamblia* 3.9%. The prevalence (not shown in the table) for *Taenia spp* was 3.6% (n=12) and for *Hymenolepis nana* 0.9% (n=3). These last two parasite groups were not classifiable into the eggs per cover slip fields of light, medium and heavy. Multiple parasite infections (defined as two or more worm types) were observed in 97 children (i.e. 16.8% of the study population).

Table 4.3: Parasite prevalence and intensity of infection

Species	**Intensity**	**n (%)**
Ascaris lumbricoides	0-Nil	248(72.7)
(Roundworm)	1-Light	45(13.2)
	2-Medium	35(10.3)
	3-Heavy	13(3.8)
	Total	341
Trichuris trichiura	0-Nil	157 (46.0)
(Whipworm)	1-Light	145 (42.5)
	2-Medium	38(11.1)
	3-Heavy	1(0.3)
	Total	341
Hookworm *spp*	0-Nil	322(96.7)
	1-Light	9(2.7)
	2-Medium	2(0.6)
	3-Heavy	-
	Total	333
Schistosoma haematobium	0-Nil	344(75.4)
(Urinary bilharzias)	1-Light	64(14.0)
	2-Medium	46(10.1)
	3-Heavy	2(0.4)
	Total	456
Schistosoma mansoni	0-Nil	336(98.8)
(Intestinal bilharzia)	1-Light	-
	2-Medium	1(0.3)
	3-Heavy	3(0.9)
	Total	340
Giardia lamblia	0-Nil	320(96.1)
	1-Light	10(3.0)
	2-Medium	2(0.6)
	3-Heavy	1(0.3)
	Total	333

4.3.1.3 Nutritional status

In this study 7.3% of the children were stunted and 0.7% were underweight (Table 4.4). When considering BMI, either as Z-scores (allowing for age) or absolute ranges (not allowing for age), childhood obesity is detected, with 3.1% of the children being in excess of 2 SD above the median and 8.4% having a BMI in excess of 18.5 (WHO, 1995).

Table 4.4: Anthropometric Z-scores for height-for-age (HAZ), weight-for-age (WAZ) and body mass index (BMI).

	Z – scores (SND)*				
	<-2	-2 to –1	-1 to +1	1-2	>2
Height for Age n=520	38 (7.3%)	167 (32.2%)	299 (57.5%)	15 (2.9%)	1 (0.2%)
Weight for Age n=517	4 (0.7%)	108 (20.9%)	385 (74.5%)	17 (3.3%)	3 (0.5%)
BMI for Age n=516	-	122 (23.7%)	328 (63.5%)	50 (9.7%)	16 (3.1%)

	BMI range**			
	<16	16-	17-	>18.5
BMI n=516	200 (38.7%)	160 (30.8%)	113 (22.0%)	43 (8.4%)

* **Standard normal deviate**

** **Minimum value was 12, maximum 25.**

A total of 16.5%, 28.1% and 34.7% of the children were deficient with respect to haemoglobin <12g/dl, ferritin <20ng/ml and retinol <20μg/dl (Table 4.5). Further analyses were performed on measures of under-weight (wasting), stunting, and obesity; and on levels of vitamin A, haemoglobin, ferritin (as an indicator of iron status) and parasite prevalence. Significant associations were identified for under-weight children: these were with serum ferritin <12ng/ml (P<0.05), vitamin A <20μg/dl (P<0.01) and prevalence of whipworm infection (0.05<P<0.10). For stunting, an association with only vitamin A <20μg/dl (P<0.05) was identified. For BMI (i.e. obesity) haemoglobin below 12g/dl (0.05<P<0.10) was identified. Vitamin A at less than 10μg/dl was not significantly associated with these anthropometric measures, nor was haemoglobin at either less than 11 or 11.5g/dl. Non-significant associations may be due to the small sample sizes occurring in the sub-group analyses.

Low levels of Vitamin A (<20μg/dl) were associated with low levels of ferritin (<20ng/ml), P<0.01 and low levels of haemoglobin (<12g/dl), P<0.01. There was no association between ferritin and haemoglobin at any of the levels considered in Table 4.5.

Table 4.5: Micronutrient ranges for Haemoglobin, Serum ferritin and Vitamin A.

Haemoglobin (g/dl) (n=401)		Serum ferritin (ng/ml) (n=207)		Serum retinol (μg/dl) (Vitamin A) (n=335)	
	n (%)		n (%)		n (%)
<11	12(3.0)	<12	14 (6.8)	<10	20(6.0)
11 – 11.4	19 (4.8)	12 – 19	44 (21.3)	10 – 19.9	96 (28.7)
11.5 – 11.9	35 (8.7)	20 – 29	61 (29.5)	20 – 29.9	132 (39.4)
12 – 12.9	148 (36.9)	30 – 49	68 (32.9)	=>30	87 (26.0)
13 – 13.9	144 (35.9)	=>50	20 (9.7)		
=>14	43 (10.7)				

4.4 Discussion

This randomised community-based study has established that stunting, subclinical vitamin A deficiency, anaemia and parasite infections are significant public health problems among school children. This burden of macro and micronutrient deficiencies and parasitaemia clearly indicates that school children continue to be inflicted with the diseases associated with pre-school children. The results of this study were compared with a large national study of pre-school children to assess the persistence of these macro- and micronutrient deficits in school children. The prevalence rates of stunting, wasting and micro-nutrient deficiencies were lower than those among pre-school African children reported by the South African Vitamin A Consultative Group (SAVACG), while vitamin A deficiency and anaemia persisted among school children. In comparison to other published studies of school children (van Stuijvenberg *et al*, 1997; Kruger *et al*, 1996; Sickle *et al*, 1998; van Stuijvenberg *et al*, 1997) (Table 4.6), there was considerable variation in health status. There were no published studies that examined the full spectrum of anthropometric, micronutrient and parasitic status of South African school children, as seen in this work.

Table4. 6: Comparison of health status of South African Children

				ANTHROPOMETRY		VITAMIN A (ug/dL)			HAEMOGLOBIN (g/dl)		SERUM FERRITIN (ng/ml)			MEAN SERUM IRON mmol/l	PARA SITE MEAN PREVA LENCE
STUDY AREA (YEAR)	URBAN/ RURAL	POP. AGES	n	UNDER WEIGHT (WAZ)	STUNTED (HAZ)	<10	<20	<30	MEAN	<12	MEAN	<12	<20 UG/L	-----	-----
Ndunakazi KZN (1995)	Rural	African 6-11yrs	252	3.5%	12.2%	-	39.1%	-	12.57	29.5%	------	----	27.8%	12.6	34.3%
Worcester W Cape (1995)	Urban	School Children 6-12yrs	148	16.6%	17.2%	0%	1.8%	23.7%	------	13.3%	21.0	-----	-----	11.7	-----
Cape Town (1995)	Urban	School Children 6-11yrs	228	5.7%	8.3%	5.2%	59%	95.2%	12.4	28.5%	45.2	3.5%	59%	-----	-----

Worcester W Cape (1995)	Urban	Coloured 6-8yrs	247	14.0%	17.9%	-	-	-	12.1	42.5%	-----	15.6%	-----	------	-----
SAVACG National (1994)	Both	National 6-71mo	4788	9.3%	22.9%	3.3%	33%	77.7%	12.0	----	35	9.8%	-----	------	-----
SAVACG KZN (1994)	Both	National 6-71mo	511	4.2%	15.6%	2.6%	38.3%	80.4%	-----	-----	-----	13.4%	-----	------	-----
Vulamehlo KZN (1995)	Rural	School children 8-10 yrs	579	0.7%	7.3%	6.0%	34.7%	74.1%	12.82	16.5%	30.94	6.8%	28.1%	12.56	53.9%

4.4.1 Nutritional Status

Globally the prevalence of stunting has declined from 48.8% in 1980 to 39.9% in 1995. In Sub-Saharan Africa as a whole, no decline was reported. In South Africa however, a twenty-year review of nutritional status of South Africans by Vorster *et al* (1997) found that for rural African primary school children (6 –16 years), the prevalence of under-weight children declined from 48.9% (1978 to 1993) to 8.7% (1994) while stunting declined from 33.6% (1978 to 1993) to 14.6% (1994). In comparison, the Partnership for Child Development (PCD, 1998), in a report of anthropometric status in five developing countries undertaken in the mid 1990's, found that 48% of children were under-weight and 51% of children were stunted.

The low prevalence of stunting and wasting observed in this study might indicate a continuing decline in this occurrence among rural African children. A low level of obesity was also found in these children, as measured by a BMI of more than 2 SD above the median. It should be noted that this level of obesity arises from the use of the UK reference population: a reference population that has obvious morphometric differences in the timing of height and weight growth from that of rural African children (Cole *et al*, 1995). Consideration should therefore be given to the quantification of obesity as indicated in this study. The difficulties in relation to classifying obesity in children have been reviewed by Prentice (1998). Clinically, centile curves and Z-scores from the UK reference population give a useful measure of obesity, but the problem arises when making cross-cultural comparisons between large cohorts of children. In this study, both BMI Z-scores and absolute ranges are shown, to allow useful comparison with other populations.

With declining prevalence of stunting and wasting, it is important to monitor obesity trends in South African children since it has important implications for the control of the emerging epidemics of chronic degenerative conditions among adolescents and adults.

4.4.2 Micronutrient Deficiencies

The prevalence of marginal vitamin A deficiency (serum retinol below 20 μg/dl) at 35% was similar to the level of 38% found among rural KwaZulu-Natal pre-school children in 1994 (SAVACG, 1995) and lower than those found in a Cape Town study (59%) (Sickle, 1998) and a further KwaZulu-Natal study (39.1%) (van Stuijvenberg *et al* ,1997), both undertaken in 1995 (Table 4.6). However, another study undertaken in a rural area of Western Cape reported a low prevalence (1.8%) of vitamin A deficiency for 6 – 12 year old children (van Stuijvenberg *et al*, 1997). Overall, the trend suggests a persistence of marginal vitamin A deficiency among South African children. In pre-school children vitamin A supplementation has significantly reduced mortality and morbidity, while the World Bank (1993) has suggested this form of supplementation as one of the most cost-effective health strategies available. Vitamin A deficiency may be associated with a decrease in cellular immunity, an increasing prevalence of infection and an increased mortality rate (Filteau *et al*, 1994). Marginal vitamin A status as found in this study may reduce resistance to infection, and may increase the severity of infections - with negative impacts on school attendance and scholastic achievement. It was also found here to be significantly associated with both stunting and wasting. This fact, along with the approximately one-third prevalence of marginal vitamin A deficiency observed in this study, and the levels seen in the other studies, suggests that it remains a significant public health problem for South Africa. The low vitamin A status may be due to dietary factors. Hence, targeted micronutrient supplementation is likely to benefit the school-aged group.

The low prevalence of anaemia, 16.5%, as defined by a haemoglobin level below 12g/dl, observed in this study is in contrast with other South African studies (Table 4.6) which found prevalences of anaemia ranging from 28.5% to 30.0% respectively, among African children aged 6-14 years. This level of anaemia was significantly associated with a reduced serum ferritin (<12 ng/ml) and a reduced serum retinol (<20 μg/dl). The low prevalence of anaemia is consistent with low levels of malnutrition and moderate levels of parasitaemia found in this study. The prevalence of iron depletion as measured by serum ferritin below 12 ng/ml was low - 6.8%. However, as measured at less than 20 ng/ml, the prevalence was 28.1%. These levels of iron depletion were lower than those found among pre-school and school going South African children (SAVACG, 1995) (Table 4.6). Many factors influence iron depletion in situations of infection, inflammation and malignancy, and therefore ferritin is not a good index of iron stores. This may well be the case in this study, even with low levels of anaemia, because of the moderate levels of parasitaemia as well as other undiagnosed infections. Iron deficiency anaemia is not likely to be a problem among these children since both anaemia and reduced serum ferritin did not coexist in this study.

4.4.3 Parasitic infections

The prevalence of helminth infections in this study - as measured by roundworm (27.3%), whipworm (53.9%) and urinary bilharzia (24.5%) - was lower than previously reported in South Africa; as is the case for multiple parasite infections (Schutte *et al*, 1981, 1995). The light intensity of the majority of infections in this study is consistent with the lower levels of under-nutrition and micronutrient deficiency, for which parasites are an important contributor. The WHO (1995) policy of universal deworming, when total prevalence of helminthic infections exceed 50%, suggests that this may be an important intervention in this community.

4.5 Conclusion

The relevance of current nutritional intervention programmes in the context of moderate levels of deficiency and the balance between universal and targeted nutritional interventions for a middle income country such as South Africa raises important policy questions about the relationship between economic and social developmental interventions to improve health status. Combining micronutrient supplementation and deworming, as proposed for the RCT phase, is likely to produce significant health and educational gains. The study emphasised the need to improve school-based health promotion and PHC interventions among school-aged children.

Chapter 5: A randomised controlled trial (RCT) of the effect of anthelminthic treatment and micronutrient fortification on health status and school performance of rural primary school children

5.1 Introduction

In Chapter 1 it was noted that the precise pathways of the associations between helminthic infection and micronutrient deficiencies and its impact on intellectual and health impairment during childhood (Dalman 1990; Beaton *et al*, 1992; Bundy & Del Rosso 1993) are not well understood (Pollit 1990; Warren *et al,* 1993; UNICEF 1997). It was further noted that the South African government was fully committed to overcoming the legacy of apartheid and its negative impact on the health of children, and had instituted a number of health programmes to reduce malnutrition and parasite infestations. The purpose of this RCT was to determine the extent to which anthelminthic treatment alone or anthelminthic treatment combined with micronutrient fortification improves nutritional status and school performance in rural primary school children in South Africa. The primary outcomes of the study were the impact of deworming and micronutrient fortification on nutritional status and performance in scholastic and cognitive tests.

Previous baseline studies in South Africa (Chapter 4) have demonstrated that African children suffer from significant public health problems of micronutrient deficiencies (including vitamin A and iron), parasite infections and stunting (Jinabhai *et al,* 1999; Van Stuijvenberg *et al,* 1999). Therefore, it was important to examine the additive or synergistic impact of both micronutrient fortification and deworming on health status. Traditional global control programme strategies are based on single interventions (Beaton *et al*, 1992; UN ACN 1997; UNICEF 1997) and are not normally sensitive to the synergistic effects of other factors. The potentiating and inhibitory ability of such multiple health interventions to achieve maximum impact on the primary outcomes are poorly understood and often neglected (UN ACN 1997). The therapeutic efficacy under local conditions of interventions such as vitamin A supplementation and deworming, as part of a basic and integrated package of health services (World Bank 1993), and their incorporation into supplementary feeding programmes, requires further investigation (UN ACN 1997). In many middle-income and developing countries (including South Africa), children suffer from multiple health problems prompting governments and international agencies to implement integrated health and development programmes (World Bank 1993; Health Systems Trust 1997). The South African government has initiated a national Primary School Nutrition Programme (PSNP), to improve nutritional status and educability of school children (Health Systems Trust 1997). Measuring both sets of outcomes (health and scholastic status) could provide a framework for assessing the possible impact and sustainability of such health and development programmes.

5.2 Methods

The detailed methods have been summarized in Chapter 3 and are described here. A community-based, double-blind randomized placebo controlled trial was undertaken over four months in 1995. Eleven schools were randomly selected from a list of all 72 government primary schools in the Vulamehlo Magisterial District in rural KwaZulu-Natal (giving an approximate sampling rate of 15%). All the grade 3 pupils between 8 and 10 years of age in these schools were chosen for inclusion into the study. Grade 3 pupils were chosen as they had the benefit of at least two years of schooling to enable measurement of concentration and learning skills, and were more likely to benefit from a feeding programme (Richter *et al*, 1994). Beyond 10 years, pubertal change impacts on growth and cognitive functions and increases the proportion of confounding factors (Rauh 1996).

The calculation of the sample size has been described in chapter three. A statistical formula was applied to establish the sample size to ensure 95% power at the 5% significance level, and to allow for a drop out of 25% in the calculation to detect a statistically significant result. This calculation provided approximately 800 children as our estimated overall sample size. Based on the stratified sampling approach used in the study, a total of 579 school children with pre- and post-intervention data sets were eventually available for analysis. The analysis was based on an intention to treat.

5.2.1 Study groups and interventions

The intervention consisted of micronutrient supplementation in the form of two fortified biscuits given daily during the study period. A single dose of albendazole (400 mg) for geohelminths, and praziquantel (40 mg/kg) for schistosomiasis, or of placebo, was given once at the beginning of the study. Two women fieldworkers per school, selected by the school principal from the local community, were trained to distribute and monitor the consumption of each biscuit on a daily basis. The researchers undertook weekly checks to monitor the distribution and adherence to protocol. The women completed a weekly register of every child in the class; noted absent children and the reasons for absenteeism; the number of biscuits provided; and any side effects, complaints or other problems. All the pupils in grade 3 who did not satisfy the study criteria received non-fortified biscuits to reduce any feelings of discrimination and the possibility of exchange of biscuits amongst the pupils.

The subjects were randomly allocated into the following six study groups, with each child receiving 2 x 20g biscuits daily (the groups were homogeneous in respect of age and sex):

Group 1: Deworming, biscuit fortified with a combination of micronutrients vitamin A and iron) and other nutrients (defined below).

Group 2: Deworming, biscuit fortified with vitamin A.

Group 3: Deworming, non-fortified biscuit (no micronutrients).

Group 4: No deworming, biscuit fortified with a combination of micronutrients (vitamin A and iron) and other nutrients.

Group 5: No deworming, biscuit fortified with vitamin A.

Group 6: No deworming, non-fortified biscuit (no micronutrients).

For groups 1 and 4, the two daily biscuits contained the following combination of nutrients and micronutrients: vitamin B (25% RDA - 0.25 mg); vitamin A (50% RDA – 350 μg); iron in the form of FeEDTA (50% RDA – 5 mg); calcium (25% RDA – 200 mg) and zinc (25% RDA -2.5 mg). For groups 2 and 5, the two daily biscuits supplied 100% (700 μg) RDA vitamin A to assess the impact of vitamin A fortification alone on the study's outcome measures.

5.2.2 Outcome measures.

The primary outcome measures were changes in micronutrient status (serum retinol, haemoglobin, haematocrit, serum ferritin, serum iron and percent transferrin saturation) and changes in scholastic and cognitive test scores. The secondary outcomes measures were changes in the prevalence and intensity of helminthic infections and nutritional status. Anthropometric status (weight, height, and knee heel length) was measured, and protein status was assessed in terms of serum albumin levels.

These were all assessed at baseline and 16 weeks post-intervention. All the children with helminthic infections, anaemia and other health problems at the end of the study were treated. The collection and analysis of blood, urine and stool samples was undertaken as described above.

5.4 Results

A total of 579 pupils were included in the study by the cluster sampling method used. The response rate for the different arms of the study varied due to practical field constraints (such as traditional beliefs about giving of body fluids and the difficulty of obtaining specimens from children). This influenced our ability to collect information from all the children for each parameter under study. This is reflected in the varying sample sizes observed in the following tables. At baseline, as previously reported in chapter 4, there were no differences in the primary and secondary outcome measures (anthropometric, micronutrient, scholastic and cognitive nor parasite status) in regard to gender (and age, due to the study inclusion criteria) (Jinabhai *et al,* 1998; Jinabhai *et al,* 1999). Furthermore, it was also established that there were no differences in these outcome measures, at baseline, with respect to the six arms of the study. This suggests that randomization to the control and intervention groups was effective. For these reasons the following analysis will not include age and gender breakdowns. The baseline characteristics of all study children are given in Table 5.1.

Table 5.1: **Measures of baseline anthropometric, micronutrient and cognitive status.**

	n	Mean	SD	95% CI
Anthropometric status				
Height (cm)	520	127.73	5.87	127.23-128.23
Weight (kg)	517	26.89	3.75	26.63-27.27
Knee Heel (cm)	418	40.14	2.31	39.92-40.36
	Percentage (number of children)			
Stunted [1] (%)	7.3% (38 of 520)			
Underweight[2] (%)	0.8% (4 of 517)			
Micronutrient status				
Anaemia (%)	15.5% (66 of 425)			
Subclinical vitamin A Deficiency (%)	34.4% (103 of 299)			
Cognition				
Raven CPM [3]	578	13.49	1.29	13.20-13.78

1. **Height-for-age z scores < - 2SDs of the NCHS**
2. **Weight –for-age z scores < -2SDs of the NCHS**
3. **Geometric means, SD.**

Over 7% of children were stunted and almost none were seen to be underweight (<-2 SDs of the National Center for Health Statistics (NCHS) reference median for height-for-age and weight-for age). Subclinical vitamin A deficiency (serum retinol <0.70 μmol/L) found in 34.7% of the children is considered to be a public health problem (UN ACN 1997). When this is considered over the six study groups (Table 5.5), no statistically significant difference was evident at either baseline or post-intervention between the groups. When considering within group variation, the reduction observed in group 2 (the group dewormed with 100% RDA vitamin fortification), from 32.1% to 15.1% in subclinical vitamin A deficiency, approached statistical significance (P=0.067). The differences observed in the remaining five groups were not statistically significant. The average reduction in subclinical vitamin A deficiency over the study period was 5%. Anaemia (defined as haemoglobin < 120 g/L) was found in 15.5% of pupils and remained constant over the study period. These baseline parameters as well as cognition (Raven's CPM) did not vary significantly across any of the study groups considered later in this results section (P>0.40). For Raven's CPM the score in Table 5.1 was the total number of correct responses. When the participants' scores were converted to percentiles, using the normative data from the manual (Raven *et al,* 1990), they were found to be at the lower end of the scale (10th percentile). The Raven's CPM was not measured post-intervention since it was not expected to change during the short study period (Raven *et al,* 1990). However, it is presented since it is a known measure of the level of intellectual development.

Analysis of the changes in the mean values of the primary and secondary outcome measures before and after the intervention are examined namely: changes in parasite status (Table 5.2), micronutrient status (Table 5.3), cognitive and scholastic test scores (Table 5.4), and detailed changes in serum retinol status across the six arms of the study (Table 5.5). In these tables the differences between pre- and post-intervention and across the micronutrient intervention and deworming groups were analysed. A more detailed analysis was undertaken at baseline and no significant differences were observed ($P>0.20$) for any parameter with respect to micronutrient fortification, deworming and cognition (except for two cognition parameters GMT ($P=0.027$) and SDMT ($P=0.010$), which will be further discussed). There was no significant treatment effect on any of the anthropometric variables under study (height, weight, knee heel, height-for-age or weight-for-age) however, as expected statistically significant post-intervention gains were observed for height, weight and knee heel reflecting growth over the study period.

Table 5.2: **Changes in parasite prevalence and intensity: Number of pupils with helminth infections.**[8]

DEWORMED GROUP						
	Nil n %	Light n %	Moderate n %	Heavy n %	Prevalence (%)	P value
Ascaris lumbricoides						
Pre	116 (71.2)	23 (14.1)	17 (10.4)	7 (4.3)	28.8	<0.0005
Post	182 (93.3)	6 (3.1)	5 (2.6)	2 (1.0)	6.7	
Trichuris trichiura						
Pre	75 (46.3)	68 (42.0)	18 (11.1)	1 (0.6)	53.7	0.013
Post	117 (60.0)	69 (35.4)	8 (4.1)	1 (0.5)	40.0	
Hookworm						
Pre	155 (96.9)	4 (2.5)	1 (0.6)	0 -	3.1	0.018#
Post	195 (100)	0 -	0 -	0 -	0	
Schistosoma haematobium						
Pre	166 (75.5)	29 (13.2)	23 (10.4)	2 (0.9)	24.5	<0.0005
Post	159 (95.8)	6 (3.6)	1 (0.6)	0 -	4.2	
NON-DEWORMED GROUP						
	Nil n %	Light n %	Moderate n %	Heavy n %	Prevalence (%)	P value
Ascaris lumbricoides						
Pre	131 (73.6)	22 (12.4)	18 (10.1)	7 (3.9)	26.4	0.32
Post	150 (68.5)	36 (16.4)	27 (12.3)	6 (2.7)	31.5	

NON-DEWORMED GROUP						
	Nil n %	Light n %	Moderate n %	Heavy n %	Prevalence (%)	P value
Trichuris trichiura						
Pre	81 (45.5)	77 (43.3)	20 (11.2)	0 -	54.5	0.96
Post	98 (44.7)	104 (47.5)	15 (6.8)	2 (0.9)	55.2	
Hookworm						
Pre	167 (96.5)	5 (2.9)	1 (0.6)	0 -	3.5	0.90
Post	213 (96.8)	5 (2.3)	2 (0.9)	0 -	3.2	
Schistosoma haematobium						
Pre	178 (75.4)	35 (14.8)	23 (9.8)	0 -	24.6	0.93
Post	136 (75.6)	17 (9.4)	22 (12.2)	5 (2.8)	24.4	

**Fisher's exact test used.**

***** **All children with pre and post stools results were examined.**

5.4.1 Anthelminthic treatment

A comparison of the parasite prevalences amongst the non dewormed and dewormed groups of children indicates little difference, confirming that the randomisation was effective in evenly distributing children to both of these arms of the study (Table 5.2). When comparing the dewormed and non-dewormed groups, this analysis found that there was no significant treatment effect of deworming on the primary outcome measures of micronutrient, scholastic and cognitive status ($P>0.40$). With respect to the secondary outcome measures, in the dewormed group anthelminthic treatment produced a significant decrease in the prevalence of *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm and *Schistosoma haematobium* ($P<0.0005$, $P=0.013$, $P=0.018$ and $P<0.0005$ respectively) while the non-dewormed groups showed no significant changes in parasite prevalence across the intervention period (Table 5.2). A further post-hoc analysis of the effect of deworming on children who were parasite positive at baseline also found no significant effects of deworming at the group level ($P>0.10$). From Table 5.2 it is clear that parasite infections in this study constitute a public health problem; with *Trichuris trichiura* alone having pre-intervention prevalence levels in excess of 50% - the level recommended by the World Health Organization (WHO) for treatment of helminth infections (WHO 1998).

Table 5.3: Changes in micronutrient status for the three micronutrient intervention groups.

	VITAMIN A + IRON GROUP				VITAMIN A GROUP				NON-FORTIFIED GROUP				
	n	Mean	SD	95%CI	n	mean	SD	95%CI	n	mean	SD	95%CI	P value#
Serum Retinol (μmol/L)													
Pre	95	0.83	10.70	0.75- 0.90	94	0.84	10.14	0.77 - 0.91	110	0.85	10.66	0.78 - 0.92	0.91
Post	96	0.89	11.42	0.81- 0.97	93	0.94	8.64	0.87 - 1.00	113	0.82	10.62	0.75 - 0.90	0.056
Change	95	0.06*	8.33	0.002- 0.12	92	0.10*	8.44	0.04 - 0.16	110	-0.04	10.77	(-0.11) - 0.03	0.009
Haemoglobin (g/L)													
Pre	139	128.97	1.23	126.91-131.03	140	127.70	0.94	126.12 -129.28	146	128.09	1.10	126.28 -129.90	0.61
Post	125	129.24	0.91	127.63-130.85	124	128.32	0.87	126.78 -129.86	131	129.18	0.78	127.84 -130.52	0.63
Change	123	-0.07	1.16	(-2.14)- 2.00	121	0.94	0.79	(-0.48) - 2.36	128	0.68	0.91	(-0.91) - 2.30	0.69
Haematocrit													
(%)	139	37.74	1.09	37.20-38.29	140	37.18	1.08	36.71-37.65	146	37.49	1.11	36.86-38.14	0.37
Pre	125	36.39	1.07	35.93-36.85	124	36.20	1.07	35.76-36.65	131	36.39	1.06	36.02-36.77	0.77
Post	123	-1.48*	3.26	(-2.06)-(-0.90)	121	-0.94*	2.44	(-1.38)-(-0.51)	128	-1.42*	4.11	(-2.14)-(-0.70)	0.40
Change													

	VITAMIN A + IRON GROUP				VITAMIN A GROUP				NON-FORTIFIED GROUP				P value#
	n	Mean	SD	95%CI	n	mean	SD	95%CI	n	mean	SD	95%CI	
Serum Ferritin (μg/L)													
Pre	48	29.04	1.70	24.87 - 33.90	64	25.75	1.77	22.32 - 29.72	65	26.63	1.58	23.78-29.81	0.47
Post	55	31.54	1.73	27.17 - 36.60	55	25.73	1.73	22.19 - 29.84	53	25.01	1.68	21.66-28.87	0.053
Change	39	1.61	19.45	(-4.69) - 7.92	44	-5.14	23.83	(-12.38) - 2.11	45	-0.67	9.07	(-2.79)- 2.66	0.22
Serum Iron (μmol/L)													
Pre	144	12.42	6.66	11.32 -13.52	153	12.06	5.76	11.14 - 12.98	171	13.14	5.52	12.30 -13.97	0.25
Post	128	13.27	5.39	12.32 - 14.21	133	11.57	4.40	10.82 - 12.33	149	13.09	5.16	12.35 -13.92	0.010
Change	126	1.14	7.24	(-0.13) - 2.42	131	-0.78	6.78	(-1.95) - 0.39	148	-0.17	6.73	(-1.27) - 0.92	0.076
Transferrin Saturation (%)													
Pre	143	16.29	9.46	14.73 - 17.85	153	15.58	7.60	14.37 - 16.80	171	17.08	7.49	15.95-18.21	0.26
Post	128	17.76	7.42	16.47 - 19.06	133	15.07	6.06	14.03 - 16.11	149	17.36	7.11	16.02-18.51	0.003
Change	125	1.89	8.85	0.32 - 3.45	131	-0.88	8.73	(-2.39) - 0.63	148	0.02	9.19	(-1.47)- 1.51	0.042

	VITAMIN A + IRON GROUP				VITAMIN A GROUP				NON-FORTIFIED GROUP				P value#
	n	Mean	SD	95%CI	n	mean	SD	95%CI	n	mean	SD	95%CI	
Albumin (g/L)													
Pre	145	46.19	4.56	45.44-46.94	153	46.40	4.24	45.73 - 47.08	172	46.32	3.63	45.77 - 46.87	0.91
Post	124	44.52	3.97	43.81-45.22	126	45.49	3.84	44.81 - 46.17	143	44.89	3.44	44.33 - 45.46	0.11
Change	124	- 1.64*	5.48	(-2.62)-(-0.67)	125	-0.98*	4.94	(-1.85)-(-0.10)	143	-1.61*	4.25	(-2.31)-(-0.90)	0.47

* Significance at P<0.05

\# P value from one-way ANOVA.

5.4.2 Changes in micronutrient status

Comparison of the three micronutrient intervention groups with regard to serum retinol found that while at baseline all the children had similar serum retinol values (P=0.91), at post-intervention both of the vitamin A fortified groups had higher observed mean levels than the non-fortified group (P=0.056). The changes measured pre- and post-intervention were calculated – not as simple arithmetic differences - but based on the actual differences in the means of all the children in the respective groups. This is the reason for the variations in the values for the change (delta).

For the two fortified groups there was also a significant increase across the intervention period, which was not observed for the non-fortified group (P<0.05) (Table 5.3). The group fortified with 100% RDA vitamin A also showed a greater increase in serum retinol when compared to the two other groups (P=0.009).

For the following: haemoglobin; haematocrit; serum ferritin; serum iron; percent transferrin saturation; and albumin, at baseline there were no significant differences between the pupils in the three different micronutrient intervention groups (Table 5.3). For haemoglobin no significant differences were found post-intervention or across the three intervention groups (i.e. no treatment effect). The majority of children had haemoglobin levels within the normal range. Similarly, for haematocrit there were no differences post-intervention in mean haematocrit between the three groups (P=0.77). However, there was a significant decrease in haematocrit across the intervention period for each of the three micronutrient intervention groups (P<0.05), including the group receiving iron fortification (a similar decline post-intervention was observed for albumin) (Table 5.3).

The post-intervention serum ferritin level for the group receiving both vitamin A and iron fortification was higher than that measured in the other groups (P=0.053). There was no significant change in serum ferritin levels over the intervention period for any of the groups (Table 5.3). The mean post-intervention serum iron level in the group receiving 100% RDA vitamin A fortification was significantly lower (P=0.01) than the other groups. The group receiving vitamin A and iron fortification showed an increase in serum iron over the intervention period, whereas the other two groups showed a decrease - this was of borderline statistical significance (P=0.076). For transferrin saturation post-intervention the mean value in the 100% RDA vitamin A fortified group was lower than that observed in the other two groups (P=0.003). The group receiving vitamin A and iron fortification showed a clear increase in transferrin saturation, both singularly and when compared to the other two groups seen in Table 5.3 (P<0.05).

Table 5.4: Changes in cognitive & scholastic status for different micronutrient intervention groups

	VITAMIN A + IRON GROUP				VITAMIN A GROUP				NON-FORTIFIED GROUP				P value#
	N	mean	SD	95%CI	n	mean	SD	95%CI	n	mean	SD	95%CI	
RAVLT													
Pre	173	25.91	6.75	24.90-26.92	182	26.95	7.00	25.93-27.97	185	26.18	7.01	25.17-27.20	0.34
Post	166	35.61	7.85	34.40-36.81	176	36.47	7.97	35.28-37.66	185	35.89	6.67	34.92-36.85	0.55
Change	160	9.86*	7.22	8.73-10.99	169	9.56*	6.89	8.51-10.60	171	9.95*	6.71	8.93-10.96	0.86
GMT													
Pre	184	28.18	8.02	27.01-29.34	192	30.23	6.21	29.34-31.11	202	29.37	7.82	28.29-30.46	0.027
Post	170	32.52	7.47	31.39-33.65	178	33.69	7.42	32.59-34.79	186	33.48	7.96	32.33-34.63	0.32
Change	170	4.21*	5.00	3.45- 4.96	178	3.47*	5.46	2.66- 4.27	186	3.92*	5.37	3.15- 4.70	0.42
SDMT													
Pre	184	15.37	6.62	14.41-16.33	192	16.60	6.79	15.63-17.56	202	14.69	5.52	13.92-15.45	0.010
Post	169	20.09	8.66	18.77-21.40	178	21.53	6.76	20.53-22.53	187	20.89	7.16	19.86-21.93	0.21
Change	169	4.57*	8.17	3.33- 5.81	178	4.81*	7.34	3.72- 5.89	187	6.22*	6.98	5.22- 7.23	0.077

* **Significance at $P<0.05$**

\# **P value from one-way ANOVA.**

RAVLT – Reys Auditory Visual Learning Test

GMT – Group Mathematics Test

SDMT – Symbol Digit Modalities Test

5.4.3 Changes in scholastic and cognitive status

Changes in this primary outcome measure were analysed across the three micronutrient intervention groups and across the dewormed and non-dewormed groups. As mentioned previously, there were little differences in the baseline test scores with respect to both the three micronutrient interventions and the two deworming and non-deworming arms of the study. The overall baseline mean score for RAVLT of 26.35, measuring the sum of correct responses over five consecutive learning trials, is lower than that reported by MacPherson (1991). Similarly, the mean baseline SDMT score of 15.03 was lower than the norms provided by Smith (1982) and a South African study (Andersen 1994). The GMT scores for children between 8-10 years of age were converted to a mathematics quotient (MQ), as described in the manual, to provide a MQ of 78 which falls within the normal range: between 60 -100 (Young 1980).

As shown in Table 5.4, while there were significant gains in the test scores before and after the interventions, there were no significant treatment effects on these scholastic and cognitive scores across the three intervention groups (Table 5. 4). This analysis was repeated for the dewormed and non-dewormed groups and, as mentioned earlier, there were no significant treatment effects (data not presented). Thus neither the micronutrient nor the deworming interventions demonstrated any significant treatment effects across the six arms of the study.

Table 5.5: Changes in Serum Retinol (μmol/L) status by the six intervention groups.

	N	Mean	SD	95%CI	Subclinical vitamin A deficiency (%)#
Group 1: Deworming, biscuit fortified with combination of micronutrients					
Pre	41	0.85	10.17	0.73-0.96	31.7
Post	42	0.92	9.99	0.87-1.02	26.2
Change	41	0.07	7.36	(-0.01)-0.15	5.5
Group 2: Deworming, biscuit fortified with vitamin A					
Pre	53	0.84	10.44	0.74-0.94	32.1
Post	53	0.95	8.16	0.87-1.03	15.1
Change	52	0.11*	8.37	0.03-0.19	17.0
Group 3: Deworming, unfortified biscuit					
Pre	43	0.89	12.27	0.76-1.02	37.2
Post	44	0.77	9.02	0.50-0.86	31.8
Change	43	-0.13*	10.35	(-0.24)-(-0.02)	5.4
Group 4: No deworming, biscuit fortified with combination of micronutrients					
Pre	54	0.82	11.16	0.71-0.92	37.0
Post	54	0.87	12.48	0.75-0.99	37.0
Change	54	0.05	9.06	(-0.01)-0.14	0
Group 5: No deworming, biscuit fortified with vitamin A					
Pre	41	0.84	9.87	0.73-0.95	34.1
Post	40	0.92	9.33	0.82-1.03	25.0
Change	40	0.09	8.62	(-0.01)-0.18	9.1
Group 6: No deworming, unfortified biscuit					
Pre	67	0.83	9.52	0.75-0.91	34.3
Post	69	0.85	11.50	0.75-0.95	39.1
Change	67	0.02	10.77	(-0.07)-0.11	-4.8
Overall					
Pre	299	0.84	10.48	0.80-0.88	34.4
Post	302	0.88	10.39	0.84-0.92	29.8
Change	297	0.04	9.46	(-0.001)-0.07	4.6

* Significance at $P<0.05$

\# Defined as serum retinol <0.70μmol/L

5.4.4 Treatment effects of micronutrient intervention groups.

The clear treatment effect observed in this study with regard to serum retinol is shown in Table 5.3. This effect is considered in further detail in Table 5.5, where serum retinol is examined in each arm of the clinical trial (Groups 1-6). At baseline when Duncan's multiple range test was applied, no two groups were significantly different from each other ($P>0.10$). Post-intervention Group 2, the group dewormed and fortified with 100% RDA vitamin A, was significantly different from the other groups ($P<0.05$), with the highest mean serum retinol level - suggesting an additive effect between vitamin A fortification in combination with deworming (Table 5.5). Further analysis of the changes in serum retinol across all six intervention groups found that only Group 3 (deworming and no micronutrient fortification) was significantly different from the other groups ($P<0.05$), where a decline in serum retinol level over the 16-week intervention was observed. An overall general ANOVA test produced a statistically significant result over these six groups ($P<0.01$). When the other study variables measuring micronutrient status (haemoglobin, haematocrit, serum ferritin and serum iron) were analysed, no two groups at any stage of the study were seen to be significantly different from each other. However, transferrin saturation did show a limited treatment effect, with its levels increasing over the intervention period in Groups 1&4 (the groups fortified with 50% RDA vitamin A, iron and other nutrients), decreasing in Groups 2&5 (the groups fortified with 100% RDA vitamin A), and showing no change in Groups 3&6 ($P<0.05$).

Analysis of the primary and secondary outcome variables in a factorial ANOVA showed that only the treatment effect upon serum retinol reached statistical significance ($P<0.05$).

5.5 Discussion

This clinical trial has sought to establish the impact of micronutrient fortification with vitamin A, iron and anthelminthic treatment on a set of primary and secondary outcome measures amongst school children, with a view to informing the planning and implementation of nutritional supplementation and deworming programmes. It has shown that the additive combination of vitamin A and iron fortification produced significant treatment effects – although when the interventions of vitamin A, iron, and anthelminthic treatment were considered - the impact was uneven and a mixed pattern of results emerged. This study confirms that the public health problems of subclinical vitamin A deficiency, parasite infections and stunting identified amongst South African pre-school children continues to persist amongst school-aged children (SAVACG 1995, WHO, 1998).

Major challenges have been identified for public health and nutrition programmes for the next decade (World Bank 1993; Ross 1998). These include the need to develop effective intervention programmes, establish the additional benefits of vitamin A fortification amongst school-aged children, and to explore the potential contribution of vitamin A supplementation in reducing progression to symptomatic AIDS (Ross 1998). The specific context for this study was amongst rural school children with vitamin A deficiency (at a level that constitutes a public health problem); seen together with stunting, parasitic infections, anaemia, and an escalating prevalence of HIV amongst adolescents (Department of Health 1999). The limitations of food-based dietary interventions to reduce vitamin A deficiency emphasize the importance of determining the effectiveness of supplementation programmes (Ross 1998).

In this study there was a clear treatment effect when providing a biscuit fortified with vitamin A on one of the primary outcome measures, namely serum retinol levels of rural primary school children. However, the changes observed in the serum retinol levels of children receiving 50% RDA vitamin A and iron fortification were not significantly different from those receiving 100% RDA vitamin A; although the latter showed a slightly greater increase in serum retinol. The non-fortified group showed a decrease in serum retinol. The detailed analysis of the impact on serum retinol across all six intervention groups revealed significant changes in the vitamin A status of the children given vitamin A fortification, who had been dewormed (Groups 1, 2), compared to groups that were not dewormed (Groups 4, 5). This suggests that vitamin A combined with deworming may have a greater impact than vitamin A fortification on its own. The substantial reduction in the prevalence of subclinical vitamin A deficiency in the fortified and dewormed group has important clinical significance. The overall changes across all six groups are significant. While other studies have reported similar findings regarding vitamin A supplementation, our study further explored the treatment effects of combining iron fortification and deworming with vitamin A fortification (van Stuijvenburg *et al,* 1999).

The lack of change in haemoglobin status, either post-intervention or between-group treatment effect, may be due to the low prevalence of anaemia at baseline. South

African studies have shown that the mean haemoglobin of children is highly variable (Jinabhai *et al,* 1999; Van Stuijvenberg *et al,* 1999), while in other parts of Africa (for example, Zanzibar) the prevalence of anaemia remains high (Stolzfus *et al,* 1997). The significant decrease in haematocrit in all groups in our study after intervention was unusual and has been reported previously (Van Stuijvenberg *et al,* 1999). Since the decline was observed over all arms of our study, it is likely to be due to external factors - which may include the effects of malnutrition or perhaps haemodilution during the study period. A similar decrease was also observed for albumin.

Concerning the indicators of iron status, there was a marginal treatment effect on transferrin saturation in the vitamin A and iron fortification group, suggesting increased uptake of iron and the benefits of iron fortification. This is supported by the post-intervention gains in serum iron and serum ferritin, in the vitamin A and iron fortified groups only, in comparison with the groups receiving only vitamin A or no fortification. The lack of a treatment effect on serum iron and serum ferritin may suggest that their levels were not low enough at baseline to have an impact, and that there was no potentiating effect of vitamin A supplementation in this study. Other studies have demonstrated that vitamin A fortification improves serum retinol, serum ferritin, serum iron and transferrin saturation amongst children (Bloem *et al,* 1990; Van Stuijvenberg *et al,* 1999).

With respect to the other primary outcome measure, there was no clear difference observed in micronutrient status or cognitive and scholastic scores between the dewormed and non-dewormed groups. A possible reason for this lack of treatment effect was that only half the children had parasite infections at baseline, and the study design did not allow for the randomization of children with and without parasites to the six main intervention groups. The negative results obtained in the post-hoc analysis of children with parasites at baseline suggest that short-term treatment (4 months) is unlikely to improve anthropometric and micronutrient status. However, anthelminthic treatment significantly reduced parasite prevalence amongst the dewormed children. The reduction of post-intervention prevalence of *Trichuris* infection, to 40%, was less than the decline in prevalence for the other parasites. This confirms the findings of other studies that albendazole is less effective against *Trichuris* infection (Albonico *et al,* 1994).

Several studies have reported that anthelminthic treatment has had varying effects on children's anthropometry, micronutrient status and mental performance (Stephenson *et al,* 1989; Thein- Hlaing *et al,* 1991; Bundy *et al,* 1992; Hall 1993; Ekanem *et al,* 1994; Rousham *et al,* 1994; Watkins & Pollitt 1997; Stolzfus *et al,* 1998). Kenyan and Burmese studies found that deworming of children significantly improved growth (Stephenson *et al,* 1989; Thein- Hlaing *et al,* 1991), but studies in Bangladesh and Nigeria failed to report similar improvements (Ekanem *et al,* 1994; Rousham *et al,* 1994). Deworming has had a similar, inconclusive impact on micronutrient status. In Zanzibar deworming had no significant impact in reducing the prevalence of anaemia and serum ferritin, despite the high prevalence of anaemia (Stolzfus *et al,* 1998). A review of the impact of deworming on mental performance found that treatment of intestinal helminthic infections has had mixed results (Watkins & Pollitt 1997). Possible reasons suggested for these equivocal results, regarding the impact of deworming on children's health and cognitive status, have included biological, nutritional and epidemiological considerations (Hall 1993). Bundy *et al* (1992) have emphasized that the intensity of infection and the helminth species also influence health outcomes. In exploring the complex relationship between anthelminthic treatment and micronutrient supplementation and its impact on nutritional and health status, Stoltzfus *et al* (1997) found small improvements in the growth of children in a school-based deworming programme and concluded that effective anthelminthic programmes required additional dietary or disease control interventions. Donnen *et al* (1998) found that while vitamin A supplementation improved the growth of malnourished preschool children, deworming had no impact. The results from our study reflect this mixed picture and confirm that further studies are required to explore this relationship.

While previous studies have shown benefits in school achievements and cognitive tests resulting from deworming programs (Bundy & Del Rosso 1993; Watkins & Pollitt 1997), in rural Guatemala deworming amongst 7-12 year old children (even those with high parasite loads) failed to demonstrate an effect on school performance (Watkins *et al.* 1996). In the Guatemalan study albendazole was found to be successful in the treatment of *Ascaris* infection but was shown to be less effective against *Trichuris* – results similar to our findings.

The cognitive and scholastic test data indicate a significant increase in mental performance post-intervention. However, there were no significant treatment effects of micronutrient fortification or deworming on mental functioning. These findings require further analysis with particular reference to the validity of the test battery and its application under field conditions. The use of the new test battery may explain the significant differences seen at baseline across the micronutrient intervention groups with respect to the group mathematics test and the symbol digit modalities test - a difference not seen post-intervention. The significant post-intervention changes in the cognitive and scholastic test scores need to be interpreted with caution, since the reliability and validity of these as *grouped* tests have not previously been assessed. Traditionally they have been used at an individual level. Further development of this test battery as group tests is required to establish norms for rural African children before further interpretations can be undertaken. This set of results from a community-based study, involving rural African children, serves to stimulate debate about the development of standardised and reliable group tests for field conditions. Richter *et al* (1994) also note the complexity of measuring the effects of feeding on cognitive and scholastic performance, the limitations of the school terms on the study period and the methodological compromises associated in selecting a suitable test battery - especially when going from the laboratory conditions to the field (school) setting.

Finally, the duration of the interventions (4 months); moderate to low prevalence of micronutrient deficiencies and parasitic infections; and the fact that only 5mg elemental iron was given daily (rather than a higher dose as used by Buzina-Suoticanec *et al* 1998) may have masked the potential treatment effect of these interventions. However, this study supports the additive benefits of combining interventions. Such interventions allow targeting of disadvantaged groups through the implementation of primary school nutrition programmes. For these programmes to be cost effective, health planners need to identify the prevalence of micronutrient deficiencies (iron and vitamin A) and the prevalence and intensity of specific parasite species for population-based interventions.

5.6 Conclusions and Recommendations

In this study, although parasite prevalence and intensity were found to be moderate to low, deworming still significantly reduced overall parasite levels. Vitamin A fortification was seen to significantly improve serum retinol levels although iron supplementation at the dose provided was less effective. It is known that vitamin A fortification has the potential to reduce morbidity and mortality amongst children and to possibly reduce severity, transmission and progression of HIV infection (Beaton *et al,* 1992; Ross 1998). This is important in areas where HIV prevalence has reached epidemic proportions, such as in Central and Southern Africa, and suggests the potential benefits of school-based micronutrient interventions. Where parasites exist as a public health problem, deworming in combination with micronutrient fortification is likely to have a greater impact than single interventions. Although this study was of limited duration there is still a clear suggestion of an additive effect of vitamin A fortification and deworming, even in areas of moderate to low parasite prevalence. This supports the value of multiple interventions at school and community level.

Chapter 6: The prevalence of overweight and obesity and changes in body mass index (BMI): Implications for the nutritional transition amongst school children

6.1 Introduction

As child survival rates have improved, there has been a growing concern about the increases in overweight and obesity amongst both adults and children. Child obesity is associated with several risk factors for chronic diseases, including heart disease in later life (Cole T *et al*, 2000, WHO, 1998). Many middle-income and developing countries continue to face the double burden of infectious and poverty associated diseases, and now, the emerging concerns with chronic diseases. Thus, both from a public health perspective, and as a contribution to the processes of health systems reform, it is irnportant to monitor trends in child obesity (World Bank, 1993, NDOH, 1999). This nutritional transition facing developing and middle-income countries also has important implications for preventive strategies to control chronic degenerative diseases (Popkin B, 1994, WHO 1998, Monyeki KD, 1999). Obesity is a preventable condition and early signs of increasing prevalence offer opportunities to develop preventive and promotive strategies (Intemational Task Force on Obesity, WHO 1998). Cole *et al* (2000), while supporting the call for the monitoring of trends in child obesity because of its public health importance, have drawn attention to the difficulties in quantifying these trends and comparing them internationally.

Until recently, concerns have been expressed that the existing Body Mass Index (BMI) curves used widely in the UK, USA and other countries were not internationally representative centile curves (Cole T *et al*, 1995; de Onis M 1997). Prentice (1999) has explored the clinical and epidemiological applicability of body mass index - BMI (weight (kg)/ height (m)^2) as a measure of obesity amongst children, but has also noted the problems of choosing an appropriate reference population and defining centile cut-off for monitoring the levels of fatness amongst children. The WHO (1997) has also noted the flaws in the internationally used NCHS based growth curves and currently new international reference curves are being developed. WHO (1995), using the National Centre for Health Statistics (NCHS) data as the reference data, had recommended that the cut-off point for being at risk for overweight indicator be set at >= 85th centile for adolescents. Recognising that BMI was an inexact measure of total body fat, they had recommended that the "obesity" be limited to those who are at risk for overweight and have high levels of subcutaneous fat, even though they recognized that there was inadequate evidence of the universal applicability of these particular cut-offs.

As a result of these concerns the International Obesity Task Force (IOTF) in 1999 recommended that the adult cut-off points for BMI be used to develop internationally acceptable BMI centiles for children (Bellizzi MC, Dietz WH, 1999). Cole (2000) and his co-workers developed sex and age specific cut-off points for BMI for overweight and obesity in children using these adult cut-off points. They undertook an international survey of six large nationally representative cross sectional growth studies and developed age and sex specific centiles for children that, at age 18 years, passed through the internationally acceptable adult cut-offs for overweight and obesity. They have suggested that this method addresses the two main problems of defining internationally acceptable cut-off points for body mass index for overweight and obesity in children, namely the use of an internationally acceptable heterogeneous reference population and the definition of appropriate cut-off points (Cole, 2000). While they have recommended that these cut-off points be used in international comparisons of prevalence of overweight and obesity, they however note that the selected reference populations are not ideal and probably represent Western populations adequately, but not all parts of the world. In particular, they noted the lack of data from Africa and called for further research to study BMI patterns in children in Africa (Cole *et al*, 2000).

The South African population, especially during the post-apartheid period, has seen many changes including rapid urbanisation, with consequent changes in lifestyles and an increasing emphasis on western diets (Walker *et al,* 1997; May J 1998). These dietary influences are spreading to rural areas, contributing to the nutrition transition. While Popkin *et al* (1994) have estimated the prevalence of obesity amongst children in developing countries as being between 7 – 10%; Monyeki *et al* (1999) have noted the lack of data from African children.

There is an emerging pattern of both an epidemiological and demographic transition (Buso D, 1999). In responding to these challenges, the South African governments health policy has been radically re-orientated towards Primary Health Care (PHC) within a District Health System (DHS) (NDOH, 1999). Health sector reform in South

Africa, as in many other developing and middle-income countries, aims to provide equitable, cost-effective and appropriate health services (NDOH, 1999). Both processes – the epidemiological transition and the health sector reforms – need to be carefully managed so as to ensure that current and future services meet the health needs of all the people, and that the full spectrum of communicable and non-communicable disease (NCD) burdens are adequately addressed. To meet these challenges it is necessary to understand the possible trajectory of developing chronic diseases in later life amongst all sections of the populations. Investigating aspects of the nutritional transition in South Africa, with specific reference to the changing prevalence of overweight and obesity amongst children (as measured by increasing BMI), would contribute to our understanding of these complex processes. It would also offer important opportunities for developing preventive strategies to reduce overweight and obesity amongst children, and thereby ameliorate the burden of NCD.

The WHO Global Database on Child Growth and Malnutrition (1997) has identified the major objectives of nutritional surveillance as i) measuring nutritional status, ii) targeting populations and sub-groups, iii) evaluation of interventions, iv) monitoring secular trends, v) advocacy for nutritional policies and programmes, and vi) training and education of health professionals. Nutritional surveillance systems in South Africa are poorly developed and the assessment of overweight and obesity amongst children, together with the continuing monitoring of malnutrition trends, would be an additional component of such a nutritional surveillance system. This would contribute to meeting some of the objectives set by the WHO Global surveillance system.

The purpose of this study was to assess the prevalence of overweight and obesity in South African school children in order to understand the nature and magnitude of this particular aspect of the nutritional transition occurring in this country. The specific objectives were to obtain cross sectional anthropometric data from primary and secondary sources; extrapolate the calculated BMI values onto the IOTF recommended cut-off points for child overweight and obesity; and estimate the changes in prevalences over time amongst school children in South Africa (SA). Recommendations for the prevention and management of overweight and obesity, from a public health perspective, are considered for policy makers, communities and health planners.

6.2 Methods

As described in Chapter 3, a cross sectional anthropometric survey of rural children was undertaken in southern KwaZulu-Natal, one of nine provinces in South Africa. This community-based study targeted all the classes with Standard 1 (Grade 3) pupils between 8 - 10 years of age, selected from 11 schools by using random numbers - from the seventy two schools in Vulamehlo Health District - giving a total sample of 800 children. The details of the sampling frame selection of subjects and measurements have been described in detail in an earlier chapter and are summarised here. Secondary anthropometric data from two other cross sectional studies, the National Schools Survey (1994) and the KIDS (1998), were then used to provide a time series analysis of trends in BMI before and after the primary Vulamehlo study. This analysis of trends was then used to explore changes in nutritional status as one component of the nutritional transition.

6.2.1 Anthropometric measures.

The children's height (cm) was measured using a stadiometer. Each child, if wearing shoes, removed the shoes and, with heels touching the rear of the stadiometer and back and head against the stadiometer pole, had his/her height measured twice to the nearest mm and the average of two measures used. After removing sweaters, the child's weight (kg) was measured using a calibrated Masskot electronic scale and two measurements were recorded to ensure accuracy. Body mass index (BMI) were computed.

The measurements undertaken in Vulamehlo were compared with two other South African data sets: the South African National Schools' Survey (1994), including the provincial data for KwaZulu-Natal. The South African National Schools' Anthropometrical Survey (1994) was a national study undertaken by the Department of Health; the provincial data for KwaZulu-Natal derives from this survey. In February 1994 more than 3,300 schools representing all the Education Departments participated in this survey, which collected nutritional status data on 105 000 school beginners. Ten schools from each magisterial district throughout the country were chosen based on population representation, and stratified according to the proportion of the population in each district. The sample of children was drawn from school lists provided by each Education Department – at each school 40 children (20 each in the first and second grades and 10 males and 10 females) were selected. The birth date, weight and height of each child were measured by trained nurses. The final analysis included data in respect of 97 790 children – representing 4.9% of the estimated 2 million children in those grades in 1994. This was considered a representative sample of the total population.

The 1993 Project for Statistics in Living Standards and Development (PSLSD) provided the first comprehensive household database for South Africa. The households surveys in the PSLSD in KwaZulu–Natal were re-surveyed in the 1998 KwaZulu-Natal Income Dynamics Study (KIDS) (May *et al*, 2000). These were based on the households selected in the KwaZulu-Natal Anthropometrical Survey 1993 (which only measured children up to the age of 6 years) (May *et al*, 2000), part of the first national household survey to collect information on the socio-economic condition of households; and included weights and heights of children up to six years of age. A consortium of South African survey groups and universities used a two-stage self-weighting design with clusters chosen proportionally from census enumerator sub-districts, and a random sample of 1558 of all races was then selected. The 1993 sampling frame was representative of the entire province. The 1998 KIDS survey followed up on these previously selected households, but excluded 112 white and 53 coloured households and included only African and Indian households (n=1393). Of these, 222 (14.3%) were lost to follow-up in 1998 (May *et al,* 2000).

6.2.2 Methodological issues and definition of overweight and obesity

Considerable debate continues regarding the best reference population and growth curves to use for the definition and quantification of overweight and obesity. Cole *et al* (2000) have produced the most comprehensive and global data set from representative countries in the world, and have used this to develop BMI reference curves and cut-off points for establishing the prevalence of overweight and obesity based on the recommendations of the International Obesity Task Force (IOTF). The LMS method used by Cole *et al* (2000) has been previously described and their computerised models were applied to data sets to generate prevalences of overweight and obesity. They obtained data on BMI from six large nationally representative cross sectional surveys on growth from Brazil, the Netherlands, Singapore, Great Britain, Hong Kong and the United States. Notably absent were any data sets from Africa, since none of the existing data sets met their inclusion criteria. The adult BMI cut-off points for overweight at age 18 years, greater than 25 kg/m^2, and for obesity of 30 kg/m^2, were extrapolated to generate body mass index centiles for children and provide age and sex specific child cut-off points based on the adult cut-off points. As recommended by Cole *et al* (2000), and for the purposes of this study, the mid-year cut-off values were used to estimate the number of children above or below this value for each age and sex specific cohort, to provide a prevalence of overweight and obesity in our data sets. While the search for a truly representative reference population continues, our use of the IOTF reference curves and cut-off points adds to the process of contributing to this data set. This is one of the first studies to apply its reference population and cut-off points to data sets in KwaZulu-Natal and South Africa, using globally representative data to establish past and current trends for overweight and obesity amongst SA children.

However, the data analysis needs to be treated with caution for the following reasons: The anthropometric data were collected at different time points with varying levels of accuracy and training of the field workers and different cohorts of children. While nutritionists were involved in all the studies, the collated analysis would have similar problems as with any other meta-analysis. We have collected all the basic demographic and anthropometric data (age, gender, height and weight) from all the original sources and reviewed the data sets carefully, including comparison with the original sources and consultations with nutritionists and researchers involved in the studies, to ensure accuracy and consistency in the analysis.

A second related issue is the usefulness of cross-sectional and longitudinal studies. While repeated cross-sectional surveys on different samples at different points in time can be used to assess certain changes over time, they have less utility in measuring dynamic changes (May *et al*, 2000). For the purposes of this study, which is to assess the extent and nature of one component of the nutritional transition, they are useful in providing early signs or indicators of change in nutritional status. Ideally, these observations need to be confirmed by longitudinal studies – both to understand the deeper epidemiological and demographic factors influencing such changes - and to quantify the nature and magnitude of these changes.

6.3 Results

The prevalence of overweight and obesity amongst the children in the three studies is presented by age and gender for children in all the age cohorts, and then comparisons only of the children in the age cohort 8.0 to 10.9 years - the age cohort investigated in the primary Vulamehlo study site.

The demographic profile (age, sex distribution) of the children in the three studies - the National Schools Survey (1994) (including the KwaZulu-Natal sample), the Vulamehlo and the KIDS 1998 studies - are presented first (Tables 6.1, 6.4 and 6.7) and Fig. 3. The prevalence of overweight and obesity by all the age cohorts is then presented for the National and KwaZulu-Natal Schools (Table 6.2), Vulamehlo (Table 6.5) and the KIDS study (Table 6.8). The prevalence of overweight and obesity - distributed by sex - across all the studies, is shown in Table 6.3 (National and KwaZulu-Natal study), Table 6.4 (Vulamehlo) and KIDS 1998 (Table 6.9). The final analysis of the prevalence of overweight and obesity was then restricted only to children in the age cohort 8.0 to 10.9 years (Table 6.10, Fig. 2).

There was no clear pattern with regard to the age distribution of overweight and obesity in all the studies. However there was a consistent and marked trend for females demonstrating a higher prevalence of overweight and obesity across all the studies (Tables 6.4 and 6.7) with the exception of the KIDS 1998 study, which showed a slightly higher prevalence of obesity amongst males compared to females - - 3.3% against 2.9% - (Table 6.9 and 6.10).

The most important observation is the substantial increase in the prevalence of overweight and obesity over the time periods of these three cross sectional studies. With respect to overweight, the overall total prevalence in 1994, of 2.3% in the national sample and 2.8% in the KwaZulu-Natal sample of children, increased to 5.1% in the 1995 Vulamehlo study and to 19% in the KIDS 1998 study. Obesity prevalences increased from 0.4% in the national and 0.5% in the KwaZulu-Natal

1994 studies to 0.6% in the Vulamehlo study and to 6.2% in the KIDS 1998 study (Table 6.10 and Fig.4).

Table 6.1: Demographic Profile: National & KwaZulu-Natal Schools 1994 – Number and percent (%)

AGE (years)	NATIONAL			KWA-ZULU NATAL		
	SEX		TOTAL	SEX		TOTAL
	Males	Females		Males	Females	
4-4.9	334 (0.4)	411 (0.4)	745 (0.8)	72 (0.4)	49 (0.3)	121 (0.7)
5-5.9	4751 (5.2)	5400 (5.9)	10151(11.0)	944 (5.8)	1124(7.0)	2068(12.8)
6-6.9	13450(14.6)	14902(16.2)	28352(30.8)	2333(14.4)	2523(15.6)	4856(30.0)
7-7.9	14187(15.4)	14249(15.5)	28436(30.9)	2358(14.6)	2415(14.9)	4773(29.5)
8-8.9	8033(8.7)	6940(7.5)	14973(16.3)	1400 (8.7)	1257(7.8)	2657(16.4)
9-9.9	3874(4.2)	2934(3.2)	6808(7.4)	689(4.3)	527(3.3)	1216(7.5)
10-10.9	2037(2.2)	10(0.0)	2047(2.2)	365(2.3)	2(0.0)	367(2.3)
11-11.9	559(0.6)	4(0.0)	563(0.6)	102(0.6)	0	102(0.6)
TOTAL	47225(51.3)	44850(48.7)	92075(100)	8263(51.1)	7897(48.9)	16160(100)

There was an even distribution of males and females in the study samples, with over three quarters of the children between 6 – 9 years.

Table 6.2: Prevalence of Overweight and Obesity by Age- National & KwaZulu-Natal Schools Survey 1994 - Number and percent (%)

NATIONAL SCHOOLS						
AGE (years)	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
4-4.9	682(0.7)	63(0.1)	745(0.8)	730(0.8)	15(0.0)	745(0.8)
5-5.9	9509(10.3)	642(0.7)	10151(11.0)	9996(10.9)	155(0.2)	10151(11.0)
6-6.9	26831(29.1)	1521(1.7)	28352(30.8)	27996(30.4)	356(0.4)	28352(30.8)
7-7.9	26943(29.3)	1493(1.6)	28436(30.9)	28159(30.6)	277(0.3)	28436(30.9)
8-8.9	14534(15.8)	439(0.5)	14973(16.3)	14898(16.2)	75(0.1)	14973(16.3)
9-9.9	6711(7.3)	97(0.1)	6808(7.4)	6797(7.4)	11(0.0)	6808(7.4)
10-10.9	2034(2.2)	13(0.0)	2047(2.2)	2045(2.2)	2(0.0)	2047(2.2)
11-11.9	561(0.6)	2(0.0)	563(0.6)	562(0.6)	1(0.0)	563(0.6)
Total	87805(95.4)	4270(4.6)	92075(100)	91183(99.0)	892(1.0)	92075(100)

KWAZULU-NATAL SCHOOLS						
AGE (years)	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
4-4.9	106(0.7)	15(0.1)	121(0.8)	119(0.7)	2(0.0)	121(0.7)
5-5.9	1884(11.7)	184(1.1)	2068(12.8)	2030(12.6)	38(0.2)	2068(12.8)
6-6.9	4534(28.1)	322(2.0)	4856(30.1)	4786(29.6)	70(0.4)	4856(30.0)
7-7.9	4475(27.7)	298(1.8)	4773(29.5)	4713(29.2)	60(0.4)	4773(29.5)
8-8.9	2563(15.9)	94(0.6)	2657(16.4)	2636(16.3)	21(0.1)	2657(16.4)
9-9.9	1195(7.4)	21(0.1)	1216(7.5)	1216(7.5)	0.0	1216(7.5)
10-10.9	363(2.2)	4(0.0)	367(2.2)	366(2.3)	1(0.0)	367(2.3)
11-11.9	101(0.6)	1(0.0)	102(0.6)	102(0.6)	0.0	102(0.6)
TOTAL	15221(94.3)	939 (5.7)	16160(100)	15968(98.8)	192(1.2)	16160(100)

The prevalence of overweight and obesity ranged between 4.6% to 1.2%, respectively.

Table 6.3: Prevalence of Overweight and Obesity by Sex – KwaZulu-Natal and National Schools 1994-Number and percent (%)

NATIONAL SCHOOLS – ALL CHILDREN						
SEX	OVERWEIGHT		Total	OBESITY		Total
	Normal	Overweight		Normal	Obesity	
Males	45516(49.4)	1709(1.9)	47225(51.3)	46857(50.9)	368(0.4)	47225(51.3)
Females	42289(45.9)	2561(2.8)	44850(48.7)	44326(48.1)	524(0.6)	44850(48.7)
TOTAL	87805(95.4)	4270(4.6)	92075(100)	91183(99.0)	892(1.0)	92075(100)

NATIONAL SCHOOLS – ONLY CHILDREN 8.0 – 10.9 YEARS						
SEX	OVERWEIGHT		Total	OBESITY		Total
	Normal	Overweight		Normal	Obesity	
Males	13696(57.5)	248(1.0)	13944(58.5)	13907(58.3)	37(0.2)	13944(58.5)
Females	9583(40.2)	301(1.3)	9884(41.5)	9833(41.3)	51(0.2)	9884(41.5)
TOTAL	23279(97.7)	549(2.3)	23828(100)	23740(99.6)	88(0.4)	23828(100)

KWAZULU-NATAL SCHOOLS – ALL CHILDREN						
	Normal	Overweight	Total	Normal	Obesity	Total
Males	7900(48.9)	363(2.2)	8263(51.1)	8187(50.7)	76(0.5)	8263(51.2)
Females	7321(45.3)	576(3.6)	7897(48.9)	7781(48.1)	116(0.7)	7897(48.8)
TOTAL	15221(94.2)	99(5.8)	16160(100)	15968(98.8)	192(1.2)	16160(100)

KWAZULU-NATAL SCHOOLS – ONLY 8.0 – 10.9 YEAR OLD CHILDREN						
	Normal	Overweight	Total	Normal	Obesity	Total
Males	2405(56.7)	49(1.2)	2454(57.9)	2444(57.6)	10(0.2)	2454(7.9)
Females	1716(40.5)	70 (1.7)	1786(42.1)	1774(41.8)	12(03)	178642.1)
TOTAL	4121(97.2)	119(2.8)	4240(100)	4218(99.5)	22(0.5)	4240(100)

The prevalence of overweight and obesity in the age group 8.0 to 10.9 years in KwaZulu-Natal was higher than the national average.

Table 6.4: Demographic Profile: Age, sex distribution in Vulamehlo - Number and percent (%)

AGE (years)	SEX		TOTAL
	Male	Female	
8.0 – 8.9	114(16.0)	147(20.6)	261(36.7)
9.0 – 9.9	137(19.2)	158(22.2)	295(41.4)
10.0 – 10.9	75(10.5)	81(11.4)	156 (21.9)
TOTAL	326(45.8)	386(54.2)	712(100.0)

Table 6.5: Prevalence of overweight and obesity by age in Vulamehlo - Number and percent (%)

AGE (years)	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
8.0 – 8.9	216(4.1)	20(3.2)	236(37.2)	234(36.9)	2(0.3)	236(37.2)
9.0 – 9.9	248(39.1)	11(1.7)	259(40.9)	257(40.5)	2(0.3)	259(40.9)
10.0 – 10.9	137(21.6)	2(0.3)	139(21.9)	139(21.9)	0	139(21.9)
TOTAL	601(94.8)	33(5.2)	634(100)	630(99.4)	4(0.6)	634 (100)

Table 6.6: Prevalence of overweight and obesity by sex in Vulamehlo - Number and percent (%)*

SEX	OVERWEIGHT			OBESITY		
	Normal	Overweight	Total	Normal	Obesity	Total
Males	281(43.6)	8 (1.2)	289(44.8)	289(44.8)	0.0	289(44.8)
Females	331(51.3)	25(3.9)	356(55.2)	352(54.6)	4(0.6)	356(55.2)
TOTAL	612(94.9)	33 (5.1)	645(100.0)	641(99.4)	4(0.6)	645(100.0)

* All the children in the study did not provide anthropometric data – hence the variations in the sample sizes.

In comparison with the National Schools Study (1994), the prevalence of overweight in rural Vulamehlo (5.2%) was almost double; while the prevalence of obesity showed a slight increase (0.6%).

Fig. 3 Distribution of Sex amongst Children in the four studies

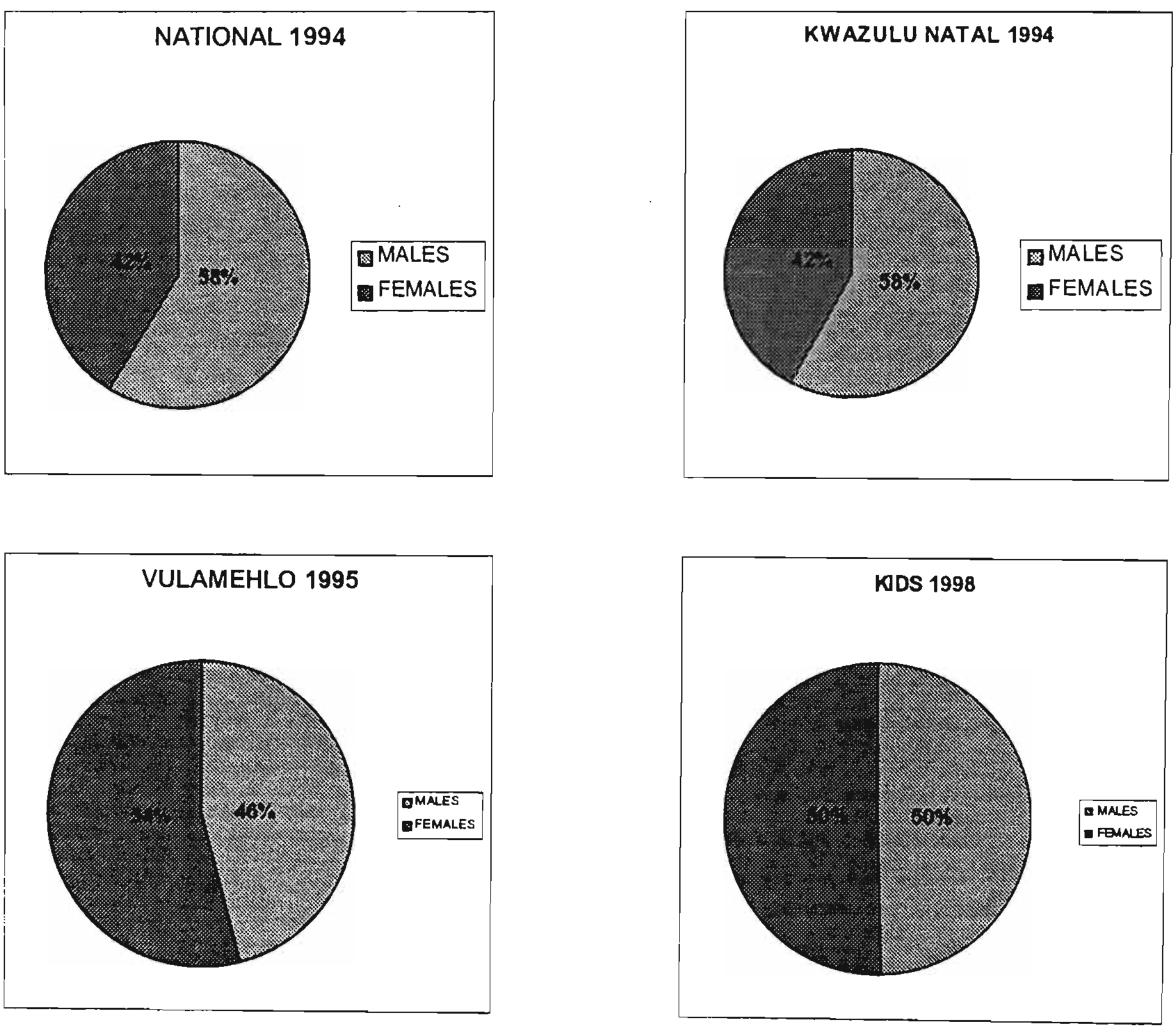


Table 6.7: Demographic profile - KIDS 1998 study- Number and percent (%)#

AGE	SEX		TOTAL
	Male	Female	
0-0.9	35 (1.9)	31 (1.7)	66 (3.6)
1-1.9	91 (4.9)	66 (3.6)	157 (8.5)
2-2.9	79 (4.3)	89 (4.8)	168 (9.1)
3-3.9	73 (3.9)	89 (4.8)	162 (8.8)
4-4.9	85 (4.6)	78 (4.2)	163 (8.8)
5-5.9	70 (3.8)	83 (4.5)	153 (8.3)
6-6.9	106 (5.7)	84 (4.5)	190 (10.3)
7-7.9	97 (5.2)	112 (6.1)	209 (11.3)
8-8.9	91(4.9)	102 (5.5)	193 (10.4)
9-9.9	81 (4.4)	84 (4.5)	165 (8.9)
10-10.9	83 (4.5)	74 (4.0)	157 (8.5)
11-11.9	28 (1.5)	39 (2.1)	67 (3.6)
TOTAL	919 (49.7)	931 (50.3)	1850 (100.0)

The children in the KIDS study included both the Black and Indian children.

There was an even sex distribution, while a quarter of the children were between 8-10 years.

Table 6.8: Prevalence of overweight and obesity by age - KIDS 1998 study

AGE (years)	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
2-2.9	105 (6.5)	63 (3.9)	168(10.3)	136 (8.4)	32 (2.0)	168 (10.3)
3-3.9	106 (6.5)	56 (3.4)	162 (10.0)	133 (8.2)	29 (1.8)	162 (10.0)
4-4.9	117 (7.2)	46 (2.8)	163 (10.0)	143 (8.8)	20 (1.2)	163 (10.0)
5-5.9	115 (7.1)	38 (2.3)	153 (9.4)	132 (8.1)	21 (1.3)	153 (9.4)
6-6.9	140 (8.6)	50 (3.1)	190 (11.7)	170 (10.4)	20 (1.2)	190 (11.7)
7-7.9	169 (10.4)	40 (2.5)	209 (12.8)	194 (11.9)	15 (0.9)	209 (12.8)
8-8.9	151 (9.3)	42 (2.6)	193 (11.9)	175 (10.8)	18 (1.1)	193 (11.9)
9-9.9	134 (8.2)	31 (1.9)	165 (10.1)	158 (9.7)	7 (0.4)	165 (10.1)
10-10.9	132 (8.1)	25 (1.5)	157 (9.6)	150 (9.2)	7 (0.4)	157 (9.6)
11-11.9	58 (3.6)	9 (0.6)	67 (4.1)	65 (4.0)	2 (0.1)	67 (4.1)
Total	1227(75.4)	400 (24.6)	1627(100)	1456 (89.5)	171 (10.5)	1627(100)

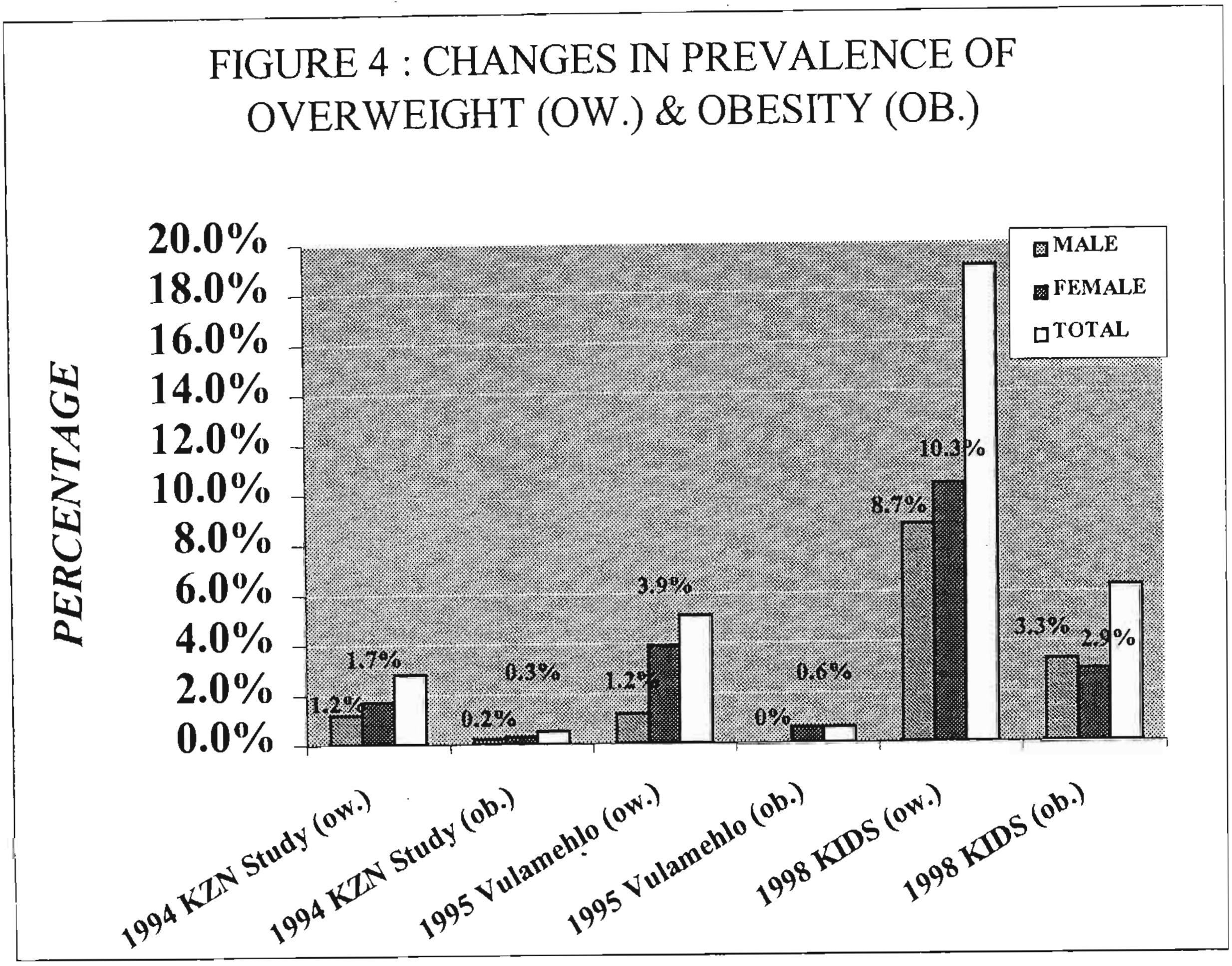
TABLE 6.9: Prevalence of Overweight and Obesity KIDS 1998 study No. & percent (%)

ALL CHILDREN IN STUDY						
	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
Male	606 (37.2)	187(11.5)	793(48.7)	714(43.9)	79(4.9)	793(48.7)
Female	621(38.2)	213(13.1)	834(51.3)	742(45.6)	92(5.7)	834(51.3)
Total	1227(75.4)	400(24.6)	1627(100)	1456(89.5)	171(10.5)	1627(100)
ONLY CHILDREN 8.0 – 10.9 YEARS						
	OVERWEIGHT		TOTAL	OBESITY		TOTAL
	Normal	Overweight		Normal	Obesity	
Male	210(40.8)	45(8.7)	255(49.5)	238(46.2)	17(3.3)	255(49.5)
Female	207(40.2)	53(10.3)	260(50.5)	245(47.6)	15(2.9)	260(50.5)
Total	417(81.0)	98(19)	515(100)	483(3.8)	32(6.2)	515(100)

Table 6.10: Prevalence of Overweight and Obesity amongst 8.0 – 10.9 year old Children – Comparison of Three Studies

STUDIES	OVERWEIGHT			OBESITY			Total Sample
	Males	Females	Total	Males	Females	Total	
National Schools Survey 1994 data	248(1.0)	301(1.3)	549(2.3)	37(0.2)	51(0.2)	88(0.4)	23828(100)
KwaZulu-Natal data	49(1.2)	70(1.7)	119(2.8)	10(0.2)	12(0.3)	22(0.5)	4240(100)
Vulamehlo study 1995 data	8(1.2)	25(3.9)	33(5.1)	0(0)	4(0.6)	4(0.6)	645(100)
KIDS 1998 data	45(8.7)	53(10.3)	98(19.0)	17(3.3)	15(2.9)	32(6.2)	515(100)

A comparison of the prevalence of overweight and obesity amongst the three studies clearly indicates a rising trend: from 2.3% overweight in 1994 to 19.0% in 1998, and 0.4% obesity in 1994 to 6.2% in 1998 (Table 6.10 and Fig.4). These increases in the prevalence for both overweight and obesity over these time periods are statistically significant – $p < 0.001$.



6.4 Discussion

This study has found that the prevalence of overweight and obesity amongst a cohort of rural children undertaken in 1995 in Vulamehlo was higher than that of a national and provincial sample of school children undertaken in 1994 in the same age and sex cohorts. The 1994 Schools Study included both rural and urban children. Further comparisons with the KIDS 1998 study demonstrate substantial increases in these prevalences. This preliminary study of increasing prevalence of over-nutrition amongst rural and urban children in KwaZulu-Natal provides strong epidemiological evidence that the early stages of a nutritional transition are underway amongst school children. The substantial increases in overweight and obesity prevalences in the 1998 KIDS data, over such a short period of time, requires further analysis to confirm these findings and needs to be treated with caution. Likewise, the comparisons of these cohorts over the different time periods must be regarded as crude, since the 1994 Schools and the 1998 KIDS studies were of both urban and rural children.

This is one of the first studies in Africa to use the IOTF guidelines and cut-off points for estimating the prevalence of overweight and obesity. This study also provides data and prevalence rates that allow for international comparisons, using globally agreed definitions and cut-off points. While considerable debate continues about the appropriateness of various cut-off points and the merits of the different measures of BMI, these prevalence data - using cut-off points based on an internationally representative sample of children - provide researchers, policy makers and health managers with an epidemiological foundation to plan health services, including school based health promotion programmes (IOTF, 1999). Cole *et al* (2000) have previously noted that an important omission in the development of their internationally representative sample of BMI curves was data from Africa. This study is a contribution to extending this data set and exploring the patterns of BMI in South African children. Thus, the greatest value of developing these data sets is to contribute to an existing international data set and increase its representative nature. It provides additional reference values to that provided by the NCHS cut-off points for BMI where the reference population is drawn from the USA - which has some of the highest rates of adult obesity in the world (WHO 1995).

This study also addresses the main criticism of the use of the 85th and the 95th centiles of body mass index for age and sex as recommended cut-off points to identify overweight and obesity (which are based on the US reference population), while the chosen centiles points are arbitrary. de Onis (1997) has questioned the universal applicability of these NCHS data as the choice for the reference population, and has called for further research to develop new reference curves as has been recommended for the WHO / NCHS growth curves. The value of this study lies in its use of the IOTF cut-off points, which are based on the universally accepted adult cut-off points for the definition of overweight and obesity (Cole *et al*, 2000). Comparisons of the prevalences of overweight and obesity with previous South African and international studies are difficult to make because they used different cut off points for the definition of overweight and obesity; previous studies used the 85th and 95th centiles of BMI for age and sex.

The IOTF (1998) has noted that populations with stunted children, especially in countries undergoing rapid nutrition transition, may have an altered relationship between BMI and adiposity. Despite these limitations, the trends observed in this comparative study strongly suggest that a nutritional transition is underway amongst primary school children, with increasing prevalence of overweight and obesity.

Despite the limitations of using secondary data sets for comparisons, the prevalence of overweight and obesity investigated in this study fulfils some of the following objectives of nutritional surveillance as defined by the WHO Global Database on Child Growth and Malnutrition (1997). These are i) measuring nutritional status, ii) targeting populations and sub-groups, iii) evaluation of interventions, iv) monitoring secular trends, v) advocacy for nutritional policies and programmes, and vi) training and education of health professionals. The findings that stunting and wasting continues to co-exist with early signs of increasing overweight and obesity, as suggested by this study, allows identification of school children as an important target for nutritional and educational interventions which require regular monitoring and further evaluation to assess the changes in these prevalences. Furthermore, it provides opportunities for longitudinal studies to assess the impact on adolescent and adult morbidity and mortality, especially from chronic degenerative conditions. This in turn has significant implication for health policy development and the planning and allocation of resources, especially between PHC-based DHS and hospital services.

With regard to health promotion and preventive strategies for controlling obesity and heart diseases, Ebrahim *et al* (2001) have urged caution in applying health promotion interventions that have not been successful in developed countries; and instead called for context-appropriate health research and interventions and locally-relevant health policies in developing countries. They argue that part of the explanation for the rapid rise in obesity in the last two decades is that "the US environment is a potent and global cause of obesity" (Ebrahim *et al*, 2001). In the South African context rapid urbanisation, emergence of new elites amongst African communities, powerful focus in the media on American and westernised cultures, and increasing consumption of alcohol and tobacco are all cause for urgent action to address the impending epidemic of chronic diseases. Hence, the strategies developed for the control of this emerging nutritional problem recommended by the IOTF (1999) need to be carefully related with the existing Integrated Nutrition Programme (INP), the Guidelines for SHS and the Health Promoting Schools programme. All stakeholders in the health, education, community, NGO and development sectors need to collectively explore and implement programmes that address the double burden of continuing under-nutrition and emerging overweight and obesity.

From an epidemiological perspective, it is important to establish the measure of correlation between prevalence rates measured by the WHO-recommended 85th centiles as cut-off points for overweight and the IOTF cut-off points. Wang *et al* (2000) compared the prevalence of overweight amongst children (aged 6-9 years) and adolescents (aged 10-18 years) using the WHO and the IOTF standards using data from China, Russia and the USA. Using the K coefficient as a measure of agreement, they found an excellent agreement ($K \geq 0.8$) between the two standards and conclude that the two standards are comparable, and further recommended the IOTF standard for international use (Wang *et al,* 2000). Similar comparisons are called for amongst data from African children to confirm this level of agreement.

In interpreting these data it is important to stress that the level of school children's growth, which is consistent in later life with the least occurrence of degenerative diseases, is poorly understood (Walker *et al,* 1998). This is pertinent in countries like SA, where mild to moderate malnutrition continues to persist. Walker *et al* (1997) and others have expressed concerns about the impact of urbanisation and increasing mortality rates from chronic degenerative diseases. Steyn *et al* (2000), in their analysis of the Birth to Ten (BTT) cohort study in Soweto, identified significant levels of risk factors for cardiovascular disease amongst 5-year-old urban children and advocated health promotion targeting these risk factors.

These comparisons need to be treated with caution since the Vulamehlo study was of only rural Black children; while the other two studies being compared included both rural and urban children of different race groups. Furthermore, even though standardised protocols for measuring weight and height were used in all the studies, other variations in sample selection - training of field workers and other field conditions - may have influenced the final measurement and analytical protocols (May *et al*, 2000).

6.5 Conclusions and Recommendations

Obesity as a public health problem requires to be addressed from a population or community perspective for its prevention and management. Recommendations to increase physical activity, improve diets, control weight gain and promote healthy life styles must involve policy makers, communities and health and education planners. The IOTF / WHO (1998) has identified three levels of prevention strategies aimed at chronic multifactorial conditions such as obesity: universal / public health prevention (directed at everyone in the population), selective prevention (directed at subgroups at risk for obesity) and targeted prevention (directed at high risk individuals). These strategies should be integrated with other noncommunicable (NCD) prevention efforts, especially in countries like South Africa which continue to face the double burden of communicable and NCD's.

Ideally, the choice of indicators and the cut-off points should be linked to functional and biological outcomes such as obesity-related disorders (high blood pressure, elevated serum lipoproteins, insulin or glucose levels). They should also be sensitive to, and specific for, local and regional characteristics. Further research is needed to establish such associations and to validate these indicators.

Considering the geographic, population and socio-economic diversity of the South African population and the varying trajectories of the epidemiological / nutritional transition, it is recommended that provincial and national surveys be undertaken to confirm the rising prevalence of overweight and obesity using the recently published IOTF reference curves and cut-off points. The relevance of these reference populations for developing growth curves need to be reviewed to establish the appropriateness of the value of using the adult cut-off points for children. These studies would serve as a baseline to monitor the nutrition transition (and trends towards overweight and obesity), focus targeted health promotion programmes and develop appropriate health policies and services.

Chapter 7: Epidemiology of helminth infections: Implications for parasite control programmes - a South African perspective

7.1 Introduction

This study was set in KwaZulu-Natal, the third poorest province in South Africa, with a population of over 8.5 million (Development Bank of Southern Africa (DBSA) 1994 and a high prevalence of HIV/AIDS (Department of Health, 1998). The majority of the population live in rural areas, where lack of adequate sanitation and safe water supplies compound the poor socio-economic circumstances (DBSA, 1994) and place communities at increased risk of helminth infections.

While intestinal nematodes and schistosomiasis are recognised as public health problems in the developing world (Savioli *et al*, 1992), their epidemiology is known to vary throughout the world. This requires the development of context-specific parasite control strategies and programmes. The World Health Organization (WHO) has recommended three strategies for the control of helminthic infections: universal, targeted and selective treatment (Montresor *et al*, 1998). For the development of effective South African control programmes and strategies, and implementation of a national parasite control programme, detailed information is required in respect of the epidemiology of helminth infections (prevalence, intensity, cure rates and re-infection rates) in order to control parasite transmission. In South Africa the prevalence and intensity of helminth infections nationally is unknown (Schutte *et al*, 1995; Fincham *et al*, 1996), and little is known about cure and re-infection rates. However, local studies in South Africa have found high prevalences of intestinal nematode infections in the provinces of the Western Cape (Fincham *et al*, 1996), Mpumalanga (Evans *et al*, 1987) and KwaZulu-Natal (Kvalsvig *et al*, 1991); while schistosomiasis is endemic in approximately one quarter of South Africa (Schutte *et al*, 1995). It is well documented that children are the most vulnerable group and in recent years cost-effective treatment options for helminth infections have become available to address the burden of disease amongst children, since it has been recognised that large numbers of children can be reached through school-based programmes (Montresor *et al*, 1998).

With this focus, the South African Government, like many other middle-income and developing countries, initiated a national Primary School Nutrition Programme (PSNP) which included parasite control and targeted school children (Department of Health, 1994). The development of this programme and its relationship to parasite control provides important opportunities to promote child development, through helminth control programmes, based on international strategies.

The Primary School Nutrition Programme (PSNP) was launched in 1994 to address problems of poverty, malnutrition (protein energy malnutrition and short-term hunger), micronutrient deficiencies (vitamin A, iodine and iron), parasitic infections and improved nutrition education (Department of Health, 1994). The aims of the PSNP were to improve children's learning capacity and the quality of schooling by integrating school nutrition into a network of school and community-based initiatives. The programme targeted needs in the rural and informal settlement areas. Based on the association between parasitic infections and impaired cognitive function - and education outcome measures such as absenteeism, under enrolment and high dropouts - a deworming programme was recommended where epidemiological evidence suggested high prevalence of infections (Department of Health, 1994). Four intervention components were recommended: a basic food supplement, micronutrient supplementation, parasite control programme and nutrition education (Department of Health, 1994). An integrated nutrition strategy, incorporating all the different nutrition programmes and services, was established as part of the Mother, Child and Women's Health Programme at national and provincial levels (Department of Health, 1994, Republic of South Africa White Paper, 1997). Although the objectives of the South African Parasite Control Programme were to reduce the transmission of parasite infections through treatment, health education, sanitation and environmental preventive measures (Department of Health, 1994, KwaZulu-Natal Department of Health, Integrated Nutrition Programme Business Plan 2000), in reality the existing programme has largely focussed on treatment of school children.

UNICEF (1997) has recommended guidelines for developing a national strategy for helminth control, including the use of existing school health services and other systems, and the integration of helminth control into existing (child health) programmes for sustainable child health care and development. The strategy should include a situational analysis to assess the extent of helminthic problems, to identify prevalent species (and hence the appropriate drugs to be used in the programme) and the groups at risk (UNICEF, 1997). Establishing the need for a Parasite Control Programme depends basically on prevalence data; which in turn have to recognise that the geographic distribution of infections is localised and uneven, variations occurring amongst intestinal helminth and schistosomes (which require water sources for transmission) and age-related target groups such as school children and adults. Likewise, universal or targeted mass treatment, as recommended by WHO, is indicated when prevalences exceed 50% (UNICEF, 1997). UNICEF recommended that for the purpose of monitoring and evaluating programmes, consideration needed to be given to both coverage (interval between treatments and proportion of target group treated) and the effects of treatment on prevalence and intensity of helminths and target groups. Initial epidemiological surveys provide baseline data; from these we can assess changes and measure the impact of the programme. All of these policies and programmes have a strong focus on women and children, with specific reference to nutritional improvement and parasite control. Many of the policy and programmatic elements of the South African programme are consistent with these international trends as recommended by UNICEF and WHO (UNICEF, 1997, Montresor *et al*, 1998).

The impact of deworming in combination with micronutrient supplementation, as part of the RCT, has been described in Chapter 5. The purpose of this chapter was to examine the epidemiology of helminthic infections in greater detail amongst rural school children in KwaZulu-Natal, as a contribution to the existing SA Parasite Control Programme. Specific objectives were to determine the prevalence and intensity of intestinal nematode infections, namely *Ascaris lumbricoides, Trichuris trichiura,* hookworm, and the schistosomes - *Schistosoma mansoni* and *Schistosoma haematobium*. Other objectives included determining the efficacy of treatment using single-dose albendazole 400mg for intestinal nematode infections and praziquantel 40mg/kg for schistosomiasis; determining the re-infection rate after treatment; and making recommendations to guide parasite control programmes. The approaches recommended by WHO and UNICEF for developing parasite control programmes served as the basis for developing a conceptual framework (Table 7.1) which linked the epidemiological profiles of helminth infections with the policy and programme elements, to provide a perspective for other developing countries.

Table 7.1 Conceptual framework linking Epidemiological factors to Parasite Control Programmes

Epidemiological factors	Application & interpretation	Programme implementation
Prevalence Intensity	Establish magnitude of problem Burden of disease- Individual/community level	Enable targeting: universal, selective, targeted Define high risk groups for treatment
Treatment efficacy Re-infection rates Multiple infections	Define appropriate treatment regimens Efficacy, suitable choice of drugs, single or multiple doses	Frequency of treatment Training of appropriate personnel, teacher and/or health workers in parasite control and micronutrient programmes
Defining cohorts & distribution: Age: pre-school / school child Geographic: urban, rural, altitude Socio-economic / development status	Distribution patterns of disease burden Multi-factorial causality	Targeting Comprehensive multiple or selective interventions School or community-based programme or both Monitoring and evaluation

7.2 Method

This nested intervention study was part of the RCT described in Chapter 5 and followed a similar methodological approach as described in Chapter 3. It measured prevalence and intensity of helminth infection at T1 baseline (prior to treatment), T2 (two weeks after treatment for an approximate 50% sub-sample of the population) and T3 (sixteen weeks post treatment). Serial measurements were undertaken amongst rural primary school children over the study period. The intervention consisted of a single dose of albendazole (400mg) for intestinal helminthes, and praziquantel (40mg/kg) for schistosomiasis, or placebo - given after taking the baseline measurements. All the children with helminthic infections at the end of the study were treated.

Eleven schools were randomly selected from all primary schools in Vulamehlo in the Ugu North District of rural southern KwaZulu-Natal. Ugu North was chosen as being representative of rural areas in this province, with underdeveloped social services and communities with low socio-economic status. The sampling strategy has already been described in chapters 3 and 5. Previous work on helminth infections on African KwaZulu-Natal school pupils (Evans *et al*, 1987; Schutte *et al,* 1977) influenced the calculation of the sample size. In the RCT sampling frame, it was estimated that at least 95 children per study arm would be adequate to detect at least a 20% decline in levels of *Trichuris trichiura* (recognised as one of the most common helminth to be found in KwaZulu-Natal) at 5% statistical significance with 80% power. From the main study sample generated for the RCT study, 268 pupils provided stool samples pre-treatment and sixteen weeks post-treatment, and were selected for this nested study. Of the 268 pupils recruited, 129 (48%) were randomly allocated as part of the treated group and 139 (52%) to the untreated group. To analyse the efficacy of treatment, a further random sample of 124 stool samples was obtained two weeks post-treatment (i.e. a 46.3% sub-sample). Of these, 66 (53.2%) were from the treated group and 58 (46.8%) the untreated group.

7.2.1 Anthropometric measurements

All children participating in the study were weighed without sweaters, (using a Masskot electronic scale) and their barefoot height measured using a stadiometer. Weight-for-age Z-scores and height-for-age Z-scores were computed. The reference population used in calculating these indices was that given by the National Center for Health Statistics (NCHS) (Hamill *et al*, 1979). Values less than 2 SD below the median for weight-for-age are taken as a measure of underweight, while those below the median for height-for-age are taken as a measure of stunting.

7.2.2 Analysis of stool and urine samples

Stool and urine samples were collected from all pupils prior to treatment (i.e. at baseline/pre-treatment T1), from the sub-sample two weeks after treatment (T2), and then sixteen weeks after treatment (T3), to determine the prevalence and intensity of helminth and schistosomiasis infections.

The stool samples were fixed in 10% formalin. For the stool analysis, two aliquots were measured from the homogenized stool sample (using a Stomacher Lab

Blender Model 80 – BA 7020) and analysed separately (Gyorkos *et al,* 1989; Ritchie *et al*, 1948). The stool investigation determined the prevalence of infection of *Ascaris lumbricoides, Trichuris trichiura,* hookworm, and *Schistosoma mansoni*. An aliquot of the urine samples was analysed for *Schistosoma haematobium* using a helminth filter (Visser *et al*, 1972). The intensity of helminths was quantified at the Medical Research Council (MRC) laboratory, Durban, as described above.

7.2.3 Assessment of Nutrition Policy and Programmes

A brief policy analysis of the key South African government documents relating to helminthic control at national and provincial levels (Department of Health, 1994, Republic of South Africa White Paper (1997), KwaZulu-Natal Department of Health, Integrated Nutrition Programme Business Plan (2000)) clearly indicated the need for integrated programmes. The relevance of international strategies for the promotion of child development through helminth control programmes for developing countries such as South Africa are discussed (Montresor *et al,* 1998).

7.3 Results

Data are presented in respect of school children for whom both pre- and post-intervention stool and urine results were available, from the primary rural study population. As mentioned previously, limitations of resources and field constraints restricted the collection of specimens from all the children in the original study sample. The examination of a total of 268 children was considered sufficient to establish the epidemiological profile of parasites. The study recruited 103 boys (45 in the treated and 58 in the untreated groups) and 165 girls (84 in the treated and

81 in the untreated groups); the mean age of boys was 109.2 (SD 6.9) and for girls, 107.8 (SD 6.4) months. There was no significant difference in age across gender and treatment group (P>0.10) at baseline, nor for anthropometric indices (height, weight, height-for-age and weight-for-age) with respect to gender (P>0.10). From the two main study time points (T1 and T3) there was no statistically significant difference in anthropometric indicators with respect to both gender and treatment groups (P>0.10) (Table 7.2).

Table 7.2: Anthropometric parameters for the two treatments groups, pre-treatment (T1) and 16 weeks post-treatment (T3).

Treated Group:						
Time point	Height (cm)			Weight (kg)		
	n	mean	SD	n	mean	SD
T1	129	127.8	6.9	127	27.1	3.6
T3	124	129.4	6.8	124	28.5	4.0
	Height-for-age <-2 SD			Weight-for-age <-2 SD		
	n	(%)		n	(%)	
T1	8	(6.2)		1	(0.8)	
T3	12	(9.7)		1	(0.8)	
Untreated Group:						
Time point	Height (cm)			Weight (kg)		
	n	mean	SD	n	mean	SD
T1	137	127.3	5.0	136	26.8	3.5
T3	126	129.1	5.4	126	28.0	3.6
	Height-for-age <-2 SD			Weight-for-age <-2 SD		
	n	(%)		n	(%)	

T1	13 (9.5)	1 (0.7)
T3	14 (11.1)	1 (0.8)

In this study, stunting (low height for age) ranged from 6.2% to 11.1% in the children examined, but did not vary significantly across group or time period (P>0.50); while low weight for age (underweight) appeared constant at approximately 0.8% throughout (P>0.80). When considering the prevalence and intensity of helminth infections by age and gender, no significant differences were observed for any of the parasite groups under study with respect to gender (P>0.40); hence no further analysis in respect of age and gender will be presented in this paper.

At baseline/pre-treatment (T1), over 50% of the children were infected with *Trichuris trichiura* (Table 7.3 presents this information per treatment group). Less than 30% were infected with *Ascaris lumbricoides* and very few children (approximately 3%) were infected with hookworm. *Schistosoma haematobium* was the most common of the schistosome infections, with approximately one fifth of the children infected. Less than 1% was infected with *Schistosomia mansoni.*

Table 7.3: Prevalence and intensity of helminth infection (n=268) pre-treatment (T1) and 16 weeks post-treatment (T3).

Helminth species	Time period	Intensity of infection # Nil	Light	Moderate	Heavy	Prev. (%)	P
Ascaris lumbricoides							
Treated	T1	91	19	13	6	29.5	
	T3	123	2	3	1	4.7	<0.0005
Untreated	T1	100	20	14	5	28.1	
	T3	102	21	12	4	26.6	0.89
Trichuris trichiura							
Treated	T1	62	53	13	1	51.9	
	T3	80	44	4	1	38.0	0.03
Untreated	T1	64	60	15	-	54.0	
	T3	65	65	7	2	53.2	1.00
Hookworm *spp*							
Treated	T1	124	3	1	-	3.1	
	T3	129	-	-	-	-	0.06
Untreated	T1	133	4	-	-	2.9	
	T3	135	3	1	-	2.9	1.00
Schistosoma haematobium							
Treated	T1	87	25	-	-	22.3	
	T3	89	3	-	-	3.3	0.0002
Untreated	T1	89	25	-	-	21.9	
	T3	72	21	3	-	25.0	0.72
Schistosoma mansoni							
Treated	T1	128	-	1	-	0.8	
	T3	127	-	-	-	-	1.00
Untreated	T1	138	1	-	-	0.7	
	T3	133	-	1	-	0.7	1.00

 # Intensity of infection is defined as number of children in the light, moderate and heavy groups.

Treatment with albendazole resulted in a significant decrease in prevalence sixteen weeks later (T3) for *Trichuris trichiura* and *Ascaris lumbricoides* infections (P<0.03 and P<0.0005, respectively, 3). There was an indication that hookworm infection declined in the treated group (P=0.06, but based on very small numbers). There was, however, a significant decrease in schistosome infections after treatment with praziquantel (*Schistosoma haematobium*, P<0.0002).

Although *Trichuris trichiura* was the most prevalent helminth infection, the majority of infections were of light intensity; approximately 80% being classified as light over both treatment groups at T1, 19% as moderate, and approximately 1% as high (Table 7.3). For *Ascaris lumbricoides,* the pattern at T1 was approximately 50% classified as light, 35% moderate and 15% high. At T1, all the children with *Schistosoma haematobium* had light infections. When considering the change in intensity of infection to T3 for the treated group, significant declines were observed in intensity (high-moderate, moderate-light, etc.) for *Trichuris trichiura*, *Ascaris lumbricoides* and *Schistosoma haematobium* (P<0.05, P<0.0001 and P<0.005 respectively). For the untreated group, no clear declines were observed (P>0.15 in all cases). For hookworm and *Schistosoma mansoni,* the numbers were too small to make any conclusive statement.

A sub-sample of 124 children is considered in Table 7.4 at three study time points: pre-treatment (T1), two weeks post-treatment (T2) and 16 weeks post-treatment (T3). The effects of treatment per helminth species on prevalence and intensity for this sub-sample over the intervention period (T1 to T3) remains as reported for the main sample given in Table 7.3. However, the decline for *Trichuris trichiura* becomes non-significant (P=0.03, Table 7.3; P=0.16, Table 7.4).

Table 7.4. Prevalence and intensity of helminth infection, for the sub-sample of children (n=124), pre-treatment (T1), 2 weeks post-treatment (T2), and 16 weeks post-treatment (T3).

Helminth species	Time point	Intensity of infection # Nil	Light	Moderate	Heavy	Prev. (%)	P
Ascaris lumbricoides							
Treated	T1	48	9	6	3	27.2	
Cure rate 94.4%	T2	64	-	1	-	1.5	0.0001
	T3	63	-	2	1	4.5	0.0001
Untreated	T1	43	9	4	2	25.9	
	T2	43	8	5	1	24.6	0.96
	T3	41	10	5	2	29.3	0.83
Trichuris trichiura							
Treated	T1	31	32	3	-	53.0	
Cure rate 40.0%	T2	45	20	1	-	31.8	0.02
	T3	40	24	2	-	39.4	0.16
Untreated	T1	22	28	8	-	62.1	
	T2	25	26	5	2	56.9	0.70
	T3	24	30	3	1	58.6	0.85
Hookworm *spp*							
Treated	T1	63	2	1	-	4.5	
Cure rate 66.7%	T2	65	1	-	-	1.5	0.62
	T3	66	-	-	-	-	0.24
Untreated	T1	57	1	-	-	1.7	
	T2	56	1	-	-	1.7	1.00
	T3	57	1	-	-	1.7	1.00
Schistosoma haematobium							
Treated	T1	38	18	-	-	32.1	
Cure rate 72.2%	T2	53	5	-	-	8.6	0.003
	T3	42	2	-	-	4.5	0.001
Untreated	T1	34	11	-	-	24.4	
	T2	45	11	-	-	19.6	0.54
	T3	44	9	-	-	17.0	0.51
Schistosoma mansoni							
Treated	T1	65	-	1	-	1.5	
Cure rate 100%	T2	66	-	-	-	-	1.00
	T3	65	-	1	-	1.5	1.00
Untreated	T1	57	1	-	-	1.7	
	T2	56	1	-	-	1.7	1.00
	T3	53	-	1	-	1.8	1.00

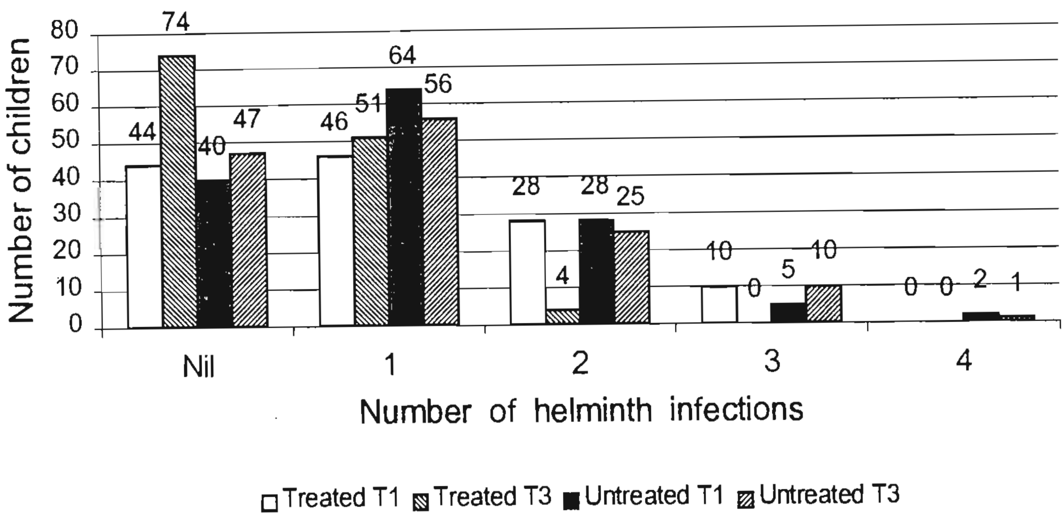
 # Intensity of infection is defined as number of children in the light, moderate and heavy groups.

When considering the change in helminth prevalence from T1 to T2, similar results to the time period T1 to T3 are observed however, with the decline in *Trichuris trichiura* again obtaining statistical significance (P=0.02). Treatment with albendazole for *Ascaris lumbricoides* proved very effective, with a 94.4% cure rate from T1 to T2. For hookworm infections, although two thirds of the children were cured, this was based on very small numbers. For *Trichuris trichiura* infections a cure rate of 40% was obtained. Treatment of schistosomal infections with praziquantel resulted in a cure rate of just under 75% for the children infected with urinary schistosomiasis and a complete cure for the single moderately infected child with *Schistosoma mansoni.*

When considering re-infection rates across the different helminth species by treatment group - where re-infection is defined as those who were helminth-positive at T1, negative at T2 and positive again at T3 - no significant differences were observed. This may well arise from the fact that very small numbers of individuals were in the sub-set of data defined for re-infection (less than 20 in all cases for any of the species and treatment groups).

A comparison of multiple helminth infections was undertaken (Figure 5). At pre-treatment (T1) 183 (68.2%) children had one or more helminth species. Most children (170 (63.4%) had one or more nematode infections, with 79 (61.2%) in the treated and 91 (65.5%) in the untreated group. There were 30 (23.3%) children in the treated group and 24 (17.3%) in the untreated group with two or more nematode infections. Only 3 (2.6%) in the untreated group had three nematode infections. There were an equal number of children in each treatment group who were infected with *Schistosomiasis haematobium* (25), and one child in each group was also infected with *Schistosomiasis mansoni.*

FIGURE 5: Prevalence of multiple helminth infections pre and post treatment (T1 and T3).



Sixteen weeks after treatment (T3) the overall pattern of multiple infections significantly declined in the treated group but remained relatively unchanged in the untreated group (Figure 5). Overall for all helminth types, the change in infections (T1 to T3) in the treated group is highly significant ($P<0.0001$) and non-significant in the untreated group ($P=0.51$). When separating this out for nematodes and schistosomes, the decline seen in the treated group is very significant ($P<0.0001$ and $P=0.0002$, respectively) and non-significant for the untreated group ($P=0.53$ and $P=0.99$).

7.4 Discussion

This epidemiological study has established the helminth species, prevalence and intensity of infections and drug treatment modalities amongst rural school children in KwaZulu-Natal. The levels of prevalence and intensity of infections that have been discovered confirm not only that a public health problem exists, but also that this burden of disease, according to international recommendations, requires mass treatment (Montresor *et al*, 1998). The relative efficacy of treatment with albendazole differs for the different nematode infections (Albonico *et al*, 1994). This study found high cure rates for *Ascaris lumbricoides* and hookworm infections, with lower cure rates for *Trichuris trichiura* infection, as previously reported (Albonico *et al,* 1994; Bartoloni *et al*, 1993). It is difficult to draw firm conclusions concerning re-infection rates, due to the very low numbers of re-infected children in this population. At the time of this study, laboratory and resource constraints necessitated that limited analysis of stools and urine is undertaken, as detailed in the methods.

Using the conceptual framework developed for this study (Table 7.1) this epidemiological profile (in the context of the existing parasite control programmes) provides a sound scientific foundation for defining the cohorts of children for targeted treatment and the specific treatment regimens and frequency of treatment. This would contribute to improving the relevance and effectiveness of the PCP. Furthermore, it provides opportunities for integrating the PCP into other school-based interventions.

KwaZulu-Natal - with a quarter of the population of South Africa - has climatic, geographic, environmental and socio-economic factors uniquely different from the rest of the country. KwaZulu-Natal has a long coastal strip alongside the Indian Ocean with a sub-tropical climate and soils conducive to the spread of helminth infections. This differs from other provinces. The population mixture also differs from other provinces, and in comparison with the national Human Development Index (HDI) of 0.69, the HDI for KwaZulu-Natal is 0.58. Understanding the epidemiology of helminthic infections in this region is essential for the effective implementation and monitoring of the Integrated Nutrition Programme (INP) and the Parasite Control Programme (PCP). The appropriate selection of the WHO's strategies of universal, selective or targeted treatment for the control of nematode infections requires both a broader epidemiological perspective of these factors and the development of Parasite Control Programmes that are sensitive and specific for each region and country, and which ensure sustainability.

In a meta-analysis of the effects on growth of anthelminthic drugs used for treating children, Dickson *et al* (1999) reported that drug treatment was associated with some positive effects on weight and height, but noted that there was significant heterogeneity between the trials' results. Our study did not find any differences in anthropometric measurements between the treatment groups, nor over the intervention period for weight-for-age and height-for-age. However, a small but persistent level of protein energy malnutrition as measured by both stunting (height-for-age) and low weight-for-age was found throughout the study population (Table 7.2).

The results of this study indicate that a public health problem exists in rural KwaZulu-Natal, which requires a parasite control programme. Previous studies have shown that children of school-going age have the highest prevalence and intensity of most helminth infections other than hookworm (Montresor *et al*, 1998). This study supports these findings, with hookworm and *Schistosoma mansoni* both having very low prevalences.

Other studies in Africa have confirmed that school-based treatment programmes can be a cost-effective strategy for controlling intensity of helminth infection even where transmission is high (Albonico *et al,* 1994; Bartoloni *et al,* 1993). These studies have demonstrated that extra doses of albendazole may improve the efficacy of treatment. Mebendazole has been shown to be equally effective in the treatment of trichuriasis and ascariasis (Booth *et al*, 1992; Guyatt, 1999). In KwaZulu-Natal the prevalence of hookworm infection has been shown to be low; so albendazole, which has proven to be more effective in the treatment of hookworm, may not necessarily be the drug of choice. These findings suggest that benzimadazole; albendazole and mebendazole could be used for treatment of helminth infection in KwaZulu-Natal - depending on cost.

7.5 Summary and Conclusion

This study has established the specific characteristics of parasites in this region, the burden of disease amongst school children and the efficacy of treatment regimens in relation to the Parasite Control Programme. Further development of the PCP requires consideration of the frequency of treatment in differing geographic areas, roles of the teachers and health workers in regular treatment programmes and monitoring the impact of the programme. The sustainability of the gains obtained from the existing vertical parasite control programme requires integration of comprehensive multiple interventions. By focussing on anthelminthic treatment of children, nutrition education, water and sanitation - and linking this with community-based women and children's health programmes - the burden of disease amongst school children can be reduced. Such interventions can contribute to the alleviation of the multi-factorial problems of individual and community level poverty, under-development and morbidity from infections and nutritional deficits. While the prevalence of parasitic infestation in this study has not been as high as reported in other studies from this region, there would still be merit in considering a Parasite Control Programme. However, the morbidity associated with parasitic infestation needs to be further investigated for a mass based programme.

The public health problems of parasite infections (endemic in many developing countries) identified in this study amongst primary school children can be addressed by school-based anthelminthic treatment programmes. The conceptual framework developed for this study has established the parasite specific characteristics of the helminth infections (prevalence and intensity) and treatment regimens (appropriateness and efficacy), and allowed focussed targeting (e.g. school-based multiple drug interventions) in KwaZulu-Natal. These findings have important implications in the development of cost-effective national parasite control programmes and are consistent with international recommendations (UNICEF, 1997).

Chapter 8: Epidemiological study of the cognitive and scholastic performance of primary school pupils in KwaZulu-Natal, South Africa

8.1 Introduction

A growing body of scientific evidence, both nationally and internationally, has noted the cumulative impact of macro and micronutrient deficits, parasitic diseases and socio-economic and environmental deprivations on the physical, cognitive and scholastic status of children and adolescents (Kvalsvig *et al,* (1991). The cognitive and scholastic performance of school children was a primary outcome measure in this study. As such it is important to explore the different factors that influence this variable, issues around its measurement and levels of test sores in South African children. The United Nations Educational Social and Cultural Organisation (UNESCO) has recommended assessing scholastic and cognitive performance to provide qualitative measures to assess the impact of health and nutrition interventions in the education sector (UNESCO, 1989). Many of these nutritional deficiencies are amenable to cost-effective interventions, with considerable potential for health promotion at household and community levels. To comprehensively address these multiple concerns, it is important to assess, monitor and improve cognitive and scholastic status of school children.

Beaumont (1995) has identified two basic forms of neuropsychological assessments: structural descriptions based changes in neurological and anatomical changes; and functional descriptions based on psychological and behavioural assessments (independent of neuroanatomical structures). The latter has grown in importance in recent years because the generation of cognitive models of normal and abnormal performance – which constitutes the body of cognitive neuropsychology – provides behavioural approaches to management and remediation of a wide range of health problems (Beaumont, 1995). The five main goals of neuropsychological assessments – medical and psychological interventions, management, prognosis and monitoring of behavioural changes, all independent of an assessment of neuroanatomical structures - provide powerful tools for a multi-disciplinary range of professionals.

The assessment of intellectual abilities and individual differences lies at the core of the discipline of psychology. There are few areas of human performance that cannot be objectively assessed using psychometric tests. In addition to the assessment of intelligence using the various Wechsler tests and their derivatives; common areas of cognitive assessment include the evaluation of verbal, numerical, visuospatial, clerical, memory, and mechanical aptitude (van Eeden & de Beer, 2000). Measurement of these abilities has relevance for the control of a range of modern epidemics and emerging psychosocial problems such as substance abuse (smoking, alcohol, drugs), sexual infections (STD's, HIV/AIDS), child and marital abuse as well as nutritional disorders (obesity, anorexia). These epidemics have strong behavioural components, which respond poorly to medical interventions alone. A combination of bio-medical and psychosocial treatment interventions is more likely to succeed in controlling these problems. Harding and Beech (1995) have supported the need to develop assessment tools for use by multi-disciplinary teams to address and provide comprehensive health care for many of these modern epidemics. They have noted that the development of *cognitive neuropsychology* as a distinct approach within neuropsychology, and the generation of cognitive models of normal and abnormal performance, has greatly facilitated the description of a person's functional status independent of structural / anatomical localization (Harding & Beech, 1996). The emergence of these epidemiological, clinical and methodological trends presents bio-psycho-social challenges to psychologists and clinicians to jointly undertake multi-disciplinary intervention.

Globally there has been a major shift in child health strategies from a focus on child survival towards child development; which increasingly emphasizes social, cognitive and scholastic development of children (PCD, 2000). Declining trends in childhood mortality and morbidity have resulted in a stronger focus on health promotion amongst school-aged children to prevent health problems in adulthood. The emerging evidence that childhood risk factors (such as obesity) predispose to adolescent and adult diseases provides added impetus to maintain health-promoting behaviours into these later stages of adolescent development. The increased emphasis on pre-and primary school education requires a better understanding of the cognitive and scholastic status of school children.

Currently there are no globally accepted methods or test batteries for cognitive and scholastic tests applicable to all children across differing socio-economic, educational, cultural and geographic backgrounds. Cognitive development is influenced by both intrinsic / genetic as well as environmental factors, which further compound the problem of developing national or internationally acceptable norms (Lezak, 1995). While the psychological status of children with clinical abnormalities and those in institutional settings has been studied, there is a paucity of guidelines, standardised norms or instruments for assessing the scholastic, cognitive and developmental status of school children at community level throughout Africa - including South Africa (Viljoen *et al*, 1994; Grieve KW, 2000). Testing children's cognitive and scholastic performance in a developing country raises many concerns. Most standardised tests used in the developed world are not suitable in the very different development context experienced by pupils in primary schools in South Africa (Grieve KW, 2000). Methodological issues that arise range from the choice of constructing a suitable test battery; adaptations to cater for cultural, educational, linguistic and geographic variations; logistical field considerations such as the use of appropriate testers; language of communication; individual or group administration; and finally the analysis, interpretation and validation of the data with internal and external norms (Lezak, 1995, van Eeden & de Beer, 2001, Viljoen *et al*, 1994). Nell (2000) has highlighted the challenges that confront South African neuropsychologists when assessing non-Western clients, although the issues he raises (such as test-wiseness and cultural determinants of mind) are relevant for all researchers and clinicians who administer cognitive and ability tests in a cross-cultural setting. One recurring theme that emerges from local and international studies conducted in developing countries, is that scores on psychometric tests tend to be significantly lower than those obtained from citizens in developed countries. While this trend is particularly prominent in Sub-Saharan Africa (Nell, 1997; Zindi, 1994), it has also been noted in Latin America and New Zealand (Ardila, 1995; Shepard & Leathem, 1999; Stricks *et al*, 1998). Lezak (1995) has recommended that measurement of behavioural performance requires a comparison standard, which may be either normative (derived from an appropriate population) or individual. Noting that measurement and interpretation of cognitive data is complex, she recommends that both approaches need to be considered in the context of the objectives of each study.

Such comparative studies of the scholastic and cognitive status of school children are essential in identifying those factors that are likely to have the maximum impact on improving their status. This is supported by Richter *et al* (1994), who noted the complexity of assessing the effect of school feeding, while recognising the diversity of urban and rural South African settings. Communities living under different environmental, physical and socio-economic conditions would respond differentially to health interventions. Such studies would provide a crude perspective on the relative impact of environmental factors on their cognitive and scholastic status, and the potential for policy and programmatic interventions to address these deficits. It is important to stress that the relative contribution of environmental factors to cognitive development of children is complex and fraught with many methodological, cultural and other problems. This study did not address all of these issues: rather it presents some epidemiological profiles of the psychological status of school children as a contribution towards addressing these questions.

The main purpose of the RCT study, described in Chapter 5, was to measure the impact of deworming and micronutrient supplementation (vitamin A and iron) on children's health and cognitive and scholastic status. To do this, a battery of tests was developed to assess the cognitive and scholastic status of rural primary school pupils and has been reported on in a previous chapter. This chapter describes the process of developing appropriate and relevant norms for school aged children in Africa, which could serve as a basis for i) assessing their cognitive and scholastic status and potential; ii) monitoring the contribution and potential impact of the various educational, health, developmental and teacher training / enhancement programmes on their scholastic and cognitive status; and iii) evaluation of the actual impact of these programmes on these cognitive scores as outcome measures. The overall objective of this study was to develop and apply a battery of tests to assess the cognitive and scholastic status of South African primary school children. Data from these rural children was then compared with data from three other study sites, with different school types, socio-economic and environmental backgrounds, to provide a comparative psychological profile of over a thousand children. This chapter presents data on the cognitive and scholastic status of this cohort of school children in KwaZulu-Natal, undertaken as part of the pre-intervention phase of the larger study.

8.2 Methods

The descriptive study consisted of three phases. The first phase was the development and piloting of a battery of tests to measure cognitive and scholastic functions of primary school children; the second phase was the application of this test battery through a community-based cross sectional study in rural schools in the Vulamehlo Magisterial District; and the third phase compared the results of the rural children with that of children from three urban schools with differing socio-economic profiles.

The selection of the three urban schools was determined by school type, so as to provide a comparative analysis. The urban schools were differentiated into two public / government schools: one from a formal settlement (Umlazi) and the second from an informal settlement (Besters), while the third school was an elite, model C public school, near the University of Natal. Since the age cohort in the primary site, Vulamehlo, was 8 - 11 year old children, this criteria influenced the selection of children in the other three schools, which in turn influenced the sample size. In urban schools, all children in this age cohort in the selected schools were chosen for inclusion in the study.

It is important to stress that the central purpose for the selection of the following test battery was to allow for the measurement of changes in the cognitive and scholastic test scores of the children, before and after the nutritional and health interventions. Hence, only those tests likely to demonstrate changes during this study period, likely to be sufficiently robust to be used in different study sites with varying resources, and suitable for group administration to large cohorts of children, were selected. Richter *et al* (1994), in their study of the cognitive and behavioural effects of a school breakfast programme, also chose tests related to learning capacity and an information-processing model of attention and arousal, as used in previous nutritional intervention studies. She also noted that younger, growing children were more likely to benefit from feeding programmes, and accordingly chose grade 2 and 3 children for her study.

Phase 1: Development and piloting of the Test Battery

The issue of test selection in cross-cultural psychometric research is a complex one. While it could be argued that basic cognitive processes such as memory and problem-solving are universal abilities, there is recognition that cultural and ecological factors influence not only the development of cognitive abilities, but also the ways in which these are expressed behaviourally (Lezak, 1995, Nell, 2000). The development of "culture-fair" tests has received some attention by researchers working in this area although Ardila (1995) argues that test adaptation for use (such as giving oral instructions instead of written instructions) represents a more appropriate solution to the challenges of cross-cultural data collection. Examples of South African adaptations include one by Solarsh (1999) in which a measure of verbal problem solving was adapted for local use through changes to the illustrations, language, administration and scoring.

The principle investigator supervised the development of the test battery in consultation with a wide range of educationists and clinical, educational and counselling psychologists with experience of working with African children in KwaZulu-Natal. Arising out of these consultations, the following tests were selected: the Raven's Coloured Progressive Matrices (CPM), Rey's Auditory-Verbal Learning Test (RAVLT), Symbol Digit Modalities Test (SDMT) and Young's Group Mathematics Test (GMT).

While this collection of tests cannot be considered to represent a comprehensive range of scholastic and cognitive functions, the selected measures assess a range of functional domains relevant to the educational process such as attention and concentration, working memory, visual scanning, psychomotor speed, short-term verbal memory, nonverbal reasoning and conceptual ability, and mathematical problem-solving. Tarter and Edwards (1986) have also recommended that scholastic tests need to be included in any psychological assessment test batteries, to provide a comprehensive test battery. The functions measured by these tests, the pilot and modified forms of administration and the scoring of these tests are now described.

a) Raven's Coloured Progressive Matrices (CPM)

This is a non-verbal measure of the level of intellectual development. It is also described as a "test of observation and clear thinking", and regarded as a perceptual test. Instructions can be given in the testee's home / preferred language. It is designed for use with both young children (age of 5.5+ years) and adults, and is considered a culture-free test, which can be administered to groups of people (Grieve *et al*, 2000). However, care needs to be exercised as defects of vision, inattentiveness and inability to understand instructions render group test procedures hazardous (Raven *et al*, 1990).

This test indicates whether a person is, or is not, capable of forming comparisons and reasoning by analogy; and if not, to what extent (s)he is capable of apprehending and perceiving discrete figures as spatially related wholes, and analysing and organising them into their components. It also measures the degree to which a person's capacity for abstract thinking has developed and may reasonably be expected to mature (Raven, 1960). Concurrent validity studies show a moderate correlation (about 0.7) between Raven and conventional tests of intelligence such as the Wechler and Stanford-Binet scales (Burke, 1985, Esquivel, 1984). There is a higher correlation with performance than verbal subscales; the test has been confirmed as a valid measure of nonverbal intelligence amongst children from culturally, economically and linguistically diverse backgrounds. Carlson and Jensen's study (1981) indicated that the CPM was equally reliable for Hispanic, Anglo and Black people (in the USA).

This test consists of 36 problems divided into three subscales (A, Ab, B) of 12 items each. The items are arranged in order of difficulty both within and between the scales. "Each item consists of a coloured abstract design with a missing piece to be completed by selecting the best alternative choice, based on characteristics ranging from discreet form to more complex logical relationships" (Esquivel, 1984). It is an untimed test and thus assesses power of thinking rather than speed.

A child from age eight onwards can usually work alone - provided there is adequate supervision - and when allowed to work quietly at his own speed without interruption usually gives a consistent and reliable sample of his mental functioning (Raven, Court and Raven, 1990). Both Raven (1960) and Lezack (1995) recommend that the total test scores for all the 36 items be converted into percentiles and this is how the data is presented in this study.

(b) The Symbol Digit Modalities Test (SDMT)

This test involves written language symbols and is generally considered a culture-free test, can be used with children speaking languages other than English and regardless of age or level of education (Lezack, 1995). The written version is administered either individually or in groups and is used, amongst others, to demonstrate any educational difficulties, dyslexia, aphasia or cerebral dysfunction. The SDMT offers an economical method for early screening of apparently normal children for possible covert manual motor defects, visual acuity, oculomotor coordination, and visuo-spatial orientation difficulties. The test is also of value in assessing reading readiness and reading disabilities in children beginning formal education.

The SDMT has consistently shown sex differences at all ages with females performing better than males, this is attributed to "greater speed and accuracy in writing by females or to the higher incidence of sinistrality in males" (Smith, 1982). The test has practice examples, which have to be done in order to assess whether the testee understands instructions. The testee is then given 90 seconds to work on his/her own at as fast but careful a pace as he/she can manage. For scoring, the total number of correct responses of each child, and the group means were compared to both internal and international norms.

(c) Rey's Auditory Verbal Learning Test (RAVLT)

This is a test of auditory memory and allows for evaluation of immediate recall / immediate memory span, new learning through repetition, susceptibility to interference and recognition memory. The Zulu version developed by MacPherson (1991), on school children was administered. For the translation into Zulu, the following words were altered to make them culturally acceptable - the word "turkey" was replaced with "chicken" and "ranger" with "herdboy" (MacPherson1991). Lezak (1995) has noted the need to minimize cultural bias in the original RAVLT word list in research with the WHO, resulting in the construction of a word list of common categories which have universal familiarity, while retaining the list length and administration format. She further noted that comparisons between subjects in Germany and Zaire had found low intercultural variability – and reported correlations of 0.45 to 0.55 (Lezak, 1995).

The test consisted of a list of 15 words, which were read out loud to the testees for five consecutive trials followed by a free-recall test. Upon completion of the five trials, an interference / distraction list was presented, followed by a free-recall of the list. Further, a delayed recall of the first list was tested without presenting the words again. Finally, a list of 50 words was used to see if the testee was able to recognize the words that were in the first list. Studies have stated that age, sex and intellectual level contribute to performance on the RAVLT (Spreen and Strauss, 1991). Lezak (1995) describes the RAVLT as measuring "immediate memory span, provides a learning curve, reveals learning strategies, measures both short and longer term retention and allows for comparison between retrieval efficiency and learning". While the test is normally administered orally on an individual basis - in this study group administration was undertaken. The children were expected to write their answers and were given two minutes for each trial. The analysis in this paper was based on the total of the first five trials (I to V), compared to local and international data (MacPherson, 1991).

(d) Young's Group Mathematics Test (GMT)

The test is suitable for use with groups of children over a wide range of ability. It is made up of two sections - an oral and computation section. Each section is subdivided into two parts. Thus overall, the test is made up of: oral one, oral two, computation one and computation two. The children were given two practice examples for the oral section, and then instructed to continue on their own within seven seconds for each question - except for the clock question. Each question had to be repeated before children could answer. Each computation also had two practice examples and then the children were allowed eight minutes to work on their own. The test was adapted and administered in Zulu. The following modifications were made - "tarts" was changed to "cakes", "engine" to "truck", "marbles" to "balls"; and the names "Dick and Jim" were changed to "Sipho and Thembi".

As recommended by Young (1995), raw scores are presented. These range from 0 to a maximum possible score of 58; with a good correlation between the GMT and other number tests, with satisfactory concurrent and predictive validity; including comparisons with group reading and picture tests.

8.3 Standardization, validation and reliability of test Administration

The principle investigator provided overall scientific co-ordination to ensure methodological, administrative and logistical rigour. The administration of all tests followed standard procedures, as outlined in the test manuals. A qualified counselling psychologist trained four Zulu speaking testers - a clinical psychology intern, two clinical psychology post-interns and a social science graduate with a psychology major - to ensure that they gave the same instructions and followed identical procedures in the field for consistency of results. The pilot provided an opportunity for field training of the testers under the supervision of the clinical psychologist. Each tester was also assigned three assistants who were briefed by the psychologist as to their tasks. The rationale was for the assistants to have some basic knowledge of what was expected from the testees, and to identify those children experiencing problems during the testing.

Additional measures to assess validity were undertaken for the following tests. For the Raven's CPM, as the test became progressively more difficult from A, Ab to B, the number of correct responses declined. Secondly, the variation in the range of responses for the norms for the board form of the test was checked. Both these checks were undertaken and confirmed its validity. For the RAVLT the lists of words were presented on cassette tape in order to reduce variation in verbal administration.

8.4 The Pilot Study site and Subjects

The pilot study was conducted in a rural primary school, approximately 80 kilometres north of Durban. The school was selected on the basis of it being a typical rural public school. The aim was to assess the practical aspects of conducting all the tests in one sitting, and to observe the school children for signs of exhaustion and apathy during the full duration of the test, and how children would perform on the test measures. The test instructions were translated into Zulu. Twenty children were chosen from a grade 3 class. Of these four, (20%) were eight years old, seven (35%) were nine years old and nine (45%) were ten years old, with a mean age of 9.25. Six (30%) were girls and fourteen (70%) were boys.

The following observations were made in the pilot study:

(i) The test battery appeared to be adequate in that it allowed for the measurement of a wide range of performance, and children were able to complete the tests.

(ii) The time taken to administer all the tests was approximately three hours (09h.00 – 12h.00) with a 15 minute break. This appeared to be adequate for the children and the interviewers within the constraints of the timetable.

(iii) The children maintained a high level of interest in the tests and did not complain of, or exhibit, any tiredness. It was concluded that it was feasible to conduct all the tests in one session.

(iv) The timing of responses needed to be strictly adhered to.

(v) The test scores of the children in the pilot were within a range, which suggested sufficient individual differences with adequate allowance for improvement in performance to avoid any ceiling effect.

(vi) To prevent copying, testees did not share desks.

The pilot study confirmed the suitability of the test battery and the following modifications were made: the instructions of all the tests were translated into Zulu to reduce bias amongst the testers and improve communication with the children; an answer booklet was compiled for each testee as the writing down of the names and the distribution and collection of each answer sheet was time consuming and disruptive.

Phase 2: Field application of the test battery

The second phase, which was part of the RCT and has been described previously, involved the application of the test battery at eleven rural primary schools randomly selected from a list of all 72 government primary schools in the Vulamehlo Magisterial District in rural KwaZulu-Natal. This gave an approximate sampling rate of 15%. All the grade 3 pupils between 8 and 11 years of age in these schools were chosen for inclusion into the study. Grade 3 pupils were chosen as they had the benefit of at least two years of schooling to enable measurement of concentration, learning and mathematic skills.

Vulamehlo Magisterial District is between 1-2 hours by road away from Durban, and consists of undulating terrain with wattle and daub traditional homesteads situated at intervals on the grassy hillsides. It is a poor area with 47% of household income below the minimum basic household level, a high rate of unemployment (only 32.4% of economically active persons were formally employed) and a low literacy rate (40.1% were illiterate – defined as less than 6 years schooling). Only 5% of households had access to land for ploughing and most households lacked electricity. The characteristics of this community are similar to many rural districts in KwaZulu-Natal, whilst the children included in this study (all children in grade 3 of 8-11 years of age) were selected as representative of rural primary school children in KwaZulu-Natal.

Phase 3: Comparative Study in three urban schools

The urban schools were differentiated into two public / government schools, one from a formal township (Umlazi) and the second from an informal settlement (Besters), while the third school was an urban, elite government school (Manor Gardens). The communities identified for the study were typical of the community profiles described, and ensured that the schools chosen and the children examined were representative of that particular community. Convenience sampling was the method used to select the schools for the study, since the overall purpose of the study was to obtain psychological and cognitive test scores for comparison with the test scores of the rural children from the primary study site in Vulamehlo. For the same reason, all the children in grade 3 were included in the study, provided they satisfied the inclusion criteria defined for the main study. This resulted in variations in the sample size.

- **Umlazi school study site**

Umlazi is a formal urban township about 15 km south of Durban, established many decades ago and consisting of a large formal and a smaller informal housing sector. The overwhelming majority of the community are Africans, employed in both the formal and informal sectors, reflected in mixed patterns of development, which is typical of many urban African townships in South Africa (May J *et al*, 1999). A public combined primary (CP) school was selected as the study site. The school principal, in consultation with the parents committee, consented to allow all the 88 children between the ages 8 - 10 years in Grade 3 (standard one) to participate.

- **The Besters school study site**

The Besters community - established by the occupation of land by squatters in 1985 - is located within the Durban Municipality (Coutsoudis *et al*, 1994). The area was released to the Urban Foundation (UF) for infrastructural upgrading (building of roads, pit-latrines, and water standpipes) in 1989 with funds from the Independent Development Trust (IDT) and the Durban Municipality. The UF estimated that the 3400 shacks housed 18 000 - 20 000 people. A cross-sectional study assessing the community's health status in 1991 found the demographic, environmental and morbidity profiles of Besters were consistent with both South African and international studies of informal communities, which are amenable to primary health care (PHC) interventions. Patterns of health service utilization reflected inappropriate use of the tertiary hospital in the city centre and grossly fragmented patterns of utilization, both between preventive and curative care, and between antenatal and maternity services (Jinabhai *et al*, 1991). A primary school was selected for the study, and signed consent to examine the children was obtained from the parents, with permission from the school authorities.

- **Manor Gardens school study site**

This is a middle class suburb near the University of Natal, in central Durban, consisting of parents in formal employment, and a well developed community with very good educational, housing, health and social services. The majority of children in this community attend the only primary school in the area – a "model C" school that was previously for "white" pupils administered by the Natal Education Department. It is a well-resourced school with a multi-ethnic pupil complement. Signed informed consent was obtained from the parents and the school principal authorised the study. All the children in Grade 3 were examined.

8.5 Ethical approval

The Ethics Committee, Faculty of Medicine, University of Natal, approved the protocol, while informed consent was obtained from each parent, and authorization from the school authorities and the tribal councils.

8.6 Data analysis

Data entry and analysis used EPI-INFO and SPSS. A comparative analysis of the cognitive test scores was undertaken to establish differences in terms of sex and age and to express the scores in relation to various reference populations. Independent two-sample and one-way analysis of variance (ANOVA) were performed. For statistical significance a probability value of $P<0.05$ was taken.

An important limitation identified by Spreen and Strauss (1991) is that few neuropsychological tests present information about the score distribution in a normal population; and they have recommended that for analysis and interpretation of test scores a profile of all raw scores be translated into standard scores, z-scores or percentiles ranks. Where appropriate we present data in this format to address this limitation and to allow for comparisons with other studies.

8.7 Results

The cognitive and scholastic performance of 1018 rural and urban school children was investigated, and the distribution of the scores of the four components of the test battery by age, gender and geography (rural / urban study sites) were analysed. Firstly, the results of the rural Vulamehlo school children are presented followed by a comparison of the test scores all the children, including the three urban schools. The test scores of our subjects are then compared to national and international test scores, to assess differences.

- **Data from the rural Vulamehlo schools**

Data in respect of a total of 806 children, 450 (55.8%) boys and 356 (44.2%) girls, were analysed from two perspectives – an internal analysis and a normative evaluation as suggested by Viljoen *et al* (1994). For the internal analysis the mean, standard deviation and confidence intervals of the test scores of the children were examined in terms of sex and age distribution (Tables 8.1 and 8.2) to assess the reliability of the data. For the normative evaluation, the total scores for each one of the tests were compared with the norms as recommended by the manuals. The critical issue was to examine the value of the norms recommended in the test manuals and their applicability for rural South African children.

Table 8.1: Cognitive & Scholastic performance scores of Rural Children by gender

Test	Boys		Girls		Total		P value§
	(mean, sd, 95% CI) n=450		(mean, sd, 95% C) n=356		(mean, sd, 95% CI) n=806		
Raven's (CPM)	13.4	3.2	14.6	4.4	13.9	3.9	P<0.0005
	13.1-13.7		14.2-15.1		13.7-14.2		
Symbol Digit (SDMT)	14.3	6.3	15.6	6.9	14.9	6.6	P=0.01
	13.7-14.9		14.9-16.3		14.4-15.3		
Rey's (RAVLT)	24.6	7.6	22.3	7.3	23.6	7.6	P<0.0005
	23.9-25.3		21.6-23.1		23.1-24.1		
Group Maths (GMT)	29.4	7.1	28.5	7.2	29.0	7.2	P=0.10
	28.7-30.0		27.8-29.3		28.5-29.5		

§ **Independent samples t-test for sex.**

As shown in Table 8.1, girls achieved higher scores for the Ravens CPM than boys and this gender difference was statistically highly significant ($P<0.0005$). For the SDMT indicating the number of correct answers within a timed period, girls also performed significantly better than boys ($P=0.01$). The results of the Rey's (RAVLT) indicated that boys achieved a higher score than the girls ($P<0.0005$). A similar result was noted for the group mathematics test (GMT) but the differences were not statistically significant ($P=0.10$).

Table 8.2: Cognitive & Scholastic performance scores of Rural Children by age and gender

Test	Age Group (years)						P value§
	8-		9-		10-		
	(mean, sd, 95% CI)		(mean, sd, 95% CI)		(mean, sd, 95% CI)		
Boys	n=177		n=175		n=98		
Raven's (CPM)	13.3	3.1	13.3	3.0	13.7	3.8	P=0.53
	12.8-13.8		12.8-13.7		12.9-14.5		
Symbol Digit (SDMT)	14.1	6.2	14.2	6.1	14.8	6.9	P=0.66
	13.2-15.0		13.3-15.1		13.4-16.2		
Rey's (RAVLT)	24.8	7.8	24.4	7.6	24.7	7.2	P=0.84
	23.7-26.0		23.2-25.5		23.2-26.1		
Group Maths (GMT)	29.6	6.8	29.0	7.4	29.7	7.3	P=0.69
	28.6-30.6		27.9-30.1		28.2-31.2		
Girls	n=128		n=145		n=83		
Raven's (CPM)	14.3	4.2	14.6	4.4	15.1	4.8	P=0.49
	13.6-15.1		13.9-15.4		14.0-16.1		
Symbol Digit (SDMT)	15.2	6.4	15.3	6.6	16.7	7.9	P=0.26
	14.0-16.3		14.2-16.4		14.9-18.4		
Rey's (RAVLT)	22.0	6.8	23.5	7.6	20.9	7.4	P=0.03
	20.8-23.1		22.2-24.7		19.3-22.5		
Group Maths (GMT)	27.7	7.6	29.6	6.7	28.1	7.3	P=0.09
	26.4-29.0		28.5-30.7		26.5-29.7		

§ One-way ANOVA over age group.

When considering sex and age (Table 8.2), for boys there was an indication that 10 year old boys had higher scores then their 8 and 9 year old counterparts. For most tests, however, this did not reach statistical significance (P>0.5 in all cases). For girls the same pattern holds for Raven's CPM and Symbol Digit (SDMT), i.e. a hint of increasing score with increasing age, but not reaching statistical significance (P>0.2 in both cases). For Rey's (RAVLT) and Group Maths (GMT) a drop in score is observed in the 10 year old girls, this was statistically significant for Rey's (P=0.03) and had borderline significance for Group Maths (P=0.09). When comparing across sex for every age group, it appears that girls perform better than boys for Raven's (CPM) and Symbol Digit (SDMT), all differences being statistically significant for Raven's (P<0.05 in all cases) and non-significant for SDMT (P>0.1 in all cases). For Rey's (RAVLT) and Group Maths (GMT) the opposite holds, with the scores for boys across all age groups mostly being higher than those for girls. However, these differences are statistically non-significant for GMT (P>0.1 in all cases), and for Rey's only reached statistical significance in the 8 and 10 year olds (P<0.01 in both cases).

Table 8.3. National and International Test Scores

	Age (years)						Notes
Rey's (RAVLT)							
South Africa MacPherson (1991)	**6–8 years**		**8–10 years**		**10–12 years**		
	Boys	Girls	Boys	Girls	Boys	Girls	
	34.1 (6.6)	33.4 (8.2)	42.6 (8.3)	33.4 (8.2)	42.8 (6.66)	43.0 (7.3)	
International Forrester & Geffen (1991) British Children	**7–8 years**		**9–10 years**		**10-12 years**		No sex data.
	38.9 (7.9)		46.7 (5.4)		46.9 (5.0)		
Symbol Digit (SDMT)							
South Africa MacPherson (1991)	**6-8 years**		**8-10 years**		**10-12 years**		
	Boys	Girls	Boys	Girls	Boys	Girls	
	16.7 (7.4)	14.4 (7.8)	23.6 (8.9)	22.1 (7.9)	24.1 (8.3)	28.1 (6.6)	
International Smith (1991) North American Children	**8 years**		**9 years**		**10 years**		
	Boys	Girls	Boys	Girls	Boys	Girls	
	23.3 (7.0)	23.6 (5.7)	26.5 (8.1)	26.9 (8.1)	28.1 (7.3)	29.9 (8.5)	
Raven's (CPM)							
International Raven (1960) British Children	**8 years**	**8.5 years**	**9 years**	**9.5 years**			No sex data. Raw scores converted to 50th centiles
	20	21	22	23			
International Spreen & Strauss(1991) North American Children	24	26	27	28			
Group Mathematics Test (GMT)							
International Young (1970) British Children	**7 years**	**8 years**	**9 years**	**10 years**			No sex data. Percents - success rate out of max 58
	27 (46.5%)	40 (69.0%)	51 (87.9%)	56 (96.5%)			

In addition, the scores from our test battery were then compared to scores derived from other local and international studies that were available (Table 8.3). It was difficult to directly compare our data with those of other reported studies due to the high variability of the reporting. Not all the studies presented the results disaggregated to each age and sex cohort, nor did they present the standard statistical parameters, such as mean (whether arithmetic or geometric), standard deviations, confidence intervals or the sample sizes. The results in Table 8.3 reflect that our mean study scores (Tables 8.1 and 8.2) were lower than those reported by other authors, including the norms presented in the standard test manuals. To assist with the comparison for Raven's, our data when expressed as 50^{th} centiles is as follows:

	8 years -	9 years -	10 years -	Total
Boys	13	13	13	13
Girls	13	14	14	14

The children in this study have much lower CPM scores compared to other international studies. When comparing our data with the Raven's Manual, it would appear that the scores given above are more reflective of children aged between 5 and 6 years of age, suggesting either that the children are in deficit by some 3 to 5 years, or that new norms are required for rural South African children.

- **Comparison of Test Scores between Rural and Urban School children**

First, the effect of sex and geographic location of the study sites on the four components of the test battery will be explored. With respect to Raven's CPM test, there were significant differences for the rural Vulamehlo children (boys scores were lower than girls), and in Umlazi and Besters (in both sites girls scores were higher than boys); while in Manor Gardens there were no significant differences (Table 8.4).

Table 8.4: Comparison of Cognitive & Scholastic test scores by study site and sex - All children

Test	Study site	Boys (mean)	Boys (sd)	Boys (n)	Boys (95% CI)	Girls (mean)	Girls (sd)	Girls (n)	Girls (95% CI)	Total (mean)	Total (sd)	Total (n)	Total (95% CI)	P value[§]
Raven's (CPM)	Vulamehlo	13.4	3.2	450	13.1-13.7	14.6	4.4	356	14.2-15.1	13.9	3.9	806	13.7-14.2	P<0.0005
	Umlazi	16.3	4.9	30	14.4-18.1	14.1	4.1	36	12.7-15.5	15.1	4.5	66	14.0-16.2	P=0.05
	Besters	14.2	5.3	61	12.9-15.6	16.7	5.7	59	15.2-18.2	15.5	5.6	120	14.4-16.5	P=0.02
	Manor Gardens	26.4	4.6	14	23.7-29.0	25.9	6.3	12	21.9-29.9	26.1	5.4	26	24.0-28.3	P=0.84
	Total	14.0	4.2	555	13.6-14.3	15.1	5.0	463	14.7-15.6	14.5	4.6	1018	14.2-14.8	P<0.0005
	P value[¶]	P<0.0005				P<0.005				P<0.0005				
Symbol Digit (SDMT)	Vulamehlo	14.3	6.3	450	13.7-14.9	15.6	6.9	356	14.9-16.3	14.9	6.6	806	14.4-15.3	P=0.01
	Umlazi	15.8	8.2	30	12.7-18.8	16.7	8.0	36	14.0-19.4	16.3	8.0	66	14.3-18.3	P=0.63
	Besters	15.2	10.3	61	12.5-17.8	13.1	6.5	59	11.5-14.8	14.2	8.7	120	12.8-15.7	P=0.20
	Manor Gardens	27.5	10.2	14	21.6-33.4	26.3	3.5	12	24.1-28.6	27.0	7.7	26	23.8-30.1	P=0.71
	Total	14.8	7.3	555	14.2-15.4	15.6	7.1	463	15.0-16.3	15.2	7.2	1018	14.7-15.6	P=0.07
	P value[¶]	P=0.38				P=0.02				P=0.14				
Rey's (RAVLT)	Vulamehlo	24.6	7.6	450	23.9-25.3	22.3	7.3	356	21.6-23.1	23.6	7.6	806	23.1-24.1	P<0.0005
	Umlazi	19.0	6.0	30	16.7-21.2	24.0	6.6	36	21.7-26.2	21.7	6.8	66	20.1-23.4	P<0.005
	Besters	23.2	8.6	58	20.9-25.4	18.6	10.0	55	15.9-21.3	20.9	9.5	113	19.2-22.7	P=0.01
	Manor Gardens	41.0	5.5	14	37.8-44.2	36.8	6.9	12	32.4-41.2	39.1	6.4	26	36.5-41.7	P=0.11

	Total	24.6	8.1	552	22.4	8.1	459	23.6	8.2	1011	P<0.0005
		23.9-25.2			21.6-23.1			23.1-24.1			
	P value¶	P<0.0005			P<0.005			P<0.005			
Group Maths (GMT)	Vulamehlo	29.4	7.1	450	28.5	7.2	356	29.0	7.2	806	P=0.10
		28.7-30.0			27.8-29.3			28.5-29.5			
	Umlazi	27.2	8.0	30	26.2	6.1	36	26.6	7.0	66	P=0.54
		24.2-30.2			24.1-28.2			24.9-28.4			
	Besters	29.5	8.4	60	30.0	10.3	59	30.0	9.4	119	P=0.78
		27.4-31.7			27.3-32.7			28.1-31.5			
	Manor Gardens	46.7	8.0	14	48.0	7.1	12	47.3	7.4	26	P=0.67
		42.1-51.3			43.5-52.5			44.3-50.3			
	Total	29.7	7.8	554	29.1	8.2	463	29.4	8.0	1017	P=0.19
		29.1-30.4			28.3-29.8			28.9-29.9			
	P value¶	P=0.29			P=0.06			P=0.02			

¶ One-way ANOVA over study site excluding Manor Gardens; when Manor Gardens included P<0.0005 in all cases.

§ Independent samples t-test for sex.

Overall scores were highly significantly different ($p < 0.0005$), with girls having higher test scores (Table 8.4). In respect of a rural urban comparison, all the urban schools had significantly higher test scores for Raven's CPM than rural schools – this result remained significant even when the model C Manor Gardens school was excluded form this analysis. The SDMT test scores indicated a mixed picture. The girls had higher test scores in Vulamehlo and Umlazi, including the overall scores (which approached borderline significance, $p = 0.07$), while boys had higher scores in Besters and Manor Gardens. The test scores for urban girls were significantly higher. For Rey's AVLT test scores, only in Umlazi did the girls have higher scores, while in the other three test sites boys had higher scores, including the overall test scores. All these results were significant except for Manor Gardens. All the urban children had significantly higher test scores ($p < 0.005$). The GMT test scores did not show any significant differences across sex, while urban girls had significantly higher scores.

When the test scores of each individual age cohort were examined separately for boys and girls for each of the four components of the test battery by study sites (Tables 8.5 and 8.6), no clear pattern of increasing scores with age was noted. Likewise there was considerable variation in the comparison between urban and rural children – generally urban children had higher test scores.

Table 8.5: Gender Comparison of Cognitive & Scholastic test scores by Study Site: All Boys

Test	Study site	Age Group (years)									P value[§]
		8-			9-			10-			
		(mean, sd, n, 95% CI)			(mean, sd, n, 95% CI)			(mean, sd, n, 95% CI)			
Raven's (CPM)	Vulamehlo	13.3	3.1	177	13.3	3.0	175	13.7	3.8	98	P=0.53
		12.8-13.8			12.8-13.7			12.9-14.5			
	Umlazi	17.7	3.5	10	16.5	5.8	14	13.3	3.3	6	P=0.22
		15.2-20.2			13.1-19.9			9.8-16.8			
	Besters	12.5	5.2	14	13.7	3.9	15	15.3	5.8	32	P=0.24
		9.5-15.5			11.5-15.8			13.2-17.4			
	Manor Gardens	26.4	4.8	13	26	-	1	-	-	-	P=0.94
		23.5-29.3			-			-			
	Total	14.2	4.7	214	13.6	3.5	205	14.1	4.4	136	P=0.26
		13.6-14.9			13.1-14.1			13.3-14.8			
	P value[¶]	P<0.0005			P<0.002			P=0.19			
Symbol Digit (SDMT)	Vulamehlo	14.1	6.2	177	14.2	6.1	175	14.8	6.9	98	P=0.66
		13.2-15.0			13.3-15.1			13.4-16.2			
	Umlazi	12.9	5.5	10	18.9	8.8	14	13.2	9.1	6	P=0.14
		9.0-16.8			13.9-24.0			3.7-22.7			
	Besters	10.0	5.5	14	11.9	6.4	15	19.0	12.0	32	P<0.001
		6.8-13.1			8.4-15.5			14.6-23.3			
	Manor Gardens	25.6	7.7	13	52	-	1	-	-	-	P<0.001
		21.0-30.2			-			-			
	Total	14.5	6.9	214	14.6	6.9	205	15.7	8.6	136	P=0.26
		13.5-15.4			13.6-15.5			14.2-17.2			
	P value[¶]	P=0.05			P<0.01			P=0.04			

Rey's (RAVLT)	Vulamehlo	24.8	7.8	177	24.4	7.6	175	24.7	7.2	98	P=0.84
		23.7-26.0			23.2-25.5			23.2-26.1			
	Umlazi	16.4	6.3	10	18.7	5.8	14	24.0	2.4	6	P=0.04
		11.9-20.9			15.3-22.1			21.4-26.6			
	Besters	17.2	5.7	13	20.5	9.1	13	26.7	7.7	32	P<0.005
		13.8-20.7			15.0-26.0			23.9-29.5			
	Manor Gardens	40.3	5.6	13	45	-	1	-	-	-	P=0.47
		37.3-44.1			-			-			
	Total	24.9	8.9	213	23.8	7.9	203	25.1	7.2	136	P=0.25
		23.7-26.1			22.7-24.9			23.9-26.3			
	P value¶	P<0.0005			P<0.01			P=0.36			
Group Maths (GMT)	Vulamehlo	29.6	6.8	177	29.0	7.4	175	29.7	7.3	98	P=0.69
		28.6-30.6			27.9-30.1			28.2-31.2			
	Umlazi	23.9	8.2	10	31.1	7.3	14	23.8	5.5	6	P=0.04
		18.0-29.8			26.8-35.3			18.1-29.6			
	Besters	26.8	7.2	14	26.9	10.3	15	32.1	7.4	31	P=0.05
		22.6-30.9			21.2-32.6			29.4-34.8			
	Manor Gardens	46.5	8.3	13	49	-	1	-	-	-	P=0.78
		41.6-51.5			-			-			
	Total	30.2	8.2	214	29.1	7.8	205	30.0	7.4	135	P=0.35
		29.1-31.3			28.0-30.2			28.7-31.2			
	P value¶	P=0.02			P=0.34			P=0.03			

¶ **One-way ANOVA over study site excluding Manor Gardens, when Manor Gardens included P<0.0005 in all cases for age 8-, ranging over 0.05<P<0.005 for age 9-.**

§ **One-way ANOVA over age group.**

Table 8.6: Gender Comparison of Cognitive & Scholastic test scores by Study Site: All Girls

Test	Study site	Age Group (years)									P value[§]
		8-			9-			10-			
		(mean, sd, n, 95% CI)			(mean, sd, n, 95% CI)			(mean, sd, n, 95% CI)			
Raven's (CPM)	Vulamehlo	14.3	4.2	128	14.6	4.4	145	15.1	4.8	83	P=0.49
		13.6-15.1			13.9-15.4			14.0-16.1			
	Umlazi	12.1	2.8	9	14.5	4.8	19	15.5	2.8	8	P=0.20
		10.0-14.2			12.2-16.8			13.3-17.7			
	Besters	16.1	5.1	14	14.3	6.7	11	17.8	5.4	34	P=0.19
		13.1-19.0			9.7-18.8			15.9-19.6			
	Manor Gardens	27.8	4.3	10	16.5	7.8	2	-	-	-	P=0.01
		24.7-30.8			-53.4-86.4			-			
	Total	15.2	5.3	161	14.6	4.6	177	15.8	5.0	125	P=0.11
		14.3-16.0			13.9-15.3			15.0-16.7			
	P value[¶]	P=0.09			P=0.96			P=0.03			
Symbol Digit (SDMT)	Vulamehlo	15.2	6.4	128	15.3	6.6	145	16.7	7.9	83	P=0.26
		14.0-16.3			14.2-16.4			14.9-18.4			
	Umlazi	16.4	6.9	9	18.2	8.6	19	13.5	7.5	8	P=0.38
		11.2-21.7			14.1-22.4			7.2-19.8			
	Besters	10.0	4.2	14	11.1	6.4	11	15.1	6.7	34	P=0.02
		7.6-12.4			6.8-15.4			12.8-17.4			
	Manor Gardens	26.5	3.8	10	25.5	0.7	2	-	-	-	P=0.73
		23.8-29.2			19.1-31.8			-			
	Total	15.5	6.9	161	15.5	7.0	177	16.0	7.6	125	P=0.76
		14.4-16.6			14.4-16.5			14.7-17.4			
	P value[¶]	P=0.01			P=0.02			P=0.48			
Rey's (RAVLT)	Vulamehlo	22.0	6.8	128	23.5	7.6	145	20.9	7.4	83	P=0.03
		20.8-23.1			22.2-24.7			19.3-22.5			
	Umlazi	25.1	5.3	9	24.5	6.7	19	21.5	8.0	8	P=0.48
		21.0-29.2			21.3-27.7			14.8-28.2			

	Besters	11.6	7.4	14	17.7	11.6	8	21.7	9.2	33	P<0.005
		7.3-15.9			8.1-27.4			18.4-25.0			
	Manor Gardens	37.1	6.5	10	35.5	12.0	2	-	-	-	P=0.78
		32.4-41.8			-72.5-143.5			-			
	Total	22.2	8.3	161	23.4	7.9	174	21.1	7.9	124	P=0.05
		20.9-23.5			22.3-24.6			19.7-22.6			
	P value¶	P<0.0005			P=0.10			P=0.87			
Group Maths (GMT)	Vulamehlo	27.7	7.6	128	29.6	6.7	145	28.1	7.3	83	P=0.09
		26.4-29.0			28.5-30.7			26.5-29.7			
	Umlazi	22.4	6.6	9	26.8	6.1	19	28.9	3.5	8	P=0.07
		17.4-27.5			23.9-29.7			26.0-31.8			
	Besters	26.0	6.8	14	27.4	12.2	11	32.6	10.5	34	P=0.08
		22.1-29.9			19.2-35.5			28.9-36.2			
	Manor Gardens	49.7	6.4	10	39.5	3.5	2	-	-	-	P=0.06
		45.1-54.3			7.7-71.3			-			
	Total	28.6	9.2	161	29.2	7.1	177	29.4	8.3	125	P=0.70
		27.2-30.1			28.2-30.0			27.9-30.8			
	P value¶	P=0.11			P=0.19			P=0.03			

¶ One-way ANOVA over study site excluding Manor Gardens, when Manor Gardens included P<0.0005 in all cases for age 8-, for age 9- P=0.94, P=0.01, P=0.03, P=0.06 for Raven's, SDMT, Rey's and Group Maths respectively.

§ One-way ANOVA over age group.

8.8 Discussion

This study presents cognitive and scholastic data in respect of 1018 rural and urban children from community based samples, as a contribution towards developing a suitable test battery for local South African conditions. Overall there was no consistent pattern in the test scores across age, sex and location. Generally, girls had higher scores than boys for some of the tests, while urban children were better than rural children were. The test scores of the semi-private model C school, Manor Gardens, were higher then those from all the public schools, and tended to skew the distribution of all the urban test scores and tended to be similar to those of the national and international scores. Significant differences in test scores of urban children remained significant even after the exclusion of the scores of the Manor Gardens children. There was a clear gradation of test scores, the two urban schools having higher scores than the rural schools, with the semi-private model C school having scores higher than all the schools in this sample, and approaching the scores of the national and international norms. These variations amongst KwaZulu-Natal schools clearly suggest the negative impact of educational and environmental deprivation on the children.

However, the overall test scores for all the schools across the battery are lower than those observed in other local and international studies, with little possibility of a ceiling effect with respect to the main RCT study. These findings present a number of important challenges for scientists in analysing the test scores; for educationists, parents and communities in interpreting their significance; and for psychologists in assessing the clinical and psychological implications. The results of this test battery provide preliminary baseline data for comparison with other studies and to measure the impact of interventions on these cognitive and scholastic test parameters.

Burke (1985) has noted that the scores for Raven's CPM show a significant increase with increasing years of education and socio-economic status. This has implications for our study where comparisons of Raven norms based on North American and British children are made with rural children from Africa with differing socio-economic and educational backgrounds. The findings of our study of lower CPM results suggest that educational levels and socio-economic status in the context of this study are critical contributing factors. It is interesting to note that the CPM scores of 8-11 year old South African children compare with the scores of 5-6 year old British children, indicating an educational deficit. In addition, the Ravens CPM mean score for persons with less than six years of schooling was reported as being the value of 14 (Anderson, 1994), supporting the view that educational deprivation may be the major contributor to the low scores amongst children in this study. The importance of years of education and urbanization as moderators of test performance has also been emphasised by Nell (2000), who suggests that they override ethnicity in terms of importance. He also believes that they are more important than the traditional sources of variance such as age, gender and socio-economic status.

Results from other South African studies using a variation of the Raven's CPM, that is the Ravens Standard Progressive Matrices (RSPM), amongst children has found a mixed picture. Owen *et al* (1992), found significant differences between RSPM scores of children from different socio-cultural groups – African children obtaining lower scores than white children; while Crawford-Nutt *et al* (1976), found that the performance of African pupils approximated the British norm. Grieve *et al* (2000), in her study of African university students found their performance was poorer on the RSPM, with test scores ranging approximately one SD below overseas data, suggesting that the test is not "culture blind". Similar results were obtained by Zindi (1994) in a study comparing Zimbabwean and British adolescents using the RSPM. Specifically, Zimbabwean pupils scored almost two standard deviations below their British counterparts. While there may be a number of reasons for this discrepancy, it seems clear that we cannot rely on the assumption that nonverbal problem-solving tasks like the Ravens Progressive Matrices are culture-free. A similar conclusion is reached by Ardilo and Moreno (2001) following the administration of verbal and nonverbal cognitive tests to rural Aruaco Indians aged 8 to 30 years. They found that contrary to expectation, nonverbal measures were the least appropriate tests for cultural use in relation to verbal measures.

Spreen and Strauss (1991) report that there are few normative studies of cognitive tests, which are based on large samples of healthy children. They further note that educational and cultural differences may invalidate comparisons of current North American samples, and conclude that further data for subjects grouped by age, sex and intellectual level need to be gathered. The results from our grouped tests for RAVLT are lower than those of a local study and international norms. Similarly the results from the SDMT of this study compared to the provisional scores reported by MacPherson are lower. The following factors may need to be considered. The pupils in our study, although differing in ages from 8-11 years, were all in their third year of education (grade 3). They were all at the same educational level. Other studies may have presented the test scores of children of varying ages, but at different educational levels. Other reasons for the lower scores may be that the study subjects were from a rural area and traditionally in South Africa these areas have been the most disadvantaged (Budlender, 2000)

When considering the Group Mathematics Test, the lower scores of these rural South African children in comparison to Young's data (1995) clearly suggest an educational deficit; these lower scores being more reflective of the raw scores obtained by seven-year-old British children.

8.9 Summary and Conclusion

In summary, the scores of all four tests in the battery are in the lower range. Viljoen *et al* (1994), using a different test (the Bender-Gestalt) also found that comparison of Zulu-speaking and American children indicated a maturity deficit of several years, and suggested that comparisons with other studies must be treated with caution. This is supported by Tarter and Edwards (1986) who have also cautioned that neuropsychological impairment is not necessarily associated with an intellectual deficit or educational difficulties, since children are undergoing cognitive development, which is not complete until mid–adolescence. Grieve *et al* (2000), in her study of university students who also obtained lower scores compared to the norms, suggested that the poorer performance might be due to "limitations in the required ability to deploy cognitive processes because of the lack of the necessary opportunities to develop them". Such observations are not new. For example, both Zindi (1994) and Ardila (1995) suggest that individuals from rural areas are disadvantaged by a lack of familiarity with psychometric testing and that lower scores may simply reflect a failure on the part of the examiner to deploy culturally sensitive tasks of achievement.

Recognising these limitations, a further issue that requires consideration is the relevance and applicability of international test scores for developing country contexts. Viljoen *et al* (1994) noted the lack of normative data for South African population groups and that factors, such as age, cultural, socio-economic and educational backgrounds, are critical in determining test performance and that existing normative data may not be appropriate when used in different populations. This viewpoint is supported by the findings of a recent study by Shanahan, Anderson, and Mkhize (in press) in which Zulu-speakers reported significantly higher levels of psychological distress when compared with their overseas counterparts. These findings may have serious implications for clinicians in making diagnostic judgements for South African populations, based on inadequate normative data drawn from foreign populations.

The educational deficit identified in this test battery clearly indicates the impact of the inferior "Bantu" educational system that African children have experienced in South Africa. The combination of an inadequate educational system coupled with rural poverty, deprivation and under-development has negatively impacted on the cognitive and scholastic development status of these children. This was also reported on by Budlender (2000). This observation suggests that interventions that compensate for these educational and developmental deprivations are likely to further enhance the future capabilities of these children. Viljoen *et al* (1994) noted that it was unclear to what extent his norms of the Bender Gestalt test represented the true capabilities of rural Zulu speaking children subjected to educational deprivation. However, he has suggested that the norms developed by his study for the Bender Gestalt test represented the current capacities of rural Zulu speaking children; and to that extent were clinically useful; and recommended the development of local normative data and valid and reliable assessment instruments in the South African setting. Grieve *et al* (2000), stresses the importance of taking into account the context of test subjects, and not using normative data as the sole basis for the interpretation of test scores. We would place our study in this perspective.

A clear strength of this study was it's cross sectional nature and that it was designed to represent a wide cross section of 8-11 year old school children from rural and urban settings. The battery of tests was designed and piloted specifically for South African school children, to measure a range of scholastic and cognitive functions. The battery was administered under the supervision of a clinical psychologist who also validated the scoring and the marking of all the tests.

There are a number of limitations in our study. Firstly, group administered tests may serve to magnify performance deficits if individual difficulties are not picked up by the examiners during test administration. The extent to which this may have occurred in the current study is unknown.

A second limitation lies in the problems associated with the administration of instruments that are poorly normed and or validated. In this respect, the effects of writing the responses in the verbally presented memory task (RAVLT) may have influenced recall ability. Further validation studies are required in order to show that that this adaptation of the AVLT is a legitimate test of verbal memory.

A third limitation lies in the use of measures that do not permit effective data comparisons. In this respect, the lack of means and SDs on the Group Mathematics Test makes it difficult to make meaningful comparisons between our subjects and individuals on whom the test was normed. In addition, future studies in this area should consider the use of tests and/or data analyses that allow for the separate evaluation of age and education effects in comparison with published normative data.

This study did not explore the relationship between children's scores presented here from the different study sites and socio-economic status of parents, duration of schooling, parental education levels and home language. These issues require further investigation to draw conclusions regarding the relative contribution of these factors to low scores identified.

It must be stressed that individual testing continues to be relevant for clinical interventions. However, for the battery to be of future use for screening and assessing cognitive and scholastic functions in the South African context, group tests need to be field tested in place of the more time-consuming individual clinical assessments. For the development of normative values for a South African population, larger studies that include geography, education, and cultural and socio-economic factors need to be undertaken. The methodological modifications of this test battery, necessitated by field conditions, require that these results be treated with caution and need further validation by larger and more representative future field trials. These results however are presented with all their strengths and limitations. The aim would be to contribute to the methodological development of relevant test batteries for South African school children, especially its application in educational and health development.

Chapter 9: Environmental influences - Prevalence of lead poisoning amongst children in KwaZulu-Natal

9.1 Introduction

Recent epidemiological studies show that mental and behavioural development of children is adversely affected by environmental exposure to very low levels of lead (US Environmental Protection Agency (EPA)1986, Needleman 1993, Hawson *et al,* 1996) and that lead pollution must be regarded as a threat to children's health in every country. At present, information on prevalence of childhood lead poisoning in South Africa (SA) is very limited; and the few studies, restricted almost exclusively to one (Cape) province, suggest that many children in the country are at risk of being poisoned by lead in their environment. For instance, a study of first-grade children in Woodstock, Cape Town found that about 70% of the white children and 95% of the mixed-race children had PbB levels above 10μg/dl, the current action level in the United States, and about 13% of the mixed-race children had PbB levels greater than or equal to 25 μg/dl (von Schirnding *et al,* 1991).

Some indication that elevation of PbB is a country-wide problem comes from recent measurements showing ambient levels of lead in air that are high enough to constitute a hazard to the children in most urban areas. Average airborne lead concentrations in Durban range from 0.4 (residential) to 1.8 (industrial) $\mu g/m^3$

compared to 0.03μg/m^3 in rural areas of the province (Nriagu *et al,* 1996). Reported average concentrations of Pb in air in other cities of South Africa also range from 0.4 to 1.5 μg/m^3, with the values in winter being greater than 1.0μg/m^3 (Albertyn, Personal Communication, 1995). The current average concentrations in SA are similar to those of the urban areas of the United States in the 1970s when childhood lead poisoning was known to be rampant (US EPA 1986).

The objectives of this study were to examine, for the first time, the prevalence of elevated blood lead levels in children in rural and urban communities in KwaZulu-Natal; the risk factors for lead exposure at the level of household; child behavior and parental behavior; and the unique socio-ecological features that predispose the children in an informal settlement to lead poisoning. Blood lead (PbB) levels obtained during the study provide a reference database that can be used to follow changes in childhood PbB levels associated with the introduction of unleaded petrol into South Africa early in 1996.

9.2 Methods: Study design, sites & subjects

This cross sectional prevalence study involved over 1200 children in age groups of 3 - 5 and 8 - 10 years which were selected from communities with different levels of lead in their environments. One study group consisted of Grade I pupils from Vulamehlo, a rural area located about 90-140 km from Durban. The other group was a random selection of children from three sections (Mzomusha, Nhlungwane and Ezimangwane) in the informal settlement of Besters that participated in the study. The study protocols used in Besters and Vulamehlo were somewhat different and are described separately below. EPI-INFO (version 6.0) was used for data analysis.

9.2. 1 Besters

Community support was an important element in the study. Through community consultations, permission and authorization were obtained from the communities of Besters, Mzomusha, Nhlungwane and Ezimangwane, the Inanda Community Development Trust and the City of Durban Health Department. The protocol for the study was approved by the Ethics Committee of the Faculty of Medicine, University of Natal, and sanctioned by Inanda Community Development Trust. Subsequently, community group facilitators were used to identify the housing units for the study, ensure that the children came to the clinic for blood sampling and assisted with collection of soil/dust samples around houses.

The following sub-communities participated in the study: Besters (Sections 1-4), Mzomusha (Sections A, C and D), Ezimangwani (Section 1) and Nhlungwane (Section 4). Survey maps showing the house numbers in each sub-community were obtained from the Inanda Community Development Trust. The house numbers were entered into a computer from which a randomized set of housing units were generated for the study. About 400 housing units were initially selected.

The household questionnaire was developed using the previous health and welfare survey by Jinabhai *et al* (1993), as a guide. In addition to questions on household characteristics, specific questions to explore environmental risk factors for lead poisoning were included. The respondents were also asked to rank the environmental problems in their communities. The questionnaire was tested in a pilot study involving 30 households, or about 7% of the selected sample of housing units.

Experienced Zulu-speaking interviewers from the SA Medical Research Council (Durban) were trained to administer the questionnaire. Each interviewer worked with a facilitator from the community who identified the housing units and served to reassure the residents. The interviewers were told to go to the unit with the next higher number where (a) the selected number could not be found, (b) there was nobody at home, or (c) the occupants were not willing to participate in the study. Less than 10% of the selected household units were replaced in the field for these reasons. The interviewers averaged about eight households per day. The number of households that participated in the study was 384, and contained over 2000 individuals. The survey was completed during July 1995.

The head of the household or adult respondent was asked to sign a copy of the consent form (Zulu translation) and informed as to when to bring the children 3-5 or 8-10 years of age to the community health clinic for further tests. At the clinic, the height, weight and knee-heel ratio of each child was measured. A physical examination was undertaken. About 2.5 ml of the venous blood was draw, by a trained nurse into a lead-free plastic vacutainer containing dry potassium EDTA. The puncture point was cleansed with alcohol, soapy water and then with distilled water. The blood was drawn, carefully mixed with the anti-coagulant and then stored in a cooler box. All samples were frozen as soon as they got back to the laboratory. Of the 637 children (of the correct age group) identified from the questionnaire, 452 actually participated in the study. The high capture rate (71%) can be attributed to the enthusiastic support from the community. Blood samples could not be obtained from about 10% of the volunteers because the veins were too small or the child was too afraid to allow the sample to be drawn safely.

9.2.2 Vulamehlo

The study group was restricted to Standard I pupils (8-10 years old) from the following elementary schools: Dududu, Hluthankungu, Vukaphi, KwaMaquza, Nomandla, Dumisa, Soul, St. Michaels, Tholimfundo and Zamafuthi. All the pupils in each class were asked to participate and each child was given a consent form which was signed by the parent or guardian and returned to the study team. Over 800 children were recruited. Blood samples were collected in June 1995. For the pupils who were not available in late June (which was close to end of the term), a second visit was made in early August to collect the blood; the second set of samples constituted less than 10% of the sample population. The puncture point was properly cleaned as described above. About 2.5 ml of venous blood was drawn into lead-free plastic vacutainers that had dry EDTA. The blood samples were stored in an ice box and when returned to the laboratory, were quickly frozen.

9.2.3 Laboratory methods

A 1 ml blood sample was digested with 10 ml of trace metal-grade nitric acid in a sealed Teflon bomb of a microwave digestion system. The digestion resulted in a clear solution which was diluted to 25 ml with Mill-Q water (Millipore Corp., Bedford, Masachussets). The digestion was done in batches of 12 samples and each batch included a reference blood sample (NIST 955a). The digestion of samples in any batch was repeated if the lead content of the reference blood sample deviated from the certified value by ± 10%. Analysis of blood samples was performed in the School of Public Health, University of Michigan, USA and followed the ultra-clean laboratory procedure developed for water samples with very low metal levels (Nriagu *et al*,1993, 1995).

In particular, all the labware that came into contact were decontaminated by the nine-step process described by Nriagu *et al* (1993). Lead concentration in each sample solution was measured using a graphite furnace atomic absorption spectrometer (GFAAS) equipped with a Zeeman background corrector. Replicate analysis of several samples show the range of error to be + 10% for all blood lead data reported.

9.3 Results

Informal settlements are rapidly expanding in Kwa-Zulu Natal and generally consist of dense shantytowns of self-constructed shelters under different conditions of informal or traditional tenure. The settlements contain over a quarter of the population of KwaZulu-Natal province and are different in terms of shelter type, degree of official recognition and location (Hindson *et al,* 1994). Congregation of large numbers of people into informal habitation in urban areas entails several environmental health risks, such as childhood lead poisoning. The populations of Besters proper, Ezimangwane, Nhlungwane and Mzomusha are estimated to be 50 000, 20 000, 8000 and 7800 respectively (Hindson *et al,* 1994). These settlements are functionally linked to Durban through employment, migration, survival networks, wage incomes and, most recently, administration. In view of the limited information available on these settlements, it was necessary to obtain some basic demographic data for the communities studied.

Key data from the household survey are summarized in Table 9.1.The majority (77%) of the housing units in Besters were built of daub and wattle, 8% of discarded metal/wooden containers and only 6% of brick (Jinabhai *et al,*1993). Most (60%) of the houses have two to three rooms and 47% of the housing units are located less than 100 m from a road. The houses are poorly ventilated (70% of the rooms have one or no window) and 57% of respondents reported roof leaks. The majority (92%) owned their housing units and 80% of the families had lived in Besters for over 3 years. The duration of residence and large percentage of close family relations in the household indicated a stable community.

The number of persons per household varied from one to 20 and averaged 5.4. About 51% of the heads of households attained an educational level of Standard 5 to 10, and 54% of the households had an income in the range of R1-R1000, derived primarily from formal (39%) and self employment (16%). Most of the households obtained their water from communal taps using plastic containers for storage.

Table 9.1: Socio-demographic profile of the study population in Besters

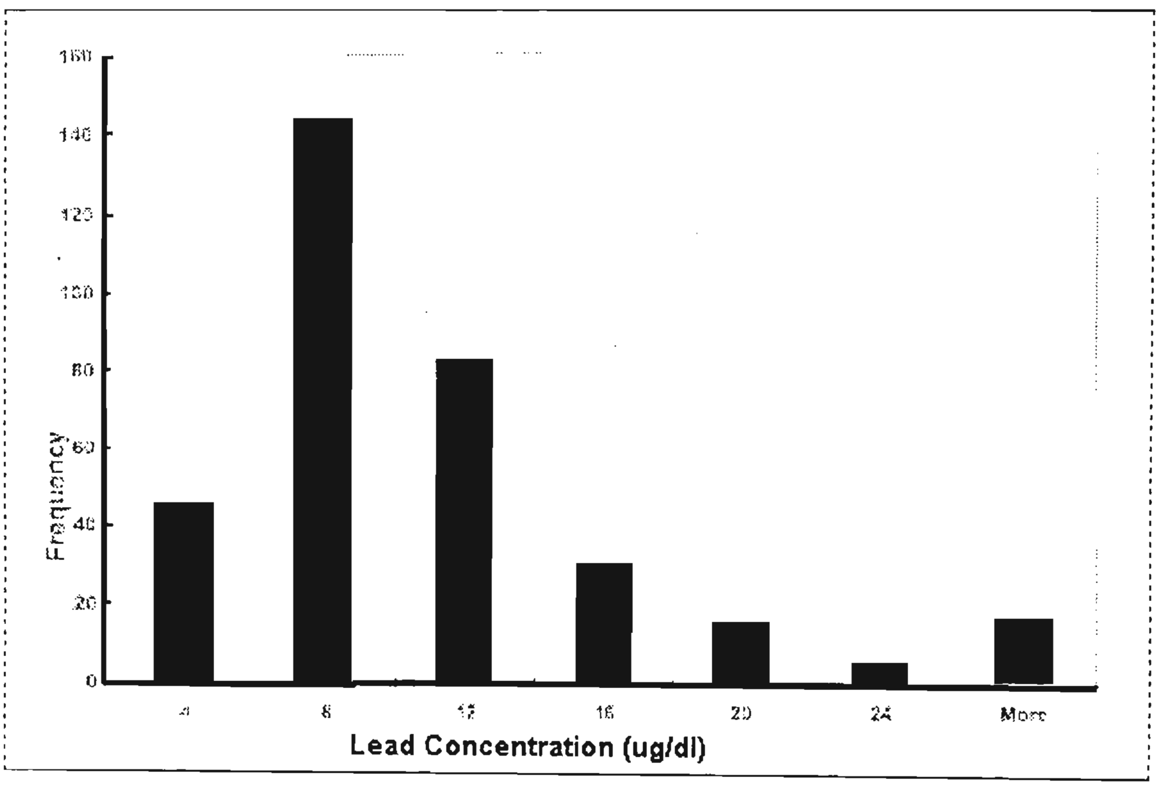
Characteristic feature	Frequency	Percentage
Housing units surveyed		
Besters	215	56
Ezimangweni	55	14
Nhlungwane	42	11
Mzomusha	72	19
Age and sex of children in survey		
3 - 5: male	183	29
3 - 5: female	181	28
8 - 10: male	146	23
8 - 10: female	127	20
Education of household head		
< Std 2	40	10
Std 3 - Std 4	54	15
Std 5 - Std 10	185	48
No schooling	25	6.5
Unknown	80	1.5
Household income/month		
< R 500		34
R 501-R 1000		76
Over R1001		4.0
Unknown		28
Source of income		
Formal employment		39
Informal activity		16
Self employment		7.3
Unemployment		30
Other		8.3
Distance of house from highway or tarred road		
< 100 m		39
100 - 500 m		47
> 500 m		9.1
Number of rooms in house		
1		29
2		45
3+		20
House sweepings/week		
1 – 2 times		1.6
3 – 4 times		4.0
> 5 times		93
Child playing outside		
< h/day		11 (6.6)[a]
3 – 6 h/day		38 (34)[a]
> 7 h/day		29 (31)[a]

[a] for 3 - 5 years old, percentage for the 8 - 10 years old are given in brackets

Litter, lack of sewers for wastewater and animal waste disposal are of particular concern to the residents. There were smokers in 30% of the households and about 49% of the children had respiratory problems. The highest ranked environmental problems from the residents' perspective include overcrowding (97%), inadequate recreational facilities for children (93%), lack of wastewater disposal (85%) and litter (83%). Environmental issues such as food poisoning (9%), acid rain (16%), noise (24%) and air pollution (47%) received lower ranking and may be symptomatic of the level of knowledge regarding lead poisoning. It is evident that education of the community must be an important adjunct to any strategy for reducing the risk of childhood exposure to lead in their environment.

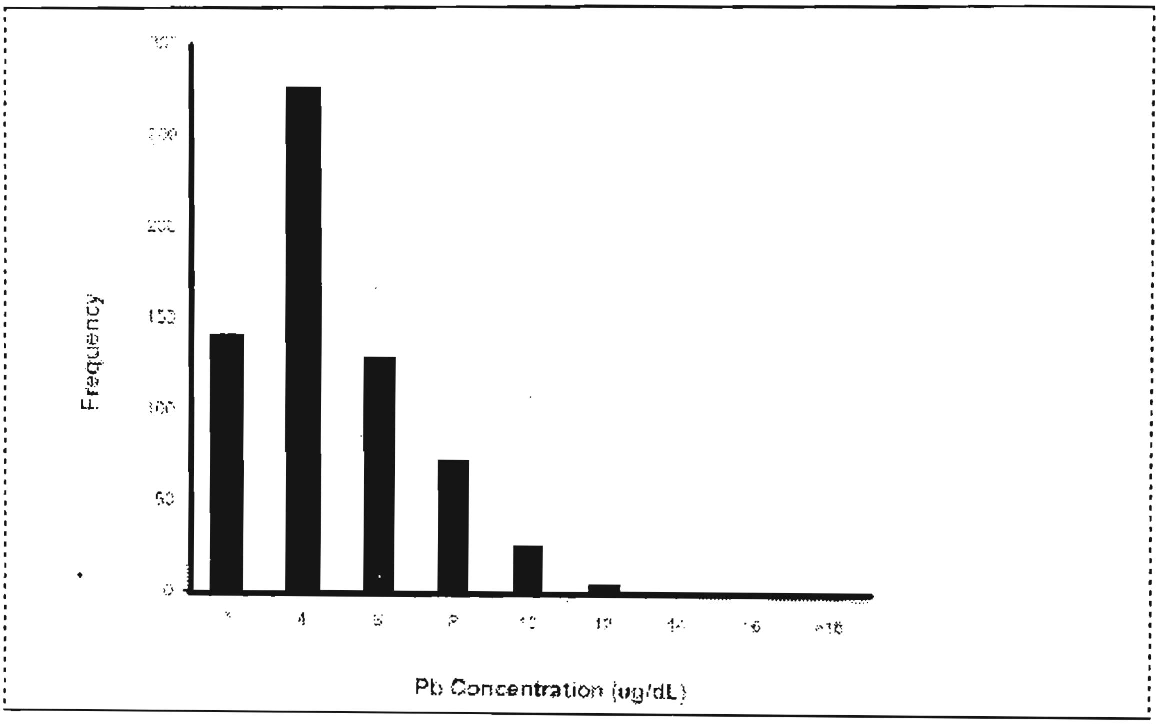
Blood lead (PbB) levels amongst children in Besters showed a skewed distribution (Table 9.2, Histogram 1). About 30% of the children had PbB > 10 μg/dl, a level for concern recommended by the US Centres for Disease Control (1991). About 5% of the children had PbB > 25 μg/dl. Average PbB value for all children was 10 μg/dl. The blood lead values for Besters may be compared with the following recent (1991) averages in various parts of Cape Town: 16 μg/dl (n=243) in Woodstock, 16 μg/dl (n=48) in Schotcheskloof, 14 μg/dl(n=115) in Hout Bay, and 15 μg/dl (n=104) in Mitchell's Plain. In all areas of Cape Town over 90% of the children were reported to have PbB > 10 μg/dl (von Schiriding *et al,* 1995). Higher prevalence of elevated PbB levels in Cape Town is consistent with the observed higher concentrations of atmospheric lead concentrations in that city compared to Durban.

Histogram 1. Blood lead in peri-urban Besters.



The distribution of PbB in Vulamehlo children is surprisingly similar to the pattern for US children, 1-5 years old, during the 1988-1991 period (Pirkle *et al,* 1994). The PbB levels (Table 9.2, Histograms 1, 2) point to the fact that some children in rural areas of KwaZulu-Natal are also at some risk of getting lead poisoning. Mean PbB value for US children was 3.6 μg/dl compared to 3.8 μg/dl (n=660) in Vulamehlo. About 8.9% (5.5.% amongst white children) of the US children PbB > 10 μg/dl compared to 2% in Vulamehlo. The similarity is not surprising since the ambient air concentrations of lead in Vulamehlo (0.03 $\mu g/m^3$) are similar to current levels in many rural and even urban areas of the United States (US EPA 1992). In their study of children from Wupperthal, a rural area in northwestern Cape Province, Grobler *et al* (1985), found average PbB level of 3.4 μg/dl which was claimed to be "representative of background whole blood lead level of South Africans." A number of other studies reported similar high PbB levels (often > 10 μg/dl) in other rural areas of the Cape province (von Schiriding *et al* ,1995). This study found many children in Vulamehlo with PbB in the range of 0.2 - 1.0 ug/dl, well below the so-called "background" value. Furthermore, the PbB concentrations in rural KwaZyulu-Natal are many times higher than the 0.02 ug/dl estimated to be the pretechnological background value for the general population (Flegal *et al,* 1992).

Histrogram 2: Blood lead in rural Vulamahelo



There are major differences in PbB levels in various sub-communities of Besters (Table 9.2, Histogram 1). For all ages and both sexes, highest average concentration (17.4 μg/dl) was found in Ezimangwane. The highest concentration observed (108 μg/dl) was in this neighbourhood and over 10% of the children there had PbB >30 μg/dl. The lowest concentrations (range, 2.6 to 15.6 μg/dl; average, 6.1 μg/dl) were found in Nhlungwane. The neighbourhood disparities can be attributed to differences in length of tarred roads,(hence vehicular volume) proximity to the major highway and to the volume and nature of cottage industries.

In general, PbB levels for children 3 - 5 years old in Besters are higher than those for 8 - 10 year olds, both for males and females (Table 9.2). The difference between the two age groups may be related to the fact that younger children are apt to play in dirty contaminated local environments. For the 8 - 10 year olds, the PbB levels of males are commonly higher than those of females, but there is little difference in PbB between the sexes in the 3 - 5 year age group. It is not clear why the younger children in Ezimangwane seem to be particularly predisposed to excessive exposure to lead.

Average PbB levels in school age children (8-10 years old) in rural areas of KwaZulu-Natal are well below those in Besters (Table 9.2). The difference can be attributed to higher environmental lead levels in Besters. Average atmospheric lead level in Besters was 0.26 μg/m^3 compared to 0.03μg/ m^3 in Vulamehlo.

Average concentration of lead in soils was also higher in Besters (58 μg/g) compared to Vulamehlo (14 μg/g) (Nriagu J Unpublished data, 1996). To a large extent, automobile exhaust pipes account for most of the difference in ambient lead levels of urban versus rural areas, and most likely for the difference in PbB levels between Besters and Vulamehlo. Our results differ from the claim by the South African Department of National Health and Population Development (1992), that the contribution to the body of lead from petrol is extremely small.

Table 9.2: Average blood lead levels (μg/dl) in children from different communities in KwaZulu-Natal

Location [a]	3-5 year old	8-10 year old	Both ages
Mzomusha [a]			
Male	11.6	9.2	10.3
Female		9.5	9.5
Both sexes		9.3	10.1
Ezimangwane [a]			
Male	35.8 [b]	11.6	21.3
Female	18.6	6.6	12.3
Both sexes	24.8	8.6	17.4
Nhlungwane [a]			
Male	7.1	5.8	6.4
Female	6.9	4.3	5.8
Both sexes	7.0	5.3	6.1
URBAN BESTERS			
Male	7.9	8.4	8.1
Female	8.9	6.6	8.1
Both sexes	8.7	7.3	8.1
RURAL VULAMEHLO			
Dududu		3.6	
Tholimfundo		3.0	
Nomandla		3.1	
Zamafuthi		2.3	
Hluthankungu & Soul		3.1	
St.Michaels& KwaMaquza		4.2	

[a] Semi-urban communities in Durban Metropolitan area

[b] This value is biased by a few outliers

[c] Schools in rural areas of Vulamehlo – both sexes.

The questionnaire (used in Besters only) included several items on child and parental risk behaviours as well as household risk factors that may result in undue exposure to lead. Bivariate analysis and analysis of variance was performed using the Mann-Whitney or Kruskal-Wallis test (since the distribution of PbB is skewed, for the two groups with significance set at 90% confidence interval for this study.

Because of the unique socio-ecological features of informal settlements, traditional risks factors identified in many studies may not be valid in Besters. Since most of the households get their water from communal taps, lead in the distribution system is of little concern. No significant association was found between PbB and the type of containers (plastic, metal or earthenware) used to collect or store the water. The daub and wattle structures were rarely painted so that lead paint was not a factor of concern. Amongstst the household risk factors, there was a significant association between PbB and distance of housing unit from tarred roads ($P=0.0673$; $x^2 = 5.4$), number of rooms in the house, ($P = 0.0571$; $x^2 = 12$) number of rooms used for sleeping ($P=0.0857$; $x^2 =8.2$) and leaking roof ($P=0.0627$; $x^2 =3.4$). No correlation was found with the number of times the rooms were swept or the presence of pests in the house. Strong association was found with the type of fuel used in cooking ($P = <0.0001$, $x^2=17$), heating ($P=0.0024$; $x^2=9.3$) (wood, gas, paraffin or electricity) and lighting (candles, paraffin or electricity; $P=0.0022$; $x^2=9.4$)). Whether the child was present while the food was being cooked, or slept in the same room where the food was prepared, did not appear to affect the PbB values. The number of smokers in the house was also significantly associated with PbB (P = 0.0003; x^2 = 21).

There was no significant association between children's PbB and the educational attainment or income of the head of the household. This should not be surprising; other risk factors should overide the minor differences in socio-economic conditions in the settlement. In fact, the community was selected for study so as to minimize the socio-economic determinants of childhood lead exposure. Blood lead levels were not significantly associated with a number of child risk behaviors, such as where they played (around the house, on the street or the park), number of hours played outside per day, sucking of thumbs or frequency of hand washings per day. The significance of the associations, or lack thereof, are discussed below.

9.4 Discussion

This study demonstrates that many children in semi-urban areas of KwaZulu-Natal have PbB above 10μg/dl. A small number of children in rural areas also have PbB above this level of concern. The habitation pattern for Durban and other cities of South Africa (SA) is rather unique in that the affluent communities live in inner cities and the economically deprived communities (mainly Africans) are confined to peri-urban or rural areas. This has implications in terms of the exposure of different racial groups to lead. A recent study found average airborne lead levels in Durban to be 1.8, 0.86, 0.56 and 0.56 μg/m^3 in industrial, commercial, park / beach and residential areas respectively, compared to 0.26 μg/m^3 in Besters, a semi-urban community (Nriagu *et al,* 1996). These elevated atmospheric levels suggests that large numbers of children in the inner city of Durban, regardless of the race, are at risk of being exposed to lead poisoning. In addition, houses in the older parts of the city may contain lead pipe and lead paint. The prevalence of chronic lead poisoning observed in Besters may be symptomatic of a widespread public health problem throughout the Durban area. A cross-sectional study to ascertain the cultural differences in susceptibility to lead poisoning in Durban is urgently needed.

Lead pipe (water contamination) and lead paint are not important risk factors in Besters so that the major sources of lead exposure are likely to be food, air/dust/soil and traditional medicines. Dietary exposure to lead in SA is basically unknown. Since few households in Besters or Vulamehlo possess refrigerators, the people presumably depend mostly on fresh produce or canned foods. Although a number of food brands use lead solder (from a brief inspection of shelves of a local food store), the practice is uncommon. It is conceivable that some of the children with elevated levels of PbB have derived their excess lead from habitual consumption of cheap cans of food with lead solder.

Traditional medicines are still widely used amongst the Zulu population of KwaZulu-Natal. Our survey, however, found that local clinics and hospitals were preferred by 82% of parents and care givers in Besters. Other potential sources of lead exposure in local townships include local pottery glazed with lead, and rainwater collected from contaminated roof tops. Regardless of the exact pathways, this study clearly demonstrates that the combined routes result in lead exposures that are excessive, likely to produce disease and need to be reduced.

The disparity in average PbB values in Besters and Vulamehlo helps to put the relative contributions from various sources in perspective. With few roads, no electricity, no pipe-borne water, no hospitals, few clinics and an economy based on subsistence farming, children in Vulamehlo are more likely to be exposed to lead from traditional local foods, medicines and other sources. Average PbB in these rural children have risen (3.8 μg/dl) but are small compared to those in Besters (10 μg/dl). The difference (6 μg/dl) can be atributed to lead pollution in the air-dust/soil, continuum of the urban environment. It is not surprising that there is a significant association of PbB with distance of housing unit from a road in Besters.

The absence of significant relationships between PbB and child risk behaviours in Besters is contrary to what is typically found in other countries (Gottlieb *et al,* 1994; Norman *et al,*1994) or even in formal settlements in the country (von Schirnding 1988). The dustiness of these settlements would result in extensive contamination of both indoor and outdoor environments, and this could have obscured the effect attributable to how long or where the child plays outside.

Correlation with heating and cooling is probably related to the fact that many types of lead-containing material (printed paper, cardboard boxes, painted woods and other solid wastes) are often used for these purposes. Sweeping of the floor with a broom would only serve to resuspend contaminated dusts in the air and would offer little protection to the child. Association of PbB with the number of rooms in the house, the size of the household or roof leak indirectly reflects deficiencies in hygienic habits of individual households.

The importance of cottage industries on childhood PbB levels in local townships should be noted. A substantial fraction (25%) of the heads of households had informal jobs, or were self employed. Common service repair activities in homes in these settlements involved appliances, batteries, electronics, welding and painting. Lead solder and lead compounds used in such activities can result in extensive contamination of the home environment. This strongly suggests that exposure to lead from informal cottage industries may be responsible for some of the elevated PbB values in both Besters and Vulamehlo.

Although lead poisoning (in its acute form with defined clinical symptoms) is a notifiable medical condition in South Africa, few cases have been reported during the past 5 years. A number of studies, however, have reported high prevalence of chronic lead poisoning in the paediatric population of the Cape province (von Schimding *et al,* 1988, 1991, 1995; Deveaux *et al,* 1986).

Our study shows, for the first time, that large numbers of children are also at risk of being poisoned by lead in KwaZulu-Natal province especially in urban areas. There is little published data on PbB levels amongst children in other provinces. Chronic plumbism in children chould, in fact, be expected in most cities of SA, since recent studies have shown elevated levels of airborne lead in urban areas. Public awareness of the health hazards of lead poisoning remains very limited in the country and little attempt is being made to identify and control the sources of lead exposure.

The primary potential source of airborne lead in most urban areas is the automobile exhaust pipe. A risk reduction strategy that has been adopted by most developed countries involves reducing lead levels in petrol. This has been accompanied by sharp declines in PbB levels in many segment of the population (von Schirnding *et al,* 1988, 1995; Stromberg *et al* ,1995). Lead content of petrol sold in South Africa was reduced from 0.84 g/l in 1983 to 0.4 g/l in 1989, and early in 1996 unleaded petrol was introduced (von Schiriding *et al,* 1995; Nriagu *et al,* 1996). This may not alleviate the problem of childhood lead poisoning, since only a small fraction (30%) of atmospheric lead emission in the country comes from motor vehicle emmissions (Nriagu *et al,* 1996). More importantly the unique socio-ecological features of rural and urban South African communities suggest that the trajectory of change in PbB will be different from that reported in Europe or North America. For instance, a study of children, 4 - 6 years old, in the Cape found no difference in average PbB levels between 1982 and 1991 (von Schirnding *et al,* 1995), even after the reduction of lead content of petrol by half.

Reference has also been made to the close similarity in PbB of rural children in the Cape in 1982 (Grobler *et al,* 1985) and Vulamehlo in 1995. Maresky and Grobler (1993), found a small reduction in PbB of Cape Town residents, from 9.7 μg/dl in 1984 to 7.2 μg/dl in 1990.

Table 9.3 : Distribution of blood lead levels (μg/dl) in Umlazi children [a]

Age	Blood lead levels (μg/dl)			
(years)	**0 - 10**	**11 - 19**	**> 20**	**Total [b]**
0 – 3	52	106	13	171 (27%)
4 – 7	33	131	17	181 (28%)
8 – 11	81	145	4	230 (36%)
> 11	25	29	1	55 (9%)
Total [b]	191(30%)	411(65%)	35(5%)	637

[a] These samples were analyzed by the National Centre for Occupational Health (NCOH), Johannesburg by graphite furnace atomic absorption method.

[b] Percentage of each age or blood lead category is given brackets

Table 9.3 shows the PbB content of blood samples obtained from children in Umlazi in 1985 (Unpublished study, Department of Community Health, 1985). Umlazi is a formal (African) settlement in the southern part of Durban (both Umlazi and Besters are now part of the new Durban Metropolitan system). The study involved 637 children from birth to the age of 13 years. The remarkable thing is that the average PbB in Umlazi (12 μg/dl) and prevalence of values above 10 μg/dl (65%) are only slightly higher than those of Besters even though the samples were taken 10 years apart.

The studies cited above tend to suggest that the susceptibility to lead in the environment may be different and that the rate of change of PbB in South African children following the introduction of unleaded gasoline will likely be much slower than reductions in reported rates in developed countries. Socio-ecological factors of African townships, likely to affect the exposure and rate of PbB change include excessive dustiness, narrow streets and overcrowding, vibrant outdoor lifestyle, prevalence of contaminated rain water, malnutrition, poor hygienic conditions, cottage industries, use of lead-containing medicines and cosmetics, and endemic communicable diseases (Nriagu 1992).

9.5 Conclusions and Recommendations

The South African constitution has enshrined the right to an environment that is not harmful to health; and rights to equity, justice and social development; while the government has also signed the Convention on the Rights of the Child (CRC). In keeping with these fundamental rights, the Department of Environmental Affairs and Tourism has adopted a policy of sustainable resource management as part of a national environmental policy, which involves investigating the health implications of domestic fuel use and vehicle emissions of leaded petrol, with a view to developing an integrated pollution control strategy (Dept. of Environmental Affairs 1995).

This study supports the need and urgency for such investigations and provides a timely database that can be used to follow the decline in PbB levels of children in KwaZulu-Natal in response to the removal of lead in petrol sold in the province. Exposure to atmospheric lead pollution constitutes a serious public health problem that is amenable to preventive actions. It presents important challenges for health authorities to reduce these exposures and the resulting blood lead levels, to eliminate the associated impairment of mental development.

In summary, the prevalence of elevated blood lead (PbB) levels in rural and semi-urban areas of Kwazulu-Natal as well as the risk factors for elevation of PbB amongst children in informal settlements are presented. The study investigated over 1200 children in two age groups - 3-5 and 8-10 years old. Average PbB level in Besters, an informal settlement in the Durban metropolitan region, was 10 μg/dl with 5% of the children showing PbB level of greater than 25 μg/dl. By comparison, average PbB value in Vulamehlo, a rural area located 90-120 km from Durban, was 3.8 μgldl and 2% of the PbB was greater than 10 μg/dl. The results show that many children in KwaZulu-Natal are at risk of being poisoned by lead. Household factors significantly associated with PbB levels in children include distance from tarred roads, overcrowding, hygienic habits in the household and the burning of solid wastes for heating or cooking. Lack of significant association with childhhod risk behaviours is attributed to the overiding influence of high levels of contaminated dusts both indoors and outdoors. Despite the recent introduction of unleaded petrol in South Africa, a number of unique socio-ecological factors are expected to slow the change in PbB levels of children in some townships and rural areas.

Chapter 10: An evaluation of School Health Services in KwaZulu-Natal, South Africa

10.1 Introduction

An important component of understanding the epidemiological status of school children is the strategies, programmes and services through which these problems can be addressed. The strategy of Health Promoting Schools (HPS), through the existing School Health Services (SHS) system, integrated with other health, education and development polices and services, offer both important opportunities to address the health problems identified in this study, as well mechanisms for the current and future monitoring and on-going evaluation of the health status of school children.

Over the last few years The National Departments of Health (NDOH) and Education (DOE) have produced a number of policy documents that provide a strategic and institutional framework for the development of an integrated school-based educational and health service. These draft guidelines provide a framework and context for implementing the recommendations that emerged from this evaluation (Department of Health 2000). Globally, a number of international agencies have also begun to develop policies, strategies and programmes to explore the potential role and contribution of SHS to promoting and protecting the health of this neglected group of children (Dolan 2000). These perspectives are summarised in Fig. 1 and Table 1.2 in Chapter 1 of this thesis. The policies that deal specifically with SHS will be reviewed in this chapter, and their potential contribution will be explored in the discussion.

School Health Services (SHS) offer an opportunity to access large numbers of children for interventions that can improve their health. School Health Services' focus incorporates prevention, early diagnosis, treatment and referral of health problems. This is a vital contribution towards achieving Primary Health Care (PHC) goals, particularly for this important target group of children and young people. Studies from many countries emphasise that health and nutritional problems have a significant impact on school participation and performance (Leslie and Jamieson 1990).

KwaZulu-Natal is the third poorest province in South Africa with a population of about 9 million people of whom 97% speak Zulu at home. Of these, 62% live in rural areas and many lack access to piped water, adequate sanitation and electricity. The province has over 5 000 schools with an enrolment of 2.8 million pupils. Many of these schools are situated in rural areas, which have limited access to health facilities (Education Foundation 1996). In many cases, the health problems of pupils receive inadequate attention. The School Health Services provides an important opportunity for on-site identification of health problems, treatment, referral, and preventive and promotive health care for children who may otherwise not be reached by other health services.

The history of KwaZulu-Natal has had a significant impact on the current situation of School Health Services. Previously there were 5 administrative structures with differing policies, resources and management. This project aims to assist in the development of a coordinated quality School Health Service based on the principles of equity and efficiency.

10.2 Purposes of Study

This study investigated the role and contribution of School Health Services in KwaZulu-Natal as a programme for implementing micronutrient supplementation, deworming and other health interventions to improve the health of school-aged children.

10.2.1 Objectives

Aspects of the School Health Services that were investigated included the services provided and their distribution; assessment of health inspection; health education and referral processes undertaken by the School Health Teams; perceptions of managers, providers and recipients of the service; and the costs of the provision of the service in KwaZulu-Natal. These are schematically presented in Fig. 6.

Fig. 6: Objectives of the SHS Evaluation

To describe the activities and distribution of the School Health Services in KwaZulu-Natal

To assess the health inspection and the process of referrals

To review the School Health Services from management's perspective

To describe how providers and recipients view the School Health Services and their recommendations for improvement

To determine the nature and content of health education in schools and the role of the school health nurse.

To determine the cost of the School Health Services and providers' utiliisation of resources

In order to

↓

To make recommendations to management about the School Health Services

10.3 Methods, Study design & Subjects

This was cross sectional descriptive study investigating several components of SHS, to provide a comprehensive picture of SHS in KwaZulu-Natal. Table 10.1 illustrates the study design for each component of the study (as listed in Fig. 6) and the target groups.

Table 10.1. Objectives, Study design and Target groups

Objectives of the study	Study design	Study sites, target groups and sample sizes
Situational Analysis of School Health Services Distribution of services	Self-administered, structured postal questionnaire	All School Health Team Members in KwaZulu-Natal (293)
Perceptions of parents, pupils and teachers towards SHS	Interview admin. Questionnaire for parents & pupils	Health inspection and referral process 26 schools in Health Region B; 12 referred pupils per school - plus parents/ caregivers
	Key informant interviews	9 persons from 5 health administrations
	Separate focus group discussions with parents, pupils and teacher	15 schools from Health region B (165 pupils, 97 parents, 115 teachers)
Cost analysis	Cost and output information	All teams rendering SHS in KwaZulu-Natal

10.4 Results

Data in respect of each component of the study will be presented – starting with the province-wide Situation Analysis of the quantitative and qualitative features of the services, coverage, impact and resources of the SHS and then the perceptions of pupils, parents and management for the effective rationalisation of the service.

In KwaZulu-Natal there were School Health Teams in all the 8 health and education regions in the province. In total there were 95 teams in the province, consisting of nearly 300 members –of these 149 respondents answered the postal questionnaire (51% of the sample). While they have been coordinated provincially since 1994, many have continued to operate according to their previous guidelines. As an example, School Health Teams vary considerably from area to area, depending on the administrative authority. While a professional nurse leads them all, they vary in size from a team of 7 to only one person. The staff within the teams also varies in qualifications. The number of schools and pupils targeted by the teams also differs considerably. School Health Teams in rural areas contend with added difficulties, as many rural schools are situated in areas with poor roads and no telephones; and in rainy weather access to schools is difficult.

Fig. 7: Qualification profile of school health teams

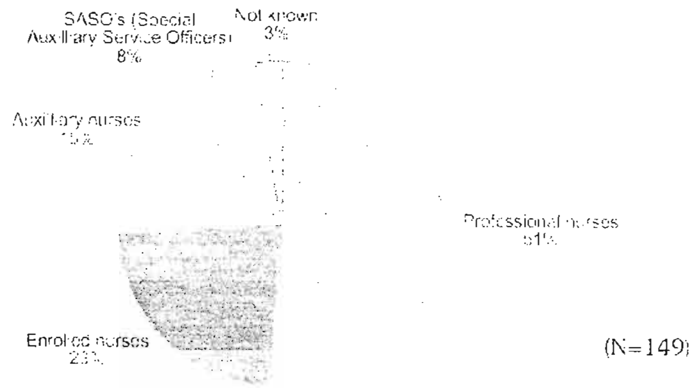


Fig. 8: Gender profile of school health teams (N=149 - 51%)

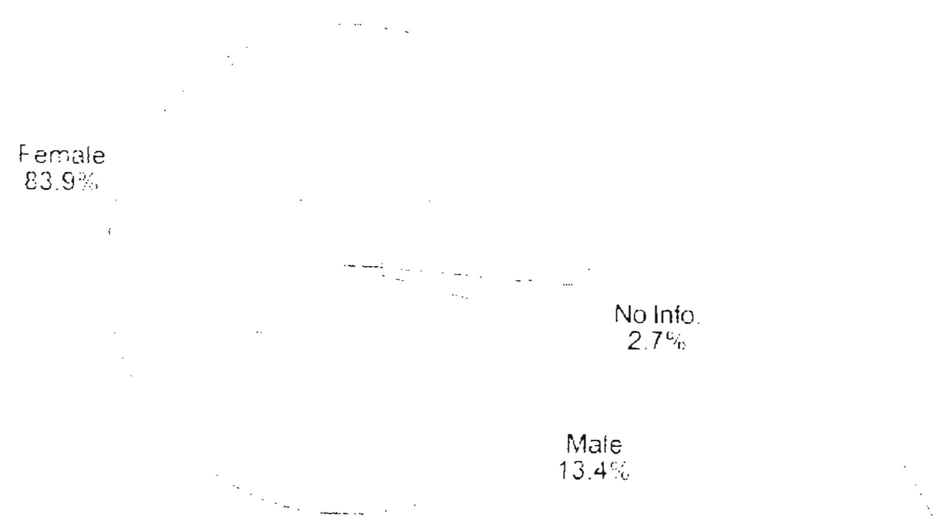
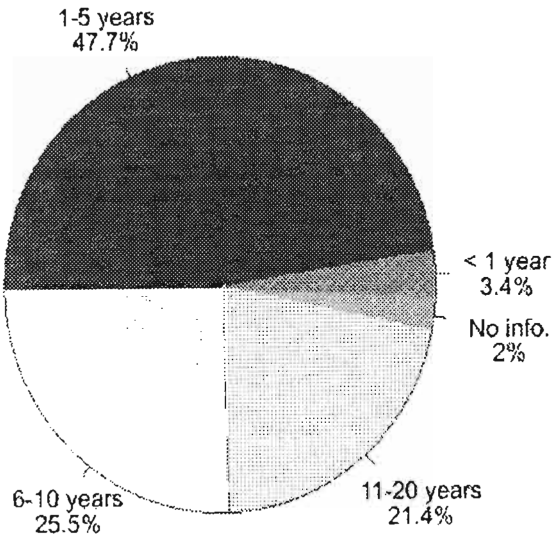


Fig. 9: Duration of service of School Health Teams



Mean duration of service 6.7 years

10.4.1 Main Activities of School Health Teams

The School Health Teams were involved in a wide range of activities: 74% of all teams were involved in health inspection, and 80% were involved in health education. Other important activities included home visits, immunisation and community projects. 5% of teams were involved in dental treatment, 5% in environmental health, 7% in general primary health care activities and 3% were involved in programmes for children during school holidays.

The profile of activities for each team depended on many factors, most importantly the previous administrative structure. Many school nurses, particularly those from the more rural-based School Health Teams, spent a considerable amount of their time involved in activities not directly related to school health. For example, many were involved in provincial immunisation campaigns, community projects or other primary health care activities. While these are clearly important activities, they do divert the time from school-based activities.

10.4.2 Pupils targeted by School Health Services

The large number of schools and pupils in KwaZulu-Natal meant that not all the children in all the classes could be screened or examined. It was thus necessary to target classes, so that the school nurse saw every child at least once during his/her years at primary school. The classes that were targeted by most teams were grade 1 and grade 6.

10.4.3 Coverage of SHS

Only 10.7% of School Health Teams managed to visit all the schools that were targeted for the year. School Health Teams targeted between 2 and 168 schools each year, and the number of schools visited by each of the School Health Teams ranged from between 0 to 105. Only teams with a target number of 35 or less succeeded in visiting all their schools. The total number of children reported screened and/or examined was estimated at 453 227 providing coverage for about 18% of all the pupils, with an average of 5 737 pupils seen per team. School Health Teams are required to do a second follow-up visit to each school to check that the identified health problems have been addressed. Only 11% of respondents indicated that they had carried out follow-up visits to all their targeted schools.

These data also illustrate the considerable differences between the administration of School Health Services between those who were previously under the KwaZulu and NPA NHD departments. The ex-KwaZulu teams targeted many more pupils, but these targets were not met. The ex-NPA teams provided medicines for minor ailments and this could be the reason for their referral rates being the lowest.

10.4.4 Impact of School Health Services

In 1995, of the 803 schools in Region B, only 302 schools (36%) were visited by the School Health Services. In this region, there were 21 School Health Teams with a total of 37 staff. Thus the impact of the programme on the lives of the majority of the pupils was questionable, because of the inadequacy of the service provided.

However, of the pupils that were screened or examined by the School Health Services, 27% (16,813) were found to have health problems and 9,297 of these were referred. This indicates that a large number of children had health problems which, without the School Health Services, would have gone unattended.

10.4.5 Health Problems

Interviews were conducted amongst 212 randomly selected pupils from health region B - 73% (156) had been previously seen by a school nurse. Common problems included dental caries (28%), eye problems (17.9%) and skin problems (12.2%); while other problems included tonsillitis, chest problems, stomach ache, worms, bilharzia, malnutrition, epilepsy, hernia, undescended testes, and rape.

10.4.6 Referrals Patterns

Of the 156 pupils who had been seen by a school nurse, 108 (70%) were given a letter of referral for further attention to the problem. However, only 53% of these children actually went for treatment. More children went for treatment in urban areas than in the rural areas. Reasons given for not going for further treatment ranged from lack of money (20%), no time (12.5%), parents not perceiving the need for treatment (12%) and use of home remedy (7.5%). Another important problem was the lack of referral to specialist services for the SHS teams. These included social, mental and psychological services. This was particularly acute in the rural areas.

10.4.7 Perceived Role of School Health Teams in Health Inspection

Pupils appreciated and welcomed the role and contribution of the school nurses and described them as helpful, caring and professional. Pupils requested that the nurses should dispense medicines so that their health problems would receive prompt treatment. Parents recognised the importance of the school nurses and appreciated their practical assistance. They realised that the school nurses had the requisite professional skills and knowledge to identify health problems that would remain undetected. Teachers also recognised the importance of the nurses in identifying health problems that they had not detected. They were concerned about the lack of follow-up and requested that there be greater amount of liaison and information sharing between the nurses, the education sector (teachers) and the community.

10.4.8 Perceived Role of School Health Teams in Health Education

Pupils regarded health education as necessary, informative and interesting and requested more sex and AIDS education, as well as information about first aid. Parents requested more sex education in schools as they expressed their concern about teenage pregnancy. Teachers expressed the urgent need for age-appropriate sex education and indicated that they would be prepared to assist with health education. They also expressed concern about child abuse, and requested more information on First Aid.

10.4.9 Summary of Problems

Problems as identified by the school health teams	Problems as identified by parents, pupils & teachers	Problems as identified by the school health management
• Poor / insufficient transport • Too many schools and pupils to visit • Too few staff • Inadequate equipment	• Irregular visits to schools • Poor targeting of classes & pupils • Lack of money and medicines for referrals and treatment • Inadequate liaison between parents, teachers and school nurses	Irregular visits to schools • Lack of accountability, monitoring of expenditure and performance • Lack of resources • Poorly motivated staff • Poorly defined role of school health services within the district health system

10.4.9.1 Human resources

Insufficient school health staff was noted as a serious problem in this study. This is evidenced by the poor coverage that the service is able to achieve. When school health staff was interviewed, this was identified to be one of the most serious problems by 57% of all staff. They attributed this to the large number of schools they were expected to visit and the high enrolment figures at schools.

10.4.9.2 Transport

School Health Teams consistently complained about the problem of transport. These included complaints about insufficient vehicles, lack of repair of vehicles, sharing vehicles with other services, and unsuitable vehicles.

10.4.9.3 Equipment

Many School Health Teams (59%) were concerned about their lack of basic equipment. This included equipment needed for health education, as well as that needed for basic medical examinations (e.g. audiometers)

10.4.9.4 Medical Supplies

There was no standard policy concerning the availability of essential drugs by School Health Teams. Some were able to prescribe while others were dependent on referring children, even for minor ailments that could easily have been immediately treated by the school health nurse. This largely depended upon the previous administrative authority. The arguments against providing treatment included the inability to obtain parents' permission for treatment and concerns over the administration of medication. However, those school nurses who were unable to prescribe felt that this detrimentally affected the delivery of the service.

10.5 Cost Analysis of KwaZulu-Natal School Health Services

The total cost of delivering School Health Services in the province in 1995 was estimated to be approximately R8 750 000. The average unit cost of screening a child was between R42 (range R31 - 63). The cost for personnel and transport form the bulk of the costs of the School Health Services. It is reported that scarcity of resources available for the provision of School Health Services means that the objectives of this services cannot always be met. However there are poor information systems and lack of co-ordination and accountability, which means that cost data should be interpreted with caution. This requires urgent attention. The process of obtaining costs and details on the services rendered by the teams proved to be an extremely difficult one. In many instances there were little or incomplete records kept on costs. There was also a lack of standardisation in the records kept on service provided, and on the children who were screened. In most cases, not only were teams not recording costs, they were also unaware of what money has been allocated or budgeted for them. In cases where budgets did exist, nurses were not aware of their existence. Costing was further complicated by the fact that many School Health Teams, particularly in the ex-KwaZulu areas, shared resources with the clinics or hospitals where they were based. No records were kept as to where resources are split between these services.

10.5 Discussion: Implications and Challenges

This study investigated the quantitative and qualitative characteristics of SHS in KwaZulu-Natal, during a period of transition from the pre to a post apartheid system. It found that many of the features of the previous governments policies and service delivery systems were still in place as the newly established departments struggled to transform them.

The results of the study indicate the poor coverage of pupils by the School Health Services. This is a cause for concern, particularly in the rural and ex-KwaZulu areas, where the need is greatest. The inequitable distribution of services was very evident in this study, where there is one school nurse to 10,000 students in urban areas, compared to one nurse for nearly 90,000 in rural areas. The service would be more effective if there was improved targeting of services. In other words, the School Health Services need to be shifted from the relatively well-resourced areas; where they are currently providing relatively good coverage, to the poorer areas; where the coverage is inadequate. School Health Services should be able to respond to the differing needs of the various communities. This study showed that in some areas this would mean concentrating on problems associated with inadequate sanitation and dirty water, whereas in other areas priority needs concern overweight and issues of violence. Given the rise of HIV and AIDS in the province, School Health Services are going to need to play a central role in not only prevention, but also in assisting with the acceptance of HIV positive children within schools. The focus by the World Health Organisation on 'Health Promoting Schools' offers opportunities for encouraging community support and increasing health awareness.

The School Health Policy Guidelines (NDOH 2001) and the Triasano policy of the Department of Education (NDOE) provide a legislative and strategic policy framework for the transformation of the SHS described in this study. Both the

National Departments of Health (NDOH) and Education (NDOE) have over the last few years produced a number of policy documents that provide a strategic and institutional framework for the development of an integrated school-based educational and health services. The School Health Policy Guidelines (NDOH 2001) produced by the Maternal, Child and Women's Health (MCWH) Directorate (NDOH) in conjunction with the Child Health Policy Institute (CHPI) of the Child Health Unit, UCT, summarises the benefits of expanding SHS and its integration into existing health and education policies.

The World Health Organisation (WHO) defines a Health Promoting School (HPS) as a school that "continuously strengthens its capacity as healthy setting for living, learning and working". It is furthermore described as "a school, which aims at achieving healthy lifestyles for the total school population by developing supportive environments conducive to the promotion of health. It offers opportunities for, and requires commitments to, the provision of a safe and health-enhancing social and physical environment." It is a global initiative that is based on health promotion principles. The five components of a Health Promoting School has been derived from the key objectives of the Ottawa Charter a guiding document of health promotion:

- The development of healthy policies at all levels including schools
- The development of health-related skills of the school community
- The provision of services that can respond appropriately to the needs of the school community

- Community action and participation in the development of the school as a healthy setting
- The establishment of supportive environments, both physically and through the school culture, for health and development

10.5.1 Department of Health

The 1997 White Paper on the Transformation of the Health Sector, and the Draft National Health Bill (1999), presents the framework for the transformation of the health system in South Africa into a unified national health system. The plan for the national health system is based on the principles of the primary health care approach that emphasises community participation and health promotion. The policy focuses on districts as the major locus of implementation. An integrated package of essential PHC services has been made available to the entire population at the first point of contact, and priority is given to the provision of maternal, child and women's health services. Specific principles and objectives relating to the health of school-aged children include:

- Nutrition programmes should be integrated and sustainable, and target the most vulnerable groups, especially children and women.
- MCWH services should be comprehensive and integrated, and should be accessible to mothers, children, adolescents and women of all ages.
- Individuals, households and communities should have adequate knowledge and skills to promote positive behaviour related to maternal, child and reproductive health.

- MCWH services should be efficient, cost-effective and of a good quality.
- The mass media will be used to popularise key prevention concepts and develop life skills education for youth in and out of school.
- A comprehensive and community-based mental health and related service (including substance-abuse prevention and management) should be planned and co-ordinated at the national, provincial, district and community levels, and integrated with other health services.

10.5.2 The Adolescent and Youth Health Draft Policy

A holistic and integrated approach to health is presented in this document that covers children and youth aged 10 to 24 years. It prioritises the following health priorities for this group: sexual and reproductive health, mental health, substance abuse, violence, birth defects and inherited disorders, nutrition and oral health. The National Guidelines for the Development of Health Promoting Schools (HPS) provides the framework for the delivery of school health services.

10.5.3 Department of Education Policy – Tirisano "working together"

The Tirisano policy framework "A Call To Action: Mobilising Citizens To Build A South African Education and Training System for the 21st Century" aims to improve conditions in the public schools system, and the implementation plan has five core programme. Of these HIV/AIDS, school effectiveness and teacher professionalism and organisational effectiveness of education departments are of particular relevance for the development of HPS.

In summary, the current policy and strategic framework of the two main government departments – Health and Education – are converging to address the problems identified in this study. It is important to note that current budgetary constraints are likely to limit the ability of Provincial Health Departments to provide a fully-fledged SHS. Current priorities for Health Departments are to develop an efficient and functioning PHC services and as these services expand to consider developing SHS as part of the overall PHC based District Health System.

10.6 Conclusions & Recommendations

This study showed that teachers, parents and pupils all consider the School Health Services to be very important. This is supported by international literature which clearly illustrates the unique role of School Health Services in identifying children with health problems which otherwise may go undetected (Dolan 2000, World Bank 1999). The coverage of this service is generally poor with only 10.7% of all School Health Teams reporting that they had visited all their targeted schools for that year. The total number of pupils screened and/or examined during 1995 was estimated to be about 500 000, representing approximately 18% coverage. In addition, there was poor follow-up of services. This is important given the results of this study, which showed that only a half of all referred students actually end up going for treatment.

School Health Services were found to mainly target primary school children. Health inspection was focused on grades 1 and 6, with some other classes also receiving health education. This does appear to be appropriate targeting, however, given the inequitable coverage of the School Health Services. This is a cause for concern, as many of the most needy schools do not receive these important services.

The majority of teams had limited resources to adequately deliver the service. These included a shortage of personnel, transport and equipment. KwaZulu-Natal suffers from serious management problems resulting from the previous fragmentation of the province, varying policies and protocols, inequitable distribution of staff, and undefined roles and responsibilities. This is made worse by poor information systems, which are not standardised and are uncoordinated, yet consume a considerable amount of valuable staff time. This needs urgent attention. Mechanisms for feedback are virtually non-existent in most areas of the province. This makes rational decision-making extremely difficult and requires urgent attention.

School Health Services need to be part of the core package of primary health care services, and should be an integral part of all district health systems. At present, district health systems are slow to develop in KwaZulu-Natal, and in many areas the boundaries suggested for health districts do not coincide with those suggested as education districts. This is an area of concern and does not encourage intersectoral collaboration. At present, School Health Services are unable to provide all the services that they would wish to. They have a potentially important role to play in curative services, as illustrated by this study, where without School Health Services, many children with service health problems would have gone undetected. They also have an important role in health education. However, given the current inadequate staffing, they are unable to provide both preventative and promotive services well. It is therefore essential that there is some prioritisation of services that are delivered. In addition, it is important that further research is done on a core package of services, which should be provided by all School Health Teams. The cost of delivering this service also needs to be evaluated.

Recommendations

The overarching recommendation is that the current and future draft policy guidelines reviewed above should be approved by the respective national and provincial authorities for implementation to address the uncoordinated, fragmented and poorly resourced SHS, as part of an integrated DHS.

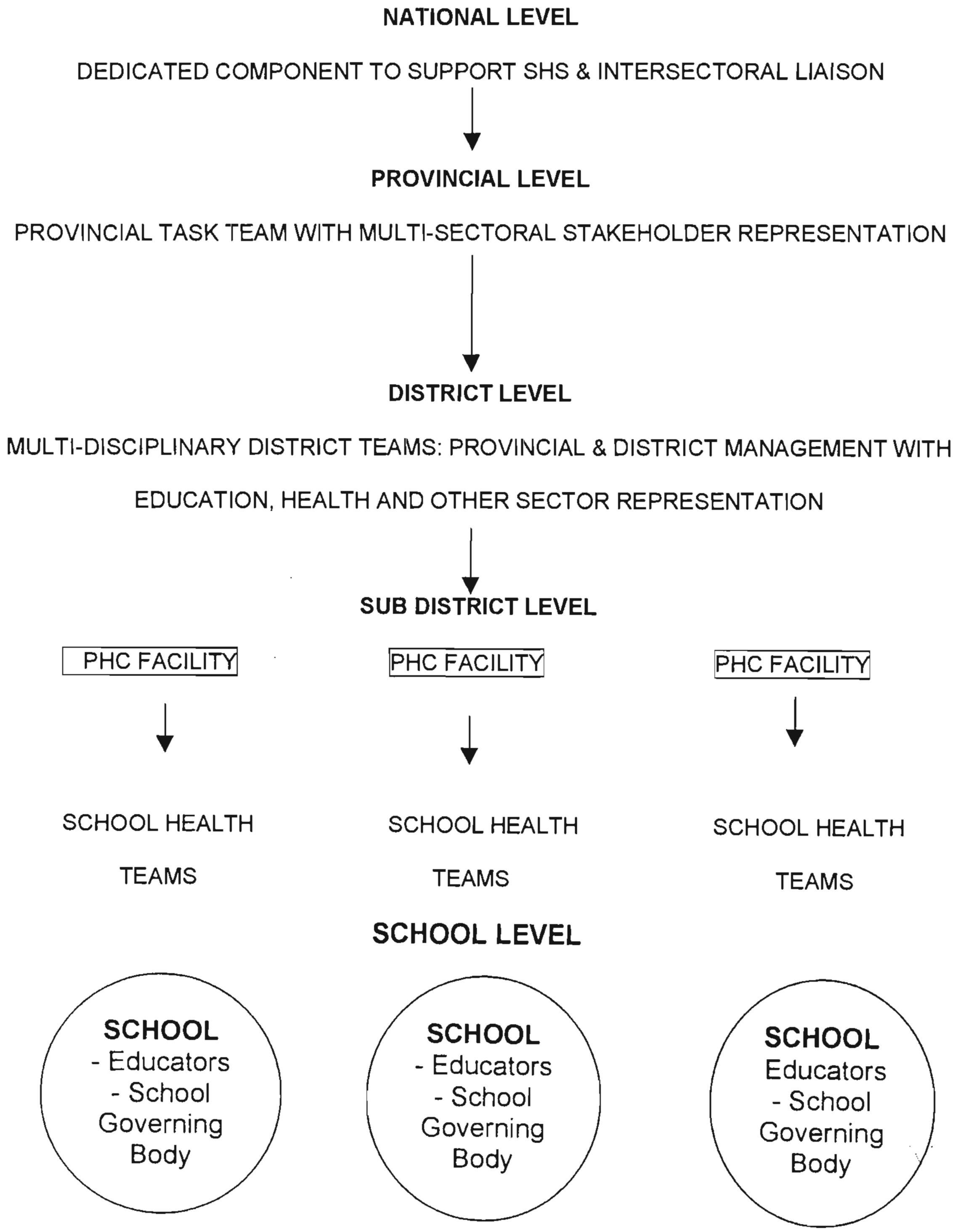
There needs to be commitment from the Department of Health at the national level about rendering School Health Service. While most operational decisions should be left to the provinces, guidance and direction is needed from the national level - particularly at this time when the provinces lack experience and capacity. This particularly relates to setting standards for what should be provided within the package of School Health Services, monitoring and information systems.

Provincial policy is required to address issues such as:

- setting standards of care
- the core packages of services to be offered by all School Health Teams
- targeting of schools and pupils
- redistribution of resources

At the regional level, there needs to be a coordinator who can monitor standards, provide support and supervision, and give feed-back of statistics collected by the School Health Teams. School Health Services should become the responsibility of the district health services. They should be responsible for their own budgets, and accountable to the district management. Districts should consider developing "Health Promoting Schools", with School Health Teams being a central resource. Many of these recommendations have been adopted by the draft School Health Policy Guidelines of the NDOH. The models proposed by these Guidelines provide for a co-ordinated system of service delivery, integrated with the DHS - as outlined in Fig. 10; while Fig.11 provides a framework for the inter-sectoral co-ordination of other services and programmes, with SHS.

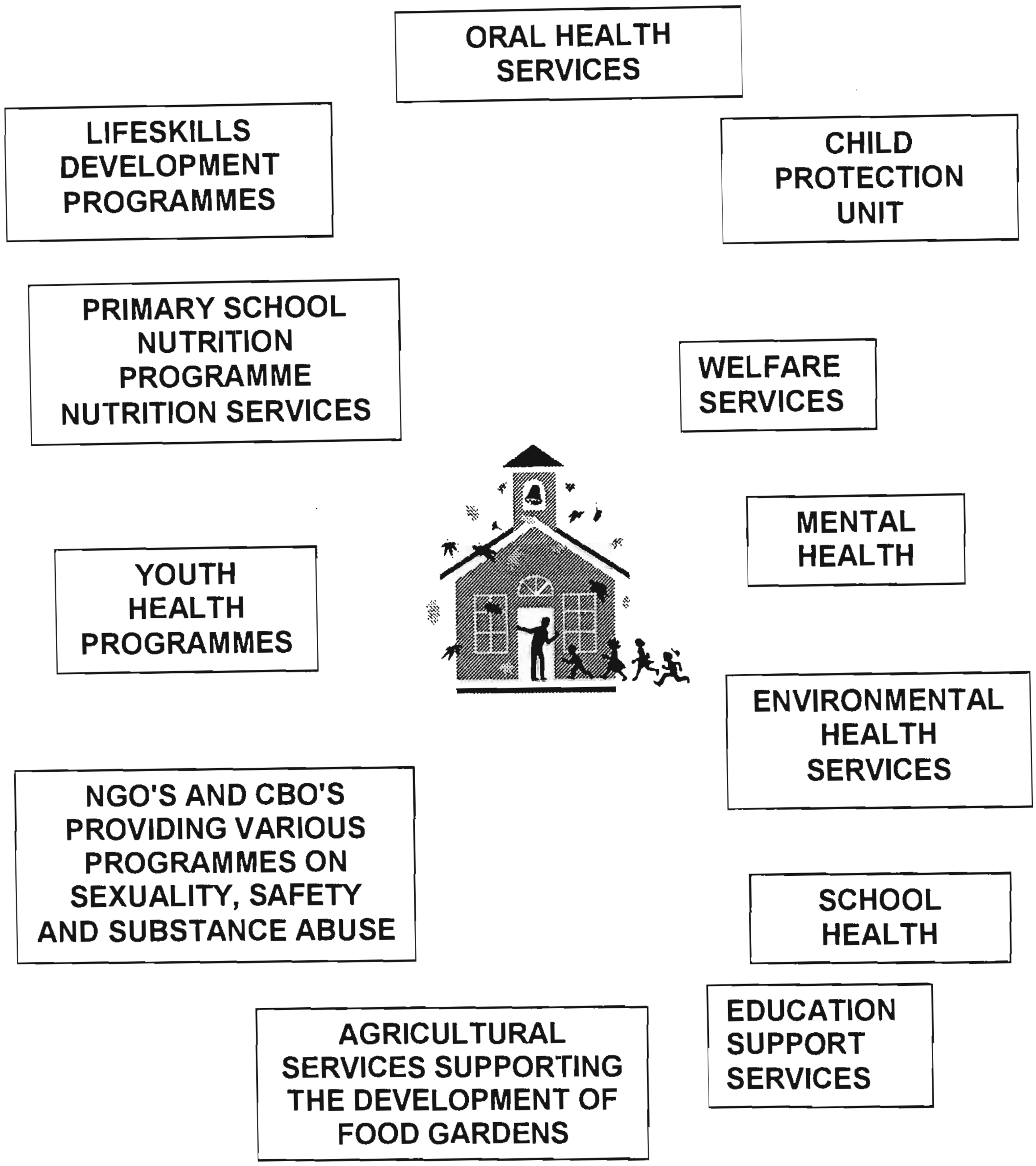
Fig. 10: Model of delivery (NDOH Policy Guidelines)



Source: Adapted from Department of Health (2001). School Health Policy Guidelines. Child Health Sub-Directorate, Maternal, Child and Women's Health Directorate, Pretoria.

* School health teams: PHC nurses, social workers, psychologists, environmental health officers, health promoters and other staff targeting school aged children linked with school health committees in addressing the health needs of school communities, to provide training and service.

Fig. 11: Schematic Map of health and development programmes targeting schools



Source: Adapted from the Department of Health (2001). School Health Policy Guidelines. Child Health Sub-Directorate, Maternal, Child and Women's Health Directorate, Pretoria.

Chapter 11: Discussion, Conclusions and Recommendations

11.1 Introduction

This overview chapter summarizes the clinical and epidemiological aspects of the health status of school children in KwaZulu-Natal; reviews the existing policy and programme context for addressing these issues; and makes recommendations for further research. In respect of the primary purpose of this thesis, this epidemiological study has established that school children face a number of public health problems, as summarized below, and that the burden of the health problems identified amongst pre-school children by the SAVACG study is also prevalent amongst school children. This study has clearly established that the assumption that school children are healthy because they have "survived" the morbidity and mortality of childhood is not valid. The neglect of this age cohort is no longer acceptable and serious attention and resources need to be directed to address the health problems identified. This is vital if we are to safeguard the health and development of future generations.

11.1.1 Epidemiological and Nutrition Transitions amongst School children

The finding of an unacceptably high prevalence of stunting co-existing with a rising prevalence of overweight and obesity (and other diseases) is a clear indication of the epidemiological and nutritional transition occurring in South Africa and many other middle income and developing countries. This evidence suggests that this may be the early stage of changes in the nutritional profile of school children, which has important implications both both for the nutritional transition and the potential for developing chronic diseases in adulthood. There were significant associations both in respect of the rising prevalence of overweight rural and urban school children, and for the time series analysis. Although these findings are based on different cross sectional studies, represent secondary data, and therefore need to be interpreted with caution – they nevertheless suggest a clear trend towards increasing overweight and obesity. Projections of these trends over time, and extrapolation of the increasing proportions of school-aged children surviving from childhood illnesses, suggest an emerging crisis. There are three important considerations concerning this crisis. Firstly, these trends reflect the impact of Westernisation, and especially the adoption of diets which are high in saturated fats, sugar and refined foods, and low in fibre. Secondly, the potential for developing chronic diseases in later life is increased. And thirdly, the implications for the form and content of health services delivery require attention. It is critical that low and middle-income countries facing rapid changes in dietary practises, physical activity and obesity, learn from the lessons of higher income countries and try to direct the nutritional transition in more healthy directions (Popkin 1994).

A similar pattern of school children at risk emerges with regard to micronutrient deficiency and parasite infections. Compared to the findings from the SAVACG study of pre-school children and previous studies of school children, the prevalence of anaemia, vitamin A deficiency and parasitaemia appear to be declining. However, these prevalence rates, in terms of internationally accepted WHO criteria, would still be regarded as public health problems requiring intervention. Anaemia and vitamin A deficiency are associated with reduced immunity and increased morbidity and mortality. Both anaemia and parasite infections have been associated with deficits in intellectual and scholastic performance and reduction in active learning capacities. Investments in school feeding programmes and educational enhancement programmes are likely to have limited benefits, unless these underlying problems are addressed.

11.1.2 Combining micronutrient supplementation and deworming interventions

While previous studies have examined single interventions to address micronutrient deficiencies or parasite infections, this study has established that some of these health problems can be significantly reduced through a combination of micronutrient fortification and deworming interventions. The significant improvements in vitamin A and parasitic status as a result of the combined health interventions create opportunities for the health and education sectors, in consultation with communities, to alleviate these problems. The recommended combination of micronutrient supplementation and deworming interventions need to be linked to other interventions such as school feeding programmes. Such interventions would address the primary outcomes of macro and micro-nutrient deficiencies, parasitic infections and poor cognitive status as well as the related outcome of developing integrated comprehensive school health policies and programmes, as outlined in the rationale for the conceptual framework of this study (Table 1.2). These interventions have been identified as cost-effective investments in health and education (del Rosso, 1996).

11.1.3 Assessment of Cognitive & Scholastic status

This is one of the first studies to examine the physical health status of school children in relation to their cognitive and scholastic performance. While the psychological test battery that was developed in this study was specifically for the purpose of measuring performance before and after the health interventions, it has relevance and applicability in the wider context of health and educational sector reforms. Both Health and Education Departments have adopted an holistic approach to improving the overall development of school children, and to maximise their investments. They have recognised that achievements of high educational outcomes require improvement of both the health status of children and educational infrastructure. Measuring the impact of these interventions requires the regular assessment of the cognitive and scholastic performance of children. Refinement and further development of this test battery is required to establish its validity, relevance and acceptability under South African conditions in rural, peri-urban and urban settings.

More importantly, we need to address the poor performance of the school children on this test battery, compared to national and international "norms". This study strongly suggests that the educational deprivations of the previous apartheid government, coupled with the generally poor socio-economic, environmental and educational circumstances, appear to be primarily responsible for this poor performance. This is supported by other studies by Grieve *et al* (1999), and Richter *et al* (1994), who have found similar levels of poor performance amongst South African students. Although the sample size of the children from the semi-private model C school was small, the test performance from this "advantaged" school clearly suggests that improvements in socio-economic circumstances are likely to lead to improvements in educational outcomes. There has been a complex discourse on the role and value of psychological tests in South Africa. Many psychologists and activists have been critical of the way in which the HSRC in particular, developed and applied these tests amongst different race groups to attempt to justify racial and cultural differences in aptitude - and therefore the policies of apartheid (Owen 1998, Nell 2000). While these debates concerning the ability of psychological tests to assess intellectual, cognitive and scholastic performance in different communities will continue; this study has identified the following important reasons why these tests may be useful and necessary in the post-apartheid period. Firstly, it is critical to have a measure of the full spectrum of the (school) child's development: – physical, social, psychological and scholastic - to assess developmental potential. Secondly, it is important to assess changes over time, and to establish trends between and within communities and regions: this could help to identify areas of inequity and under-development. Thirdly, the impact of the multiple health, social, educational and developmental interventions that the SA government and the private sector has undertaken, need to be evaluated – to measure both the benefits and cost effectiveness. This could assist in targeting – universally or selectively – groups, regions and age and gender cohorts. Finally, some of these psychological tests are useful for counselling students, advising them on subject and career choices; and assisting teachers, parents and employers in career development (Owen 1998). Scientists and practitioners need to broaden the focus of the discourse from a polemical nature to address the needs of the public health and education sectors for relevant assessment tools.

11.1.4 Impact of Environmental Circumstances

A consequence of industrialisation and urbanisation is the exposure to atmospheric pollution, and the consequent finding of increasing levels of lead in the blood of rural and urban school children. This finding is especially disturbing since lead poisoning adversely affects cognitive and intellectual functions and haematological status. This is likely to aggravate the adverse impact of existing nutritional deficits and parasitic infections. All three of these factors have a cumulative impact on scholastic performance of school children. Just as in the case of school feeding programmes where the call has been made to feed the child and not the worms, likewise in the case of school enhancement programmes, attention would have to be given to reducing adverse environmental exposure to atmospheric lead.

11.1.5 Integration of interventions with health & education policies, programmes and services

Each of the chapters dealing with the specific aspects of the problems investigated in this epidemiological study has identified the magnitude (prevalence) and some of the associated risk factors in exploring the multi-factorial aetiology, and describes the impact on the physical and the psycho-social development of school children, and the potential benefits from multiple interventions. While clinical interventions at the level of each individual child are important, from a public health perspective it is important to target a wider audience of children, parents, teachers, policy makers and professionals in provincial and national departments of health and education.

Factors at the macro level such as policies, programmes and services – which function at provincial and national levels - are also influenced by global strategies of international agencies such as WHO, UNICEF, UNESCO, and the World Bank. Other factors at an intermediate level (such as dietary practices and school feeding programmes, school, household and environmental circumstances, and education services) also directly affect the status of the school child (Fig.1.2). Thus there is a need for appropriate alignment of health interventions aimed at children – in schools or at community level - with policies and strategies at all of these levels (Table 1.2). A review of existing policies, strategies, programmes and services through which the identified health interventions could be mediated clearly established the potential to favourably impact on the overall development of school children.

The evaluation of SHS in KwaZulu-Natal, in the context of the legislative, policy and strategic goals of the Departments of Health and Education, reveal a significant gap between political commitment and service delivery, and a general lack of convergence. While a number of excellent policy documents and carefully thought out strategies exist at the national level, these have been poorly adopted or implemented at the provincial or district levels. This is unfortunate since the findings of this study, confirmed by other research evidence, clearly indicates the value of implementing many of the recommendation made in the preceding chapters (CHU, 1997). Likewise, existing programmes such as the School Health Services and the PSNP still remain vertical programmes and suffer from a lack of management capacity, resources and strategic focus. The lack of implementation in respect of the considerable opportunities that exist to substantially improve the health and well-being of school children requires urgent action – both at governmental and community levels. This is important since South Africa has ratified the United Nations Convention on the Rights of the Child (1996), which commits the government to fulfil its legal and constitutional obligations to children. This prioritisation of children in the country is expressed in the government's First Call for Children, which resulted in the creation of a special role for children in the Constitution (CHU 1997).

How best can this evidence be used to inform policies and programmes, and to develop integrated approaches to address these multiple problems facing school children? These multi-factorial interventions cascade through several levels: local (school and community based), provincial and national departments, and global (WHO, UNICEF, UNESCO, PCD, World Bank) (Table 1.2). Over the last few years, the South African government has implemented a number of far reaching policies and strategies. Three policies which have a direct impact on school children, have been reviewed - the Primary School Nutrition Programme (PSNP); the School Health Policy Guidelines (which include the strategy of Health Promoting Schools (HPS); and the District Health System (DHS) policy. (As distinct from *policies and strategies*, each one of these *programmes and services*, offer considerable potential to directly impact on school children. They would also serve to overcome the existing gap between national polices and local service delivery.

- **Primary School Nutrition Programme**

It is important to stress that the current PSNP and its predecessor, the NNSDP, were not primarily school feeding programmes. The NNSDP included many components; including school feeding, self help schemes, cottage industries, gardening and skills development. A national evaluation of the Primary School Nutrition Programme (PSNP) undertaken by the Health System Trust - (HST 1997) to provide a comprehensive assessment of its main problems, weaknesses and strengths, and its management and implementation – found that:

- The PSNP has been limited to being a vertical school feeding programme
- Deworming, nutrition education and micronutrient supplementation - considered to be more cost-effective interventions than school feeding - have not been systematically implemented as part of the PSNP
- There is inadequate management capacity
- The coverage of school feeding has been poor and inconsistent
- The feeding often happens at an inappropriate time of the day
- there is sub-standard quality and quantity of food
- Some of the foods may also have a negative impact on healthy eating habits.

The HST report recommended the development of stringent criteria for school feeding, including targeting to fewer schools; using a needs-based formula for the allocation of funds to schools; and improvement in the management system, taking into account the under-resourced nature of many rural communities. This should include monitoring and evaluation - focused on process and outcome indicators - in order to optimise the quality and quantity of school meals, with the energy content of the school meal not dropping below the current guideline of 20% to 25% of the recommended daily allowance (RDA) for energy. It further recommended that the PSNP should be transformed from being a vertical feeding programme to being a comprehensive school nutrition programme - as part of a broader package of priority school-health activities of the national Integrated Nutrition Programme (INP) - with adequate funding, incorporating a school-based micronutrient supplementation programme; and to provide appropriate mass treatment for parasites and nutrition education (Fig.12).

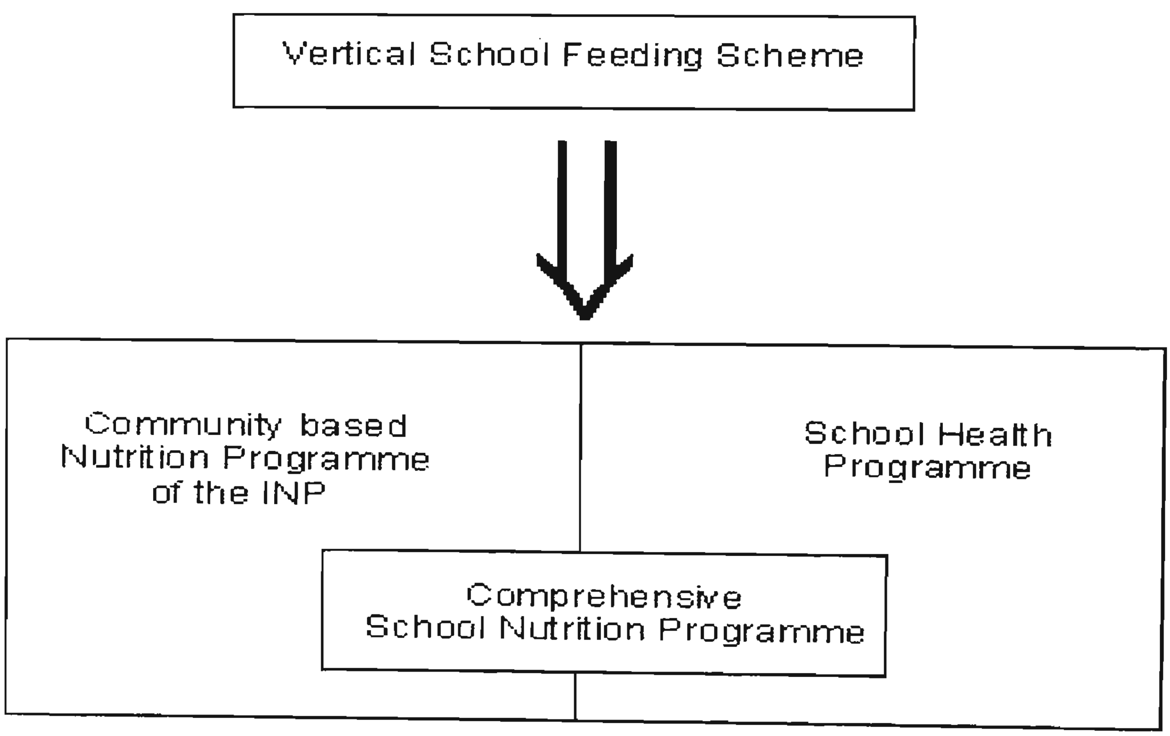


Fig.12: Developing an Integrated School Nutrition Programme

The transformation of the PSNP and its integration into the INP and School Health Policies should be part of a comprehensive School Health Programme. The evaluation recognised the potential in that "the PSNP could be utilised as a catalyst for the development of school health programmes involving parent committees in the promotion of school health; and as a spring-board for the development of community-based nutrition programmes" (HST 1997).

- **School Health Policy Guidelines**

The need to integrate the existing nutrition programmes into the SHS has received support in the draft School Health Policy Guidelines (Department of Health 2001). It recognises that there are more schools than clinics and more educators than health personnel, and that school settings therefore provide a unique opportunity to access a large proportion of the population at a critical age to influence their choices for healthy lifestyles and improve their long-term health status. The school infrastructure and education system provides various facilities and mechanisms for promoting health through the curriculum, as well as being available to health workers for direct interventions to children. In addition, schools provide links to families and the broader community. These relationships allow for the spreading of health and development promotion beyond learners attending the school. As mentioned in an earlier chapter, the Department of Education has embarked on a major review of the school curriculum, with a strong focus on Outcomes Based Education (OBE) (Education Foundation 2000).

The proposed goal of school health is to promote the optimal health and development of children and the communities in which they live by developing a comprehensive school health service, operating within the framework of Health Promoting Schools, that responds equitably to the varying health and development needs of learners.

Fig.13: The following specific objectives for HPS have been identified:

- Re-orientate existing school health services to function within the Health Promoting Schools framework
- Render SHS within the comprehensive PHC approach
- Identify and manage the health needs of the learners in partnership with the school community,
- Facilitate the creation of a safe and healthy environment in schools, that supports the healthy development of children and the communities in which they live
- Support the school community in addressing barriers to learning
- Facilitate the use of participatory and peer education methods such as Child-to-Child for the development of health related skills
- Use and strengthen the existing referral systems and community resources
- Monitor and evaluate the progress of the service on an ongoing basis and to use the information for planning and improving the service
- Conduct research relevant to the needs of school children and the development of the service

Fig. 14 A number of principles have been enunciated

- School health services should be established within the framework of Health Promoting Schools
- SHS should be prioritised within a comprehensive and integrated PHC system, with adequate resources and political commitment
- School health services should operate within a multi-disciplinary context, co-ordinated with programmes in other sectors making maximum use of existing resources
- Services should be equitable and accessible to all children in schools
- Parents and children should be actively involved in their health care
- Children should be the primary focus of the service
- The rights of children should be upheld and promoted by the kind and quality of health services provided
- School health services should be appropriately informed by local priorities and culture
- School health policy should take cognisance of policies of the other key departments particularly Education policies

The principles and objectives of the SHS identified above are exemplary. They provide a framework for addressing many of the programme elements identified in this thesis and for developing integrated approaches. Likewise, the package of SHS identified would go a long way to meet some of the short-term needs of school children, for curative, promotive and rehabilitative care. School health services should be available to schools, and local PHC services be represented on school based health teams. The services selected in the minimum package make maximum use of this contact time. The delivery of these services should be informed by a situation analysis of the local priority health needs of school-aged children and the locally available health and development resources.

Important areas of health education and promotion include HIV/AIDS prevention; hygiene and sanitation; growth and development including healthy lifestyles; sexuality and lifeskills; nutrition and safety; and accident prevention. In summary, these guidelines provide an important framework for the implementation of SHS programmes at district and local levels.

Fig. 15 THE PACKAGE OF SHS

- Vision screening
- Physical examination
- Monitoring nutrition status
- Oral hygiene monitoring and education
- Immunisation guided by national EPI
- Health education and promotion
- Monitoring chronic and infectious health conditions
- Treatment of minor ailments
- Counselling
- Referral

11.2 Methodological issues

Two innovative features of this thesis are the application of the IOTF guidelines for the assessment of overweight and obesity, and the development of a test battery to measure cognitive and scholastic performance. To the best of our knowledge, this is the first time that the recently developed IOTF criteria for assessing over-nutrition have been applied in South Africa, and possibly in Africa. At national and international levels, much discussion has occurred about the appropriate reference population to use for international comparisons and the relevant cut-off points to quantify the prevalence of over-nutrition (WHO 2000, Cole *et al,* 2000). The recently released IOTF guidelines have addressed both these concerns and developed a new set of curves based on an intemationally representative population, using the widely accepted adult cut-off points for overweight and obesity. A major omission in the development of this international data set was the lack of any data samples from Africa. The results of this study not only contribute to this gap in our knowledge of these trends in African countries, but also serve to assess the validity and reliability of the IOTF reference curves. While the trends identified in this study needs to be treated with caution since some of the data were from secondary sources as indicated previously, there is a clear trend towards over-nutrition amongst rural and urban school children from all community groups.

The development, application and interpretation of the psychological test battery is however more complex and fraught with problems. There has been considerable discourse around the issue of cross-cultural reliability of any test measure –

scholars have questioned the usefulness and application of tests across cultures (Nell 2000). For the purposes of this study, the primary objective was to investigate the impact of a set of health interventions, to assess changes in psychological status - under controlled conditions – and to interpret these changes with specific reference to the interventions. Further interpretations of the results of this test battery outside this context, and generalisations to the wider population, require further reliability and validity checks of the test battery. Again, in this study, the general trends and the overall distribution of the test scores in relation to local and international normative data, have been recorded. Comparisons with other published studies confirm the findings of our study that overall, the performance scores of the school children are in the lower ranges - attributable to educational and environmental deficits - as confirmed by other published work, Grieve *et al* (2000), Viljoen 1994.

11.3 Lessons from international experiences

A number of global initiatives reviewed in the earlier part of this thesis suggest that their policy and strategic content has much of value. However, the main limitation of many of these international initiatives is the need to make them specific to our country, region and district. This study in KwaZulu-Natal has established a sound epidemiological foundation of the status of school children. This would serve as the framework for selectively integrating those aspects of the global programmes that are relevant, effective and appropriate for South African conditions. Having identified the health problems confronting school children and demonstrated the value of combined, integrated intervention, the challenge is to draw from international experiences and lessons so as to rationalize and focus existing resources to maximize their impact. Caution needs to be expressed with regard to multiplicity of objectives, strategies, programme funding and reporting and accountability processes of the international, non-governmental and donor agencies. South Africa has a substantial body of experience, resources and epidemiological, technical and programme skills to be able to develop context specific programme. Partnerships with intemational agencies need to ensure that these goals are fulfilled.

11.4 Conclusions

This study has investigated the epidemiological and health status of school children in urban and rural parts of KwaZulu-Natal and established the following epidemiological profile.

- ANTHROPOMETRIC STATUS
  Stunting, declining prevalence of wasting in rural children
  Increasing prevalence of overweight & obesity – especially urban children

- MICRONUTRIENT STATUS
  Anaemia, vitamin A deficiency, low serum ferritin.

- ENVIRONMENTAL EXPOSURE
  Increasing blood lead levels – lead poisoning in urban children

- PARASITE INFECTIONS
  Endemic parasite infestations – geohelminths & schistosomiasis

- COGNITIVE & SCHOLASTIC PERFORMANCE
  Lower scores compared to local & international norms.

In conclusion, the most important aspect of all of these epidemiological studies is that they have explored the ***cumulative impact*** of multiple factors – nutritional and dietary deficiencies, parasitic infections, adverse environmental exposures (to lead) – on a comprehensive range of indicators of the health and development of school children. This thesis has attempted to explore the multiple dimensions affecting school children, some of the interactions amongst these epidemiological factors and to identify points of intervention that would have optimum impact. The results of this study have important implications for current and future policies, programmes and services aimed at school children. The central feature of this collection of studies is that the status of the school child is adversely influenced by many factors. This recognition of the multi-factorial aetiology of the identified health problems requires integrated strategies, programmes and services. Furthermore, the findings presented in this thesis provide strong evidence of the benefits and value of maximising the impact of such comprehensive, integrated interventions. These benefits include the synergies inherent in multiple interventions, including their cost-efficiency and effectiveness. Demonstration of effectiveness and impact is likely to stimulate mobilisation of additional resources.

11.5 Recommendations

These can be grouped into two levels: specific and general recommendations.

11.5.1 Specific recommendations

1 The components of the nutritional transition identified in this study – stunting co-existing with increasing overweight and obesity – calls for nutrition programme that provides:

a) school feeding for the malnourished child
b) dietary control and physical activity for the overweight, and
c) nutrition education for the broader community.

2 Combined micronutrient and deworming programmes targeting those schools and communities identified as at risk. WHO recommends that parasite prevalence exceeding 50% calls for universal deworming programmes at least twice a year. Both geohelminths and schistosomal infections would need to be targeted in this province.

3 The existence of sub-clinical vitamin A deficiency exceeding 30% requires a vitamin A supplementation programme, preferably linked to a food fortification strategy. Ideally, this should be linked to the calls for similar vitamin A supplementation of pre-school children.

4 The identification of anaemia calls for additional iron supplementation – linked to the above vitamin A supplementation programme.

5 With respect to lead poisoning, all those children exceeding the 10μg/dl of blood lead levels require monitoring, while those exceeding the 25μg/dl level require clinical intervention.

11.5.2 General recommendations

1 Existing guidelines such as those for School Health Services should be adopted immediately and all provinces and districts should begin to develop plans and programmes for their implementation. The establishment of the SHS is urgent, and serves as the primary vehicle for implementation of the above-mentioned specific recommendations, and the delivery of the other components of the HPS strategy and the PSNP.

2 The draft policy on Health Promoting Schools (HPS) be finalised and serve as the strategic focus and foundation for comprehensive programmes, through the SHS.

3 The existing PSNP and the recommendations arising from several evaluations of this programme be implemented and integrated into the SHS. As noted above, a specific school-feeding component should be identified, targeted to malnourished children, and should include the elements of vitamin A and iron supplementation and deworming. The nutrition education component has to address both the elements of malnutrition and over-nutrition.

4 Establishment of an epidemiological surveillance system with the following functions:

a) confirm the trends identified in this study, specifically the prevalence of stunting, overweight and rising blood lead levels

b) monitoring and evaluation of all policies and programmes and their impact

c) define criteria for targeting school children – geographically, in terms of needs

d) contribute to the process of resource allocation.

5 Methodological development of appropriate cut-off points for measuring overweight and obesity; and an appropriate and relevant battery of tests to assess cognitive and scholastic performance. With respect to the former, the IOTF guidelines need to be further tested, and comparisons made with other measures of nutritional status such as the NCHS standards, to confirm validity and reliability.

6. Assess the recommendations of the international agencies, and review the lessons from global experiences as to their relevance and applicability in terms of the policies, programmes and existing services in South Africa. While much can be learnt from such best practises, caution needs to be exercised in adopting these recommendations without assessing their relevance and potential for integration into existing programmes.

7. Further research areas that are identified, include:

- Investigation of the nutritional changes and potential for transition and the value of the new IOTF cut-off points for measuring the prevalence of overweight and obesity.
- Development of locally valid cognitive and scholastic test batteries, especially for use in the school setting
- Measuring the impact of atmospheric pollution, specifically the consequences of lead poisoning on the cognitive development of children.

8. International experiences are critically evaluated to assess the relevance for SA conditions, and appropriately integrate the lessons and experiences into policies and programmes.
9. Finally, the above recommendations need to be considered in the context of the budgetary, personnel, management and other constraining factors facing the public health sector. The above recommendations provide the conceptual and strategic perspectives. The practical implementation of these recommendations requires a rigorous analysis of the management and resource capacity of each component of the public health service for its implementation.

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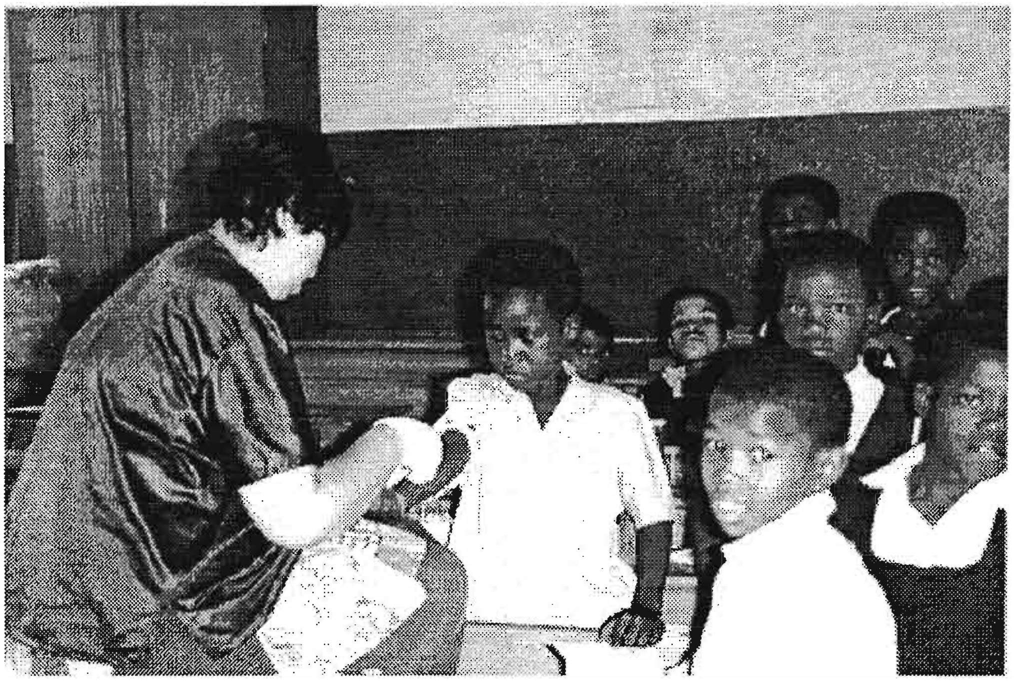
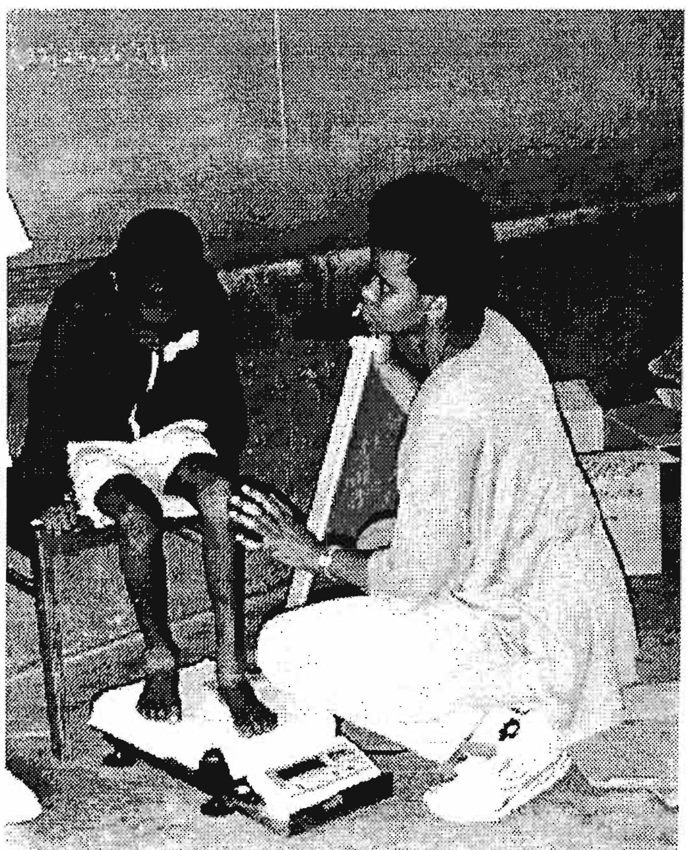
Appendix 1 – Map

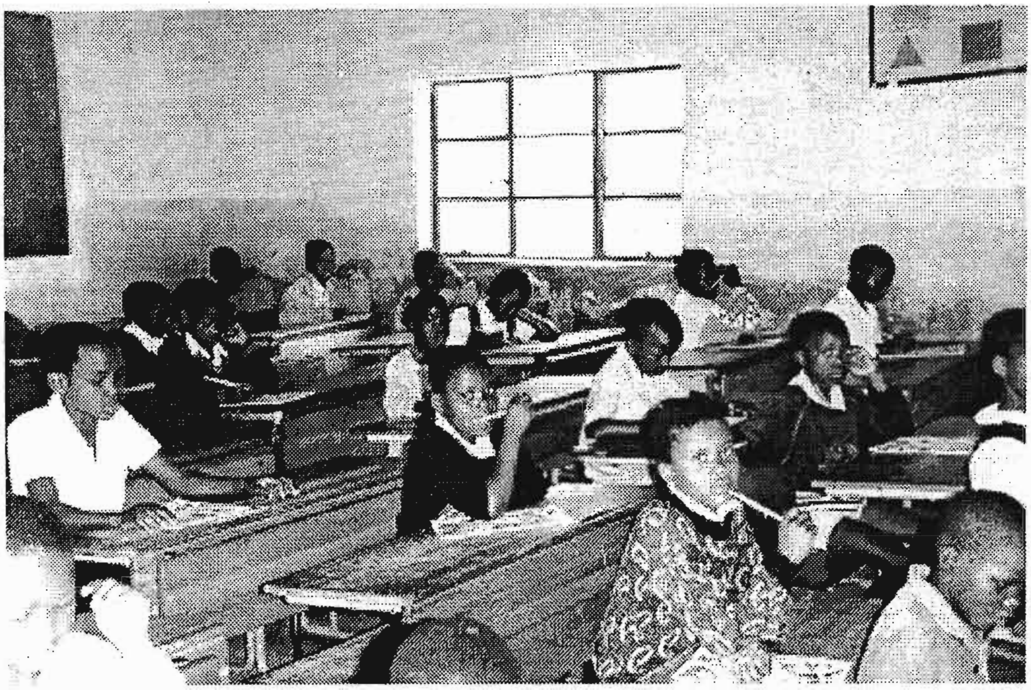
Appendix 2 – Photographs



1. Collecting blood samples from pupils at a rural school



2. Anthropometry: Measuring height and weight of a rural pupil



3. Grade 3 Pupils preparing for the cognitive / scholastic tests

4. A rural school in the Vulamehlo Magisterial District