Evaluating the impact of World Health Organization 'Nutrition-Friendly Schools Initiative' approaches on adolescent nutrition outcomes in rural Sri Lanka

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Abstract

Background
Sri Lanka is a lower-middle income country (LMIC) currently experiencing a double burden of malnutrition. School-based approaches to promoting a healthy diet are one potentially promising method to address these public health challenges. The World Health Organization's 'Nutrition-Friendly Schools Initiative' (NFSI) provides a framework of best practices for school-based approaches to promote healthy diets among students, but there has been a dearth of research assessing the impact of NFSI approaches on student nutrition outcomes.

Objectives
This thesis aims to describe the nutritional quality of the diets of adolescent students living in rural Sri Lanka, to identify if there was significant district- or school-level variation in the nutritional quality of these diets, and to see if there were significant associations between the schools' NFSI approaches (summarised as the number of NFSI actions that schools were implementing) to promote healthy diets and student nutrition outcomes.

Methods
This study was part of a larger World Bank-funded project entitled 'Integrating Nutrition Promotion and Rural Development.' Data were collected in July-August 2014 and August-September 2015 from secondary school students (n=1300) and principals of schools (n=49) in three rural districts of Sri Lanka using clustered randomised sampling methods. Students' demographics and diets were assessed using the WHO Global school-based student health survey (GSHS) and a validated food frequency questionnaire (FFQ). School actions to promoting healthy diets were collected using the 'NFSI tool' which was administered as a semi-structured interview with school staff. Diet quality was summarised using the Diet-Quality Index-International, BMI Z-scores, and intake of selected nutrients. Multilevel analyses were used to examine associations between school NFSI actions and student outcomes, while controlling for confounders at both the school- and student-levels.

Results
Results indicated that student's diet quality was low, with notable deficiencies in protein and calcium. There was no significant between-district variation in student outcomes, but there was significant between-school variation, suggesting that there was a 'school-effect' on diet quality. However, multilevel analyses indicated that at both baseline and follow-up there were no significant associations between the number of NFSI actions that schools reported and student nutrition outcomes.

Conclusions
This study was, to the best of my knowledge, the first formal evaluation of NFSI actions and student outcomes. Further research is needed to examine associations between NFSI actions and student outcomes over a longer time-frame. Additionally, more work is needed to identify whether or not school variation in diet quality is due to school nutrition-promoting actions that are not currently included in the NFSI, actions that are not detected by the NFSI tool or other factors that are not measured in this study. In addition to conducting more research on the NFSI, further research is also needed to understand more generally the most effective school-based approaches to improve students' diets.

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Declaration of authorship

I declare that I have read and understood both the University's disciplinary regulations on plagiarism and the Education Committee's information and guidance on academic good practice and plagiarism. I declare that this thesis is entirely my own work except where otherwise indicated. I have clearly indicated the presence of all material I have quoted from other sources with appropriate references. I have acknowledged appropriately any assistance I have received in addition to that provided by my supervisors.

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List of abbreviations

AI: adequate intake

ANOVA: analysis of variance

BMI: body mass index

DQI: diet quality index

DQI-I: diet quality index international

FFQ: food frequency questionnaire

G: Grams

GCEO-Level: General Certificate of Education (GCE) Ordinary Level

GDP: gross domestic product

GSHS: Global school-based student health survey

HPS: health-promoting schools

INPARD: the 'Integrating Nutrition Promotion and Rural Development' project

Kcal: kilocalories

LKR: Sri Lankan rupees

LLMICs: low- and lower-middle income countries

LMICs: low- and middle-income countries

MG: milligrams

MLM: multi-level modelling

NCDs: non-communicable diseases

NFSI: Nutrition-Friendly Schools Initiative

PE: physical education

RAP: Re-awakening Project (World-Bank Funded development project)

RDA: recommended daily allowance

RNI: recommended nutrient intake

SDS: standard deviation score

SD: standard deviation

SEM: socio-ecological model

SES: socioeconomic status

STEPs: WHO STEPwise approach to chronic disease risk factor surveillance

TBSP: tablespoon

UN: United Nations

UNICEF: United Nations International Children's Fund

USD: United States Dollars

WASH: water, sanitation and hygiene

WHO: World Health Organization

Glossary

Adequate Intake: A recommended average daily nutrient intake level, based on experimentally derived intake levels or approximations of observed mean nutrient intake by a group of healthy people that are assumed to be adequate. This is used when a recommended dietary allowance cannot be established.

Adolescence: a rapid phase of human development with specific health and developmental needs and rights. A time when individuals develop knowledge and skills, learn to manage emotions and relationships, and acquire attributes and abilities that are important for transitioning into adulthood. Typically defined to be a person falling between the ages of 10 and 19 years.

Anaemia: a condition in which there is a deficiency of red cells or of haemoglobin in the blood, resulting in pallor and weariness.

ANOVA: a statistical method in which the variation in a set of observations is divided into distinct components. One-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups.

Anthropometrics: the science of measuring the size and proportions of the human body.

Body Mass Index (BMI): is a simple index commonly used to classify overweight and obesity in schoolchildren and adults; it is calculated as a person's weight (in kg) divided by his or her height (in m2); it does not distinguish weight associated with muscle from weight associated with fat and therefore provides only a crude measure of fatness.

Calcium: A mineral found mainly in the hard part of bones, where it is stored. Calcium is essential for healthy bones and is also important for muscle contraction, heart action, and normal blood clotting.

Canteen: an area provided by an organization such as a school for its students or staff to eat.

Capacity-building: the development and strengthening of human and institutional resources.

Dependent variable: In mathematical modelling, the dependent variables depend on the values of independent variables, and represent the output or outcome whose variation is being studied. It is possible to have multiple dependent or independent variables.

Diet Quality Index (DQI): a composite measure used to evaluate dietary intake, usually based on patterns such as micro- or macro-nutrient intake.

Diet Quality Index-International (DQI-I): A tool developed by Kim et al for global monitoring and exploration of diet quality across countries. The major categories of the index are variety, adequacy, moderation and overall balance.

Double burden of malnutrition: is characterised by the coexistence of undernutrition, along with overweight and obesity, or diet-related noncommunicable diseases, within individuals, households and populations, and across the life-course.

Environmental: relating to or arising from a person's surroundings.

Exposure variable: In mathematical models, this is sometimes called a "predictor variable", a "risk factor" or an "input variable". In regression, this variable is used in predicting or explaining the 'outcome variable.'

Folic acid: A B vitamin that is a key factor in the synthesis of DNA and RNA. A deficiency of folic acid causes megaloblastic anaemia. Lack of folic acid during pregnancy is associated with increased risk in birth defects.

Food Frequency Questionnaire (FFQ): A questionnaire used to obtain frequency and portion size information about food and beverage consumption over a specified period of time.

Food group: A food group is a collection of foods that share similar nutritional properties or biological classifications. Nutrition guides typically divide foods into food groups and recommend daily servings of each group for a healthy diet.

General Certificate of Education (GCE) Ordinary Level: Also called the O-level, this is a subject-based academic qualification.

Global school-based health survey (GSHS): A project conducted in collaboration with the WHO and the US Centers for Disease Control. The GSHS is a collaborative surveillance project designed to help countries measure and assess the behavioural risk factors and protective factors in 10 key areas among young people aged 13 to 17 years. The GSHS is a relatively low-cost school-based survey which uses a self-administered questionnaire to obtain data on young people's health behaviour and protective factors related to the leading causes of morbidity and mortality among children and adults worldwide.

Gross Domestic Product (GDP): The total value of good produced and services provided in a country during one year.

Health Promoting School (HPS): A school that works to strengthen its capacity as a healthy setting for living, learning and working. The concept of health promoting schools was developed by the WHO in the 1990s. A health promoting school aims to promote adoption of lifestyles conducive to good health, provide an environment that supports and encourages healthy lifestyle and enable students and staff to take actions for healthier communities and living conditions.

High-income countries: According to the World Bank, a country with a gross national income per capita of US $12,236 or more (in 2016). The word "high-income" is often used interchangeably with "First World" and "developed country"

Independent variable: in mathematical modelling, the independent variables represent inputs or causes, such as potential reasons for variation. Models and experiments test to determine the effects that the independent variables have on the dependent variables. It is possible to have multiple dependent or independent variables.

Institutional: relating to, formulated by or managed by an organization founded for a religious, educational, professional or social purpose.

Integrating Nutrition Promotion and Rural Development (INPARD): A research project funded by the World Bank and involving collaboration between researchers from the University of Oxford, University of Colombo and Australian National University. The INPARD project aimed to identify the feasibility of linking rural development with nutrition promotion in Ampara, Moneregala, and Kurunegala, Sri Lanka.

Interpersonal: relating to relationships or communication between people.

Intersectoral/Multisectoral Action: Actions affecting health outcomes undertaken by sectors outside the health sector, possibly, but not necessarily, in collaboration with the health sector. Health equity through intersectoral action.

Intrapersonal: taking place or existing within an individual's mind.

Iron: An essential mineral which is necessary for the transport of oxygen (via haemoglobin in red blood cells). Deficiency of iron is a common cause of anaemia.

Kilocalories (kcal): A unit of energy representing the energy needed to increase the temperature of a given mass of water by 1 °C.

Life cycle approach: A perspective which looks across an individual's or a cohort's life experiences or across generations for clues to current patterns of health and disease. This approach recognizes that past and present experiences are shaped by wider social, economic and cultural contexts.

Low- and lower-middle income countries: Low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,005 or less in 2016; lower middle-income economies are those with a GNI per capita between $1,006 and $3,955; Sri Lanka is a lower-middle income country.

Low- and middle-income countries: Low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,005 or less in 2016; lower middle-income economies are those with a GNI per capita between $1,006 and $3,955; upper middle-income economies are those with a GNI per capita between $3,956 and $12,235; Sri Lanka is a lower middle income country.

Multivariable (or 'multi-variate) analysis: involves observation and analysis of more than one statistical outcome variable at a time (as opposed to 'univariable' or 'univariate' analysis.

Noncommunicable Diseases (NCDs): Diseases which are not passed from person to person, which typically are of long duration and slow progression. The four main types of NCDs are cardiovascular diseases, cancers, chronic respiratory diseases and diabetes.

Nutrient: a substance that provides nourishment essential for the maintenance of life and for growth.

Nutrition-friendly schools initiative (NFSI): A WHO school-based initiative with the potential to address the double-burden of nutrition problems throughout the life course. The NFSI is designed to address all aspects of malnutrition according to country situation. It emphasizes addressing underlying factors through multiple strategies that are part of multisectoral food and nutrition action plans.

Pediculosis: Infestation with lice.

Physical Education (PE): Also known as physical training, PE is an educational course related to maintaining the human body through physical activity.

Pilot study: a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, and effect size (statistical variability) in an attempt to predict an appropriate sample size and improve upon the study design prior to performance of a full-scale study.

Policy: a course or principle of action adopted or proposed by an organization or individual.

Premature NCD mortality: Conventionally defined as the probability of dying between ages 30-70 from diabetes, cardiovascular disease, cancer or chronic respiratory disease.

Random intercept model: In the context of examining student and school outcomes with multi-level analysis, a random intercept model assumes that the school effects (intercepts) are random but that there is common linear effect (slope) of the explanatory variables (which are controlled for) within groups.

Random slope model: In the context of examining student and school outcomes with multi-level analysis, a random slope model describes a type of model where both the school effects (intercepts) and the effects of students (slopes) are random and vary between schools.

Re-awakening Project (RAP): A development project funded by the World Bank and implemented by Sri Lanka's Ministry of Economic Development. This project aimed to improve the livelihoods of people living within the poorest districts of Sri Lanka. It followed a community-drive development model and orchestrated the formation of village development organizations that focused on strengthening infrastructure, providing training, building capacity and developing livelihoods.

Recommended Daily Allowance (RDA): A nutrition recommendation which represents the average daily level of intake sufficient to meet the nutrient requirements of nearly all (97-98%) of healthy people.

Recommended Nutrient Intake (RNI): The amount of a nutrient that is enough to meet the needs of nearly all (97.5%) of people within a group.

Residuals: In modelling, the residual for each observation is the difference between the value of y predicted by the equation and the actual value of y.

Scabies: A contagious skin disease marked by itching and small raised red spots, caused by a tiny burrowing mite called Sarcoptes scabiei.

Scoping Review: A review to map rapidly the key concepts underpinning a research area and the main sources and types of evidence available, and can be undertaken as stand-alone projects in their own right, especially where an area is complex or has not been reviewed comprehensively before". Unlike a systematic review, which focuses on a well-defined question where appropriate study designs can be identified in advance, while a scoping study tends to address broader topics where many different study designs might applicable.

Socioecological Model (SEM): A framework for understanding the complex variety of factors which influence health behaviours. This thesis drew upon the SEM to identify factors which should be considered and adjusted for in analyses investigating school-based influences on student nutrition.

Socioeconomic status (SES): an economic or sociological measure of a person's economic and social position in relation to others, based on income, education, and occupation.

Stakeholder: an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project.

STEPwise approach to chronic disease risk factor surveillance (STEPS) survey: The WHO-recommended framework for surveillance. This approach defines core variables for surveys, surveillance and monitoring instruments to ensure data comparability over time and between countries. For countries interesting in using the STEPwise approach, the WHO provides standardized materials and methods as part of technical collaboration with countries.

Stunting: low height for age. Stunting reflects the cumulative effects of undernutrition and infections since and even before birth. This measure can therefore be interpreted as an indication of poor environmental conditions or long-term restriction of a child's growth potential.

Systematic Review: A specific type of literature review that collects and critically analyses multiple research studies or papers using methods that are selected before one or more research questions are formulated, and then finding and analysing studies that relate to and answer those questions in a structured methodology.

Underweight, stunting, wasting and overweight: these indicators are used to measure nutritional imbalance resulting in undernutrition (assessed from underweight, wasting and stunting) and overweight. Child growth is internationally recognized as an important indicator of nutritional status and health in populations.

United Nations (UN): An international intergovernmental organization founded in 1945. The organization's mission is guided by the Charter of the United Nations, which was signed on 26 June 1945. Due to its international character, the UN can take action on current issues confronting humanity including peace and security, climate change, sustainable development, human rights, disarmament, terrorism, humanitarian and health emergencies, gender equality, governance, food production and more. The UN includes specialized agencies which work to fulfill its duties, including the Food and Agriculture Organization, the World Bank and the World Health Organization.

United Nations International Children's Fund (UNICEF): A United Nations program that provides humanitarian and developmental assistance to children and mothers in developing countries.

Vitamin A: Vitamin A is retinol. Carotene compounds are converted by the body to vitamin A (retinol). Deficiency of vitamin A leads to night blindness.

Wasting: low weight for height. Wasting in children is a symptom of acute undernutrition, usually as a consequence of insufficient food intake or a high incidence of infectious diseases, especially diarrhoea. Wasting in turn impairs the functioning of the immune system and can lead to increased severity and duration of and susceptibility to infectious diseases and an increased risk for death.

Water, Sanitation and Hygiene (WASH): UNICEF's WASH team works to improve water and sanitation services, as well as basic hygiene practices globally. Clean water, basic toilets and good hygiene practices are essential for the survival and development of children.

World Health Organization: A specialized agency of the United Nations that is concerned with international public health. The WHO was established in 1946 and has headquarters in Geneva Switzerland.

Z-scores or standard deviation classification system: is one of the different systems by which a child or a group of children anthropometric data can be compared to the reference population. It is widely recognized as the best system for analysis and presentation of anthropometric data. Z-score (or SD-score) = (observed value - median value of the reference population) / standard deviation value of reference population

1 Background, definition of research questions and thesis outline

1.1 Introduction to Chapter One

The purpose of this chapter is to provide background information and to summarise the principles which will be addressed in this study. After describing the study context and some of the theoretical foundations to this work, this chapter summarises how I came to be involved in this work. Next, it outlines the purpose of this research study. Finally, it provides an overview of the chapters in this thesis.

1.2 Background history of Sri Lanka

This study takes place in Sri Lanka, a lower-middle income country (LMIC) experiencing rapid economic, demographic and epidemiological transition[1, 2]. Within the population, there is a double-burden of under- and over-nutrition[3, 4], a term which is used to describe the co-existence of wasting, stunting and micronutrient deficiencies (under-nutrition) along with overweight and obesity (over-nutrition)[5].

Sri Lanka has an estimated population of 21 million people (2016) and a per capita income of 3,634 United States Dollars (2014)[6]. In 2009, 27 years of civil conflict ended[1] when government forces overwhelmed the Liberation Tigers of Tamil Ealem[7]. In January 2010, Sri Lanka achieved a lower-middle income country (LMIC) status and in 2011 it had the highest Human Development Index rank[2] in South Asia[8]. Sri Lanka is known for relatively high life expectancy and low maternal mortality, coupled with low health care costs, particularly when compared to the United States, United Kingdom, and India[9]. It spends just 3.5% of total expenditure on health as a percentage of gross domestic product (GDP), while the

[1]The conflict was estimated to have killed 80,000-100,000 people.
[2] A composite statistic of life expectancy, education and per capita income indicators.

United Kingdom spends 7.6% and the United States spends 8.3%[10]. Additionally, Sri Lanka has recently been recognised for success in the areas of education, gender equality, construction of roads, reintegration of those affected by conflict, and livelihood development[11]. Furthermore, the country has high levels of school participation, with 98% of males and females attending primary school (2008-2012) and 85.8% of males and 90.7% of females attending secondary school[12].

Despite these gains, Sri Lanka has made slower progress in areas related to poverty, hunger and malnutrition among children. Like LMICs, the country is facing a double burden of malnutrition. According to data from 2008-2012[12], 21% of children are moderately or severely underweight, 17% are stunted[3] and 15% are wasted[4]. Estimates from 2012 indicated that 17% of births are classified as low birth weight[512]. According to a 2009 report, around a third of child have anaemia[13]. In Ampara, Moneragala and Kurunegala, the districts where this project is based, the prevalence rates of anaemia were 50.7%, 36.3% and 29.1% respectively. Nationally, the poorest populations have the highest rates of anaemia (34%) compared to the wealthiest populations (31.5%). When stratified by mother's education, those with no maternal education had the highest prevalence (41.9%), while those with higher levels[6] had the lowest prevalence (25.4%).

As the country faces health problems associated with malnutrition, it also faces emerging diseases related to excessive energy consumption. The prevalence of overweight, obesity and abdominal obesity among Sri Lanka adults is estimated to be 25.2%, 9.2% and 26.2%,

[3] Below minus two standard deviations from median height for age of reference population.
[4] Below minus two standard deviations from median weight for height of reference population.
[5] Less than 2,500 grams.
[6]The indicator for education was 'passed GCEA-levels and above'.

respectively[4]. Non-communicable diseases (NCDs) are increasing and premature mortality from NCDs[7] is 18%[10].

In 2010, Sri Lanka's Minister of Healthcare and Nutrition adopted a National Nutrition Policy which had the goal of achieving and maintaining the nutritional well-being of all Sri Lankans[14]. The plan emphasised a life cycle approach to nutrition, with aims to 'Ensure all pre-school and primary schoolchildren have access to adequate and safe nutrition, which will optimise their growth and development' (Statement 5.1.4) and 'Reduce undernutrition and obesity (malnutrition) among adolescents, enabling them to be healthy and productive adults' (Statement 5.1.5)[14].

1.3 Rationale for investigating role of schools in promoting healthy eating

Schools have been identified as key settings for combatting the double burden of nutrition-related ill health[15, 16]. There are a number of reasons for this: schools provide an infrastructure for implementing interventions[17] and represent the location where the greatest number of children spend the greatest amount of time[18]. Furthermore, school-based interventions are likelier to become institutionalised and sustained over time[19] compared to interventions that are implemented outside of existing institutions or organisations.

1.4 Schools as sites for promoting nutrition

School-based promotion of healthy diets stems from a larger tradition of 'settings-based' approaches to health promotion. The 'settings-based' approach to health promotion emerged from the World Health Organization's (WHO's) Ottawa Charter for health promotion[20], which is underpinned by the idea that health is both created and lived by people within the contexts of their everyday life. Rather than focusing on what makes people

[7] Dying between ages 30-70 from diabetes, cardiovascular disease, cancer or chronic respiratory disease.

ill, this approach focuses on what makes populations healthy[218]. Importantly, the settings-based approach shifts the focus from being solely on individual behaviours to an extended view which includes environmental influences on health behaviours. In the decades following the Ottawa Charter, attention has been given to the conceptual development, practical use, formal evaluation and reporting of 'setting-based activity'[22]. The charter has been influential both in developing the concept of health promotion, but also in shaping public health practice. However, it has also been criticised for focusing on the needs of industrialised countries and failing to address those of non-industrialised countries. At the meeting where the charter was developed, only 38 countries were represented. Better representation from developed countries may have led to a charter that was more globally relevant[23].

Following the Ottawa charter, the concept of 'Health-promoting schools' (HPS) framework was developed. In 1991, the WHO hosted a conference on creating supportive environments for health in Sundsvall, Sweden[24] . In 1997, the WHO developed these principles further at a health promotion conference in Jakarta, Indonesia in which participants called upon international and national agencies, governments, communities, nongovernmental organisations and the private sector to support the development of HPS[25]. There is not a strict definition of an HPS[26], but in general, it has the following aims: 1) Promote adoption of lifestyles conducive to good health; 2) Provide an environment that supports and encourages healthy lifestyles and; 3) Enables students and staff to take actions for healthier communities and living conditions[26]. The HPS approach is holistic, concentrating not only on education, but also on the wider determinants of nutrition behaviour such as the environment, physical health services, prevention programmes, psychological health services, nutritional and food safety services, social services, physical education and more [27, 28].

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[8] This focus is described as being 'salutogenic', from the Latin *salus* (health) and Greek *genesis* (origin)

The HPS framework plays a prominent role in several key WHO documents related to nutrition and NCDs, including The WHO's 'Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition'[29], WHO Global Action Plan for the prevention and control of NCDs[30] and the Ending Childhood Obesity report[31], which provide a series of priority actions for Member States. The Global Action Plan places a focus on creating health- and nutrition-promoting environments through nutrition education, in schools and other settings. It specifically highlights creating health-promoting schools as a global strategy for addressing modifiable risk factors related to NCDs. In 2017, WHO published guidance to support country implementation on adolescent health within global public health[32]. The report highlights the importance of prioritising, among other health concerns, NCDs, nutrition and physical activity and discusses the need to identify cost-effective methods to improve adolescent health, thereby reducing the future adult burden of disease. In its summary of the determinants of health, the report notes that schools play a 'vitally important role in promoting and protecting adolescent health' (page 8). Indeed, investing in school health is a key priority for inter-sectoral action to prevent disease[33].

The HPS framework also plays a key role in Sri Lankan national policies, such as the Sri Lankan Ministry of Health's 'Multisectoral Action Plan for the Prevention and Control of NCDs (2016-2020)[34].' The policy explicitly prioritises health-promoting schools as part of a wider strategy to improve population health. Similarly, Sri Lanka's Ministry of Education has a 'Nutrition Promotion Policy' which is structured around HPS concepts[35]. For more information about school-based nutrition programmes in Sri Lanka, please see Appendix One.

The best evidence related to the HPS framework comes from a recent Cochrane review investigating the effectiveness of HPS for improving the health and well-being of students and their academic achievement[26]. The study examined evidence from 67 trials involving interventions using the HPS approach. The review, which drew evidence from interventions in 1,345 schools and 98 districts, found that HPS approaches had positive effects by reducing student BMI, increasing physical activity and fitness levels, improving fruit and vegetable consumption, decreasing cigarette use and reducing reports of students being bullied. However, most of the studies were conducted in high-income (n=59) and upper-middle income (n=5) countries, with just three studies from lower-middle income (India and Egypt) and low-income (Tanzania) countries. The findings, while promising, highlight a need for more research into the effects of health-promoting school policies within LMICs. Arguably, in these contexts, where large proportions of the population still face food insecurity and poverty, schools may play an even more important role as a safety net than they do in higher income countries. Furthermore, the review mostly featured randomised controlled trials or evaluations of brief interventions, rather than longer term changes to the environment which were sustained over time. These longer-term changes are more likely to have an effect on student outcomes.

From the HPS framework, a number of different school-based health and nutrition initiatives and programmes have emerged. In 2000, the 'Focusing resources on effective school health' (FRESH) initiative was launched at the World Education Forum[9]. The FRESH initiative aimed to provide existing school health and nutrition programmes implemented by United Nations agencies and NGOs with a common framework to facilitate interagency coordination, concerted action, and consistent advice to country programmes and projects. The FRESH package placed an emphasis on school-based health policies, safe water and sanitation facilities, skills-based health education and school-based health and nutrition services[36]. In 2002, the World Food Programme and the United Nations International Children's Emergency Fund (UNICEF) outlined 'The Essential Package' of

[9] Participating agencies included WHO, UNICEF, UNESCO and World Bank

cost-effective interventions[10] to improve the nutritional status and health of school children[37].

1.4.1 The Nutrition-friendly schools initiative

In 2006, the WHO developed a framework that outlined and formalised HPS approaches with a focus on nutrition. This framework is called the 'Nutrition-friendly schools initiative,' (NFSI). The NFSI provides specific recommendations for schools to create environments that promote healthier diets by adopting nutrition policies, enhancing awareness and capacity-building, developing nutrition and health-promoting curriculum, creating a supportive environment and fostering links with supportive health services. Given my interest in the role that schools may play in improving nutrition within LMICs, coupled by a lack of research on the effects of the NFSI package on student outcomes, my thesis focused on investigating the relationship between the implementation of school-based NFSI actions and nutrition outcomes among students. A logic model describing the hypothesised relationship between NFSI actions and student outcomes is provided in Figure 1.1.

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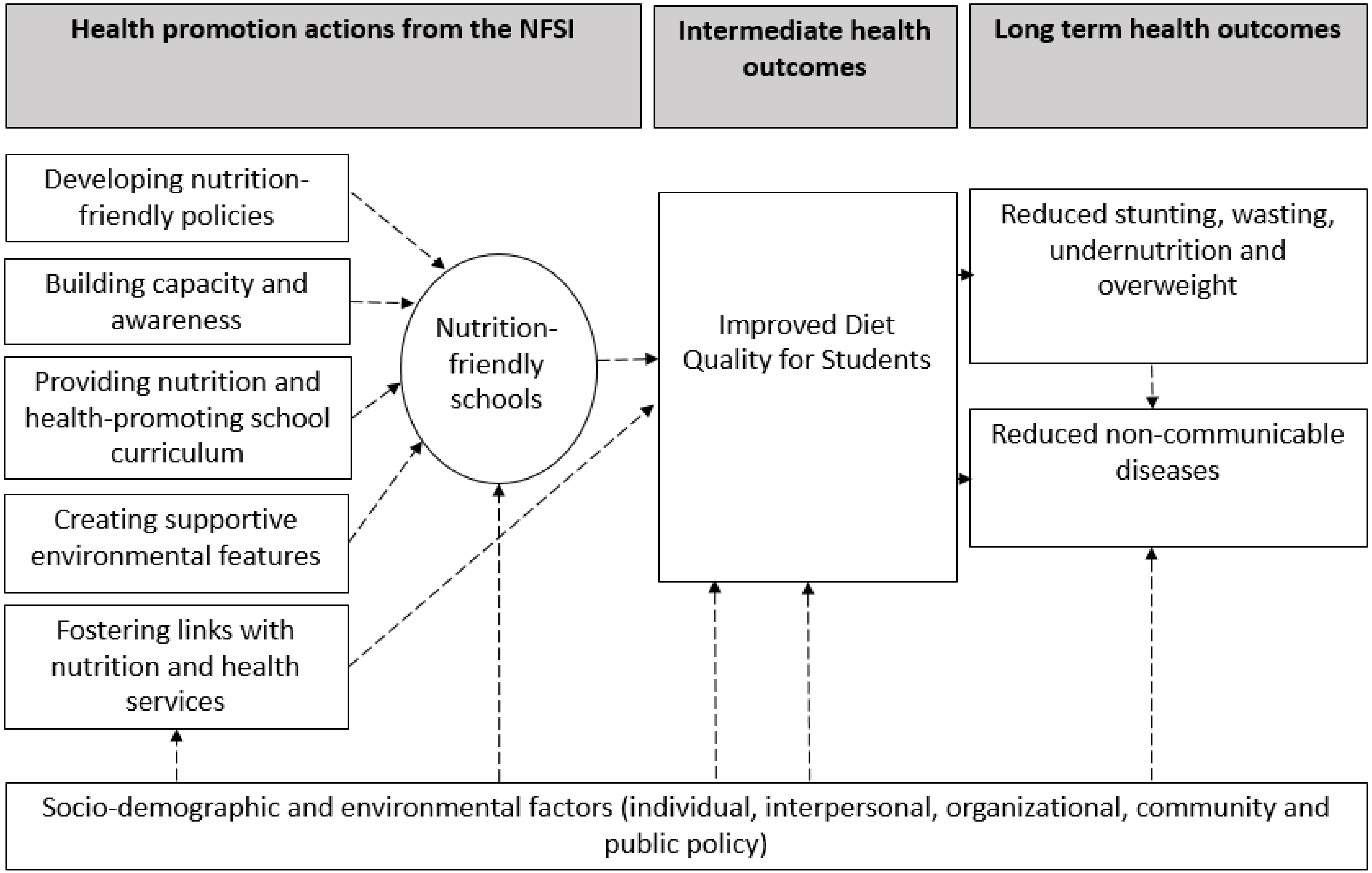
[10] Interventions include: supporting basic education; food for education (on-site meals and take-home rations); promotion of girls' education; potable water and sanitary latrines; health, nutrition and hygiene education; systematic deworming; micronutrient supplementation; HIV and AIDS education and life-skills training; psychosocial support; malaria prevention; school gardens; and improved stoves.

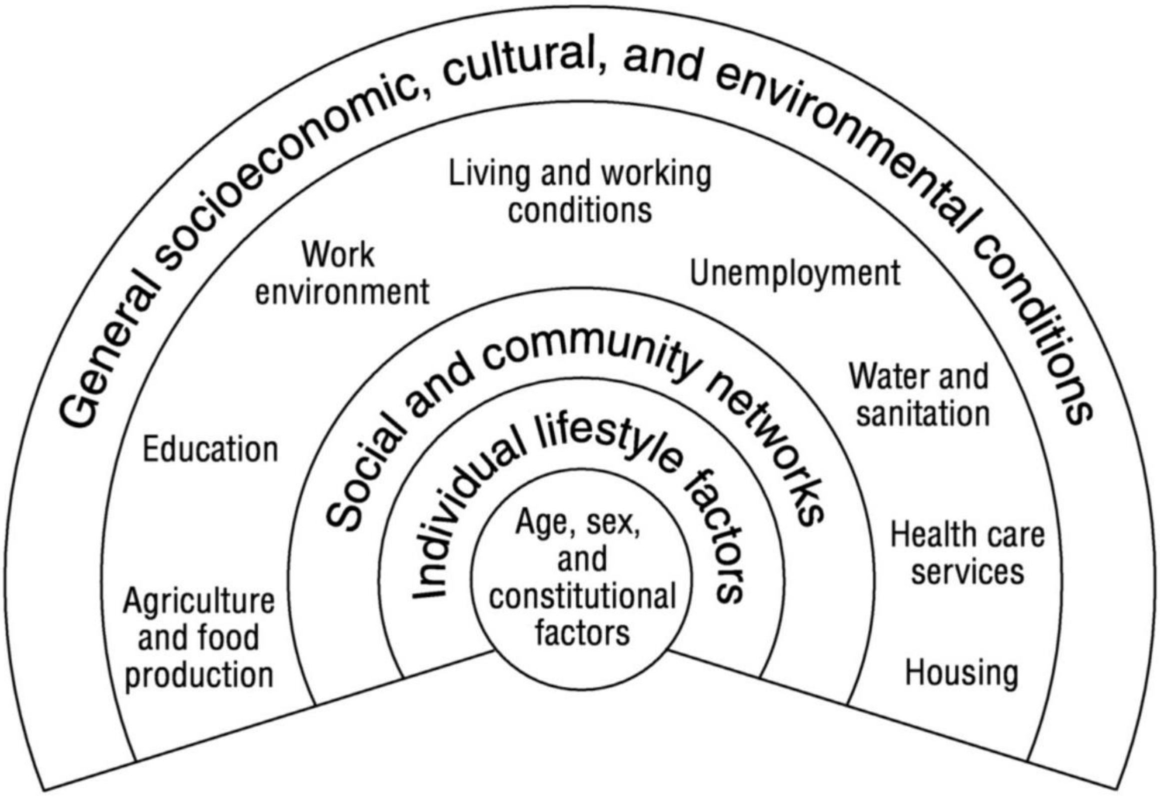
Figure 1.1. Logic model describing the hypothesised relationship between WHO 'Nutrition-friendly schools initiative' approaches and student outcomes



1.4.2 The socio-ecological model of health

The HPS framework, the NFSI and settings-based approaches to health promotion are based on the socio-ecological model (SEM), which provides a framework for understanding the multiple factors and barriers that affect health behaviours. According to the SEM to health promotion,[38, 39] health behaviour is shaped by many factors which occur (and interact with one another) at a number of levels. These influences may change children's attitudes and behaviours either directly or indirectly through parents and caregivers[40]. The key concepts behind the SEM are that health behaviour influences and is influenced by factors occurring on multiple levels and that individual behaviour affects and is affected by the social environment [39, 41]. Dahlgren and Whitehead describe the socio-ecological perspective in a figure which features a series of layers that represent the determinents of health behaviours and the interconnections among these determinants (Figure 1.2)[38]. Their model recognises that humans live within social, political and economic systems[42-45] and behaviour is the product of interactions between intrapersonal, interpersonal, institutional, environmental and political factors[46].

Figure 1.2. The main determinants of health[47]



Townsend *et al* developed and applied an SEM to describe the promotion of healthy eating in schools[39]. The model, which was adapted from earlier models and frameworks[38, 46, 48-50], featured multiple levels of influence for health behaviours and outcomes (Table 1.1). These include demographic, intrapersonal, interpersonal, institutional, community and public policy levels of influence. Building upon this work, a more recent study by Moore *et al* provides evidence to support a socio-ecological approach through case studies that demonstrate key specific issues that emerge from a multilevel approach to school food. These include engaging the whole school community, identifying effective and sustainable programmes, acknowledging that policies or actions taken at one level may not produce the intended outcomes due to mediating factors at other level, and implementing multiple interventions, which can lead to synergistic effects[51].

Table 1.1. A Socio-ecological framework for the investigation of the promotion of healthy eating in schools[39, 46]

Levels of influence	**Description**
Demographic	Constitutional and biologically determined factors that have been found to be associated with variations in dietary choice such as sex and age
Intrapersonal	Individual characteristics that reside within the person and can influence dietary choice, such as personality, behaviour and attitudes towards healthy eating
Interpersonal	An individual's relationships and social environment that affect eating behaviour by providing norms, social support and behaviour modelling
Institutional	Policies, informal structures and rules in schools that may constrain or promote healthy eating
Community	Relationships between schools and other organisations or institutions, and informal social networks within schools themselves
Public policy	Policies and legislation at a local or national level that regulate or support healthy eating promotion in schools

Source: Townsend *et al*, Public Health Nutrition, 2013

The SEM provides a useful framework for identifying influences on dietary behaviour[43, 45, 52-54]. For this reason, I used the model to structure my thesis and to identify factors beyond the school (such as individual characteristics) which should be considered and adjusted for in the analyses investigating school-based influences on student nutrition outcomes. At the same time, the SEM has been criticised for including too many variables, which limits its applications for research[43, 45].

There are alternative models that could be used based on pyschosocial theories that have been developed to predict, explain, and change health behaviours[55], including the Health Belief Model[56, 57], the Theory of Planned Behaviour[58], the Transtheoretical Model of Health Behaviour Change[59], but these models have been criticised for placing undue influence on the individual and their personal intentions[43]. This criticism cannot be ignored, particularly in instances involving children and adolescents. Baranowski *et al* found that ony a small amount of variability in diet choice among children was related to personal intentions[60]. Furthermore, my research questions focused on how school environments can improve health and unlike the alternative models that I've just described, the SEM provides a means of identifying areas where these types of environmental changes can be made.

1.5 Description of the health determinants which are considered in this thesis

This section describes some of the individual demographics, intrapersonal factors and institutional factors that are considered in this thesis.

1.5.1 Sex, age, ethnicity and socio-economic status

Demographic factors such as sex and age have been found to be associated with dietary quality. In many developing countries, females are more likely to suffer from nutritional deficiency than males, for reasons related to their biology, low social status, poverty, lack of education and other socio-cultural traditions[61, 62]. There is also evidence that dietary choice is influenced by age, sex[63] and ethnicity[64]. Socioeconomic status and food security has also been found to be associated with lower dietary quality[65].

1.5.2 Diet-related characteristics

Individual factors, including preferences and perceptions, are also likely to influence dietary behaviour and the quality of a person's diet. For example, some individuals have a greater preference for consuming breakfast than others[66], and breakfast consumption is associated with having higher dietary quality[67]. How a person feels about their body (*i.e.* if they perceive themselves to be over- or under-weight) is also likely to influence their dietary behaviour and, in turn, the quality of their diets[68].

1.5.3 School and multisectoral influences on diet

There is a large body of evidence that school policies and practices may benefit the nutritional behaviours of students[26]. Additionally, fixed school characteristics, such as school size and type, may play a role in influencing diet. For example, larger schools or certain types of school may have access to more resources[69], which may enhance their capacity to implement health-promoting policies.

Beyond the school gates, the actions of multi-sectoral institutions, such as those involved with agriculture, development or health, may also influence adolescent nutrition[70]. This DPhil work was conducted with a larger multisectoral rural development project called 'Integrating Nutrition Promotion and Rural Development' (INPARD). Some of the schools where I collected data were located in 'INPARD' areas and others were not, so this difference was accounted for in my analyses.

1.6 My involvement in the present work

Before starting this DPhil, I was working as a researcher at the University of Oxford. I was leading on several projects investigating associations between school food environments and student health outcomes in the United Kingdom. This work resulted in two peer-reviewed papers. The first was a systematic review of evidence about the influence of retail food outlets surrounding schools on student nutrition outcomes[71]. The second paper was a primary research study which examined associations between retail food outlets around schools and student obesity outcomes in Berkshire, UK[72]. From this work, I developed an interest in the role that school environments may play in improving the health of students. I decided that for my doctoral research, I wanted to focus on this issue of school environments and their influence on student outcomes, as I had done earlier, but among a different population.

At the same time that I was starting to think about potential DPhil projects, my supervisors were applying for funding for the INPARD project. I approached them and asked if I could become involved with their project. I told them that I was primarily interested in associations between school environments and student outcomes. Their study, which aimed to investigate the feasibility of integrating nutrition promotion into rural development projects, would provide me with 1) access to schools (both students and school principals); 2) access to data collectors; 3) funding support for travel to and from Sri Lanka for field visits. In turn, I would provide the following: 1) identification of tools to collect data about school environments and student nutrition outcomes; 2) identification of methods to examine associations between school environments and student outcomes; 3) coordination and supervision of data collection within schools; 4) cleaning and processing of data sets; 5) analysis of data sets; 6); interpretation and presentation of results.

It is important to explain the boundaries between my DPhil project and the INPARD project. My research was conducted within the INPARD project, but its focus varied from the INPARD project's focus. The INPARD data collection focused on households and adults, and their analysis focused on evaluating how and if multi-sectoral nutrition promotion and rural development activities led to positive changes in health outcomes. My research, by contrast, focused on students and schools, and on examining how school NFSI approaches (and change in NFSI approaches) were related to student nutrition outcomes. My analyses controlled for whether or not schools were involved with the INPARD project, but that was as far as my evaluation of the INPARD project intervention went.

1.6.1 My contribution to the INPARD project

Working with the INPARD project, my unique contribution was as follows. First, I identified the NFSI as a key framework for school-based nutrition promotion, and based on my recommendations, the NFSI was integrated into INPARD multi-sectoral health promotion activities. I was responsible for identifying the methods and tools used for the school-based data collection, analysis and interpretation of results. This involved identifying or developing all of the tools that were used (the FFQ, the GSHS, the STEPs survey, the NFSI tool for researchers), proposing these tools to the INPARD team prior to starting the study, identifying and proposing methods of data collection and analysis to the INPARD team, coordinating the data collection, providing training to the data collectors, cleaning and processing the datasets, completing the analyses (including development of a diet-quality index and completing multi-level analysis), contributing as a lead author on school-based chapters in INPARD reports, presenting findings to local- and national stakeholders, presenting findings at international conferences and serving as a leading or contributing author on peer-reviewed INPARD publications (Detailed in Appendix 18). All of my decisions regarding the research tools and the methods that I used in the school-based data collection were discussed and approved with my supervisors and the INPARD team prior to applying for and receiving ethics approval or starting the 2014 data collection. Without my involvement in the INPARD project, INPARD would not have worked within schools to implement school-level environmental changes, nor would it have collected data from schools.

Because I was collecting data at two time points, and my exposure variable was school NFSI approaches (measured against student outcomes), I wanted to see if a *change* in school approaches led to a *change in* dietary outcomes (Research Question Four), and I hypothesized that school involvement with the INPARD project may lead to change in NFSI approaches. Therefore, I suggested that the NFSI be included as one part of INPARD's larger multisectoral approach to nutrition promotion. The INPARD team was receptive to my suggestion, and as part of their larger multisectoral nutrition promotion strategy, they integrated the NFSI into their intervention. Schools in INPARD intervention areas were given training on what the NFSI was and why it was important. After receiving this training, schools were offered support from sectors outside of the education department, such as the departments of agriculture and development, in order to identify and initiate projects which could help them to strengthen their current approaches related to creating nutrition-friendly environments.

1.6.2 What changed over the course of this DPhil study

When I initially started on this project, I considered, as a secondary research question, evaluating the effectiveness of the INPARD project. However, following the initiation of the INPARD project, it became clear that such an evaluation was beyond the scope of a single DPhil project, due to several factors. First, my primary research interest was about associations between school approaches to nutrition promotion and student outcomes. Evaluating this relationship was going to require extensive resources to develop methods for evaluating school environments, creating a diet-quality index, coordinating data collection from 50 schools over two time points and learning and applying the methods of multi-level analysis to a large hierarchical data set. I recognised that, although involvement in INPARD might affect the ability of schools to develop NFSI approaches, there was great variation at baseline between schools in the number of NFSI approaches that were being implemented. The complex nature of the INPARD intervention meant that an evaluation of INPARD would have overshadowed my primary research questions. Therefore, I decided to focus on my primary research questions, to investigate if NFSI approaches were associated with pupil outcomes at baseline and follow-up. That said, I did consider the INPARD intervention in my data collection, and I did control for it within my analyses.

1.7 Purpose of this research study

This thesis aims to examine associations between school-based approaches recommended within the WHO's 'Nutrition-friendly schools initiative' (NFSI) and student nutrition-related outcomes. In order to do so, its first objective is to describe adolescent diets in rural Sri Lanka. Then, it aims to examine between-district and between-school variation in student nutrition outcomes. Finally, this study examines associations between implementation of NFSI recommendations and student nutrition outcomes.

In achieving these aims, this project answers the following research questions:

1. What is the nutritional quality of the diets of adolescent students living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?
2. Is there significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?
3. Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets?
4. Using longitudinal baseline and follow-up data, are there significant associations between changes in implementation of NFSI recommendations and changes in the nutritional quality of students' diets?

1.7.1 How this work fits within the context of the socio-ecological model

Earlier in this chapter, I described the socio-ecological model and the ways in which health behaviour is influenced by a variety of demographic, intrapersonal, interpersonal, community and political factors. Therefore, when thinking about what people eat and why, it is important to look beyond individual choice and at some of the larger structural factors which may influence behaviour. School approaches may contribute to some of these structural influences on student's health behaviours. As the Nutrition-friendly Schools Initiative (NFSI) framework suggests, schools can influence health behaviour (and specifically diet) in ways that require engaging with all of the levels of the socio-ecological framework. Using the terms that Townsend *et al* proposed in 'a socio-ecological framework for investigation of the promotion of healthy eating in schools,' I will briefly describe how the proposed actions of the NFSI (related to policy, capacity, curriculum, culture and network) correspond to the socio-ecological framework. The scientific evidence for these recommendations is detailed in Chapter Two, which presents a literature review for the various components of the NFSI.

1.7.1.1 Policy

First, schools have political environments which may influence dietary behaviours. The organization may adopt or propose principles or actions that either support or create barriers to healthy eating. The NFSI recognises this in its emphasis on creating nutrition-friendly policies. For example, schools may have policies which ban the sale or promotion (via advertising) of sugary drinks on the school premises, or policies which propose that other actions, including the other NFSI actions (such as having nutrition outreach activities for families, developing nutrition and health-promoting school curriculum, creating supportive environments or providing supportive health services) are implemented. Institutional policies, such as school-nutrition policies, are often influenced, too, by public policy at the local or national levels.

1.7.1.2 Capacity

Having a policy for something is not the same as *implementation* of the policy. In order to turn proposed ideas about creating nutrition-friendly environments or developing nutrition-promoting school curriculum into real actions, institutions must strengthen capacity, as recognised in part two of the NFSI. Capacity building involves developing skills and resources within the school to ensure that nutrition-friendly policies can actually be implemented. Capacity building recognises the influence that both interpersonal and intrapersonal factors may have in shaping nutrition behaviour. For example, the NFSI recommends engaging larger community networks of students, parents and staff members in disseminating and hosting activities in the areas of nutrition and health-related issues. This recommendation recognises that it is important to build capacity, not only through engagement with individual students, but also by engaging the people that have influence on them.

1.7.1.3 Curriculum

Both the socioecological model and the NFSI acknowledge the importance of individual knowledge related to nutrition and health. In the socioecological model, the individual's knowledge and attitude toward healthy eating are *intrapersonal* characteristics. However, school curriculum is often determined by public and institutional policy, as well, and its efficacy in shaping knowledge and attitudes may depend upon the expertise of teachers and the support of parents or peers (*intrapersonal* influences). This is one illustration of how a single health promoting action (such as offering health-promoting curriculum) often draws upon the influences of multiple levels of the socioecological model.

1.7.1.4 Culture

The socioecological model and the NFSI highlight the role that environmental conditions may have on influencing health behaviours. For example, schools can create supportive environments by effectively implementing policies that ensure that school meals, food vendors and snack bars promote healthy eating, or ensuring that students have adequate places to eat. Another way to conceptualise these environmental conditions is to think about the *culture* of a school, for example, by having staff which are role models in encouraging a healthy lifestyle or school environments that deliver positive messages toward nutrition and active living. As with other health promoting actions, efforts to create supportive environments are often influenced by many levels of the socioecological model, including public policy, community factors, institutional factors and interpersonal factors.

1.7.1.5 Network

Finally, by emphasising the interactions between individuals and social and community networks, the socioecological model highlights the influence that *networks* may have on health behaviours. The NFSI recommends that schools draw upon larger networks in the community in order to ensure that students are healthy and have access to the support that they may need from families and medical services. For example, it recommends that schools regularly monitor student's growth and development and implement feedback systems with parents and health services to ensure that students who are not healthy receive the support that they need.

The health promotion actions recommended by the NFSI, along with an explanation of how these actions recognise the various levels of the socio-ecological model, are described in Table 1.2.

Table 1.2. Description of the school's health promotion actions, the interim student health outcomes and the longer term health outcomes.

	NFSI Health promotion actions	**Interim health outcomes**	**Longer term health outcomes**
	Policy[1] Capacity[2] Curriculum[3] Culture[4] Network[5]	Improved diet quality	Reduced underweight Malnutrition Non-communicable diseases
Measurement tools	NFSI tool for researchers	Food frequency questionnaire (FFQ)	Anthropometrics
My involvement	Identifying the NFSI framework, proposing its integration into the INPARD project to the team, developing and piloting the NFSI tool, coordinating the data collection within schools, cleaning and processing the data, completing the analyses	Identifying the FFQ and methods, proposing the methods to the team, developing a diet-quality index, coordinating data collection from students, cleaning and processing data, completing the analysis of data	Coordinating data collection, cleaning and processing the data, identifying the methods for creating age- and sex-adjusted BMI categories, proposing methods to the team, completing the analyses

[1]In the socioecological framework, this corresponds with the higher levels of influence related to 'institutional policies' and 'public policy.'
[2]Corresponds with 'intrapersonal' and 'intrapersonal' factors.
[3]Corresponds with 'institutional', 'intrapersonal' and 'public policy' influences.
[4]Corresponds with 'institutional', 'interpersonal' and 'community' influences.
[5]Corresponds to 'interpersonal,' 'institutional,' and 'community influences.'

The table above provides a simplified summary of my DPhil research. It shows my interest in evaluating the health promotion actions of the NFSI (related to policy, capacity, culture, curriculum, culture and network) and the influence that these health promoting actions may have on the interim and longer term health outcomes of students. This table also summarises the tools that I used to measure the NFSI actions and my specific involvement in ensuring that these data were collected.

1.8 Chapter outlines

1.8.1 Chapter One

This first chapter delivers background information on Sri Lanka, the importance of nutrition during adolescence, the public health challenge of adolescent nutrition in low- and middle-income countries (LMICs) and the rationale for investigating the role of schools in promoting healthy eating. It discusses the role of schools as sites for promoting nutrition and summarises the WHO's NFSI framework. It also provides a logic model, which describes the hypothesised relationship between adopted NFSI policies and improved nutritional quality among students. Chapter One also describes how the NFSI helps to address the main determinants of health and fits within the larger socio-ecological model of health. The chapter introduces the socioecological framework for the investigation of the promotion of healthy eating in schools and describes the determinants which are considered in the thesis. These include individual demographics (such as sex, age, ethnicity and socioeconomic status), intrapersonal factors (such as diet-related attitudes and preferences) and institutional factors, such as school and multisectoral influences on diet. To provide additional context, Chapter One provides an explanation of how I came to be involved with the present work and how that work changed over time. Next, Chapter One outlines the purpose of this research study, and how this work fits within the context of the socio-ecological model.

1.8.2 Chapter Two

Chapter Two describes a scoping review on the evidence for the NFSI and school-level influences on students' diets. First, the chapter describes the methods (including databases searched, inclusion and exclusion criteria and methods of extracting results). Next the chapter describes study results. Findings suggested that there was a strong evidence base related to the positive influence of NFSI approaches in schools, especially in the areas of nutrition- and health-promoting curriculum. However, the results from this review also highlighted a dearth of research on the effects of implementing the whole NFSI package on student outcomes, and a lack of research from LMICs. Results from this review suggested that the research proposed in this DPhil project—to evaluate the influence of NFSI approaches on student outcomes—would add a valuable contribution to the literature.

1.8.3 Chapter Three

Chapter Three describes the study methods that were employed in this research study. First, the chapter describes the study design, sampling, recruitment and data collection methods. It discusses ethical considerations related to participant consent, confidentiality and anonymity. It describes the process of recruiting study participants and discusses the practicalities involved in data collection, which was completed through collaboration with the INPARD project. The chapter goes on to describe how I collected student-level data using the Global school-based student health survey (GSHS) and a Food Frequency Questionnaire (FFQ) and school-level data using the Nutrition-friendly schools initiative (NFSI) Tool for Researchers. Next, the chapter describes the process of constructing independent, dependent and exposure variables to create multi-level models to answer research questions three and four. Finally, this chapter explains the analysis plan for answering the research questions, including the levels of the data structure, model specifications, the process of examining district- and school-level variation in student outcomes (to answer research question two), and the process of building multi-level models (to answer research questions three and four).

1.8.4 Chapter Four

Chapter Four presents descriptive findings and results to answer the project's four research questions. First, the chapter presents descriptive student-level results from the Global school-based health survey (GSHS) on student demographics, diet-related characteristics and anthropometrics. Next, the chapter presents descriptive results from the NFSI tool for researchers on school approaches to promoting healthy diets and the total number of NFSI actions that schools reported.

Chapter Four goes on to present the results aimed at answering the first research question: 'What is the nutritional quality of the diets of adolescent students living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?' It presents the baseline descriptive results using the DQI-I and other dietary outcomes according to individual student and school characteristics. The next section of this chapter provides the results for answering the second research question: 'Is there significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?' It investigates whether there was significant variation in student nutrition outcomes by district and by school. Based on these findings, the chapter presents the multi-level modelling results to answer research question three: 'Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets?' Finally, this chapter presents the results for answering research question four: 'Using longitudinal baseline and follow-up data, are there significant associations between changes in implementation of NFSI recommendations and changes in the nutritional quality of students' diets?' It answers this question by describing how DQI-I scores and NFSI actions changed over time, before providing the results from the multi-level models.

1.8.5 Chapter Five

Chapter Five provides a discussion of the main findings of the thesis. It unpicks the results of the four research questions and contextualises where they sit within the larger knowledge base. It includes an in-depth discussion on what this work contributes to this field of research. The chapter also discusses the strengths and limitations of this study and considers the implications and recommendations for policy, practice and research.

1.9 Funding

This DPhil research was funded by a studentship from the University of Oxford's Nuffield Department of Population Health. This project was conducted through collaboration with the 'Integrating Nutrition Promotion and Rural Development' (INPARD) project, which was funded by World Bank's South Asian Food and Nutrition Security Initiative (SAFANSI).

1.10 Summary of chapter one

This chapter provided background information and a general overview of principles which will be addressed in this study. It explained how Sri Lanka is a lower-middle income country (LMIC) experiencing a double burden of under- and over-nutrition. Nutrition is an important but often overlooked public health consideration, particularly among adolescent populations living within LMICs. Schools have been identified as key settings for promoting healthy diets. The WHO concept of 'Health-promoting schools' plays an integral part of WHO strategies related to improving child and adolescent nutrition and preventing NCDs. The best evidence related to health-promoting schools comes from a Cochrane review which, drawing evidence from interventions in 1,345 schools, found that health-promoting schools improved students' BMI, physical activity levels and diets, and reduced cigarette consumption and bullying [32]. However, the review also highlighted a dearth of research from LMICs.

Some of the concepts behind health-promoting schools are formalised within the WHO's NFSI framework which outlines specific ways that schools can promote healthy diets. Health-promoting schools, the NFSI and settings-based approaches to health promotion are based on the socioecological model (SEM), which provides a framework for understanding the complex variety of factors which influence health behaviours. This thesis drew upon the SEM to identify factors which should be considered and adjusted for in analyses investigating school-based influences on student nutrition, including individual demographics, intrapersonal factors and institutional characteristics. To illustrate the associations between school approaches to promoting healthy diets and student outcomes, this chapter provided a logic model which outlined the hypothesised relationship between school NFSI approaches and student outcomes. It described how the socio-ecological model (SEM) of health was used to frame the thesis and identified the various factors that were included in analyses examining school-level influences on nutrition.

After providing this overview of the theoretical foundations of this thesis, this chapter explained how I came to be involved in the present work. I collected data through collaboration with the 'Integrating Nutrition Promotion and Rural Development' (INPARD) project. My specific role involved leading on the school- and student-based research, which involved identifying the methods and tools for data collection, discussing them with the team, coordinating the data collection, training the data collectors, processing the data sets, completing analyses and presenting results. This chapter explained how my research questions evolved over time. Ultimately, the thesis had four research questions: 1) What is the nutritional quality of the diets of adolescent students living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka? 2) Is there significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka? 3) Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets? 4) Using longitudinal baseline and follow-up data, are there significant associations between changes in implementation of NFSI recommendations and changes in the nutritional quality of students' diets? After defining the research questions, this chapter helped to orient the reader by providing a summary outline of the thesis chapters.

2 A scoping review of the World Health Organization Nutrition-Friendly Schools Initiative

2.1 Abstract

This chapter provides a summary of a scoping review that I conducted to examine the evidence behind the World Health Organization's (WHO's) 'Nutrition-friendly schools initiative' (NFSI)[11]. Review papers, systematic reviews and meta-analyses were identified through a key word search related to the 26 NFSI Criteria. The following databases were searched: PubMed, Campbell, 13E, Cochrane library, and PDQ-Evidence databases. Papers were required to have been published between January 2000 and January 2015. Reviews were included if they integrated the results of several primary research studies on interventions related to the NFSI Essential Criteria and where a considerable part of these primary studies had taken place in the school setting. Study quality was graded using an adapted version of the 'Assessment of Multiple Systematic Reviews' criteria. Three researchers independently reviewed the studies, identified each study's aims, search methods and results. Heterogeneity in study aims, methods and measures precluded meta-analysis, so a narrative approach was used to describe study findings. Results were organised according to the relevant NFSI criteria. A total of 49 studies were included in this report: 36 systematic reviews (including one Cochrane review and one Campbell review), 13 meta-analyses and one scoping review. The included studies were published between 1998 and 2015, with around half (n=27) published within the last five years. Results indicated a strong evidence base related to particular components of the NFSI, especially in the areas of nutrition- and health-promoting curriculum. This review found strong evidence related to the positive effects of engaging families and community members, involving communities in nutrition- and

[11] A full report was submitted to WHO Headquarters in December 2016

health-related outreach and creating supportive environments through the provision of school meals, vendors or snack bars to encourage healthy eating.

2.2 Background

In 2006, the WHO launched the NFSI. Its founders recognised the importance of nutrition during childhood and adolescence and believed that schools were at the foundation of effective nutrition promotion policy. The NFSI identified the actions that schools should take to address the double burden of malnutrition and to enable schools to implement intervention programmes that would improve the health and status of young people[15]. The NFSI also aimed to integrate school-based programmes from across organisations[12] [73, 74]. Its content was drawn from expert opinion, findings from a Cochrane systematic review on the effectiveness of diet, physical activity and or lifestyle and social support interventions designed to prevent childhood obesity[75], a National Institute for Health and Clinical Excellence (NICE, UK) review of studies that aimed to prevent obesity in school children, or to improve diet and/or physical activity[76] and qualitative reviews by Flynn *et al*[77]. A series of inter-agency consultations and discussions of this evidence ultimately led to the framework, which is described in Box 2.1.

[12] Organisations included the Food and Agriculture Organization, United Nations Children Fund (UNICEF), World Bank, Education Development Center (EDC), Save the Children (SC), Partnership for Child Development (PCD) and a Standing Committee on Nutrition (SCN) and governmental organisations from Brazil, Finland and Ireland.

Box 2.1 Summary of the Nutrition-friendly schools initiative

1. Having a Written Nutrition-Friendly Schools Policy

- 1.1 Development of a Written Nutrition-Friendly Schools Policy that addresses all five points described in this framework, and it includes elements described in 1.2 - 1.5.
- 1.2 Rationale: *e.g.* promotion of healthy diet and eating practices, increased physical activity; prevention of undernutrition, micronutrient deficiencies, overweight and/or obesity and other nutrition-related chronic diseases; also contributory conditions such as unhygienic school environments, untrained school staff, lack of information in the community
- 1.3 Objectives: with timelines and clear milestones
- 1.4 Action plan: The whole school approach contributing to healthy living and lifestyles to include description of processes, organisational structure, roles and responsibilities, rights/ equity/ non-discrimination, strong commitment by all concerned stakeholders, including family and community
- 1.5 Monitoring and evaluation plan for the NFSI Policy

2. Enhancing Awareness and Capacity Building of the School Community

- 2.1 Dissemination of the Nutrition-Friendly Schools Policy
- 2.2 Activities for families and community, community involvement and outreach in the area of nutrition and health related issues
- 2.3 School staff training in nutrition and health related issues

3. Developing a Nutrition and Health-promoting School Curriculum

- 3.1 Culturally appropriate and effective nutrition education
- 3.2 Age, sex and culturally appropriate physical education curriculum
- 3.3 Healthy living and life-skills education curriculum
- 3.4 Regular monitoring of school curriculum relevant to NFSI, and evaluation of impact of the education against the objectives

4. Creating a Supportive School Environment

- 4.1 School meals, food vendors and snack bars (if present) promote healthy eating
- 4.2 Positive messaging towards nutrition and active living
- 4.3 Absence of marketing of foods and beverages at school
- 4.4 Access to an adequate eating place if the school provides food and/or beverages to the children
- 4.5 Adequate school cooking facilities
- 4.6 Access to safe drinking water
- 4.7 Promotion of safe hygiene and sanitary behaviour
- 4.8 Availability of clean and separate toilets, for boys and girls
- 4.9 Opportunity for all age groups to access space and school sporting facilities for physical activity in and outside of curriculum
- 4.10 Affirmative action against bullying, stigmatization, and discrimination
- 4.11 School staff as role models in encouraging healthy eating and healthy lifestyle

5. Providing Supportive School Nutrition and Health Services

- 5.1 Regular monitoring of children's growth development
- 5.2 Effective feedback system for parents and children of findings of the regular monitoring
- 5.3 Supportive school health service, including a referral system

2.2.1 Summary of NFSI Components

The NFSI framework first recommends having a written nutrition-friendly schools policy, and ensuring that the policy has a clear rationale, objectives, an action plan and a monitoring and evaluation plan. The second component relates to enhancing awareness and capacity-building within schools by sharing the nutrition-friendly school policies, holding activities for families and communities, outreach in the area of nutrition/health and hosting staff training on nutrition/health. The third component, developing a nutrition and health-promoting curriculum, recommends that schools provide age-, sex- and culturally-appropriate curricula that is regularly monitored and evaluated. The NFSI also places an emphasis on creating a supportive school environment and makes recommendations related to school meals, the absence of marketing, school cooking facilities, safe drinking water, clean and separate toilets for boys and girls and employing school staff that are role models in encouraging healthy eating. Finally, the fifth component relates to providing supportive school nutrition and health services, monitoring students' growth, implementing a feedback system and providing supportive school health services.

2.3 Methods

2.3.1 Study design and evidence considered

This evidence review consolidates various sources of evidence, including guidance from WHO and international agencies as well as scientific literature. WHO guidance comprises both those approved by the WHO Guidelines Review Committee after its establishment in 2009, and other guidance documents such as previous guidelines, guidance manuals, recommendations, official statements and other forms of high-level guidance that have been adopted or endorsed by the World Health Assembly. However, the main focus is to scope and review relevant systematic reviews related to the NFSI Essential Criteria.

2.3.2 Searching strategies and inclusion criteria

Review papers, systematic reviews and meta-analyses were identified by WHO staff through a key word search related to the 26 NFSI Essential Criteria, e.g. school and diet, nutrition, food, vending machines. The PubMed, Campbell, 13E UKAID, Cochrane library, and PDQ-Evidence databases were searched for relevant reviews published between January 2000 and January 2015. Reviews were included if they integrated the results of several primary studies of interventions related to the NFSI Essential Criteria, and where a considerable part of these primary studies had taken place in the school setting.

Table 2.1. Inclusion criteria for review of evidence for the NFSI

Population	Intervention	Comparator	Outcomes
School-aged children, ranging in age from four to 19 years	School-based programmes, interventions or characteristics relevant to the NFSI criteria	Schools or students who did not have the school-based programme, intervention or characteristic of interest	Student outcomes related to student diet, health and well-being School outcomes: environmental features such as food availability

2.3.3 Grading the quality of review articles

The Assessment of Multiple Systematic Reviews (AMSTAR) to grade quality of reviews was used as a basis for assessing the quality of the reviews, with a slight adaptation to assign a scoring system to different attributes of the ten components.

2.3.4 Evidence summaries

Three researchers independently reviewed the studies and identified each study's aims, search methods, inclusion criteria (study type, participants, interventions, outcome measures, methods of analysis, etc.) and overall results (e.g. description of studies included, study effect of interventions). For each paper, the researcher also specified relevant NFSI components. Due to differences in study aims, methods and measures, meta-analysis was not appropriate. Therefore, I took a narrative approach to summarise study findings. I organised our summary of results by grouping studies according to the relevant NFSI criteria. Many studies were relevant to more than one component of the NFSI.

2.4 Results

The searches identified a total of 527 papers (after duplicates were removed). Based on reviews of titles and abstracts, papers were excluded for failing to synthesize results from primary studies, if a considerable proportion of studies were not performed in the school setting or if the studies did not address pre-, primary- or secondary schools. Papers were subsequently summarised to address relevance to the NFSI framework.

2.5 Descriptive analysis of the selected reviews

A total of 49 studies were included in this report: 35 systematic reviews (including one Cochrane review and one Campbell review), 13 meta-analyses and one scoping review (Table 2.2, Table 2.3) (Figure 2.1). The included studies were published between 1998 and 2015, with around half (n=27) published within the last five years (Figure 2.2).

Figure 2.1. Summary of search information

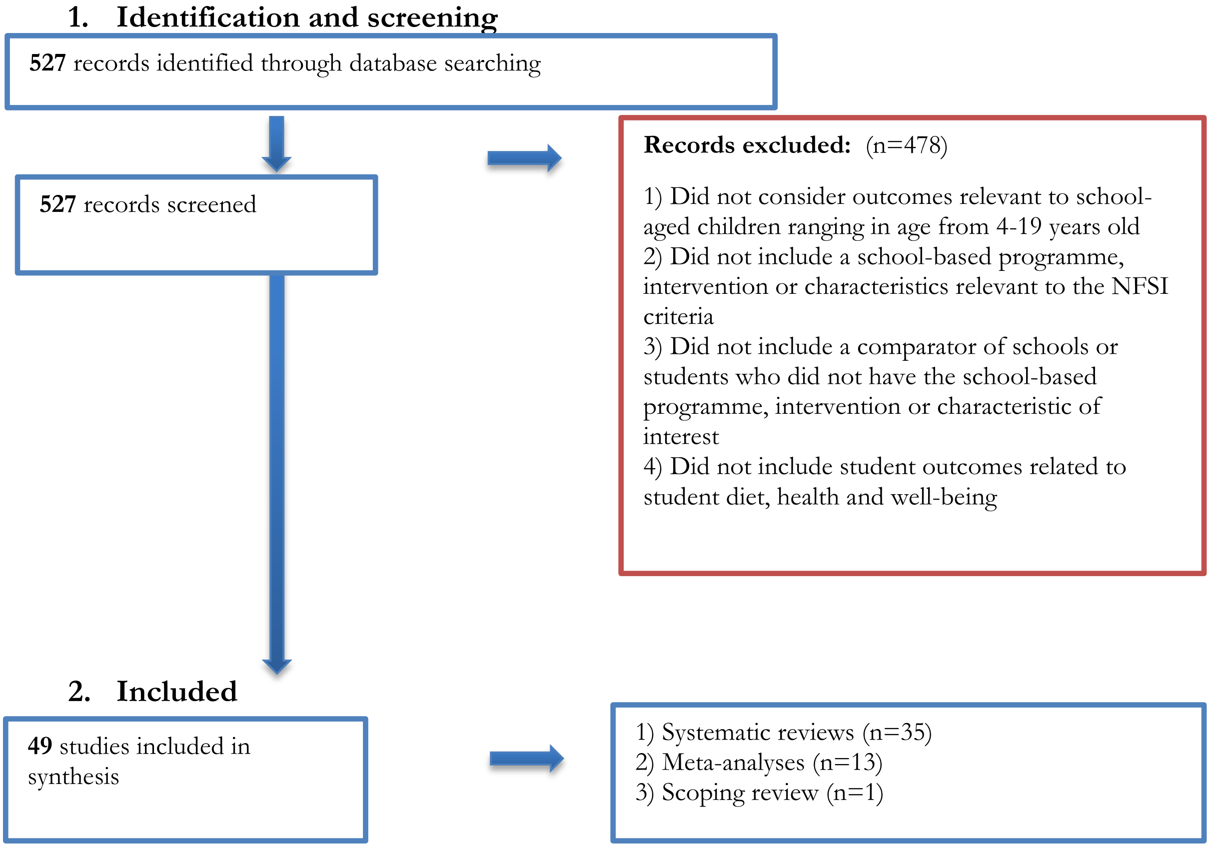


Figure 2.2. Publication year for included studies

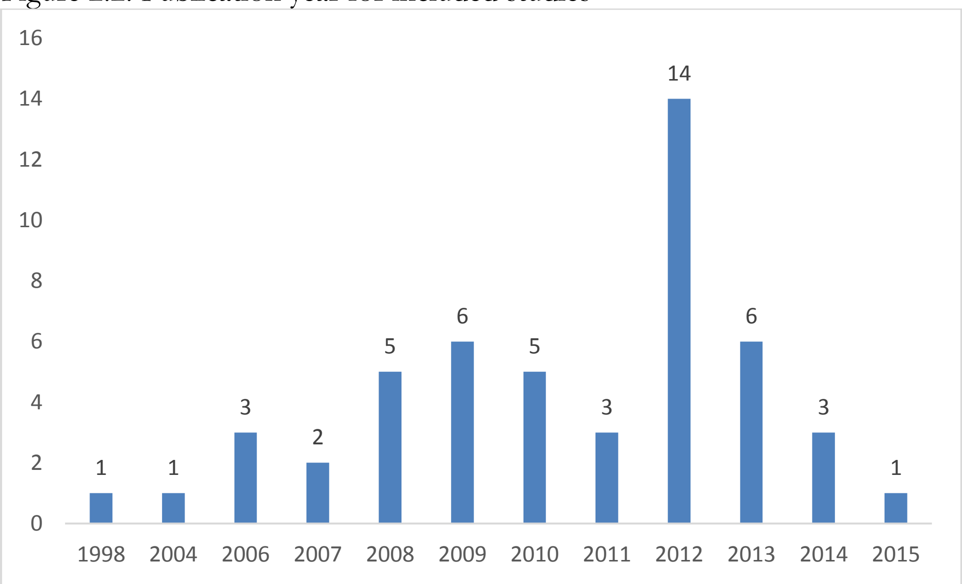


Table 2.2. Description of included studies

Author, year	Relevant NFSI Essential Criteria	Study type	Sample Age (years)	Setting
Barbero *et al*, 2012[78]	2.2, 4.10	Included both review and primary research studies. Restricted studies to (1A) meta-analysis of randomized, controlled clinical trials; (1B) randomized controlled clinical trials; (2A) suitably designed, nonrandomized controlled studies; and (2B) uncontrolled studies, such as pre-post studies and cohort studies.	6-16	Primary and secondary schools from around the world, but most commonly in the United States, Australia and Europe.
Beets M *et al*, 2009[79]	4.9	Randomized controlled trials or quasi-experimental (using pre- and post-tests with no control and no randomization)	≤18	The United States and Europe, low and high income
Best *et al*, 2011[80]	4.1	Eligible study designs were restricted to experimental controlled efficacy or effectiveness studies including randomized controlled trials (RCT), quasi-experimental controlled clinical trials (CCT), and controlled before and after studies (CBA), as defined by the Cochrane Collaboration.	6-18	Eleven of the 12 studies were conducted in developing or transitional countries and 11 provided the intervention at schools.
Birdthistle I *et al*, 2011[81]	4.7, 4.8	Empirical research only	4-18	Lower and middle income countries (LMIC) as defined by 2009 World Bank Criteria within educational settings (e.g. a public, independent or private school)
Brown *et al*, 2009[82]	3.1, 3.2, 4.1	RCTs or controlled clinical trials of lifestyle interventions (comparing interventions with usual care or other active interventions).	5-18	Most of the research was from the United States. Of the 38 studies, 17 were from America, 3 were from the UK, 2 were from Australia, 2 were from Germany and the remaining 14 were based in European and non-European countries. Twenty three of the studies were set in primary schools and 12 were in secondary schools. Two were based in a kindergarten or preschool and one was based in a 'high school' (students aged 16-18 years).
Cairns G *et al*, 2013[83]	4.1, 4.3	For the questions on the effect of marketing, all studies were included if they could demonstrate marketing as the independent variable acting on one of five pre-specified measures of effects. Study design was assessed using the Bradford-Hill criteria for determining if observed associations between variables may be inferred to be causal or simply correlational	2-15	Most of the research was from the United States, plus a number of other countries including Australia, Canada, the Islamic Republic of Iran, Italy, Malaysia, the Netherlands, New Zealand, Portugal and the United Kingdom.
Chriqui JF *et al*, 2014[84]	1, 4.1	Quantitative studies focused on the food and beverage environment in elementary, middle, or high schools and to have examined the effects of a formally adopted (i.e., "on the books") big "P" policy enacted at the state and/or district levels as the independent variable in the study. Studies could be either cross sectional or longitudinal.	School aged	United States
De Bourdeaudhuij I *et al*, 2010[85]	2.2, 3.1, 3.2, 4.1, 4.2, 4.9	Any	6-18	Western, Southern and Northern Europe
de Sa *et al*, 2008[86]	1, 2.2, 3.1, 4.1, 4.2	Studies with a control group for comparison and a follow-up period of at least 3 months. Papers with an English abstract published in any language were considered	School aged	The United States, Europe, and New Zealand
Demetriou Y *et al*, 2012[87]	3.2	Controlled trials comparing intervention groups and controlled groups.	6-19	No specific countries.
Dudley *et al*,	3.1, 3.2,	The study was based on the criteria of the PRISMA (Preferred Reporting Items for Systematic Review and	5-12	13 countries. All but one (Trinidad and Tobago) were from OECD

2015[88]	4.1, 4.2	Meta-Analysis) Statement. The studies included were mostly quantitative in nature: randomized, quasi-experimental and cluster-controlled studies.		countries: United States, United Kingdom, Ireland, Greece, Australia, Italy, Norwegian, Canada, New Zealand, Iceland, the Netherlands,
Farrington *et al*, 2009[89]	4.10	Experimental: Studies were required to compare an intervention group to a control. These included randomized experiments, experimental control comparisons with before and after measures of bullying, other experimental-control comparisons and quasi-experimental age-cohort designs.	School aged	Most of the studies came from the United States and Canada (n=15).
Flodmark *et al*, 2006[90]	2.2, 3.1, 3.2, 4.1	Experimental (must include at least 12 months of follow up and a control group)	School aged	The United States (n=5), Great Britain (n=2), Russia (n=2), Finland and Germany.
Flynn *et al*, 2006[77]	2.2, 3.1, 3.2	Any study describing a program with the required outcome or process indicators. Case studies, surgical interventions or programs with marketing materials were excluded.	≤17	The majority of the 147 studies were implemented in either clinical settings (37%, n=55) followed by primary (kindergarten through grade six) schools (31%, n=45). Fewer than 3% (n=5) of programs were implemented in pre-school settings or homes.
Ganann *et al*, 2012[91]	2.2, 2.3, 3.1	Acceptable designs for this review included systematic reviews (included research syntheses and meta-analyses), randomized and non-randomized studies (including cluster-controlled and controlled time series), interrupted time series (to assess changes that occur over time), and before-after studies with controls. Relevant clusters within studies, included school units, classrooms or communities rather than individuals as the unit of analysis. `	5-18	This review does not outline the country where research was based, but it does identify the 'settings'. The most common intervention locations included schools, followed by communities or community centres, and homes. Most studies implemented multi-faceted intervention strategies to increase FV access or consumption. These included involving teachers (n=130), school administrators (n=32) and/or other school personnel (n=49).
Griebler *et al*, 2014[92]	3.1, 3.2, 3.3, 4.1, 4.2, 4.4, 4.9, 4.10, 4.11, 5.1	All types of empirical studies or reports describing empirical research about student participation in decision-making about health promotion measures at school were included.	5-19	US, UK, Canada, Sweden, India, China, Australia, Czech Republic, Denmark, Sweden, Macedonia, Iceland, Portugal, Slovenia, Netherlands, Norway, plus 19 non-specified EU countries.
Guerra *et al*, 2013[93]	3.1, 3.2, 3.3, 4.2, 4.9, 4.11	Randomized controlled trials that included elements of physical activity were analysed.	6-16	Canada, US, England, Switzerland, Australia, Spain, China, France, Belgium, Germany
Harris *et al*, 2009[94]	3.2	Randomized controlled trials and controlled clinical trials. The control group could not have received the intervention and must have continued with the existing physical education curriculum, with no change in duration or intensity.	5-18	Twelve studies were conducted in the United States, 3 in Canada and 1 in each of Australia, Chile and Sweden.
Health Canada *et al*, 2004[95]	1, 1.4, 1.5, 2.2, 2.3, 3.1, 3.2, 4.2	Only prospective studies with a control group were considered relevant. Both cohort and RCTs were included.	6-18	School and community-based settings
Hingle *et al*, 2010[96]	2.1	Randomized controlled trials	2-18	The majority of interventions (n=16) were delivered in schools, while the remaining eight studies were implemented in community settings. Three studies took place outside of the United States — in Australia, Belgium and France.
Howerton *et al*, 2007[97]	3.1, 4.1, 4.2	Controlled trials that included measures of fruit and vegetable intake pre- and post-test.	7-12	Elementary schools (mostly in the United States, including Colorado, Minnesota, Alabama, California). The setting is not fully described in the descriptive tables.

Jaime *et al*, 2009[98]	4.1	Randomised and non-randomised, controlled and non-controlled trials and cross-sectional studies carried out after the implementation of school-based nutrition policies which had a non-exposed comparison group.	2-18	Pre-schools (n=1), primary (n=7) and secondary schools (n=10). The majority of nutrition guideline studies (8 of 9) and regulation of food availability (2 of 2) came from the USA. Price intervention studies came from Europe (n=6) and the United States (n=2).
Janssen *et al*, 2010[99]	3.1, 3.2	Cross-sectional studies, case-control studies, cohort studies (prospective and retrospective) and intervention studies (including randomized and quasi experimental designs) were eligible for inclusion in the systematic review	5-17	National settings are not described in the paper, but appendices provides the country of selected outcome indicating a range from North America, Europe and Asia. ; Cholesterol: 4 American, 1 Greek, 1 Chinese, 1 French; Hypertension: 1 Canadian, 1 American, 1 Danish), Blood pressure: 5 American, 1 mixed, 1 Chinese); Metabolic syndrome: (2 American, 2 Danish, 2 mixed European, 1 Iranian, 1 Mexican); Most of the obesity measures were from America (8) and Canada (5).
K.K. Pucher *et al*, 2013[100]	4.9	Randomized controlled trials or cross-over controlled trials, quasi-experimental (using pre- and post-tests)	5-18	School-based settings
Katz *et al*, 2008[101]	2.2, 2.3, 3.1, 3.2	Studies were required to include a control measurement (either with pre/post-measures or using control group(s); and follow participants for at least 6 months from the beginning of the intervention.	3-18	Most studies (n=13) took place in elementary schools, 3 took place in middle schools and 3 targeted high school students. Ten took place in the United States, whereas nine were conducted overseas.
Knai *et al*, 2006[102]	1, 2.2, 2.3	Studies were required to have a control group	5-18	Twelve came from the United States, followed by 2 from the UK and 1 from Ireland.
Krishnaswami *et al*, 2012[103]	2.2	Randomized controlled trials, matched-control experiments, and observational and quasi-experimental (nested cross-section, pre–post) designs. Studies were required to assess outcomes relative to a control group or, for observational studies, to have a sample size 50 and control for confounders.	School aged	Primarily the United States. Interventions involved diverse groups (African-American, Hispanic, Native American, rural, urban, and low-income)
Kristjansson *et al*, 2007[104]	4.1	Randomized controlled trials, non-randomized controlled clinical trials (CCTs), interrupted time series (ITS), and controlled before and after studies (CBAs) were included. Control groups could be either “no-treatment” controls (lunch or breakfast at home or no feeding/fortification) or placebo controls (e.g. low energy glucose syrup at school). Other study designs were excluded.	5-19	Nine were performed in higher income countries and nine in lower income countries.
Kropski *et al*, 2008[105]	2.2, 3.1, 3.2, 4.1	Experimental or quasi-experimental	School aged	All interventions took place at schools. The country where the study took place was not described completely in text or tables, but there were studies from around the world including the United States, United Kingdom, Asia, South America, Germany, Canada
Lavelle *et al*, 2012[106]	3.1, 3.2, 3.3, 4.1, 4.2, 4.9	Cluster randomized controlled trials (RCT), Efficacy trial, Quasi-experimental, pilot RCT, Quasi-RCT, pilot prospective study	≤18	The United States, Australia, Germany, Spain, Brazil, France, Netherlands, India, Canada, Singapore, Egypt, Belgium, Ireland, China, Chile, Switzerland, Greece, Thailand, UK
Li *et al*, 2008[107]	3.1, 3.2	Experimental studies (pre- and post-test measures)	3-19	Schools in mainland China. All of the studies were conducted in major cities, such as Beijing and Shanghai,

				or in Eastern coastal areas. One study was conducted in four cities, including one in Western China.
Lima-Serrano *et al*, 2014[108]	2.2, 2.3, 3.1, 4.2	Quantitative experimental or observational studies in which an intervention group was compared at least twice (pre-test and post-test)	11-17	The projects were manly conducted in Europe (n=17), and the United States (USA) (n=12).
Lonsdale *et al*, 2012[109]	2.3, 3.1, 3.2, 3.3, 4.9, 4.11	We included studies employing experimental (e.g., randomized controlled trials and cross-over designs) and quasi-experimental methods. Cross-sectional and cohort designs were excluded. No limitations were set regarding the duration of the intervention or the follow-up period.	School aged	The United States, United Kingdom, Belgium, and Australia
MacArthur *et al*, 1998[110]	3.1, 3.2	Studies were required to contrast two groups within the study and provide individual-level measures in the analysis.	9-11	Elementary schools in the United States
Niemeier *et al*, 2012[111]		Experimental RCTs: Studies that assessed characteristics of participants who were randomized to intervention and non-participating control groups. Studies that compared multiple types of interventions were included if they also reported characteristics of a non-participating control group. Studies that reported on control groups that participated in unrelated activities or received a simple piece of related material (i.e. a pamphlet about healthy lifestyles, but not an instructional manual for weight-reduction) were also included in this review.	2-19	Interventions within schools and the larger community (including clinics)
Nixon *et al*, 2012[112]	2.2, 3.1, 3.2, 3.3, 4.2, 4.11	RCTs and other studies with a controlled assignment of participants and with a follow-up period of minimum 6 months.	4-6.9	Europe, North America, Asia, and Australia. Preschool or school level.
Polanin *et al*, 2012[113]	4.10	They included only studies that used a treatment-control research design. These designs included true experimental randomly assigned groups, non-random quasi-experimental designs, and non-randomly assigned matched group. They also included all control group types; these included wait list, treatment-as-usual, and "straw-man." However, single-group pre/post-test (e.g., gain scores) and cohort designs were excluded.	12-12	United States (7) and Europe (4, Belgium, Finland, Greece, and Italy)
Ridgers *et al*, 2012[114]	2.2, 3.2, 4.2, 4.9, 4.11	Studies were required to (1) have a measure of physical activity as the outcome variable; (2) specifically example physical activity during recess and/or lunchtime; (3) examine associations between physical activity and other variables; (4) be published in English.	5-18	United States (n=16), UK, Northern Ireland (n=12); Australia (n=5); Norway (n=4); New Zealand, (n=3); Taiwan, Japan, Portugal (n=2); Hong Kong, Mexico, the Philippines, Canada, Belgium, Hungary, Spain and France (n=1); 1 study collected data across multiple countries
Robertson-Wilson *et al*, 2012[115]	1	Related to a government law, bill, or policy reflective of "physical activity" (since 2000)	5-18	School settings in the USA
Robinson-O'Brien *et al*, 2009[116]	2.2, 3.1	Studies examining the effects of garden-based nutrition-education programs for youth	5-15	School settings in the USA
Saraf *et al*, 2012[117]	2.2	Comparative or pre-post studies of school-based interventions that focused on physical activity, nutrition, obesity-related risk factors, sedentary habits and tobacco consumption to prevent non-communicable diseases.	School aged	School settings
Silveira *et al*, 2011[118]	2.2, 3.1, 3.2, 3.3, 4.1	RCT design; the intervention and control groups were contemporaneous and received the same cumulative duration of treatment or non-treatment.	5-18	School and classroom settings
Sobol-Goldberg *et al*, 2013[119]	Package - comprehensive	RCTs	5-18	School-based programs

Stevens *et al*, 2010[120]	3.1, 3.2	Does not specify	10-14	School based, community centre, paediatric and adolescent clinics
Van Cauwenberghe *et al*, 2010[121]	3.1, 4.1	There were no restrictions on study design, study duration, follow-up period, intervention strategies, control condition and on who delivered the intervention. Studies were considered regardless of their design.	6-18	Conducted in European Union countries and within school settings
Van Lippevelde *et al*, 2012[122]	2.2	Controlled trials with a design in which at least a school-only intervention group was compared with a school-plus-family intervention group	6-18	US (n=3), Australia, Belgium
Wang *et al*, 2013[123]	1	Controlled studies	School aged	School-based settings
Williams *et al*, 2013[124]	2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3	Any experimental or observational study design (randomised controlled trial, controlled before and after study, interrupted time series, cohort study or cross-sectional study). Studies were required to have a minimum follow up or exposure of six months.	4-11	Most of the studies took place in the US (n=16), with the remaining five from Australia, Canada, Italy, Mexico and the UK.

Table 2.3 Study interventions, outcomes and summary of findings

Author, year	Intervention	Outcome	Summary Description
Barbero *et al*, 2012[78]	School-based interventions directed at pupils to prevent or reduce bullying or violence in the school environment.	Study outcomes included both the components of effective interventions and the interventions' reported effects (e.g. reduction of bullying, aggressive behaviour).	This systematic review included 32 articles on school interventions to prevent bullying found that the likelihood of program success is enhanced when programs involve all disciplines, involve parents, are culturally-adapted and ensure long-term continuity.
Beets M *et al*, 2009[79]	After-school intervention in public or private schools with component of PA promotion.	Quantitative outcome measure of physical activity and/or physical fitness.	This meta-analysis of 13 studies with after-school interventions to improve physical activity found positive effect on 4 out of 6 outcome domains considered.
Best *et al*, 2011[80]	Provision of multiple micronutrient (MMN) fortified foods (foods with at least three micronutrients, although B-vitamins were considered one micronutrient).	Studies were required to test the independent effect of MMN fortification by comparing an MMN-fortified food to either an unfortified food or a food fortified with only one or two micronutrients. Outcomes included: biochemical measurements of micronutrient status or prevalence of micronutrient deficiencies, indicators of g indicators of growth or body composition, prevalence of stunting, wasting, or underweight; indicators of morbidity (prevalence, incidence, duration, and/or severity), including absence from school; cognitive outcomes, including academic performance.	This systematic review of 12 studies examined the effects of multiple micronutrient (MMN) fortification on children's micronutrient status, anthropometrics and cognition.
Birdthistle I *et al*, 2011[81]	Provision of separate toilets for girls, School-based water, sanitation and hygiene (WASH) interventions	Educational (school enrolment, attendance or completion) and health (e.g. infectious borne diseases, sexual health, reproductive health, psycho-social health) outcomes.	This review did not find evidence to answer its primary research question (on separate toilets for girls), but identified 12 studies about school-based water, sanitation and hygiene (WASH) interventions which suggested beneficial effects on educational outcomes.
Brown *et al*, 2009[82]	A "lifestyle intervention" (including activities aimed to increase healthy eating, increase physical activity, reduce sedentary behaviour, behaviour therapy, social support and education for diet and activity).	Body Mass Index (BMI)	Among the 38 studies included in this review, one of three (33%) diet studies, five of fifteen (33%) physical activity studies and nine of twenty (45%) combined studies found significant and positive differences between intervention and control groups for BMI.
Cairns G *et al*, 2013[83]	This review did not look at evidence of effectiveness of and intervention per se, i.e. prohibition of marketing of foods and beverages to children. However, it reviewed current marketing practices and how these affect children's knowledge, behaviour and health. All forms of commercial food promotion targeting children aged 2-15 years were considered.	The outcome measures for effects were nutrition knowledge, food and beverage preferences, purchase behaviours, consumption behaviours and diet-related health indicators.	This systematic review of 99 primary studies and 16 review articles of food and beverage marketing to children found that current marketing practice predominantly promotes low nutrition foods.
Chriqui JF *et al*, 2014[84]	State laws, school district policies that influence BMI, weight, and presence of competitive food and beverages.	1) BMI and weight outcomes 2) student food and/or beverage consumption, purchasing, or dietary intake 3) in-school competitive food and beverage availability or access	This systematic review of 24 studies on state and district competitive food and beverage laws and policies found overwhelming positive outcomes for policies focused on in-school availability and consumption, but mixed outcomes for health

			outcomes (BMI or obesity/overweight).
De Bourdeaudhuij I *et al*, 2010[85]	All interventions within the school setting aimed at the primary prevention of obesity and obesity-related diseases in which the main component or one of the components was the promotion of a healthy diet combined with physical activity.	Relevant measures related to obesity (e.g. BMI, skin-fold thickness), diet (e.g. fat intake, fruit and vegetable intake), physical activity behaviour (e.g. minutes of activity, active travel to school) and related behavioural determinants (e.g. attitudes, knowledge, social support, self-efficacy).	This descriptive systematic literature review of educational and multicomponent obesity prevention programmes in European schools suggested that interventions focusing on education only have less effect on obesity prevention than multicomponent programmes.
de Sa *et al*, 2008[86]	All interventions based in school or pre-school, applied to individuals or populations, encouraging fruit and/or vegetable consumption.	Primary outcomes: Changes in fruit and/or vegetable intake or in knowledge, attitude or preference to fruits or vegetables Secondary outcomes: impact on other food intake and BMI.	This systematic review of 30 controlled intervention studies to promote fruit and/or vegetable consumption in children in school settings concluded that school schemes are effective at increasing both intake and knowledge, as 70% of studies increased FV intake.
Demetriou Y *et al*, 2012[87]	The interventions had to take place within a school setting and had to include a physical activity component. After-school interventions were not included in this review.	Three levels of outcomes: physical activity, attitude/feelings about physical activity, and health and overall fitness (including BMI).	Systematic review of 129 studies of PA interventions. Almost a third of all studies reported a positive effect, which was more common among interventions combining PA and cognitive components.
Dudley *et al*, 2015[88]	Elementary school-based interventions delivered by teachers: 1) Curriculum initiatives or evaluations 2) Nutrition-friendly school initiatives 3) Community programs linked to curricula or delivered by schools (e.g. community gardens) 4) Health/nutrition education programs related to improving dietary habits 5) Environmental school change strategies implemented by classroom teachers 6) Environmental interventions/industry partnerships focused on point-of-purchase consumption linked through classroom based education 7) Social marketing campaigns 8) Policies that seek to improve dietary habits of elementary school children (i.e. school board level, provincial or national level).	The main outcomes of interest included student consumption, preference and knowledge of nutrient dense foods. This also includes the measures of food consumption, preference or knowledge, change in environments, food disappearance and food sales (in school cafeterias).	This systematic review of 49 studies reported the findings of teaching strategies linked to healthy eating outcomes for primary school children.
Farrington *et al*, 2009[89]	Programs designed specifically to reduce school bullying. Studies that targeted aggression were excluded. Individual programs varied, so a narrative description of included programs was provided. Key elements of the program included whole-school anti-bullying policies, classroom rules, school conferences, curriculum materials, classroom management, cooperate work groups, work with bullies and victims, work with peers, providing information for teachers and parents and other elements.	Bullying was measured using self-report questionnaires, peer ratings, teacher ratings, or observational data.	This Campbell Review of 89 reports (describing 53 different anti-bullying programs and a meta-analysis of 44 evaluations) showed that overall, school-based anti-bullying programs are effective at reducing bullying and victimization.
Flodmark *et al*,	Obesity- and over-weight prevention programs with at least one year of follow up. Interventions were not	Percentage of overweight/obese subjects, body mass index (BMI)	This review evaluated 10 new obesity prevention interventions (9 of which involved a school-based component) and found that

2006[90]	restricted to school-based programs and components of the programmes were not specified. There were 10 studies on prevention included in this review, and a detailed description is provided for 10. Nine of the 10 described studies involved a school-based recruitment or intervention.	or skinfold thickness	interventions had a positive effect on preventing obesity in 3 studies, but no differences were found between groups in seven studies.
Flynn *et al*, 2006[77]	A wide range of strategies from policy implementation or legislation affecting whole populations to individualized therapy or counselling of individuals in an experimental setting. Most included programs included health education on diet, physical activity or both (69%) and engagement in physical activity (64%) was the next most common intervention. The use of behaviour modification (50%) and involvement of family (52%) were also common. Following a specifically prescribed diet such as the traffic light diet was implemented in 35% of programs. The incorporation of psychosocial support (25%), incentives or rewards (26%) and changes to the environment (17%) was less frequent. Prescribing of a diet was the most common element of the clinic setting while it was the least common element in both school settings.	Programs had to include at least one of the following outcomes: Indices of overweight and obesity (anthropometry, body mass index, body fat distribution, growth rates, other*) Risk factors for obesity (exercise/activity levels, fitness, dietary habits/food choice, psychosocial factors, e.g. body image/self-esteem, anxiety, depression, other*) Chronic disease risk factors/markers associated with obesity (blood pressure, blood glucose and insulin levels, blood lipids levels, leptin levels, other*) Chronic disease associated with obesity (Type 2 diabetes, cardiovascular disease, cancer, other*) Adverse effects (eating disorders, smoking, other*) Programs could also include one of the following process indicators: Numbers invited versus numbers completing program Descriptions of individuals or community groups participating Other information evaluating how program was proceeding (acceptability/popularity, access, other*).	This report appraised the quality of 500 programmes, using the highest quality programmes (n=147) to develop recommendations for best practice.
Ganann *et al*, 2012[91]	Community-based interventions intended to bring about changes in FV access and consumption for five and 18 year olds, which included nutrition-friendly schools initiatives, child nutrition programs, community programs, health education, environmental school changes, social marketing campaigns, policies intended to increase access to FV, and policies intended to increase consumption of FV.	Primary outcomes included measures of both access to and consumption of fruit, vegetables, or both. Evidence of intervention effects included: measures at individual, family, school or community levels. Measures of FV access included: FV supply (i.e. market inventory): change in food environments, food disappearance and food sales. Food supply measures included information about which foods were distributed to different regions. Market inventory refers to records a food supply organization keeps about which foods are being ordered or are available. Measures of FV consumption included: diet and food intake records (self-reported or by parents/teachers), food frequency questionnaires/balance sheets, food wastage and plate waste; and micronutrient measures. Secondary outcomes included awareness of importance/impact of FV consumption among targeted groups.	This scoping review identified 289 unique studies and found that schools were one of the most common intervention locations and most of the interventions adopted a multi-faceted approach.
Griebler *et al*, 2014[92]	All reports describing student participation in designing, planning, implementing and/or evaluating school health promotion were considered.	Effects of student participation in designing, planning, implementing and/or evaluating school health promotion measures on the participating students, on other students, on the health promotion measure or on the school were considered.	Descriptive systematic literature reviewing the measurable impact of student participation in health programs with documentation showing its positive impact. Positive personal effects include increased satisfaction, motivation and ownership, increase in skills, competencies and knowledge, personal development, health-related

			effects, and influence on student perspective.
Guerra *et al*, 2013[93]	During school physical activity interventions.	Primary outcome: BMI Secondary outcomes: Body weight, blood pressure.	This meta-analysis of 11 studies randomized trial intervention studies to promote physical activity and prevent obesity, overweight, and cardiovascular disease concluded that interventions need to be at least one school year in length and physical activity should be moderate to vigorous for at least the WHO recommended length of 60 minutes per day.
Harris *et al*, 2009[94]	School-based physical activity interventions (taking place during regular class time) and that lasted for a minimum of 6 months.	Objective data for BMI from before and after the intervention.	Systematic review and meta-analysis of 18 studies on effect of school-based physical activity interventions that found interventions did not improve BMI, but had other beneficial health effects.
Health Canada *et al*, 2004[95]	Primary prevention intervention relevant to public health/ health promotion in Canada. Studies that assessed the effectiveness of interventions focused either solely or in an integrated way on improving nutritional intake, enhance physical activity and decreasing physical inactivity; studies that addressed one intervention or integrated a number of types of interventions (e.g. educational information, support groups, increasing activity during physical education classes); and, studies where the intervention was carried out in either the school, the family and/or the community.	Studies with one or more of the following child and youth outcomes were included: changes in total caloric intake and percent calories from fat, fruit and vegetable intake, changes in body fat, changes in perception of body image, self-reported changes in the duration, rate and frequency of physical activity, changes in VO2 max, and self-reported changes in inactivity (proxy measures include the number of hours per day of use of video devices).	This report examined the effectiveness of interventions for promoting healthy weight, preventing overweight/obesity and increasing physical activity among school-aged children and youth and found that positive outcomes are modest at best and many results are inconsistent between studies. The skill and motivation of teachers to comply with programs needs to be addressed. Multi-faceted programs are more effective than others, and resources for planning, implementation, monitoring and evaluation of these programs should be made available.
Hingle *et al*, 2010[96]	Trials of an obesity prevention, chronic disease prevention, or health promotion intervention involving a parent component (directly or indirectly engaging parents to support or assist children or adolescents to achieve changes in dietary intake.	Child dietary intake as a behaviour change target and as a measured primary or secondary outcome.	This review of 24 papers found that direct methods (as opposed to the more frequently used indirect methods) to engage parents in dietary interventions were more likely to result in positive outcomes.
Howerton *et al*, 2007[97]	School-specific interventions to increase fruit and vegetable consumption among children.	Net fruit and vegetable consumption difference and relative change (%).	This systematic review and meta-analysis evaluated the effect of school-based nutrition interventions on child vegetable and fruit consumption and found that interventions led to an increase in consumption.
Jaime *et al*, 2009[98]	Food or nutrition policies (nutrition guidelines, regulation of food and beverage availability, price intervention). Interventions whose focus was only on education or behavioural interventions without changes in school food environment were excluded.	Menu composition, availability and sales of food and beverages at school, student's dietary intake and BMI.	Systematic review of 18 studies examining impact of nutrition policy on BMI which found that some policies have improved the food environment and dietary intake, but their impact on BMI has been limited.
Janssen *et al*, 2010[99]	Physical activity: For the observational studies, there were no limitations placed on the form of physical activity (e.g., questionnaire, activity diary, pedometer, and accelerometer) or fitness (cardiorespiratory or	7 health indicators: high blood cholesterol, high blood pressure, the metabolic syndrome, obesity, low bone density, depression, and injuries.	Systematic review of 86 papers (113 outcomes).

	musculoskeletal fitness) measurements. For intervention studies, all cardiorespiratory and/or musculoskeletal based interventions were eligible for inclusion. Intervention studies were excluded if they included a dietary (e.g., caloric restriction) or other behavioural risk factor component (e.g., smoking cessation) that may have independently affected the health outcomes and subsequently made it impossible to distinguish the independent effect of the physical activity portion of the intervention.		
Pucher KK *et al*, 2013[100]	Interventions addressing healthy lifestyles in the general school population.	Quantitative outcome measure of general synonyms of physical activity and/or physical fitness. Studies excluded if without school grades, national test examinations or GPAs as outcome measure.	This is a meta-analysis of 7 studies.
Katz *et al*, 2008[101]	School-based interventions related to nutrition, physical activity, reduction in television (TV) viewing or combinations thereof, aimed to prevent unnecessary weight gain or manage weight among pupils.	Commonly used weight-related outcomes (BMI, body weight, etc.).	This systematic review and meta-analysis included 21 papers described 19 studies (8 included in meta-analysis) and examined the influence of school-based interventions on body weight, finding that combination nutrition and physical activity interventions are effective at achieving weight reduction in schools.
Kidger *et al*, 2012[125]	School environment exposure or intervention. For question 2 on the school environment in cohort studies, the exposure variable or target of the intervention was an aspect of the school environment that related to structural, pedagogic, or relational features of school life.	Papers were required to include at least 1 outcome measure of emotional health (positive or negative) or self-harm/ suicidal behaviour.	This review of 39 papers examined associations between emotional health among adolescents and school environmental exposures and found limited evidence to support that the school environment has a major influence on adolescent mental health.
Knai *et al*, 2006[102]	The intervention had to promote a diet high in fruit and vegetables. This could involve dietary advice taking any form (for example, verbal or written nutrition education, single or multiple contacts with individuals or groups), publicity campaigns, social marketing approaches, or by increasing production such as home gardening.	Change in fruit and/or vegetable intake, derived from self-reported measures or observation, or from availability data—if used as a proxy for intake.	This systematic review of 15 studies found evidence to suggest that multi-component interventions are most effective means of increasing fruit and vegetable consumption among children.
Krishnaswami *et al*, 2012[103]	The intervention was required to have a minimum level of "participatory involvement." This required evidence of (1) either formal or informal structures of partnership or empowerment AND (2) minimum participatory features: at least one school–community partner (students, parents, teachers/staff, administrators, local policymakers, academic/community-based agencies) involved in at least one research stage (prioritizing need, intervention design, delivery, data analysis/results dissemination).	Statistical reporting and analysis of quantitative nutrition, weight, or physical activity outcomes.	This systematic review of 16 studies found a positive relationship between levels of 'community engagement' and outcome performance in school-based interventions related to diet, physical activity and body weight.

Kristjansson *et al*, 2007[104]	Included: Meals (breakfast or lunch) or snacks (including milk) administered in a school setting. If a study included two or more experimental groups given different types of meals, they chose the meals with the highest energy and/or protein content for data extraction and analysis. Excluded interventions: micronutrient supplementation or fortification of existing meals, stand-alone nutrition education in schools or at home, obesity prevention programs, breastfeeding programs, food stamps, modifications to school meals to change nutrient content, community kitchens, food banks, and feeding centres.	Physical health outcomes included nutritional status (anthropometry, bone mineral density, bone mineral content, micronutrient status, and haemoglobin, and hematocrit). Both hemoglobin and hematocrit are indices of anaemia, a condition in which the blood cannot carry enough oxygen, and most often due to iron deficiency. Psychological health outcomes included educational outcomes (e.g., school achievement in math, reading, or spelling, school enrolment, school attendance) and other tests of cognition such as intelligence test scores, psychomotor and mental development, attention, memory, reasoning, verbal fluency, vocabulary, on-task behaviour. Behavioural outcomes included on-task behaviour, attention problems, and behaviour problems. Adverse outcomes included stigmatisation, dependency, disruptive behaviour at school, and obesity or excessive weight loss. Excluded outcomes: Reduction of dental caries, increased nutritional knowledge, and intermediate physical health outcomes such as reduction of hunger and nutrient intake.	This review of 18 studies on the effectiveness of school feeding programs found that school meals may have some small benefits for disadvantaged children.
Kropski *et al*, 2008[105]	Interventions were required to be curricular and/or environmental (as opposed to extracurricular) in design, and to apply preventive interventions involving both overweight and normal-weight children.	Primary or secondary outcomes in terms of BMI, a measure of body fat or obesity/overweight prevalence reported at least 6 months post-baseline.	This systematic review summarizes evidence on school-based interventions for overweight/obesity prevention and concludes that the overall quality of the evidence must be considered weak and therefore, does not draw specific conclusions.
Lavelle *et al*, 2012[106]	Physical activity, nutrition, sedentary behaviour	Methodology provided a total of 60 results for inclusion from the 43 studies provided. 40 out of 60 suggested a reduction in BMI in the intervention group compared with the control group.	Evaluates impact of school-based interventions on children's BMI. 43 studies were included in the meta-analysis and provided significant evidence that school-based interventions can significantly reduce a child's BMI, especially if they include a physical exercise component.
Li *et al*, 2008[107]	Intervention strategies were required to focus on modification of diet and lifestyle. Interventions varied across studies but the majority focused on improving the level of knowledge, physical activity levels and/or diet of overweight children and adolescents.	Weight-related outcomes which included changes in the prevalence of overweight and obesity, weight, skin-fold thickness, BMI Z score, biochemical markers (such as blood glucose, blood lipid profile, aerobic fitness and blood pressure), and changes in knowledge and behaviour.	This was a systematic review of 22 Chinese studies investigating the effectiveness of interventions aimed at preventing overweight and obesity among children and young people; 18 studies reported a significant effect but none of the included studies were rated as high-quality, leaving the authors to conclude that evidence is limited.
Lima-Serrano *et al*, 2014[108]	School-based behaviour change interventions. Implementation activities were performed in six areas, which were classified as interactive lessons, peer mediation, improving accessibility by environment changes, activities with parents, with community, and tailored message; and they mainly addressed facilitators and barriers, social influences (peers, family, school, media and community), cognitive, emotional and behavioural skills, and including multiple components.	Physical activity, health nutrition, mental and holistic health, and risk behaviour prevention.	This systematic review examines the effect of school-based interventions across a range of different behaviour domains from 35 moderate- or strong- quality studies and found some moderate to large, short- and long-term effects on behavioural and intermediate variables.

Lonsdale *et al*, 2012[109]	Studies must have tested an intervention, namely a deliberate attempt to implement a change to usual teaching practice in order to increase the proportion of PE lesson time spent in MVPA. Studies focusing on a comparison of conditions, but not an intervention, were excluded. For example, a study comparing active learning time during ball games (e.g., soccer) versus net sports (e.g., badminton) would not have been included, because both types of activities are considered part of usual practice in PE.	Studies needed to include a measure of the proportion of PE lesson time spent in MVPA. This measure could be objective (e.g., accelerometer) or involve systematic direct observation by an independent rater (e.g., SOFIT; System for Observing Fitness Instruction Time)	Determines the effectiveness of interventions designed to increase the proportion of PE lesson time that students spend in moderate-to-vigorous physical activity (MVPA) and found that students in intervention conditions spent 24% more lesson time in MVPA compared with students in usual practice during PE lessons.
McArthur *et al*, 1998[110]	Elementary school-based cardiovascular program with nutrition (heart healthy eating) as a component. Interventions included special classroom curriculum, planned exercise, take-home activities and food selection activities.	A quantifiable measure of eating behaviour.	This meta-analysis of 12 studies found that school-based CVD health promotion programs had a significant effect on the diets of fourth and fifth grade students.
Niemeier *et al*, 2012[111]	Original interventions that targeted weight-related health and health behaviours of children or adolescents.	Pre-measurements, and post-measurements that were conducted immediately following the interventions, to assess the effectiveness of the interventions and that included body mass index (BMI). In order to maintain consistency, studies that did not provide data sufficient for analyses of effect sizes of intervention and control groups' BMI means were not included.	This review and meta-analysis suggests that weight- related health interventions that require parent participation more effectively reduce body mass indexes of child and adolescent participants as shown in 36 studies. In addition, longer interventions that include parent participation appear to have greater success.
Nixon *et al*, 2012[112]	All interventions occurred within pre-school or school settings and were aimed at interventions to prevent obesity.	Relevant measures for 'weight status changes' 'physical activity and dietary changes', and 'determinants of behaviour changes.'	This systematic review of 12 obesity prevention studies among 4-6 years old in the school or preschool setting highlighted parental involvement to result in higher rate of success.
Polanin *et al*, 2012[113]	Anti-bullying interventions = based solely within a school system and intended purposefully to modify bystander intervention behaviour. Subsequently, they excluded studies that focused on changing bullying behaviours primarily and collected a bystander measure only as a secondary procedure.	Bystander intervention. They defined bystander intervention as an intention to intervene, intention to stop bullying, direct intervention or respond assertively to a bullying situation.	This meta-analysis of 11 school-based bullying prevention programs found that programs were successful at increasing bystander intervention, with larger effects for sigh school samples compared to younger student samples.
Ridgers *et al*, 2012[114]	Policies and environments conducive to physical activity being provided during recess or lunchtime.	Must have a measurable amount of physical activity during recess or lunchtime, and examine physical activity with other variables.	This systematic review of 53 studies found that providing access to facilities, equipment, and policies have the potential to increase physical activity levels.
Robertson-Wilson *et al*, 2012[115]	Involved the evaluation of a school-based law, bill, legislation, or policy.	The impact of a school-based law, bill, legislation, or policy on physical activity in school children.	The evaluation of impact of policies on school-based physical activity from a review of 13 studies indicated that such policies can affect health outcomes, specifically by increasing levels of physical activity.
Robinson-O'Brien *et al*,	Garden-based youth nutrition intervention programmes. Two general categories of studies: in-school garden-	Outcomes evaluated in this review include fruit and vegetable intake, willingness to taste fruits and vegetables, and fruit and	Findings from this review suggest that garden-based nutrition intervention programs may have the potential to promote increased

2009[116]	based nutrition education research and afterschool or community garden-based nutrition-education research.	vegetable preferences, fruit and vegetable knowledge, self-efficacy to consume fruits and vegetables, and other nutrition-related outcomes.	fruit and vegetable intake among youth and increased willingness to taste fruits and vegetables among younger children; however, empirical evidence in this area is relatively scant.
Saraf *et al*, 2012[117]	Physical activity, nutrition, obesity-related risk factors, sedentary habits, and tobacco consumption. A comparison control group was used or pre-intervention and post-intervention effects were studied on the same group. In addition, school-based interventions with a family and or community component were also included.	Change in knowledge, attitude, practices, body mass index, weight, skin fold thickness, etc.	The literature search identified 37 studies. The proportion of studies showing a positive result was 83% (10/12) among those that involved family, 87 %(7/8) that involved both community and family, and 76% (13/17) that involved school only. Overall, 80% of the studies reported at least some evidence of a positive intervention effect.
Silveira *et al*, 2011[118]	Interventions were school-based, consisting of behavioural lifestyle changes recommended by health professionals or school teachers.	Study reported at least one anthropometric (absolute or standardized measure of body mass index [BMI], skin folds, circumferences and percentage of body fat or lean mass) or dietary outcome (measured with a food recall or food frequency questionnaire).	From the 24 articles included in the systematic review, there was evidence of positive effects on anthropometry and of increase in fruit and vegetable consumption from interventions that were duration > 1 year, introduction into the regular activities of the school, parental involvement, introduction of nutrition education into the regular curriculum, and provision of fruits and vegetables by school food services.
Sobol-Goldberg *et al*, 2013[119]	School-based prevention programmes designed to reduce BMI in healthy children, through changing eating habits by increasing intake of healthy foods and decreasing consumption of unhealthy foods; and by changing patterns of activity to more physical and less sedentary. Interventions were classified as informative and educational (e.g., information on proper nutrition and physical activity), cognitive (e.g., strategies for attitude and perception change), behavioural (e.g., daily monitoring and registering of eating patterns and physical activity) and environmental (e.g., making accessible water coolers and organized sports) and parental support (e.g., parent child events on healthy lifestyle).	BMI	This meta-analysis of 32 RCTs found that school-based obesity prevention programmes were effective in significantly reducing BMI, especially among children, though less so among adolescents. Largest effects were seen for comprehensive programmes of more than 1 year duration with parental support.
Stevens *et al*, 2010[120]	Studies were considered only if the aim of the obesity prevention intervention was to improve healthy behaviours through multicomponent activities (e.g., included both diet and physical activity	Personal factors (Knowledge, Self-esteem, Motivation), Behavioural Factors (Diet, and Physical and Sedentary Activity), Environmental Factors (Neighbourhood Safety, Parental Involvement, Family Support)	Eight studies reviewed found that findings support personal, behavioural, and environmental factors that contribute to obesity in children, yet results for ethnic minorities were inconclusive.
Van Cauwenberghe *et al*, 2010[121]	Primary prevention of obesity and diseases related to obesity in which the main component or one of the components was the promotion of a healthy diet. The studies in the present review were, however, not limited to interventions explicitly aiming to contribute to obesity prevention. Rather, all interventions that targeted dietary behaviours that may be associated with obesity risk were	Reported effects on dietary behaviour or on anthropometrics	This systematic review of 42 studies found strong evidence for multicomponent interventions on fruit and vegetable intakes in children while limited evidence was found for educational and environmental interventions. In adolescents moderate evidence was for educational interventions but limited evidence for multicomponent programmes.

	included. Furthermore, papers that deal with the implementation, feasibility, applicability or cost-effectiveness of the interventions were accepted for further review.		
Van Lippevelde *et al*, 2012[122]	School-based interventions which focused on behaviours related to obesity risk.	Nutrition or physical activity-related behaviour or an anthropometrical outcome	This systematic review of five studies comparing school-only and school-plus-family interventions to promote nutrition and physical activity did not find consistent evidence and concluded that more research was needed.
Wang *et al*, 2013[126]	School-based interventions on nutrition involving health-promoting activities in all or one or two of the following three areas: school ethos/environment/policy, nutrition curriculum, and/or family/community.	Student nutrition outcomes (including dietary consumption, nutrition-knowledge and school environments.	This systematic review of 19 nutrition promotion programmes using the HPS approach found that it can improve participants' diets and also help develop related healthy behaviour such as hygiene and food safety.
Williams *et al*, 2013[124]	Primary school policies related to diet and/or physical activity and/or broader intervention programs.	Body mass index (using valid reference curves to define overweight and obesity), body mass index z-score or standard deviation score, percentage of body fat, waist circumference, waist-to -hip ratio, waist-to-height ratio, skin pinch/skin fold thickness.	This review of 21 studies undertook random effects meta-analysis to examine pooled results from diet, physical activity or combined policies and interventions and found that multifaceted (e.g. combined) interventions demonstrated significant reductions in weight-related outcomes.

As part of their inclusion criteria, most papers required studies to follow an experimental design, including randomised controlled trials or other studies with pre- and post-intervention tests and a control group. All of the reviews included school-aged children, ranging in age from 4 to 19 years. While most of the reviews did not restrict papers based upon the country of research, the vast majority of included studies were based in the United States and Europe.

2.5.1 Interventions

Study interventions and outcomes are provided in Table 2 and discussed below.

2.5.1.1 Multi-component programmes

This study included reviews which analysed a range of school-based interventions related to components of the NFSI. Many of the interventions implemented a range of educational and environmental changes which fell under a broad category of school-based health promotion activities (Williams *et al*, Pucher *et al*, Krishnaswami *et al*,, Saraf *et al*, Lavelle *et al*, Griebler *et al*, Flynn *et al*, Stevens *et al*, Health Canada *et al*, Brown *et al*, Lavelle *et al*) obesity prevention programmes (Nixon *et al*, De Bourdeaudhuij I *et al*, Niemeier *et al*, Sobol Goldberg *et al*, Van Cauwenberghe *et al*, Hingle *et al*, Katz *et al*, Krishnaswami *et al*, Kropski *et al*, Li *et al*, Van Lippevelde *et al*, Griebler *et al*).

2.5.1.2 Nutrition programmes

Ten studies focused on school-based nutrition interventions (de Sa *et al*, Silveira *et al*, Wang *et al*, Dudley *et al*, Ganann *et al*, Howerton *et al*, Jaime *et al*, Knai *et al*, Kristjansson *et al*, McArthur *et al*), which included health promoting activities in areas related to school environments and policies, provision of school meals, changes to nutrition curriculum or programmes to engage families and communities. Robinson O'Brien *et al* considered the effects of in-school garden based nutrition education. Cairns *et al* investigated the effects of marketing practices and commercial food promotion on children. A review by Best *et al* looked specifically at the effects of micronutrient fortification of foods.

2.5.1.3 Physical activity programmes

Several reviews focused entirely on school-based physical activity interventions (Beets M *et al*, Demetriou Y *et al*, Harris *et al*, Janssen *et al*, Ridgers *et al*, Lonsdale *et al*, Guerra *et al*). Several reviews also looked at the effect of legislation, such as state laws or school district policies that influence physical activity (Robertson-Wilson *et al*, Williams *et al*).

2.5.1.4 Other programmes

Three of the included reviews evaluated anti-bullying programs (Barbero *et al*, Farrington *et al*, Polanin *et al*) and one evaluated the effects of school-based water, sanitation and hygiene (WASH) interventions (Birdthistle *et al*).

2.5.1.5 Outcome Measures

The most common outcome measure considered by the reviews in this report was related to pupil dietary consumption, which was reported by 31 studies. Six studies focused specifically on pupil's consumption in fruit and vegetables. In addition to pupil dietary behaviours, several reviews also included papers considering environmental features related to diet such as food access and availability within schools (Chriqui JF *et al*, Robinson-O'Brien *et al*, Stevens *et al*, Ganann *et al*, Jaime *et al*) or pupil knowledge, attitudes, perceptions or beliefs related to diet (De Bourdeaudhuij I *et al*, Demetriou Y *et al*, Robinson-O'Brien *et al*, Stevens *et al*, Health Canada *et al*, Dudley *et al*). Around half (n=26 studies) included outcomes related to student BMI or weight categories and 14 included studies related to physical activity.

2.5.1.6 Relevance to Essential Criteria

Most of the included reviews were relevant to more than one of the NFSI criteria and in many cases, due to the research questions and reporting methods, it was not possible to untangle the effects of specific components from one another. The number of reviews relevant to each component of the NFSI criteria ranged from zero to 24, with the most evidence available for components 3.1 (Culturally appropriate and effective nutrition education), 3.2 (Age, sex and culturally appropriate physical education curriculum), 4.1 (School meals, food vendors and snack bars (if present) promote healthy eating) and 2.2 (Activities for families and community, community involvement and outreach in the area of nutrition and health related issues).

2.5.2 Quality assessment

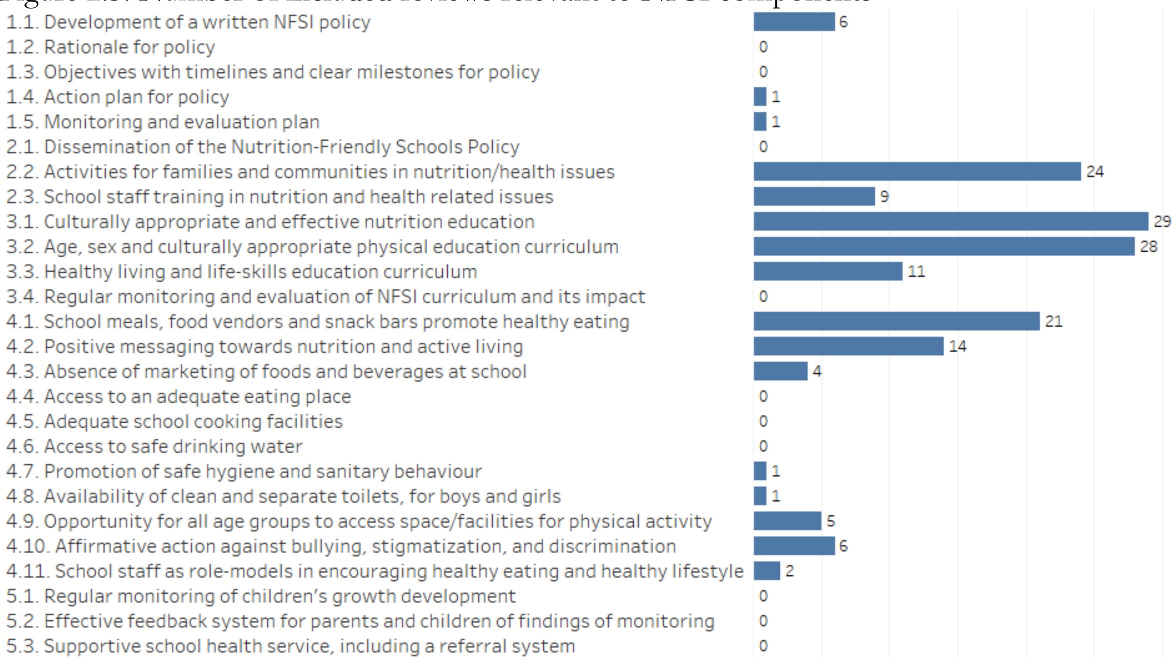
The quality assessment scores assigned to each paper varied widely between studies from 2.75 (Howerton *et al*) to 8 points (Harris *et al*), which was the maximum number of possible points. The most common reasons that papers received a low score (e.g. Howerton *et al*, Ridgers *et al*) were failure to use at least two independent data extractors or failure to include a consensus procedure in the review process. Reviews were also deducted points for failing to include grey literature (e.g. International Clinical Trials) or articles published in languages other than English. Finally, points were deducted from papers that did not assess the quality of included studies (assessing study design, use of randomization or blinding, sample characteristics, confounders or loss to follow up). Around half of our papers received at least four of eight possible points. I included six papers that had a score of at least seven out of eight points (Beets *et al*, De Sa *et al*, De Bourdeaudhuij *et al*, Harris *et al*, Kidger *et al*, Lima-Serrano *et al*).

Description of evidence for the components of the NFSI

Findings were summarised according to their relevant NFSI criteria. Many of the interventions related to multiple criteria (*e.g.* changes to both curriculum and family nutrition promotion activities), and it was not possible to isolate the effects of one NFSI activity from another. In these instances, I describe the overall effect of these multicomponent interventions.

The number of available studies for each component varied widely, with the most evidence available for components 3.1 (Culturally appropriate and effective nutrition education) (Figure 2.3). As shown in the figure below, there were several components where there was no evidence.

Figure 2.3. Number of included reviews relevant to NFSI components



2.5.2.1 Component 1: Having a nutrition-friendly schools policy

In summary, the evidence on the first component of the NFSI suggests that school-based policies may lead to positive changes in students' diets, food hygiene, food availability and physical activity levels.

Chriqui *et al* reviewed research on the effects of school competitive food and beverage policies (enacted at the state or district level) on obesity, consumption and availability within schools and found that 15 of the 24 studies reviewed reported positive associations between the policies and in-school availability and access to competitive foods (9 out of 13 studies), student consumption of foods (5 out of 9 studies) and obesity/overweight outcomes (2 of 4 studies)[84]. De Sa *et al* also found that school schemes may increase fruit and vegetable intake and nutrition knowledge[86], while Knai *et al* found that having a school nutrition policy was a key component of successful interventions to promote fruit and vegetable consumption among children and adults[102]. An evaluation of the effectiveness of health-promoting school (HPS) approaches by Wang *et al* found that such approaches may improve student diets, hygiene and food safety practices[123]. A 2004 report by Health Canada found only limited evidence that environmental influences can improve fruit and vegetable intakes and inconclusive evidence that they can improve breakfast habits[95]. At the same time, it found moderate evidence that educational interventions can improve diet behaviour.

There was also evidence that school policies can improve student physical activity. For example, Robertson-Wilson *et al* found that state school-related policies in the US had a positive impact on school implementation of recommendations, with most states meeting or exceeding recommendations of providing students with 30 minutes of daily physical activity[115].

2.5.2.2 Component 2: Enhancing awareness and capacity-building

The second component of the NFSI encourages schools to engage families and the larger community in its promotion of nutrition- and health-related issues. This review found some evidence to suggest that community partnerships may enhance the effects of school-based health promotion interventions. For example, Krishnaswami *et al* found that obesity prevention interventions with greater school and community partnerships were associated with more successful diet, physical activity and weight-related outcomes[103]. Another review of 12 obesity prevention studies among children aged four to six years old in the school or preschool setting found that parental involvement resulted in higher rates of success[112]. A meta-analysis to determine the effectiveness of school-based strategies for obesity prevention and control found that studies involving parents and families improved body weight among school children[101].

Parental or community involvement has been linked to the success of interventions promoting fruit and vegetable consumption[102]. Higher perceived encouragement from parents, peers, and the school as a whole, was associated with higher self-reported physical activity levels during recess periods, particularly in adolescents[114]. Family involvement is also beneficial for other outcomes; Barbero *et al* found that school interventions to prevent bullying are more successful when they involve the parents of children[78].

Several systematic reviews[77, 78, 85, 86, 90, 91, 95, 101, 105, 108, 117, 118, 127, 128] considered the effectiveness of multicomponent nutrition interventions which included elements such as parental or community involvement. While these studies did not exclusively assess the effect of family or community-specific components, there was moderate evidence to suggest that interventions which integrate multiple activities such as parent involvement into a larger strategy are more effective than those which focus on just one intervention component. Williams *et al* evaluated the effect of combined policies (*e.g.* those that aim to improve both physical activity and diet) and found that the interventions which involved stakeholder involvement and engagement with families were particularly effective[124].

A meta-analysis of school-based interventions to improve daily fruit and vegetable intake among children found that multi-component interventions which included communication with parents and projects for students to do at home with parents, were estimated to improve daily fruit and vegetable consumption by 20-30 grams per day[129]. Van Sluijs *et al* also found that school-based interventions which involve family or community members may lead to positive results[130]. A Cochrane review by Waters *et al* of effective obesity prevention strategies highlighted the importance of parent support and home activities that encourage children to be more active, eat more nutritious foods and spend less time in screen-based activities[128].

2.5.2.2.1 School staff training in nutrition and health related issues

No studies in this review looked specifically at the effect of school staff training on student outcomes, but there were several that considered the effects of multi-component interventions which included, among other activities, efforts to engage and train staff. For example, Knai *et al* reviewed 11 studies using teacher involvement as part of an intervention to increase fruit and vegetable consumption and found that special training of teachers appeared to be associated with increased fruit and vegetable intake among students[102].

Katz *et al* found that teacher training may provide value to large school-based obesity-prevention and control interventions[101]. These findings were corroborated by an updated Cochrane review by Waters *et al* which found that effective obesity-prevention strategies included offering support for teachers and other staff to implement health promotion strategies and activities through professional development and capacity-building activities[128]. Similarly, in a meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons, Lonsdale *et al* observed that effective intervention strategies included providing teachers with professional learning opportunities that focused on class organisation, management and instruction[109].

2.5.2.3 Component 3. Developing a nutrition and health-promoting curriculum

2.5.2.3.1 Culturally appropriate and effective nutrition education

In this review, there were several systematic reviews examining the effectiveness of multi-component school-based interventions to improve nutrition-related outcomes among school children. Many of these interventions included education alongside a range of other activities [86, 90, 95, 97, 99, 101, 105, 106, 108, 109, 112, 124, 131]. The best evidence suggests that interventions which go beyond education-only approaches in order to include environmental changes are more effective [85, 121]. In particular, interventions which aim to improve both diet and physical activity may help prevent childhood obesity[82]. A meta-analysis of school-based diet interventions, including many educational activities such as special classroom curricula, planned exercises, take-home activities and food-selection activities, had a small, but significant beneficial effect on student diets[110]. Multicomponent interventions which included changes to the curriculum (problem-solving, home-based projects) improved daily fruit and vegetable consumption [129]. Langford *et al* conducted an assessment of Health-promoting schools and found that interventions which made changes to the curriculum (alongside changes to the schools ethos or environment and engagement with families or communities) were associated with improved outcomes related to student body mass index (BMI), physical activity, physical fitness, fruit and vegetable intake, tobacco use, and bullying[132].

A meta-analysis on the effectiveness of educational interventions (targeting behavioural modification, nutritional intake and physical activity behaviours) to prevent or treat childhood obesity found that educational interventions were associated with a significant reduction in waist circumference, BMI and diastolic blood pressure[127]. In a Cochrane review of research to prevent childhood obesity, Waters *et al* found strong evidence to support beneficial effects of educational child obesity prevention programmes on BMI, especially among children aged six to twelve years[128].

2.5.2.3.2 Age, sex and culturally appropriate physical education curriculum

A review by Katz *et al* found evidence suggesting that physical activity interventions contributed only minimally to weight reduction in students, but findings were based on a small number of studies with heterogeneous outcomes[101]. Similarly, Guerra *et al* conducted a meta-analysis of 11 randomized school-based physical activity interventions and found that, despite the potential benefits of physical activity promotion in schools, the physical activity interventions did not have a statistically significant effect on student BMI or blood pressure[93].

A larger systematic review of the evidence around school-based interventions that included a physical activity component by Demetriou *et al* considered 75 studies measuring the effects of school-based physical activity interventions on BMI and found that 28.0% had a positive effect, 2.7% had a negative effect and 69.3% had no effect [87]. Positive effects were more frequently reported for intermediate outcomes related to student's motor performance, physical activity levels and physical activity knowledge. Interventions which combined both physical activity and physical activity education were more likely to have a positive effect on BMI.

In a review on the effectiveness of interventions to promote physical activity, Van Sluijs reviewed 57 studies (including 20 school-based interventions) and found inconclusive evidence of an effect [130]. Six studies evaluated school-based interventions which also included family or community involvement (including three high quality randomised controlled trials). Two of these large high quality trials showed significant positive results, leading the authors to suggest strong evidence of an effect of school-based physical activity interventions involving families or community members.

Waters *et al* found evidence to suggest that providing increased school sessions for physical activity throughout the school week may help improve student BMI. Results suggested that effective interventions focused on improving students' physical activity levels, body image and fundamental movement skills[128].

2.5.2.3.3 Healthy living and life-skills education curriculum

This literature review did not find evidence evaluating the effects of healthy living and life-skills education on student outcomes. As with some of the other components, there were some reviews which looked at the effects of multi-faceted interventions that included some level of healthy living and life-skills education[106, 109, 124, 128, 129, 131, 132]. For example, Williams *et al* summarised five multifaceted interventions which had combined aims to improve physical activity, diet and overall healthy living[124]. Three of the five multifaceted intervention policies-- which included healthy living and life-skills education-- were associated with positive outcomes related to lower BMI, lower weight gain and reduced prevalence of overweight.

Silveira reviewed 12 studies that adopted at least two of the following three common intervention components: classroom activities, parental involvement, and school nutrition policy. Ten of these interventions were associated with a reduced prevalence of overweight and obesity and with increased consumption of fruits and vegetables among children and adolescents[118].

Evans *et al* evaluated multi-component interventions which integrated changes in curriculum (such as problem-solving, home-based projects, etc.) and found that school-based multi-component interventions improved daily fruit and vegetable consumption[129].

In another review, Hersch *et al* examined the evidence from eight studies which measured the impact of cooking programmes on food preparation skills, dietary intake, cooking confidence, fruit and vegetable preferences, attitudes toward food and cooking and food-related knowledge and found that cooking programmes may have a positive impact on children's food-related preferences, attitudes and behaviours[133].

2.5.2.4 Component 4. Creating a supportive environment

2.5.2.4.1 School meals, food vendors and snack bars (if present) promote healthy eating.

This section describes the evidence from the literature that was related to food availability and provision of school meals. Participation in school breakfast programmes (n=5 studies) was associated with a significantly lower BMI-Standard Deviation Score (SDS) among students[124]. Brown *et al* found some evidence to suggest that dietary interventions (such as providing breakfast in schools) may help prevent students from becoming overweight in the short term[82]. By contrast, a review which summarised European and 'grey' literature on the effectiveness of school-based interventions found inconclusive evidence that environmental interventions can improve breakfast habits for children[121]. The results may also vary depending on the country. For example, in developing countries, school feeding programmes have been found to be associated with positive effects on energy intake, micronutrient status, school enrolment and school attendance[134].

Kristjansson *et al* conducted a systematic review of 18 studies to determine the effectiveness of school feeding programmes in improving physical and psychosocial health for disadvantaged school students and found that school meals may have some small benefits for disadvantaged children[104]. Evidence from randomized controlled trials in low-income countries found that children who were fed at school gained an average of 0.39 kg more than controls over 19 months, attended school more frequently and had better education and cognitive outcomes compared to control groups. Additionally, there is also some evidence to suggest benefits related to providing students with foods that have been fortified with micronutrients[80].

In a Cochrane review on interventions for preventing obesity among children, Waters *et al* found that improving the nutritional quality of school food, creating healthy environments and promoting cultural practices that encourage healthier consumption may help prevent obesity[128].

2.5.2.4.2 Government policies

This literature review also included papers that considered the effect of government policies on schools and students. Chriqui *et al* investigated the effects of state and district laws (n=24) on school environments and student outcomes. The state and district legislation had an overwhelmingly positive effect on school food availability and student dietary consumption, but the effects on longer-term health outcomes (BMI or obesity/overweight) were mixed[84].

2.5.2.4.3 Positive messaging towards nutrition and active living

There were no studies that exclusively looked at the effectiveness of positive messaging, but some findings can be gleaned from multi-component interventions which included some elements of positive messaging toward nutrition and active living[95, 108, 124, 128, 129, 131, 132]. Findings suggested that interventions which include multiple actions, individually tailored feedback and environmental changes to improve nutrition and physical activity were most likely to be effective at preventing obesity[85]. Among adolescent girls, delivering individually-tailored activity and nutrition feedback was one particularly promising strategy[86].

2.5.2.4.4 Absence of marketing of foods and beverages at school

There was a dearth of research considering the effects of food and beverage marketing within schools. Cairns *et al* demonstrated that in-school marketing is a popular approach that food and beverage marketers adopt to increase their sales, and that the current marketing practices predominantly promote foods and beverages that are of low nutritional value. The review found modest evidence to suggest that marketing affects children's nutrition knowledge and perceptions, food preferences, food consumption behaviours and diet-related health status. It found strong evidence that food promotion can directly influence purchasing choices and encourage preferences for particular categories or brands of food[83].

2.5.2.4.5 Promotion of safe hygiene and sanitary behaviour

School-based water, sanitation and hygiene (WASH) interventions have been associated with increased student enrolment and attendance, increased hand washing, and reduced absenteeism[81], but their impact on nutrition-related outcomes has not been fully investigated. A lack of water in schools has been associated with increased absenteeism in developing countries, particularly among menstruating females who require access to sanitation facilities[135]. Schools that provide access to adequate sanitation facilities have observed a decrease in diarrheal and gastrointestinal diseases, which has an effect on nutrition status[136].

2.5.2.4.6 Availability of clean and separate toilets, for boys and girls

There is no evidence on the nutritional benefits of providing clean and separate toilets for boys and girls. Birdthistle *et al* attempted to conduct a review to determine the impact that provision of separate toilets for girls on primary and secondary school enrolment, school attendance, school completion, educational outcomes or health[81], but could not identify any studies which examined these exposure and outcome measurements. Due to the lack of evidence, the authors looked at studies evaluating school-based water, sanitation and hygiene (WASH) interventions[81].

2.5.2.4.7 Opportunity for all age groups to access space and school sporting facilities for physical activity in and outside of curriculum

There is a large body of evidence outlining the positive effects of promoting physical activity among students, but less research on the effects of providing students with physical activity facilities. A meta-analysis by Beets *et al* demonstrated that after school programmes with a physical activity component can be beneficial in improving physical activity levels and health[79]. Ridgers *et al* considered 53 studies examining correlates to students' physical activity during recess and found that providing access to outdoor and indoor spaces was positively associated with recess-time physical activity[114]. Multicomponent physical activity interventions suggest that school-based efforts to improve physical activity may be strengthened by taking actions that extend beyond changing education, to include other actions, such as increasing the amount of active lesson time[85]. Bonnell *et al* found that interventions which targeted environmental changes alongside actions to empower students may contribute to increased self-efficacy among students and increased physical activity among boys[137].

2.5.2.4.8 Affirmative action against bullying, stigmatization, and discrimination

There is no evidence examining the effect of anti-bullying initiatives on nutrition-related outcomes among schoolchildren. More generally, there is research about effective campaigns to prevent bullying. For example, the most effective techniques focus on improving social and intrapersonal skills, modifying attitudes and beliefs and engaging multiple stakeholders such as professionals and parents[78]. Corroborating these findings, Farringdon *et al* also found evidence from 53 anti-bullying programmes which suggested that school-based anti-bullying programmes are effective at reducing bullying and victimization[89]. A third review by Polanin *et al* found that anti-bullying programmes significantly increased bystander intervention behaviour[113]. Bonell *et al* investigated the effectiveness of school environment interventions which strengthened relationships between students and staff and found that such interventions may reduce violence and aggression[137]. In a Cochrane review to assess the effectiveness of the WHO health-promoting school framework in improving the health and well-being of students and their academic achievement[132], Langford *et al* found an association between health-promoting schools and a reduction in cases of students reporting to have been bullied.

2.5.2.4.9 School staff as role models in encouraging healthy eating and healthy lifestyle

There is a dearth of research on the effect that staff role models may have in encouraging healthy eating and healthy lifestyles. More generally, Nixon and colleagues identified effective behavioural models and strategies to prevent obesity among four to six year old children in a preschool or school setting and found that interventions with the highest levels of success involved modelling healthful eating and physical activity[112]. A second review examined correlates of childrens' and adolescents' physical activity during school recess and found that higher perceived encouragement from the school as a whole was associated with higher self-reported physical activity levels among students[114].

2.6 Discussion and conclusions

2.6.1 Summary

This review examined evidence underlying the WHO NFSI recommendations to promote healthy diets among students. Findings from this review suggest that multi-component interventions—those which integrate both environmental and educational changes within schools-- are more effective than interventions which focus exclusively on education[102, 129]. The evidence in this review suggests that parental and community involvement may also contribute to the success of school-based interventions to improve diet[129] and physical activity[130], and to prevent bullying[78].

To summarise the evidence on creating supportive school environments, provision of school meals and micronutrient fortification may improve students' micronutrient status, but there is mixed evidence related to its impacts on student growth, morbidity and cognitive development[134]. Two systematic reviews found evidence to suggest that provision of breakfast may strengthen obesity-prevention efforts among schoolchildren[82, 124]. Among disadvantaged students in particular, school meals may have some physical and psychosocial benefits[104]. Despite all of the potential benefits that may come with making positive changes to school food availability, many intervention studies continue to focus exclusively on educational interventions. These single-component interventions are less likely to have an effect.

There is some evidence to suggest that, as part of a larger nutrition-promoting strategy, positive feedback and messaging to students may play an important role in encouraging healthy behaviour[85, 86].

Research highlighted here demonstrates the importance of keeping the marketing of foods and beverages outside of schools. The work presented in this review suggests that food and beverage companies target children and such strategies are likely to have an effect on students' diet-related preferences and behaviours[83].

The Nutrition-friendly schools initiative (NFSI) recommends the availability of clean and separate toilets for boys and girls. While this review found a dearth of research on the effects of gender-appropriate toilets and sanitation in schools, there has been research on school-based water, sanitation and hygiene (WASH) interventions and these have demonstrated beneficial effects on educational outcomes among girls[81].

The evidence also underscores the importance of providing all age groups with facilities for sport and physical activity, both inside and outside of curriculum[85, 114]. Allocating more time for physical activity and providing facilities for physical activity is likely to be more effective than simply providing students with information about the value of physical activity[137].

The NFSI recommends affirmative action against bullying, stigmatization and discrimination and, as part of a larger effort to create health-promoting schools, anti-bullying interventions may reduce bullying within schools[78, 89]. I did not find any papers that linked anti-bullying interventions to nutrition outcomes.

Finally, the NFSI recommends that school staff act as role models in encouraging healthy eating and healthy lifestyle behaviours. Reviews in this study showed that school staff do indeed play a key role in modelling healthy behaviours[112]. Perceived encouragement from school staff is associated with higher levels of self-reported physical activity levels during recess[114].

2.6.2 Where research has been done and where more is needed

Findings from this review suggest that there is evidence to support many of the recommendations related to the benefits of engaging families and communities in promoting healthy behaviours, providing nutrition and physical education curriculum and providing nutritious school food. More research is needed to understand the benefits of implementing other recommendations, such as having school nutrition policies, providing school cooking facilities, providing students with canteens and providing students with safe drinking water.

2.6.3 Interpretation

Schools around the world vary in terms of their resources and cultures, and it may not be possible to develop recommendations that are universally applicable or feasible for every school. Often, due to resource constraints, school authorities must prioritise some approaches over others. The WHO Regional Office for Europe provides a tool for the development of school nutrition programmes[138] which outlines steps and recommendations for designing a school nutrition policy. Additionally, it provides guidance on children's diets, including their nutritional requirements, and recommendations for providing nutrition education. Additional guidance is provided by several other United Nation (UN) initiatives which work in the area of school health, including the Global School Health Initiative[139], which aims to increase the number of health-promoting schools, Focusing Resources on Effective School Health (FRESH), which works to raise awareness in the education sector of the value of implementing effective school health programmes as an advocacy strategy[140] and the Global school-based student health survey, which supports member states to measure and assess the behavioural risk factors and protective factors among young people[141].

For schools that are attempting to address problems associated with the marketing and advertising of foods to children within schools, the WHO Western Pacific Region Office has developed a guide for school principals on restricting the sale and marketing of sugary drinks around schools[142].

The NFSI makes recommendations related to improving both nutrition and physical activity behaviours among school children. More information on physical activity recommendations and supportive policies in promoting physical activity is available in the WHO's Global Physical Activity Recommendations[143]. The WHO School Policy Framework provides additional guidance for developing and implementing school policies and programmes that promote healthy diets and increase levels of physical activity[144].

2.6.4 Strengths and Limitations

To the best of my knowledge, this is the first review to systematically assess and summarise the evidence underpinning the NFSI criteria. One of the main limitations of this review is that, while the NFSI is a package that includes multiple components which are likely to have synergistic effects, I am limited in the conclusions that I can draw about the effects of such an intervention. I did not identify any reviews which assessed the effect of the whole NFSI package on school children's outcomes and relied instead on evidence that considered one or a few components. As a consequence, I am not able to assess the synergistic effects that may result from interventions that include all components of the NFSI. Multicomponent interventions in schools tend to be more effective than single component interventions[95].

2.6.5 Recommendations for future work

Future work is needed to assess the impacts of the NFSI as a whole on the health and nutrition outcomes of school children and communities. Many of the outcomes associated with nutrition, such as body weight, micronutrient status, bone density or eating habits, develop over time. Unfortunately, however, many of the studies included in this review relied on cross-sectional data which did not measure these long-term effects. Future research studies may benefit from collecting individual-level outcome measures from students at various time points, ideally over a number of years.

Most of the research in this review—and in the larger area of school-health—relies on evidence from developed countries, particularly in the United States and Europe. More research is needed from low- and middle-income countries (LMICs), where school health promotion may play an important role, not only in promoting students' diets, but also in improving education outcomes.

In conclusion, this report highlights a substantial body of scientific evidence supporting the NFSI recommendations for schools to adopt nutrition policies, enhance awareness and capacity-building, develop nutrition and health-promoting curricula and create supportive environments. At the same time, it identifies several areas where more research is needed, including benefits related to the provision of school health services, access to adequate eating places and school cooking facilities. Work is also needed to assess the effects of the NFSI as a package rather than just its individual components.

2.7 Summary of chapter

This chapter summarised a literature review to examine the evidence underpinning the WHO NFSI. This review found research to support many areas of the NFSI, including the importance of adopting multi-component interventions that involve making both environmental and educational changes along with the importance of engaging families, staff and other stakeholders in health-promotion interventions. At the same time, this review also highlighted areas where more research is needed, particularly in assessing the effects of the whole NFSI package, rather than just the effects of one or two of its components.

3 Methods

3.1 Introduction to Chapter Three

This chapter provides a description of the project methods, including sampling, ethical considerations, data collection from students and schools, data processing and analysis. It goes on to describe the process of constructing independent, dependent and exposure variables to examine associations between school NFSI approaches and student nutrition outcomes. Next, the chapter outlines the analysis plan.

3.2 Description of the timeline, population and study settings

Baseline data from students and principals were collected in June-August of 2014 and follow-up data were collected in August-September 2015. The follow-up data collection, which was originally planned for June-August of 2015, was postponed for two months[13] and was completed in August-September 2015 (Figure 3.1).

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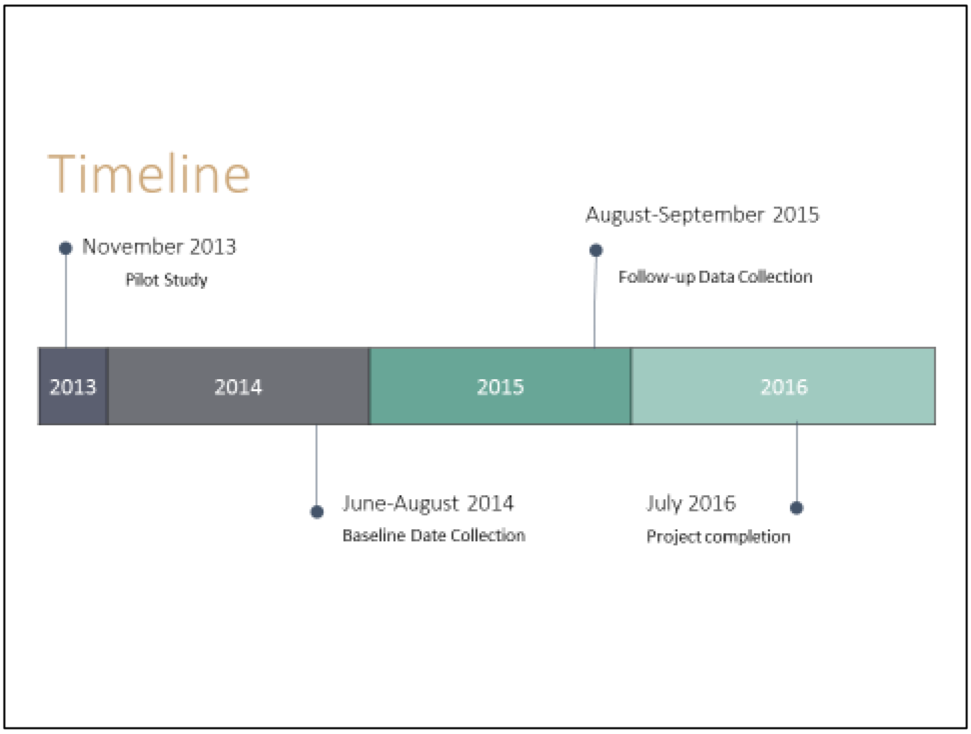
[13] The follow-up data collection was delayed by two months due to upheaval caused by the 2015 political elections in Sri Lanka.

Figure 3.1. Project timeline

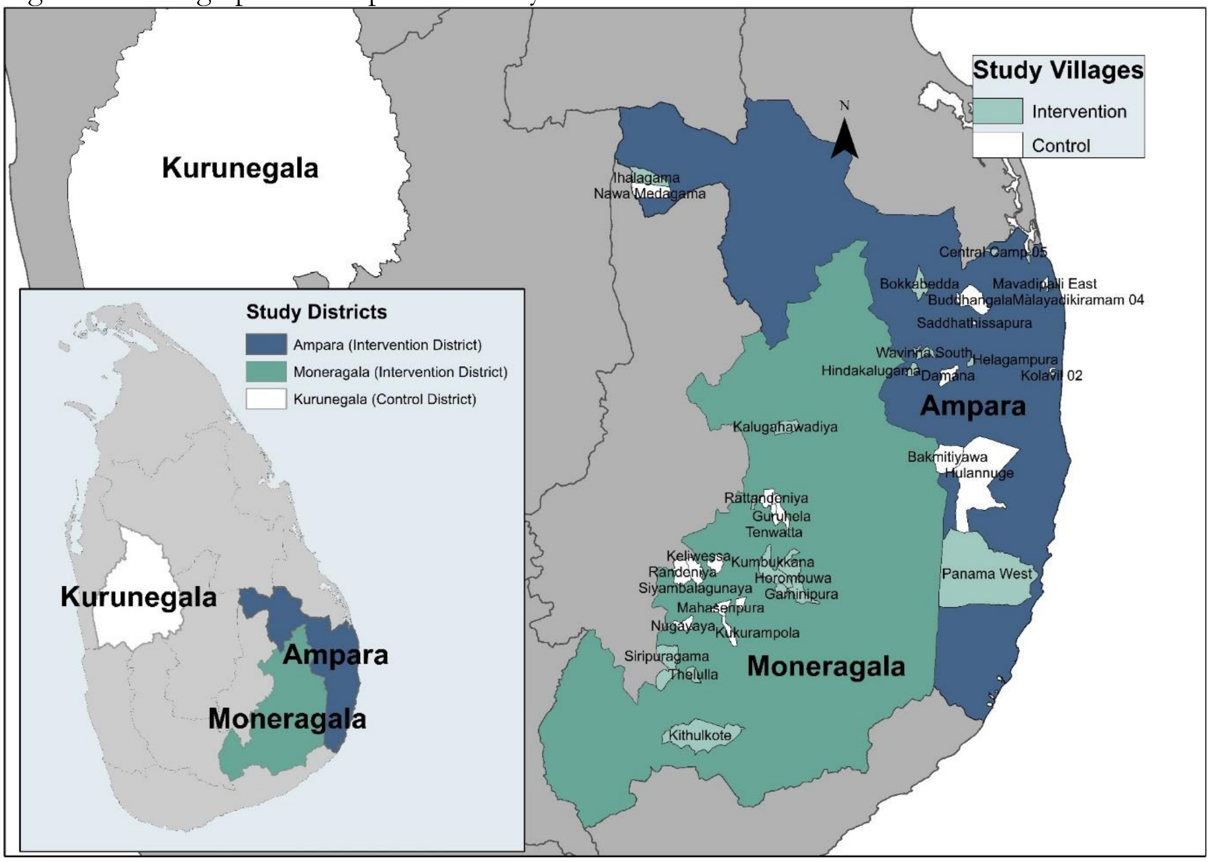


My data collection was supported through the INPARD project, which provided me with funding to pay for Sri Lankan and Tamil speaking researchers to administer the surveys and collect the data. My role was to identify the methods and tools for collecting data within schools, to discuss these methods with the INPARD team prior to gaining ethics approval, to provide training on data collection methods and to prepare and analyse the data. During my involvement with the project, I completed four field visits to Sri Lanka between June 2014 and November 2016. During these trips, I visited schools, met with the INPARD team, helped to coordinate the data collection, trained the data collectors, attended INPARD workshops and presented project findings to stakeholders at the local and national level.

Data were collected from secondary school students and school principals from schools within three districts: Ampara and Moneregala (districts where the INPARD intervention was taking place within select villages and schools) and Kurunegala (a geographically isolated district where no intervention was taking place). More details about the INPARD project and my specific involvement with the project are provided in Appendix Four.

Moneregala and Ampara are located in the Southeast corner of Sri Lanka (Figure 3.2). Children in Moneregala have a high prevalence of adverse nutrition outcomes including low birth weight, stunting, wasting, anaemia and severe acute malnutrition[145]. Ampara, which is located in the Eastern province of Sri Lanka, is a post-conflict area facing unique challenges related to resettlement and reconstruction following three decades of civil war. Kurunegala is demographically similar to Moneregala and Ampara, but is located more centrally in the North western Province. Like Moneregala, it has some of the highest prevalence rates of child malnutrition in the country.

Figure 3.2. Geographic description of study location



Data were collected at baseline and follow-up from villages and schools within Ampara, Moneragala and Kurunegala

3.3 Sampling methods

Schools were selected using a three-stage clustered randomised sampling method. This technique involved selecting schools through a multi-stage stratification procedure based on geography, intervention status and school category (Appendix Five).

INPARD staff requested and obtained a list of all government schools from the Ministry of Education. In the first stage, schools were stratified according to district (Ampara, Moneragala and Kurunegala). Next, they were stratified according to whether or not the school was located in a village where the intervention was taking place. This step was necessary only for Ampara and Moneragala because in Kurunegala, no interventions were taking place. Finally, schools were arranged into four groups according to their school category, which were defined by the Sri Lankan Ministry of Education. Sri Lanka's classification system for schools is as follows: 1AB: Schools which have advanced level science stream classes; 1AC Schools having advanced level arts/commerce streams (but no science stream); Type 2: Schools having classes only up to grade 11; Type 3: Schools having classes only up to grade eight[146]. This resulted in a sample of 50 schools (Table 3.1).

From each stratum, schools were selected using 'probability proportional to size' (PPS), a method that was used to ensure that every student had an equal chance of selection. This process was conducted using Microsoft Excel (Microsoft Corporation, Kirkland, USA) and was completed using a series of stages. In first stage of PPS sampling, larger clusters (*i.e.* schools with more students) had a greater probability of being sampled. In the second stage, the exact same numbers of individuals were sampled per cluster, which means that students in larger schools had a lower probability of being sampled. Overall, this second stage of sampling compensated for the first, which ensured that every student has the same probability of being sampled[147].

Table 3.1. Description of stratum used in study sampling methods

Region	Ampara						Moneregala						Kurunegala		
Village	Intervention			Control			Intervention			Control			Control		
School Type	1AB	1C	2	1AB	1C	2	1AB	1C	2	1AB	1C	2	1AB	1C	2

Sampling from both control *schools* (located in districts where the intervention was taking place, but only in select schools) and control *districts* (a district where the intervention was not taking place—*i.e.* Kurunegala) helped prevent the potential effect of intervention contamination.

3.3.1 Sampling students

The INPARD study employed a clustered sampling design (students clustered within schools), which meant that the students' responses could not be assumed to be independent[14]. Furthermore, clustered sampling leads to standard errors which are higher than those from simple random sampling[148]. These methods had important implications for the statistical analysis, which will be described in subsequent sections.

One class from each of the selected schools (n=50)[15] was chosen to participate in the INPARD study. School authorities were asked to select a class where there were at least 30 students. According to sample size calculations (Table 3.2-3.3), the project needed 900 students from 36 schools (25 students per school), so the sampling methods ensured that the INPARD project surpassed the minimum requirements. Sample size calculations were based on the proportion of students eating five or more fruit or vegetables a day, based on the 2008 Sri Lankan Global school-based student health survey results[149].

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[14] Students within the same school are more likely to be similar to each other.
[15] The original sample had 50 schools, but due to lost data, the final sample included just 49 schools.

Table 3.2. Calculations for student sample size

Calculation of the student sample size based on consumption of fruit and vegetables	
z score for 95% confidence interval (z)	1.96
Margin of error (d)	5%
Design effect[2] *(D_{eff})*	3.32
Percentage of students eating 5 or more fruits or vegetables[2] *(p)*	22.4
Sample size needed ($n= z^2*p(100-p)/d^2$)	268
After correction for the design effect ($n^i = n* D_{eff}$)	890

Table 3.3. Calculations for school sample size

Calculation of the school sample size based on consumption of fruit and vegetables	
Design effect[2] *(D_{eff})*	3.32
Average cluster size [2] *(c)*	84
Student sample size (n^i)table	890
Number of schools needed ($n^s=n^i/c* D_{eff}$)	36
Required number of students per school (n^i/ n^s)	25

3.3.2 Inclusion criteria

Students between the ages of 12-18 years attending secondary schools were eligible to participate. I excluded students who were under the age of 12 years, those who were diagnosed with long term medical conditions or those who were attending private or international schools.

3.4 Ethical considerations

There are special ethical considerations related to working with children. I sampled students aged 12-18 years, because 12 is the age that WHO advises that individuals are able to give consent[150].

3.4.1 Consent

Ethics approval was granted from the University of Oxford and the University of Colombo (Appendix Six). A week before the data collection, each school sent students' parents a letter providing detailed information about the project and instructions if they wished to opt out of the survey. On the day of the survey, students who had not opted out were invited to participate. Those who agreed to participate provided written informed consent. Even after providing consent, participants were notified that at any point in the study, they were eligible to opt out.

3.4.2 Confidentiality and anonymity

The INPARD data collectors administered the questionnaires to ensure that students' responses could not be seen by teachers, school staff or other students. The classroom was arranged to ensure that answers could not be seen between students. Students' individual names were not recorded. After completing the questionnaire, surveys were collected in a box that was placed centrally in the classroom. At the request of the ethics committee, questions about sensitive information (such as drug or alcohol use) were deliberately put on the last pages of the GSHS, to reduce the likelihood that these answers would be seen by others. All completed questionnaires were stored using safety precautions, including storing the completed surveys in a locked cupboard accessible only by the principal investigators, for five years. After completing the project and publishing the results in reports and peer-reviewed articles, the data will be destroyed.

3.4.3 Recruitment

The INPARD project received permission for accessing schools and other institutions from Sri Lanka's Ministry of Education, provincial-level authorities and zonal education offices. Selected schools were invited to participate via a letter which was signed and administered through the Ministry of Education. The letter was sent to schools several months before the data collection was scheduled and contained background information about the school aims. It asked schools to nominate a school contact who could liaise with INPARD staff and act as a point of contact. All of the schools (n=50) that received this letter agreed to participate. The appointed school representative and INPARD staff coordinated dates and logistics for baseline data collection. School principals provided the INPARD project with permission to reach teachers and students during school hours.

3.5 Data collection

Data collection was conducted by several research teams over the course of the INPARD study. There were two teams. One was based in Moneregala, and one was based in Kurunegala. In addition to collecting data from their respective districts, both teams shared the responsibility of collecting data from Kurunegala. Due to the project timeline, there was some change in the staff between baseline and follow-up data collection for both teams. I visited these teams on four different field visits between June 2014 and November 2016 to provide training, oversee the data collection and monitor the data transcription processes. Because my supervisors and I were based in Oxford, all day-to-day management of the project was conducted by an INPARD research coordinator. INPARD rented two offices—one in Ampara and one in Moneregala. Within each office, there was a team of four to five local researchers responsible for administering the surveys, translating the results and transcribing the results into digital format.

On the day of the survey administration, the INPARD teams from Ampara and Moneregala travelled from their offices to the schools.

Data were collected from a geographically large part of the country. Extensive driving was required as the data collectors moved between villages and schools. There are about 250 kilometres between Ampara and Kurunegala and 100 kilometres between Ampara and Moneregala. The quality of the roads varies—on the main interstates between districts, travel time is minimal due to the availability of paved roads. However, in the rural areas where we were collecting data, roads were often unpaved and it was time-consuming to move between villages and schools. One of the largest expenses for the INPARD project stemmed from paying for three rented vans and drivers and paying for the cost of petrol.

When INPARD staff arrived at schools, the school liaison took the researchers to the classroom which had been selected for data collection. The researchers explained the study procedures to the students and staff in Tamil or Sinhalese, depending on the school's taught language. Students were asked to complete two paper-based surveys: the food frequency questionnaire (FFQ) and the WHO Global school-based health survey (GSHS). Along with receiving verbal instructions from the INPARD researchers, students received written instructions. On average, the two surveys took about two hours to complete.

3.5.1 Evaluating students

3.5.1.1 The Global school-based health survey (GSHS)

The GSHS is a school-based self-administered questionnaire designed to assess behavioural risk factors and protective factors among children and young people 13-17 years of age (Appendix Seven)[141]. It was developed by the World Health Organization (WHO) and the United States Centres for Disease Control (CDC) and has been used globally, allowing countries to make between-country comparisons regarding the prevalence of health behaviours[151].

Figure 3.3. Secondary students completing the Global school-based health survey (GSHS) at a school in Moneregala

The GSHS asks questions that relate to the leading causes of morbidity and mortality among children worldwide, including alcohol use, diet behaviours, drug use, hygiene, mental health, physical activity, protective factors, sexual behaviours, tobacco use and violence/unintentional injury. The questionnaire also asks students how many times per day they usually ate fruit, vegetables or carbonated soft drinks. Additionally, it asks other diet-related questions such as how frequently students consumed breakfast, whether or not students felt that they were the right body weight and how often students went hungry due to lack of food at home.

In addition to asking questions about health behaviours, the GSHS assesses student demographics such as sex and age. To supplement these demographic questions, I also included six modified questions about socioeconomic status from the WHO STEPwise approach to surveillance (STEPS) survey[151], which asked students about their household income, their maternal and paternal occupation and their maternal and paternal level of education.

3.5.1.2 The Food Frequency Questionnaire (FFQ)

The primary outcome in this study was the dietary intake of students, which was assessed using a food frequency questionnaire (FFQ). The FFQ is the most common method of assessing dietary intake[152]. It has two components: a food list and a frequency response section to describe the frequency and amount of consumption. Selecting items for the food list is an important and difficult task. In order to reduce respondent burden, the list cannot be too long. At the same time, the list must be able to describe foods which are eaten often by the population of interest, which contain the nutrients of interest, and which vary in consumption patterns from person-to-person. Unlike alternative methods (such as a 24-hour dietary recall, which is based on foods and amounts consumed on a specific day), the FFQ assesses usual intake over a longer period of time[152] (Appendix Eight).

Figure 3.4. Secondary students completing the food frequency questionnaire (FFQ) at a school in Moneregala

3.5.1.2.1 Validation of the Sri Lankan Food Frequency Questionnaire

This project used an FFQ which had been validated to assess nutritional intake among Sri Lankan adults[153]. The FFQ is based on eight food groups and contains the main foods comprising the diets of Sri Lankan adults. It has a total of 85 items and 12 colour photographs which the students used to determine the portion sizes of consumed foods. It was validated using 100 randomly selected healthy adults who completed both the FFQ and a 7-day weighed-intake dietary record[153]. Jayarwardena *et al* used paired sample t-tests, Pearson's correlation coefficients, kappa tests and Bland-Altman analysis to determine the correlation and the level of agreement for energy and micronutrients and found good agreement between methods[153].

3.5.1.2.2 Administration and processing of the FFQ

The FFQ was administered to students within the classroom on the day that the NFSI and GSHS data were collected. It was then transcribed from the paper surveys and analysed in 'Nutrisurvey,' an English translation of a professional German nutrition software which conducts nutrient analysis[11].

The FFQ for this project included many commonly consumed mixed dishes (including more than 10 types of curries). To analyse the nutrient content of these foods, they were broken down into composite parts using a recipe database which contained the mixed foods' ingredients and amounts, preparation methods and yields. The following dietary measures were produced for each student:

Daily intake of foods: Daily consumption of 87 food items, grouped into 8 food components (cereals or equivalents, vegetables, pulses, meat/poultry and meat/poultry products, fruits, drinks, miscellaneous and alcohol).

Nutrient intake: A nutritional analysis of the daily micro- and macro-nutrient composition of students' diets including total energy protein, fat, carbohydrates, dietary fibre, alcohol, cholesterol, vitamins (A, B1, B2, B6, B12, folic acid) and minerals (sodium, potassium, calcium, magnesium, phosphorus, iron, zinc).

Nutrient analysis involves using a database of food composition, a coding system for matching foods on the FFQ to foods within the database and software for calculating the nutrients. Altogether, this raw data included 107 dietary measures per student, collected at two time points. As part of the data processing and cleaning, I excluded observations with implausible values from the analysis, which included students who had a reported intake of greater than 10,000 calories per day.

3.5.1.3 Anthropometrics

After students completed the surveys, they were weighed and measured by trained researchers using a Seca scale and stadiometer (Seca, Hamburg, Germany). Students were asked to remove their shoes and to wear light clothing only. The measured height and weight values were used to calculate BMI Z-scores and weight categories using recommendations from the International Obesity Taskforce criteria[154].

Figure 3.5. Secondary students being weighed and measured at a school in Moneregala

3.5.1.4 Demographics

The GSHS does not assess students' socioeconomic status (SES), beyond a single question that asks about frequency of going hungry due to lack of food. Between baseline and follow-up data collection, I applied for and was granted ethics approval to ask students about SES using a modified version of the WHO STEPwise approach to surveillance (STEPS) survey[151], which asks questions about ethnicity, education, occupation and household income. To make these appropriate for use with adolescents, I asked students to report *parental* education and occupation.

The main advantage of using the modified STEPs question was that the questions had already been translated into Sinhalese and Tamil and the relevant categories for ethnicity, occupation, education and household income had already been identified for use with INPARD's adult data collection. This measure had practical benefits, given a tight timeline between the ethics application and the pre-scheduled data collection. However, these measures had not been validated for use with adolescents.

3.5.2 Evaluating schools

3.5.2.1 The Nutrition-friendly schools initiative tool for researchers

I worked with the WHO to develop a tool to evaluate the extent to which schools were following recommendations outlined in the NFSI framework (Appendix Nine). The tool, which was designed for use as a semi-structured interview with school principals, was piloted in Sri Lanka in early 2014. In order to minimise the amount of time required to use the tool, the tool employed the use of skip questions and check boxes. The tool follows the format of the NFSI, and assesses policies and practices related to nutrition policies, actions to enhance awareness and build capacity, developing a nutrition and health-promoting school curriculum, creating a supportive school environment and providing supportive school nutrition and health services. On the day of the school data collection, while the students were completing the GSHS and FFQ surveys, one member of the INPARD staff met with the school's principal to administer the semi-structured interview. Interviews were conducted in Tamil or Sinhalese.

Figure 3.6. Interviewing a school principal at a school in Moneregala, Sri Lanka.

In order to gain contextual information about the schools, the NFSI tool asked principals to report if students received free school meals from the government. In Sri Lanka, eligibility for free meals depends on the age and size of students in the school (rather than the socioeconomic status of students, as it does in some other countries such as the United Kingdom[155] or the United States[156]). The tool also asked principals to report the number of students and teachers in their schools.

3.5.2.1.1 'Having a written nutrition-friendly schools policy'

The first component of the NFSI is 'having a written nutrition-friendly schools policy.' In initial pilot testing, the data collectors asked if schools had a school nutrition policy. Participants in pilot tests noted that the Sri Lankan Ministry of Education provides a mandatory 'canteen policy' which outlines regulations related to school food provision and theoretically, all schools should have received this policy. This project was interested in learning about the activities which went *beyond* this mandatory policy, so I decided to break the question about school policy into two parts: 1) 'Did your school receive a canteen policy or a policy related to school food from the education authorities?' And 2) 'Does your school have any other policies (written or unwritten) on healthy eating?' Additionally, I asked participants to describe how long the policy had been in place and to identify the aims of the policy. In the NFSI framework, the WHO recommends that nutrition-friendly school policies include elements such as a 'rationale,' 'objectives with timelines and clear milestones,' 'an action plan,' and a 'monitoring and evaluation plan.' I asked principals to identify whether or not their policy had these elements.

Additionally, the NFSI recommends that schools have a policy action plan which includes specific elements such as 'a whole school approach contributing to healthy living and lifestyles,' 'a description of processes,' 'organisational structure,' 'roles/responsibilities,' 'non-discrimination' and 'a strong commitment by all concerned stakeholders (including family and community)'. I included questions about these components in the NFSI tool.

Figure 3.7. A classroom at one school in rural Moneregala

Section four of the NFSI, which focuses on 'Creating a supportive school environment,' includes a recommendation that schools implement `Affirmative action against bullying, stigmatization, and discrimination'. In pilot tests, the terms 'affirmative action' and 'bullying, stigmatization and discrimination' caused some confusion. I worked with local Sri Lankan researchers to rephrase this to a term that would be clearer. In this case, the term was 'The promotion of harmony between all students, irrespective of background.'

The NFSI also places an emphasis on having a monitoring and evaluation plan for the nutrition policy. I asked school principals if they had a monitoring and evaluation plan, and whether or not they were measuring the policy's dissemination, implementation or associated health outcomes.

Figure 3.8. A secondary school in rural Ampara

Based on the NFSI recommendations, I asked principals if schools worked with students' families to promote healthy eating messages inside and outside of schools. I then asked how many activities to promote healthy eating the school had held for families in the past 12 months. During pilot work with the NFSI tool, there was some confusion about what constituted an 'action.' Therefore, I specified that actions referred to events or measures, beyond informal discussions, that were organised by the school.

The NFSI recommends that, in addition to engaging with families of students, schools engage with communities as they address nutrition- and health-related issues. I asked principals if they worked with the community or participated in any sort of nutrition- or health-related outreach activities.

3.5.2.1.2 Enhancing awareness and capacity-building

The second component of the NFSI relates to enhancing awareness and capacity-building within the school community. This includes activities related to policy dissemination, community involvement and training of staff in nutrition and health-related issues. I asked if school staff received training in nutrition- or other health-related issues.

3.5.2.1.3 Developing a nutrition and health-promoting school curriculum

The third essential component of the NFSI framework relates to developing a nutrition and health-promoting school curriculum. I asked questions to assess if schools provided physical education that was age-, sex- and culturally-appropriate, including whether or not 'it changed between grades to account for age,' 'it was different for boys and girls' and 'it included culturally-appropriate activities.' I also asked if schools offered curriculum related to healthy living and life-skills. To get a sense of whether or not healthy eating and nutrition education within schools included practical skills, I asked if students received training in skills such as cooking.

3.5.2.1.4 Creating a supportive school environment

The fourth essential criteria of the NFSI relates to creating a supportive school environment. Most of the questions in the NFSI tool were about these environmental characteristics.

The first recommendation of this component relates to having school meals, food vendors and snack bars that promote healthy eating. I asked schools to identify the types of food that were offered at schools, such as fresh fruit or vegetables, fruit juice, milk, sweets, or other common Sri Lankan foods (such as rice, curry and roti). In addition to having foods which promote healthy eating, the NFSI recommends that schools create a supportive environment by providing positive messaging towards nutrition and active living and prohibiting the marketing of foods and beverages at school. I asked schools if they believed that there was ‘positive messaging towards nutrition and active living within schools.’ Another key NFSI recommendation related to creating a supportive school environment involves providing children with access to safe drinking water, so this was something that I assessed.


Figure 3.9. Outside of a canteen at a secondary school in Moneregala, rural Sri Lanka

As part of its criteria for creating a supportive environment, the NFSI also recommends that schools maintain adequate cooking facilities and provide children with access to an adequate eating place. I asked principals where children eat meals and most schools reported that the classroom was the space that was available.

Figure 3.10. Secondary students eating a mid-morning meal at a school in Moneregala

The NFSI places an emphasis on schools providing space and sporting facilities for physical activity, both inside and outside of curriculum. I asked the principals if the schools had areas available for active play outside of physical education lessons.

To get a sense of the resources that schools had available for physical education, I asked if schools had changing rooms, washing facilities, outdoor space, indoor space (specifically for physical activity), sports equipment and audio/video equipment.

The final criteria of the NFSI relates to providing children with supportive school nutrition and health services, so I asked if school measured students to monitor their growth and development. As a follow-up question, I asked if they implemented a feedback system to report the results from the monitoring back to parents and children.

3.5.2.2 Summary of data collecting tools

Table 3.4 summarises the tools that I used to collect data from students and schools. From students, I collected data on diet using a food frequency questionnaire, anthropometrics using measurements from trained data collectors, socioeconomic status using revised questions from the WHO's 'Stepwise approach to surveillance (STEPs)' survey, and demographics or other health behaviours (including diet-related characteristics such as breakfast consumption) using the WHO global school-based health survey (GSHS). I collected data on school approaches to promoting healthy diets using the 'NFSI Tool for Researchers.'

Table 3.4. Tools developed for the study and outcome indicators

Age group/ Level	Outcome category	Outcome indicator	Data source
Children 12-18 years of age*	Diet	Diet Quality Index	Food Frequency Questionnaire (FFQ)
	Anthropometrics	Proportion of children classified as underweight, healthy weight, overweight and obese according to WHO and International Obesity Task Force categories	Anthropometric measurements taken by trained researchers following standard protocol
	Socioeconomic status	Maternal and paternal education, maternal and paternal occupation, household income	Revised questions from the WHO NCD Disease Risk Factor Survey, part of the STEPwise approach to surveillance (STEPs) survey
	Demographics and diet-related characteristics	Proportion of children who are current smokers and consume alcohol (current/ever consumed) - (WHO definitions)	Global School-based Health Survey (GSHS)
School principals	School approaches to nutrition promotion	NFSI Actions	NFSI Tool for researchers

3.6 Data processing

3.6.1 Data entry

The GSHS, FFQ and NFSI results were transcribed from paper surveys by the INPARD data collectors and provided to me in excel spread sheets. Each of the three districts had a different set of methods for transcribing and coding the data. I created a standardised coding method and processed the GSHS data according to the WHO's official recommendations[151] in terms of checking for internal consistency and removing biologically implausible height and weight values.

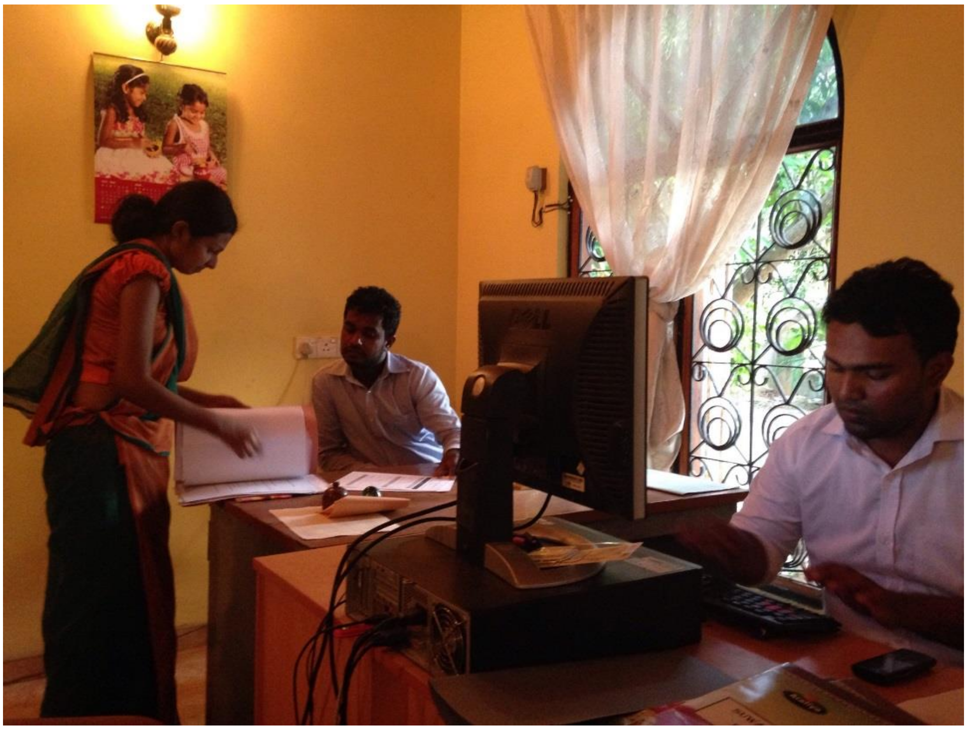


Figure 3.11. Data collectors at the 'Integrating Nutrition Promotion and Rural Development' project office in Ampara, Sri Lanka

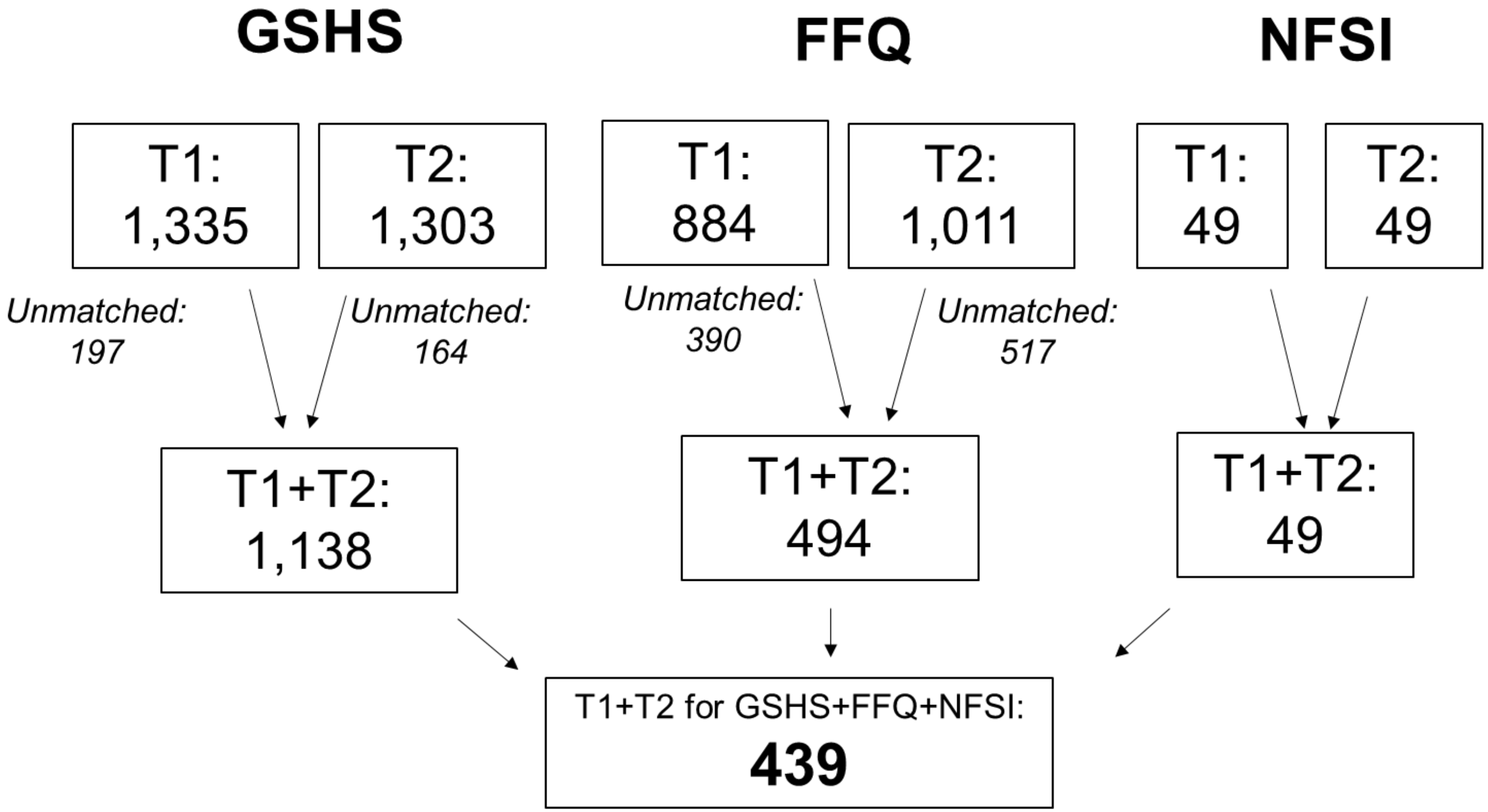
The student-level GSHS and FFQ surveys were labelled with a unique individual and school identifier. The NFSI was labelled with a school identifier. All paper-based surveys were taken to the INPARD offices in Ampara or Moneregala where the answers were transcribed from paper to digital copies. The responses from school principals included some qualitative findings which were translated from Sinhalese and Tamil into English. The GSHS results were sent to me within four months of the data collection completion. The FFQ surveys, however, were sent to a research team based at the University of Colombo, where trained nutritionists manually entered the results into a nutrition database. The results were exported into individual files and sent to me in batches for cleaning and processing.

Figure 3.12. Team members from the 'Integrating Nutrition Promotion and Rural Development' project

3.6.2 Linking datasets

Each student survey had a unique identifying code which was used to link school-level data (from the NFSI), student demographic data (from the GSHS) and dietary outcome data (from the FFQ). A summary of the matches between datasets is provided in Figure 3.13. The initial loss of more than 50% of our sample was related to several factors, including coding errors in the unique identifiers, missing data from several schools at both time points, and loss to follow-up among students.

Figure 3.13. Description of initial matches, based on student identifiers, between the three surveys, over time



Abbreviations: T1: Baseline, T2: Follow-up, GSHS: Global school-based health survey, FFQ: Food frequency questionnaire, NFSI: Nutrition-friendly schools initiative tool

Figure 3.14. Storage of the paper-based surveys at the 'Integrating Nutrition Promotion and Rural Development' office in Ampara, Sri Lanka

3.7 Constructing variables

To investigate associations between school approaches and student outcomes, I needed to convert the raw data into variables that could be used in multi-level analysis to examine associations between school approaches to promoting healthy diets and student nutrition outcomes. This involved constructing independent and dependent variables, along with an exposure variable, which would summarize the number of NFSI actions that schools were implementing.

3.7.1 Independent and dependent variables

Data from the food frequency questionnaire were converted into a 'diet quality index.' In my models investigating associations between school approaches and diet quality, I would need to control for other student characteristics (student independent variables), which included demographics (age, sex, ethnicity, maternal education) and diet-related characteristics (breakfast patterns, feelings about body weight and food security). The next step would be to construct the exposure variable, which summarised the number of NFSI actions that schools were implementing

3.7.1.1 Dependent variables: Student dietary outcomes

The primary outcome related to students' diet intake, which was measured using the FFQ. This section describes how I converted the raw measures from the FFQ into a summary score of diet quality using the diet quality index-international index (DQI-I). It also describes key components from the DQI-I scores (dietary variety, adequacy, moderation and balance).

3.7.1.1.1 Developing a diet quality index

Compared to single nutrient measures, a composite measure provides a more effective means of assessing variability within the diet and the overall diet quality[157]. Traditionally, nutritional epidemiologists have focussed on the health effects of single nutrients, but this 'reductionist approach' has its limitations because it fails to assess dietary quality comprehensively[152, 158]. For this reason, some researchers have preferred using composite measures of diet quality, which have been found to be associated with diet-related biomarkers[159] and may be more strongly associated with health outcomes compared to a single nutrient[160].

3.7.1.1.2 Types of diet quality indices

There are a number of overall diet measures which have been developed, including the Diet Quality Index[161] and the Healthy Eating Index[162]. A review to summarise the range of diet quality indices and their associations with health-related outcomes by Marshall *et al*[163] identified 119 studies using 80 different diet quality indices to assess diet among children and adolescents. Most of these indices were not appropriate for this project, due to their focus on high-income countries where the primary health concern related to over-nutrition[163]. In Sri Lanka, more than one in five children is moderately or severely underweight, 17% are stunted and 15% are wasted[12], so it was important that the diet quality index consider factors relevant to under-nutrition, such as the adequacy of energy and protein. Furthermore, many of the diet quality indices[164] required nutritional data that I did not have. Based on these factors, I decided to use the DQI-I developed by Kim *et al*, which has been validated for use in many different contexts[157]. Unlike the original Diet Quality Index (DQI)[161, 165], which was developed in 1999 to reflect the dietary quality of populations within the United States, the DQI-I was developed to be useful in a range of culturally and economically diverse contexts and includes components that make it appropriate for use in countries where undernutrition is a problem. It considers aspects of the diet that are relevant to my study, such as micro-nutrient adequacy and protein adequacy, while also giving attention to consumption of foods high in fat, sugar or salt. Furthermore, unlike for other indices, I had most of the required data to calculate the DQI-I.

The DQI-I has been used to provide a summary measure of diet quality in previous research, including research examining the effectiveness of school policies and programmes related to promoting a healthy weight in school children[166], suggesting that its use in the context of my project would be building upon a larger body of research.

3.7.1.1.3 Description of the Diet Quality Index-International

The DQI-I assesses the quality of a diet based on four components: its variety, adequacy, moderation and overall balance. The DQI-I is based on worldwide and individual national dietary guidelines from the WHO[167] and the United States Department of Agriculture (USDA)[168, 169]. More details regarding the rationale for developing the index are documented elsewhere[161, 162, 165].

The DQI summarises overall diet quality by considering a variety of measures related to the following recommendations: reducing fat intake to 30% or less of energy, reducing saturated fatty acid intake to less than 10% of energy, reducing cholesterol to less than 300 mg daily, eating five or more servings a day of vegetables and fruits, eating six or more servings a day of breads, cereals and legumes, maintaining protein intake at moderate levels (levels lower than twice the RDA (0.8 grams (g) per kilogram of body weight)[170], limiting daily intake of sodium (6 g, 2,400 milligrams (mg) or less) and maintaining adequate calcium levels[161]. Based on these criteria, the DQI creates a quantitative summary of four dietary components: dietary adequacy, variety, moderation and balance. The DQI-I draws upon both food- and nutrient-based values. Specific scoring methods are described later in this section.

3.7.1.1.4 Modifications to the DQI-I

While the DQI-I appeared to be the most appropriate option for my purposes, I did not have all of the data that the index requires. The DQI-I calculates moderation based on the percentage of energy from three types of fat: cholesterol, saturated fat and non-saturated fat, each of which is worth six points. However, my data included only fat and cholesterol, so I made the maximum possible scores for fat and cholesterol nine points each. This redistribution of points ensured that the scale would still have a maximum value of 100 and that the potential moderation score would still have a maximum of 30 points.

Additional modifications were made for the 'Overall balance score,' which contributes up to 10 points to the total DQI-I score. The original DQI-I included a component related to the fatty acid ratio of polyunsaturated to monounsaturated to saturated fat, with the ideal ratio receiving up to four points. I did not have these data, so I increased the value of the other 'Overall balance component,' which was based on the ratio of carbohydrates to protein to fat. Originally, the maximum score was worth six points in the DQI-I, but I increased it to be worth 10 points (Table 3.5).

Table 3.5. Diet Quality Index-International (DQI-I) components, scores, cut points and baseline proportions as used in this thesis, adapted from Kim *et al*[157]

Component	Possible Points (pts)	Scoring
Variety	**0-20 pts**	
Overall food group variety (meat/poultry/fish/eggs; dairy/beans; grain; fruit; vegetable)	15 pts	≥1 serving[a] from each food group/day
	12	Any 1 food group missing/day
	9	Any 2 food groups missing/day
	6	Any 3 food groups missing/day
	3	≥4 food groups missing/day
	0	None from any food groups
Within-group variety for protein source (meat, poultry, fish, dairy, beans, eggs)	0–5 pts	
	5	≥ 3 different sources/day
	3	2 different sources/day
	1	From 1 source/day
	0	None
Adequacy	**0–40 pts**	
Vegetable group	0–5 pts	
	5	≥3–5 servings/day
	0	0 servings/day
Fruit group	0–5 pts	
	5	≥2–4 servings/day
	0	0 servings/day
Grain group	0–5 pts	
	5	≥6–11 servings/day
	0	0 servings/day
Fibre	0–5 pts	
	5	≥30 g/day
	0	0 g/day
Protein	0–5 pts	
	5	≥10% of energy/day
	0	0% of energy/day
Iron	0–5 pts	
	5	≥100% RDA (AI)/day (15 mg)
	0	0% RDA (AI)/day
Calcium	0–5 pts	
	5	100% AI/day (1300 mg)
	0	0% AI/day
Vitamin C	0–5 pts	
	5	100% RDA (RNI)/day (75 mg)
	0	0% RDA (RNI)/day
Moderation	**0–30 pts**[b]	
Total fat	0–9 pts*	
	9	≤ 20% of total energy/day
	6	>20–30% of total energy/day

	0	>30% of total energy/day
Cholesterol	0–9 pts*	
	9	≤ 300 mg/day
	6	>300–400 mg/day
	0	>400 mg/day
Sodium	0-6 pts	
	6	≤ 2400 mg/day
	3	>2400–3400 mg/day
	0	≥3400 mg/day
Empty calorie foods	0–6 pts	
	6	≤3% of total energy/day
	3	>3–10% of total energy/day
	0	>10% of total energy/day
Overall balance	**0-10 pts[c]**	
Carbohydrate:Protein:Fat Ratio (kcals)	10 pts	
	10	55-65:10-15:15-25
	7	52-69:9-16:13-27
	3	50-70: 8-17: 12-30

Abbreviations: RDA: Recommended Daily Allowance; AI: Adequate Intake; RNI: Recommended Nutrient Intake

[a]Serving sizes were on recommended servings sizes from the 1994 USDA Food Guide Pyramid[165]
[b]The points for total fat and cholesterol were modified from the original max of six points to a new max of nine points due to the lack of data on saturated fat (a component which was included in the DQI-I for a maximum of six points).
[c]Additional modifications were made for the 'Overall balance score.' The original DQI-I included a component related to the fatty acid ratio (PUFA: MUFA:SFA). I did not have these data, so I increased the value of the other 'Overall balance component,' which was based on the macronutrient ratio. Originally, the maximum score was worth six points in the DQI, but I increased it to be worth 10 points.

In making the DQI-I score relevant to my study population, I made an addition modification to the way that foods were classified. In the original DQI-I, the 'grains, rice and bread' category did not include starchy vegetables such as plantains or potatoes. However, in the Sri Lankan food based dietary recommendations[171], starchy vegetables were included in the 'grain group' with other foods like rice and bread. Therefore, when I was categorising foods into groups, I aligned my analysis with the Sri Lankan recommendations and included starchy vegetables in the 'grains, rice and bread' category rather than in the 'vegetable' category.

In order to be consistent with the Sri Lankan recommendations, I also made a modification related to the scoring for fibre. The original DQI-I specifies a range of 'adequate fibre' to be 20-30 g. I chose ≥ 30 g, based on the standard dietary requirements which are recommended in Sri Lanka[171]. For the other recommendations related to calcium, protein, vitamin C and iron, I followed recommendations outlined in the original DQI-I[170].

3.7.1.1.5 Determining serving sizes

The DQI calculations for an 'adequate diet' are based on the numbers of servings for vegetables, fruits and grains and for a 'varied diet' are based on the numbers of servings of various food groups (meat, poultry, fish and eggs; dairy and beans; grain, fruit and vegetables) or within-group protein sources (meat, poultry, fish, dairy, beans and eggs).

In its raw form, the FFQ data provided daily consumption of particular foods in terms of grams per day. To convert grams of food per day to numbers of servings, I first grouped foods into categories. I estimated the serving sizes for different food groups mainly using the Sri Lankan Dietary Recommendations[171]. These provide estimates of the serving sizes of rice/breads, vegetables, fruits, beans, meats and dairy products (see Table 3.6).

Table 3.6. Description of Daily Sri Lankan Diet Recommendations

Food groups	**Servings (Adolescents)**	**Servings (Adults)**	**Serving Size**
Cereals and starchy food	7-10	6-11	1 cup (130-140 g) rice, 1 slice (50 g) bread
Fruits	2	2-3	1 medium size fruit*, ½ cup of cut fruit*, 2 Tbsp (20-30 g) dried fruit
Vegetables	2-3	3-5	3 Tbsp (1/2 cup) cooked*, 1 cup raw salads (200 mL)
Pulses, fish, meat, eggs, nuts	2-3	3-4	30 g of cooked fish/poultry/meat, 3 Tbsp cooked pulses*, 1 egg, 15 g dried fish
Milk or milk products	2	1-2	1 cup (200 mL) milk, 1 cup (100 mL) yogurt, 30 g (2 Tbsp milk powder)
Nuts and oil seeds	2-3	2-4	1 Tbsp (15 g)

Abbreviations: Tbsp: Tablespoon; mL: Millilitres
Note: The Sri Lankan Diet Recommendations do not specify all serving sizes in terms of grams. I calculated the grams per serving for selected foods using the USDA Food and Nutrient Database[172]

3.7.1.1.5.1 Components of the Diet Quality Index-International

The diet quality index-international bases its scores on variety, adequacy, moderation and overall balance. These are described in more detail below.

3.7.1.1.5.1.1 Variety

The variety score was based on two components: the overall food group variety and the within-food group variety for protein sources. The maximum overall variety score of 20 points was given to students who included at least one serving per day of food from each of the five food groups: meat, poultry, fish, eggs; dairy and beans; grain; fruit; vegetables. Beans and dairy are combined into the same food group in the DQI-I because beans are a major source of calcium in many developing countries within Asia and intake of dairy foods alone would under-represent true intakes of calcium-rich foods in these contexts[157]. If students ate at least one serving from each of the five food groups per day, they were given 15 points. For each food group that was missing, the points were reduced by three, so that students with one food group missing per day were given 12 points, those with two missing per day were given nine points, etc.

Using the DQI-I, I also evaluated variety within protein sources (meat, poultry, fish, dairy, beans and eggs). A diet which draws protein from a diverse set of sources is considered superior to a diet which draws protein from the same source. When students derived protein from more than three different sources per day, they were given five points. When the number of sources decreased, the scores also decreased.

3.7.1.1.5.1.2 Adequacy

The adequacy score evaluates whether or not students included dietary elements which are required to guarantee a healthy diet (as a precaution against undernutrition). It is based on the student's consumption of foods from each of the following groups: vegetables, fruit, grains, and levels of intake of fibre, protein, iron, calcium and vitamin C. The scores that students received were based on percentage attainment of recommended intakes on a continuous scale. For example, a student who obtained 100% of the recommendations for fruit and vegetables, would get the highest score of five points. Following the Sri Lankan dietary recommendations, adequate consumption of fibre was defined as more than 30 g per day. Adequate protein was defined as greater than or equal to 10% of total energy. The adequacy of iron, calcium and vitamin C was based on the dietary reference intake (DRI) from the United States National Research Council Food and Nutrition Board[170] of 1,300mg per day of calcium, 75 mg per day of vitamin C and 15 mg per day of iron. I used these recommendations to be consistent with the methods that were used in calculating the DQI-I scores, which were based on recommendations from the United States.

3.7.1.1.5.1.3 Moderation

The DQI-I includes a moderation score which evaluates the intake of food and nutrients that are associated with chronic diseases and which may need restriction. When energy intake from total fat was ≤20% of total energy intake, the highest score of nine points was given and when it was >30%, the lowest score of zero points was given. When cholesterol was ≤300 mg/day, the highest score of nine points was given and when it was >400 mg per day, the lowest score of zero points was given. When sodium was ≤2400 mg/day, the highest score of six points was given and when it was >3400 mg/day, the lowest score of zero points was given.

The DQI-I also evaluates the intake of foods that are of high in fat, sugar or salt, which it calls 'empty calorie foods.' The DQI-I assesses, as a percentage of total daily calories, how much of a student's diet comes from these foods, which may provide energy but few nutrients[173].

The allocation of points was based on the percentage of calories which came from these foods. If more than 10% of a student's daily calories came from these foods, then they received a score of zero. If fewer than 3% came from these foods, students received the highest score of six points.

3.7.1.1.5.1.4 Overall balance

The final component of the FFQ examines the proportionality of macronutrients. This aspect of the DQI-I was based on the proportion of energy from carbohydrates, protein and fat. The DQI-I based recommendations on the proportion of macronutrients in guidelines published by the WHO[167] and outlined in Table 3.5, which shows a gradation of points, with the highest point value (10 points) being allocated to diets that had a macronutrient ratio of carbohydrate: protein to fat of 55-65% carbohydrates, 10-15% protein and 25% fat and the lowest point value of three being allocated to diets that had a macronutrient ratio of 50-70% carbohydrates, 8-17% protein and 12-30% fat.

3.7.1.1.5.2 Additional dietary outcomes: calcium, protein and fibre

In addition to using the DQI-I as an outcome variable, I included the following nutrients as outcome measures: calcium, protein and fibre. These nutrients are among those which are related to common nutritional concerns in adolescence[174], and are related to low consumption of fruits and vegetables, whole grains, calcium and low-fat dairy and high consumption of sugar-sweetened beverages and fast food[175]. I chose to focus on calcium, protein and fibre because they were particularly low in my sample at baseline. According to the age- and sex-specific recommendations for adolescents[175], most students in my sample had adequate intake of folic acid, vitamin A, B6, iron and zinc. I did not have data for vitamin E intake.

3.7.1.1.5.2.1 Calcium

Adolescents require more calcium than children or adults due to an increase in skeletal growth[175]. About 45% of peak bone mass is attained during adolescence; so adequate intake is necessary to reduce risk of fractures and osteoporosis over a lifetime[176]. Adolescents are recommended to consume 1,300 mg of calcium per day[170].

3.7.1.1.5.2.2 Protein

Protein is the building block for the body's cells, and plays a functional role for creating enzymes and hormones[175]. Adolescents require protein in order to maintain existing lean body mass and to develop additional lean body mass during growth; an adolescent who is consistently eating inadequate levels of protein may experience reductions in linear growth, delays in sexual maturation, and reduced accumulation of lean body mass[175]. There are a number of recommendations for protein consumption. The DQI-I defines adequate protein as greater than or equal to 10% of energy from protein, which is based on the lower level of the Dietary Reference Intakes, which recommend that 10 to 35 percent of calories should come from protein[177]. This recommendation is consistent with the Sri Lankan Food Based Nutrition recommendations, which also recommends that 10-15% of daily energy requirements should come from protein[171]. According to this definition, 73.8% of students did not get adequate protein.

3.7.1.1.5.2.3 Fibre

Consuming a diet high in fibre is associated with many health benefits, including a reduced risk of diseases (such as heart disease, stroke, hypertension, diabetes and gastrointestinal disorders), improved lipid concentrations and lower blood pressure[178]. The recommended intake for adolescents of fibre (grams per day) ranges from 26 to 38 grams[175]. The Sri Lankan dietary recommendations cite 30 grams per day[171].

3.7.1.2 Independent variables

3.7.1.2.1 Student independent variables

The student-level variables were collected using the Global school-based health survey and included individual-level student demographics (age, sex, ethnicity, maternal education) and student diet-related characteristics (breakfast patterns, feelings about body weight and food security) (Table 3.7).

Table 3.7. Student-level variables, categories and modifications

Student-level variable	Response categories	Modified response categories
Age	12 years	None
	13 years	
	14 years	
	15 years	
	16 years	
	17 years	
	18 years	
Sex	Male	
	Female	
How often did you go hungry because there was not enough food in your home (past 30 days)* During the past 30 days, how often did you eat breakfast*	Never	Never, Rarely or Sometimes
	Rarely	
	Sometimes	
	Most of the time	Most of the time or Always
	Always	
How do you describe your weight*	Very underweight	Not the right weight
	Slightly underweight	
	About the right weight	About the right weight
	Slightly overweight	Not the right weight
	Overweight	
Which of the following are you trying to do about your weight*	I am not trying to do anything about my weight	Maintain current weight
	Stay the same weight	
	Gain weight	Gain weight
	Lose weight	Lose weight
Ethnic/cultural background* Passed G.C.E (O/L) and above	Sinhala	Sinhala
	Sri Lankan Tamil	Tamil
	Indian Tamil	
	Sri Lankan Moor	Moor
	Other	Other
	I don't know	
Maternal education*	I don't know	Below O levels
	No schooling	
	Up to grade 5	
	Passed grade 6-10	
	Passed G.C.E (O/L)	
	Passed G.C.E (A/L)	
	Degree and above	

Variables with a '*' symbol were modified for the analysis.

3.7.1.2.2 School-level independent variables

The analyses controlled for several school-level variables, which included school type, the number of enrolled students (school size), school district and whether or not the school was involved in the Re-Awakening/INPARD project (Table 3.8).

Table 3.8. Description of school-level variables and categories

School-level variable	Categories
Fixed school characteristics	
School Type	1AB, 1C, 2
Number of enrolled students	Quartiles
School District	Ampara, Moneregala, Kurunegala
School's involvement in the multisectoral re-awakening/INPARD project	Yes, No

3.7.1.2.3 Applying the independent variables to the socio-ecological model

Table 3.9 summarises the independent variables used within this analysis according to the appropriate levels of the socio-ecological model. The focus of this thesis is on the relationship between school environments and student nutrition outcomes, so most of the factors in this analysis apply to the individuals (inter- and intra-personal variables) and to schools (institutional and community variables). Some of the variables described here could apply to more than one level. While national school policies are uniformly distributed across schools in Sri Lanka, one community-level variable which distinguished some schools from others was whether or not the school was involved with the INPARD project.

Table 3.9. Summary of variables included in the analysis, showing variables of influence on students' diet quality according to levels in the socio-ecological model

Demographic	Intrapersonal	Interpersonal	Institutional	Community
Sex	Breakfast consumption	Food security (hunger at home)	School type*	Number of students enrolled at school*
Age	Feelings about body weight	Maternal education	School District*	Multisectoral INPARD intervention
Ethnicity			Total number of NFSI actions*	

School-level variables are marked with a '' symbol

3.7.1.3 Constructing an exposure variable

The exposure variable was a summary variable describing the number of NFSI actions that schools were implementing (collected using the NFSI tool for researchers). Schools were scored 0-12 points, based on 12 actions (one point per action) related to having a written nutrition-friendly schools policy, enhancing awareness or capacity-building in the school community, creating a supportive school environment or providing supportive school nutrition and health services.

3.7.1.3.1 Methods of creating a summary index score for NFSI actions

An aggregate exposure measure was chosen to enable me to capture multiple actions (related to policy, capacity, culture and network) in a single measure. Theoretically, it would have been possible to build separate models for each of these NFSI actions (using dummy variables to control for the other NFSI actions), but this would have generated a high volume of output and limited the statistical power of the models.

I was interested in measuring how many of the NFSI approaches schools had in place, so I created a summary measure which would enable me to do that. I chose to summarise each school's NFSI actions using the original structure of the WHO NFSI framework. The number of questions in the NFSI tool was not equally distributed across the five components. In order to follow the WHO's framework, in which each of these components are equally important (and so as not to give extra weight to components which happened to have more questions), I ensured that a school could get an equal number of points for actions in each component.

The NFSI questionnaire originally included 148 measures. For the summary index score, I included the measures which were most theoretically relevant (*i.e.* those which were explicitly outlined in the NFSI framework) and which provided between-school variation. This meant that school curricular actions were excluded, due to the lack of variation between schools.

The final summary of actions was based on school activities related to having a nutrition-friendly policy, enhancing awareness and capacity-building of the school community, creating a supportive environment and providing supportive school nutrition and health services. Schools could get one point for each of three actions related to each component, for a total of 12 actions (Table 3.10).

Table 3.10. Description of the Nutrition-friendly schools initiative (NFSI) summary variable for calculating 'Number of NFSI actions'

NFSI Component	Actions for summary variable	Number of points
Having a written nutrition-friendly schools policy	Having a policy on nutrition or healthy eating (written or informal)	1
	Having a policy which included NFSI-recommended components (objectives, timelines and milestones)	1
	Including a monitoring or evaluation plan in the policy	1
Enhancing awareness and capacity-building within the school community	Sharing the nutrition- or healthy-eating policies with parents, students, staff and the community	1
	Holding activities for families and the community in the area of health and nutrition	1
	Holding training sessions for staff on healthy eating or related issues	1
Creating a supportive school environment	Promoting the availability of healthy food within schools. Schools were given credit for this action if they provided fresh fruit, vegetables and milk within schools and if they banned the sale of sugar-sweetened soft drinks or sweets from the school premises	1
	Providing school children with access to safe drinking water, hand washing facilities (taps and soap) and clean, separate toilets for boys and girls	1
	Providing school children with access to sporting facilities for physical activity (inside and outside of curriculum)	1
Providing supportive school nutrition and health services	Feeding back the results of the regular monitoring and evaluation to school children	1
	Feeding back the results of the regular monitoring and evaluation to parents	1
	Offering a referral system for medical support	1
	Total Possible Points for 'Number of NFSI Actions'	12

3.8 Analysis Plan

Having created the student dependent and independent variables, along with a school-level exposure variable, the next step in this project was to investigate associations between student and school-level data (investigating frequencies of the dependent nutrition-related variables) and cross-tabulations of the independent school-level variables. These descriptive results provided information about the diet quality of students and allowed me to identify if there were any associations or patterns between the independent and dependent variables. Once this initial descriptive analysis was complete, I could carry the variables over into multi-level analysis, a method which allowed me to account for the clustered sampling methods employed in this project. While traditional methods assume the independence of observations, multi-level modelling (MLM) methods account for the non-independent, hierarchical data structure of students ('level 1 units') clustered within schools ('level 2 units')[179], and helped to ensure that standard errors of regression coefficients were not under-estimated[148].

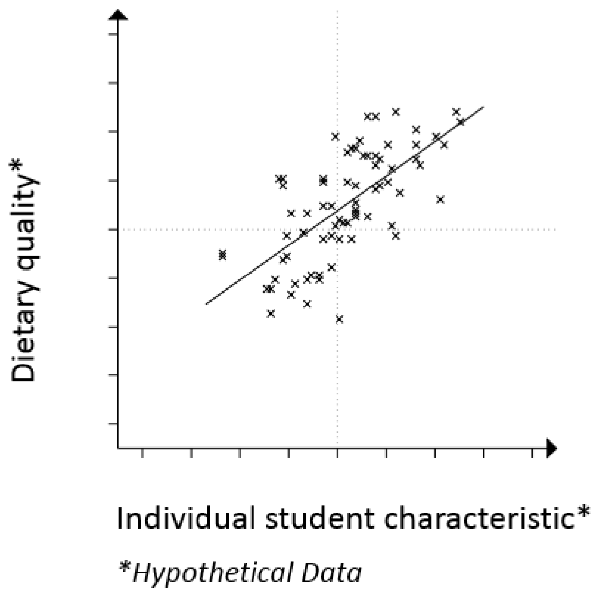
MLM techniques enabled me to answer research questions three and four about associations between school implementation of NFSI actions and student nutrition outcomes. If I had observed a strong association between school actions and student diet quality, for example, there would still have been a possibility that the results were due to confounding variables at the level of the students. Differences in the student populations between schools might have led to differences between schools. For this reason, it was important to also assess if observed associations remained once I'd controlled for individual student characteristics. The advantage of MLM was that it allowed me to separate the potential influences at both the individual- and school-levels.

Analyses were run using Stata 14.2 and MLWin 2.31 using a package developed by Leckie and colleagues[180].

3.8.1 Levels of the data structure

In order to explain the data structure in MLM, I have illustrated it below with a few hypothetical examples. In Figure 3.15, the dependent variable (*e.g.* DQI-I score, calcium, fibre, protein, etc.) from students at one of the schools is plotted against a student-level predictor variable and the relationship is summarised by a regression line. This figure shows how students in one school vary in their dietary outcome against some individual-level predictor.

Figure 3.15. Hypothetical example of a regression line which shows level 1 (student) variation. Figure modified from Rasbash *et al* (2014)[148]



In the example of a random intercept model (Figure 3.16), each line represents one school. The lines have different intercepts and show the 'level 2 variation.' In this hypothetical example, the schools are considered a random sample from a large underlying population of schools, and 'school' is considered to be a random classification. This model is known as a random intercept model—it assumes that the school effects (intercepts) are random but that there is common linear effect (slope) of the explanatory variables (which are controlled for) within groups[148]. In this example, the slope for all lines is the same, suggesting that the individual characteristics of students within each school have the same effect on diet quality. The fact that each line has a different intercept suggests that there is a difference in diet quality among students, but that this difference is not due to individual student characteristics[148]. These differences could arise from differences between schools, in things like, for example, implementation of the NFSI recommendations. This figure also suggests that the difference between schools is constant across the range of diet quality scores; this is called simple level 2 variation.

Figure 3.16: Random intercept model which shows level 2 (school) variation in school summary lines

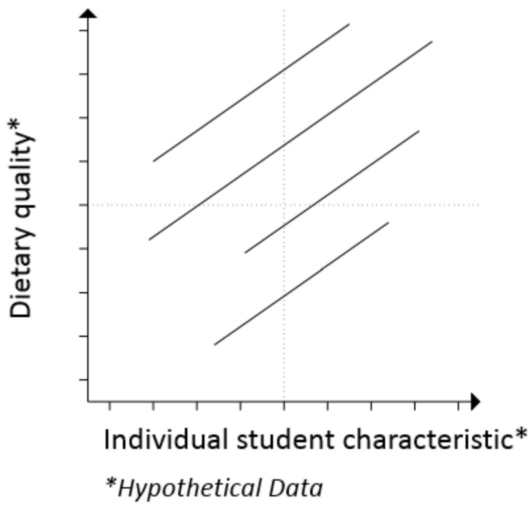
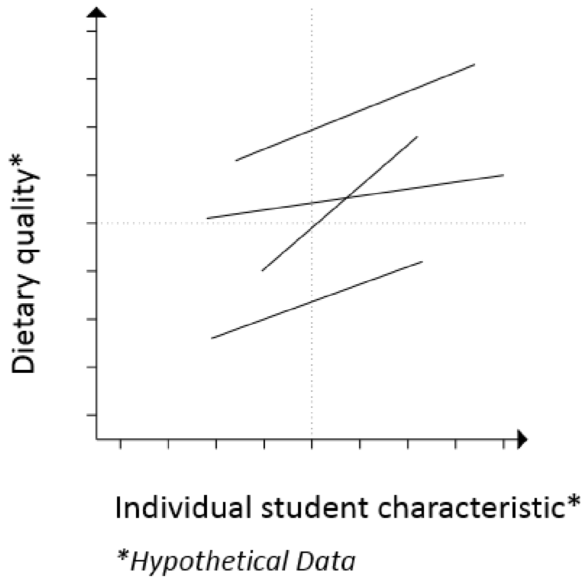


Figure modified from Rasbash *et al* (2014)[148]

However, a more complex model allows the slopes of the lines to vary (Figure 3.17), suggesting that the differences between the schools depends on the student-level characteristics (this is called complex level 2 variation). In random-slope models, both the school effects (intercepts) and the effects of students (slopes) are random and vary between schools[148].

Figure 3.17: Random slope models, which show complex level 2 (school-level) variation. Figure modified from Rasbash *et al* (2014)[148]



3.8.2 Identifying if a random intercept or random slope model was appropriate

The variance components model assumed that the only variation between schools was in their intercepts, but I wanted to allow for the possibility that the lines for different schools had different slopes. Using a likelihood ratio test, I compared a model where both the intercept and the slope varied randomly across schools to a single slope model. The difference between models was not significant, indicating that the more elaborate random slope model did not fit the data better than the single slope model. This meant that a random intercept model was an adequate method for further analyses.

3.8.3 District-level variation (research question two, part one)

In order to identify if there was district- and school-level variation in student outcomes among students (research question two), I investigated if a two-level model (including children nested within schools) or three-level model (including children nested within schools nested within districts) was needed for this analysis. This involved building three models:

Model ∝: Random intercept model adjusting for no covariate (this is the null model)

Model βi: Random intercept model including schools

Model βii: Random intercept model including schools and districts

I then used likelihood ratio tests to compare results from Model ∝ and Model βi, to see if there was significant variation occurring at the level of the school and at the level of the district.

3.8.4 School-level variation (research question two, part two)

To identify if there was school-level variation in nutrition outcomes (and whether the data were suitable for multi-level analyses), I calculated the significance of school-level variance for the dependent variables using baseline outcomes. This involved building the following models:

Model ∝: Random intercept model adjusting for no covariate (this is the null model)

Model βi: Random intercept model including student demographics

Model βii: Random intercept model including student demographics and student diet-related characteristics

The purpose of Model ∝ was to see if there was sufficient school-level variation for MLM. Then, adding in the student-level variables (Model βi and βii), I could see if this variation was due to differences between the schools or due to differences between characteristics of the students within the schools.

3.8.5 Associations between NFSI policies and student outcomes at baseline (research question three)

In order to answer the third research question ('Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets?'), I presented baseline results which examined associations between the student outcomes and the number of NFSI actions that schools were reporting, while controlling for fixed school characteristics and student characteristics. To answer the research questions for the baseline data, I calculated the following models using dependent and independent variables from baseline:

Model 1: Univariable random intercept model including only the <u>number of NFSI actions</u>

Model 2: Multivariable random intercept model including the number of NFSI actions, while controlling for <u>fixed school characteristics</u>

Model 3: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics and <u>student demographics</u>

Model 4: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics and <u>student diet-related characteristics</u>

In model 4, the student diet-related variables (level of food insecurity, frequency of breakfast consumption, feelings about body weight) were included only in a final model because they were likely to be closely related to the dietary outcomes, introducing problems of collinearity.

3.8.6 Associations between change in NFSI policies and student outcomes at follow-up (research question four)

In order to answer the final research question, I conducted analyses that were similar to the baseline analyses, but using follow-up data and controlling for baseline dietary outcomes and the change in NFSI actions over time. Controlling for baseline student dietary outcomes and baseline NFSI actions was important because it enabled me to account for change over time in both the exposure and outcome variables.

Model 1: Univariable random intercept model including only the number of NFSI actions

Model 2: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics

Model 3: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics and student demographics

Model 4: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics and student diet-related characteristics

Model 5: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics, student diet-related characteristics and the baseline dietary outcomes

Model 6: Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics, student diet-related characteristics, baseline dietary outcome, and the change in number of NFSI actions over time

The analysis for research question four included only students who had data available at both baseline and follow-up, so the sample size for answering research question four was smaller than the sample size for answering research question three, which used baseline data only. Because the outcome variable was the follow-up DQI-I score (while controlling for baseline DQI-I score), the analysis involved looking at a *change* in DQI-I scores. A decrease in DQI-I scores, therefore, in this instance, referred to a drop in the score that an individual had at follow-up compared to the score that they had at baseline.

3.9 Summary of chapter

Data were collected from secondary school students and school principals within three districts of rural Sri Lanka (Ampara, Moneregala and Kurunegala) using a clustered sampling design based on district, intervention status and school-type. Baseline data were collected in June-August of 2014 and follow-up data were collected in August-September 2015. I received funding support to collect data in collaboration with the INPARD project. My specific involvement involved identifying the NFSI as an important component of school-based health promotion (and proposing its integration into the INPARD intervention), identifying the tools and methods for data collection (the FFQ, the GSHS, the NFSI Tool for Researchers, the STEPs survey, construction of a diet quality index, multi-level modelling) and proposing these methods to the INPARD project staff prior to the start of the project. In addition to selecting the tools and methods for this project, I led on the training of the data collectors and processing and analysis of the datasets. Student data were collected using the WHO GSHS, the WHO STEPs survey and a validated FFQ. School data were collected using the NFSI tool, which assessed school approaches to improving students' diets. The raw data collected with these tools were used to generate dependent, independent and exposure variables. The primary dependent variable was student diet quality, generated using the FFQ. Student independent variables were age, sex, ethnicity and maternal education, collected using the GSHS and STEPs survey. The school-level independent variables included school type, the number of enrolled students, the school district and whether or not the school was involved in the INPARD project. The exposure variable was a summary variable describing the number of NFSI actions that schools were implementing.

After constructing variables at both the student- and school-levels, I investigated associations between student-level and school-level data to identify if there were any associations or patterns between the independent and dependent variables. Multi-level modelling (MLM) methods allowed me to account for the project's clustered sampling methods, helped to ensure that standard errors of regression coefficients were not underestimated and allowed me to examine associations between school characteristics and student outcomes. As part of the analysis, I identified whether it would be more appropriate to use a random intercept model, or a more complex random slope model and found that the random intercept model was an adequate method for further analyses. Subsequently, MLM methods were used to answer research questions two, three and four by building a series of models to investigate district- and school-level variation, associations between NFSI policies and student nutrition outcomes at baseline, and associations between change in NFSI policies and student nutrition outcomes at follow-up. The results from these models are provided in the next chapter.

4 Results

This chapter presents this study's results. First, it provides descriptive results of student demographics, anthropometrics and diet-related characteristics. Then, it provides the descriptive results from schools, including a summary of school NFSI actions. Next, the chapter provides the results for research question one, by presenting baseline descriptive results of the dietary outcomes and examining differences in dietary outcomes by sociodemographic factors. Next the chapter presents the results for the second research question, investigating between-district and between-school variation in dietary outcomes. It goes on to provide the results for research question three, related to associations between NFSI actions and student nutrition outcomes at baseline. Finally, the chapter presents the results to answer research question four, related to associations between changes in NFSI approaches and nutrition outcomes over time.

4.1 Descriptive results from students

This first section describes student demographics, anthropometrics and diet-related characteristics, which were collected from students using the WHO's Global school-based student health survey (GSHS). This information provided me with key background information related to student ethnicity, socioeconomic status, the level of food security that students had at home and how students felt about their body weight. Additionally, this section presents baseline anthropometric data, which supported my aims to understand the nutrition status of students. These data were included in my final models to answer research questions three ('Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets?') and four ('Using longitudinal baseline and follow-up data, are there significant associations between changes in implementation of NFSI recommendations and changes in the nutritional quality of students' diets?'). It was important to control for these factors, which could be confounders in my investigation on the relationship between school nutrition approaches and student outcomes.

4.1.1 Student demographics

Student demographic data were provided by 1,336 students at baseline (Table 4.1). Overall, the sample was 52% female, but the proportion of males and females varied between districts. In Kurunegala, for example, 44% of the sample was female. The age and sex distribution of students indicates that most students were aged 15 years or younger. I excluded five students who were 11 years old from the subsequent analyses for ethical reasons; 12 years is the age when WHO advises informed consent.

The ethnic composition of students roughly reflected the ethnic composition of the country, where the majority (74.9%) are Sinhalese, 11.2% are Sri Lanka Tamil, and 9.2% are Sri Lankan Moor[181]. In my sample, the majority of students were Sinhalese, but 9% considered themselves 'Sri Lankan Moor'[16], and 5% considered themselves Tamil. The most ethnically diverse region was Ampara, which was about 68% Sinhala, 21% Sri Lankan Moor and 11% Sri Lankan Tamil.

[16] A category which refers to native speakers of the Tamil language and predominantly followers of Islam.

Table 4.1. Student demographics, by district, baseline

	Ampara		Moneregala		Kurunegala		Total	
	n	%	n	%	n	%	n	%
Sex								
Female	273	56.29	298	52.84	113	43.97	684	52.37
Male	212	43.71	266	47.16	144	56.03	622	47.63
Age (years)								
12	28	5.77	17	3.00	1	0.39	46	3.51
13	122	25.15	51	8.99	18	6.95	191	14.57
14	175	36.08	196	34.57	86	33.20	457	34.86
15	146	30.10	277	48.85	148	57.14	571	43.55
16	14	2.89	19	3.35	5	1.93	38	2.90
17			5	0.88	1	0.39	6	0.46
18			2	0.35			2	0.15
Ethnicity								
Sinhala	336	67.61	491	98.99	259	96.28	1,086	56.05
Sri Lankan Moor	102	20.52	2	0.40	7	2.60	111	8.80
Indian Tamil	2	0.40	1	0.20			3	0.24
Sri Lankan Tamil	56	11.27	2	0.40	3	1.12	61	4.83
I don’t know/missing	1	0.20					1	0.08
Maternal education								
No schooling	33	6.64	19	3.83	5	1.86	57	4.52
Up to grade 5	98	19.72	55	11.09	12	4.46	165	13.07
Passed grade 6-10	163	32.80	163	32.86	71	26.39	397	31.46
Passed G.C.E (A/L)	36	7.24	42	8.47	32	11.90	110	8.72
Passed G.C.E (O/L)	117	23.54	149	30.04	113	42.01	379	30.03
Degree and above	11	2.21	12	2.42	15	5.58	38	3.01
I don’t know or missing	39	7.85	56	11.29	21	7.81	116	9.19
Household income (Sri Lankan Rupees)								
Less than 10,000	79	15.90	78	15.73	38	14.13	195	15.45
10,001-20,000	76	15.29	71	14.31	36	13.38	183	14.50
20,001-30,000	54	10.87	38	7.66	30	11.15	122	9.67
30,001-40,000	83	16.70	98	19.76	46	17.10	227	17.99
More than 40,000	32	6.44	27	5.44	24	8.92	83	6.58
I don’t know or missing	173	34.81	184	37.10	95	35.32	452	35.82
Total	**485**	**100.00**	**564**	**100.00**	**257**	**100.00**	**1,306**	**100.00**

Total calculations are based on the number of student respondents for the question about ‘age’. Mother’s education and household income was collected from students at follow-up only.

The most complete measure of parent SES was maternal education. According to student reports, around 40% mothers had passed the General Certificate of Education (GCE) Ordinary Level (GCE O/L) and above. Around a third of students did not report their household monthly income. For those that did report it, around half reported a monthly household income of less than 30,000 Sri

Lankan Rupees[17] a month, which is below the national mean for rural populations, which was 42,184 Sri Lankan Rupees per month in 2013[182]. A possible explanation of this result is that I was collecting data from three of the poorest districts in Sri Lanka. According to data from the larger INPARD project found that around half of adults in the area reported their employment status as 'unemployed.' Around a third of adults (29.6% in intervention and 32.4% in control) reported a household income of <10,000 Sri Lankan Rupees (LKR) (around $65 United States Dollars (USD)) per month and around 40% (38.2% in intervention and 37.0% in control) reported living on 10,000-19,999 per month, which is far below the country's average monthly household income, which was estimated to be 46,207 LKR (about $300 USD) in 2012 [182].

4.1.2 Students' diet-related characteristics

In this section, I report the diet-related characteristics of students at baseline: food security, frequency of breakfast consumption and feelings about body weight. These variables are likely to be associated with dietary outcomes, so it is important to control for them in the analyses of this thesis[18].

4.1.2.1 Hunger and food security

The GSHS asked students 'How many times in the past 30 days have you gone hungry due to lack of food?' and most students reported 'never' or 'rarely' going hungry. The proportions were similar for boys and girls. The proportions who reported 'never' or 'rarely' were similar across districts (92% in Ampara and Kurunegala, 84% in Moneregala) (Table 4.2).

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[17] Approximately $200 United States Dollars

[18] These diet-related measures came from the Global school-based student health survey. Diet quality, which was the outcome measure for this thesis, was measured using a Food Frequency Questionnaire (FFQ).

Table 4.2. Frequency of going hungry due to lack of food in the past 30 days, by district, baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Never	388	78.07%	350	70.56%	203	75.46%	941	74.56%
Rarely	68	13.68%	112	22.58%	51	18.96%	231	18.30%
Sometimes	30	6.04%	22	4.44%	11	4.09%	63	4.99%
Most of the time	4	0.80%	10	2.02%	3	1.12%	17	1.35%
Always	4	0.80%	1	0.20%	-	--	5	0.40%

4.1.2.2 Breakfast consumption

Students were also asked to report frequency of eating breakfast in the past 30 days and at baseline, the majority reported eating breakfast 'always' or 'most-of-the time'. For those that did not eat breakfast, their main reason for not eating breakfast was a 'lack of time' or 'not feeling able to eat in the morning,' rather than a 'lack of food' (Table 4.3).

Table 4.3. Frequency of eating breakfast (past 30 days) and main reason for not eating breakfast, by district

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
How often did you eat breakfast (past 30 days)?								
Never	13	2.62%	21	4.23%	6	2.23%	40	3.17%
Rarely	44	8.85%	59	11.90%	31	11.52%	134	10.62%
Sometimes	65	13.08%	67	13.51%	20	7.43%	152	12.04%
Most of the time	106	21.33%	112	22.58%	73	27.14%	291	23.06%
Always	265	53.32%	237	47.78%	139	51.67%	641	50.79%
I don't know, Missing	4	0.80%	-	--	-	--	4	0.32%
I always eat breakfast	317	63.78%	279	56.25%	176	65.43%	772	61.17%
Main reason for not eating breakfast								
I cannot eat in the morning	84	16.90%	98	19.76%	39	14.50%	221	17.51%
I do not have time for breakfast	80	16.10%	94	18.95%	45	16.73%	219	17.35%
There is not always food in my home	2	0.40%	2	0.40%	-	--	4	0.32%
Some other reason	10	2.01%	23	4.64%	8	2.97%	41	3.25%
I don't know, Missing	4	0.80%	-	--	1	0.37%	5	0.40%

4.1.2.3 Feelings about body weight

Students described how they felt about their weight and most students in both groups felt that they were 'about the right weight' (66% of girls, 65% of boys). Around 20% of girls and 24% of boys felt that they were either 'slightly' or 'very underweight.' Around 12% of girls and 9% of boys felt that they were 'overweight' or 'slightly overweight' (Table 4.4).

Table 4.4. Description of responses to the question 'How do you describe your weight?' by district

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Very underweight	20	4.02%	23	4.64%	10	3.72%	53	4.20%
Slightly underweight	144	28.97%	92	18.55%	60	22.30%	296	23.45%
About the right weight	268	53.92%	334	67.34%	175	65.06%	777	61.57%
Slightly overweight	41	8.25%	40	8.06%	20	7.43%	101	8.00%
Overweight	20	4.02%	6	1.21%	2	0.74%	28	2.22%
I don't know, Missing	4	0.80%	1	0.20%	2	0.74%	7	0.55%

4.1.3 Anthropometrics

At baseline, around 42% of students (60% of males and 34% of females) were underweight. Around 50% of students (60% of females and 40% of males) fell into a healthy weight range, while around 6% of students were overweight or obese. The highest proportion of underweight students was in Kurunegala (43%) and the lowest was in Ampara (40%). Regionally, the highest proportion of overweight or obese was in Kurunegala (8%) and the lowest was in Ampara (5%) (Table 4.5).

Table 4.5. Age- and sex-adjusted body weight categories, by district

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Underweight	197	39.64%	210	42.34%	117	43.49%	524	41.52%
Normal	264	53.12%	244	49.19%	125	46.47%	633	50.16%
Overweight	21	4.23%	26	5.24%	18	6.69%	65	5.15%
Obese	4	0.80%	6	1.21%	3	1.12%	13	1.03%
I don't know, Missing	11	2.21%	10	2.02%	6	2.23%	27	2.14%

4.2 Descriptive results from schools

This section describes the summary of NFSI actions at baseline. The full set of NFSI survey results is provided in Appendix Ten.

4.2.1 Summarising school approaches: number of NFSI Actions

4.2.1.1 Having a written nutrition-friendly schools policy

At baseline, most schools had a written or informal policy on healthy eating. The percentage of schools with these policies ranged from 55% of schools in Ampara to 70% of schools in Kurunegala. The percentage of schools with policies that included objectives, timelines and clear milestones ranged from 0% (Moneregala) to 50% (Kurunegala). There were also wide differences in the percentage of schools with monitoring and evaluation plans, ranging from 5% (Moneregala) to 60% (Kurunegala) (Table 4.6).

Table 4.6. Number and percentage of schools reporting to follow NFSI actions related to having a school nutrition policy, by district, baseline

	Ampara		**Moneregala**		**Kurunegala**		**Grand Total**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Written or informal policy on healthy eating	11	55.00%	11	57.89%	7	70.00%	29	59.18%
Policy has objectives, timelines and clear milestones	6	30.00%	-	--	5	50.00%	11	22.45%
Policy has monitoring and evaluation plan	9	45.00%	1	5.26%	6	60.00%	16	32.65%

4.2.1.2 Enhancing awareness and capacity-building of the school community

At baseline, the percentage of schools with a nutrition policy that had been shared with parents, students, staff, and community ranged from 0% (Moneregala) to 30% (Kurunegala). The percentage who reported holding activities for families and communities in areas related to health ranged from

10% (Ampara) to 40% (Kurunegala). Around a quarter of all schools reported that they had held training sessions for staff on healthy eating or related issues (Table 4.7)

Table 4.7. Number and percentage of schools reporting to follow actions for NFSI recommendations related to enhancing awareness and capacity-building, by district, baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Policy has been shared with parents, pupils, staff, and community	3	15.00%	-	--	3	30.00%	6	12.24%
School has held activities for families and community in area of health	2	10.00%	3	15.79%	4	40.00%	9	18.37%
School has held training sessions for staff on healthy eating or related issues	5	25.00%	4	21.05%	3	30.00%	12	24.49%

4.2.1.3 Creating a supportive school environment

At baseline, around 20% of schools provided fresh fruit, vegetables and milk within schools and did not allow sugar-sweetened soft drinks or sweets to be available to school children on the premises, ranging from 0% (Moneregala) to 25% (Ampara). Around 18% of schools provided students with access to safe drinking water, hand washing facilities (taps and soap) and clean, separate toilets for boys and girls. Most schools reported to provide school sporting facilities for active play, ranging from 63% in Moneregala to 95% in Ampara (Table 4.8).

Table 4.8. Number of schools reporting to follow actions related to NFSI recommendations for creating a supportive environment, by district, baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
School meals promote healthy eating	7	35.00%			2	20.00%	9	18.37%
Access to safe drinking water, handwashing facilities (taps and soap) and toilets for boys and girls	5	25.00%	2	10.53%	2	20.00%	9	18.37%
School sporting facilities available for active play	19	95.00%	12	63.16%	9	90.00%	40	81.63%

4.2.1.4 Providing supportive school nutrition and health services

The final set of NFSI recommendations relates to providing supportive nutrition and school health services in the form of regularly monitoring and evaluating children's growth and development, providing an effective feedback system to students and parents with the results of the regular monitoring and evaluation and offering supportive school health services, including a referral system. Nearly all schools monitored and evaluated students' height and weight. Due to the lack of variation in this activity, schools were awarded points for feeding back the results to school children and parents or offering a referral system for medical support.

At baseline, 84% of schools made the anthropometric results available to school children and 61% reported that they shared the results with parents. At baseline, none of the schools had a referral system for medical support (Table 4.9)

Table 4.9. Number of schools reporting to follow NFSI recommendations related to providing supportive school and nutrition health services, by district, baseline

	Ampara		**Moneregala**		**Kurunegala**		**Grand Total**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
School has feedback system that makes findings available to pupils	14	70.00%	19	100.00%	8	80.00%	41	83.67%
School has feedback system that makes findings available to parents	12	60.00%	16	84.21%	2	20.00%	30	61.22%

4.2.2 Total number of school actions

Based on the number of activities that schools reported, each school was given a score (ranging from 0-12) in the areas of nutrition policy, enhancing awareness and capacity-building, creating a supportive environment and providing supportive health services.

At baseline, schools followed an average of 1.14 actions (SD 0.98) related to nutrition policy, ranging from 0.63 actions (SD 0.60) in Moneregala to 1.80 actions (SD 1.40) in Kurunegala. The average number of actions related to enhancing awareness and capacity-building of the school community was 0.55 (SD 0.82). Schools reported an average of 1.18 (SD 0.83) actions related to creating a supportive school environment, ranging from 0.74 (Moneregala) to 1.30 (Kurunegala). On average, schools reported 1.45 actions related to providing supportive school nutrition and health services, ranging from 1.0 action in Kurunegala to 1.84 actions in Moneregala (Table 4.10).

Table 4.10. Average number of NFSI-recommended actions, by NFSI component and district, at baseline

	Ampara		**Moneregala**		**Kurunegala**		**Grand Total**	
	Avg.	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**
Having a nutrition policy (Max=3 actions)	1.30	0.80	0.63	0.60	1.80	1.40	1.14	0.98
Enhancing awareness and capacity of school community (Max=3 actions)	0.50	0.76	0.37	0.68	1.00	1.05	0.55	0.82
Creating a supportive school environment (Max=3 actions)	1.55	0.76	0.74	0.65	1.30	0.95	1.18	0.83
Providing supportive school nutrition and health services (Max=3 actions)	1.30	0.92	1.84	0.37	1.00	0.67	1.45	0.77

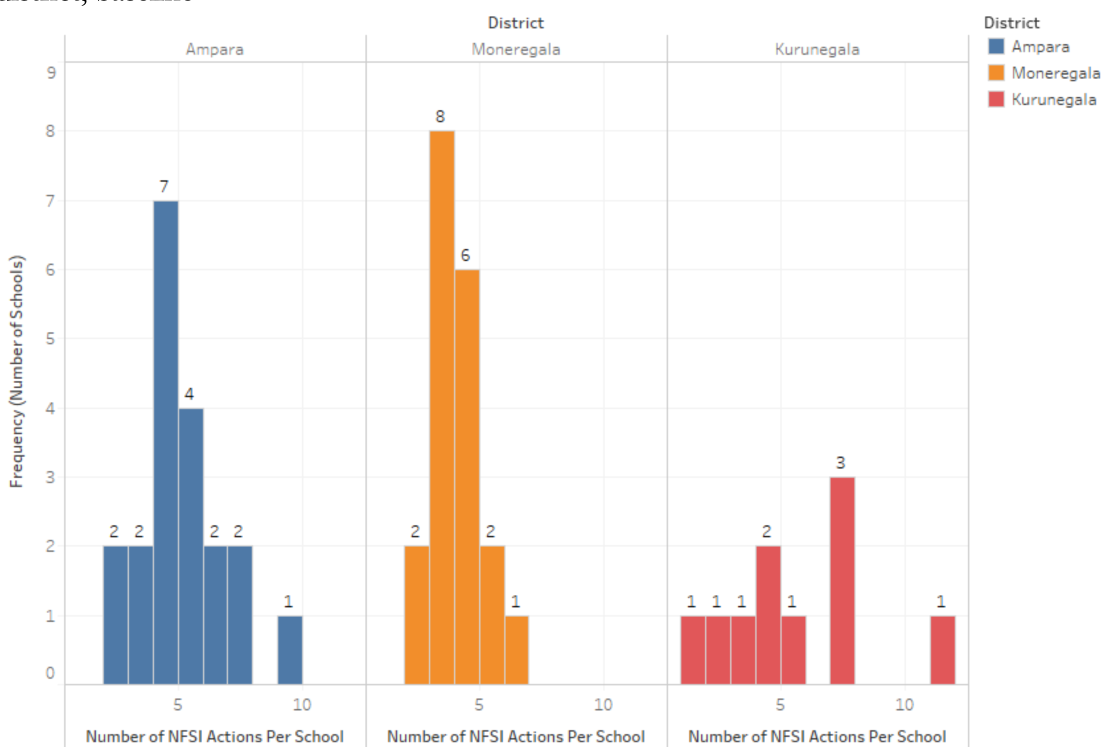
I summed the total number of actions that each school reported. At baseline, the total number of NFSI actions that schools reported to be following ranged from one to 11. The total number of actions varied between regions. At baseline, it was highest among schools in Kurunegala (5.10, SD 2.96) and lowest among schools in Moneregala (3.58, SD 1.02) (Table 4.11).

Table 4.11. Description of the mean total number of NFSI actions implemented by schools, by district, baseline

	Avg.	Std. dev.	Min.	Max.
Ampara	4.65	1.73	2.00	9.00
Moneregala	3.58	1.02	2.00	6.00
Kurunegala	5.10	2.96	1.00	11.00
Grand Total	4.33	1.90	1.00	11.00

At baseline, the most frequent number of actions was 4 (n=15 schools). One school in Kurunegala reported 11 NFSI actions (Figure 4.1).

Figure 4.1. Distribution of the number of NFSI actions that schools reported implementing by district, baseline



4.3 Results for research question one

This section presents the results for research question one, 'What is the nutritional quality of the diets of adolescent students living in the rural districts of Ampara, Moneregala, and Kurunegala, Sri Lanka?' First, this section describes the baseline descriptive results of the dietary outcomes (shown in the third column of Table 4.12). Additionally, this section examines differences by student characteristics such as socioeconomic status.

Table 4.12. Variables involved in investigating associations between student characteristics and diet

Student characteristics	**School characteristics**	**Student outcomes**
Demographics	*Number of NFSI Actions in the areas of:*	*Dietary outcomes*
Age	Nutrition policy	Diet Quality Index-International score
Sex	Capacity-building	Calcium
Ethnicity	Creating a supportive environment	Fibre
Maternal Education	Links to health services	Protein
	Total number of NFSI actions	
Diet-related characteristics	*Fixed School-characteristics*	*Measured anthropometrics*
Breakfast Patterns	Type of school	BMI Z-score
Feelings about body weight	School size	

4.3.1 Baseline descriptive results of the DQI-I

The total DQI-I score was the sum of points related to dietary variety, adequacy, moderation and balance. At baseline, the mean total DQI-I score was 58.88 (SD 11.62) out of 100 possible points. The total DQI-I scores were comparable across regions, with the lowest scores (57.32, SD: 11.67) in Moneregala and the highest (60.67, SD: 12.48) in Ampara (Table 4.13).

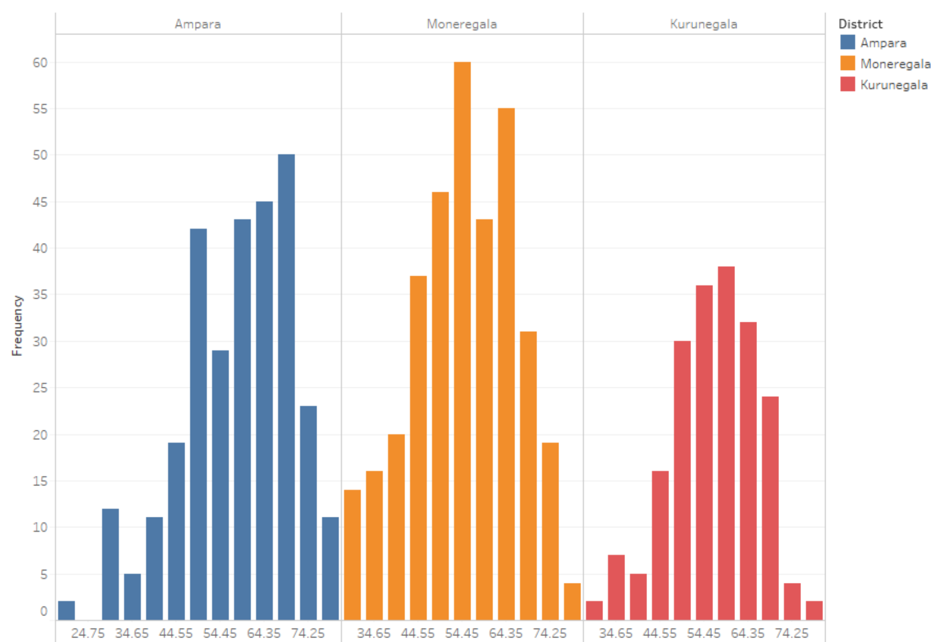
Table 4.13. Average total Diet Quality Index-International score, by district, baseline (n=833)

District	Avg. Total score	Std. dev. of Total score
Ampara	60.67	12.48
Moneregala	57.32	11.67
Kurunegala	58.96	9.70
Grand Total	58.88	11.62

Maximum possible total score was 100 points

The distribution of scores at baseline is pictured in Figure 4.2. Shapiro-Wilk tests were used to examine the hypothesis that the total score was normally distributed at baseline. This generated a p value of < .01, which indicated that I could reject the hypothesis that the score was normally distributed. Normality tests are useful but not infallible and therefore, conventional wisdom supports using a frequency histogram to double-check the distribution. As shown below, the distribution is roughly normal. This is consistent with the central limit theorem, which states that the sampling distribution will be normal or nearly normal if the sample size is large enough[19][183].

Figure 4.2. Distribution of DQI-I score, by district, baseline (n=833)



[19] Conventionally thought by some statisticians to be at least 40 observations.

4.3.1.1 Variety

The average total variety score across districts was 12.94 (SD 4.45). Total variety scores ranged from 12.42 (Moneregala) to 13.45 (Ampara) (Table 4.14).

The overall variety score reflected two components. The first variety score reflected the number of food groups represented in the diet and the second variety score reflected the number of protein sources. For the food group score, the scores ranged from 11-12 out of 15 possible points across districts, with the highest variety observed in Ampara and the lowest observed in Moneregala (Table 4.14). Around 40% of students had at least one serving of food from each of the five food groups.

For the protein variety score, 7% of students received the highest score (meaning that they had at least one serving of protein from at least three sources) In both groups, around 70% had protein from less than two different sources. The most common source of protein was from beans, with around 44% of students reporting to have at least one serving of beans per day. The second most common source of protein was from fish, with about one third of students reporting to consume at least one serving of fish per day. Around a fifth of students had at least one dairy serving per day. Consumption of meat, poultry and eggs was low among all groups, with less than 5% of students having at least one serving per day.

4.3.1.2 Adequacy

The mean adequacy score for all groups was 18.99 (SD 8.89), which was less than half of the 40 possible points. The highest scores for nutritional adequacy at baseline were in Ampara and the lowest were in Moneregala (Table 4.14).

For students in both groups, the adequacy scores were low. About 40% of students were consuming adequate fruit (two or more servings per day) and 75% were getting adequate vegetables (three or more servings per day). Most students were getting adequate grain or carbohydrate servings (of at least six servings a day). Fibre consumption was low in both groups, with less than a third consuming adequate fibre amounts, defined as at least 30 grams per day. Only about a quarter of students were meeting protein requirements, defined as having a diet in which at least 10% of energy came from protein. Just 3.6% of students were meeting calcium recommendations of at least 1,300 mg per day.

4.3.1.3 Moderation

Of 30 possible points, the mean moderation score was 25.35 (SD 3.85), with the highest scores in Moneregala (26.20) and the lowest scores in Ampara (24.31) (Table 4.14).

Most students (around 99%) in both groups received the highest score for moderation of cholesterol (consuming ≤ 300 mg/day). The majority of students (68%) received the highest score for moderation of fat (allocated to diets in which the percentage of energy from fat was ≤ 20% of energy). For most of the remaining students, fat accounted for between 20-30% of energy. More than half of students received the highest moderation score for sodium (allocated to diets with ≤2400 mg), but around 12% of students received the lowest score (allocated to diets with ≥3400 mg). Moderation of intake from empty calorie foods was more varied. Around 22% of students received the highest score for moderation of empty calorie foods (allocated to diets where ≤3% of daily energy came from processed foods high in fat, sugar and salt). More than 75% of students received a mid-level score of three points because their consumption of empty calorie foods accounted for 3-10% of daily energy intake.

4.3.1.4 Balance

The balance score for students in all districts was low. Out of ten possible points, on average, students had an average balance score of 1.60 (SD 2.83) (Table 4.14). The highest mean balance score was in Ampara (2.25) and the lowest was in Kurunegala (1.14).

Table 4.14. Description of variety, adequacy, moderation and balance scores, by district, baseline (n=833).

	Total variety[a]		**Food group variety[b]**		**Protein variety[c]**		**Adequacy[d]**		**Moderation[e]**		**Balance[f]**	
District	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**	**Avg.**	**Std. dev.**
Ampara	13.45	4.66	11.92	3.45	1.53	1.64	20.67	9.28	24.31	4.64	2.25	3.15
Moneregala	12.42	4.39	11.17	3.35	1.24	1.39	17.38	9.15	26.2	3.13	1.32	2.65
Kurunegala	13.12	4.15	11.68	3.12	1.44	1.46	19.3	7.24	25.41	3.31	1.14	2.44
Grand Total	12.94	4.45	11.55	3.35	1.39	1.5	18.99	8.89	25.35	3.85	1.6	2.83

[a]The maximum total variety score was 20 points
[b]The maximum food group variety score was 15 points
[c]The maximum protein variety score was 5 points
[d]The maximum adequacy score was 40 points
[e]The maximum moderation score was 30 points
[f]The maximum balance score was 10 points

Fewer than 2% of students received the highest score for balance, which was awarded to students who had diets which in terms of energy, had a carbohydrate to protein to fat ratio of 55-65:10-15:15-25[20]. Most students received the lowest score of zero points. Low points for balance related to failure to meet the recommended proportionality in macronutrient intake, particularly due to low protein and high carbohydrate consumption. On average, 9.5% of students' calories came from protein and 73% came from carbohydrates.

4.3.2 Differences in DQI-I scores by socio-demographic factors

This section describes mean DQI-I scores according to these individual level factors such as age, sex and constitutional factors. To compare differences in total score by socio demographic factors, I used Analysis of Variance (ANOVA) calculations. ANOVA relies on the assumption that there is homogeneity of variances. I tested the equality of variances between groups using Levene's robust test statistic in Stata[184].

I compared mean DQI-I scores by sex using t tests with Welch adjustments to account for differences in sample sizes between groups. There was a small but significant difference in total DQI-I scores between males and females, with males having a slightly higher score (Table 4.15).

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[20] In other words, the highest points were allocated to diets in which 55-65% of calories came from carbohydrates, 10-15% of calories came from protein and 15-25% of calories came from fat.

Table 4.15. Description of DQI-I total scores, by sex, age and BMI category, baseline (n=833)

	Baseline		**Follow up**	
	Avg.	**Std. dev.**	**Avg.**	**Std. dev.**
District				
Ampara	60.67	12.48	53.79	13.06
Moneregala	57.32	11.67	53.13	10.87
Kurunegala	58.96	9.7	50.85	11.69
Grand Total	58.88	11.62	52.74	12.01
Female				
Ampara	59.53	12.26	52.19	12.79
Moneregala	55.34	11.72	52.23	10.48
Kurunegala	56.15	10.17	49.51	12.04
Male				
Ampara	61.96	12.81	55.69	13.26
Moneregala	59.75	11.23	53.69	11.46
Kurunegala	61.44	8.50	51.55	11.29
Grand Total	60.94	11.15	53.72	12.14

I also tested the variances and mean differences in total DQI-I scores by age group. Levene's robust test statistic indicated that the variances were equal. Oneway ANOVA of total score by age group indicated no significant differences in total DQI-I scores between age groups (Table 4.15).

I examined the variance of total scores between age- and sex-adjusted weight categories. Levene's robust test statistic indicated that the variances were not equal. Therefore, rather than using ANOVA (which assumes that they are), I used the F star test in Stata, which is a modification of the standard F test that is much less sensitive to violations of the homogeneity of variance assumption. Results from this test suggested that there were no significant differences in mean total DQI-I score between weight categories (Table 4.15).

I did not collect individual data on maternal education and ethnicity at baseline. However, I did collect these data at follow-up, and among students where I had both baseline and follow-up data, I was able to link baseline dietary outcome data with follow-up maternal education and ethnicity measures. Cross-tabulations and analyses examining differences in DQI-I scores according to these socioeconomic measures are presented in Appendix 11 rather than in the main manuscript, because they represent a different population than the one that is presented in these other analyses. The results indicated that there were significant differences in total DQI-scores according to ethnicity, with Sri Lankan Tamil groups having the highest DQI-I scores and Sinhalese groups having the lowest (F star for differences between groups=7.84, p=0.0008) (n=712). Students with mothers who had a higher level of education had significantly higher DQI-I scores (Difference= -1.8, 95% CI: -3.4 to -0.7).

4.3.3 Additional dietary outcomes: calcium, protein and fibre

4.3.3.1 Calcium

In this project's sample of adolescents, calcium consumption was low across students in all districts. The average calcium consumption was less than half of the recommended levels of 1,300 mg of calcium per day[170]. Calcium consumption by district ranged from a low in Moneregala of 452.6 mg (SD 296.0) to a high in Ampara of 569.4 mg (SD 408.7) (Table 4.16). Across districts, fewer than 4% of students had adequate calcium intake. Ampara had the highest percentage of students meeting recommendations (7%) and Moneregala had the lowest (2%).

4.3.3.1.1 Differences in calcium consumption by socio-demographic factors

I compared mean calcium intake by sex using t-tests (with Welch adjustments). The mean score for females was lower than for males, but this difference was not significant. ANOVA tests indicated that there were no significant differences in calcium consumption by age, but average daily consumption ranged from 384.09 mg (among 16-year-olds) to 540.61 mg (among 13-year-olds) (Table 4.16).

Table 4.16. Average daily calcium consumption, by district, sex and age, baseline (n=833)

	Avg.	Std. dev.	Differences between groups
District			
Ampara	569.42	408.7	Analysis of variance: Between Groups: F Value=9.98; p-value =0.0001
Moneregala	452.64	296.0	
Kurunegala	484.33	264.8	
Sex			
Female	484.47	343.1	Differences between males and females: 36.04 (-10.19 to 82.29); Difference >0 p=0.0632
Male	520.52	332.4	
Age			
12 years	534.54	464.1	Analysis of variance: Between Groups: F Value=0.54; p-value=0.7047
13 years	540.61	371.2	
14 years	493.46	345.9	
15 years	499.20	309.1	
16 years	385.09	380.6	
17 years	452.85	66.0	
Grand Total	500.87	337.1	

Appendix 11 shows results examining differences in calcium according to ethnicity and maternal education among a subset of students. Results indicate that there were significant differences in calcium according to ethnicity, but not according to maternal education (n=712).

4.3.3.2 Protein

The mean protein consumption is described below (Table 4.17). Protein consumption ranged from 51.1 grams per day in Moneregala to 59.9 grams per day in Ampara. When I applied the DQI-I definition of adequate protein consumption to students (10% of total energy intake), most students (78.33%) did not meet minimum recommendations

4.3.3.2.1 Differences in protein consumption by socio-demographic factors

I compared mean protein intake between males and females using t-tests (with Welch adjustments). The mean score for females was 50.9 grams (95% CI 48.9-52.9) and for males it was 60.8 grams (95% CI: 58.3-63.3). This difference of 9.90 grams between sexes was significant ($p \leq 0.001$) (Table 4.17).

Daily protein consumption ranged from 45.5 grams among students aged 17 to 58.6 grams among students aged 13. Despite these differences, ANOVA tests indicated that there were no significant differences in protein consumption by age (Table 4.17).

Table 4.17. Daily protein consumption (in grams), by district, sex, and age, baseline (n=823)

	Avg.	Std. dev.	Difference between groups
District			
Ampara	59.94	27.65	Analysis of variance: Between Groups: F Value=11.53; p-value <0.0001
Moneregala	51.10	20.92	
Kurunegala	56.54	20.37	
Sex			
Female	50.89	21.44	Differences between males and females: 9.90 (53.97 to 57.21); Difference >0: p<0.001
Male	60.79	25.06	
Age			
12 years	55.35	31.55	Analysis of variance: Between Groups: F Value=0.66; p-value=0.6223
13 years	58.56	27.31	
14 years	55.41	25.06	
15 years	54.99	20.68	
16 years	50.27	26.87	
17 years	45.45	8.84	
Grand Total	**55.47**	**23.67**	

Appendix 11 examines differences in protein according to ethnicity and maternal education among a subset of students. Results indicate that there were significant differences in protein according to ethnicity, but not according to maternal education (n=712).

4.3.3.3 Fibre

Average daily fibre consumption ranged from 21.8 grams per day in Moneregala to 26.6 grams per day in Ampara (Table 4.18). Analysis of variance indicates that there were significant differences by district in fibre consumption. Following the Sri Lankan Dietary recommendations definition of adequate fibre intake, which is 30 grams per day[171], about a quarter of students (22.47%) were consuming adequate amounts of fibre.

4.3.3.3.1 Differences in fibre by socio-demographic factors

I compared mean fibre intake by sex using t-tests with Welch adjustments. The mean score for females was 22.6 grams (95% CI: 21.3-23.9) and for males it was 24.7 grams (95% CI: 23.5-26.0). This difference of 2.20 grams between sexes was significant (Table 4.18).

Table 4.18. Daily fibre consumption, by district, baseline (n=833)

District	Avg.	Std. dev.	Difference between groups
District			
Ampara	26.57	16.11	Analysis of variance: Between Groups: F Value=11.83; p-value <0.0001
Moneregala	21.78	11.72	
Kurunegala	22.22	10.13	
Sex			
Female	22.57	13.91	Differences between males and females: 2.20 (0.39 to 4.01); Difference >0: p<0.0087
Male	24.76	12.55	
Age			
12 years	26.11	17.46	F star test results: F*=1.111, p=0.3585
13 years	25.52	14.53	
14 years	22.72	13.10	
15 years	23.89	12.88	
16 years	19.10	13.21	
17 years	18.20	2.69	
Grand Total	**23.61**	**13.32**	

For a subset of students, I examined differences in fibre intake according to ethnicity and maternal education. Results indicate that there were significant differences in fibre according to ethnicity, with Sri Lankan Tamil groups having the highest intake and Sinhalese groups having the lowest, but there were no significant differences in fibre intake according to maternal education(n=712)(Appendix 11).

4.3.3.4 BMI Z-scores

This section reports results on BMI Z-scores at baseline according to IOTF reference populations[154]. Average BMI Z-scores ranged from -0.68 in Ampara to -0.71 in Moneregala. Levene's test statistic indicated that variances of BMI Z-scores were not equal between groups, so the F star (which is less sensitive to violations of homogeneity of variance) was used to examine differences between districts. These results indicated that there were no significant differences in BMI Z-scores by district (Table 4.19).

4.3.3.4.1 Differences in BMI Z-scores by socio-demographic factors

There were also no significant differences in BMI Z-scores by age (Table 4.19). Despite decreases from ages 13 to 17 in BMI Z-scores, with the older age group having the lowest BMI Z-scores, those at 12 years of age were third lowest, leading to no linear trend across the age groups.

T-tests with Welch adjustments indicated that males had significantly lower BMI Z-scores compared to females (Table 4.19).

Table 4.19. BMI Z-score, by district, sex, and age baseline (n=812)

	Avg.	Std. dev.	Difference between groups
District			
Ampara	-0.68	1.23	Analysis of variance: Between Groups: F Value=0.272; p-value 0.7618
Kurunegala	-0.69	1.22	
Moneregala	-0.75	1.17	
Sex			
Female	-0.43	1.14	Differences between males and females: -0.60 (-0.76 to -0.44); Difference <0: p<0.0001
Male	-1.03	1.19	
Age			
12 years	-0.89	1.30	Analysis of variance: Between Groups: F Value=0.81; p-value=0.7618
13 years	-0.59	1.26	
14 years	-0.71	1.19	
15 years	-0.71	1.19	
16 years	-0.93	1.12	
17 years	-1.73	0.96	
Grand Total	-0.71	1.20	

In Appendix 11, using a subset of students who had linked data from baseline and follow-up, I examined differences in BMI Z-scores according to ethnicity and maternal education. Results indicate that there were significant differences in BMI Z-scores according to ethnicity, with Sri

Lankan Moors having the highest BMI Z-scores and Sinhalese groups having the lowest. There were also significant differences in BMI Z-scores according to maternal education, with students whose mothers had higher levels of education having significantly higher BMI Z-scores compared to students whose mothers had lower levels of education (Appendix 11).

Additional analyses related to student dietary outcomes may be found in Appendix 12. Analyses include a description of fat consumption, a description of food groups and servings, main sources of protein, main sources of carbohydrates and main sources of foods high in fat, sugar and salt (Appendix 12).

4.4 Results for research question two

This section presents the analyses and results to answer research question two: 'Is there significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?' First, this section examines differences in student outcomes according to school-level characteristics. Then, this section presents multi-level models to examine between-district and between-school variation in dietary outcomes. Table 4.20 shows the mean dietary outcome variables according to district, by baseline. The far right column shows the results from examining differences between districts.

Table 4.20. Total DQI-I score, daily calcium (mg), daily protein (g), daily fibre (g) and BMI Z-score, by district, baseline

	Ampara		**Moneregala**		**Kurunegala**		**ANOVA**	
	Avg.	**SD**	**Avg.**	**SD.**	**Avg.**	**SD**	**F value**	**p-value**
Total score	60.67	12.48	57.32	11.67	58.96	9.70	6.70	<0.01
Calcium (mg)	569.42	408.71	452.64	295.96	484.33	264.76	9.98	<0.01
Protein (g)	59.94	27.65	51.10	20.92	56.54	20.37	11.53	<0.01
Dietary Fibre (g)	26.57	16.11	21.78	11.72	22.22	10.13	11.83	<0.01
BMI Z-score	-0.68	1.23	-0.75	1.17	-0.69	1.22	0.27	0.76

To see where the differences in the means were occurring, I conducted Bonferroni, Scheffe, and Sidak multiple comparison tests. These tests examine the differences between each pair of means. The tests showed that at baseline, there were no significant differences in the total DQI-I scores between Ampara and Kurunegala (a difference of 1.71, $p=0.33$) or Kurunegala and Moneregala (1.65, $p=0.33$), but all three tests showed significant differences between Ampara and Moneregala (difference 3.36, $p<.001$) (Appendix 13). These differences between the regions suggested that it was important to examine if I should include region as a level in my multi-level models.

I used ANOVA to compare differences in calcium consumption by district (after checking the assumption that the variance in calcium consumption was equal between groups[21]). Oneway ANOVA indicated that there were significant differences at baseline between districts. The significant differences were between Ampara and Kurunegala (difference of 85.09, $p=0.02$) and between Moneragala and Ampara (difference of 116.78, $p=0.001$) (Appendix 13).

ANOVA tests indicated that there were significant differences in protein consumption between districts at baseline. Ampara had significantly higher mean protein consumption than Moneregala ($p\leq.01$) (Appendix 13).

Average daily fibre consumption values varied widely between districts, with the highest levels in Ampara and the lowest levels in Moneregala. ANOVA indicated that there were significant differences between groups. There were significant differences in fibre consumption between Ampara and Kurunegala (a difference of 4.3 grams, $p<0.001$) and between Moneragala and Ampara (a difference of 4.79 grams, $p<0.001$) (Appendix 13).

[21] In all instances, before ANOVA tests were conducted, I used Levene's test statistic to check the assumption of equal variance between groups. The F* test was used in instances where there was not equal variance between groups.

Levene's test statistic indicated that variances of BMI Z-scores were not equal between districts, so the F star test (which is less sensitive to violations of homogeneity of variance) was used to examine differences in BMI Z-scores between districts. These results indicated that there were no significant differences in BMI Z-scores by district.

4.4.1 Investigating associations between district and dietary outcomes

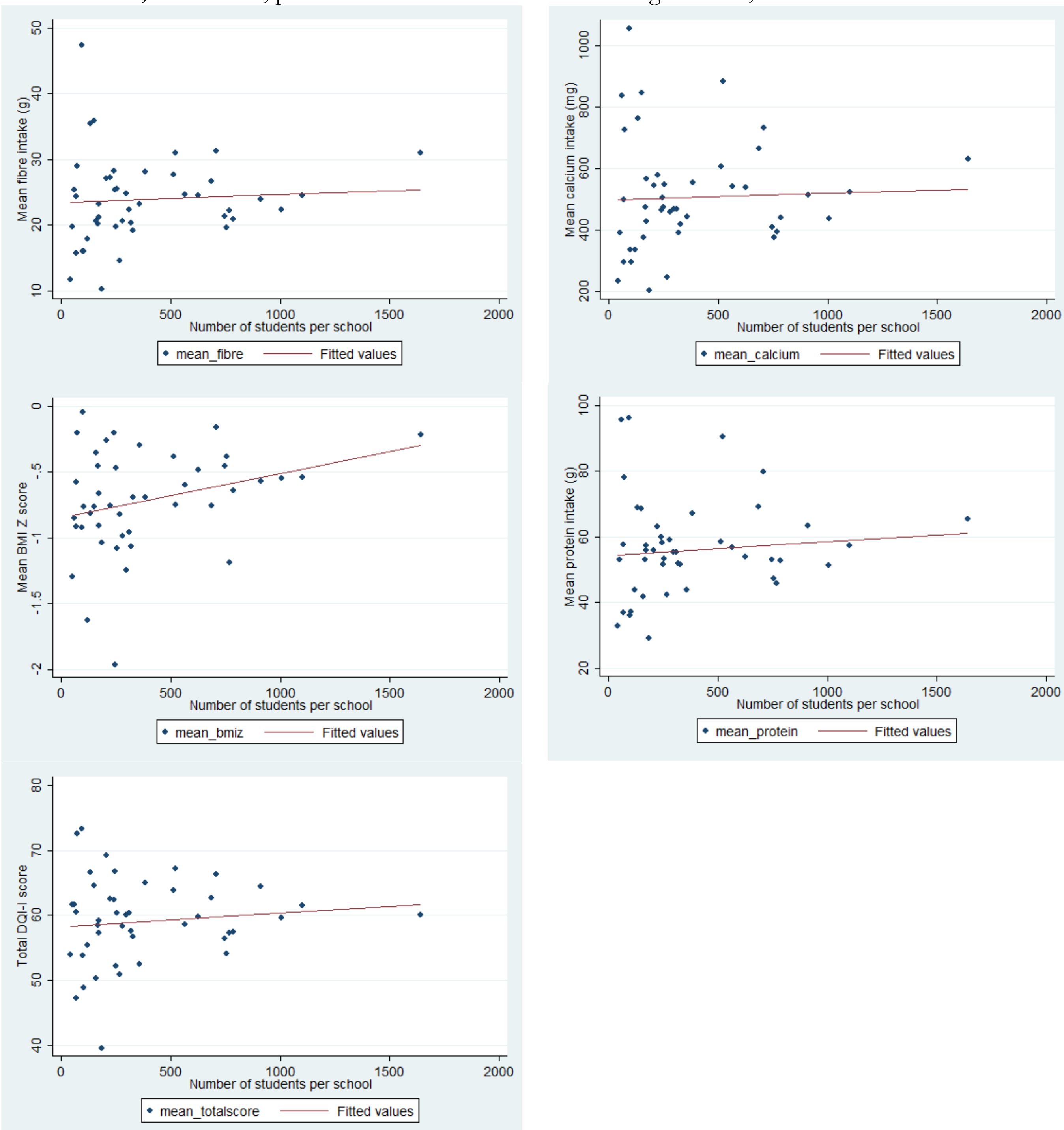
To compare differences in total diet quality index-international (DQI-I) scores by district, I used Analysis of Variance (ANOVA) calculations. ANOVA relies on the assumption that there is homogeneity of variances. I tested the equality of variances between groups using Levene's robust test statistic in Stata[184]. I tested the null hypothesis that the variances between districts were equal, and calculated a Levene's robust test statistic of 7.13 ($p=0.0008$), indicating that I could accept the null and use ANOVA to test homogeneity of variances. A oneway ANOVA test in Stata produced a significant F value of 6.70, which indicated that the means were not all equal (Table 4.20).

4.4.2 Investigating associations between school-level characteristics and dietary outcomes

4.4.2.1 School size and diet

At baseline, there was a small non-significant increase in DQI-I scores according to school size. There was greater variation in outcomes amongst the smaller schools (Figure 4.3). Similarly, there were no significant associations between school size and calcium intake, fibre intake, protein intake or BMI Z-score. As with DQI-I scores, there was greater variation for these outcomes among the smaller schools compared to the larger schools.

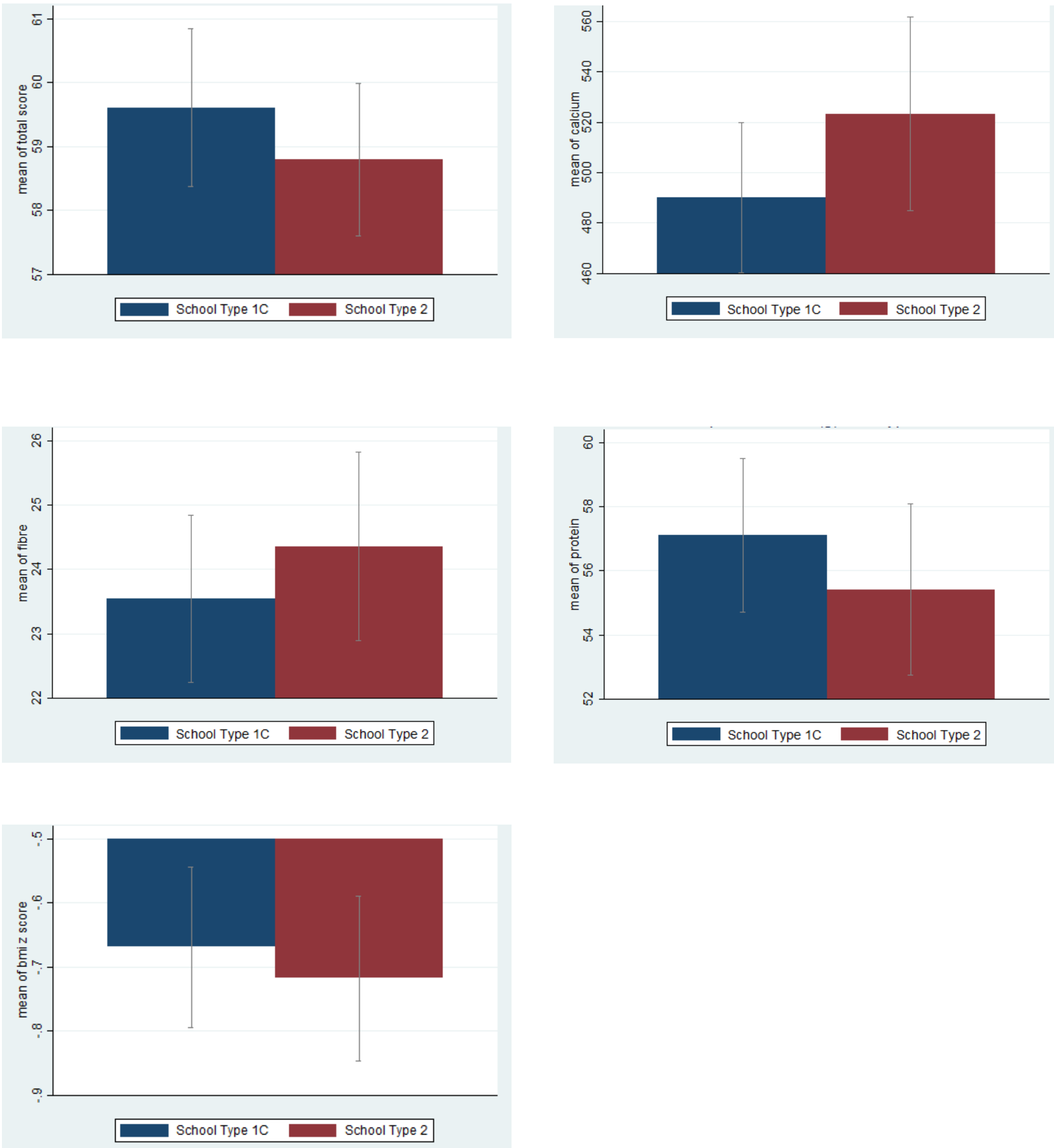
Figure 4.3. Scatterplots showing number of students per school and mean total DQI-I score, calcium intake, fibre intake, protein intake and BMI Z-score among students, baseline



4.4.2.2 School type and diet

Mean DQI-I scores did not vary significantly by school type at baseline (Figure 4.4). At baseline, mean DQI-I scores were slightly lower in Type 2 schools, but their confidence intervals overlapped with Type 1C schools (School Type 1C: 59.61 (58.37 to 60.84); School Type 2: 58.81 (57.71 to 60.00)). By contrast, mean calcium intake was slightly higher in Type 1C schools, but confidence intervals overlapped between schools (School Type 1C: 490.04 (460.15 to 519.93); School Type 2: 523.36 (484.72 to 562.00)). Mean dietary fibre intake was also higher in Type 2 schools, but again, the confidence intervals were overlapping (School Type 1C: 23.54 (22.25 to 24.84); School Type 2: 24.37 (22.91 to 25.85)). Protein intake showed the opposite trend, with higher intake observed among Type 1C schools (School Type 1C: 57.10 (54.70 to 59.51); School Type 2: 55.43 (52.75 to 58.12)), which may have accounted for the higher diet quality score observed in these schools. BMI Z-scores were lower in Type 2 schools compared to Type 1C schools (School Type 1C: -0.67 (-0.79 to -0.54); School Type 2: -0.71 (-0.85 to -0.59)), but confidence intervals were overlapping.

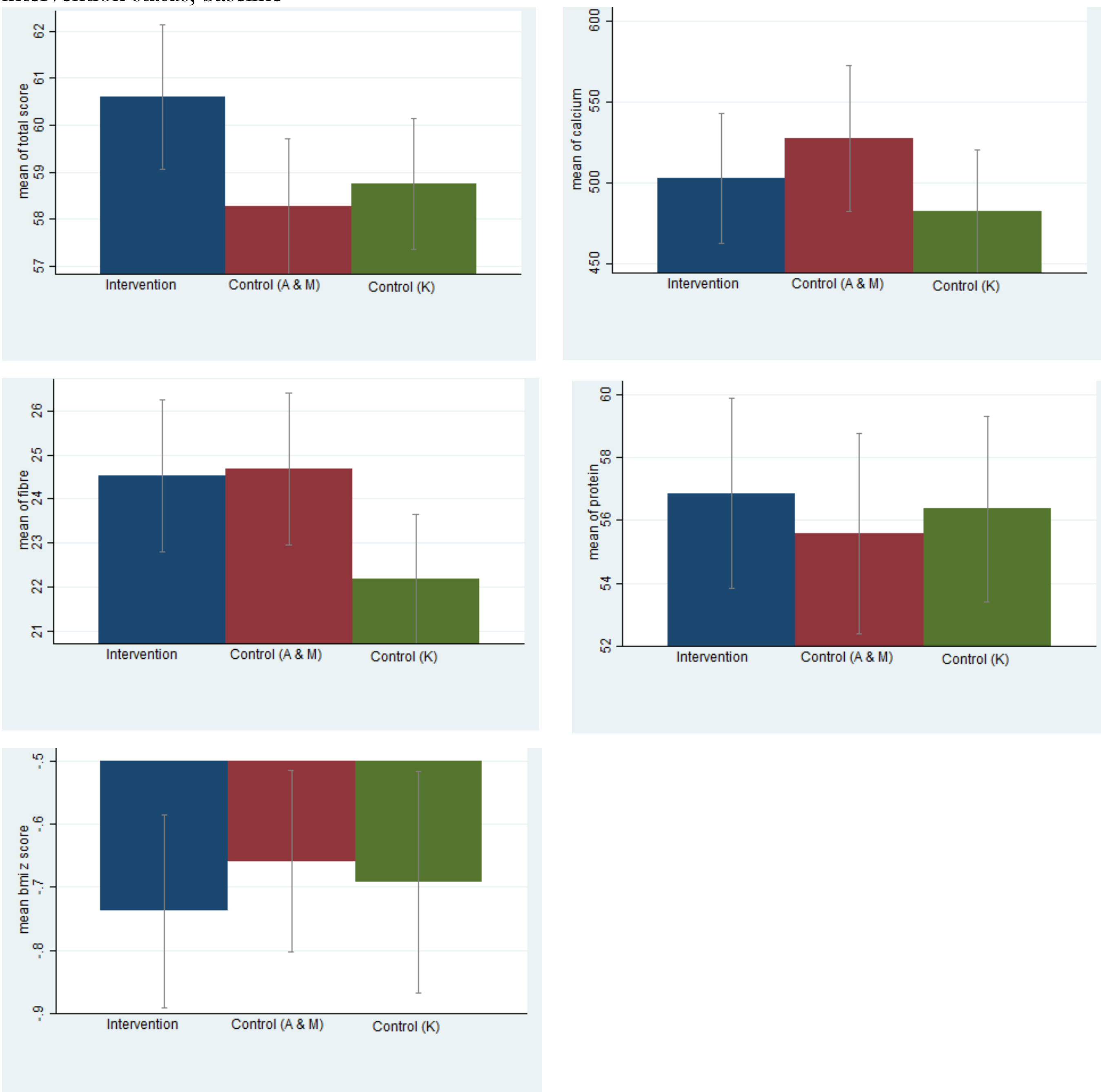
Figure 4.4. Mean DQI-I scores, calcium intake, fibre intake, protein intake and BMI Z-scores by school type, baseline



4.4.2.3 Intervention status and diet

I examined associations between dietary outcomes and the INPARD intervention status of schools (Figure 4.5). The highest mean DQI-I score was among INPARD intervention groups (60.60, (59.06 to 62.15)), compared to control groups in Ampara and Moneregala (58.28, (56.83 to 59.72)) and in Kurunegala (58.76, (57.35 to 60.16)), but confidence intervals were overlapping. Similarly, confidence intervals in mean calcium intake by intervention status also overlapped, with a mean of 503.01 mg (462.64 to 543.38) in intervention groups, compared to a mean of 527.66 mg (482.37 to 572.94) among control groups in Ampara and Moneregala and a mean of 444.35 mg (444.35 to 520.89) among control groups in Kurunegala. The confidence intervals in fibre intake also overlapped, but the highest scores were seen among intervention groups (24.52, (22.78 to 26.26)) and control groups in Ampara and Moneregala (24.72, (22.98 to 26.45)) compared to control groups in Kurunegala (22.17, (20.70 to 23.64)). There were also overlapping confidence intervals related to protein intake according to intervention status at baseline. The highest mean values for protein were observed among intervention groups (56.86, (53.82 to 59.91)) and control groups in Kurunegala (56.36, (53.40 to 59.32)) compared to control groups in Ampara and Moneregala. The lowest BMI Z-scores were observed among intervention groups (-0.74, (-0.89 to -0.58)), followed by control groups in Kurunegala (-0.69, (-0.87 to -0.51)) and control groups in Ampara and Moneregala (-0.66, (-0.80 to -0.52)), but once again, all confidence intervals were overlapping.

Figure 4.5. Mean DQI-I scores, calcium intake, fibre intake, protein intake and BMI Z-scores by intervention status, baseline



* Control (A&M) =Control (Ampara and Moneregala); Control (K) =Control (Kurunegala)

4.4.3 Investigating if there was significant variation in outcomes by district

To answer research question two, I needed to determine whether or not there was significant between-district variation in student nutrition outcomes. In order to do this, I built and compared several multi-level models to determine whether a two-level model (including children nested within schools) or a three-level model (including children nested within schools nested within districts) was a better fit for the baseline student- and school-level data.

Using DQI-I scores as an outcome variable, I built the following models:

Model α: Random intercept model adjusting for no covariate (the null);

Model βi: Random intercept model including school level;

Model βii: Random intercept model including school and district levels

Likelihood ratio tests were used to compare results from Model α and Model βi. These models indicated that there was significant variation in DQI-I scores between students and schools (with around 20.9% of the observed variation occurring at the level of the school), but there was no significant variation occurring at the level of the district (Table 4.21). These findings answered half of research question two (regarding district-level variation) and indicated that in moving forward, a two-level model was more appropriate for this data set compared to a three-level model.

Table 4.21. Results of models α to β for Total DQI-I score

Total DQI-I Score	α) Null model	β) Schools	Bii) Schools + Districts
Constant	59.25 (58.40, 60.10)	59.26 (57.46, 61.06)	59.05 (56.48, 61.61)
Random effects parameters: Unexplained variance			
Level 1: student (n=719)	135.4 (121.42, 149.42)	110.36 (98.58, 122.13)	110.33 (98.56, 122.10)
Level 2: school (n=45)		29.10 (13.66, 44.54)	26.33 (11.55, 41.11)
Level 3: district (n=3)			2.73 (-5.52, 10.98)
LRT significance at school level		p<0.001	
LRT significance at district level			p=0.257

4.4.4 Investigating if there was significant variation in outcomes by school

The next step was to investigate the significance of school-level variance (the second half of research question two) using baseline DQI-I scores as the outcome measure using three additional models:

Model α: Random intercept model adjusting for no covariate (the null)

Model βi: Random intercept model including all student-level demographic variables

Model βii: Random intercept model including all student-level diet-related variables

Significant between-school variation would answer research question two and demonstrate the suitability of using multi-level modelling techniques to answer research questions three and four. Likelihood ratio tests for each of the models were used to estimate whether or not there was significant school-level variation (Table 4.22).

Table 4.22 Results of models α to β for total DQI-I score, including student-level factors

Total DQI-I Score	**α) Null model**	**βi) + Student demographics**	**βii) + Student diet related characteristics**
Constant	59.22	61.27	58.54
LR test significance at school level			
95% CI	13.25, 43.88	11.55, 39.22	13.09, 42.92
p value	<0.001	<0.001	<0.001
Student-level variables			
Gender			
Male		0 (0, 0)	0 (0, 0)
Female		-3.8 (-5.38, -2.21)	-3.99 (-5.56, -2.42)
Age		Wald p=0.58	Wald p=0.66
12		0 (0, 0)	0 (0, 0)
13		1.91 (-3.35, 7.17)	1.64 (-3.58, 6.86)
14		2.89 (-2.05, 7.83)	2.49 (-2.41, 7.4)
15		3.79 (-1.18, 8.76)	3.36 (-1.58, 8.31)
16		0.95 (-6.2, 8.11)	0.46 (-6.66, 7.58)
17		0.69 (-21.27, 22.65)	1.36 (-20.45, 23.17)
Maternal education			
Below O-levels		0 (0, 0)	0 (0, 0)
O-levels and above		1.55 (-0.13, 3.23)	1.5 (-0.17, 3.16)
Ethnicity		Wald p=0.19	Wald p=0.21
Tamil		0 (0, 0)	0 (0, 0)
Sinhala		-4.29 (-10.79, 2.21)	-4.05 (-10.64, 2.53)
Sri Lankan Moor		-0.7 (-8.01, 6.62)	-0.45 (-7.88, 6.97)
Food Security			
Food insecure			0 (0, 0)
Food secure			-0.04 (-2.88, 2.79)
Eats Breakfast			
Never/Rarely/Sometimes			0 (0, 0)
Most of the time/Always			1.97 (0.12, 3.82)
Feelings about weight:			
Feel they are the right weight			0 (0, 0)
Do not feel they are the right			2.2 (0.48, 3.91)
Unexplained school level variance	28.57 (7.81)	25.38 (39.22)	28.00 (7.61)
Proportion explained	20.4%	19.1%	21.0%
Level 1 n =	712	712	712
Level 2 n =	45	45	45

"Wald test ** = significant at the 1% level, * = significant at the 5% level

Column two of the table below shows the estimated constant and the variation that is occurring at the school level before controlling for any student-level variables (Model **∝)**. This shows that the constant is a DQI-I score of 59.22. School level variation has 95% confidence range of 13.24-43.88. The fact that the p-value for this range is <0.001 suggests that before controlling for any student level characteristics, there appears to be a 'school effect' in DQI-I scores. The third column (model βi) shows how the constant for DQI-I changes when we account for student sex, age, maternal education and ethnicity. The constant increases from 59.22 (in the null model) to 61.27. The school variation remains significant, with a p-value of <0.001. Finally, in the third model (model βii) shows what happens when we include, in addition to the student demographic data, the student's food-related characteristics (such as if they have access to food at home, whether or not they eat breakfast, and how they feel about their body weight)[22]. The results indicate that even after controlling for these food related characteristics, school level variation is significant (13.09-42.92, p<0.001). These findings suggested that multi-level modelling was an appropriate method for answering the research questions.

The same models were run for the other dietary outcomes at baseline: calcium, fibre, protein and BMI z-score (Tables 4.23, 4.24, 4.25 and 4.26).

[22] The diet-related characteristics were put into the model at the final stage (and separately from the other student-level variables) because they may account for a large proportion of the variation related to student outcomes or for school-level variation. This would leave little remaining variation and would make it difficult to detect significant associations.

Table 4.23. Results of models α to β for calcium (mg per day), including student-level factors

Total DQI-I Score	**α) Null model**	**βi) + Student demographics**	**βii) + Student diet related characteristics**
Constant	508.70	792.31	738.11
LR test significance at school level			
95% CI	8557.26, 30531.94	6044.36, 24094.41	6831.81, 25930.64
p value	<0.001**	0.075	0.026
Student-level variables			
Gender			
Male		0 (0, 0)	0 (0, 0)
Female		-52.01 (-98.53, -5.49)	-55.87 (-102.2, -9.53)
Age		Wald p=0.74	Wald p=0.73
12		0 (0, 0)	0 (0, 0)
13		-90.32 (-244.18, 63.55)	-94.34 (-247.61, 58.93)
14		-29.02 (-173.06, 115.02)	-36.15 (-179.77, 107.46)
15		-18.19 (-162.94, 126.57)	-26.75 (-171.16, 117.66)
16		-55.43 (-264.42, 153.55)	-68.8 (-277.4, 139.79)
17		63.85 (-577.98, 705.67)	94.49 (-544.85, 733.83)
Maternal education			
Below O-levels		0 (0, 0)	0 (0, 0)
O-levels and above		29.58 (-19.61, 78.78)	28.05 (-20.94, 77.04)
Ethnicity		Wald p=.007	Wald p=.007
Tamil		0 (0, 0)	0 (0, 0)**
Sinhala		-261.96 (-439.83, -84.08)	-263.05 (-443.12, -82.99)
Sri Lankan Moor		-143.46 (-342.79, 55.87)	-139.17 (-341.28, 62.94)
Food Security			
Food insecure			0 (0, 0)
Food secure			-10.42 (-94.2, 73.37)
Eats Breakfast			
Never/Rarely/Sometimes			0 (0, 0)
Most of the time/Always			27 (-27.58, 81.57)
Feelings about weight:			
Feel they are the right weight			0 (0, 0)*
Do not feel they are the right weight			65.16 (14.59, 115.73)
Unexplained school level variance	19544.6 (5605.89)	15069.38 (4604.7)	91919.88 (5026.114)
Proportion explained	17.16%	13.9%	15.1%
Level 1 n =	712	712	712
Level 2 n =	45	45	45

Wald test ** = significant at the 1% level, * = significant at the 5% level

Table 4.24. Results of models α to β for fibre (g per day), including student-level factors

Total DQI-I Score	**α) Null model**	**βi) + Student demographics**	**βii) + Student diet related characteristics**
Constant	23.92	32.9	30.77
LR test significance at school level			
95% CI	10.38, 40.95	7.61, 33.72	8.39, 35.45
p value	<0.001**	0.0255	0.0037
Student-level variables			
Gender			
Male		0 (0, 0)	0 (0, 0)*
Female		-2.58 (-4.46, -0.7)	-2.71 (-4.58, -0.84)
Age		Wald p=0.72	Wald p=0.71
12		0 (0, 0)	0 (0, 0)
13		-2.14 (-8.34, 4.07)	-2.41 (-8.58, 3.76)
14		-1.09 (-6.89, 4.7)	-1.38 (-7.15, 4.39)
15		0.35 (-5.47, 6.17)	0 (-5.8, 5.79)
16		-2.43 (-10.85, 5.98)	-3.26 (-11.65, 5.12)
17		-4.53 (-30.4, 21.33)	-2.95 (-28.67, 22.77)
Maternal education			
Below O-levels		0 (0, 0)	0 (0, 0)
O-levels and above		1.53 (-0.45, 3.52)	1.41 (-0.56, 3.38)
Ethnicity		Wald p=.009*	Wald p=.008*
Tamil		0 (0, 0)	0 (0, 0)*
Sinhala		-8.7 (-15.66, -1.74)	-8.85 (-15.86, -1.85)
Sri Lankan Moor		-2.92 (-10.7, 4.85)	-2.97 (-10.81, 4.86)
Food Security			
Food insecure			0 (0, 0)
Food secure			2.09 (-1.3, 5.47)
Eats Breakfast			
Never/Rarely/Sometimes			0 (0, 0)
Most of the time/Always			0.58 (-1.62, 2.79)
Feelings about weight:			
Feel they are the right weight			0 (0, 0) *
Do not feel they are the right			3.01 (0.97, 5.05)
Unexplained school level variance	25.66(7.80)	20.67(6.66)	21.92 (6.9)
Proportion explained	14.15%	11.9%	12.7%
Level 1 n =	712	712	712
Level 2 n =	45	45	45

“Wald test ** = significant at the 1% level, * = significant at the 5% level

Table 4.25. Results of models α to β for protein (g per day), including student-level factors

Total DQI-I Score	**α) Null model**	**βi) + Student demographics**	**βii) + Student diet related characteristics**
Constant	56.56	79.25	74.33
LR test significance at school level	57.11, 191.27	37.40, 138.94	43.45, 153.51
p value	<0.001**	<0.001**	<0.001**
Student-level variables			
Gender			
Male		0 (0, 0)	0 (0, 0)
Female		-10.57 (-13.88, -7.26)	-10.92 (-14.21, -7.63)
Age		Wald p=0.33	Wald p=0.36
12		0 (0, 0)	0 (0, 0)
13		-6.11 (-17.08, 4.86)	-6.55 (-17.46, 4.36)
14		0.81 (-9.47, 11.09)	0.16 (-10.08, 10.39)
15		1.79 (-8.54, 12.13)	1.08 (-9.22, 11.38)
16		-2.4 (-17.31, 12.51)	-3.35 (-18.21, 11.51)
17		-7.85 (-53.61, 37.92)	-5.58 (-51.11, 39.95)
Maternal education			
Below O-levels		0 (0, 0)	0 (0, 0)
O-levels and above		1.6 (-1.91, 5.1)	1.47 (-2.01, 4.96)
Ethnicity		Wald p= 0.0005**	Wald p=0.0007**
Tamil		0 (0, 0)	0 (0, 0)*
Sinhala		-20.39 (-33.39, -7.38)	-20.23 (-33.45, -7.01)
Sri Lankan Moor		-6.63 (-21.24, 7.98)	-6.36 (-21.24, 8.52)
Food Security			
Food insecure			0 (0, 0)
Food secure			0.2 (-5.75, 6.14)
Eats Breakfast			
Never/Rarely/Sometimes			0 (0, 0)
Most of the time/Always			3.13 (-0.75, 7)
Feelings about weight:			
Feel they are the right weight			0 (0, 0)
Do not feel they are the right			4.72 (1.13, 8.31)
Unexplained school level variance	124.19 (34.23)	88.17(25.9)	98.48(28.08)
Proportion explained	19.9%	15.7%	17.57%
Level 1 n =	712	712	712
Level 2 n =	45	45	45

"Wald test ** = significant at the 1% level, * = significant at the 5% level

Table 4.26. Results of models α to β for BMI Z-score, including student-level factors

Total DQI-I Score	**α) Null model**	**βi) + Student demographics**	**βii) + Student diet related characteristics**
Constant	-0.70	-1.20	-1.11
LR test significance at school level			
	-0.02, 0.07	0, 0	0, 0
p value	0.26		
Student-level variables			
Gender			
Male		0 (0, 0)	0 (0, 0)
Female		0.60(-0.43, 1.04)	0.61(0.43, 0.78)
Age		Wald p=0.95	Wald p=0.94
12		0 (0, 0)	0 (0, 0)
13		0.20 (-0.34, 0.74)	0.22 (-0.32, 0.76)
14		0.25(-0.25, 0.74)	0.26(-0.23, 0.76)
15		0.24 (-0.25, 0.73)	0.26 (-0.23, 0.75)
16		0.31 (-0.42, 1.04)	0.29 (-0.42, 1.03)
17		0.38 (-1.90, 2.70)	0.48 (-1.83, 2.80)
Maternal education			
Below O-levels		0(0,0)	0(0,0)
O-levels and above		0.29 (0.11, 0.47)	0.29 (0.11, 0.47)
Ethnicity		Wald p=0.01	Wald p=0.01
Tamil		0(0,0)	0(0,0)
Sinhala		-0.24 (-0.69, 0.22)	-0.25 (-0.71, 0.20)
Sri Lankan Moor		0.26 (-0.22, 0.74)	0.25 (-0.23, 0.74)
Food Security			
Food insecure			0(0,0)
Food secure			0.02 (-0.30, 0.34)
Eats Breakfast			
Never/Rarely/Sometimes			0(0,0)
Most of the time/Always			-0.17 (-0.37, 0.03)
Feelings about weight:			
Feel they are the right weight			0(0,0)
Do not feel they are the right			0.05 (-0.14, 0.24)
Unexplained school level variance	0.02 (0.02)	0 (0)	0 (0)
Proportion explained	14.9%	0%	0%
Level 1 n =	702	702	702
Level 2 n =	44	44	44

"Wald test ** = significant at the 1% level, * = significant at the 5% level

For the multi-level models of calcium, fibre and protein (Tables 4.24-4.26), the results were similar to the results with the DQI-I scores. School-level variation is significant before controlling for student characteristics (in the null model), but it remains even after controlling for student demographics and student diet-related characteristics.

In contrast to the results from the models for DQI-I scores, calcium, fibre, there was no significant between-school variation in BMI Z-score in Models α (p=0.26) or the subsequent models that controlled for student demographics and diet-related characteristics. This suggests that, while it would be worthwhile examining the 'school effect' of dietary outcomes among students, there was not as much compelling evidence to examine the 'school effect' of BMI Z-scores.

Post-estimation Wald tests were used to compare the coefficients for the various students to see if there were significant differences in dietary outcomes according to student demographics or diet-related characteristics. Results indicated that at baseline, there were significant differences in DQI-I scores by sex, breakfast consumption and feelings about body weight. There were significant differences in consumption of calcium, fibre and protein by sex, ethnicity and feelings about body weight.

4.5 Results for research question three

This section describes the results for the third research question, related to associations between schools' implementations of WHO-recommended Nutrition-friendly schools initiative (NFSI) recommendations and the nutrition outcomes of their students at baseline, and whether or not these associations remain after adjusting for school, student- and environmental characteristics.

4.5.1 Results to preliminary steps

Before starting on the multi-level analysis to answer this research question, there were several preliminary steps required, including looking at associations between the number of school NFSI actions and outcomes and checking assumptions of residual normality.

4.5.1.1 Examining associations between school NFSI actions and dietary outcomes

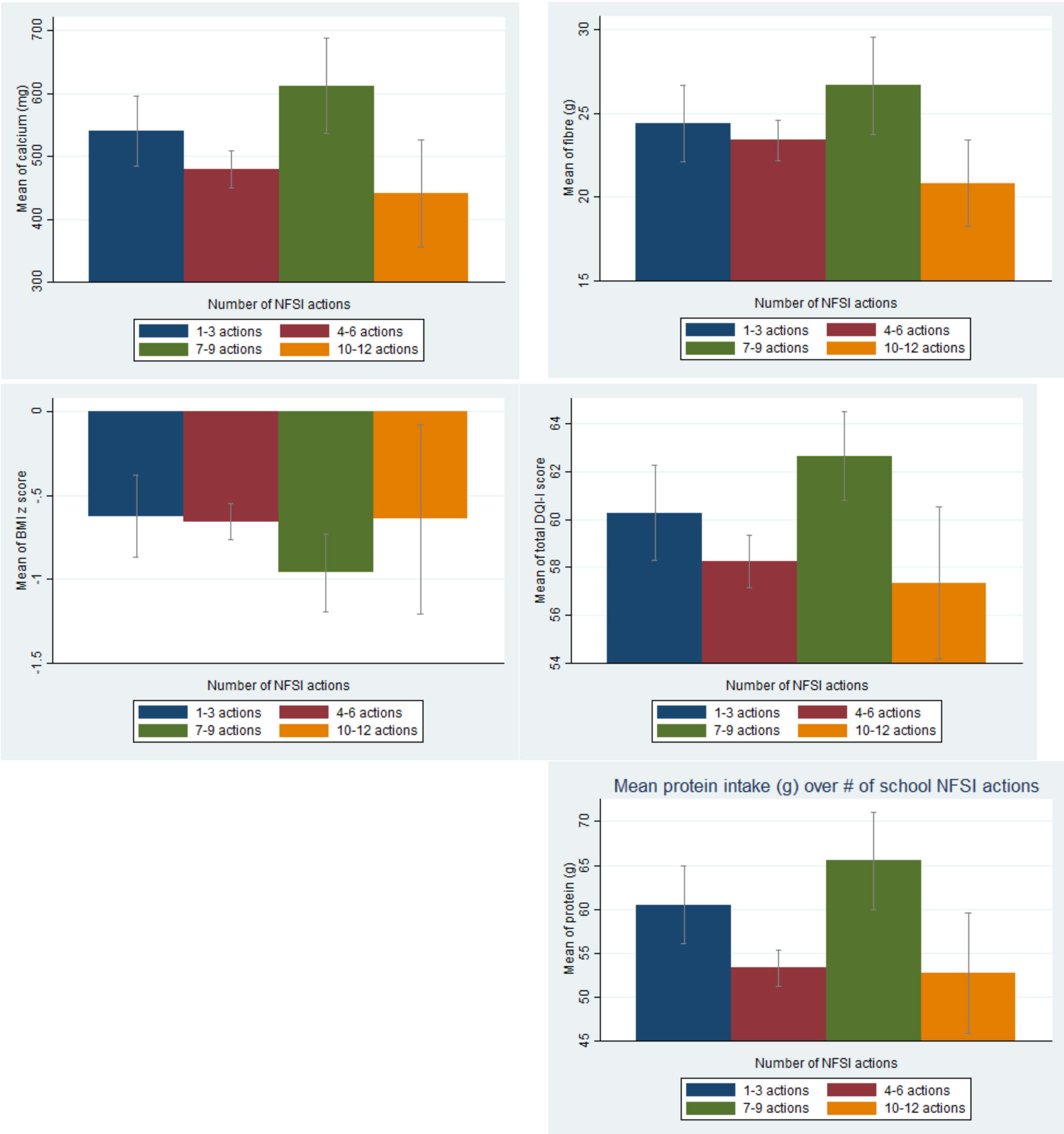
There were no clear linear associations between the number of NFSI actions that schools had in place and mean diet quality scores, calcium, fibre, protein intake or BMI Z-scores. Table 4.27 shows the number of NFSI actions that schools had in place according to NFSI category (policy actions, capacity actions, environment actions and support actions) and the mean outcome scores for schools according to the number of those actions. The table demonstrates that some of the highest outcome scores occurred among schools that had a middle-range number of actions. The DQI-I scores, calcium intake, fibre intake, protein intake and BMI Z-scores did not increase as the number of actions increased.

Table 4.27. Mean DQI-I, calcium, fibre and protein scores, by number of NFSI actions, baseline

	Avg. total DQI-I score	Std. dev. of total DQI-I score	Avg. Calcium	Std. dev. of Calcium	Avg. Fibre Intake	Std. dev. of Fibre Intake	Avg. Protein Intake	Std. dev. of Protein	Avg. BMI Z-score	Std. dev of BMI Z-score
Policy Actions Sum										
0	58.8	11.9	493.9	286.3	23.6	12.8	55.3	22.7	-0.8	1.2
1	58.1	12.1	502.7	362.6	24.0	13.6	55.3	25.3	-0.6	1.2
2	61.0	12.2	526.8	381.8	25.0	16.1	56.8	29.2	-0.7	1.2
3	60.6	9.2	519.8	277.6	23.5	10.5	59.2	19.8	-0.8	1.2
Capacity Actions Sum										
0	58.8	12.0	510.4	350.4	24.0	13.7	55.8	24.1	-0.7	1.2
1	61.0	10.1	505.6	267.2	24.8	10.9	58.7	22.2	-0.5	1.2
2	59.0	12.2	507.6	356.8	23.6	15.1	55.8	29.1	-0.9	1.1
3	57.4	6.7	440.8	178.1	20.8	5.4	52.8	14.3	-0.6	1.2
Environment Sum										
0	56.8	12.5	452.5	241.4	22.3	10.0	52.3	20.2	-0.7	1.3
1	58.3	11.4	470.3	309.4	22.6	12.0	55.9	28.2	-0.6	1.3
2	59.2	11.2	481.6	271.5	23.2	12.2	54.0	19.6	-0.7	1.1
3	61.6	12.5	662.4	490.3	29.0	18.0	64.4	29.9	-0.8	1.2
Support Sum										
0	61.7	11.4	573.8	334.4	26.3	14.2	60.5	25.6	-0.5	1.2
1	58.3	11.4	471.0	300.3	22.3	11.7	54.3	22.3	-0.7	1.2
2	58.9	11.8	506.4	349.3	24.1	13.8	56.0	25.2	-0.7	1.2
Total Actions Sum										
1-3	60.3	10.8	539.4	307.3	24.4	12.6	60.5	24.6	-0.6	1.3
4-6	58.2	12.3	479.5	329.4	23.4	13.4	53.3	23.3	-0.6	1.2
7-9	62.6	9.5	612.2	387.0	26.6	14.8	65.5	28.5	-1.0	1.2
10-12	57.4	6.7	440.8	178.1	20.8	5.4	52.8	14.3	-0.6	1.2
Total	59.2	11.7	507.4	335.0	24.0	13.4	56.2	24.6	-0.7	1.2

Figure 4.6 provides a visual representation of the findings that are tabulated in Table 4.27. Each figure represents one of the five outcomes, which is plotted on the Y axis. On the x-axis, there is a bar chart which shows the categorized number of NFSI actions. As shown in the figures below, when the mean DQI-I scores were plotted against the grouped number of NFSI actions that schools reported, the confidence intervals overlapped. The highest DQI-I scores were found among schools that reported 7-9 NFSI actions (58.25, 57.14 to 59.36) and the lowest scores were found among schools that reported 10-12 actions (57.35, 53.91 to 60.79). A similar pattern was observed with calcium, with schools reporting 7-9 actions having a mean of 440.82 mg (349.25 to 532.39) and the lowest among schools with 10-12 actions (440.82 mg, 349.25 to 532.39). As with the other outcomes, the highest mean fibre intake was observed in the schools reporting 7-9 NFSI actions (26.65 g, 23.74 to 29.55) and the lowest mean fibre consumption was among schools reporting the highest number of actions (20.83 g, 18.04 to 23.61). With protein consumption, the pattern was similar, with the highest mean consumption among schools reporting 7 to 9 actions (612.17 g, 536.15 to 688.19) and the lowest among schools reporting 10-12 actions (440.92 g, 349 to 532.40). The lowest BMI Z-scores were observed among schools reporting 7-9 actions (-0.96, -1.19 to -0.73). The BMI results for schools reporting 1-3, 4-6 and 10-12 actions were all similar (-0.62 (-0.87 to -0.38); -0.66 (-0.76 to -0.55); -0.64 (-1.25 to -0.03), respectively)).

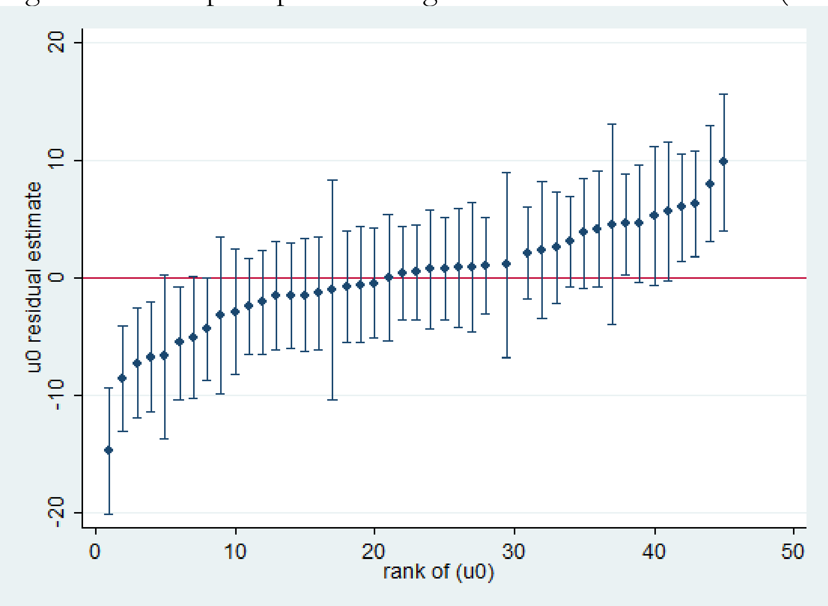
Figure 4.6. Mean DQI-I scores, calcium intake, fibre intake, protein intake and BMI Z-scores over the number of NFSI actions that schools reported, baseline



4.5.1.2 *Checking assumptions of residual normality*

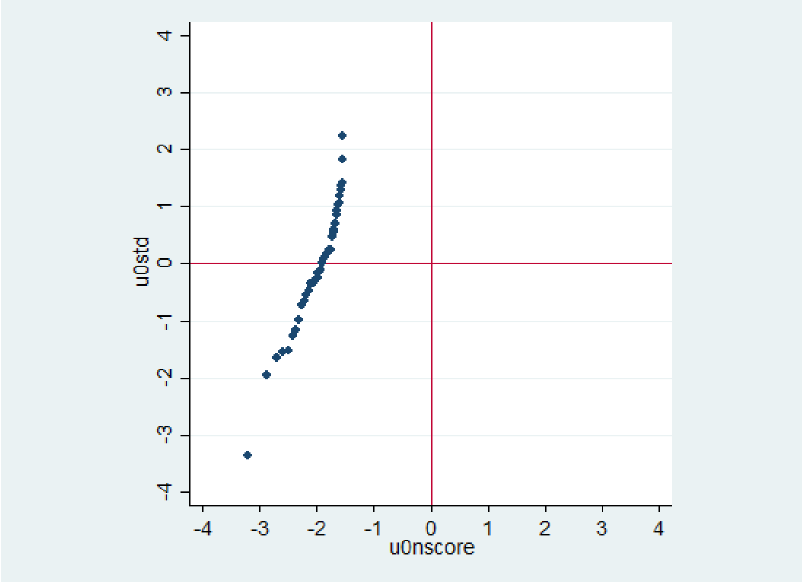
One of the assumptions of the multi-level model is residual normality, which I investigated by plotting the residuals from the null multi-level model for total DQI-I score at baseline using a caterpillar plot (Figure 4.7). This figure shows the residuals for the 47 schools. These residuals represent school departures from the overall mean, as predicted by a fixed parameter of β0. For the schools at the low and high end of the X axis, there was an area where the confidence intervals do not overlap, which means that there are schools that differ significantly ($p<0.05$) from the average.

Figure 4.7. Caterpillar plot showing the residuals from schools (n=47), baseline



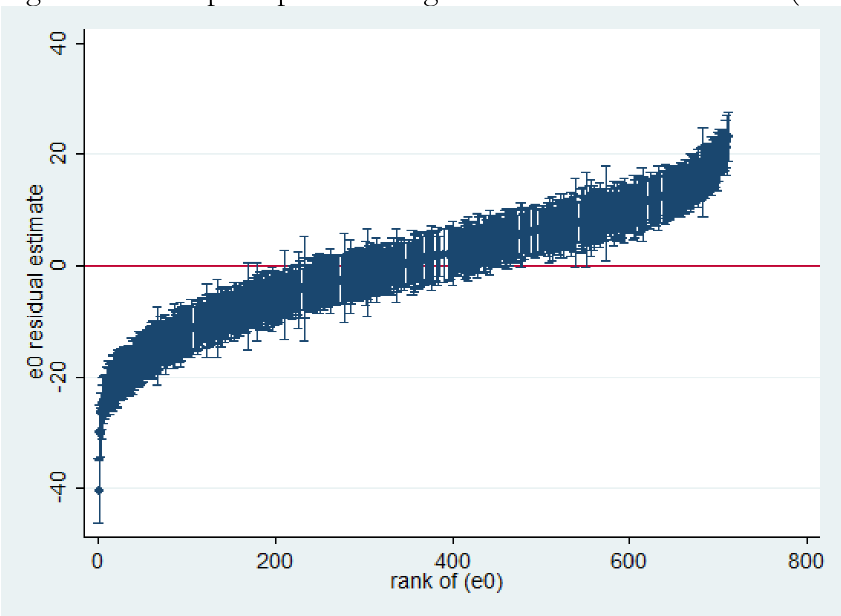
The plot in Figure 4.7 looks fairly linear, suggesting that the assumption of normality was reasonable, but to double check, I investigated school residuals using a normal probability plot (Figure 4.8). The plots follow an approximately straight line, suggesting few departures from normality.

Figure 4.8. Normality plot for school residuals (n=47) DQI-I scores, baseline



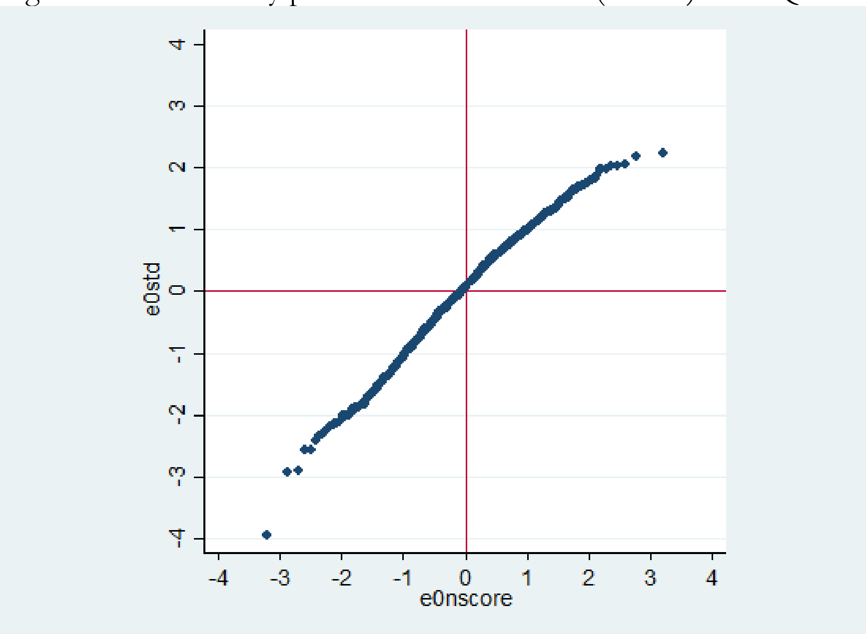
I used a similar method to plot the student residuals from residuals from the null multi-level model for DQI-I scores at baseline. The caterpillar figure below shows the residuals for 712 students (Figure 4.8). Aside from one outlier on the far left, the plot looks fairly linear.

Figure 4.9. Caterpillar plot showing the residuals from students (n=712), baseline



A normality plot (Figure 4.10) confirmed that the assumption of normality was reasonable and it was appropriate to move forward with multi-level modelling. In addition to these normality tests, my sample was likely to be approximately normally distributed due to the sample size, which was sufficiently large according to the central limit theorem.

Figure 4.10. Normality plot of student residuals (n=712) for DQI-I scores, baseline



4.5.2 Multi-level models to answer research question three

After completing the preliminary steps described above, I was able to calculate the multi-level models to answer the third research question, related to associations between school NFSI actions and student nutrition outcomes at baseline. This involved building four models: 1) Univariable random intercept model including only the number of NFSI actions; 2) Multivariable random intercept model including the number of NFSI actions, while controlling for <u>fixed school characteristics</u>; 3) Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics and <u>student demographics</u>; Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics and <u>student diet-related characteristics.</u> Results are shown in Table 4.28.

Table 4.28. Results of models using the count of NFSI actions for all dietary outcomes, baseline

	1	2	3	4
	Univariable	**With fixed school characteristics**	**With student demographics**	**With student dietary characteristics**
Total DQI-I score				
Constant	56.90	55.39	54.94	54.50
Co-efficient for NFSI actions variable	0.47	0.49	0.74	0.70
95% CI	-0.50, 1.43	-0.50, 1.48	-0.17, 1.66	-0.25, 1.66
Level 1 n =	712	712	712	706
Level 2 n =	45	45	45	45
Unexplained school-level variance	27.91	26.19	19.95	22.17
95% CI	12.88, 42.95	11.89, 40.49	8.47, 31.45	9.78, 34.54
Calcium (mg)				
Constant	446.39	381.05	570.66	578.79
Co-efficient for NFSI actions variable	12.71	16.56	23.28	20.98
95% CI	-12.92, 38.34	-9.98, 43.10	1.17, 45.39*	-1.98, 43.94
Level 1 n =	712	712	712	706
Level 2 n =	45	45	45	45
Unexplained school level variance	19068.32	17837.43	9394.97	10638.97
95% CI	8286.26, 29850.38	7582.05, 28092.81	2835.37, 15954.57	3575.02, 17702.93
Fibre (g)				
Constant	22.20	20.54	29.75	20.62
Co-efficient for NFSI actions variable	0.35	0.55	0.80	0.78
95% CI	-0.61, 1.31	-0.43, 1.54	-0.06, 1.66	-0.08, 1.66
Level 1 n =	712	712	712	706
Level 2 n =	45	45	45	45
Unexplained school level variance	25.30	22.93	14.02	13.89
95% CI	10.17, 40.42	8.83, 37.04	3.87, 24.17	3.80, 24.00
Protein (g)				
Constant	30.89	50.95	70.31	70.48
Co-efficient for NFSI actions variable	0.73	1.05	1.63	1.46
95% CI	-0.15, 1.62	-1.06, 3.17	-0.09, 3.35	-0.38, 3.30
Level 1 n =	712	712	712	706
Level 2 n =	45	45	45	45
Unexplained school level variance	15.33	119.96	63.14	77.82
95% CI	4.65, 26.00	54.69, 185.24	23.17, 103.13	31.73, 123.91

*Significant results ($p<0.05$)

As the table above shows, the first univariable model investigated associations between the number of NFSI actions that schools took to promote healthy dietary choices and associations with dietary outcomes. At baseline, there were no significant associations between school NFSI actions and students' total diet quality scores, calcium, fibre, or protein values. This is indicated by the confidence intervals for the coefficients of the NFSI actions variable. As the Table 4.28 shows, for all four outcomes, the confidence intervals cross zero (Total DQI-I score: -0.50, 1.43; Calcium: -12.92, 38.34; Fibre: -0.61, 1.31; Protein: -0.15, 1.62).

The second model investigated if there were any associations after controlling for fixed school characteristics such as school type, school size and multi-sectoral support for improving nutrition. After controlling for these school variables, there were still no significant associations between school NFSI actions and student outcomes. As seen in the first model, the coefficients of the NFSI actions variable for all four outcomes cross zero (Total DQI-I score: -0.50, 1.48; Calcium: -9.98, 43.10; Fibre: 0.43, 1.54; Protein: -1.06, 3.17).

The third model investigated if there were any associations after controlling for characteristics of the children within the schools, such as sex, age, ethnicity and maternal education. There were no significant associations between school NFSI actions and diet quality, fibre or protein intake (once again, all of the coefficient confidence intervals cross zero), but there was a significant association between school NFSI actions and calcium intake among students. Students in schools that were implementing more NFSI actions had higher calcium intake of 23.28 grams (95% CI: 1.17, 45.39). This was the only significant association observed at baseline.

However, after controlling for student diet-related variables such as food insecurity, frequency of breakfast consumption and how they felt about their body weight (Model 4), there were no significant relationships between the number of school NFSI actions and dietary outcomes at baseline.

In all four models, there was significant between-school variation in diet quality, calcium, fibre and protein consumption, but this was not due to the number of NFSI actions that schools were taking, fixed school characteristics, student demographics or student diet-related characteristics.

4.6 Results to answer research question four

4.6.1 Differences in student nutrition outcomes between baseline and follow-up

These descriptive results show how the district mean DQI-I scores changed over time.

Between baseline and follow-up, mean student DQI-I scores decreased in all districts from a mean of 58.9 (SD 11.6) to 52.7 (SD 12.0) (Table 4.29). The mean decrease was largest in Kurunegala, where it dropped from 58.9 to 50.9, and smallest in Moneregala, where it dropped from 57.3 to 53.1.

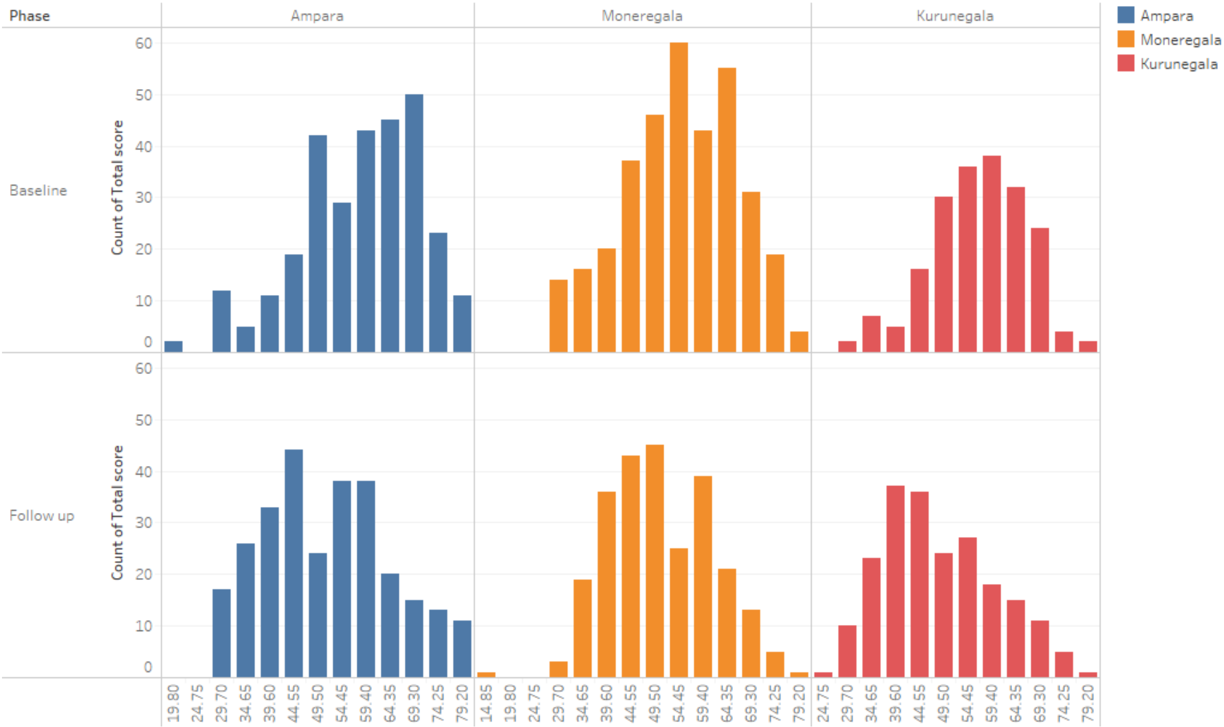
Mean DQI-I scores decreased for both males and females, but the decrease for males was slightly larger. At follow-up, the difference between males and females had gotten smaller, with girls having a mean of 51.5 and boys a mean of 53.7 (Table 4.29).

Table 4.29. DQI-I total score, by sex and district, baseline and follow-up

	Baseline		Follow up	
	Avg.	**Std. dev.**	**Avg.**	**Std. dev.**
District				
Ampara	60.67	12.48	53.79	13.06
Moneregala	57.32	11.67	53.13	10.87
Kurunegala	58.96	9.7	50.85	11.69
Grand Total	58.88	11.62	52.74	12.01
Female				
Ampara	59.53	12.26	52.19	12.79
Moneregala	55.34	11.72	52.23	10.48
Kurunegala	56.15	10.17	49.51	12.04
Male				
Ampara	61.96	12.81	55.69	13.26
Moneregala	59.75	11.23	53.69	11.46
Kurunegala	61.44	8.50	51.55	11.29
Grand Total	60.94	11.15	53.72	12.14

The distribution of the total DQI-I scores reflects the decrease in scores over time among all three districts (Figure 4.11).

Figure 4.11. Distribution of DQI-I scores, by district, over time



This section discusses the change in the variety, adequacy, moderation and balance scores between baseline and follow-up. The overall trends were similar between intervention and control groups; the variety, adequacy and balance scores decreased, while moderation scores increased.

When the results were stratified by sex, the trends were similar for both males and females for variety, moderation and balance scores. There was little change in variety, moderation and balance scores across intervention and sex groups, but adequacy scores dropped substantially among all groups.

The variety score, which was based on consuming foods from a range of food groups and the variation of protein sources, decreased in all districts. Across districts at follow-up, mean variety scores dropped by about one half of a point across districts (Table 4.30).

Adequacy scores, which were based on consumption of foods required to prevent under-nutrition, also decreased over time. At baseline, students received about half of the available points for adequacy, with a mean of 19.0 out of a maximum possible 40 points. At follow-up, adequacy scores had dropped about 6.5 additional points (Table 4.30). The largest drop was observed in Kurunegala.

Between baseline and follow-up, there was an increase in average moderation scores across all districts. The most pronounced change was observed in Ampara, where scores increased from 24.3 to 26.6 (Table 4.30).

At both baseline and follow-up, students received low average scores for balance due to a failure to meet the recommended proportionality in macronutrient intake (which was due to students' high carbohydrate intake and relatively low protein intake). Over time, average balance scores dropped in all districts, especially in Ampara (Table 4.30).

Table 4.30. Variety, adequacy, moderation and balance scores by district, baseline and follow-up

	Baseline		Follow up	
	Avg.	**Std. dev.**	**Avg.**	**Std. dev.**
Variety				
Ampara	13.45	4.66	12.92	5.12
Moneregala	12.42	4.39	12.32	4.89
Kurunegala	13.12	4.15	12.04	4.75
Grand Total	12.94	4.45	12.47	4.94
Adequacy				
Ampara	20.67	9.28	12.93	9.24
Moneregala	17.38	9.15	12.92	8.17
Kurunegala	19.30	7.24	11.13	8.83
Grand Total	18.99	8.89	12.42	8.80
Moderation				
Ampara	24.31	4.64	26.63	2.64
Moneregala	26.20	3.13	26.90	3.31
Kurunegala	25.41	3.31	26.77	3.03
Grand Total	25.35	3.85	26.76	2.99
Balance				
Ampara	2.25	3.15	1.30	2.71
Moneregala	1.32	2.65	0.98	2.36
Kurunegala	1.14	2.44	0.92	2.24
Grand Total	1.60	2.83	1.08	2.47

In addition to reporting on the shift in DQI-I scores over time, I measured changes in calcium, protein and fibre consumption, which were found to be low among students across groups at baseline. Average calcium consumption was relatively stable between baseline and follow-up. While it dropped in Ampara (from 569 mg to 505 mg) and Kurunegala (from 484 mg to 465 mg), calcium consumption increased slightly in Moneregala (Table 4.31).

Between baseline and follow-up, the percentage of students consuming adequate calcium (1,300 mg per day) dropped, but the trend was not consistent across districts. Stratified by district, there was a slight increase in the proportion getting adequate calcium in Moneregala (from 1.7 to 1.9%), while there was a decrease in Ampara and Kurunegala (from 6.9 to 2.5% and from 2.1 to 1.0%, respectively).

Average protein consumption increased over time, but the trend varied between districts. In Ampara and Kurunegala, protein consumption dropped (from 59.9 to 56.6 grams and from 56.5 to 54.4 grams, respectively), while in Moneregala, it increased from 51.1 to 59.8 grams (Table 4.31).

According to the definitions of adequate protein consumption outlined in the DQI-I and the Sri Lankan Food-Based dietary guidelines, the proportion of students consuming adequate protein increased from 25.7% to 27.9%. However, the trends varied between districts. While the proportion increased in Moneregala (from 24.6% to 26.7%) and Kurunegala (from 20.9% to 29.3%), it decreased by about 2% in Ampara (from 30.1% to 28.0%).

There was a large drop in fibre consumption across all districts over time, with average consumption levels decreasing from around 24 to 14 grams per day (Table 4.31). Using the definition of adequate fibre consumption from the Sri Lankan Food-Based Dietary Guidelines (30 grams per day), the percentage meeting recommendations dropped from around 24.1% to 9.4% over time. The trend was observed across all districts.

Table 4.31. Average daily calcium, protein and fibre consumption at baseline and follow-up, by district, baseline and follow-up

	Baseline		**Follow up**	
	Avg.	**Std. dev.**	**Avg.**	**Std. dev.**
Calcium				
Ampara	569.42	408.7	504.68	320.3
Kurunegala	484.33	264.8	465.29	234.9
Moneregala	452.64	296.0	501.57	259.8
Grand Total	500.87	337.1	492.52	278.2
Protein				
Ampara	59.94	27.65	56.62	25.67
Kurunegala	56.54	20.37	54.42	21.24
Moneregala	51.10	20.92	59.81	24.47
Grand Total	55.47	23.67	57.08	24.14
Fibre				
Ampara	26.57	16.11	13.95	11.15
Kurunegala	22.22	10.13	12.65	9.47
Moneregala	21.78	11.72	14.18	9.82
Grand Total	23.55	13.28	13.66	10.26

This thesis focuses on DQI-I scores, calcium, protein and fibre, but additional analyses describing change in consumption of fat, protein, carbohydrates and high fat, sugar and salt foods are provided in Appendix 15. To summarise, mean fat consumption increased over time, largely due to an increase in Moneregala from 40.3 (SD 24.9) g to 48.0 (SD 27.6) grams. Across districts, the percentage of calories coming from fat remained relatively stable over time at around 17%.

Over time, rice consumption increased from 8.4 (SD 3.8) daily servings to 9.3 (SD 7.9) daily servings. There was a small increase in consumption of foods high in fat, sugar, and salt, from 5.03 (SD 5.0) to 5.5 (SD 8.5) daily servings. Consumption of meat also increased from 1.6 (SD 1.6) to 2.15 (SD 3.2) servings.

Vegetable consumption decreased from 6.8 (4.9) to 3.6 (4.2) daily servings. As with vegetables, consumption of fruit dropped from around 2.4 (SD 2.4) to 2.7 (SD 1.7) servings per day.

Similarly, mean consumption of beans decreased from 1.22 (SD 1.29) to 0.94 (0.97) servings per day.

4.6.2 Differences in NFSI scores over time

This section describes the summary of NFSI actions and how they changed between baseline and follow-up, according to their NFSI component.

4.6.2.1 Having a written nutrition-friendly schools policy

Over time, there was an increase in the number of schools with a written or informal policy on healthy eating (from 59% to 71%). There was a decrease in the number of schools with a policy that had objectives, timelines and clear milestones (from 22% to 16%) and an increase in the percentage of schools with policies that had a monitoring and evaluation plan (from 33% to 41%) (Table 4.32).

Table 4.32. Number and percentage of schools reporting to follow NFSI actions related to having a school nutrition policy, by district, baseline and follow-up

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Written or informal policy on healthy eating	Baseline	11	55.00%	11	57.89%	7	70.00%	29	59.18%
	Follow up	15	75.00%	12	63.16%	8	80.00%	35	71.43%
Policy has objectives, timelines and clear milestones	Baseline	6	30.00%			5	50.00%	11	22.45%
	Follow up	7	35.00%			1	10.00%	8	16.33%
Policy has monitoring and evaluation plan	Baseline	9	45.00%	1	5.26%	6	60.00%	16	32.65%
	Follow up	14	70.00%	1	5.26%	5	50.00%	20	40.82%

4.6.2.2 Enhancing awareness and capacity-building of the school community

There was an increase from 12% to 29% in the number of schools sharing a policy with parents, staff and community, and an increase from 18% to 43% of those holding health-promotion activities for the larger community. The number of schools providing training for staff on healthy eating increased from 25% to 31% (Table 4.33).

Table 4.33. Number and percentage of schools reporting to follow actions for NFSI recommendations related to enhancing awareness and capacity-building, by district, baseline and follow-up

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Policy has been shared with parents, pupils, staff, and community	Baseline	3	15.00%			3	30.00%	6	12.24%
	Follow up	12	60.00%	1	5.26%	1	10.00%	14	28.57%
School has held activities for families and community in area of health	Baseline	2	10.00%	3	15.79%	4	40.00%	9	18.37%
	Follow up	14	70.00%	3	15.79%	4	40.00%	21	42.86%
School has held training sessions for staff on healthy eating or related issues	Baseline	5	25.00%	4	21.05%	3	30.00%	12	24.49%
	Follow up	9	45.00%	4	21.05%	2	20.00%	15	30.61%

4.6.2.3 *Creating a supportive school environment*

At baseline, around 20% of schools provided fresh fruit, vegetables and milk within schools and did not allow sugar-sweetened soft drinks or sweets to be available to school children on the premises. By follow-up, this had dropped nearly 16%.

At baseline, around 18% of schools provided students with access to safe drinking water, hand washing facilities (taps and soap) and clean, separate toilets for boys and girls, and this dropped by 4% over time. There was also a small decrease in the number of schools reporting to have sporting facilities, from 82% to 69% (Table 4.34).

Table 4.34. Number of schools reporting to follow actions related to NFSI recommendations for creating a supportive environment, by district, baseline and follow-up

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
School meals promote healthy eating	Baseline	7	35.00%			2	20.00%	9	18.37%
	Follow up	2	10.00%					2	4.08%
Access to safe drinking water, handwashing facilities and toilets for boys and girls	Baseline	5	25.00%	2	10.53%	2	20.00%	9	18.37%
	Follow up	3	15.00%	2	10.53%	2	20.00%	7	14.29%
School sporting facilities available for active play	Baseline	19	95.00%	12	63.16%	9	90.00%	40	81.63%
	Follow up	17	85.00%	12	63.16%	5	50.00%	34	69.39%

4.6.2.4 Providing supportive school nutrition and health services

Nearly all schools reported that they monitored and evaluated students' height and weight. Due to the lack of variation in this activity, schools were awarded points for feeding back the results to school children and parents or for offering a referral system to provide medical support.

At baseline, 84% of schools made the anthropometric results available to school children and at follow-up this dropped to 80%. It was less common for schools to have a feedback system to share the results with parents, with around 61% at having one at baseline and 82% having one at follow-up. At baseline, none of the schools had a referral system for medical support, but at follow-up, 51% did (Table 4.35).

Table 4.35. Number of schools reporting to follow NFSI recommendations related to providing supportive school and nutrition health services, by district, baseline and follow-up

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
School has feedback system that makes findings available to pupils	Baseline	14	70.00%	19	100.00%	8	80.00%	41	83.67%
	Follow up	13	65.00%	19	100.00%	7	70.00%	39	79.59%
School has feedback system that makes findings available to parents	Baseline	12	60.00%	16	84.21%	2	20.00%	30	61.22%
	Follow up	17	85.00%	16	84.21%	7	70.00%	40	81.63%
School has a referral system for medical support	Follow up	6	30.00%	12	63.16%	7	70.00%	25	51.02%

4.6.2.5 *Summarising school actions over time*

Over time, the average number of actions related to having a nutrition policy, enhancing awareness and capacity of the school community, and providing a supportive school environment increased (Table 4.36).

Table 4.36. Average number of NFSI-recommended actions, by NFSI component, baseline and follow-up

	Baseline		Follow up	
	Avg.	Std. dev.	Avg.	Std. dev.
Having a nutrition policy (Max=3 actions)	1.14	0.98	1.29	1.06
Enhancing awareness and capacity of school community (Max=3 actions)	0.55	0.82	1.02	1.13
Creating a supportive school environment (Max=3 actions)	1.18	0.83	0.88	0.60
Providing supportive school nutrition and health services (Max=3 actions)	1.45	0.77	2.12	0.73

The total number of NFSI actions increased from 4.33 (SD 1.90) actions at baseline to 5.31 (SD 2.11) actions at follow-up. The mean number of actions increased among schools in Ampara and Moneregala, but decreased among schools in Kurunegala. At follow-up, the total number of actions was highest, on average, among schools in Ampara (6.45, SD 2.37). The mean total number of actions increased from 4.33 (SD 1.90) to 5.31 (SD 2.11) (Table 4.37).

Table 4.37. Description of the mean total number of NFSI actions implemented by schools, by district, baseline and follow-up

	Baseline				Follow up			
	Avg.	**Std. dev.**	**Min.**	**Max.**	**Avg.**	**Std. dev.**	**Min.**	**Max.**
Ampara	4.65	1.73	2.00	9.00	6.45	2.37	1.00	9.00
Moneregala	3.58	1.02	2.00	6.00	4.32	1.38	2.00	8.00
Kurunegala	5.10	2.96	1.00	11.00	4.90	1.73	2.00	8.00
Grand Total	4.33	1.90	1.00	11.00	5.31	2.11	1.00	9.00

4.6.3 Findings from multi-level analysis

In this section, I describe the results for research question four, using baseline and follow-up data to examine associations between the change in dependent dietary outcomes and the change in the number of NFSI actions that schools were completing. This involved using data from students where I had collected both baseline and follow-up results. These models accounted for how an individual student's outcomes changed over time.

I calculated the four models using independent and dependent variables from follow-up. Unlike previous analyses, these calculations accounted for students' baseline dietary outcomes and for the change in the number of NFSI actions that schools were implementing over time: **Model 1:** Univariable random intercept model including only the number of NFSI actions; **Model 2:** Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics; **Model 3:** Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics and student demographics; **Model 4:** Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics and student diet-related characteristics; **Model 5:** Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics, student diet-related characteristics and the baseline dietary outcomes; **Model 6:** Multivariable random intercept model including the number of NFSI actions, while controlling for fixed school characteristics, student demographics, student diet-related characteristics, baseline dietary outcome, and the change in number of NFSI actions over time (Table 4.38).

Table 4.38. Results of models using the count of NFSI actions for all dietary outcomes, follow-up

	1 Univariable	**2 With fixed school characteristics**	**3 With student demographics**	**4 With student dietary characteristics**	**5 With baseline dietary outcome**	**6 With change in number of NFSI actions**
Total DQI-I Score						
Constant	52.19	53.26	59.02	61.44	56.07	56.94
Co-efficient for change in NFSI Actions variable	0.12	0.10	0.07	0.14	0.16	-0.05
95% CI	-0.85, 1.08	-0.83, 1.03	-0.84, 0.97	-0.84, 1.12	-0.78, 1.11	-1.32, 1.21
Level 1 n =	421	421	421	421	421	421
Level 2 n =	38	38	38	38	38	38
Unexplained school level variance	23.65	19.70	17.31	13.83	11.83	11.69
95% CI	6.28, 41.02	4.30, 35.1	3.24, 31.38	1.70, 25.96	0.77, 22.9	0.70, 22.68
Calcium (mg)						
Constant	506.88	541.53	441.92	524.11	492.26	515.61
Co-efficient for NFSI actions variable	-1.60	-0.79	-4.37	-1.64	-1.97	-7.52
95% CI	-21.58, 18.37	-20.45, 18.87	-24.86, 16.12	-24.81, 21.54	-24.76, 20.83	-37.88, 22.84
Level 1 n =	421	421	421	421	421	421
Level 2 n =	38	38	38	38	38	38
Unexplained school level variance	9018.54	7985.77	8875.76	8320.562	7817.65	7653.38
95% CI	1661.98, 16375.1	1161.36, 14810.17	1666.98, 16084.53	1445.16, 15195.96	1204.73, 14430.56	1120.86, 14185.91

Fibre (g)						
Constant	79.35	82.89	69.12	78.05	81.07	77.97
Co-efficient for NFSI actions variable	-0.25	-0.26	-0.35	-0.37	-0.38	0.37
95% CI	-3.55, 3.05	-3.32, 2.79	-3.77, 3.00	-4.27, 3.54	-4.3, 3.54	-4.81, 5.56
Level 1 n =	421	421	421	421	421	421
Level 2 n =	38	38	38	38	38	38
Unexplained school level variance	276.60	201.19	270.66	285.2168	289.01	284.06
95% CI	73.76, 479.45	35.81, 366.57	74.69, 466.64	83.06, 487.38	85.06, 492.97	82.39, 485.74
Protein (g)						
Constant	60.43	63.16	59.50	68.34	59.02	62.43
Co-efficient for NFSI actions variable	-0.55	-0.49	-0.61	-0.21	-0.22	-1.10
95% CI	-2.38, 1.29	-2.31, 1.34	-2.55, 1.34	-2.34, 1.93	-2.32, 1.87	-3.84, 1.64
Level 1 n =	421	421	421	421	421	421
Level 2 n =	38	38	38	38	38	38
Unexplained school level variance	89.03	81.58	98.53	86.44	81.31	77.52
95% CI	25.76, 152.3	21.94, 141.23	31.43, 165.63	25.79, 147.08	23.37, 139.25	21.44, 133.59

The follow-up analysis included only students who had both baseline and follow-up dietary data available (n=421 students from 38 schools). At follow-up, there were no significant associations between the number of NFSI actions that schools were taking and students' total diet quality scores, calcium, fibre, or protein intake. In the table, this is indicated by the fact that the coefficient for NFSI actions variable has a 95% confidence interval that crosses zero for every outcome in the univariable model, in the model that accounted for fixed school characteristics, in the model that accounted for student demographics, and in the model that accounted for student dietary characteristics. The results remained unchanged in the next model, which included, in addition to the school and student characteristics, the baseline dietary outcomes and the change in the NFSI actions. What this means is that, as with the findings for research question three (examining baseline data only), over time (accounting for change in NFSI scores and change in DQI-I scores), there were no significant associations between NFSI actions and student nutrition outcomes.

4.7 Summary of chapter

This chapter provided the results to this DPhil project. The first section described student-level characteristics such as demographics and diet-related characteristics. Results indicated that the ethnic composition of the sample was similar to the national composition, with most students identifying as Sinhalese. Around 40% of students reported that their mothers had an education of a GCO/Level or above. Most students lived in households that were living on a household income that was below the national average for rural populations. However, few students reported ever going hungry due to 'lack of food at home' and most students reported eating breakfast 'always' or 'most of the time.' Most students felt that they were 'about the right weight,' but a small proportion felt that they were 'underweight' and around a tenth felt that they were 'overweight' or 'obese.' In reality, around 60% of females and 40% of males fell within a healthy weight category, while 34% of females and 58% of males were underweight.

This chapter went on to describe the results from schools, which indicated that the number of NFSI actions that schools had in place ranged from 2-11 actions (SD 1.85). Scatterplots and cross-tabulations of NFSI actions and dietary outcomes indicated that there were no clear linear associations between the number of NFSI actions that schools had in place and mean DQI-I scores, fibre, or protein intake.

After providing descriptive data from students and schools, this chapter went on to describe the results for answering research question one, 'What is the nutritional quality of the diets of adolescent students living in the rural districts of Ampara, Moneregala, and Kurunegala, Sri Lanka?' Student dietary intake was characterised using a DQI-I score. At baseline, the mean total DQI-I score was 58.88 (SD 11.62) out of 100 possible points and the distribution of scores was approximately normal across districts. The average total variety score, which was based on the variety of protein sources and the variety of food groups, was 12.94 (SD 4.45) out of 20 possible points. Out of 40 possible points, the average adequacy score was 18.99 (SD 8.89). Less than a third of students were consuming adequate fibre, only about a quarter were consuming recommended amounts of protein and fewer than 5% of students were consuming adequate amounts of calcium. Out of 30 possible points, the average moderation score was 25.35 (SD 3.85). Out of ten possible points related to balance, on average, students had a score of 1.60 (SD 2.83). Males had a significantly higher mean total DQI-I score and significantly higher protein consumption compared to females. The foundation of student diets was starchy carbohydrate foods, including rice, bread, roti and potatoes, with the average students consuming around nine servings per day. Students also consumed around 2.4 servings of fruit and 6.8 servings of vegetables per day.

The next section of this chapter provided the results to answer research question two: 'Is there significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?'

This chapter found that at baseline, there were significant between-district differences in DQI-I scores, calcium, protein and fibre consumption, but there were no significant between-district differences in BMI Z-scores. At baseline, there were no associations between school size and DQI-scores, calcium, fibre or protein, but there was more variation among smaller schools. Similarly, DQI-I scores, calcium, fibre, protein and BMI Z-scores all had overlapping confidence intervals according to school type and intervention status. Results from multi-level models and likelihood ratio tests indicated that there was significant variation in DQI-I scores between students and schools, but there was no significant variation occurring at the level of the school district. There was, however, variation in DQI-I scores, calcium, fibre and protein occurring at the level of the school, and this variation remained even after controlling for student demographics and diet-related characteristics. By contrast, there was no significant between-school variation in BMI Z-scores.

Next, this chapter described the results to answer research question three: 'Using cross-sectional data at baseline, are there significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of their students' diets?' Multi-level models found that after controlling for fixed school characteristics, student demographics and diet-related characteristics, there were no significant associations between school NFSI actions and student outcomes.

This chapter went on to describe the results to answer research question four: 'Using longitudinal baseline and follow-up data, are there significant associations between changes in implementation of NFSI recommendations and changes in the nutritional quality of students' diets?' First, this section described the ways in which DQI-I scores and NFSI actions changed over time. Between baseline and follow-up, mean student DQI-I scores decreased in all districts from a mean of 58.9 (SD 11.6) to one of 52.7 (SD 12.0). Variety, adequacy and balance scores decreased, while moderation scores increased. There was an increase in the consumption of rice and bread, meat, and foods high in fat, sugar and salt, and a decrease in the consumption of servings of fruit, vegetables and beans. Over time, the mean total number of NFSI actions that schools reported increased from 4.33 (SD 1.90) to 5.31 (SD 2.11). Multi-level models, which controlled for fixed school characteristics, student demographics and student dietary characteristics, indicated that there were no significant associations between the change in school NFSI actions and the change in DQI-I scores or other dietary outcomes.

5 Discussion

The purpose of this final chapter is to discuss this study's main findings, consider my contributions and highlight how the work has added evidence to a larger field of research. This critically evaluates the study's strengths and limitations and compares the research findings to other research. Finally, this chapter discusses the implications and recommendations for future research, policy and practice.

5.1 Summary of main findings

Research question one asked "What is the nutritional quality of the diets of adolescent students living in the rural districts of Moneregala, Ampara and Kurunegala, Sri Lanka?" To answer this question, this study collected detailed data on student dietary intake using a validated food frequency questionnaire, and described dietary intake using a diet-quality index. Results from two time points demonstrated that students had overall low diet quality, with notable deficiencies in protein and calcium, and a high intake of refined carbohydrates. Given the importance of nutrition during adolescence[175], it was concerning that 42% of students were underweight and that the majority had inadequate protein and calcium intake.

Research question two sought to identify if there was "significant district- or school-level variation in the nutritional quality of the diets of adolescents living in the rural districts of Moneregala, Ampara and Kurunegala." Findings from this study demonstrated that there was no significant *between-district* variation in dietary outcomes, but there was significant *between-school* variation, and that this school-level variation was not related to school type, the INPARD intervention activities, student demographics or other student diet-related characteristics. These findings suggested that there was a 'school effect,' on student dietary intake, indicating that school environments may have an influence on student nutrition outcomes.

However, as shown by the analyses for research questions three and four—which aimed to see if there were significant associations between schools' implementation of WHO-recommended NFSI actions and the nutritional quality of students' diets-- between-school variation in student nutrition outcomes could not be explained by the number of NFSI actions that schools reported. There were no significant relationships between the number of NFSI actions that schools were taking and the dietary outcomes that were observed at baseline (research question three) or between the changes in school actions and dietary outcomes over time (research question four).

5.2 Contributions

5.2.1 My unique contribution to the project

For this thesis, I collaborated with the INPARD project to collect data on school environments and student outcomes among rural schools and student populations. My unique contribution to this work included identifying the NFSI as a key part of school-based health promotion and identifying the methods and tools for the school- and student-based research and analysis. I chose the research tools (i.e. the FFQ, the GSHS, STEPs socioeconomic survey questions), developed and piloted the NFSI tool for researchers, identified and proposed the methods for the school- and student-based analysis to the INPARD team prior to applying for ethics approval or initiating the project, piloted and trained the data collectors, cleaned and processed the datasets, developed methods of generating an adapted diet quality index to characterise student diets, developed methods for using multi-level analysis to examine associations between school environments and student outcomes, and completed two literature reviews (a scoping review on the NFSI, in collaboration with the WHO headquarters, and a review on NCD morbidity and mortality and socioeconomic status in LMICs). During this time, I also co-authored a *Lancet Global Health* systematic review on associations between NCD risk factors and socioeconomic status within LMICs[185]. I presented results from my school- and student-based research within INPARD workshops with local and national policy makers in Sri Lanka and at international scientific conferences (Appendix 18). Additionally, I co-authored a qualitative research paper on school principals on barriers to healthy eating[70]. In turn, the INPARD project provided me with support for data collection, access to school principals and students, and support with study logistics. It also provided me with opportunities to present findings to Sri Lankan regional, national and international stakeholders. Finally, INPARD provided me with funding to complete my field work.

5.2.2 How this research contributes to the literature

This research, to the best of my knowledge, represents the first nutritional dietary study to collect longitudinal food-frequency data from rural Sri Lanka. Food-frequency data requires extensive time and resources to collect, analyse, and interpret. In turn, these data are valuable because they provide a very description of dietary intake which enables researchers to analyse complex dietary characteristics, such as daily intake of micronutrients. A less expensive, less labour-intensive method (such as asking students about how many portions of fruit and vegetables eaten per day, as many global health surveys, including the GSHS and STEPs survey do) does not produce detailed information to calculate micronutrient intake.

This study provides a valuable contribution to nutrition research, not only because of the high level of detail that the data provided, but also because of the population that it described. As noted in the background of this thesis, nutrition during adolescence is crucial for ensuring healthy development and for providing a foundation to good health later in life[175]. Unfortunately, however, given the severity of other nutrition-related public health concerns in developing countries, such as micronutrient deficiency in infancy or early childhood, and NCD management among adults, adolescent nutrition is often overlooked as a public health issue. The dearth of research on adolescent nutrition in LMICs makes the findings that are presented in this thesis valuable. It is rare for research studies to have the resources to focus on this population, and what the findings show is concerning.

Another unique contribution that this study makes is its development of methods to apply Kim *et al*'s diet-quality index international[157] to the validated FFQ developed by Jayawardena *et al*[153]. Jayawardena's FFQ is frequently used in Sri Lanka, and, by developing methods for characterising diet quality with these data, findings from other studies using this tool will also be able characterise the multiple components of diet quality using a comprehensive and internationally recognised method.

Another contribution that this research study makes to the literature is the development of the NFSI tool for researchers. Given the prominent role that the NFSI plays in global health policy, the recommendations need to be evaluated against student outcomes. To the best of my knowledge, this is the first project to do so. In so doing, this thesis provides future researchers with possible methods to evaluate the NFSI approaches within wider contexts. By showing how schools can be characterised according to NFSI actions, creating a diet-quality index to characterise student diets and employing the techniques of multi-level modelling to ensure that I accounted for the hierarchical structure of the dataset, this thesis provides a valuable contribution to the research. Importantly, this kind of research does not just pose an academic challenge—it helps to answer questions which have real public health importance.

This research study also contributes to the literature by providing a longitudinal evaluation of school environments and associations with student outcomes. Additionally, it presents evidence on the effectiveness of NFSI approaches. As shown by the literature review in Chapter Two, to the best of my knowledge, there has been no prior evaluation of the influence of the whole NFSI package on student outcomes.

5.3 Strengths and limitations

5.3.1 Strengths and limitations related to sampling and recruitment

One of the other strengths of this project was its high participation rates. All 50 of the schools that were invited to join the project agreed. Such high participation rates are rare, particularly in higher income countries. Project partners reported that our high participation rates related to the project's approval and endorsement by the Sri Lankan Ministry of Education. It is also possible that in resource-poor settings such as rural Sri Lanka, schools were keen to get involved with a project that might bring in additional support.

5.3.2 Strengths and limitations related to the data collection

Collaborating with the INPARD project allowed me to collect a large volume of data from students and school principals, and to ensure high data quality. For example, all of the raw data collected from paper surveys were entered twice into excel, by two separate researchers. Results were compared and discrepancies were resolved by going back to the original source to ensure accuracy.

Unfortunately, however, collaborating with data collectors also presented challenges by giving me less control over specific aspects of the data collection. For example, quality control measures were not applied to student identifying numbers, and there were many coding errors which led to a loss of data in the final analyses. Future projects should ensure that quality control is applied to both questionnaire answers and student identifiers. Additionally, distributing all surveys (the FFQ, GSHS and STEPs questions) within a single bundle (rather than as separate documents that need to be linked together via student identifiers later) may help minimise data loss.

5.3.2.1 Project timeline

One of the strengths of this project was that it employed a longitudinal study design, which ensured that I could take account of the characteristics of individuals at two time points and could measure change in school NFSI approaches and student outcomes. The collection of data at two time points had advantages, but it also posed limitations. First, the data collection teams changed between baseline and follow-up and, while I provided standardised training to all teams, each team collected and coded data slightly in a slightly different way, resulting in several challenges during the data cleaning phase.

Additionally, while the data were intended to be collected at the same time of year for both time points (July 2014 and July 2015), the national political elections of 2015 caused significant disruption, leading to the closure of roads, offices and schools. The INPARD team and funders decided not to deploy data collectors for field work during the political campaigning period. This meant that follow-up data collection was delayed by a few months, which in turn meant that there may have been differences in the seasonal food supply between baseline and follow-up. This difference in timeframes may have had implications for the dietary outcomes, particularly for the consumption of fresh fruit and vegetables.

The longitudinal study design employed in this project was a strength, but one year may have been too short of a timeline for detecting meaningful changes, both in terms of school environments and in terms of student outcomes. While I observed a small change over time in the number of school NFSI actions, bigger changes might have been observed if the study had been carried out over a longer time-scale.

Furthermore, the short time-line of this project made it impossible to evaluate long-term outcomes such as NCDs, which develop over decades. For this reason, I chose to focus on the more proximal outcome of nutrition status, which is associated with NCD risk later in life. However, to understand the influence of school environments on NCD prevention, an ideal study would have a 50-60 year timeline. In the past, there have been NCD studies that extend over decades. For example, in 1948, the Framingham Heart Study recruited a cohort of 5,209 adults (aged 30-62 years of age). Many of the participants were followed until they died, and exam 32 from the original cohort ended in April of 201[186]. Conducting longitudinal studies with school-based cohorts is challenging, because many students move away after graduating from school, leading to a high loss-to-follow-up.

The short time-line of this project made it impossible to evaluate whether or not the school NFSI actions that were taking place in 2014 and 2015 were sustained over time. Future research should follow students and schools over a longer timeline. This would strengthen, not only the research, but the potential benefit that health promotion research activities may bring to the community. During my field work, I heard one valid criticism of the current research model, one in which researchers from high income countries will often come into LMICs to conduct brief interventions, extract data, and return to their high income countries to write reports and papers. Often, the research fails to adequately engage and empower the local communities, and therefore, many potential benefits that might be associated with the health promotion research fail to be sustained over time. In order to ensure that the benefits associated with health promotion research are sustained over time, it is important for research to build capacity within the communities where the work is taking places. By involving local stakeholders and equipping them with resources and skills to continue project activities, the benefits of health promotion projects are more likely to continue over time, and are therefore more likely to lead to positive changes.

National health policies may also play an important role in ensuring the sustainability of health promotion activities. For example, the Sri Lankan multi-sectoral action plan[34] for the prevention of NCDs includes activities for schools which may contribute to the sustainability of efforts started by INPARD. However, formal evaluation, both of the implementation and the impact of these activities, will be necessary in the years ahead.

5.3.3 Strengths and limitations related to the measures

This study was limited by its reliance on self-reported behavioural outcomes, which are susceptible to reporting biases[187]. Studies which have compared energy intake from food records to intake determined by doubly labelled water have found that misreporting is common[188], especially among children and adolescents[189]. For this reason, it is important to use validated dietary assessment tools. The FFQ that I used in this study was validated for assessing dietary intake among Sri Lankan adults, but it was not validated to assess *change* in dietary outcomes, or dietary outcomes specifically among adolescents.

Where possible, this study used validated tools (including the GSHS and the FFQ). However, due to constraints on the data collection timeline, the NFSI tool for researchers was not fully validated prior to its use. The NFSI Tool was critically assessed and modified by experts within WHO and piloted before use, which may have contributed to some content validation, but a more comprehensive validation[190] was not completed. Future studies using the NFSI tool for researchers should compare findings from reports by school principals to objective or documentary evidence. For example, if a principal reported that fresh fruit or vegetables were available within schools, researchers could validate this response by visiting the school canteen and confirming the presence or absence of these foods with objective data.

Fortunately, both the NFSI tool for researchers and the summary of NFSI actions are based on questions which could be validated in this way. For example, researchers could ask school staff to provide written documentation of their nutrition policy. Researchers could walk around the school and confirm the physical presence of changing rooms, washing facilities, and spaces available for active play. To enable future validation of the NFSI tool, I have created a checklist which outlines the specific NFSI components which can be objectively measured to confirm whether or not a principal's response is accurate (Appendix 16).

Another major limitation to this study was the respondent burden posed by the high number of questions that principals and students were asked to answer. Future studies would benefit from shortening the NFSI tool (omitting some of the subjective, non-verifiable questions, for example, about whether or not staff members are role models in healthy eating) and selecting only a subset of GSHS and STEPs survey questions.

There were also limitations related to my measures of socioeconomic status, which were not validated for use with adolescents. Many students did not answer the questions related to paternal education or household income, and reporting bias was likely. For example, the survey asked students to report parental occupation and many reported that their fathers were 'self-employed,' which may have been more socially acceptable than responding 'unemployed.' My study population included many farmers, and household wealth may have been held in assets that were not reflected by the income measures that I collected. The challenge of applying commonly used measures of socioeconomic status in developing countries is well-recognized[191] and future studies would benefit from deeper consideration of how to assess socioeconomic status among adolescents living in rural LMICs.

In my assessment of students' diets, I used the protein recommendations cited in the Sri Lankan Food Based Nutrition recommendations (10-15% of energy)[171] and the DQI-I. However, defining adequacy as a proportion of total energy intake may be problematic in certain instances. For example, for a person with low energy intake, their protein intake may fall below required levels, but proportionally, it could still be defined as 'adequate' if the ratio of protein to other macronutrients fell within certain parameters. A person's protein intake might appear *relatively* adequate but *absolutely* inadequate and vice versa. As an alternative, some experts argue for age-and sex-specific requirements, which range from 44-46 grams for females and 45 to 58 grams for males[175]. According to this definition, 28.6% of females and 25.0% of males in my sample were not eating enough protein, which is a much lower proportion than what was calculated using the DQI-International and Sri Lankan Dietary Recommendations (which found that 73.9% of males and 74.2% of females were not getting adequate amounts of protein). Despite this difference, I chose to use the Sri Lankan recommendations because I prioritised drawing upon the country's own nutrition guidance as much as possible, to make it relevant to the local population.

Finally, my assessment of school approaches to promote healthy diets could have been strengthened by asking school principals, school officials and students to identify important components that were absent from the NFSI framework during the piloting phase. As an outsider, using a framework which was developed by technical experts in Switzerland, it is unlikely that the NFSI was perfectly suited for assessing schools in rural Sri Lanka. To account for this, I made some adaptations to the NFSI tool during the piloting phase. However, future studies would benefit from making more concerted efforts to ensure the tool's relevance for specific LMIC contexts. For example, it would have been better to ask, not only 'Do the questions in the NFSI Tool for Researchers make sense?', but also, 'What is missing from this tool? Are there important school-based health promotion activities that the NFSI Took currently does not consider?' Having more critical feedback from local stakeholders about missing NFSI components would have strengthened this study.

Oranizations such as the WHO may play an important role in producing frameworks that all countries can use, but it is important for these frameworks to be adapted to local contexts.

5.3.4 Strengths and limitations related to the analysis

This study is strengthened by its use of multi-level modelling, which allowed me to identify variability in student outcomes at both the school- and student-levels. Unlike simple regression modelling, this method accounted for the clustered nature of the dataset (children nested within schools) and ensured that standard errors were not underestimated.

5.3.4.1 Multiple testing

This thesis used multiple outcomes, which introduced the problem of multiple testing and increased the chance of making a type I error (observing a statistically significant result that is occurring by chance alone). There are various statistical methods that can be used to account for multiple testing, including the Bonferroni correction, which sets the significance cut-off at α/n, where n is equal to the number of outcomes tested. For example, given that this thesis had five outcomes and $\alpha = 0.05$, it would only reject a null hypothesis if the p-value was less than 0.01. This thesis did not produce significant results in its final analyses, even at the $p \leq 0.05$ level, so such adjustments were not necessary. It is also important to consider type II errors, which occur when failing to detect an effect that is present. The probability of making a type II error is related to the power of a test. Due to problems linking datasets, the sample size in my analyses was not as large as I'd originally intended it to be, which decreased the power of my analyses and therefore increased the probability of making a type II error.

5.3.5 Strengths and limitations related to the NFSI literature review

This thesis included a literature review that was conducted in collaboration with the World Health Organization's Department for Nutrition and Development. WHO staff and interns identified peer-reviewed literature on the evidence for the NFSI criteria. After screening abstracts and full-text papers (n=527), the WHO sent me the papers which had been identified for inclusion (n=49 studies). I requested additional information related to the identification and screening process, to ensure that I could provide a summary of the information which is recommended by 'Preferred Reporting Items for Systematic Reviews and Meta-analyses' (PRISMA), which is an evidence-based minimum set of items for reporting in systematic reviews[192]. Typically, a PRISMA summary includes a description of the number of records identified through database searching, the number of abstracts screened (and a quantitative description of how and why papers were excluded), a description of the full-text articles that were assessed for eligibility (and a second quantitative description of how and why papers were excluded) and finally, a description of the number of included papers. Unfortunately, the WHO was not able to provide all of these details. Therefore, I included a simplified PRISMA figure, which describes the number of full text articles identified, the reasons for exclusion and the final number of included articles. This lack of further detail is a limitation. To ensure that I still learned the methods of systematic reviews, including the process of identification and screening, I completed a second systematic review (Appendix Two) on associations between NCDs and socioeconomic status within LMICs, which is currently in press in the Journal of Global Health and co-authored a second review in the Lancet Global Health[185]. For these reviews, I have provided a detailed PRISMA figure.

5.4 Interpretation and comparison with other research

5.4.1 Research question one

This study found that adolescents in the rural districts of Ampara, Moneregala and Kurunegala had overall poor diet quality, with particular deficiencies in protein and calcium. Average diet quality decreased between baseline and follow-up in all three districts. It is likely that some of the decrease in diet quality was due to differences in the time of year when data were collected. Aside from these seasonal changes, it is possible that Sri Lanka's rapidly changing cultural and economic environment is leading to changes in the availability and affordability of particular foods, increasing the accessibility of foods high in saturated fat, salt and sugar[193].

Results indicated that over time, rice and bread consumption increased while fruit and vegetable consumption decreased. Due to the dry season that was experienced at follow-up data collection, it is possible that individuals relied increasingly on shelf-stable, non-perishable foods. More work is needed to understand how the perishability of food may influences dietary choice in rural Sri Lanka, particularly during drought. If it is indeed an influence, additional work is needed to ensure that populations have access to nutrient-rich sources of food throughout the year, including during the dry seasons.

According to baseline data, around 42% of students (60% of males and 34% of females) in my sample were underweight, suggesting inadequate energy consumption. A recent systematic review by Jaaks *et al* sheds light on the problem of malnutrition among adolescents in many LMICs. The review found that compared to other regions globally, South Asia had the highest prevalence of underweight among adolescents; nearly double that of East Asia and the Pacific and sub-Saharan Africa. Contrary to popular belief, the prevalence of underweight is increasing in rural areas[194]. Among the wider population of young people and adults, the World Food Programme estimates that undernourishment is highest in sub-Saharan Africa, where in 2015, 226 million people were undernourished, constituting more than 40% of the population. When undernourishment is measured in terms of the total population (rather than in terms of the proportion of the total population in a given area), Asia has the highest level of undernourishment, with an estimated 552 million undernourished people (around 28% of the population)[195]. As the World Food Programme report notes, food security is complex and its dimensions are best understood when presented using a range of indicators[195].

At the same time, the prevalence of overweight and obesity among children and adolescents in developing countries is also increasing. A systematic analysis for the Global Burden of Disease Study 2013 estimates that overweight and obesity in children and adolescents in developing countries increased from 8.1% (7.7-8.6) in 1980, to 12.9% (12.3-13.5) in 2013 for boys and 8.4% (8.1-8.8) to 13.4% (13.0-13.9) in girls[196]. In Sri Lanka, the prevalence of overweight and obesity in 2013 was estimated to be 5.0% among boys (4.1-6.0) and 8.9% (7.4-10.8) among girls under the age of 20 years[196]. Among children globally, the prevalence of overweight and obesity is low. For example, in 1977-78 and in 1987 just 0.1% of children 0-5 were considered overweight or obese[126]. The problem of overweight and obesity is more apparent among adult populations, with data from the Global Burden of Disease Study 2013 finding that 19.3% (17.5-21.1) of men and 32.4% (29.9-35.1) of women aged 20 and older were overweight or obese[196].

5.4.1.1 Comparison of INPARD anthropometrics to 2008 national anthropometrics

Appendix 15 provides a comparison of my anthropometric findings to national findings from 2008, when the GSHS was administered to a nationally-representative sample of students. On that occasion, 2,611 students were surveyed with a school response rate of 100% and a student response rate of 89%[149]. My sample varied from the 2008 sample in several important ways. Aside from the six year difference, the populations varied considerably; my study was based on a rural, relatively low socio-economic population, while the 2008 sample included both urban and rural participants from a range of socio-economic backgrounds. Urbanicity is an important consideration in studies such as these. For example, in other developing countries, such as India, urbanicity has been positively associated with the prevalence of several NCD risk factors, including smoking, body mass, blood pressure and low physical activity[197]. Another difference was that my survey included both self-reported and measured data, whereas the 2008 survey included only self-reported data.

Additionally, the surveys categorised age in different ways. The 2008 survey listed the youngest category as '11 years old or younger' and the oldest category as '16 years old or older,' while my survey listed responses ranging from '11 years old or younger' to '18 years or older'. To compare between study years, I merged my 2014 sample of 16-18 year olds into a single category.

Another difference was that the 2008 survey had only self-reported height and weight, while my survey had both self-reported and measured height and weight. As the tables in Appendix 15 show, the 2008 national self-reported data indicated that approximately 49% of students were underweight and 4% were overweight or obese. My self-reported data indicated a lower proportion of underweight among my sample, and a higher proportion of overweight, with 39% of students classed as underweight and 14% classed as overweight.

When I compared the 2008 national self-reported data to my 2014 baseline *measured* data (which is much more accurate than self-report)[198], the gap was less pronounced; 44% of students were underweight and 5% were overweight or obese, which is closer to the national 2008 results. Within my sample, when I compared BMI Z-scores from the self-reported values to the BMI Z-scores that were based on measured height and weight, the measured scores were significantly ($p<0.001$) lower than self-reported scores for both males and females. My comparison of self-reported to measured weight status within my own sample indicates the importance of using measured values when possible and calls into question the accuracy of self-reported height and weight data. That said, the accuracy of knowledge about one's height and weight is likely to vary between populations[199], and it could be that overall, in the national sample, accuracy of self-report was higher than it was in my sample.

5.4.2 Research question two

This study found that there was no significant district-level variation in student outcomes. There are differences between Ampara, Moneregala and Kurunegala in terms of health outcomes and demographics. For example, according to the most recent Sri Lankan census, the proportion of children who are three or more standard deviations below the national mean height for age is 2.4% in Ampara, 5.8% in Moneregala and 2.0% in Kurunegala[13]. Among females who were head of the household, the percentage who had completed secondary school was 12.9% in Ampara, 19.1% in Kurunegala and 20.2% in Moneregala. In

Ampara and Kurunegala, about a quarter of households (25.6% and 25.1%, respectively) fell into the lowest wealth quintile, while in Moneregala, 40.7% of households fell into this category. Given these differences between Ampara, Moneregala and Kurunegala, it was surprising that there was no significant district-level variation in students' nutrition outcomes.

This study found that there was significant school-level variation in student outcomes, and this variation remained after controlling for student demographics, other student characteristics and fixed school characteristics. These findings suggest that school-based approaches may have an effect on student diet quality. This is a compelling result which warrants further investigation. None of the variables that I accounted for—student demographics, student diet related characteristics, school practices related to the NFSI—could explain this school-level variation. Results from high income countries have found similar results. For example, Maes *et al* conducted a multi-level analysis to examine individual and school level effects on health-related behaviours (including healthy and unhealthy nutrition behaviour) using multi-level modelling among adolescent schoolchildren in Belgium[200]. Substantial variation in student health behaviour (smoking and tooth brushing) was observed after controlling for individual effects, and, as with my study, the authors could not detect an effect of health promotion policy at the school. The authors concluded that the analysis 'only partially confirms the hypothesis that the school has an impact on the health behaviour of young people.' A Scottish longitudinal study investigated school effects on smoking, drinking, drug use and diet at two time-points in secondary school and identified significant variation in health behaviours after adjusting for individual characteristics and conducting a cross-classification analysis of school neighbourhood[201]. Higher levels of smoking, drinking and drug use were observed in schools that had more students disengaged from education and who knew fewer teachers, in larger schools and in schools independently rated as having a 'poorer ethos'[23]. However, for diet, a different pattern was observed compared to the other health behaviours—the individual-level characteristics of prior diet, social class and deprivation could largely explain differences between schools.

These studies both come from high income countries; I could find no published studies from LMICs using multi-level methods to examine school policy effects on nutrition outcomes. A Cochrane review by Langford *et al*[26] on health-promoting schools included 67 studies, three of which were from LMICs: there was one study examining school-based tobacco and alcohol interventions in India [202, 203], one study examining sexual health interventions in Tanzania[204], and a hand washing intervention in Egypt. Two of these[203, 204] used multi-level modelling to account for the clustered sampling methods. However, there were no studies on nutrition interventions from lower middle-income countries.

The school is just one of several environments where a child spends time. Beyond schools, the retail food environment or the home food environment is also likely to have an influence on a child's diet[71], and once children have left school, there is little that schools can do to keep children from consuming unhealthy foods. For this reason, schools may have a larger impact on a child's overall diet quality by focusing on the provision of *healthy foods* within schools, rather than focusing exclusively on trying to keep a child's overall consumption of *unhealthy foods* low.

5.4.3 Research questions three and four

As noted above, I observed significant between-school variation in diet quality, calcium and protein consumption and this variation was not due to the number of NFSI actions that schools were taking.

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[23] Based on school size, school denomination and the researcher's impressions of the school (*e.g.* welcome, organisation, student behaviour)

Sellstrom *et al* conducted a systematic review of multi-level studies of school contextual effects on student outcomes[205]. The study found four main school effects on student outcomes: having a health- or antismoking-policy, a good school climate, high average socioeconomic status, and urban location all had a positive effect on student outcomes. That said, the study findings have limited relevance to my findings because it did not include diet behaviour as an outcome measure[24] and the included studies were all based on research conducted within high income countries. I am not aware of any reviews which have examined multi-level analyses of school effects on student dietary outcomes. Despite the focus on non-nutrition related outcomes and high-income countries, the Sellstrom review has some relevance to my findings for several reasons. First, it suggests that the NFSI's emphasis on policy may indeed, be a school characteristic that deserves further inquiry. Second, it corroborates my findings that student outcomes vary between schools (even when accounting for individual characteristics) and suggests that targeting interventions to the school environment could therefore have positive effects.

Unlike the studies in Sellstrom's review, my research did not have variation in terms of whether or not schools were rural or urban—all of the schools were based in rural areas. The Sellstrom review's findings that school effects were observed more in urban environments is compelling and warrants further investigation using a study design that would include both rural and urban schools.

It is important not to confuse a non-significant finding with a significant finding of a non-effect. Within my research, there were no significant associations between the NFSI and nutrition outcomes, but this is not to say that the NFSI is ineffective. It could be, for example, that my NFSI survey did not accurately measure what schools were doing to promote healthier diets within schools.

[24] Outcomes under study were smoking habits, wellbeing, problem behaviour and school achievement.

From my surveys and field work observations, I saw that many students brought food from home or purchased food from shops that were located near schools. The availability of food in these 'out of school' environments was likely to have an effect on dietary outcomes, and it is possible that some of the observed 'school effects' on diet were actually due to unmeasured characteristics of these outside environments.

The Sellstrom review found that the average socioeconomic status of schools was an important characteristic to consider. In this study, I relied on socioeconomic measures which were not validated for use with adolescents, and it could be that the observed 'school effects' were due to the SES of the school as a whole, but that my measures failed to accurately capture the school SES. The Central Bank of Sri Lanka provides area-level measures of socioeconomic status[206], but these measures were not precise enough to correspond with individual schools. In many countries such as the United Kingdom and the United States, school socioeconomic status is frequently assessed by using the proportion of students with income-based eligibility for free school meals[207]. In Sri Lanka, free school meal eligibility is a product of student age and school size (rather than student income), so this is not a valid proxy measure.

While investigating the relationship between school approaches and student outcomes, it is important to consider other variables, aside from the school approaches, which could influence the quality of students' diets. I included a measure of home food security and maternal education, but it may have been important to consider other home environmental influences, such as family meal practices[208] or parental modelling of healthy behaviour[209]. Peer influences may also have an influence on diet[210], particularly during adolescence when young people are susceptible to peer pressure, and this was a factor that I did not explore. Additionally, I did not measure the effects of marketing and advertising, which use tactics such as celebrity endorsements to promote unhealthy products[211].

As part of research question four, I examined change in NFSI actions over time and change in student outcomes. There were no significant associations between changes in the actions that schools were taking and the nutrition outcomes of students (controlling for baseline variables). The positive effects of many school practices—from the provision of healthy food or the implementation of an effective referral system to health services—are likely to appear slowly over time. While I did observe a small increase in the number of NFSI actions that schools reported, it is possible that one year was not sufficient for detecting changes that were large enough to lead to meaningful improvements in students' diets.

At the same time, results from this study indicated that NFSI scores increased in INPARD intervention districts of Ampara and Moneregala, but they decreased in the control district of Kurunegala. These findings suggest that, given the appropriate resources, schools may be able to make positive changes to their environments. It is possible that if the time-line had been extended to more than a year, there would have been enough time to detect associations between changes in the school environment and associated changes in student outcomes. Multi-sectoral support for schools may be important for future research projects.

To the best of my knowledge, there have been no other research studies examining associations between NFSI activities and student outcomes. Delisle *et al* described piloting the NFSI in West Africa[73], and outlined the process by which pilot schools formed school nutrition committees to assess the school according to NFSI criteria. The paper provides a detailed description of how pilot schools received training workshops to help committees select and implement priority activities, but there was no evaluation of associated student outcomes.

5.5 Implications and recommendations

5.5.1 Recommendations for policy and practice

Sri Lanka, like many developing countries, is facing a nutrition transition influenced by economic and income growth, urbanization, globalization and a shift in the quality and quantity of dietary intake[212, 213]. This is likely to have lasting developmental, economic, social and medical impacts on individuals and communities[5]. Addressing malnutrition is essential for achieving the sustainable development goals[214], reducing health and social inequalities and ensuring educational attainment. Addressing these problems will require action across sectors and on many levels, from schools to households. The WHO's Global NCD Action Plan highlights some policy options related to creating healthier food environments[30], but more work is needed to translate the recommendations into practice, particularly within LMICs experiencing rapid environmental, epidemiological and demographic transitions.

Policymakers who are attempting to generate global recommendations face tremendous challenges as they work to create policies and frameworks that can be applicable across a wide range of contexts. There is no 'one-size-fits-all' approach, and as findings from this thesis suggest, one of the important challenges and opportunities for the future relates to finding ways to ensure that global recommendations are locally relevant, not only in developed, high-income countries--where the policies are often drafted--but also in rural LMICs.

Like many initiatives, the NFSI was largely generated by experts who were living in developed countries and who were drawing evidence from research studies conducted within schools in high-income countries. The fact that this study did not find significant associations between school approaches and student nutrition outcomes brought up some questions about the generalizability of the NFSI within rural LMIC contexts. One of the questions that emerged from this project was, 'How would the NFSI actions looked if they had been generated by principals living in rural Sri Lanka rather than technical experts living in Switzerland?' The stakeholders and policy makers in Switzerland certainly have a key role in promoting global health, but there is a second crucial step of translating the policies into local contexts, to ensure sustainability and relevance. This can only be done through inclusion and collaboration with the relevant stakeholders, both in making decisions and in building partnerships across ministries, sectors, and levels of authority. In this particular instance, this would mean engaging local, state, national and international groups from LMICs working within the government, private groups, non-profit groups and civil society organizations at the earliest stages of generating the NFSI framework. Having these groups at the table when frameworks such as the NFSI are being constructed may help to ensure that the barriers that these groups face are adequately addressed.

The inclusion of these stakeholders can be ensured through several mechanisms. For example, stakeholders must be included in voting and decision-making procedures and must be invited to attend meetings, surveys, public comment, public workshops, national forums and citizen advisory committees[215]. In order ensure the involvement of these groups, organizations must keep stakeholders informed and educated on the organization's governance policies. They must listen to stakeholder concerns and provide feedback, involve stakeholders to make sure that their perspective is understood, fully considered and integrated into decisions.

It is challenging to engage stakeholders, particularly when they geographically distant, but modern technology, including the widespread availability of free communication services such as e-mail and video conferencing leave few excuses for failing to include LMIC stakeholders during the process of drafting of global public health policy recommendations.

Fortunately, addressing the problem of malnutrition is a priority, both within Sri Lanka and globally. For example, WHO provides detailed guidance in its comprehensive implementation plan on maternal, infant and young child nutrition[216], which includes objectives, targets and a time frame for addressing nutrition-related illness. Schools feature prominently within these plans, with recommendations calling for the creation of supportive environments and stimulating nutrition policies outside of the health sector. It is heartening to see these developments, but more information is needed to understand the mechanisms and best practices related to multi-sectoral NCD prevention. These approaches will vary between contexts, so a tremendous challenge and opportunity awaits, both for knowledge sharing and for exploring how to translate findings between contexts.

Sri Lanka, in many ways, is exemplary when it comes to multisectoral NCD prevention. For example, the country has clear national policies aimed to reduce undernutrition and obesity among adolescents)[217], along with explicitly defined strategies[25] and indicators[26] for doing so. In 2016, the Sri Lankan Ministry of Health issued a National Multisectoral Action Plan for the Prevention and Control of NCDs: 2016-2020[34]. The policy prioritises implementing healthy canteen policies, health-promoting schools (including the development of guidelines for a healthy school), school-based health education programmes, and conducting a national school health survey[34]. It is important for this progress to be recognized, and there is an opportunity for other countries to learn from the headway that Sri Lanka has made in the nutrition promotion and NCD prevention arena.

That said, the gap between policy documentation and policy implementation is often wide, particularly in resource-scarce environments. During my field visits and early involvement with INPARD's qualitative research[70], it became clear that the school officials, families, government staff and students recognized the importance of nutrition, and were supportive of new policies which aimed to improve nutrition status. However, these stakeholders also faced many barriers, occurring at a number of levels including educational and agricultural policies,

[25]Strategies include 'creating a good nutrition enabling environment in schools (1.4.1)' 'enhancing nutrition services to non-school going adolescents (1.4.2)' and 'regular nutritional status assessment of non-school going adolescents and youth (1.4.3)'.
[26] Indicators include the prevalence of overweight, anaemia and under-weight among school children.

living and working conditions, social and community traditions and beliefs and individual knowledge and preferecnces[70]. One example of an economic barrier came from a canteen worker in Moneregala who was responsible for planning student meals. This employee worked in a school where the school nutrition committee had identified protein deficiency as an important issue to address. She explained that she wanted to include one egg per student in the daily school meal, but there was simply not enough money to pay for this. This story provided a clear example of how nutrition promotion must extend beyond providing education—it must reach also into public policy and economics, to ensure that schools have the resources that they need to make the positive changes that are recommended.

Schools in rural Sri Lanka, and globally, face budget shortfalls. School leaders are often put into the uncomfortable position of needing to prioritise where to allocate scarce funding—in one school that I visited, the principal explained that walls of the classrooms were collapsing, so classes were being held outside. In situations such as these, it is understandable why implementing some of the NFSI recommendations may not be feasible. Policy makers from education, finance and health sectors must ensure that schools have the resources that they need to provide the basic necessities of education. Then, once schools are equipped with the essentials—school buildings, funding for staff, school supplies, clean water—they may be able to start thinking about ways to implement other policies such as those recommended in the NFSI.

INPARD's qualitative research with school principals indicated that many people are moving away from locally-produced traditional foods and choosing more heavily processed and advertised foods which have recently arrived in these rapidly-developing districts[70]. As processed foods high in fat, sugar and salt become increasingly inexpensive and accessible, measures must be taken to increase the availability of healthier options. Some lessons may be learned from higher-income countries, so long as they are appropriately adapted for rural

LMIC contexts. For example, starting in 2015, the European Union, recognizing low consumption of fruit, vegetables and milk (and increased consumption of foods high in fat, salt and sugar among) among its student populations, allocated €250 million a year to subsidize fruit, vegetables and milk to school[218]. Not only does this initiative put healthier foods into the hands of students from a wide range of socioeconomic backgrounds, it supports the production of local agricultural goods. For governments struggling to balance the budget, such subsidies may not be tenable, but there are other opportunities for revenue generation. For example, the taxation of sugary drinks may provide a means to support subsidies of healthier food options. Recent examples may be drawn from other Southeast Asian countries such as India and Thailand, where governments are designing and implementing taxes on foods such as sugar-sweetened beverages[219]. The Maldives recently increased an import duty and tax on sugary drinks and tobacco products, which is one of the highest taxes on sweetened drinks globally[220].

Schools play an important role in encouraging healthier behaviour among students, as outlined in the NFSI, via education, role modelling and creating supportive environments. However, larger-scale efforts involving the actions of many multisectoral stakeholders are needed. Beyond fiscal policies, such as those outlined above[221], these multi-sectoral measures may involve agricultural policies which encourage the local production of healthy foods, cross-government collaboration to improve school food (such as school fruit schemes)[129], restrictions on marketing to children of foods high in fat, sugar and salt[222], and the development of economic policies which ensure that healthful food is accessible and affordable[193].

As economic development continues in LMICs such as Sri Lanka, health indicators—along with the traditional economic indicators—should be used to monitor and evaluate progress. While it is heartening that the Sustainable Development Goals agenda includes a formal commitment by governments to reduce by one third premature mortality from NCDs[223], a key part of this initiative will be appropriately monitoring and evaluating interventions to reduce NCDS. Indicators must extend beyond the prevalence of NCDS in order to also measure NCD risk factors.

5.5.2 Recommendations for research

Future research is needed to identify appropriate questions to assess the socioeconomic status of adolescents living in rural Sri Lanka. For these populations, widely used indicators (such as household income or parental education) may not be comprehensive enough. Research is needed to evaluate ways to broaden questions to assess other forms of household wealth, including household food production and agriculture. Other measures, such as the type of material used for roofing or flooring (which is used in the national census survey in Sri Lanka)[191], may also be useful. Once these measures have been identified, they must be validated to see if they are appropriate for use with adolescent populations.

This chapter discussed the limitations of the NFSI Tool, and opportunities to improve it through validation and more critical engagement with local stakeholders during the piloting phase of development. Additionally, the tool could be improved by including a measure to assess school-level affluence, such as the school's budget, expenses and sources of revenue. It will be important to balance the need to collect better information with the need to keep the NFSI Tool short, so as to minimize respondent burden.

Findings from this project suggested that there was some 'intervention contamination' in the INPARD project, due to the fact that Ampara and Moneregala included both intervention and control schools. In Sri Lanka, schools are managed at the district-level under regional directors and school principals from within the same district meet regularly to exchange information. Results from the INPARD project suggested that the 'intervention' principals were sharing best practices with the 'control' principals, a situation which made assessment of the INPARD project challenging. This situation provided lessons for future researchers about the value of having geographically isolated control districts (such as Kurunegala). Future research should explore how to better segment test and control schools within the same district and how to engage with school leaders to ensure that test and control groups are valid and constant. Future work is also needed to develop methods for assessing the effectiveness of complex, multi-sectoral, community-led nutrition promotion and development interventions within rural Sri Lanka.

Future research should also focus on the qualitative aspects of nutrition promotion in rural LMICs, which may enrich and strengthen interpretation of quantitative research findings.

My early involvement with qualitative research, examining the barriers to healthy dietary choice among students within a socio-ecological framework, discovered obstacles to healthy nutrition which occur at many levels[70]. This work highlighted the critical role that schools may play in promoting nutrition, but it also highlighted the importance of the home environment and other more upstream factors, such as agricultural and economic policies.

A recent WHO report highlighted the importance of 'double-duty' actions, which have the potential to address both sides of malnutrition through common interventions[224]. The report cites school food policies and programmes as potential candidates for achieving this 'double duty' status. However, findings from this study bring up questions about whether a 'one-size-fits-all' policy approach (*i.e.* one global NFSI framework which aims to simultaneously tackle both under- and over-nutrition) is the most suitable type of intervention. For my study population, the predominant nutrition problem was underweight. It is unclear that the NFSI, which was designed to tackle both under- and over-nutrition (but which was developed in a context where the predominant problem was over-nutrition), was the optimal approach. More research is needed to examine whether an alternative approach that focused specifically on school-based approaches to address food scarcity, food insecurity and undernutrition would have been more effective at improving the nutrition status of students in my population.

Future studies should integrate measures of the retail environment around schools into the characterization of 'school food environments'. A great deal of work examining associations between retailing around schools and student nutrition outcomes has been done in North America and Europe[71], but limited research has been conducted within LMICs.

Schools, particularly those in resource scarce settings, often lack the resources or capacity to fully adopt policies such as the NFSI. Additional work is also needed to advance the field of implementation research in the prevention and control of NCDs, which is a relatively new area of study. Implementation research investigates the various factors that influence whether or not a policy is implemented in the real world. A recent guide by WHO describes the various steps needed to carry out implementation research, from the initial situation analysis and knowledge synthesis, to identification of an appropriate policy or intervention, adaptation and piloting of the policy of intervention, implementing the policy or intervention, evaluation and scaling up of the policy or intervention[225].

5.5.3 Concluding remarks

This study highlighted that urgent action is needed to improve the nutrition status of adolescents living within rural Sri Lanka. By identifying and applying methods to examine associations between NFSI actions and student outcomes using a range of tools and methods, this study has laid the foundations for future work on school-based nutrition promotion within rural LMICs. This research demonstrates some of the challenges and opportunities that lie ahead. For researchers and policy-makers, future work is needed to identify the best approaches for improving adolescent nutrition within Sri Lanka. Additional work is needed to improve the monitoring and evaluation of school NFSI actions and student nutrition outcomes. Researchers and policy makers must involve and collaborate with local stakeholders to ensure the validity of their tools and the sustainability of their activities. In order to meet the Sustainable Development Goals related to the reduction of premature mortality from NCDs[214], continued work is needed to identify the particular role that schools may play within a multi-sectoral NCD prevention framework.

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Appendix One. School-based nutrition programmes in Sri Lanka

According to the WHO Global database on the implementation of nutrition action (GINA), Sri Lanka is currently implementing the following recommended interventions: monitoring growth, implementing school feeding programmes, promoting health-promoting schools (including the nutrition-friendly schools initiative), providing iron and folic acid supplementation, providing Vitamin A supplementation, providing deworming, implementing legislation on the marketing of unhealthy foods and beverages, improving food safety at vending places and providing water to schools[226]. According to a WHO global nutrition policy review[227], Sri Lanka has already made progress adopting some of the recommendations outlined in the WHO's NFSI (which is part of the 'health-promoting schools' framework). For example, the policy review notes that Sri Lanka has a referral health system for children who require nutrition interventions which was set up by the Sri Lankan Ministries of Education and Health. However, there is no published evaluation on the level of implementation or the effects of this programme on student outcomes.

Sri Lanka has a rich history of school-based health promotion, with school health programmes dating back to 1919, when medical officers were appointed to investigate children for oral diseases, hookworm, inflammation of tonsils and adenoids, malnutrition, pediculosis, eye defects and scabies[228]. During the early days of the health programme, the school medical officers observed malnutrition among the school children and recommended a free mid-day meal for schools with a high proportion of malnourished children. Between 1934 and 1935, a malaria epidemic broke out and the government started providing some schools with free meals. This tradition continues today, with the government paying students' parents or family members to prepare the meals, which are usually cooked at home and brought to school as a mid-morning meal. School eligibility for government funds to provide the meals depends upon the size of the school and the age group of the students that are covered. The

Sri Lankan Department of Health Service runs a larger school health programme which also includes public health inspections. Public health inspectors coordinate many of the activities, which include conducting quarterly surveys where schools are assessed in the following areas: provision of sanitary facilities, provision of clean drinking water, the absence of unprotected wells, the absence of unhealthy food and drinks within school premises, the absence of mosquito-breeding places, provision of garbage disposal, provision of waste management, the condition of school buildings and the measurement of school children.

Figure 1. A public health inspector (centre) at a school in Moneregala

In 2003, a dissertation in community medicine by De Silva highlighted some of the health problems which were identified during school medical inspections[229]. These included inefficiencies in the various school-based nutrition interventions and varying levels of implementation between schools. The thesis concluded that a properly planned nutrition intervention programme was needed to address Sri Lanka's nutrition problems.

1.2 The public health challenge of adolescent nutrition in low- and middle-income countries

Nutrition is an important factor for ensuring good health throughout the entire life course, but it is particularly important during adolescence[230]. There are 1.2 billion adolescents (people aged 10-19 years) in the world with 90% living in LMICs[230]. Adolescents comprise almost a fifth (19%) of the population in LMICs (and 17% of the Sri Lankan population[231]), compared to 12% of the population in industrialised countries[232].

Nutrition during adolescence is critical because of its role in ensuring proper growth, development, cognition and capacity to learn[233, 234]. Health systems in many LMICs look after the health and nutrition of young children and women, but their systems are often not organised to focus on the nutrition of adolescents[231]. Many health behaviours established early in life are tracked into adulthood[234, 235], so adolescence represents a key opportunity to encourage healthy habits that will protect individuals from disease later in life. Furthermore, the nutritional status of adolescent girls may have intergenerational effects in instances when a young woman becomes pregnant and her nutritional status is passed along to her offspring[236][27].

Foods, diets and nutritional status are important determinants of NCDs, which disproportionately affect people living within LMICs[237-239]. Nearly three quarters of all NCD deaths and 82% of premature NCD deaths occur within LMICs[240]. NCDs pose a major challenge to social and economic development [241, 242] and addressing them is a global priority[243].

[27] Adolescent fertility in LMICs tends to be higher than it is industrialised countries, but this is not the case in Sri Lanka. In Sri Lanka, there are 14.15 births per 1,000 women ages 15-19, which is on par with the rate seen in the United Kingdom (14 per 1,000), lower than the rate seen in the United States (21 per 1,000 women) and far below the average for lower-middle income countries (45.33 births per 1,000). (United Nations Population Division, Adolescent fertility rate is the number of births per 1,000 women ages 15-19. 2014).

Research from high-income countries suggests that disadvantaged and marginalised groups have a higher NCD burden, but there has been a lack of research on the relationship between socioeconomic status (SES) and NCDs within LMICs. As part of my DPhil work, I conducted a systematic review to map the literature on the socioeconomic gradient of NCDs within low- and lower-middle income countries (LLMICs). The review, which is provided in Appendix One, found that SES groups were more likely to have cancer (14 of 18 studies) and cardiovascular disease (11 of 15 papers), but high SES groups were more likely to have diabetes (7 of 11 studies). One of the most important findings from this review was the lack of research from LLMICs—just 17 of 84 LLMICs were represented, highlighting a need for work to understand and address the socioeconomic gradient of NCDs within developing countries.

During my DPhil, I co-authored a second review on NCD *risk factors* within LLMICs. This review included primary literature published between 1990 and 2015 using 13 electronic databases, including Embase and Medline, as well as a grey literature review and hand searching of references. After reviewing 4,242 records, 75 studies were included, representing 2,135,414 individuals from 39 LLMICs. The review found that poor or less educated people were more likely to have unhealthy diets compared to others who were wealthy or more educated[185].

There were no studies from Sri Lanka represented in either review, highlighting the need for more research from this part of the world.

Appendix Two. A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries

Summary

This chapter summarises a systematic review of associations between non-communicable diseases (NCDs) and socioeconomic status (SES) within low- and lower-middle-income countries (LLMICs). Sri Lanka, where this DPhil research study takes place, is a lower-middle income country (LLMIC). Contrary to popular perception, the highest burden of NCDs is observed within developing countries like Sri Lanka. However, there is a lack of research on associations between SES and NCDs within these contexts. This review provides some of the theoretical background behind my research, which focused on school-based approaches to NCD prevention. It demonstrated that low SES groups have higher NCD risk in LLMICs, which suggests that school-based approaches to nutrition-promotion—which provide access to children from all socioeconomic backgrounds—may play an important role in efforts to prevent and control NCDs.

Abstract

Research from high income countries suggests that lower SES groups have a higher risk of NCDs, but there has been a lack of research examining associations between NCDs and SES within these contexts. The aim of this systematic review was to map the literature on evidence from LLMICs related to associations between socioeconomic status and NCDs. A comprehensive literature search was conducted for research published between 1 January 1990 and 25 April 2015 using six bibliographic databases. I included studies that reported on socioeconomic status (SES) and morbidity and mortality from cardiovascular diseases, diabetes and chronic respiratory diseases within LLMICs. The final review included 57 studies

from 17 LLMICs. The results indicated that lower SES groups had the highest risk of cancer and cardiovascular diseases, but higher SES groups had the highest risk of diabetes. Findings suggest that interventions to prevent NCDs should target both low- and high-income groups. One way to target low-income groups is through school-based health promotion. Schools provide access to students from all socioeconomic groups, and so they may be an important setting for implementing NCD prevention strategies among lower SES groups.

Background

Non-communicable Diseases (NCDs) such as cardiovascular disease, cancer, diabetes and chronic respiratory diseases disproportionately affect people living within low- and lower middle-income countries (LLMICs) [1-3]. Almost three quarters of all NCD deaths and 82% of premature deaths occurring within LLMICs[4]. There has been increased interest in the relationship between NCDs, poverty and social and economic development[5], because NCDs pose a major challenge to development in the 21st century[6, 7]. The relationship between socio-economic status and health is complex and shaped by many political, social and economic factors[8]. Often, the poor are vulnerable to NCDs due to material deprivation, psychosocial stress, higher levels of risk behaviour, unhealthy living conditions, limited access to high-quality health care and reduced opportunity to prevent complications[9]. Evidence shows that low SES groups are more likely to consume unhealthy foods, use tobacco products, be physically inactive, and to be overweight or obese[10-11].

In high income countries, the evidence suggests that high socioeconomic status is positively associated with good health [12-16]. NCDs disproportionately affect lower socioeconomic groups [17]. However, there is a lack of research on the relationships between SES and NCDs within developing countries[18-20]. Global cross-country analyses suggest that living in a low- or middle- income country is associated with increased risk of developing cardiovascular diseases (CVD), lung and gastric cancer, type 2 diabetes, and Chronic Respiratory Diseases

(CRDs)[20]. These country-level comparisons also indicate that, relative to middle- and high-income countries, low-income countries have some of the highest levels of wealth-related relative inequalities in NCD risk factors [17, 21]. However, few studies have considered the relationships between SES and NCDs within LLMICs. It is not known if the trends that are observed within higher income countries also hold true within developing countries.

The UN's Sustainable Development Goals for 2030 include a goal "reduce by one third premature mortality from NCDs" (Target 3.4)[22]. In order to work toward this goal, it is important to understand the socioeconomic distribution of NCDs within developing countries.

The purpose of this review is to summarise the evidence on the socioeconomic distribution of NCDs within LLMICs. This review provides a general summary of findings according to region, followed by a detailed discussion of the types of outcomes and types of socioeconomic indicators reported.

Methods

This review included the four outcomes which contribute to the highest NCD burden[23]: cancer, cardiovascular diseases (CVD), chronic respiratory diseases (CRDs) and diabetes. We developed and published a full protocol for this review on the international prospective register of systematic reviews (reference CRD42016039030) [24] and conducted a comprehensive literature search using a combination of free text terms and subject headings to describe socioeconomic status and CVD, cancer, diabetes and chronic respiratory disease. We searched the following publication databases: MEDLINE (OvidSP), EMBASE (OvidSP), Global Health (OvidSP), Web of Science Core Collection and Dissertations & Thesis (Proquest). We also included a search of the Global Health Library, restricted to the following regional databases – AIM, LILACS, AMRO, IMSEAR, WPRIM & WHOLIS. Additionally, we hand-searched the reference sections of key articles for additional relevant papers and contacted authors for data that were not reported in published papers. Medline search terms are provided in Table 1.

Table 1. Medline search terms

# ▲	Searches
1	cardiovascular diseases/ or heart diseases/ or vascular diseases/ or cerebrovascular diseases/
2	exp Myocardial Ischemia/
3	Heart Failure/
4	exp brain ischemia/ or exp stroke/
5	exp Diabetes Mellitus, Type 2/
6	lung diseases, obstructive/ or exp pulmonary disease, chronic obstructive/
7	exp *Neoplasms/
8	((cardiovascular or cardio-vascular) adj3 disease*).ti,ab.
9	((cardiovascular or cardio-vascular) adj3 (event* or outcome* or risk*)).ti,ab.
10	((coronary or heart or myocard*) adj3 disease*).ti,ab.
11	((coronary or heart or myocard*) adj3 (event* or outcome* or risk*)).ti,ab.
12	((ischaemic or ischemic or ischaemia or ischemia) adj3 disease*).ti,ab.
13	((ischaemic or ischemic or ischaemia or ischemia) adj3 (event* or outcome* or risk*)).ti,ab.
14	myocardial infarct*.ti,ab.
15	((cerebrovascular or vascular) adj3 disease*).ti,ab.
16	((cerebrovascular or vascular) adj3 (event* or outcome* or risk*)).ti,ab.
17	stroke.ti,ab.
18	heart failure.ti,ab.
19	diabet*.ti.
20	((type 2 or type ii or noninsulin dependent or non insulin dependent or adult onset or maturity onset or obes*) adj2 diabet*).ti,ab.
21	(niddm or t2dm or tiidm).ti,ab.
22	(chronic adj2 (lung or pulmonary)).ti,ab.
23	copd.ti,ab.
24	(neoplas* or cancer* or carcinoma* or tumor* or tumour* or malignan* or leukaemia or leukemia or lymphoma?).ti,ab.

25 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24

26 exp Poverty/

27 Socioeconomic Factors/

28 Income/

29 Gross Domestic Product/

30 Economic development/

31 "Salaries and Fringe Benefits"/

32 poverty.ti,ab.

33 ((socioeconomic or socio-economic or economic) adj2 (factor? or inequalit* or indicator? or status or development)).ti,ab.

34 ((household? or house-hold? or family or families) adj3 (income or earning? or wage? or poor or wealth)).ti,ab.

35 (gross domestic product or gross national product or gdp or gnp).ti,ab.

36 (unemploy* or (employment adj2 (status or indicator? or level?))).ti,ab.

37 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36

38 Developing Countries/

39 (Afghanistan or Angola or Armenia or Armenian or Bangladesh or Benin or Bhutan or Bolivia or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Cote d'Ivoire or Ivory Coast or Djibouti or French Somaliland or East Timor or East Timur or Timor Leste or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Gold Coast or Guatemala or Guinea or Guinea-Bisau or Guam or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Kenya or Kiribati or (Democratic People* adj2 Korea) or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lesotho or Basutoland or Liberia or Madagascar or Malawi or Nyasaland or Mali or Mauritania or Micronesia or Moldova or Moldovia or Moldovian or Mongolia or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Pakistan or Palestine or Papua New Guinea or Paraguay or Philippines or Philipines or Phillipines or Phillippines or Rwanda or Ruanda or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Sierra Leone or Sri Lanka or Ceylon or Solomon Islands or Somalia or Sudan or Swaziland or Syria or Principe or South Sudan or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Timor-Leste or Togo or Togolese Republic or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe or Rhodesia).hw,kf,ti,ab,cp.

40 ((developing or less* developed or under developed or underdeveloped or low* middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or state? or population? or world)).ti,ab.

41 ((developing or less* developed or under developed or underdeveloped or low* middle income or low* income) adj (economy or economies)).ti,ab.

42 (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab.

43 (lmic or lami).ti,ab.

44 transitional countr*.ti,ab.

45 38 or 39 or 40 or 41 or 42 or 43 or 44

46 exp Mortality/

47 Morbidity/

48 Survival Rate/

49 (mortality or survival or death?).ti,ab.

50 morbidit*.ti,ab.

51 46 or 47 or 48 or 49 or 50

52 25 and 37 and 45 and 51

53 cardiovascular diseases/mo or heart diseases/mo or vascular diseases/mo or cerebrovascular diseases/mo or exp Myocardial Ischemia/mo or Heart Failure/mo or exp brain ischemia/mo or exp stroke/mo or exp Diabetes Mellitus, Type 2/mo or lung diseases, obstructive/mo or exp pulmonary disease, chronic obstructive/mo or exp *Neoplasms/mo

54 53 and 37 and 45

55 52 or 54

This review included papers published between January 1, 1990 and 27 April 2015. Papers were required to provide outcome data on cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases (CRDs) occurring within LLMICs, which were defined according to the World Bank's 2013 definition (per capita income of less than or equal to $1,045 for LICs and between $1,046-$4,125 for LMICs)[25].

To compare outcomes between different socioeconomic groups, we required papers to report NCDs stratified by an indicator of SES (See Table 2.2) and to include an internal comparison between groups. To include research from as many LLMICs as possible, this review did not restrict papers based on study design, type of SES indicator or by the summary analysis of the outcome measure.

Table 2. Population, exposure, comparator and outcome for the systematic review

Population	**Exposure**	**Comparator**	**Outcome**
General populations (different income levels) from low- and lower-middle-income countries [25]	Socioeconomic status, measured according to income, access to basic needs (e.g. housing), human capabilities (e.g. literacy), household possessions/wealth or other measures. In the initial screening, we did not restrict studies based on the type of SES or poverty indicator that the paper used.	We compared outcomes among populations from one socioeconomic level to those in another. Where possible, we focused on outcomes among the lowest SES groups and by sex.	Morbidity or mortality (including premature mortality) from NCDs from: 1) Cardiovascular diseases (coronary heart diseases and strokes) 2) Cancer 3) Diabetes (type II) 4) Chronic respiratory diseases

Identifying papers for inclusion

I was responsible for examining the titles, abstracts and full-text articles, bringing uncertainties to my co-authors (LA, KW, and NT). A second researcher (LA) checked a 10% sample of titles and full text articles. The percentage agreement was calculated and deemed acceptable using Cohen's Kappa statistics[26]. Disagreements were resolved via group consensus.

Heterogeneity in exposure and outcome measures precluded meta-analysis, so this study adopted a narrative approach that summarised studies by disease outcome and WHO region.

Quality assessment

Study quality relates to the appropriateness of its design, implementation, analysis and presentation for a given research question[27]. There were no existing quality assessment tools that were appropriate for all of the papers in this review, so I adopted a descriptive approach for quality assessment using a modified version of the Newcastle-Ottawa scale[28, 29] and methods presented by Herzog *et al.*[30]. The tool implements a points-based system to judge the quality of studies based on the selection of the study groups, the comparability of the groups and the ascertainment of the measures. I used these scores to rank study quality as 'high', 'medium' or 'low' quality and stratified them according to their study design.

Results

The search information is summarised in Figure 1 following PRISMA guidelines[31]. More than 4,000 articles were retrieved by the initial search and an additional 14 were found via hand searching. A total of 57 studies from 17 countries and presenting outcomes from 494,904 people were included in the final review (Figure 2). Around half (n=27) of the studies included in their abstract an explicit aim to investigate associations between SES and NCDs, while the remaining studies aimed to investigate a wide range of factors, including SES. Around half (n=30) published within the last six years (Figure 3). Thirty of the studies were cross-sectional, 18 were cohort studies, and nine were case-control studies. Around half of the studies in this review used population-based surveillance systems or household sampling methods to identify and recruit study participants from the community while the remaining half drew study participants from patient populations in hospital-based studies. Twenty-six of our studies were ranked as 'high' quality, 28 as 'medium' quality and 3 as 'low-quality.' The quality of papers was limited by weaknesses related to selection of controls, ascertainment of exposures/outcomes, and high non-response rates. This review included eight papers from Africa, seven from the Eastern Mediterranean, six from the Western Pacific, three from the Americas and one from the European Region. The most well represented region was Southeast Asia, which contributed 32 papers, of which 27 came from India.

Types of Outcomes

Summaries of included studies, grouped according to outcome and region, are provided in Tables 3-7.

Figure 1. Findings according to PRISMA guidelines

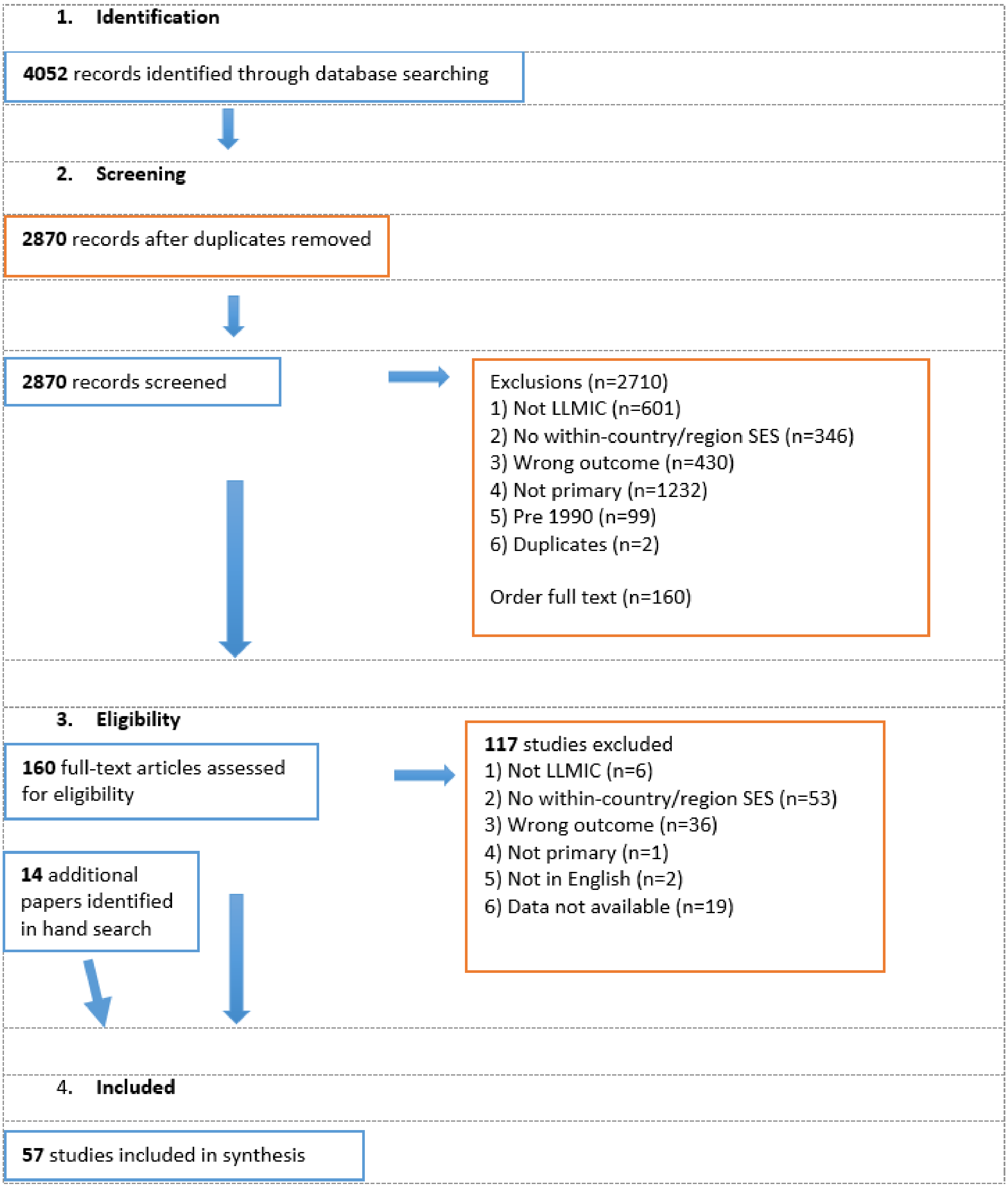

Figure 1. Map summarising countries represented in this review

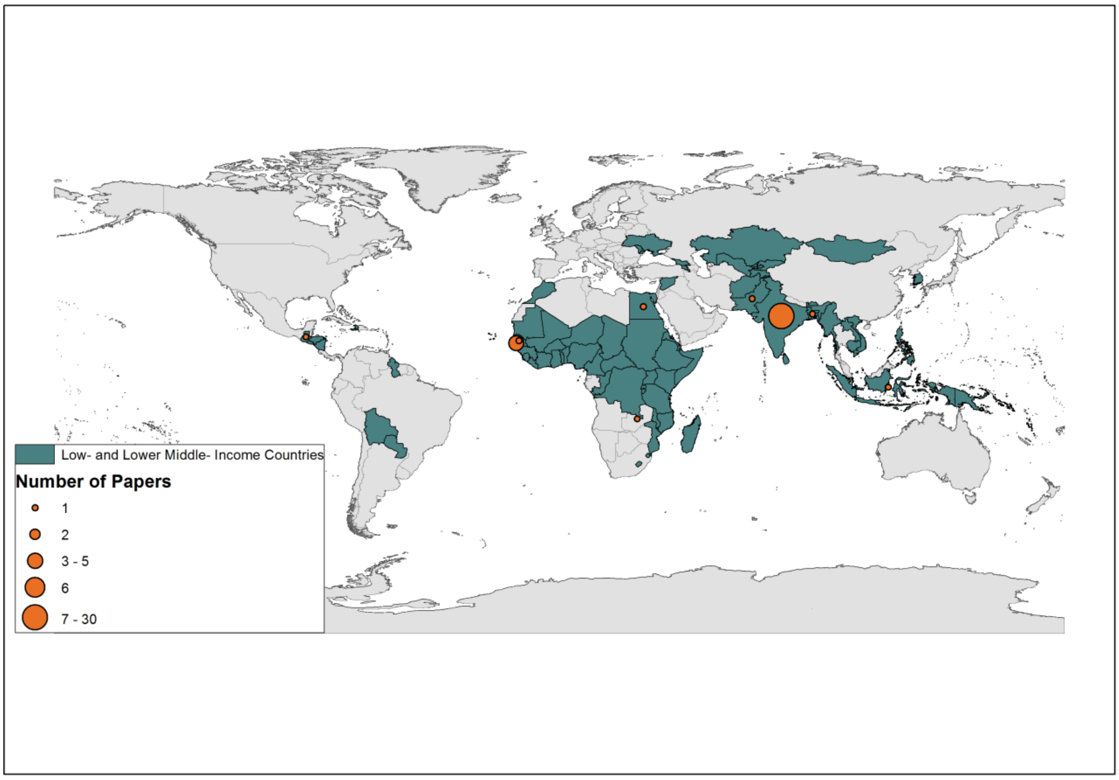

Figure 3. Number of studies by year of publication

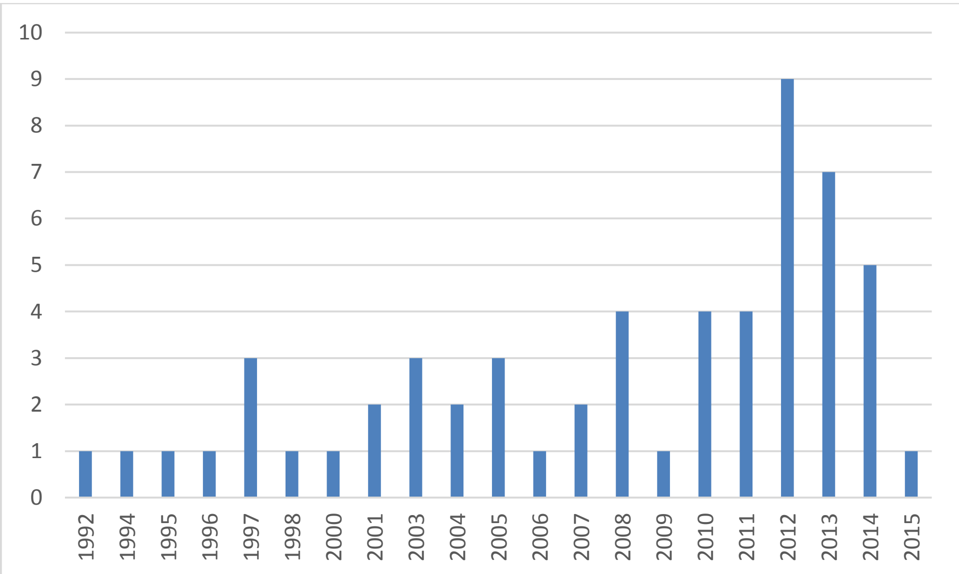

Table 3 Included studies with cancer outcomes, by region

Study	Country	Design	n	Quality	Sample	Exposure	Outcome	Highest Risk Group
Africa								A: Adjusted * <.05 **<.01 ***<.001
Jordan *et al.*, (2013)	Tanzania	Case control	345	Medium	115 cases and 230 age- and district-matched controls.	Property Index	Breast cancer	Higher property level* (A)
Misganaw *et al.*, (2013)	Ethiopia	Cross-sectional	3,709	Medium	Malignancy mortality data for 3,709 adults (15 and older) who died in Addis Ababa between 2006 and 2009 (identified via burial surveillance) and whose families could be interviewed to determine cause of death.	Education	Malignant neoplasm mortality	Higher education** (A)
Parkin *et al.*, (2000)	Uganda	Case control	194	High	Cases included 50 adults and 132 children with histologically diagnosed lymphoma. Controls were adults with cancers unrelated to HIV and children with non-infectious diseases.	Education	non-Hodgkin lymphoma	Higher education
Eastern Mediterranean								
Aziz *et al.* (2008)	Pakistan	Cohort	525	Medium	525 patients with stage I-III breast cancer presenting to the Department of Oncology from January 1997 to December 2005	SES	Event free survival in stage I-III breast cancer Overall survival in stage I-III breast cancer (n=525)	Lower SES*** (A) Lower SES** (A)
Aziz *et al.* (2010)	Pakistan	Cohort	237	High	237 women undergoing multimodality treatment for locally advanced breast cancer (LABC) treated between Jan 200 and December 2005 at Jinnah Hospital Pakistan)	SES	Event-free survival in locally advanced breast cancer Overall survival in locally advanced breast cancer	Lower SES* (A) Lower SES

Aziz *et al*. (2004)	Pakistan	Cohort	286	High	286 patients with breast cancer recruited between 1996 and 1998	SES	Breast cancer	
							Size of tumour (71)	Low SES**
							Stage at diagnosis (I)	Low SES**
							Mean number of lymph nodes positive	Low SES
							Mean time elapsed before diagnosis (months)	Low SES**
							Mean age at diagnosis (years)	Low SES**
							Five year disease free survival	Low SES***
							Five year overall survival	Low SES**
Chaouki *et al*., (1998)	Morocco	Case control	460	High	245 cases and 215 controls from Rabat Morocco. Cases of invasive cervical cancer identified among first attendants at hospital. Cases were verified histologically. Controls identified at same hospital and in a nearby general hospital.	Education	Cervical cancer	Lower education***
						Wealth (facilities at home)		Fewer facilities at home***
						Income		Lower family income***
Khan *et al*., (2015)	Pakistan	Cross-sectional	315	Low	315 female patients from Oncology Institute in Islamabad	Education	Breast cancer presentation delay	Lower education *
Region of the Americas								
Bonilla *et al*., (2010)	El Salvador	Cohort	886	High	433 de novo acute lymphoblastic leukaemia patients 0-16 years of age, diagnosed between 2000 and 2007.	Education (parent)	Event free survival (standard risk patients)	Lower education (parent)** (A)
						Income	Event free survival (High risk patients)	Lower monthly income* (A)
						Education (parent)	Event free survival (standard risk	Lower education (parent) (A)

						Income	patients) Event free survival (High risk patients)	Lower monthly income (A)
Gavidia *et al.*, (2012)	El Salvador	Cohort	251	High	251 children aged 0-16 years with newly diagnosed acute leukaemia treated at Benjamin Bloom hospital, San Salvador	Mother's education Father's education Income Household Characteristics Household Characteristics	Leukaemia patient outcome: Sepsis	Mother illiterate* (A) Father literate (A) Annual Household Income <$2000 (A) Clean water at home (A) No toilet at home (A)
						Mother's education Father's education Income Household Characteristics Household Characteristics	Leukaemia patient outcome: Infectious death	Mother illiterate (A) Father illiterate (A) Annual Household Income <$2000* (A) No clean water at home (A) No toilet at home (A)
Gupta *et al.*, (2012)	El Salvador, Honduras, Guatemala	Cohort	279	High	279 patients younger than 21 years diagnosed with AML from 2000 to 2008 in El Salvador, Honduras or Guatemala	Monthly purchasing power units Education (parent)	Leukaemia: treatment-related mortality	Higher Purchasing Power (A) Higher education (A)
SE Asia								
Ali *et al.* (2008)	India	Cross-sectional	522	Medium	Breast cancer patients from Kerala or Tamil Nadu visiting a regional cancer centre	SES Education (parent)	Late stage diagnosis of breast cancer (stages III and IV)	Lower SES (A) Illiterate* (A)

Burkart *et al*., (2011)	Bangladesh	Cross-sectional	21,551	Medium	Mortality data (n=21,551) from the Bangladesh Bureau of Statistics for period from 2002 to 2007, using a sample comprised of 1,000 primary sample units in rural and urban areas. Deaths recorded by officials quarterly and then verified through field visits.	SES (of region)	Deaths attributable to cancer	High SES region
Chankapa *et al*., (2011)	India	Cross-sectional	968	Medium	968 adult women aged 15-60 years	Education	Cervical cancer: Low-grade squamous intraepithelial lesion	Illiterate
						Monthly family income	Cervical cancer: High-grade squamous intraepithelial lesion	Lower income
Dutta *et al*., (2005)	India	Cohort	121	Medium	Between 1994 and 2001, 121 patients diagnosed with gallbladder cancer were evaluated prospectively in the gastroenterology services of two hospitals.	SES	Age of diagnosis for gallbladder cancer	Low SES* (A)
Gajalakshmi *et al*., (1997)	India	Cohort	1,747	High	1747 patients registered at population based cancer registry (part of national network) (inclusion criteria: follow up data available)	Education	Five year breast cancer survival (% by education level)	Illiterate* (A)
Mostert *et al*., (2012)	Indonesia	Cohort	143	High	145 patients diagnosed with a malignancy at academic hospital (Inclusion criteria required age to be between 0-16 years with newly diagnosed malignancy	Hospital class, insurance status	Childhood cancer (Abandonment of treatment)	Poor**
							Childhood cancer (Event-free survival)	Poor**
Patil *et al*., (2014)	India	Case control	380	High	141 cases of patients with hepatocellular carcinoma and 240 controls with chronic liver disease (age 18-70), seeking treatment at two centres in Mumbai	Income	Hepatocellular carcinoma	Higher income*
Sankaranarayanan *et al*., (1995)	India	Cohort	452	High	Cervical cancer cases (age 35-65) registered from 1 January to 31 December	SES	5 year survival from cervical cancer	Low SES* (A)

SE Asia								
Le Tran *et al.*, (2001)	Vietnam	Cross-sectional	5,034	Medium	5,034 patients with cervical cancer treated in the Central Oncology of Ho Chi Minh City from Nov. 1989-Nov 1994	Education	Cervical cancer	Illiterate*
Lan *et al.*, (2013)	Vietnam	Cohort	948	High	5,034 patients with cervical cancer treated in the Central Oncology of Ho Chi Minh City from Nov. 1989-Nov 1994	Education	Survival probability following diagnosis of breast cancer	Lower education* (A)
							Survival probability following diagnosis of breast cancer (Extended Cox model assessing effect)	Lower education* (A)
Western Pacific								
Xin *et al.*, (2014)	Mongolia	Cross-sectional	643	Medium	643 deaths	Education	Years of life lost (YLL) due to colorectal cancer and average years of life lost (AYLL) due to colorectal cancer in each region	Higher education**

Table 4. Included studies with cardiovascular disease outcomes, by region

Study	Country	Design	n	Quality	Sample	Exposure	Outcome	Highest Risk Group
Africa								A: Adjusted * <.05 **<.01 ***<.001
Miszkurka *et al.*, (2012)	Burkina Faso	Cross-sectional	4,822	Medium	4,822 adults over the age of 18 (47% male) sampled through a multi-stage stratified random cluster sampling strategy by gender, age, rural/urban setting).	Education Income	Angina (prevalence)	Some education (A) Higher income* (A)
Eastern Mediterranean								
Engels *et al.*, (2014)	Morocco	Cross-sectional	44,742	Medium	Data from 13,279 households (60,031 individuals) collected via door-to-door survey. Sampled population demographically and socio-economically representative of Morocco.	Wealth Wealth Wealth	Stroke prevalence (overall) Stroke prevalence (rural) Stroke prevalence (urban)	Lower wealth (A) Medium-levels of wealth (A) Lower wealth* (A)
SE Asia								
Chandrashekhar *et al.*, (2014)	India	Cross-sectional	370	Low	370 persons age 60 and older in urban and rural field practice area of Department of Community medicine in Gulbarga.	Education Class	CVD CVD	Some education** Middle class
Das *et al.*, (2007)	India	Cohort	51,533	High	52377 adults living in Kolkata, selected via stratified random sampling.	Slum versus non-slum	Stroke prevalence	Residents of slum areas

							Stroke incidence	Residents of slum areas
							Stroke (case fatality rate)	Residents of non-slum areas
Dogra *et al*., (2012)	India	Case control	442	Medium	442 participants (184 cases (<=40 years) with definite AMI (as per WHO criteria) and 350 (<=40 years) controls)	SES	AMI	Low SES** (A)
Kisjanto *et al*., (2005)	Indonesia	Case control	917	Low	235 cases and 682 age-matched controls of women (aged 20-44 years) from 14 hospitals in Jakarta, recruited between 1989 and 1993.	Social class	Stroke	Higher class (A)
						Education	Stroke	Higher education* (A)
Singh *et al*., (1997)	India	Cross-sectional	1,764	High	Adults living in randomly selected villages who had lived in the area since birth.	SES	CAD (males)(Crude)	High SES**
						SES	CAD (females)(Crude)	High SES*
						SES	CAD (males)	High SES (A)
						SES	CAD (females)	High SES (A)
Xavier *et al*., (2008)	India	Cohort	18,862	High	12,405 patients given a definitive diagnosis of electrocardiograph changes or suspected MI who were readmitted 30 days later.	Class	Odds of mortality after 30 days following acute coronary symptoms (CRUDE)	Poor* (A)
						Class	Odds of mortality after 30 days following acute coronary symptoms (Adjusted)	Poor (A)

Yadav R*et al*., (2013)	India	Cohort	599	High	599 stroke registry patients from urban and rural population admitted to the neurology department at a tertiary care centre in North India.	Job status	Stroke morbidity	Lower occupation category (A)
Gupta *et al*., (1994)	India	Cross-sectional	3,148	High	3148 residents aged over 20 (1982 men, 1166 women) divided into various groups according to years of formal schooling. Randomly selected from a cluster of three villages in rural India.	Education Education	CHD (men) CHD (women)	Lower education (men) Lower education (women)**
Pednekar *et al*., (2011)	India	Cohort	148,173	High	148,173 individuals aged ≥ 35 years were recruited in Mumbai during 1991-1997 and followed to ascertain vital status during 1997-2003.	Education Education	CVD mortality (men) CVD mortality (women)	Less education (A) Some education(A)
Rao *et al*., (2011)	India	Cross-sectional	2,129	Medium	Sample of adults with CVD (n=2,129) and diabetes (439) drawn from 47,302 rural and 26,566 urban households.	Education	CVD (self-reported, including hypertension)	Lower education*
Rastogi *et al*., (2011)	India	Case control	1,050	High	350 cases and 700 controls, recruited equally from New Delhi and Bangalore. The subjects' mean (SD) age was 52 (11) y, and 12% of the subjects were women	Education Income	AMI (relative risk) AMI (relative risk)	Lower education* (A) Lower income* (A)
Pais *et al*l, (1996)	India	Case control	400	High	200 Indian patients with a first acute myocardial infarction (AMI) and 200 age and sex matched controls aged 30-60years.	Income	AMI (Odds if low income)	Low income* (A)
Singh *et al*., (2005)	India	Cross-sectional	2,222	Medium	2842 randomly selected adults (25-64) who died between July 1999 to July 2001 in Moradabad, India.	Social Class 1 (More Affluent)	Circulatory Diseases (mortality)(males)	Higher social class*
Sharieff *et al* (2003)	Pakistan	Cohort	35	Medium	35 patients with heart failure in the last month of pregnancy or 5 months postpartum,	SES	Peripartum cardiomyopathy: Recovery or deterioration after 6 months	Lower SES*

Western Pacific								
Hoang *et al*., (2006)	Vietnam	Cohort	1,067	High	1067 adults (≥20 years) living in a predominantly rural area died of all causes from 1999-2003	Education SES	CVD mortality CVD mortality	Less education* (A) Non-poor (A)
Minh *et al*., (2003)	Vietnam	Cohort	64	High	249 deaths (64 related to CVD) registered in Bavi District, a population of approximately 50,000 in a rural area 60 km to the west of Hanoi.	Education Economic condition	CVD mortality CVD mortality	Inconclusive (A)
Enkh-Oyun *et al*., (2013)	Mongolia	Cross-sectional	2,280	Medium	2,280 people aged over 40 years from eight rural slums (counties villages) using WHO STEPs surveillance manual.	Education Education Education	Ischemic heart disease (IHD) prevalence (overall) IHD prevalence (men) IHD prevalence (women)	Lower education (overall) (A) Some education (men) (A) Lower education (women)** (A)

Table 5 Included studies with diabetes outcomes, by region

Study	Country	Design	n	Quality	Sample	Exposure	Outcome	Highest Risk Group
Africa								A: Adjusted * <.05 **<.01 ***<.001
Bella *et al.* (1992)	Nigeria	Case control	57	Medium	Insulin-dependent ketosis prone diabetics seen over a period of six years at University College hospital.	Social class	Diabetes	Lower Social Class**
						Education		Lower Education**
						Employment status		Non-Skilled**
Fekadu *et al.*, (2010)	Ethiopia	Case control	217	Medium	107 cases and 110 controls from two regions recruited from diabetic clinics. Age and sex controls were recruited from general medical clinics for conditions other than diabetes in both communities.	Occupation	Diabetes	Unskilled Worker** (A)
						Education		Lower Education ** (A)
						Presence of animals		Animals Sleeping In Same Room (A)
						Access to toilet		No Access To Toilet** (A)
						Access to water		No Access To Piped/Clean Water** (A)
						Hatched (vs. corrugated) roof		Hatched Roof (A)
						No. of people/house		More People In The House (A)
						No. of people/room		More People Sleeping In One Room* (A)
						Distance from clinic, km		Greater Distance From Clinic** (A)
						Possessions index		More Possessions** (A)
Ploubidis *et al.*, (2013)	Kenya	Cross-sectional	4,314	High	4,314 participants >= 50 years of age	Wealth	Diabetes (type not specified)	Wealthier* (A) (Rural)
						Wealth		Wealthier* (A) (Urban)
SE Asia								

Safraj *et al.*, (2012)	India	Cross-sectional	78,173	Medium	78,173 rural adults 35 and above.	SES	Diabetes (type not specified), SR	Higher SES* (Higher Prevalence Among SES Group 4 In All Groups) (A)
Reddy *et al.*, (2007)	India	Cross-sectional	31,866	Medium	19,973 individuals 20-69 years of age	Education	Diabetes (type not specified)	Some Education (A) (Men) Lower Education** (A) (Women)
Corsi *et al.*, (2008)	India	Cross-sectional	2,439	Medium	168,135 survey respondents aged 18–49 years (women) and 18–54 years (men).	Caste Wealth Education	Diabetes (self-report)	Scheduled Caste (A) Richest* (A) Some Education
Sayeed *et al.*, (1997)	Bangladesh	Cross-sectional	2,362	High	1,052 subjects from urban and 1,319 from rural communities (age > or = 20 years) of different socioeconomic classes were investigated.	Wealth	Non-insulin dependent diabetes mellitus	Richest* (A)
Gupta *et al.*, (2003)	India	Cross-sectional	1,123	High	1,123 adults (> 20 years living in urban India).	Education	Diabetes (self-report)	Some Education (Men) Some Education (Women)
Ajay *et al.*,	India	Cross-sectional	10,930	High	10,930 urban adults (age 20-69)	Education	Diabetes (diagnosed according to fasting glucose)	Lower Education*** (A)
Kinra *et al.*, (2010)	India	Cross-sectional	1,983	Medium	1,983 adults (aged 20-69 years) living in rural areas from 18 states in India	SES	Diabetes (based on self-report and blood glucose)	High SES** (A) (Men) Middle And High SES (A) (Women)
Samuel *et al* (2012)	India	Cross-sectional	228	High	2,218 adults (age 26-32) from urban and rural setting involved in a cohort study (birth years: 1969-73)	SES	Diabetes (blood glucose diagnosis)	Highest SES** ((A)) (Male, Urban) Middle SES ((A)) (Female, Urban) Highest SES*** (A) (Male, Rural) Highest SES*** (A) (Female, Rural)

						Education		Highest Education (A) (Male, Urban)
Zaman *et al.*, (2012)	India	Cross-sectional	4,535	High	4,535 adults (aged 30 +) recruited from rural Andhra Pradesh (mean age 49.4, SD 13.6)	Education	Diabetes (type not specified)	Educated** (A) (Male) Educated (A) (Female)
						Occupation		Skilled*** (A) (Male) Skilled (A) (Female)
						Income		High (A) (Male) High** (A) (Female)
Rao *et al.*, (2011)	India	Cross-sectional	2,129	Medium	Sample of adults with CVD (n=2,129) and diabetes (439) drawn from 47,302 rural and 26,566 urban households.	Education	Diabetes (self-reported)	Lower education*

Table 6. Included studies with chronic respiratory disease outcomes, by region

Study	Country	Design	n	Quality	Sample	Exposure	Outcome	Highest Risk Group
SE Asia								A: Adjusted * <.05 **<.01 ***<.001
Burkart *et al.*, (2011)	Bangladesh	Cross-sectional	21,551	Medium	Mortality data (n=21,551) from the Bangladesh Bureau of Statistics for period from 2002 to 2007, using a sample comprised of 1,000 PUSs in rural and urban areas. Deaths recorded by officials quarterly and then verified through field visits.	SES (of region)	Deaths attributable to Respiratory disease (%)	High SES
Chhabra *et al.*, (2001)	India	Cross-sectional	4,171	Medium	Permanent residents of Delhi who were 18+ years of age and living near one of nine permanent air quality-monitoring stations.	SES	COPD/chronic bronchitis	Lower SES (in both higher and lower pollution zones)
Chandrashekhar *et al.*, (2014)	India	Cross-sectional	370	Low	370 persons age 60 and older in urban and rural field practice area of Department of Community medicine in Gulbarga.	Education SES	Respiratory disease	Some education Middle/lower class

Table 2.7 Included studies with multiple non-communicable disease outcomes, by region

Study	Country	Design	n	Quality	Sample	Exposure	Outcome	Highest Risk Group
Africa Region								A: Adjusted * <.05 **<.01 ***<.001
Rossier *et al.*, (2014)	Burkina Faso	Cross-sectional	409	Medium	Adults (≥35 years) living in formal and informal neighbourhoods of Burkina Faso who died between 2009 and 2011. There were 409 deaths among 20,836 study participants.	Education	Mortality From NCDs (CVD, Neoplasms, Other NCDs, Asthma, Diabetes, Liver Disease)	Lower education* (A) (in both formal and informal neighbourhood's)
						Standard of living		Lower standard of living* (A) (in both formal and informal neighbourhoods)
European Region								
Jerliu *et al.*, (2013)	Kosovo	Cross-sectional	1,890	Medium	A representative sample of 1890 individuals aged ≥65 years (949 men, mean age 73 ± six years; 941 women, mean age 74 ± 7 years;	Education Self-perceived poverty	Presence of Self-Reported Chronic Diseases (CVD, Diabetes, Stomach And Liver, Lung, Neurologic Disorders, Cancer And Other Conditions)	No education (A) Poor** (A)
						Education	Multi-	No education (A)

						Self-perceived poverty	morbidity (2 or more chronic conditions)	Poor* (A)
SE Asia								
Binnendijk *et al.*, (2012)	India	Cross-sectional	38,205	Medium	Rural populations from two states in India.	Income	Self-Reported NCDs	Lower income *(Region of Odisha and Bihar)
Western Pacific								
Van Minh *et al.*, (2008)	Vietnam	Cross-sectional	2,484	Medium	2,484 adults aged 25-74 selected using stratified random sampling for personal household interview.	Education (Males) SES (Males) Education (Females) SES (Females)	Self-Reported Chronic Diseases (Including Chronic Joint Problems, Heart And Circulatory Conditions, Cancer, Diabetes, Chronic Pulmonary Diseases And Psychological Illness).	Lower education Middle SES Lower education* Lower SES*

Of the four conditions that this review considered, the most frequently reported outcome was cancer (n=21) (most commonly of the breast (n=8) or cervix (n=4)). The second most common outcome was cardiovascular disease (n=20), which included AMI (n=4), stroke (n=4), ischemic heart disease (n=1), angina (n=1), coronary heart disease (n=1), peripartum cardiomyopathy (n=2), and CVD as one aggregated group (n=3). Twelve papers included diabetes as an outcome. Two studies specified insulin-dependent diabetes and the remaining nine did not define type. Among papers that reported the method of diabetes assessment, two papers used self-report to determine diabetes status, while five specified the use of biochemical parameters. Three papers reported outcomes related to CRDs. One study looked exclusively at chronic obstructive pulmonary disease, while the remaining two studies considered respiratory diseases (type not specified) as one of several outcomes reported alongside other conditions. Four papers included in this review reported an aggregated NCD measure that included a wide range of conditions.

Measures of socioeconomic status

Thirty-five studies used education-based measures of SES (e.g. literacy or years of schooling), 22 used an aggregate SES score (based on a combination of education, income, housing, social castes or standardised scales), and 11 used an income-based measure.

Associations between non-communicable diseases and socioeconomic status

Thirty-three of the 48 significant associations that were reported among papers in this review placed lower SES groups in the highest risk category for NCDs, but the pattern was not uniform across disease categories (Figure 3).

Cancer

This review included 22 papers on cancer. Eighteen papers reported significant associations, with fourteen of these suggesting that lower SES groups have higher cancer risk, the remaining four suggested that higher income groups have a significantly higher risk of cancer (Table 3).

Thirteen papers examined associations between cancer and education. Ten papers found significant relationships, eight of which reported a higher risk among the least educated. These included studies from India[3, 32], El Salvador[33, 34], Morocco[35], Pakistan[36], and Vietnam[37, 38]. Two medium quality cross-sectional studies reported significant positive associations between education and cancer, with the more highly educated showing a greater number of years of life lost due to colorectal cancer in Mongolia[39] and higher mortality from malignant neoplasms in Ethiopia[40]. Three studies did not find significant associations between education and cancer, representing research from El Salvador, Honduras and Guatemala [41], Uganda[42]and India[43].

Among the five studies that examined associations with cancer and income [33-35, 43, 44], three reported that low-income groups had significantly higher risk [33-35]. Having a low income was associated with lower rates of event free leukaemia survival in El Salvador[33], increased odds of cervical cancer in Morocco[35], and prolonged waiting times for assessment and treatment, sepsis and infectious death among leukaemia patients with paediatric fever in El Salvador[34]. A fourth study reported that low-income patients had a higher risk of cervical cancer in India, but this was non-significant[43]. Contrary to the other studies, a fifth paper reported that higher-income patients had a significantly higher risk of hepatocellular carcinoma in India [44].

Among 13 studies that examined associations between cancer and SES as an aggregate measure or some other measure of wealth, eleven reported higher risk among those falling into lower SES. The association was significant for eight [2, 35, 36, 45-49] and non-significant for two[32, 34].The remaining study reported a non-significant association in the opposite direction, with a higher number of deaths attributable to cancer among those living in a high SES region compared to a low SES region[50].

Restricting findings to high quality papers, five of seven papers reporting on education and cancer found that the lower educated were more likely to get cancer or have poor cancer outcomes [3, 33, 35, 37, 51]. Three[33-35] of four high quality studies reporting on income and cancer found that those with lower incomes were more susceptible to cancer (and this was significant for two)[33, 34] but not for the third[35]. There were two high quality studies reporting on cancer and wealth and both found that those with lower wealth had worse outcomes[34, 35] and this was significant for one[34].

Cardiovascular Disease

This review included 19 studies that reported CVD outcomes. Among the nine studies that examined CVD and education, six found significant relationships and for five of these studies, the highest risk was observed among those with lower education [51-55]. The remaining two found that compared to those with lower levels or no education CVD risk was greatest among those with at least some education[56] or those with higher levels of education[57] (Table 2.4).

Three papers investigated associations between income and CVD[54, 58, 59] and in two, lower income groups had significantly higher risk of AMI[54, 58]. In the third study, higher income groups had a significantly higher prevalence of angina [59].

Eleven studies measured associations between SES and CVD and five reported significant findings after adjusting for confounders[50, 60-64]. Among three, CVD risk was highest among low SES groups. Lower SES was significantly associated with stroke prevalence among urban dwellers[61], AMI and risk of poor outcomes from peripartum cardiomyopathy[64].

Overall, 11 papers reported significant findings suggesting that lower SES groups had higher CVD risk, including seven studies from India, [51, 54-56, 58, 60, 65] two from the Eastern Mediterranean countries of Morocco[61], and Pakistan [64], and two from the Western Pacific countries of Mongolia [52] and Vietnam [53]. By contrast, four papers reported significant findings suggesting that higher SES groups had worse CVD outcomes, representing findings from three Southeast Asian countries (Bangladesh,[50] Indonesia,[57] India,[63] and Burkina Faso)[59]. This review did not observe clear patterns according to disease subtype or region, although India was the one country from which studies reported significant findings in both directions, with six studies indicating that lower SES groups had significantly higher CVD risk[51, 54, 55, 58, 60, 65] and one indicating that higher SES groups had significantly greater CVD risk[63]. That said, these studies were conducted in a range of regions throughout India using many different outcomes, exposures, study designs and populations. For example, Singh (2005) examined social class and mortality from circulatory diseases in Moradedabab in 2005 using a cross-sectional study design, while Dogra examined associations between AMI and SES in Chandigarh using a case-control study in 2012. Xavier examined mortality rates following coronary symptoms and class using a prospective cohort in 10 different regions and Pais examined AMI and SES using a hospital-based case control study in Bangalore in 1996.

Four high quality papers reported on education and CVD and in three, those with lower levels of education had worse outcomes[51, 53, 54]. One high quality paper reported on associations between wealth and CVD and was not conclusive. Five high quality studies reported on SES and CVD and in two, those with lower SES had worse outcomes[62, 66].

Diabetes

This review included twelve studies that reported diabetes outcomes. Overall, four papers reported significant findings which placed lower SES groups in the higher diabetes risk category, while seven reported significant findings placing higher SES groups in the higher risk category (Table 5).

Eight studies considered associations between education and diabetes and five reported significant results. In four of these, a lower education was significantly associated with diabetes in the overall study populations in Nigeria and Ethiopia [67, 68] and in two among women only in India[55, 69]. In contrast, one Indian study reported a significant association between a higher level of education and diabetes risk among women, but not men[70].

Ten studies considered associations between SES as an aggregate measure, class, occupation level or wealth and nine of these presented significant results. In seven of these, the higher SES groups were at significantly greater risk of diabetes, including studies from India, Bangladesh[71] and Kenya [72]. In contrast, two studies found that diabetes risk was greater among lower class or non-skilled workers in Nigeria[67] and lower skilled workers or people lacking access to water and toilet facilities in Ethiopia [68].

Restricting to high quality studies only, the three high quality studies reporting on associations between diabetes and education found that those with high levels of education had worse outcomes[70, 72, 73]. The paper by Zaman *et al* was the only high quality study reporting on associations between income and diabetes and found that high-income women had the worst outcomes. Two high quality studies reported on wealth and diabetes and in both, the wealthier and highest income had the worst outcomes [72, 73]. Similarly, the four high quality papers on SES and diabetes also found that those with the highest SES had the worst outcomes[70-73].

Chronic Respiratory Diseases (CRD)

Three cross-sectional studies from Southeast Asia [50, 56, 74] examined associations between SES and CRDs. A study from Bangladesh analysed all-cause and cause-specific mortality by age, gender and socioeconomic condition in urban and rural areas. While the study reported significant differences in risk of dying from CVD in high SES regions compared to low SES regions, there were no significant differences in the risk of dying from respiratory diseases. A second study from India examined morbidity patterns among urban and rural geriatric populations and associations with education and SES and found that there were no significant differences between education groups or socioeconomic classes in respiratory disease[56]. Finally, a cross-sectional study of ambient air pollution and chronic respiratory morbidity was conducted in Delhi and found no significant differences in the prevalence of chronic bronchitis or COPD by SES[74] (Table 6).

Multiple NCDs

Four cross-sectional studies[12, 75-77] reported associations between SES and NCDs as an aggregate measure rather than by specific diseases and three of them found significant relationships that identified lower SES individuals at greater risk of NCDs. In a study from Kosovo, those who perceived themselves as poor were more likely to report having chronic conditions and multi-morbidity[12]. Similarly, Vietnamese women with a lower education and lower SES were more likely to self-report chronic conditions[76]. Finally, in a cross-sectional study from Burkina Faso, adults with lower education and lower standards of living had significantly greater risk of mortality from NCDs[77]. A cross-sectional study from India reported a non-significant association between lower-income status and self-reported NCDs[75] (Table 7).

Description of findings by region

Africa

Three studies on cancer came from Africa and two reported significant results: Having a higher level of property was associated with breast cancer in Tanzania[47] and higher education was associated with malignant neoplasm mortality in Ethiopia[40]. Two of the three

African diabetes studies from Nigeria and Ethiopia found that low SES was associated with diabetes[67, 68], while one Kenyan study found that the wealthier participants had higher risk[72]. One cross sectional study in Burkina Faso found higher angina prevalence among those with a higher income[59].

Eastern Mediterranean Region

Lower SES groups had worse cancer outcomes according to four studies from Pakistan [36, 45, 46, 78]and one from Morocco[35]. Another study from Morocco reported associations between lower wealth and stroke[61].

Region of the Americas

Two studies from El Salvador found that lower SES groups had worse outcomes [33, 34], but a third study found that higher SES groups had higher treatment related mortality[41].

Southeast Asia

There were varying results in Southeast Asia: higher SES was associated with coronary artery disease[62] and higher class was associated with circulatory diseases [63]. Higher SES was associated with CVD deaths in Bangladesh[50]. However, in India, lower SES was associated with acute myocardial infarction (AMI)[60], mortality following acute coronary symptoms[65] and AMI[58]. Lower education was associated with coronary heart disease among women[51] and AMI[54]. In Pakistan, low SES was associated with peripartum cardiomyopathy[64]. High SES was associated with diabetes in India[73, 79, 80] and Bangladesh[71], but also with lower education levels[69, 81].

Western Pacific

Higher education was associated with years of lost life due to colorectal cancer in Mongolia[39], but lower education was associated with IHD among women [52]. In Vietnam, lower education was associated with CVD mortality [53] and lower SES was associated with multiple chronic conditions [76].

Europe

In Kosovo, one paper reported an association between poverty and the presence of self-reported chronic conditions[12].

Discussion

This review examined the literature and reported associations between SES and NCDs from 57 papers within 17 LLMICs. In summary, 14 of the 18 papers with significant associations between cancer and SES suggested that lower SES groups have higher cancer risk. Eleven of the 15 papers reporting significant relationships between CVD and SES suggested that lower SES groups have higher risk. In contrast, seven of 11 papers with significant findings related to diabetes and SES found that higher SES groups had higher risk. Our findings are consistent with a review by Hosseinpoor, which also found that unlike other NCDs, higher diabetes prevalence occurred among the wealthier and more educated, especially in low-income countries[17]. Sommer *et al* conducted an overview of systematic reviews on socioeconomic inequalities and NCDs. Unlike our study, this study compared outcomes between countries (rather than individuals within countries). However, similar to our findings related to cancer and cardiovascular disease, Sommer *et al* found that having low SES or living in an LMIC increased the risk of developing CVD, lung and gastric cancer and increased the risk of mortality from lung cancer and breast cancer. Unlike our study, it found that having low SES also increased the risk of developing type 2 diabetes or COPD and increased the risk of mortality from COPD[20]. Allen *et al* conducted a review on the association between SES and NCD risk factors (harmful use of alcohol, tobacco use, unhealthy diets, and physical inactivity within LLMICs). Just as this review found that low SES groups had worse outcomes related to cancer and CVD, Allen *et al* found that low SES groups had a significantly higher prevalence of tobacco and alcohol use, and consumed less vegetables, fish and fibre[21]. However, the results related to SES and NCD risk factors from Allen *et al* were inconsistent; the review also found that high SES groups were less physically active and consumed more fats, salt, and processed foods compared to low SES groups.

There are multiple reasons why more advantaged groups in LLMICs may be at a higher risk of some NCDs. For example, according to the nutrition transition theory, increasing wealth is often associated with shifts in dietary and physical activity patterns, which may lead to the predominance of nutrition-related NCDs[82]. Reported socioeconomic inequalities in NCDs may be biased by differential access to healthcare services between different SES groups[83]. It is possible that NCD cases among low SES groups were more likely to be under-diagnosed, leading to an underestimation of the true prevalence rates. These variations highlight a need to identify and implement effective development strategies that reduce the overall burden of disease without increasing health inequalities in LLMICs. These findings also demonstrate the importance of setting up national-level surveillance systems to examine the relationship between SES and NCDs using a nationally representative sample.

This review showed wide between-study variation in terms of study populations, NCD outcomes, SES measures and study designs. This review used broad inclusion criteria to ensure that it would identify relevant research from as many LLMICs as possible. Given the lack of previous reviews on this issue and, relative to research from high-income countries, the scarcity of primary research articles reporting on NCDs and SES within these countries, this review chose to err on the side of inclusion, despite the heterogeneity that such an approach might cause. That said, applying a more inclusive approach towards selection of studies in terms of exposure also poses a limitation on this study. Different measures of SES capture different underlying dimensions of a person's position in society [84]. For example, current income allows researchers to measure access to material goods and services that may influence health, but this measure is age dependent and more unstable than education or occupation. Wealth tends to be more strongly linked to social class than income, and having assets often corresponds with an ability to meet emergencies or to absorb economic shock. Education is a fairly stable measure beyond early adulthood and is likely to capture aspects of lifestyle and behaviour, but it has different social meanings and consequences in different contexts, economic returns may differ significantly across groups, and SES does not rise consistently with increases in education years. Given these differences, choosing the best variables for measuring SES should depend on consideration of the likely causal pathways and relevance of the indicator for the populations and outcome under study[84]. The causal pathway between SES and NCDs is complex, so it is challenging to identify 'the best' indicator to use when examining associations between SES and NCD outcomes. This highlights a need for more research, not only on how various SES indicators are associated with health outcomes, and how the relationship changes depending on the indicator, but also more research on the theoretical aspects of NCDs and the hypothesised causal pathways between SES and disease.

Previous studies on NCDs and LLMICs have largely focused on global cross-country comparisons. To the best of our knowledge, this is the first review to focus exclusively on the distribution of NCDs within LLMICS. Additional strengths include our comprehensive search strategy and adherence to PRISMA guidance.

Our search strategy was restricted to English search terms, which may have limited representation of research from LLMICs. This review assessed study quality using the Newcastle Ottawa scale because it allowed us to assess the quality of nonrandomised studies, but previous studies have reported low inter-reliability using this method[85] [86]. These scores should not be taken to assess the quality of the work outside of the context of this review, given that many studies had aims that extended beyond the investigation of associations between SES and outcomes.

This review's search strategy was also restricted to research from 1990-2015. This review limited the search to cover research from 1990-2015 due to the high volume of search results associated with having multiple outcomes and multiple exposure measurements, coupled with resource restraints. Rather than starting at a later time, this review chose to start in 1990 because this was the year that the Millennium Development Goals were signed, and when targets and indicators to monitor progress (including many socioeconomic indicators) started to become more widely integrated into research studies[87]. Future research may benefit from considering associations between NCDs and SES over a longer time period.

This review's search strategy (Table 2.1) included a range of exposure terms related to poverty, socioeconomic factors, income, gross domestic product, household wealth, wages, poverty, wealth and employment. However, it did not include the term 'social class.' The results from the search included many papers that used the terms we'd identified alongside the term 'social class' to describe the exposure variable. This review included these papers in the review, despite the fact that 'social class' was excluded from the initial search method, because this term that was often used interchangeably with the other SES terms. However, this decision may have biased the results by excluding other papers on social class which were overlooked by our search strategy.

This review relied on evidence from resource-scarce research environments that lack the infrastructure required to collect reliable morbidity and mortality statistics on a routine basis. Around half of our studies collected data from hospitals, research environments that are associated with well-documented limitations [49]. In addition, the data presented from surveillance systems may also have limitations. According to Das *et al*, in 1994 only 13.5% of all deaths in India were medically certified[88], and there are likely to be associations between a person's SES status and medical certification at death. Lozano *et al* also highlights regional heterogeneity and the need for sound epidemiological assessments of causes of death[89]. Many of the included studies had small sample sizes that were not nationally representative. This review included these studies in order to highlight research from as many LLMICs as possible, but this decision also severely limits the generalisability of our findings. For this reason, this review included three 'low quality' studies in our final analysis. Two were related to cardiovascular disease and one was related to cancer. Excluding these studies from our final analysis did not change the overall trends in our results. Nine of 13 papers reporting significant relationships between SES and CVD suggested that low SES groups have higher risk. Thirteen of the 17 papers that reported significant associations between cancer and SES suggested that low SES groups had the highest cancer risk. The relationship related to diabetes risk remained unchanged, with seven of the 11 papers reporting significant findings related to diabetes finding that higher SES groups have higher diabetes risk.

About half of the studies included in this review were conducted in hospital settings and there may be a bias related to the high socioeconomic profile of hospital patients, which may not represent the population characteristics of a country. Therefore, this review conducted additional analyses to explore whether or not associations between SES and NCDs differed depending on the setting. The results are as follows. For cancer, 15 of the 18 studies reporting significant associations were hospital-based studies. Of these 15 hospital-based studies, 13 reported that low SES individuals had higher cancer risk, while two reported that high SES individuals had higher risk. Of the three community-based studies, two reported that higher SES individuals had higher risk and one reported that lower SES individuals had higher risk.

For cardiovascular disease, six of the 15 papers reporting significant results were hospital-based studies. Among these six hospital-based studies, five reported that low SES individuals had higher risk of cardiovascular disease. Of the nine community-based studies, four reported that low SES individuals had higher cardiovascular disease and five reported that high SES individuals had higher risk. Of the 12 papers reporting significant associations between diabetes and SES, three were hospital-based and nine were community-based. All three of the hospital-based studies found that low SES groups had higher diabetes risk. Seven of the nine community-based studies found that high SES groups had higher risk and two found that low SES groups had higher risk.

This review suggested that the magnitude and direction of associations between NCDs and SES may vary according to the type of NCD, but our findings also suggest that the direction of the association may also depend on the type of SES indicator, which corroborates earlier findings[90]. There are advantages and disadvantages to the indicators used by studies in this review, discussed elsewhere in the literature[91, 92].

Access to healthcare and knowledge about disease conditions is associated with wealth and education [13, 83, 93, 94], which may lead to biased results when examining associations between SES and health. Vellakkal *et al* determined whether socioeconomic inequalities in the prevalence of NCDs differed if estimated by using symptom-based measures compared with self-reported physician diagnoses[83]. They found that SES gradients in NCD prevalence tended to be positive for self-reported physician diagnoses but were attenuated or became negative when using symptom- or criterion-based measures, particularly in low-income countries.

Low-SES NCD patients are particularly vulnerable; People in many LLMICs must finance health care through out-of-pocket payments, which places a burden on NCD patients and families [55, 95, 96]. The recurring nature of these costs[75], coupled with the reduced productivity that accompanies poor health[97] causes additional problems.

This review included only three articles with CRD outcomes, and none of them reported significant findings. Two of these articles did not describe the diagnostic modality. One limitation to this study is that in an attempt to include research from as many LMICs as possible, this review did not limit inclusion based on diagnostic modality. Chest X-rays, spirometry, CT scans and arterial blood gas analysis are all used for diagnosis, but these require access to healthcare facilities, which may be limited among low SES groups. It is likely that there is a high prevalence of undiagnosed COPD. Gribsby *et al* examined the association between SES and COPD prevalence using data collected in Argentina, Bangladesh, Childe, Peru and Uruguay and found that adjusted odds ratio of having COPD was lower for people who completed secondary school and lower among those with higher monthly household incomes[98]. This finding is compatible with other research which has found that poor populations tend to have a higher risk of developing COPD and its complications than their wealthier counterparts[99-101]. A recent Global Burden of Disease study examined how sociodemographic development has a different effect on the burden of COPD and asthma and show that mortality but not prevalence of asthma is strongly related to sociodemographic development[102].

This review highlights the need for more research on the associations between NCDs and SES within a wider range of LLMICS; there were 67 LLMICs from which this review did not identify any publications eligible for inclusion. More research is needed on NCD morbidity and mortality in LLMICs[103], along with the collection and presentation of SES indicators alongside these NCD measures. Lack of NCD surveillance data presents a challenge to the prevention and control of NCDs in low- and middle-income countries. Many countries lack the resources to develop and maintain an information system to collect, analyse and disseminate data and information on trends in NCDs and socioeconomic status[104]. The WHO STEPwise approach to risk factor surveillance to assess NCDs and their risk factors provides one relatively low-cost option for monitoring within-country trends, but also for making comparisons across countries[105]. The STEPwise approach to risk factor surveillance survey includes several questions on socioeconomic status. While it may not be possible to find one single measure of SES that is universally relevant across all study contexts, having more studies integrate some of these WHO measures into their reporting would strengthen the evidence base about relationships between SES and NCDs.

This review also suggests that more research is needed on the evidence for interventions that target low SES groups within LLMICs. Schools present one unique opportunity to implement health-promotion interventions because they provide access to children from all socio-economic groups. Furthermore, schools represent the place where, outside of the home, the greatest number of children spend the greatest amount of time.

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105. WHO, *WHO STEPS instrument (core and expanded)*. The WHO STEPwise Approach to Noncommunicable Disease Risk Factor Surveillance (STEPS), Geneva, 2015.

Summary of chapter

This appendix chapter described a systematic review which provided some of the theoretical foundations to this DPhil research. This systematic review examined associations between NCDs and SES within LLMICs. A comprehensive literature search was conducted for research published between 1990 and 2015 using six bibliographic databases. Inclusion criteria required studies to report on SES and morbidity or mortality from cardiovascular diseases, cancers, diabetes, and chronic respiratory diseases within LLMICs. The final review, which included 57 studies from 17 LLMICs found that lower SES groups had a higher risk of cancer and cardiovascular disease. These findings suggest that NCD prevention efforts should target low SES groups. By providing access to young people from all SES groups, school-based efforts to promote nutrition may be one particularly effective means of preventing NCDs within developing countries.

Appendix Three. Potential applications of health-promoting schools within Sri Lanka

School-based nutrition programmes in Sri Lanka

According to the WHO Global database on the implementation of nutrition action (GINA), Sri Lanka is currently implementing the following recommended interventions: monitoring growth, implementing school feeding programmes, promoting health-promoting schools (including the nutrition-friendly schools initiative), providing iron and folic acid supplementation, providing Vitamin A supplementation, providing deworming, implementing legislation on the marketing of unhealthy foods and beverages, improving food safety at vending places and providing water to schools[226]. According to a WHO global nutrition policy review[227], Sri Lanka has already made progress adopting some of the recommendations outlined in the WHO's NFSI (which is part of the 'health-promoting schools' framework). For example, the policy review notes that Sri Lanka has a referral health system for children who require nutrition interventions which was set up by the Sri Lankan Ministries of Education and Health. However, there is no published evaluation on the level of implementation or the effects of this programme on student outcomes.

Sri Lanka has a rich history of school-based health promotion, with school health programmes dating back to 1919, when medical officers were appointed to investigate children for oral diseases, hookworm, inflammation of tonsils and adenoids, malnutrition, pediculosis, eye defects and scabies[228]. During the early days of the health programme, the school medical officers observed malnutrition among the school children and recommended a free mid-day meal for schools with a high proportion of malnourished children. Between 1934 and 1935, a malaria epidemic broke out and the government started providing some schools with free meals. This tradition continues today, with the government paying students' parents or family members to prepare the meals, which are usually cooked at home and brought to school as a mid-morning meal. School eligibility for government funds to provide the meals depends upon the size of the school and the age group of the students that are covered. The Sri Lankan Department of Health Service runs a larger school health programme which also includes public health inspections. Public health inspectors coordinate many of the activities, which include conducting quarterly surveys where schools are assessed in the following areas: provision of sanitary facilities, provision of clean drinking water, the absence of unprotected wells, the absence of unhealthy food and drinks within school premises, the absence of mosquito-breeding places, provision of garbage disposal, provision of waste management, the condition of school buildings and the measurement of school children.


Figure 1.1. A public health inspector (centre) at a school in Moneregala

In 2003, a dissertation in community medicine by De Silva highlighted some of the health problems which were identified during school medical inspections[229]. These included inefficiencies in the various school-based nutrition interventions and varying levels of implementation between schools. The thesis concluded that a properly planned nutrition intervention programme was needed to address Sri Lanka's nutrition problems.

1.2 The public health challenge of adolescent nutrition in low- and middle-income countries

Nutrition is an important factor for ensuring good health throughout the entire life course, but it is particularly important during adolescence[230]. There are 1.2 billion adolescents (people aged 10-19 years) in the world with 90% living in LMICs[230]. Adolescents comprise almost a fifth (19%) of the population in LMICs (and 17% of the Sri Lankan population[231]), compared to 12% of the population in industrialised countries[232].

Nutrition during adolescence is critical because of its role in ensuring proper growth, development, cognition and capacity to learn[233, 234]. Health systems in many LMICs look after the health and nutrition of young children and women, but their systems are often not organised to focus on the nutrition of adolescents[231]. Many health behaviours established early in life are tracked into adulthood[234, 235], so adolescence represents a key opportunity to encourage healthy habits that will protect individuals from disease later in life. Furthermore, the nutritional status of adolescent girls may have intergenerational effects in instances when a young woman becomes pregnant[28] and her nutritional status is passed along to her offspring[236].

Foods, diets and nutritional status are important determinants of NCDs, which disproportionately affect people living within LMICs[237-239]. Nearly three quarters of all NCD

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[28] Adolescent fertility in LMICs tends to be higher than it is industrialised countries, but this is not the case in Sri Lanka. In Sri Lanka, there are 14.15 births per 1,000 women ages 15-19, which is on par with the rate seen in the United Kingdom (14 per 1,000), lower than the rate seen in the United States (21 per 1,000 women) and far below the average for lower-middle income countries (45.33 births per 1,000). (United Nations Population Division, Adolescent fertility rate is the number of births per 1,000 women ages 15-19. 2014).

deaths and 82% of premature NCD deaths occur within LMICs[240]. NCDs pose a major challenge to social and economic development [241, 242] and addressing them is a global priority[243].

Research from high-income countries suggests that disadvantaged and marginalised groups have a higher NCD burden, but there has been a lack of research on the relationship between socioeconomic status (SES) and NCDs within LMICs. As part of my DPhil work, I conducted a systematic review to map the literature on the socioeconomic gradient of NCDs within low- and lower-middle income countries (LLMICs). The review, which is provided in Appendix One, found that SES groups were more likely to have cancer (14 of 18 studies) and cardiovascular disease (11 of 15 papers), but high SES groups were more likely to have diabetes (7 of 11 studies). One of the most important findings from this review was the lack of research from LLMICs—just 17 of 84 LLMICs were represented, highlighting a need for work to understand and address the socioeconomic gradient of NCDs within developing countries.

During my DPhil, I co-authored a second review on NCD *risk factors* within LLMICs. This review included primary literature published between 1990 and 2015 using 13 electronic databases, including Embase and Medline, as well as a grey literature review and hand searching of references. After reviewing 4,242 records, 75 studies were included, representing 2,135,414 individuals from 39 LLMICs. The review found that poor or less educated people were more likely to have unhealthy diets compared to others who were wealthy or more educated[185].

There were no studies from Sri Lanka represented in either review, highlighting the need for more research from this part of the world.

Appendix Four. Description of the Integrating Nutrition Promotion and Rural Development Project

This DPhil project was part of a larger project entitled 'Integrating Nutrition Promotion and Rural Development' (INPARD). The INPARD project investigated the feasibility of linking a multi-sectoral rural development programme with nutrition promotion interventions in rural Sri Lanka, in order to identify whether or not this approach was effective in improving nutrition outcomes.

One of the strengths of the INPARD project was its alignment with larger national strategies to address NCDs within Sri Lanka. For example, in 2013, the WHO published a report on addressing NCDs in Sri Lanka and identified various strategies[244]. INPARD aligned itself with three of these strategies: 1) addressing the social determinants of health through multi-sectoral and multi-stakeholder coordination, 2) prioritising research and evidence-based strategies and 3) learning from demonstration projects. Another area where the INPARD project was aligned with wider strategies was in Sri Lanka's District Nutrition Action Plan, which placed an emphasis on implementing nutrition promotion within both health and non-health sectors within Sri Lanka. This emphasis on multi-sectoral nutrition promotion is particularly important in the context of Sri Lanka's rapid development. Development, sponsored by national and international agencies, is leading to rapid environmental changes, many of which may have adverse effects on nutrition and physical activity[245]. By aligning development work with nutrition promotion, the INPARD project aimed to identify mechanisms to promote health and nutrition amidst these changes[246].

The INPARD project was funded by the South Asia Food and Nutrition Security Initiative, which works to increase the commitment that governments and development organisations have to improving nutrition[247]. To support these aims, INPARD partnered with an existing development project called the 'Reawakening Project' (RaP), which was funded by the World Bank and implemented by Sri Lanka's Ministry of Economic Development. The RaP aimed to improve the livelihoods of people living within the poorest districts of Sri Lanka. Following a 'community-driven development' model[248], it orchestrated the formation of a village development organisation within each INPARD intervention village. All activities were implemented with the participation of community members. The RaP's focus was on infrastructure, training, capacity-building and livelihood development (*i.e.* provision of microfinance loans). RaP included a broad range of activities, including building new roads, funding new agricultural products and financing small businesses.

The RaP was implemented within the poorest villages in the country. When INPARD decided to partner with RaP, it chose two RaP districts (Ampara and Moneragala), where it would implement new nutrition-promotion activities alongside the existing RaP activities. INPARD would evaluate both the implementation and the effectiveness of this partnership to link the promotion of healthy diets and development by collecting data before and after the intervention. The advantage of this partnership was that it enabled INPARD to work within an existing infrastructure and to strengthen, rather than duplicate, existing efforts to promote development within the country. In terms of the allocation of roles, the RaP's role was to continue implementing its existing activities. INPARD's role was to identify pathways for promoting healthy diets among the stakeholders involved in these activities, to implement interventions along these pathways, and to evaluate the level of implementation and the effectiveness of the implementation using a range of indicators including nutrition and health outcomes.

INPARD employed a quasi-experimental study design which included both intervention and control villages and schools. The intervention was conducted in areas where the RaP was already being implemented within 57 villages in Ampara and 55 villages in Moneragala, covering a population of about 120,000 people. In order to have controls, INPARD selected demographically similar villages in Ampara and Moneragala where the RaP was not active. Additionally, due to the potential contamination of the intervention between control and intervention villages in Ampara and Moneragala, INPARD chose control villages from Kurunegala, a district which is geographically isolated from Ampara and Moneragala and where there was no intervention activity.

Ampara, Moneragala and Kurunegala are three of the poorest districts in Sri Lanka and have high levels of ethnic, religious, socioeconomic and cultural diversity. According to INPARD data, around half of adults in the area reported their employment status as 'unemployed.' Around a third of adults (29.6% in intervention and 32.4% in control) reported a household income of <10,000 Sri Lankan Rupees (LKR) (around $65 United States Dollars (USD)) per month and around 40% (38.2% in intervention and 37.0% in control) reported living on 10,000-19,999 per month, which is far below the country's average monthly household income, which was estimated to be 46,207 LKR (about $300 USD) in 2012 [182].

Description of the INPARD intervention

Multi-sectoral nutrition promotion training

INPARD implemented nutrition-promotion activities alongside existing development activities conducted by the RAP project. The INPARD intervention largely involved implementation of training and organisation of workshops among a large group of stakeholders. During the design phase of the study, INPARD conducted qualitative research with stakeholders which indicated that basic definitions and concepts about multisectoral collaboration for nutrition promotion were not understood. One of the INPARD project's initial outputs was development of a training programme on multi-sectoral nutrition promotion. It included three modules about nutrition, health promotion and inter-sectoral collaboration.

Participants attending an 'Integrating Nutrition Promotion and Rural Development Project' workshop on multi-sectoral nutrition promotion in Moneregala

INPARD staff provided the training to representatives from the Ministries of Economic development, Health, Agrarian Services, Education, Divinaguma[29] and Grama Niladahari[30]. The organisation of governmental authorities working within the districts is described in Figure 4.2. The divisional secretary regularly brings various sectors (including Divinaguma) together. Outside of the meetings coordinated by the divisional secretary, communication between the various sectors is minimal.

---

[29] A grassroots economic development initiative

[30] 'Village officers' which are publicly appointed to carry out administrative duties at the divisional level

Figure 4.3. Description of the governmental bodies working within the districts of Ampara, Moneragala and Kurunegala[249].

Generation of multi-sectoral nutrition promotion committees

In addition to offering training on multisectoral nutrition promotion, INPARD organised meetings between rural development staff and other stakeholders to discuss nutrition within their communities. One of the unique features of the INPARD intervention was that it was community led. In this instance, each village was given data describing the nutritional status of its community using baseline data collected in 2014. Then, INPARD facilitated a conversation in which the stakeholders could discuss the problems and the impact that their existing programmes and activities (such as approval of loans for small businesses) might have on the nutrition status of the local population. A committee of representatives from development, agriculture and education sectors met to discuss potential opportunities to improve nutrition, barriers to implementation and how the sectors could work together to address the barriers. For example, some school officials were keen to implement school gardening programmes, but they faced barriers related to a lack of water or expertise in agriculture. At the INPARD meetings, the education officials were able to discuss their ambitions with rural development and agricultural officers. The rural development stakeholders identified how they could help supply water, while agricultural officers volunteered to provide gardening expertise. This example illustrates how the INPARD intervention was community-led: INPARD organised the meetings and facilitated the discussion, but the activities were identified and conducted by the local stakeholders.

Figure 4.4. Secondary students learning to make compost for school garden at a school participating in the 'Integrating Nutrition Promotion and Rural Development' project in Moneregala, Sri Lanka

Training with school principals

The INPARD project also coordinated training and workshops for school staff. In a workshop for school principals, principals were given training on the common nutritional problems faced by students[31] and the potential mechanisms to address these problems using approaches recommended in the NFSI. Principals were given a peer-reviewed paper on barriers and facilitators to nutrition promotion in rural Sri Lanka[70] and materials describing the NFSI. Additionally, INPARD staff visited each school and met with the staff member that was responsible for health promotion. This staff member was given the same materials

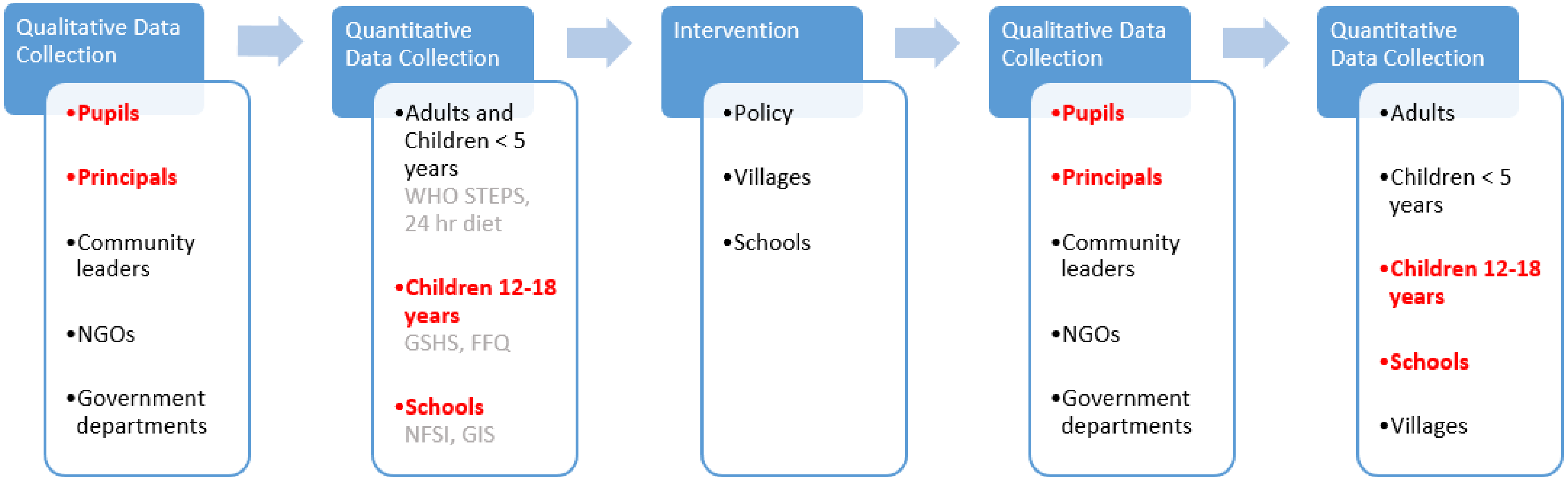
[31] The population's common nutritional problems were identified by a nutrition researcher from the University of Colombo and Sri Lanka's Regional Director of Health Services. Using existing national data, they identified four common problems that should be addressed: 'lack of fruit and vegetables,' 'high consumption of sweets,' 'high consumption of baked goods' and 'high consumption of carbohydrates (coupled with low consumption of protein).'

that the principals were given in the workshops. Schools varied in terms of how they chose to address these problems. For example, projects ranged from setting up health clubs, hosting multisectoral meetings to identify ways to improve the healthfulness of food offered within canteens, hosting meetings with school meal providers or developing school gardening programmes. INPARD also arranged visits between schools to learn about innovative interventions related to health and nutrition-promotion, such as 'health canteens,' which provided nutritious food to students in a novel way.

Evaluation of the INPARD Project

This section provides a brief description of the INPARD project's evaluation within villages. The INPARD evaluation involved collecting both qualitative and quantitative baseline and post-intervention data from a random sample of 2,000 adults, 1,300 children (aged 12-18 years) and 1,000 children (under the age of 12) (Figure 4.5).

Figure 4.5. Description of the 'Integrating Nutrition Promotion and Rural Development' (INPARD) project data collection



Abbreviations: WHO STEPS: Non-communicable Disease Risk Factor Survey, FFQ: Food Frequency Questionnaire, GSHS: Global school-based student health survey, NFSI: Nutrition-friendly schools initiative tool, GIS: Global Information Systems; NGOs: Non-governmental Organisations.

Qualitative data related to barriers in nutrition promotion and successful measures to tackle them were collected through in-depth interviews with multisectoral policy-makers and focus group discussions with teachers, community members, children, health staff, rural development staff and agricultural staff. Quantitative outcome measures included health behaviours (diet, physical activity, alcohol and smoking), anthropometrics, demographics and area-level measures related to food access.

The INPARD project timeline

The INPARD project was initiated in September 2013. Baseline data were collected in June-August 2014.

Where this DPhil sits within the INPARD project

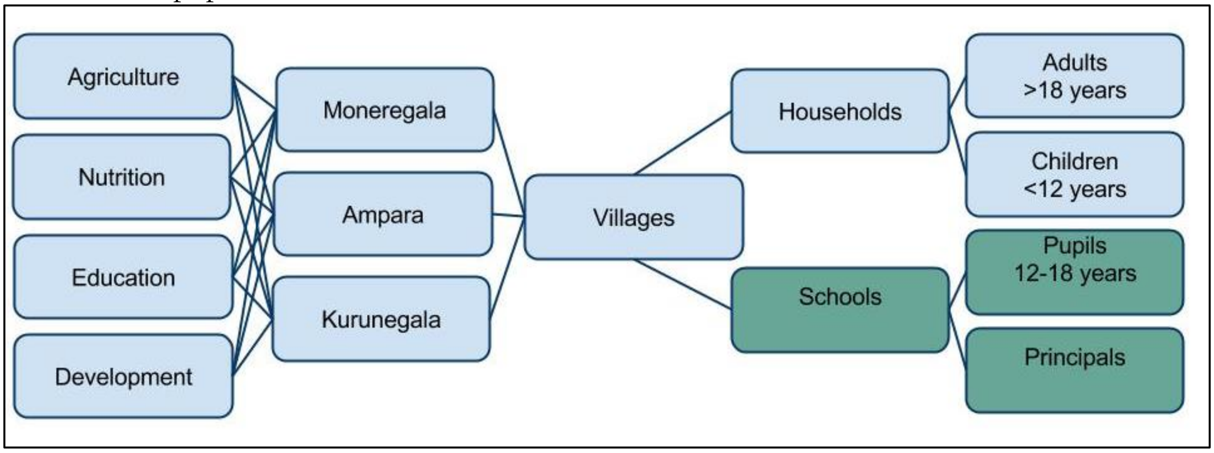
Within the INPARD project, My DPhil project involved identifying and designing the surveys and tools to collect data from school principals and students aged 12-18 and completing the evaluation of the data from these sources. Prior to this quantitative data collection, I was also involved in analysing the qualitative data collected from school principals on barriers to nutrition promotion[70]. Table 1 shows the INPARD outcome indicators and the tools which were used to collect data. To describe my involvement within the larger context of INPARD, I have indicated the outputs from the INPARD project as a whole and the outputs where I was involved.

Table 1. Tools developed for the study and outcome indicators in the 'Integrating Nutrition Promotion and Rural Development' (INPARD) project

Age group/ Level	Outcome category	Outcome indicator	Data source
Children 12-18 years of age*	Diet	Proportion of children meeting SL food-based standards	WHO Global school-based student health survey (GSHS) and Food Frequency Questionnaire (FFQ)
	Anthropometric	Proportion of children classified as underweight, healthy weight, overweight and obese according to WHO and International Obesity Task Force categories	Anthropometric measurements taken by trained researchers following standard protocol
	Physical Activity	Proportion meeting recommendations of 150 min/week	GSHS
	Other health behaviours	Proportion of children who are current smokers and consume alcohol (current/ever consumed) - (WHO definitions)	GSHS
Children 5- 12 years of age	Diet	Proportion of children meeting SL food-based standards	24 hour dietary recall (parent-report)
	Anthropometric	Proportion of children classified as underweight, healthy weight, overweight and obese	Anthropometric measurements taken by trained researchers following standard protocol
Children 1 – 5 years of age	Diet	Proportion of children meeting SL food-based standards	24 hour dietary recall (parent-report)
	Anthropometric	Proportion of children under-, normal- and over-weight.	Anthropometric measurements taken by trained researchers following standard protocol
Adults	Diet	Proportion of adults meeting SL food-based standards.	WHO STEPwise Approach to Chronic disease Risk Factor Surveillance (STEPS) and FFQ
	Anthropometric	Proportion of adults classified as underweight, healthy weight, overweight and obese	Anthropometric measurements taken by trained researchers following standard protocol
	Physical Activity	Proportion of adults meeting recommendations of 150 min/week	STEPS
	Smoking	Proportion of current smokers (WHO definition)	STEPS
	Alcohol	Proportion of adults who consume alcohol (current/ever)	STEPS
Area level measures	School	Nutrition friendliness of the school (score based on WHO Nutrition-friendly schools initiative criteria)	NFSI Assessment Tool
	Village	Food availability and access (price and the presence of food items available for purchase in village)	Food availability and price data collected by researchers
*Shaded areas indicate the areas where I was involved with the INPARD project			

The INPARD project involved working with many sectors, including agriculture, nutrition, education and development within Moneregala, Ampara and Kurunegala. Data were collected from both households and schools. Figure 1 shows a schematic representation of the INPARD project, including the sectors involved, the districts where data were collected and the populations that were studied. My DPhil project was based on the work in schools, which is highlighted in green.

Figure 1. The 'Integrating Nutrition Promotion and Rural Development' project's areas of work and the populations that were studied.



Summary

Data for this DPhil project were collected through collaboration with INPARD, a World-Bank funded project which investigated the feasibility of linking multi-sectoral rural development with projects to promote healthier diets within rural Sri Lanka. INPARD employed a quasi-experimental study design which included both intervention and control villages and schools. In intervention areas, INPARD provided community-led multi-sectoral nutrition promotion training and capacity-building support. Baseline data were collected in June-August 2014 and post-intervention follow-up data were collected in August-September 2014. Partnering with INPARD enabled me to collect data from a range of schools, students and school principals in rural Sri Lanka.

Appendix Five. INPARD sample size calculations: secondary school students

Sampling

Sample size

For a representative sample of the population sample size should be based on either the variance of the measurement in the population (for a continuous variable), or the proportion (for a discrete one).

Following the NHANES protocol I have calculated sample size with a power (desired level of precision) of 80% and have set the significance test to 5%, as this is commonly accepted in public health research. I consider other options throughout.

Simple sample size

GSHS Sri Lanka proportion of students eating > 4 fruit and vegetables a day = 0.224 =

Sample size needed to assess eat > 4 fruit and vegetables a day =

$p(1-p)*(1.96/error)^2$

5% error = 268

1% error = 6677

Clustering

Due to the clustered nature of the data, as we are collecting in schools, we need to increase the sample size to adjust for this clustering. Clustered sampling needs larger sample sizes than simple random sampling due to the similarity between individuals within clusters. We can calculate a design effect to tell us by how much we should increase our sample size to account for this clustering:

Design effect = 1 + ((average cluster size – 1) x Intra Class Correlation Coefficient (ICC))

So calculating this from the Sri Lankan GSHS =

Average cluster size = 84

ICC = 0.04

Design effect = 3.32

Sample size = 889

No. schools = Uncorrected total sample size/average cluster size x design effect

$1380/84 * 5.15 = 35$

Secondary school sampling frame

The overall sampling frame has been written such that every pupil has an equal chance of selection.

The probability (F) of a pupil being selected to be included in the project should, therefore, be a product of two sampling stages (f_1 and f_2) i.e. $F = f_1 \times f_2$, where:

f_1 = probability of selecting the school

f_2 = probability of selecting the pupil

As schools should be selected with probability proportional to number of pupils:

$f_1 = n_1 \times \frac{s}{S}$, where

n_1 = total number of schools to be selected
s = number of pupils in an individual school aged 11-16
S = total number of pupils aged 11-16

whilst $f_2 = \frac{n_2}{s}$, where

n_2 = number of pupils to be selected from each school

The overall sampling fraction for each pupil is therefore:

$$F = (n_1 \times \frac{s}{S}) \times (\frac{n_2}{s}) = \frac{n_1 \times n_2}{S}$$

This ensures that all pupils have an equal chance of selection and pupils in smaller schools do not have a greater chance of being measured.

Appendix Six. Ethics Forms

Oxford Tropical Research Ethics Committee

University of Oxford
Joint Research Office
Churchill Hospital, Oxford OX3 7LE
Tel. +44 (0) 1865 (5)72346 fax +44 (0) 1865 (5)72228
E-mail: jacqueline.gerencser@admin.ox.ac.uk

Dr Kremlin Wickramasinghe
Nuffield Department of Population Health
Old Road Campus
Headington
OX3 7LF

8 May 2014

Dear Dr Wickramasinghe

Full Title of Study: Integrating Nutrition Promotion and Rural Development (INPARD) Sri Lanka

OXTREC Reference: 536-14

Thank you for your letter of the 29 April 2014, and for your minimal risk application form. Other documents reviewed were:

Documentation	Version	Date
Protocol	V2.1	30/03/14
Consent Form for Adults	V2.1	30/11/13
Consent Form for Children	V2.1	30/11/13
Participant Information Sheet for Adults	V2.1	30/11/13
Participant Information Sheet for Children	V2.1	30/11/13
Local Ethical Approval (University of Colombo)		22/11/13
PI Signatory Page		24/04/14

The OXTREC executive team reviewed the above application on the 07 May 2014 and gave approval for this study.

Approval is given for the first five years.

This approval will be fully implemented upon final consent of the full committee at the meeting on Thursday 22 May 2014.

Yours sincerely

Dr Mary Warrell
OXTREC Chairman

Direct Line Tel: +44 (0)1865 (5)723436
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The World Bank
INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT
INTERNATIONAL DEVELOPMENT ASSOCIATION

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Mailing Address: P.O. Box 1761, Colombo.

April 10, 2015

Dr Kremlin Wickramasinghe
Co-Principal Investigator (INPARD)
BHFCPNP, Nuffield Department of Population Health
University of Oxford

Dear Kremlin:

Re. Use of Integrating Nutrition Promotion and Rural Development (INPARD) school data by Ms Julianne Williams

At the INPARD workshop held on the 16th of June 2014 in Colombo Ms Julianne Williams presented the proposal and her DPhil research questions using the INPARD school database. We are pleased to hear that the University of Oxford has provided funding for Ms Williams to work on INPARD school data and confirm that she can utilise this dataset for the agreed research.

As mentioned in the minutes of that workshop, the methods and the analysis plan presented by Ms Williams was discussed at the workshop and INPARD project partners agreed with this proposal. We look forward to hearing about the results of this analysis and sharing them with our partners.

As agreed in the initial proposal after completion of the INPARD project the final report and the dataset will be available in a public domain.

Please do not hesitate to contact me, if you need further clarification.

Yours sincerely,

Seenithamby Manoharan
Task Team Leader for INPARD and Senior Rural Development Specialist

Ethics Review Committee
Faculty of Medicine
University of Colombo
P O Box 271, Kynsey Road, Colombo 8, Sri Lanka
Telephone: +94-11-2695300 ext 240 Fax: +94-11-2691581
Email: ethicscommitteemfc@gmail.com

REFERENCE: EC-13-144

22nd November 2013.

Dr Kremlin Wickramasinghe- Researcher,
BHFHPRG, Nuffield Department of Population Health,
University of Oxford, Old Road Campus,
Headington, Oxford, OX3 7LF,
England

RE	: **Protocol No EC-13-144**
Title	: **Integrating Nutrition Promotion And Rural Development (INPARD) Sri Lanka.**
Investigators	: **Dr.Kremlin Wickramasinghe** **Professor.Sharong Friel** **Dr.Prasad Katulanda** **Dr.Nicholas Townsend** **Dr.Indika Karunathilake** **Dr.Asela Olupeliyawa** **Dr.Palitha Abeykoon** **Dr.Anoma Jayathilaka** **Dr.Neelamani S Hewageegana** **Dr.Amanthi Bandusena** **Dr.Ajith Alagiyawana** **Dr.Isurujith Kongalaliyanage** **Dr.Ranil Jayawardena** **Dr.Rajendra Surenthirakumaran** **Dr.Kandasamy Arulanandem**

Thank you for submitting the above research proposal, which was considered by the Ethics Review Committee, at its meeting on 21.11.2013. Approval is granted to proceed.

This approval relates to the following:

- Research Proposal (Version 2.1)
- Information sheets (Version 2.1)
- Consent forms (Version 2.1)
- Data collection form (Version 2.1)

Diabetes Research Unit

Department of Clinical Medicine - University of Colombo

Department of Clinical Medicine, University of Colombo, Kynsey Road, Colombo 8, Sri Lanka

Tel 00 94 112 695300, Fax 00 94 112 689188

11/12/2015,

Director of Education,

Zonal Director Office of Education,

Dehiattakandiya .

Dear Sir,

Accessing schools on Data Collection-Integrating Nutrition Promotion and Rural Development (INPARD)

We would like to express our gratitude for the valuable cooperation provided by your schools for the INPARD study. Aim of this study is to integrate rural development with nutrition promotion with multi-sectoral interventions and to evaluate the effectiveness of those interventions.

This survey needs data collection from same children in 2014 and 2015, and we did the first round data collection in these schools last year. As we mentioned in our previous letter in 2014, we have to cover the same schools to complete the study and assess the changes in nutritional status.

All the eligible students for the data collection will be provided the consent forms and information sheets prior to the data collection.

I kindly request your permission for our research team to access following schools to complete the data collection process.

We will provide final results to the local authority and educational officers for their information.

For further information, please contact – Chamil Senavirathne –Project coordinator

Phone-0711587459.

Thank you

Yours sincerely

Dr. Prasad Katulanda

Senior Lecture, Deparment of Clinical medicine

Faculty of Medicine,

University of Colombo.

Dr. Prasad Katulanda
MBBS (Col), MD, FRCP (Lond), FCCP, DPhil (Oxon)
Senior Lecturer in Medicine
Consultant Endocrinologist / Diabetologist
University Medical Unit
National Hospital Sri Lanka.

List of schools which are selected for the data collection

1)Salpitigama Vidyalaya 2)IhalagamaVidyalaya

3)Muwapetikewela Vidyalaya 4) KudagalaVidyalaya

Appendix Seven. Global school-based health survey

GLOBAL SCHOOL-BASED STUDENT HEALTH SURVEY (GSHS)

2013 CORE QUESTIONNAIRE MODULES

FINAL

2013 GSHS Core Questionnaire Modules
Updated: 01 January 2013

_20__ _______GLOBAL SCHOOL-BASED STUDENT HEALTH SURVEY_

This survey is about your health and the things you do that may affect your health. Students like you all over your country are doing this survey. Students in many other countries around the world also are doing this survey. The information you give will be used to develop better health programs for young people like yourself.

DO NOT write your name on this survey or the answer sheet. The answers you give will be kept private. No one will know how you answer. Answer the questions based on what you really know or do. There are no right or wrong answers.

Completing the survey is voluntary. Your grade or mark in this class will not be affected whether or not you answer the questions. If you do not want to answer a question, just leave it blank.

Make sure to read every question. Fill in the circles on your answer sheet that match your answer. Use only the pencil you are given. When you are done, do what the person who is giving you the survey says to do.

Here is an example of how to fill in the circles:

Fill in the circles like this ● Not like this  or 

Survey

1. Do fish live in water?
   A. Yes
   B. No

Answer sheet

1. ● Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ

Thank you very much for your help.

GSHS Core Questionnaire Respondent Demographics Module

1. How old are you?

   - A. 11 years old or younger
   - B. 12 years old
   - C. 13 years old
   - D. 14 years old
   - E. 15 years old
   - F. 16 years old
   - G. 17 years old
   - H. 18 years old or older

2. What is your sex?

   - A. Male
   - B. Female

3. In what grade/class/ standard are you?
   COUNTRY SPECIFIC RESPONSE OPTIONS

   - A. OPTION 1
   - B. OPTION 2
   - C. OPTION 3
   - D. OPTION 4
   - E. OPTION 5
   - F. OPTION 6

The next 3 questions ask about your height, weight, and going hungry.

1. How tall are you without your shoes on? ON THE ANSWER SHEET, WRITE YOUR HEIGHT IN THE SHADED BOXES AT THE TOP OF THE GRID. THEN FILL IN THE OVAL BELOW EACH NUMBER.

Example

Height (cm)		
1	5	3
0	0	0
●	1	1
2	2	2
	3	●
	4	4
	●	5
	6	6
	7	7
	8	8
	9	9
◯	I do not know	

Height (cm)		
0	0	0
1	1	1
2	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9
◯	I do not know	

2. How much do you weigh without your shoes on? ON THE ANSWER SHEET, WRITE YOUR WEIGHT IN THE SHADED BOXES AT THE TOP OF THE GRID. THEN FILL IN THE OVAL BELOW EACH NUMBER.

Example

Weight (kg)		
0	5	2
●	0	0
1	1	1
2	2	●
	3	3
	4	4
	●	5
	6	6
	7	7
	8	8
	9	9
◯	I do not know	

Weight (kg)		
0	0	0
1	1	1
2	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9
◯	I do not know	

3. During the past 30 days, how often did you go hungry because there was not enough food in your home?

- A. Never
- B. Rarely
- C. Sometimes
- D. Most of the time
- E. Always

The next 4 questions ask about what you might eat and drink.

4. During the past 30 days, how many times <u>per day</u> did you **usually** eat fruit, such as COUNTRY SPECIFIC EXAMPLES?

- A. I did not eat fruit during the past 30 days
- B. Less than one time per day
- C. 1 time per day
- D. 2 times per day
- E. 3 times per day
- F. 4 times per day
- G. 5 or more times per day

5. During the past 30 days, how many times <u>per day</u> did you **usually** eat vegetables, such as COUNTRY SPECIFIC EXAMPLES?

- A. I did not eat vegetables during the past 30 days
- B. Less than one time per day
- C. 1 time per day
- D. 2 times per day
- E. 3 times per day
- F. 4 times per day
- G. 5 or more times per day

6. During the past 30 days, how many times <u>per day</u> did you **usually** drink carbonated soft drinks, such as COUNTRY SPECIFIC EXAMPLES? (Do **not** include diet soft drinks.)

- A. I did not drink carbonated soft drinks during the past 30 days
- B. Less than 1 time per day
- C. 1 time per day
- D. 2 times per day
- E. 3 times per day
- F. 4 times per day
- G. 5 or more times per day

7. During the past 7 days, on how many days did you eat food from a fast food restaurant, such as COUNTRY SPECIFIC EXAMPLES?

   - (A) 0 days
   - (B) 1 day
   - (C) 2 days
   - (D) 3 days
   - (E) 4 days
   - (F) 5 days
   - (G) 6 days
   - (H) 7 days

The next 3 questions ask about physical activity. Physical activity is any activity that increases your heart rate and makes you breathe hard. Physical activity can be done in sports, playing with friends, or walking to school. Some examples of physical activity are running, fast walking, biking, dancing, football, and COUNTRY SPECIFIC EXAMPLES.

1. During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day? ADD UP ALL THE TIME YOU SPENT IN ANY KIND OF PHYSICAL ACTIVITY EACH DAY.

   - A 0 days
   - B 1 day
   - C 2 days
   - D 3 days
   - E 4 days
   - F 5 days
   - G 6 days
   - H 7 days

2. During the past 7 days, on how many days did you walk or ride a bicycle to or from school?

   - A 0 days
   - B 1 day
   - C 2 days
   - D 3 days
   - E 4 days
   - F 5 days
   - G 6 days
   - H 7 days

3. During this school year, on how many days did you go to physical education (PE) class each week?

   - A 0 days
   - B 1 day
   - C 2 days
   - D 3 days
   - E 4 days
   - F 5 or more days

The next question asks about the time you spend mostly sitting when you are not in school or doing homework.

4. How much time do you spend during a **typical or** usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities, such as COUNTRY SPECIFIC EXAMPLES?

   - A Less than 1 hour per day
   - B 1 to 2 hours per day
   - C 3 to 4 hours per day
   - D 5 to 6 hours per day
   - E 7 to 8 hours per day
   - F More than 8 hours per day

Global School-based Student Health Survey (GSHS)
Core-Expanded Questions for the Dietary Behaviours Module

Dietary Behaviours - Recommended core-expanded questions are shaded grey.	
1. During the past 30 days, how often did you eat breakfast? a. Never b. Rarely c. Sometimes d. Most of the time e. Always	2. How do you describe your weight? a. Very underweight b. Slightly underweight c. About the right weight d. Slightly overweight e. Very overweight
3. Which of the following are you trying to do about your weight? a. I am **not trying to do anything** about my weight b. **Lose** weight c. **Gain** weight d. **Stay** the same weight	4. During the past 12 months, have you been weighed and measured? a. Yes b. No
5. What is the **main** reason you do not eat breakfast? a. I always eat breakfast b. I do not have time for breakfast c. I cannot eat early in the morning d. There is not always food in my home e. Some other reason	6. During the past 30 days, did you **exercise** to lose weight or to keep from gaining weight? a. Yes b. No
7. During the past 30 days, did you **take any diet pills, powders, or liquids** without a doctor's advice to lose weight or to keep from gaining weight? a. Yes b. No	8. During the past 30 days, did you **eat less food, fewer calories, or foods low in fat** to lose weight or to keep from gaining weight? a. Yes b. No
9. During the past 30 days, did you **go without eating for 24 hours or more** (also called fasting) to lose weight or to keep from gaining weight? a. Yes b. No	10. During the past 30 days, did you **vomit or take laxatives** to lose weight or to keep from gaining weight? a. Yes b. No
11. During the past 30 days, did you **exercise** to gain weight? a. Yes b. No	12. During the past 30 days, did you **eat more food, more calories, or foods high in fat** to gain weight? a. Yes b. No
13. During the past 30 days, did you **take any pills, powders, or liquids** without a doctor's advice to gain weight? a. Yes b. No	14. During the past 30 days, how often did you bring your lunch to school? a. Never b. Rarely c. Sometimes d. Most of the time e. Always

15. During the past 30 days, how often was breakfast offered to you at school?

a. Never
b. Rarely
c. Sometimes
d. Most of the time
e. Always

16. During the past 30 days, how often was lunch offered to you at school?

a. Never
b. Rarely
c. Sometimes
d. Most of the time
e. Always

17. During the past 30 days, how many times per day did you **usually** drink milk or eat milk products, such as COUNTRY SPECIFIC EXAMPLES?

a. I did not drink milk or eat milk products during the past 30 days
b. Less than one time per day
c. 1 time per day
d. 2 times per day
e. 3 times per day
f. 4 times per day
g. 5 or more times per day

18. During the past 30 days, how many times per day did you **usually** eat salty foods, such as COUNTRY SPECIFIC EXAMPLES OF SALTY FOODS?

a. I did not eat salty foods
b. Less than 1 time per day
c. 1 time per day
d. 2 times per day
e. 3 times per day
f. 4 times per day
g. 5 or more times per day

19. During the past 30 days, how many times <u>per day</u> did you **usually** eat foods high in fat, such as COUNTRY SPECIFIC EXAMPLES OF HIGH FAT FOODS?

a. I did not eat foods high in fat
b. Less than 1 time per day
c. 1 time per day
d. 2 times per day
e. 3 times per day
f. 4 times per day
g. 5 or more times per day

20. During the past 30 days, how many times <u>per day</u> did you **usually** drink fruit juice, such as COUNTRY SPECIFIC EXAMPLES?

a. I did not drink fruit juice during the past 30 days
b. Less than one time per day
c. 1 time per day
d. 2 times per day
e. 3 times per day
f. 4 times per day
g. 5 or more times per day

Role of the Media and Advertising

The next 7 questions ask about how carbonated soft drinks, such as COUNTRY SPECIFIC EXAMPLES (*Do not include diet soft drinks*) and foods from fast food restaurants, such as COUNTRY SPECIFIC EXAMPLES, are advertised and sold.

21. When you watch television, videos, or movies, how often do you see advertisements for carbonated soft drinks or fast foods?

a. I do not watch television, videos, or movies
b. Never
c. Rarely
d. Sometimes
e. Most of the time
f. Always

22. During the past 30 days, how many advertisements for carbonated soft drinks or fast foods did you see when you watched **television**?

a. I did not watch television during the past 30 days
b. A lot
c. A few
d. None

23. During the past 30 days, how many advertisements for carbonated soft drinks or fast foods did you see on the **internet**? a. I did not use the internet during the past 30 days b. A lot c. A few d. None	24. During the past 30 days, how many **text messages or mobile phone calls** did you get that encouraged you to go to a carbonated soft drink or fast food company website? a. I did not receive text messages or mobile phone calls during the past 30 days b. A lot c. A few d. None
25. Can you buy **carbonated soft drinks** or get them for free in your school? a. Yes b. No	26. Can you buy **fast foods** or get them for free in your school? a. Yes b. No
27. During the past 30 days, how many advertisements for carbonated soft drinks or fast foods did you see in your school? a. I did not see any advertisements for carbonated soft drinks or fast foods in my school b. A lot c. A few d. None	
Knowledge, Attitudes, Skills, and Sources of Information	
28. During this school year, were you taught in any of your classes the benefits of healthy eating? a. Yes b. No c. I do not know	29. During this school year, were you taught in any of your classes the benefits of eating more fruits and vegetables? a. Yes b. No c. I do not know
30. During this school year, were you taught in any of your classes how to safely prepare or store food? a. Yes b. No c. I do not know	31. During this school year, were you taught in any of your classes healthy ways to gain weight? a. Yes b. No c. I do not know
32. During this school year, were you taught in any of your classes healthy ways to lose weight? a. Yes b. No c. I do not know	

The next 6 questions ask about cigarette and other tobacco use.

1. How old were you when you first tried a cigarette?

- A. I have never smoked cigarettes
- B. 7 years old or younger
- C. 8 or 9 years old
- D. 10 or 11 years old
- E. 12 or 13 years old
- F. 14 or 15 years old
- G. 16 or 17 years old
- H. 18 years old or older

2. During the past 30 days, on how many days did you smoke cigarettes?

- A. 0 days
- B. 1 or 2 days
- C. 3 to 5 days
- D. 6 to 9 days
- E. 10 to 19 days
- F. 20 to 29 days
- G. All 30 days

3. During the past 30 days, on how many days did you use any tobacco products other than cigarettes, such as COUNTRY SPECIFIC EXAMPLES?

- A. 0 days
- B. 1 or 2 days
- C. 3 to 5 days
- D. 6 to 9 days
- E. 10 to 19 days
- F. 20 to 29 days
- G. All 30 days

4. During the past 12 months, have you ever tried to stop smoking cigarettes?

- A. I have never smoked cigarettes
- B. I did not smoke cigarettes during the past 12 months
- C. Yes
- D. No

5. During the past 7 days, on how many days have people smoked in your presence?

- A. 0 days
- B. 1 or 2 days
- C. 3 or 4 days
- D. 5 or 6 days
- E. All 7 days

6. Which of your parents or guardians use any form of tobacco?

- A. Neither
- B. My father or male guardian
- C. My mother or female guardian
- D. Both
- E. I do not know

The next 6 questions ask about drinking alcohol. This includes drinking COUNTRY SPECIFIC EXAMPLES. Drinking alcohol does not include drinking a few sips of wine for religious purposes. A "drink" is a glass of wine, a bottle of beer, a small glass of liquor, or a mixed drink.

1. How old were you when you had your first drink of alcohol other than a few sips?

   - (A) I have never had a drink of alcohol other than a few sips
   - (B) 7 years old or younger
   - (C) 8 or 9 years old
   - (D) 10 or 11 years old
   - (E) 12 or 13 years old
   - (F) 14 or 15 years old
   - (G) 16 or 17 years old
   - (H) 18 years old or older

2. During the past 30 days, on how many days did you have at least one drink containing alcohol?

   - (A) 0 days
   - (B) 1 or 2 days
   - (C) 3 to 5 days
   - (D) 6 to 9 days
   - (E) 10 to 19 days
   - (F) 20 to 29 days
   - (G) All 30 days

3. During the past 30 days, on the days you drank alcohol, how many drinks did you usually drink per day?

   - (A) I did not drink alcohol during the past 30 days
   - (B) Less than one drink
   - (C) 1 drink
   - (D) 2 drinks
   - (E) 3 drinks
   - (F) 4 drinks
   - (G) 5 or more drinks

4. During the past 30 days, how did you usually get the alcohol you drank? SELECT ONLY ONE RESPONSE.

   - (A) I did not drink alcohol during the past 30 days
   - (B) I bought it in a store, shop, or from a street vendor
   - (C) I gave someone else money to buy it for me
   - (D) I got it from my friends
   - (E) I got it from my family
   - (F) I stole it or got it without permission
   - (G) I got it some other way

Staggering when walking, not being able to speak right, and throwing up are some signs of being really drunk.

5. During your life, how many times did you drink so much alcohol that you were really drunk?

   - (A) 0 times
   - (B) 1 or 2 times
   - (C) 3 to 9 times
   - (D) 10 or more times

6. During your life, how many times have you got into trouble with your family or friends, missed school, or got into fights, as a result of drinking alcohol?

   - (A) 0 times
   - (B) 1 or 2 times
   - (C) 3 to 9 times
   - (D) 10 or more times

GSHS Additional Questions

The next 6 questions ask for background information about you, your family and your household.

1. What is your ethnic background? (Please select the relevant ethnic/cultural group to which you belong)

    a) Sinhala
    b) Sri Lankan Tamil
    c) Indian Tamil
    d) Sri Lankan Moor
    e) Other
    f) I don't know

2. What is the highest level of education that your mother completed?

    a) No schooling
    b) Up to grade 5
    c) Passed grade 6-10
    d) Passed G.C.E (O/L)
    e) Passed G.C.E (A/L)
    f) Degree and above
    g) I don't know

3. What is the highest level of education that your father completed?

    a) No schooling
    b) Up to grade 5
    c) Passed grade 6-10
    d) Passed G.C.E (O/L)
    e) Passed G.C.E (A/L)
    f) Degree and above
    g) I don't know

4. Which of the following best describes your mother's main work status over the past 12 months?

a) Government employee
b) Non-government employee
c) Self-employed
d) Non-paid
e) Student
f) Homemaker
g) Retired
h) Unemployed (able to work)
i) Unemployed (unable to work)
j) Refused

5. Which of the following best describes your father's main work status over the past 12 months?

a) Government employee
b) Non-government employee
c) Self-employed
d) Non-paid
e) Student
f) Homemaker

g) Retired
h) Unemployed (able to work)
i) Unemployed (unable to work)
j) Refused

6. What is the average monthly income of the household (in rupees?)

   a) ≤10,000
   b) 10,001-20,000
   c) 20,001-30,000
   d) 30,001-40,000
   e) More than 40,001
   f) I don't know

Global School Health Survey tool *), used for* " Suwa Naguma / INPARD project funded by the South Asian Food and Nutrition Security Trust Fund, World Bank" Implemented by the Ministry of Economic Development

Appendix Eight. The Food Frequency Questionnaire

Follow the instructions given below before filling the food frequency questionnaire.

- Try to remember **how often did you consumed following foods at a meal** which were listed in the table below **during the past month.**
- When answering each question, think of the average amount of that food you had, even though you may rarely have consumed the food on its own.
- If you usually consume more than one helping, sum up all the helpings you had when considering the total amount of food you had for that particular meal. Keeping this in mind, choose the serving size closest to the total amount you consumed.
- **Indicate the frequencies you had for each food shown on this questionnaire on a Daily/Weekly/Monthly basis.**
- If you mention the frequency of daily consumption for a one particular food item, you do not need to mention it again as weekly or monthly basis. Eg; consume rice 3 times per day. Then no need to mention it again as weekly and monthly basis. Look at the example given below.
- When answering the first four questions, look at given pictures carefully and select the portion sizes of rice, vegetable, meat and dhal you are usually eating. It can be less than A/A/between A & B/B/between B & C/C/more than C.
- Similarly, you do not need to consider about the preparation methods of each food item. In the case of jak, manioc, breadfruit and potato, you can consider both (curry and boiled form) together. If you have consumed any type of green leafy vegetables, it should come under the raw of "Common Mallum".

For example:

Code	Food (Type)	Portion	# units taken at a time	Per day	Per week	Per month
100 1. W	Unpolished Rice (Red Kakulu)	According to picture	1	3	-	-
103 h	Bread	1 slice	4	-	5	-

1. When you eat RICE did you usually eat;

Figure A Figure B Figure C

Less than A	A	Between A and B	B	Between B and C	C	More than C

2. When you eat VEGETABLE, did you usually eat;

Figure A Figure B Figure C

Less than A	A	Between A and B	B	Between B and C	C	More than C

3. When you eat MEAT, did you usually eat;

Figure A Figure B Figure C

Less than A	A	Between A and B	B	Between B and C	C	More than C

4. When you eat Dhal, did you usually eat;

Figure A Figure B Figure C

Less than A	A	Between A and B	B	Between B and C	C	More than C

NutriSurvey Code	Code No	Food Type	Portion size	# of units taken at a time	Per Day	Per Week	Per Month
	100	Cereals or equivalents					
Z000085	101	Unpolished Rice (Red Kakulu)	According to picture 1				
C359031	102	Polished rice	According to picture 1				
B311000	103	Bread	1 slice				
C610011	104	String hoppers	1 medium size				
C630000	105	Roti	1 medium				
Z000083	106	Pittu	5 cm length piece				
Z000082	107	Noodles/Macaroni/Pasta	According to picture 1				
C620012	108	Hoppers	1 medium				
_134100	109	Milk rice	1 piece				
Z000195	110	Bun & Bakery products	1 medium				
Z000235	111	Thosai	1 medium				
Z000237	112	Potato	1 table spoon				
Z000236	113	Manioc	1 medium coconut spoon				
K420000	114	Boiled sweet potato	1 medium coconut spoon				
Z000237	115	Jak	1 medium coconut spoon				
Z000090	116	Breadfruit	1 medium coconut spoon				
Z000141	117	Ash plantain	1 table spoon				
	200	Vegetables					
Z000153	201	Coconut sambol	According to picture 2				
Z000171	202	Beans/ long beans/ wing beans curry					
Z000150	203	Cabbage curry					
Z000108	204	Pumpkin curry					
Z000160	205	Brinjol curry					
G910111	206	Polos curry/mallum					
Z000117	207	Carrot curry					
Z100008	208	Kohila curry					

Z100007	209	Kehelmuwa curry					
NutriSurvey Code	Code No	Food Type	Portion size	# of units taken at a time	Per Day	Per Week	Per Month
Z000132	210	Leaks curry					
Z000142	211	Bittergourd curry					
Z000102	212	Radish/Nohkol					
Z000105	213	Snakegourd/Ridgegourd					
Z000167	214	Beetroot curry					
Z000128	215	Mushroom curry					
Z000099	216	Tomato curry					
Z000125	217	Cucumber/Kakiri curry					
Z000118	218	Ladies fingers curry					
Z000223	219	Common mallum					
Z000094	220	Vegetable soup	1 cup				
	300	Pulses					
Z000220	301	Dhal curry (thick)	According to picture 4				
Z000224	302	Dhal curry (watery)	According to picture 4				
Z000070	303	Soya curry					
Z000205	304	Chick peas					
Z000209	305	Green grams					
Z000228	306	Samaposha					
	400	Meat/Poultry and meat/Poultry products					
Z000191	401	Chicken	According to picture 3				
U010021	402	Beef/Pork/Mutton	According to picture 3				
_119904	403	Meat balls/sausages	1 medium size				
Z000200	404	Egg boiled/Omelet	1				
Z000178	405	Dry fish /Sprat	1 table spoon				
T108012	406	Fish	1 medium piece				
T410121	407	Salmon	1 medium piece				

T751021	408	prawn/cuttlefish/crabs	1 medium				
NutriSurvey Code	Code No	Food Type	Portion size	# of units taken at a time	Per Day	Per Week	Per Month
	500	Fruits					
Z000039	501	Banana	1 medium				
Z000206	502	Papaya	1 piece				
F110111	503	Apple	1 medium				
F516111	504	Mango	1 medium				
F603112	505	Orange	1 medium				
F501112	506	Pineapple	Medium size				
Z000210	507	Guava	1 medium				
Z000212	508	Fruit salad	1 cup				
F504400	509	Dried fruits-Dates/ Resins	1 handful				
	600	Beverages					
Z000232	601	Nestamalt /Viva/Milo	1 glass				
Z000202	602	Full cream milk	1 glass				
M884111	603	Non fat milk	1 glass				
Z000087	604	Fresh milk	1 glass				
Z000216	605	Plain tea	1 cup				
Z000229	606	Coffee	1 cup				
Z000207	607	Fizzy drinks	200 ml				
N320011	608	Cordial/Smack/Colman	1 glass				
Z000208	609	Kola kanda/rice kanji	1 glass				
	700	Miscellaneous					
M240111	701	Yoghurt	1 cup				
Z000231	702	Ice cream	1 cup				
M713500	703	Curd	1 cup				
Z000211	704	Cheese	1 wedge				
D700111	705	Un-sweeten Biscuits	1				
D710613	706	Cream/Sweet biscuits	1				

D300011	707	Cake	1 medium size				
NutriSurvey Code	Code No	Food Type	Portion size	# of units taken at a time	Per Day	Per Week	Per Month
M160211	708	Watalappam/Pudding	1 cup				
S460011	709	Sweets	1 medium				
S111000	710	Sugar	1 tea spoon				
S331011	711	Toffee	1				
S500000	712	Chocolate	1				
Q610000	713	Butter/Margarine	1 tea spoon				
F090800	714	Jam	1 tea spoon				
-204700	715	Tomato sauce	1 table spoon				
H110601	716	Mixtures/salted nuts	1 table spoon				
	800	Alcohol					
P711000	801	Spirit	25 ml				
P100011	802	Beer	1 pint				

NutriSurvey Code	Code No	Food Type	Portion size	# of units taken at a time	Per Day	Per Week	Per Month
M160211	708	Watalappam/Pudding	1 cup				
S460011	709	Sweets	1 medium				
S111000	710	Sugar	1 tea spoon				
S331011	711	Toffee	1				
S500000	712	Chocolate	1				
Q610000	713	Butter/Margarine	1 tea spoon				
F090800	714	Jam	1 tea spoon				
-204700	715	Tomato sauce	1 table spoon				
H110601	716	Mixtures/salted nuts	1 table spoon				
	800	Alcohol					
P711000	801	Spirit	25 ml				
P100011	802	Beer	1 pint				

Appendix Nine. The NFSI tool for researchers

Assessment of the School Nutrition Environment Based on School Staff Questionnaire—**Interviewer Version**

Thank you for your help.

The questions in this interview have been developed so that staff can tell us about their school. This information will be used to improve health education, programmes and policies for students.
The questions in this document are intended to be used in a structured interview. This technique works most effectively if the conversation leaves the candidate feeling like they have been able to perform at their best and provide you with the information you need. This will work best if you do not read all the questions out exactly how they are written but use them as a tool to guide the discussion. There may also be times when you need to elaborate and provide additional prompts or details, particularly if the interviewee does not understand the question and clarification is needed. We have provided 'Notes for interviewers' in those questions in which piloting suggested this was most common.

When opening the interview:
- Thank the other person for their participation.
- Briefly introduce yourself

Outline how the interview will progress. Explain:
- The interview should take no longer than 1 hour.
- You will be using the questions in this document as discussion points and will be taking notes

Before the interview starts, request informed consent. The consent form must be signed before the interview starts.

Filling out the form:
- Unless otherwise noted, most questions require you to tick one box only. Sometimes, you will see a symbol like this next to a response to a question:

⇨Q10

This will direct you to the next question. For the example above, you should go to question 10. This is because some of the sections may not be relevant to you and should be left blank.

1. GENERAL QUESTIONS ABOUT YOU & YOUR SCHOOL

This section of the questionnaire asks some questions about you and your position in the school.

Q1.1 **How many years have you been working at the school?**

If you have been teaching less than one year please write '0' in the box.

Q1.2	**What is your position within the school?** *If you can be described by more than one of the following positions please tick all appropriate answers.*	
	[1]❑	Head Teacher/Principal
	[2]❑	Other member of senior management/Vice Principal
	[3]❑	Department/Subject Head
	[4]❑	Grade Head or Deputy Head of Grade
	[5]❑	Health/Nutrition education co-ordinator or teacher with responsibility for health education
	[6]❑	Subject teacher
	[7]❑	Other - Please specify:
	[8]❑	Don't know

Q1.3 **How many teachers work at your school?**

Q1.4 **How many students are enrolled at your school?**

Q1.5	**Which grades are taught at your school?** *Please tick all answers that apply.*	
	1❑	Grade 6
	2❑	Grade 7
	3❑	Grade 8
	4❑	Grade 9
	5❑	Grade 10
	6❑	Grade 11

Q1.6	**Does your school receive free school meals from the government?**
	[1]❑ Yes
	[2]❑ No
	[3]❑ Don't know

2. HEALTHY EATING POLICY

This section asks questions about your school's **healthy eating policies**. We define healthy eating policies as a framework of decisions, plans or actions that your school has undertaken to achieve specific goals related to healthy eating. These may be written in the form of a document or be unwritten but embedded within the culture of the school.

Q2.1	**Did your school receive a canteen policy or a policy related to school food from the education authorities?**
	[1]❑ Yes
	[2]❑ No
	[3]❑ Don't know

Q2.2	**Does your school have any other policies (written or unwritten) on healthy eating?** *Note for interviewer: If schools have both a written and unwritten answer, please tick all that apply.*
	[1]❑ Yes written ⇨ Q2.3
	[2]❑ Yes informal ⇨ Q2.3
	[3]❑ No policy ⇨ Q3.1
	[4]❑ Don't know ⇨ Q3.1

Q2.3	**Was this policy developed within the school by staff or did you receive it from outside of the school?**
	[1]❑ The policy was developed by staff in the school ⇨ Q2.5
	[2]❑ The policy came from a source outside of the school ⇨ Q2.4

Q2.4	**Which source did this policy come from?**	
	[1] ❑	The Ministry of Education
	[2] ❑	The Ministry of Health
	[3] ❑	Provisional council
	[4] ❑	Other - Please specify:
	[5] ❑	Don't know

Q2.5	**How long has this policy been in place?**	
	[1] ❑	Less than one year
	[2] ❑	One to two years
	[3] ❑	Three to four years
	[4] ❑	Five or more years
	[5] ❑	Don't know

Q2.6	**What are the aims of the policy?** *Please tick all that apply.*	
	[1] ❑	Increased physical activity among pupils
	[2] ❑	Prevention of under-nutrition
	[3] ❑	Prevention of micronutrient deficiencies
	[4] ❑	Prevention of overweight and/or obesity
	[5] ❑	Prevention of other nutrition-related chronic diseases
	[6] ❑	Promotion of a hygienic environment
	[7] ❑	Staff training
	[8] ❑	Community education related to healthy eating
	[9] ❑	Other - Please specify:

Q2.7	**In order to achieve these aims does this policy contain clearly defined objectives*?** ** We define objectives as explicitly identified goals, aims or intentions.*
	1❑ Yes ⇨ Q2.8
	3❑ No ⇨ Q2.9
	4❑ Don't know ⇨ Q2.9

Q2.8	**Are these objectives* judged against:** *Please tick all that apply.*
Time-lines	❑
Clear milestones	❑

**We define objectives as explicitly identified goals, aims or intentions.*

Q2.9 Which of the following does the policy promote in order to achieve its defined objectives? ***Please tick one box for each line.***	*1)* Yes	*2)* No	*3)* Don't know
A whole school approach to health	❑	❑	❑
A clear organizational structure for health promotion within the school	❑	❑	❑
Defined roles and responsibilities for school staff	❑	❑	❑
The promotion of harmony* between all students irrespective of background	❑	❑	❑
A strong commitment by all concerned stakeholders	❑	❑	❑
The inclusion of family and community members	❑	❑	❑

*Note for interviewer: *This question is intended to assess if the school actively discourages situations where certain students are denied opportunities or treated badly because of their ethnicity, religion or gender. Please clarify if necessary.*

Q2.10	**Does the school actively monitor and/or evaluate the impact of the policy?**
	[1]❑ Yes ⇨ Q2.10
	[3]❑ No ⇨ Q3.1
	[4]❑ Don't know ⇨ Q3.1

Q2.11	**What does the school do to monitor the impact of the policy?** *Please tick all that apply.*
It measures dissemination of the policy	❑
It measures implementation of the policy	❑
It measures health outcomes of pupils	❑

3. ENHANCING AWARENESS AND CAPACITY BUILDING

Q3.1	**Which of the following groups has the policy been shared with:** *Please tick all that apply*
	[1]❑ Parents
	[2]❑ Pupils
	[3]❑ School staff members
	[4]❑ Community members
	[5]❑ None of the above
	[6]❑ Other - Please specify:

Q3.2	**Does the school work with families of pupils to promote consistent healthy eating messages inside and outside of school?**
	[1]❑ Yes ⇨ Q3.3
	[3]❑ No ⇨ Q3.4
	[3]❑ Don't know ⇨ Q3.4

Q3.3 How many activities* to promote healthy eating has the school held for families in the past 12 months? **We define 'activities' as events or actions organised by the school; these do not include informal discussions about healthy eating.* *Note for Interviewer: Please tick 'yes' only in instances with actions, activities or events. Tick 'no' if they have only talked about promoting healthy eating at meetings or events in which the main focus was not healthy eating, such as parents' evenings.*		
	1❑	None
	2❑	One
	3❑	Two
	4❑	Three or more

Q3.4	**Does the school work with the community to promote consistent healthy eating messages inside and outside of school?**	
	1❑	Yes ⇨ Q3.5
	3❑	No ⇨ Q3.6
	4❑	Don't know ⇨ Q3.6

Q3.5 How many activities* to promote healthy eating has the school held for the local community **in the past 12 months?**		
	1❑	None
	2❑	One
	3❑	Two
	4❑	Three or more

**We define 'activities' as events or actions organised by the school; these do not include informal discussions about healthy eating.*

Q3.6	Do school staff receive training in issues related to healthy eating?
¹❑	Yes, all staff receive training ⇨ Q3.7
²❑	Yes, but only staff responsible for health receive training ⇨ Q3.7
³❑	No ⇨ Q3.8

Q3.7	How many staff training sessions in issues related to healthy eating have been held in the past 12 months?
¹❑	None
²❑	One
³❑	Two
⁴❑	Three or more

Q3.8	Do school staff receive training in other health related issues (not including healthy eating)?
¹❑	All staff ⇨ Q3.9
²❑	Yes, but only staff responsible for health receive training ⇨ Q3.9
³❑	No ⇨ Q4.1

Q3.9	How many staff training sessions in other health related issues (not including healthy eating) have been held in the past 12 months?
¹❑	None
²❑	One
³❑	Two
⁴❑	Three or more

4. DEVELOPING A HEALTH-PROMOTING SCHOOL CURRICULUM

Q4.1	**Within which grades do pupils receive compulsory education about healthy eating in a classroom setting?** *Please tick all answers that apply.* *Note for interviewer: Please tick the box only if the education is mandatory. Optional subjects do not apply.*	
	1❑	Grade 6
	2❑	Grade 7
	3❑	Grade 8
	4❑	Grade 9
	5❑	Grade 10
	6❑	Grade 11
	7❑	Other - Please specify:

Q4.2	**In which subjects do the pupils receive education about healthy eating?** *Please tick all answers that apply.*	
	1❑	Science
	2❑	Physical Education
	3❑	Life Science
	4❑	Health Science
	5❑	Other – Please specify:

Q4.3	**Which of the following do the pupils receive for education in healthy eating?** *Please tick all the boxes that apply.*	
	1❑	Grades
	2❑	Reports
	3❑	Self-assessment
	4❑	None of the above
	5❑	Other (please specify):

Q4.4	In your opinion how good is the quality of information currently given to the pupils on healthy eating in your school?
[1]❑	Very good
[2]❑	Good
[3]❑	Neither good nor bad
[4]❑	Bad
[5]❑	Very bad
[6]❑	There is no information given on healthy eating
[7]❑	I don't know as I am not involved in delivering this information

Q4.5	Do the pupils receive practical training such as cooking food?
[1]❑	Yes
[2]❑	No
[3]❑	Don't know

Q4.6 **How many hours of physical education does each grade have in their curriculum?**

Please tick one box for each line.

	None	Less than 1 hour	1 to 2 hours	More than 2 hours
Grade 6	❑	❑	❑	❑
Grade 7	❑	❑	❑	❑
Grade 8	❑	❑	❑	❑
Grade 9	❑	❑	❑	❑
Grade 10	❑	❑	❑	❑
Grade 11	❑	❑	❑	❑

Q4.7	Do you agree with the following statements about physical education curriculum at your school? *Please tick one box for each line*				
	1) Agree strongly	2) Agree slightly	3) Neither agree nor disagree	4) Disagree slightly	5) Disagree strongly
Curriculum changes between grades to account for age	❑	❑	❑	❑	❑
Curriculum is different for boys and girls	❑	❑	❑	❑	❑
Curriculum includes culturally appropriate activities	❑	❑	❑	❑	❑

Q4.8	Which of the following facilities for physical education does the school have? *Please tick all answers that apply.*
	1❑ Changing rooms
	2❑ Washing facilities
	3❑ Outdoor space
	4❑ Indoor space available specifically for physical activity
	5❑ Sports equipment
	6❑ Audio/video equipment

Q4.9	Does the school have areas available for active play outside of physical education lessons?
	1❑ Yes, the school has adequate facilities for all students
	2❑ Yes, but the facilities are not adequate for all students
	3❑ No, no facilities are available outside of physical education lessons

Q4.10	**Within which grades are pupils taught about healthy living in a classroom setting?** *Please tick all answers that apply.*
	[1]❑ Grade 6
	[2]❑ Grade 7
	[3]❑ Grade 8
	[4]❑ Grade 9
	[5]❑ Grade 10
	[6]❑ Grade 11
	[7]❑ Other - Please specify:

Q4.11	**In which subjects do the pupils receive education about healthy living?** *Please tick all answers that apply.*
	[1]❑ Science
	[2]❑ Physical Education
	[3]❑ Life Science
	[4]❑ Health Science
	[5]❑ Other – Please specify:

Q4.12	**Are the aims of the school curriculum related to healthy eating, physical activity and healthy living monitored against outcomes?**
	[1]❑ Yes ⇨ Q4.13
	[2]❑ No ⇨ Q4.14
	[3]❑ Don't know ⇨ Q4.14

Q4.13	**Which of the following outcomes does the school use to monitor these curricula?** *Please tick all the boxes that apply.*	
	[1]❑	Pupil Test/Exam Scores
	[2]❑	Pupil Behavioural Outcomes (Physical Activity, Diet)
	[3]❑	Pupil Health Outcomes (Height, Weight, etc.)
	[4]❑	Staff Reports
	[5]❑	Other – Please specify:

Q4.14	**How often does the school review its curricula on nutrition, physical activity and healthy living?**	
	[1]❑	At least once a term
	[2]❑	At least once a year
	[3]❑	Less than once a year
	[4]❑	Don't know

5. CREATING A SUPPORTIVE SCHOOL ENVIRONMENT

Q5.1	**During school hours, where can pupils obtain food outside of the school premises?** *Please tick all the answers that apply.*	
	[1]❑	Newsagents
	[2]❑	Street-vendors
	[3]❑	Tea Shops/Hotels
	[4]❑	Supermarkets
	[5]❑	Other- Please specify:
	[6]❑	None of the above

Q5.2	**Where can pupils obtain food from within school?** *Please tick all the answers that apply.*	
	[1]❑	School provided meals for free
	[2]❑	On-site school canteen
	[3]❑	Food vendors
	[4]❑	Snack bars
	[5]❑	Other – Please specify:
	[6]❑	Food is not available within the school ⇨ Q5.8

Q5.3	**Does the school have cooking facilities to prepare food on-site for students?**	
	[1]❑	Yes
	[2]❑	No
	[3]❑	Don't know

Q5.4	**Are these facilities adequate to prepare food for all students?**	
	1❑	Yes
	2❑	No
	3❑	Don't know

Q5.5	**Do you feel that the food on offer within the school complements the healthy eating taught within the classroom?** *Note for interviewer: We would like to know if the interviewee thinks the school food is healthy, this can be asked in a more a direct manner to make it clear.*	
	1❑	Yes
	2❑	No
	3❑	Don't know

Q5.6 **At what time is food available to pupils?** *Please tick one box for each line.*	Yes	No	Don't know
Before school (e.g. breakfast)	❑	❑	❑
Mid-morning	❑	❑	❑
Lunch	❑	❑	❑
At all times including after school	❑	❑	❑

Q5.7	**What foods are available to pupils within the school premises?** *Please tick one box for each line.*			
		Yes	No	Don't know
Fresh fruit and vegetables		❑	❑	❑
Curry/Rice/Roti/Hoppers		❑	❑	❑
Short eats (Cutlets, Patties, Chinese rolls)		❑	❑	❑
Sweets/Chocolate/Ice-cream		❑	❑	❑
Bottled sweet soda drinks (e.g. Cola, Sprite, Pepsi, Elephant House drinks)		❑	❑	❑
Fruit juice		❑	❑	❑
Milk		❑	❑	❑
Other – Please specify:				

Q5.8	**What spaces are available for children to eat their food?** *Note for interviewer: This is all food, whether the child brings it from home or purchases it on the school premises.*
	1❑ In the class-room ⇨ Q5.10
	2❑ In a designated eating room (e.g. canteen) ⇨ Q5.9
	3❑ Open outside area (e.g. playground) ⇨ Q5.9

Q5.9	**Is this designated eating area large enough for all children to use?**
	1❑ Yes
	2❑ No
	3❑ Don't know

Q5.10	Which of these can be found within your school? *Please tick one box for each line.*	Yes	No	Don't know
Positive messaging towards nutrition and active living		❑	❑	❑
Advertising of foods and beverages		❑	❑	❑
Access to safe drinking water		❑	❑	❑
Access to taps for hand-washing		❑	❑	❑
Availability of clean and separate toilets for boys and girls		❑	❑	❑
Availability of sanitary disposal bins in girls' toilets		❑	❑	❑

Q5.11	**How much do you agree with the following statements about your school supporting a healthy and safe environment?** *Please tick one box for each line*	*1)* Agree strongly	*2)* Agree slightly	*3)* Neither agree nor disagree	*4)* Disagree slightly	*5)* Disagree strongly
Staff are role-models in encouraging healthy eating		❑	❑	❑	❑	❑
Staff are role-models in encouraging a healthy lifestyle		❑	❑	❑	❑	❑

Q5.12	**What does your school do to discourage bullying and discrimination?** *Please describe:*

6. PROVIDING SUPPORTIVE SCHOOL NUTRITION AND HEALTH SERVICES

Q6.1	**Are the children in your school measured to monitor their growth and development?**	
	[1]❑	Yes ⇨ Q6.2
	[2]❑	No ⇨ Q6.8
	[3]❑	Don't know ⇨ Q6.8

Q6.2	**Who takes these measurements?** *Please tick all the boxes that apply.*	
	[1]❑	School teaching staff
	[2]❑	School health staff (e.g. a school nurse)
	[3]❑	Public health staff/Public health inspector
	[4]❑	School Medical Inspection personnel
	[5]❑	Other – Please specify:

Q6.3	**Which of the following grades are measured?** *Please tick all the boxes that apply.*	
	[1]❑	Grade 6
	[2]❑	Grade 7
	[3]❑	Grade 8
	[4]❑	Grade 9
	[5]❑	Grade 10
	[6]❑	Grade 11

Q6.4	**How often are these measurements taken?**	
	1❑	At least once a term
	2❑	At least once a year
	3❑	Less than once a year

Q6.5	**What measurements are taken in monitoring growth and development?** *Please tick all the boxes that apply.*	
	1❑	Height
	2❑	Weight
	3❑	Other – Please specify:
	4❑	Don't know

Q6.6	**Are the results from this monitoring reported back or made available to pupils?**	
	1❑	Yes
	2❑	No
	3❑	Don't know

Q6.7	**Are the results from this monitoring reported back or made available to parents?**	
	1❑	Yes
	2❑	No
	3❑	Don't know

Q6.8	**Which of the following does your school have in relation to health services in the school?**	
	1❑	School-based health staff such as a nurse or doctor

2❑	Visiting public health worker, such as a PHM or MOH
3❑	A room with first aid facilities
4❑	A room where sick children can rest
5❑	Other – Please specify:

Q6.9	**Is the school able to refer students to health services outside of school?**
1❑	Yes
2❑	No
3❑	Don't know

Thank you for completing this questionnaire.

Please use this space to make any comments you may have about healthy eating practices, policies and promotion/education in your school which we have not asked about. *Note for interviewer: This is an opportunity for the interviewee to bring up issues related to healthy eating in the school they think we have not covered.*

Appendix Ten. Additional baseline results from the NFSI survey

Description of NFSI survey participants and school characteristics

The NFSI Tool for researchers was designed to ask school principals about school policies and practices, and as Table 1 shows, most of the respondents were head teachers. However, in instances when the head teacher was not available, I asked data collectors to interview other school staff, including senior management or vice principals.

Table 1. Description of the position of participants involved in the NFSI assessment at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Head Teacher/Principal	16	80.00%	19	100.00%	6	60.00%	41	83.67%
Other member of senior management/Vice Principal	4	20.00%			3	30.00%	7	14.29%
Don't know or not applicable					1	10.00%	1	2.04%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

At baseline, most schools received free school meals from the government. However, the percentage from Kurunegala was much lower than Ampara and Moneregala, with just 60% of schools reporting that they received free government meals (Table 2).

Table 2. Percentage of schools receiving free school meals from the government at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Yes	19	95.00%	17	89.47%	6	60.00%	42	85.71%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

At baseline, the average school had around 385 students. However, there was a wide range, with school student populations ranging from 44 to 1,700 students per school (Table 3).

Table 3. Mean number of students per school at baseline

District	Avg. Number of students at school	Std. dev. of Number of students at school
Ampara	423.60	400.22
Moneregala	308.00	218.76
Kurunegala	455.10	350.85
Grand Total	385.20	329.28

Similarly, there was a wide range in the number of teachers in each school, with values ranging from 10 to 82 teachers per school. At baseline, the average school had 27 teachers (Table 4).

Table 4. Mean number of teachers per school at baseline

District	Avg. N teachers	Std. dev. of N teachers
Ampara	26.60	18.53
Moneregala	23.63	9.91
Kurunegala	33.50	16.95
Grand Total	26.86	15.49

The ratio of students to teachers per school was around 13 students to every teacher. Kurunegala had the lowest ratio, with around 5 students to every teacher, while Ampara had the highest ratio of 14.4 students per teacher (Table 5).

Table 5. Ratio of students to teachers per school at baseline

District	Avg. Ratio	Std. dev. of Ratio
Ampara	14.37	5.36
Moneregala	11.78	5.43
Kurunegala	11.54	4.59
Grand Total	12.79	5.36

School approaches to promoting healthy nutrition

Using the NFSI tool for researchers, I asked principals about policies and practices outlined in the WHO NFSI framework. Here I describe their responses at baseline.

The first question in the NFSI survey related to whether or not schools had received the Ministry of Education's 'canteen policy.' Most of the participants confirmed that they had (Table 6).

Table 6. Number of schools reporting to have a 'canteen policy' from the Ministry of Education at baseline

		n	%
Ampara	Yes	16	84.21%
Kurunegala	Yes	7	77.78%
Moneregala	Yes	13	68.42%
Grand Total		47	100.00%

Nutrition policies

In response to the question regarding additional policies (beyond those provided by the education authorities), around 40% of schools did not have a nutrition policy in addition to the canteen policy, around 22% had an informal additional policy and 37% had an additional written policy. Because this was a voluntary additional policy and there was more variation in responses compared to the mandatory canteen policy, this variable was later used in my summary variable of the NFSI, which is described at the end of this chapter (Table 7).

Table 7. Description of whether or not schools had any 'other policies on healthy eating' (in addition to the mandatory canteen policy) at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Yes written	9	45.00%	2	10.53%	7	70.00%	18	36.73%
Yes informal	2	10.00%	9	47.37%			11	22.45%
Don't know or not applicable	9	45.00%	8	42.11%	3	30.00%	20	40.82%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

At baseline, around a quarter of schools had a policy which had been in place for 3 or more years (Table 8).

Table 8. Length of time that the policy had been in place at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Less than a year	1	5.00%	1	5.26%	1	10.00%	3	6.12%
1-2 years	5	25.00%	2	10.53%			7	14.29%
3-4 years	4	20.00%	4	21.05%	6	60.00%	14	28.57%
5 or more years	1	5.00%	3	15.79%			4	8.16%
Don't know or not applicable	9	45.00%	9	47.37%	3	30.00%	21	42.86%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

Around half of schools had a policy which focused on increasing physical activity and promotion of a hygienic environment. Around 20% had policies aimed to prevent nutrition-related chronic diseases at baseline, but there was wide variation (from 5% of schools in Moneregala to 50% of schools in Kurunegala). Prevention of under-nutrition was a priority around 45% of schools (Table 9).

Table 9. Aims of the school nutrition policies according to school principals at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Community education related to healthy eating	Yes	6	30.00%			6	60.00%	12	24.49%
Increased physical activity among pupils	Yes	11	55.00%	6	31.58%	7	70.00%	24	48.98%
Prevention of micronutrient deficiencies	Yes	7	35.00%			6	60.00%	13	26.53%
Prevention of other nutrition-related chronic diseases	Yes	4	20.00%	1	5.26%	5	50.00%	10	20.41%
Prevention of overweight and/or obesity	Yes	6	30.00%			3	30.00%	9	18.37%
Prevention of under-nutrition	Yes	9	45.00%	6	31.58%	7	70.00%	22	44.90%
Promotion of a hygienic environment	Yes	10	50.00%	12	63.16%	5	50.00%	27	55.10%
Staff training	Yes	5	25.00%			6	60.00%	11	22.45%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

The NFSI framework recommends that nutrition-friendly school policies include elements such as a rationale, objectives with timelines and clear milestones, an action plan, and a monitoring and evaluation plan. At baseline, most schools did not have a policy which included these specific elements; 31% of schools had a policy with 'clearly defined objectives,' 22.5% had a policy with clear milestones and 27% of schools had a policy with timelines (Table 10).

Table 10. Description of schools with policies including components recommended by the NFSI at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Clearly defined objectives in policy	Yes	8	40.00%	1	5.26%	6	60.00%	15	30.61%
Are these objectives judged against a timeline?	Yes	7	35.00%	1	5.26%	5	50.00%	13	26.53%
Are these objectives judged against clear milestones?	Yes	6	30.00%			5	50.00%	11	22.45%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

At baseline, about 43% of schools had a 'clear organizational structure for health promotion in school', more than half had 'defined roles and responsibilities for school staff', around a third 'promoted harmony between all students irrespective of background' and around half had 'a strong commitment by all stakeholders' (Table 11).

Table 11. Description of schools with policy action plan components recommended by the NFSI at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
A clear organizational structure for health promotion within the school	Yes	11	55.00%	3	15.79%	7	70.00%	21	42.86%
A strong commitment by all concerned stakeholders	Yes	10	50.00%	9	47.37%	6	60.00%	25	51.02%
Defined roles and responsibilities for school staff	Yes	12	60.00%	11	57.89%	6	60.00%	29	59.18%
Does the policy promote a whole school approach to health	Yes	11	55.00%	2	10.53%	5	50.00%	18	36.73%
The inclusion of family and community members	Yes	6	30.00%	6	31.58%	6	60.00%	18	36.73%
The promotion of harmony* between all students irrespective of background	Yes	7	35.00%	1	5.26%	7	70.00%	15	30.61%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

Around a third of schools were monitoring or evaluating the impact of the policy in terms of measuring dissemination, implementation or outcomes. Ten percent of schools at baseline were measuring the policy-related health outcomes of students (Table 12).

Table 12. Monitoring and evaluation of policy impact, dissemination, implementation and outcomes at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Does school monitor/evaluate the impact of the policy?	Yes	9	45.00%	1	5.26%	6	60.00%	16	32.65%
Does school measure dissemination of the policy?	Yes	7	35.00%			6	60.00%	13	26.53%
Does school measure implementation of the policy?	Yes	5	25.00%	1	5.26%	6	60.00%	12	24.49%
Does school measure health outcomes of pupils?	Yes	4	20.00%	1	5.26%			5	10.20%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

Enhancing awareness and capacity building

The second component of the NFSI relates to enhancing awareness and capacity building within the school community. This includes activities related to policy dissemination, community involvement and training of staff in nutrition and health-related issues.

At baseline, less than a third (26.5%) of schools had a nutrition policy which had been shared with parents or with students. There were similarly low percentages of schools who had shared a nutrition policy with school staff. Just 14% shared their policy with community members at baseline (Table 13).

Table 13. Groups with whom the policy has been shared at baseline

		Ampara		Kurunegala		Moneregala		Grand Total	
		n	%	n	%	n	%	n	%
Parents	Yes	6	30.00%	6	60.00%	1	5.26%	13	26.53%
Pupils	Yes	7	35.00%	6	60.00%			13	26.53%
School staff members	Yes	8	40.00%	6	60.00%			14	28.57%
Community members	Yes	4	20.00%	3	30.00%			7	14.29%
Grand Total		20	100.00%	10	100.00%	19	100.00%	49	100.00%

At baseline, more than half of schools confirmed that they work with families to promote healthy eating messages inside and outside of school and more than half of schools reported that they had held at least one activity to promote healthy eating for families in the past year (Table 14).

Table 14. Description of the number of activities school has held for families to promote healthy eating at baseline

	Ampara		Kurunegala		Moneregala		Grand Total	
	n	%	n	%	n	%	n	%
One	1	5.0%			2	10.5%	3	6.1%
Two	2	10.0%	2	20.0%			4	8.2%
Three or more	5	25.0%	8	80.0%	5	26.3%	18	36.7%
Don't know or not applicable	12	60.0%			12	63.2%	24	49.0%
Grand Total	20	100.0%	10	100.0%	19	100.0%	49	100.0%

Around a third of schools confirmed that they had held more than one activity for the local community to promote healthy eating in the past year (Table 15). However, there was variation by district, with 40% of schools in Kurunegala reporting to hold at least three activities compared to around 5% of schools in Ampara and Moneregala.

Table 15. Description of the number of activities the school has held for the community to promote healthy eating at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
One	3	15.00%	5	26.32%			8	16.33%
Two	1	5.00%	1	5.26%			2	4.08%
Three or more	1	5.00%	1	5.26%	4	40.00%	6	12.24%
Don't know or not applicable	15	75.00%	12	63.16%	6	60.00%	33	67.35%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

I asked if school staff received training in issues related to healthy eating and at baseline, around 80% of schools provided training for staff that were responsible for health. Most schools reported that they provided more than one staff training session related to healthy eating within the past 12 months (Table 16).

Table 16. Description of the number of staff training sessions the school has held for staff related to healthy eating at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
One	6	30.00%	6	31.58%	3	30.00%	15	30.61%
Two	6	30.00%					6	12.24%
Three or more	6	30.00%	5	26.32%	6	60.00%	17	34.69%
Don't know or not applicable	2	10.00%	8	42.11%	1	10.00%	11	22.45%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

In addition to training sessions on health, I asked if staff received training on other health-related issues (which is also mentioned within the NFSI). At baseline, most reported that they had provided one or more staff training on issues related to healthy eating in the past year (Table 17).

Table 17. Description of the number of staff training session the school has held for staff related to health-related issues at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
One	7	35.00%	8	42.11%			15	30.61%
Two	2	10.00%					2	4.08%
Three or more	7	35.00%	4	21.05%	6	60.00%	17	34.69%
Don't know or not applicable	4	20.00%	7	36.84%	4	40.00%	15	30.61%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

Developing a nutrition and health-promoting school curriculum

The third essential component of the NFSI framework relates to developing a nutrition and health-promoting school curriculum. There was very little variation between schools because school curriculum is centrally organised and schools are required to follow a national mandate. At baseline, the most common grade to receive compulsory education was grade seven (75%) (Table 18).

Table 18. Principal reports of which grades receive compulsory education about healthy eating at baseline

	Ampara Baseline		Moneregala Baseline		Grand Total	
	n	%	n	%	n	%
Grade 7	13	72.22%	14	93.33%	27	75.00%
Grade 8	1	5.56%			1	2.78%
Grade 10	1	5.56%			1	2.78%
Grade 11	1	5.56%			1	2.78%

No grades receive compulsory education about healthy eating in Kurunegala

Principals indicated that healthy eating was taught in various subjects including health science, life science, physical education and science for most schools (Table 19).

Table 19. Principal reports about the subjects in which students receive education about healthy eating at baseline

		Ampara Baseline		Kurunegala Baseline		Moneregala Baseline		Grand Total	
		n	%	n	%	n	%	n	%
Health Science	Yes	16	80.00%	9	90.00%	17	89.47%	47	95.92%
Life Science	Yes	17	85.00%	10	100.00%	14	73.68%	44	89.80%
Physical Education	Yes	14	70.00%	10	100.00%	9	47.37%	37	75.51%
Science	Yes	14	70.00%	9	90.00%	14	73.68%	41	83.67%
Grand Total		20	100.00%	10	100.00%	19	100.00%	49	100.00%

To get a sense of whether or not healthy eating and nutrition education within schools included practical skills, I asked if students received training in skills such as cooking and most schools confirmed that this was part of the school curriculum (Table 20).

Table 20. Number of schools which offer training in practical skills such as cooking at baseline

	Ampara		Kurunegala		Moneregala		Grand Total	
	n	%	n	%	n	%	n	%
Yes	18	90.00%	10	100.00%	16	84.21%	44	89.80%

I asked principals if they agreed with several statements about physical education curriculum, including whether or not ‘it changes between grades to account for age,’ ‘it is different for boys and girls’ and ‘it includes culturally-appropriate activities.’ At baseline, most principals (90%) agreed that curriculum changed for age, 74% stated that curriculum included culturally appropriate activities and 18% agreed that curriculum varied for boys and girls (Table 21).

Table 21. Principal's perceptions of physical education at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Curriculum changes between grades to account for age	Agree	19	95.00%	17	89.47%	8	80.00%	44	89.80%
Curriculum includes culturally appropriate activities	Agree	15	75.00%	14	73.68%	7	70.00%	36	73.47%
Curriculum is different for boys and girls	Agree	5	25.00%	2	10.53%	2	20.00%	9	18.37%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

I asked if the aims of the school curriculum related to healthy eating, physical activity and healthy living were monitored against outcomes and at baseline, most schools responded that they were (Table 22).

Table 22. Principal's report of whether or not school curriculum relevant to NFSI (healthy eating, physical activity and healthy living) was monitored against student outcomes at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Are the aims of the school health curriculum monitored against outcomes?	Yes	16	80.00%	15	78.95%	9	90.00%	40	81.63%

Creating a supportive school environment

The fourth essential criteria of the NFSI relates to creating a supportive school environment. The first recommendation of this component relates to having school meals, food vendors and snack bars that promote healthy eating. At baseline, 47% of schools provided fresh fruit and vegetables within schools. It was slightly less common for schools to provide fruit juice (39%). Around a quarter of schools provided students with milk (22%). At baseline, 22% of schools had sweets, chocolate or ice cream available within schools and 4% had bottled sweet soda drinks available within schools. Most schools also provided food such as rice, curry, roti or hoppers and 40% provided short eats such as cutlets, patties and Chinese rolls.

Table 23. Description of foods available to students within schools at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Fresh fruit and vegetables	Yes	12	60.00%	7	36.84%	4	40.00%	23	46.94%
Fruit juice	Yes	5	25.00%	9	47.37%	5	50.00%	19	38.78%
Milk	Yes	7	35.00%	2	10.53%	2	20.00%	11	22.45%
Sweets/Chocolate/Ice-cream)	Yes	2	10.00%	6	31.58%	3	30.00%	11	22.45%
Bottled sweet soda drinks (e.g. Cola, Elephant House)	Yes			2	10.53%			2	4.08%
Curry/Rice/Roti/Hoppers	Yes	19	95.00%	12	63.16%	10	100.00%	41	83.67%
Short eats (Cutlets, Patties, Chinese rolls)	Yes	4	20.00%	9	47.37%	6	60.00%	19	38.78%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

I asked schools if they believed that there was 'positive messaging towards nutrition and active living within schools' and most believed that there was. Additionally, I asked about whether or not advertisements of foods and beverages could be found within schools and the majority of schools said that there was no advertising for such products at baseline.

Table 24. Description of school messaging and advertising policies at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Positive messaging towards nutrition and active living	Yes	14	70.00%	18	94.74%	5	50.00%	37	75.51%
Advertising of foods and beverages	Yes	2	10.00%			1	10.00%	3	6.12%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

Another key NFSI recommendation related to creating a supportive school environment involves providing children with access to safe drinking water. At baseline, most schools provided children with access to safe drinking water. Most schools also provided students with access to taps for hand washing, access to soap for hand washing and sanitary bins in girl's toilets. It was less common for schools to provide students with separate toilets for boys and girls (Table 25).

Table 25. Description of school provision of safe drinking water, hand washing facilities, toilets for boys and girls and sanitary disposal bins at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
Access to safe drinking water	Yes	14	70.00%	13	68.42%	7	70.00%	34	69.39%
Access to taps for hand-washing	Yes	17	85.00%	15	78.95%	9	90.00%	41	83.67%
Access to soap for handwashing	Yes	19	95.00%	17	89.47%	10	100.00%	46	93.88%
Sanitary bins in girls toilets	Yes	16	80.00%	16	84.21%	10	100.00%	42	85.71%
Separate toilets for boys and girls	Yes	5	25.00%	5	26.32%	2	20.00%	12	24.49%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

The NFSI recommends that schools maintain adequate cooking facilities and provide children with access to an adequate eating place, so I asked principals where children eat meals. Most schools reported that the classroom was the space that was available (Table 26).

Table 26. Description of designated spaces available for students to eat at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
In a designated eating room (canteen)	2	10.00%	1	5.26%			3	6.12%
In the classroom	17	85.00%	17	89.47%	10	100.00%	44	89.80%
Outside area (e.g. playground)	1	5.00%					1	2.04%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

When I asked schools if they had cooking facilities, around half said that they had adequate cooking facilities to prepare food on-site for all children. Among the schools where I was collecting data, it was also common for a member of the community, such as a parent or another adult living in the village, to prepare food for students at home and to bring the food to school (Table 27).

Table 27. Description of facilities for preparing food for students at baseline

	Ampara		Kurunegala		Moneregala		Grand Total	
	n	%	n	%	n	%	n	%
Yes	8	40.00%	7	70.00%	9	47.37%	24	48.98%

I asked the principals if the schools have areas available for active play outside of physical education lessons and most schools confirmed that they did (Table 28)

Table 28. Description of facilities available for active play outside of physical education at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Yes, the school has adequate facilities for all students	19	95.00%	12	63.16%	9	90.00%	40	81.63%
Yes, but the facilities are not adequate for all students	1	5.00%	3	15.79%	1	10.00%	5	10.20%
No, no facilities are available outside of physical education lessons			4	21.05%			4	8.16%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

I asked if school staff serve as role-models in encouraging healthy eating and healthy lifestyle and at baseline 83.7% of schools said that they were role models in living a healthy lifestyle and 65% said that they were role models in healthy eating (Table 29).

Table 29. Description of principal's response to statements about staff as role models in healthy eating and healthy lifestyle at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
A healthy lifestyle	Agree	20	100.00%	12	63.16%	9	90.00%	41	83.67%
Healthy eating	Agree	15	75.00%	11	57.89%	6	60.00%	32	65.31%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

To measure resources available for physical education, I asked if schools had changing rooms, washing facilities, outdoor space, indoor space (specifically for physical activity), sports equipment and audio/video equipment. At baseline, around 84% of schools had outdoor space available for physical education and 65% had sports equipment available. However, it was less common for schools to have washing facilities, changing rooms, indoor space or audio/video equipment (Table 30).

Table 30. Resources available for physical education in schools at baseline

		Ampara Baseline		Kurunegala Baseline		Moneregala Baseline		Grand Total	
		n	%	n	%	n	%	n	%
Audio/video equipment	Yes	13	65.00%	6	60.00%			25	51.02%
Changing rooms	Yes	6	30.00%	4	40.00%			14	28.57%
Indoor space for physical activity	Yes	11	55.00%	6	60.00%			17	34.69%
Outdoor space	Yes	17	85.00%	8	80.00%	16	84.21%	44	89.80%
Sports equipment	Yes	10	50.00%	5	50.00%	17	89.47%	38	77.55%
Washing facilities	Yes	7	35.00%	1	10.00%			11	22.45%
Grand Total		20	100.00%	10	100.00%	19	100.00%	49	100.00%

Providing supportive school nutrition and health services

The final criteria of the NFSI relates to providing children with supportive school nutrition and health services. At baseline, most schools measured students (height and weight) to monitor their growth and development. I also asked about the frequency of these measurements and 43% took these measurements at least once a term, while 55% took these measurements at least once a year.

Table 31 Frequency of measuring students (height and weight) at baseline

	Ampara		Moneregala		Kurunegala		Grand Total	
	n	%	n	%	n	%	n	%
Annually	11	55.00%	2	10.53%	8	80.00%	21	42.86%
Termly	8	40.00%	17	89.47%	2	20.00%	27	55.10%
Grand Total	20	100.00%	19	100.00%	10	100.00%	49	100.00%

Another part of providing supportive school nutrition and health services relates to providing effective feedback systems to report the results from the monitoring back to parents and children. Most schools made the results available to students and parents.

Table 32. Feedback systems for results from monitoring and evaluation of height and weight at baseline

		Ampara		Kurunegala		Moneregala		Grand Total	
		n	%	n	%	n	%	n	%
Parents	Yes	12	60.00%	2	20.00%	16	84.21%	30	61.22%
Pupils	Yes	14	70.00%	8	80.00%	19	100.00%	41	83.67%

According to the NFSI, supportive school health services should also include a referral system to health services. At baseline, none of the schools had a student referral system for health services, almost no schools had school-based health staff such as a nurse of doctor or a visiting public health worker. One in five schools reported that they had a room with first aid facilities and a room where sick children could rest (Table 33).

Table 33. Description of school health service facilities at baseline

		Ampara		Moneregala		Kurunegala		Grand Total	
		n	%	n	%	n	%	n	%
A room where sick children can rest	Yes	6	30.00%	5	26.32%	7	70.00%	18	36.73%
A room with first aid facilities	Yes	6	30.00%	3	15.79%	1	10.00%	10	20.41%
School-based health staff such as a nurse or doctor	Yes					1	10.00%	1	2.04%
Visiting public health worker, such as PHM or MOH	Yes	1	5.00%			1	10.00%	2	4.08%
Grand Total		20	100.00%	19	100.00%	10	100.00%	49	100.00%

Appendix 11. Differences in dietary outcomes by socioeconomic indicators at baseline

This section describes associations between dietary outcomes and socioeconomic indicators such as maternal education and ethnicity. Data on these variables were not collected at baseline, but they were collected at follow-up. Therefore, among students where I had both baseline and follow-up data, I was able to link follow-up socioeconomic data to their baseline values. Because of these methods, the sample size of students with baseline socioeconomic data was small (n=700 students) compared to the full baseline data set (n=1300 students). For this reason, I have presented these results separately from the other results examining differences in outcomes according to individual characteristics in the main thesis document.

I examined differences in total DQI-I scores, protein, calcium, fibre and BMI z-scores according to maternal education and ethnicity. I compared differences in means by ethnicity using analysis of variance. In instances where the variance was not equal between groups (according to Levene's test statistic), I compared differences using the F* test, which is less sensitive to violations of homogeneity of variance. To compare differences between maternal education groups I used t-tests. Results indicate that there were significant differences in total DQI-scores, calcium, fibre , protein and BMI z scores according to ethnicity, with Sri Lankan Tamil groups having higher DQI-I scores, calcium and protein intake and Sri Lankan Moors having higher BMI Z scores (Table 1).

Table 1. Description of dietary outcomes, by pupil demographics, at baseline (n=712)

	DQI Score (Max: 100)		Calcium (mg)		Fibre (g)		Protein (g)		BMI Z score	
	Avg.	**SD**	**Avg.**	**SD**	**Avg.**	**SD.**	**Avg.**	**SD**	**Avg.**	**SD**
Ethnicity										
Sinhala	58.4	11.5	487.0	324.1	23.1	13.0	54.2	22.6	-0.75	1.2
Sri Lankan Moor	63.3	10.9	592.9	313.3	28.6	12.3	67.6	26.4	-0.33	1.3
Sri Lankan Tamil	65.5	11.1	722.4	469.2	30.6	18.6	71.1	39.7	-0.44	0.9
Differences between groups	**F star**	**p**	**F**	**p**	**F**	**p**	**F**	**p**	**F star**	**p**
	7.835	0.0008	8.98	0.0001	8.71	0.002	14.81*	<0.001	5.83*	<0.0038
Maternal Education										
Less than O level	58.4	12.0	490.0	339.7	23.3	13.2	55.5	25.8	-0.8	1.2
O level and above	60.2	11.2	528.5	328.6	24.7	13.6	57.1	22.9	-0.5	1.2
Differences between groups	**Diff.**	**95% CI**	**Diff.**	**95% CI**	**Diff.**	**95% CI**	**Diff.**	**95% CI**	**Diff.**	**95% CI**
	-1.8*	-3.4 to -0.7	-38.43	-87.7 to 10.9	-1.40	-3.4 to 0.6	-1.5	-5.1 to 2.1	-0.3**	-0.5 to -0.1
Total	**59.2**	**11.7**	**507.4**	**335.0**	**24.0**	**13.4**	**56.2**	**24.6**	**-0.7**	**1.2**

**p<.05 **p<0.*

Note: The baseline sample of students with data on ethnicity and maternal education was limited to 712 students

Appendix 12. Additional descriptive analyses related to student dietary outcomes: fat, food groups, sources of protein and sources of carbohydrates

The average daily fat consumption was around 46 grams per day, ranging from around 40 grams in Moneregala to around 53 grams in Ampara (Table 1). I did not carry fat forward into the final analyses due to issues of multiple testing and lack of data on the type of fat that was consumed.

Table 1. Fat consumption, by district, baseline (n=833)

District	Avg. Daily Fat (G)	Std. dev. of Fat (G)
Ampara	53.40	34.18
Moneregala	40.28	24.93
Kurunegala	46.35	21.03
Grand Total	46.29	28.30

As a percentage of total energy, the percent of calories coming from fat was around 17%, ranging from around 16% in Moneregala to around 18% in Ampara (Table 4.2).

Table 2. Description of the proportion of total daily dietary energy coming from fat, by district, baseline (n=833)

District	Avg. Daily Fat Pct	Std. dev. of Daily Fat Pct
Ampara	18.25%	5.96%
Moneregala	15.99%	5.24%
Kurunegala	16.94%	4.37%
Grand Total	17.00%	5.41%

Description of food groups and servings

This section describes student diets in terms of food groups. The foundation of students' diets at baseline was based on carbohydrates or starchy foods such as rice, bread, roti or potatoes, with the average student consuming between eight to nine servings of these foods per day. The average student consumed around 2.4 and 6.8 servings of fruit and vegetables per day, respectively.

Consumption of foods high in fat, sugar, and salt was around 5 servings per day, ranging from 4.4 servings in Moneregala to 6 servings in Ampara (Table 3).

Table 3. Average servings from food groups by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Rice and bread	9.01	4.59	7.77	3.20	8.62	3.41	8.41	3.82
Vegetables	7.54	5.88	5.48	3.92	7.87	4.42	6.76	4.92
Foods high in fat, sugar, and salt	5.94	5.57	4.35	4.96	4.89	3.70	5.03	4.97
Fruit	2.82	2.70	2.32	2.35	1.76	1.64	2.36	2.37
Meat	1.65	1.62	1.47	1.59	1.63	1.75	1.57	1.64
Beans	1.32	1.60	1.05	0.92	1.36	1.29	1.22	1.29
Fish	1.09	1.22	1.06	1.37	1.06	1.14	1.07	1.26
Milk products	0.83	1.08	0.50	0.65	0.61	0.70	0.64	0.85
Eggs	0.28	0.58	0.23	0.58	0.25	0.36	0.25	0.54

Sources of protein

Meat and beans

Dietary protein came from a diverse range of food sources. The most common sources of protein at baseline were dry fish sprat (small, dry oily fish), dhal curry and fish (Table 4).

Table 4. Average daily servings of protein foods by source of protein, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Dry fish sprat	0.47	0.68	0.69	1.19	0.63	0.95	0.60	0.98
Dhal curry	0.36	0.68	0.25	0.40	0.34	0.54	0.31	0.55
Fish	0.39	0.57	0.23	0.31	0.25	0.41	0.29	0.44
Samaposha	0.20	0.41	0.16	0.24	0.34	0.67	0.22	0.44
Egg and boiled omelet	0.28	0.58	0.23	0.58	0.25	0.36	0.25	0.54
Soya curry	0.18	0.32	0.22	0.37	0.13	0.29	0.19	0.34
Chicken	0.16	0.21	0.12	0.18	0.16	0.17	0.14	0.19
Chickpeas	0.15	0.34	0.11	0.31	0.12	0.29	0.12	0.32
Salmon	0.13	0.24	0.09	0.17	0.10	0.17	0.11	0.20
Meatballs and sausages	0.07	0.33	0.04	0.13	0.14	0.88	0.07	0.47
Greengrams	0.08	0.21	0.06	0.12	0.08	0.33	0.07	0.22
Prawn, cuttlefish, and crab	0.10	0.25	0.05	0.21	0.08	0.22	0.07	0.23
Beef, pork, and mutton	0.05	0.20	0.01	0.07	0.01	0.11	0.03	0.14

Dairy

Overall, the consumption of dairy foods was low among all groups. The most common source of dairy came from full-cream milk, with students consuming around one fifth of a serving per day at baseline, followed by yoghurt, with students consuming an average of 0.16 servings per day (Table 4.42). On average, students had less than one serving of dairy per day.

Table 5. Average daily servings of milk-based foods, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Cheese	0.09	0.24	0.04	0.13	0.05	0.15	0.06	0.18
Curd	0.11	0.38	0.05	0.12	0.04	0.10	0.06	0.24
Fresh milk	0.11	0.56	0.08	0.23	0.04	0.14	0.08	0.37
Full cream milk	0.25	0.53	0.15	0.41	0.25	0.49	0.21	0.48
Nonfat milk	0.08	0.24	0.05	0.22	0.08	0.35	0.07	0.26
Yoghurt	0.20	0.28	0.13	0.18	0.16	0.20	0.16	0.22

Sources of carbohydrates

Rice and bread

Table 6 summarises the number of rice and bread servings that students consumed. Polished rice was the most common source of food from this group, with students consuming around four servings per day. Polished rice consumption ranged from 3.5 servings in Ampara and Moneregala to 4.5 servings in Kurunegala. Unpolished ('brown') rice consumption was relatively low, with daily consumption ranging from 0.02 servings in Kurunegala to 0.7 servings in Moneregala. Other common sources of carbohydrates came from string hoppers (a rice based noodle dish) (0.9 servings per day), potatoes (0.6 servings per day) and bread (0.5 servings per day).

Table 6. Summary of daily servings of carbohydrate based foods, by source of carbohydrate, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Polished rice	3.52	1.77	3.52	1.96	4.53	1.52	3.76	1.85
String hoppers	1.02	1.41	0.74	1.48	1.08	1.36	0.92	1.44
Potato	0.68	1.19	0.48	0.60	0.59	1.00	0.58	0.94
Bread	0.44	0.55	0.46	0.95	0.53	0.75	0.47	0.78
Unpolished rice	0.31	0.91	0.66	1.49	0.02	0.07	0.39	1.13
Milkrice	0.40	0.81	0.29	0.68	0.31	0.36	0.33	0.67
Hoppers	0.45	0.75	0.29	0.53	0.34	0.61	0.36	0.63
Bun and Bakery products	0.30	0.44	0.27	0.54	0.25	0.36	0.28	0.47
Roti	0.36	0.57	0.15	0.20	0.19	0.20	0.23	0.38
Manioc	0.26	0.59	0.15	0.36	0.10	0.21	0.18	0.43
Jak servings	0.23	0.55	0.23	0.42	0.10	0.27	0.20	0.45
Noodles, Macaroni, Pasta	0.20	0.31	0.15	0.24	0.15	0.23	0.17	0.26
Thosai	0.23	0.57	0.04	0.17	0.10	0.25	0.12	0.39
Ashplantain	0.19	0.84	0.09	0.18	0.08	0.25	0.12	0.53
Kolakanda or ricekanji	0.10	0.16	0.08	0.15	0.08	0.14	0.09	0.15
Breadfruit	0.11	0.30	0.06	0.13	0.11	0.44	0.09	0.29
Boiled sweet potato	0.12	0.40	0.07	0.15	0.05	0.13	0.08	0.26
Pittu	0.08	0.21	0.05	0.20	0.02	0.05	0.05	0.18

Vegetables

At baseline, students consumed a diverse range of vegetables, which came mainly in the form of vegetable-based curries (Table 7). The most common source of vegetables came from coconut sambol (1.2 servings per day), followed by 'commonmallum' (a leafy vegetable), pumpkin and leek curry (0.6 servings per day).

Table 7. Summary of daily servings of vegetables, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Coconut sambol	1.17	1.24	0.90	0.92	1.64	1.44	1.17	1.21
Commonmallum	0.61	1.00	0.49	0.63	0.68	0.65	0.58	0.79
Pumpkin curry	0.71	0.99	0.45	0.65	0.62	0.75	0.58	0.81
Leek curry	0.74	1.01	0.46	0.66	0.51	0.94	0.57	0.87
Beetrootcurry	0.53	0.81	0.37	0.61	0.70	0.92	0.51	0.77
Cabbage curry	0.60	0.81	0.29	0.43	0.54	0.73	0.46	0.67
Cucumber Kakiricurry	0.46	1.15	0.28	0.58	0.58	0.74	0.41	0.86
Beans, longbeans curry	0.30	0.42	0.26	0.27	0.34	0.34	0.29	0.35
Mushroom curry	0.26	0.71	0.17	0.38	0.38	0.65	0.25	0.58
Bitter gourd curry	0.30	0.80	0.31	0.59	0.20	0.63	0.28	0.68
Ladies fingers curry	0.35	0.57	0.18	0.24	0.19	0.31	0.24	0.41
Radish Nohkol	0.15	0.44	0.13	0.38	0.32	0.50	0.18	0.44
Brinjol curry	0.25	0.34	0.20	0.29	0.20	0.32	0.22	0.32
Tomato curry	0.18	0.36	0.28	0.55	0.15	0.26	0.21	0.43
Carrot curry	0.26	0.39	0.14	0.27	0.21	0.40	0.20	0.35
Polos curry mallum	0.16	0.34	0.21	0.31	0.20	0.28	0.19	0.32
Kehelmuwa curry	0.15	0.23	0.14	0.24	0.11	0.20	0.14	0.23
Snakegourd Ridgegourd	0.17	0.29	0.09	0.26	0.10	0.18	0.12	0.26
Kohila curry	0.11	0.31	0.10	0.31	0.13	0.31	0.11	0.31
Vegetable soup	0.08	0.24	0.04	0.12	0.07	0.13	0.06	0.17

Fruit

The most common sources of fruit in students' diets at baseline were from bananas (0.8 servings), guava (0.4 servings), mango (0.3 servings) and papaya (0.2 servings) (Table 8). Consumption of apples, pineapple and fruit salad was less common.

Table 8. Summary of daily servings of fruit, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Banana	0.87	1.28	0.86	1.37	0.76	1.21	0.84	1.30
Guava	0.42	0.62	0.38	0.74	0.45	0.68	0.41	0.69
Mango	0.50	0.84	0.34	0.73	0.08	0.19	0.33	0.71
Papaya	0.28	0.70	0.26	0.58	0.12	0.21	0.24	0.57
Orange	0.25	0.45	0.16	0.47	0.08	0.13	0.17	0.41
Dried fruit	0.19	0.50	0.09	0.46	0.04	0.10	0.11	0.43
Apple	0.14	0.28	0.08	0.13	0.09	0.16	0.11	0.20
Pineapple	0.11	0.18	0.12	0.20	0.07	0.17	0.10	0.19
Fruit salad	0.06	0.13	0.03	0.09	0.06	0.14	0.05	0.12

Sources of foods high in fat, sugar and salt

The most common source of food high in fat, sugar and salt at baseline was toffee, with the average student consuming 1.3 servings per day. Ampara consumed almost twice as much toffee (1.8 servings) as Kurunegala (0.9 servings). Other common sources of these foods came from sweet cream biscuits (0.9 servings), unsweetened biscuits (0.8 servings) and sweetened fortified drinks such as 'Nestamalt, Viva or Milo' (0.5 servings) (Table 9).

Table 9. Summary of daily servings of foods high in fat, sugar and salt, by district, baseline (n=833)

	Ampara		Moneregala		Kurunegala		Grand Total	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Toffee	1.82	3.03	1.04	1.99	0.93	1.64	1.29	2.38
Sweet cream biscuits	0.79	1.65	0.76	1.58	1.15	1.83	0.86	1.67
Unsweetened biscuits	0.68	1.55	0.80	1.74	0.80	1.19	0.76	1.56
Nestamalt, Viva, and Milo	0.53	0.70	0.54	0.73	0.53	0.57	0.53	0.68
Chocolate	0.52	0.83	0.32	0.69	0.29	0.52	0.38	0.71
Other sweets	0.44	0.94	0.33	0.71	0.35	0.65	0.37	0.79
Ice cream	0.23	0.31	0.30	0.83	0.20	0.24	0.25	0.58
Fizzy drinks	0.13	0.19	0.08	0.14	0.16	0.39	0.12	0.24
Cake	0.16	0.27	0.09	0.19	0.15	0.22	0.13	0.23
Jam	0.11	0.26	0.07	0.23	0.12	0.47	0.10	0.31
Tomato sauce	0.07	0.39	0.05	0.45	0.11	0.29	0.07	0.40
Sugar	0.10	0.50	0.01	0.11	0.00	0.05	0.04	0.31
Cordial	0.11	0.26	0.02	0.08	0.03	0.06	0.05	0.17
Butter and Margarine	0.04	0.16	0.04	0.15	0.05	0.15	0.04	0.15
Watalappam Pudding	0.06	0.17	0.01	0.03	0.03	0.14	0.03	0.13

Appendix 13. Comparing differences in DQI-I total scores, by district

Table 1. Total DQI-I score by district at baseline

	Mean	Std. Dev.	Freq.
Ampara	60.67	12.48	292
Moneregala	57.32	11.67	345
Kurunegala	58.96	9.70	196
Total	58.88	11.62	833
Analysis of variance		F value	p-value
Between groups		6.7	0.0013

Table 2. Bonferroni, Scheffe, and Sidak multiple comparison tests to identify differences in DQI-I score by district at baseline

		Bonferroni		Scheffe		Sidak	
		Ampara	**Kurunegala**	**Ampara**	**Kurunegala**	**Ampara**	**Kurunegala**
Kurunegala	**Difference**	-1.71		-1.71		-1.71	
	p-value	0.33		0.28		0.29	
Moneregala	**Difference**	-3.36	-1.65	-3.36	-1.65	-3.36	-1.65
	p-value	0.00	0.33	0.00	0.28	0.00	0.30

Table 3. Mean daily calcium intake, by district, baseline

	Mean	Std. Dev.	Freq.
Ampara	569.42	408.71	290
Moneregala	452.64	295.96	345
Kurunegala	484.33	264.76	196
Total	500.87	337.06	831
Analysis of variance		F value	p-value
Between groups		9.98	0.0001

Table 4. Bonferroni, Scheffe, and Sidak multiple comparison tests to identify differences in calcium by district, baseline

		Bonferroni		Scheffe		Sidak	
		Ampara	**Kurunegala**	**Ampara**	**Kurunegala**	**Ampara**	**Kurunegala**
Kurunegala	**Difference**	-85.09		-85.09		-85.09	
	p-value	0.02		0.02		0.02	
Moneregala	**Difference**	-116.78	-31.69	-116.78	-31.69	-116.78	-31.69
	p-value	0.00	0.87	0.00	0.57	0.00	0.64

Table 5. Protein by district at baseline

	Mean	**Std. Dev.**	**Freq.**
Ampara	59.94	27.65	290
Moneregala	51.10	20.92	345
Kurunegala	56.54	20.37	196
Total	55.47	23.67	831
Analysis of variance		F value	p-value
Between groups		11.53	<0.0001

Table 6. Bonferroni, Scheffe, and Sidak multiple comparison tests to identify differences in protein by district at baseline

		Bonferroni		Scheffe		Sidak	
		Ampara	Kurunegala	Ampara	Kurunegala	Ampara	Kurunegala
Kurunegala	**Difference**	-3.40		-3.40		-3.40	
	p-value	0.35		0.29		0.31	
Moneregala	**Difference**	-8.84	-5.44	-8.84	-5.44	-8.84	-5.44
	p-value	0.00	0.03	0.00	0.03	0.00	0.03

Table 5. Fibre by district at baseline

	Mean	Std. Dev.	Freq.
Ampara	26.57	16.11	290
Moneregala	21.78	11.72	345
Kurunegala	22.22	10.13	196
Total	23.55	13.28	831
Analysis of variance		F value	p-value
Between groups		11.83	<0.0001

Table 6. Bonferroni, Scheffe, and Sidak multiple comparison tests to identify differences in fibre by district at baseline

		Bonferroni		Scheffe		Sidak	
		Ampara	Kurunegala	Ampara	Kurunegala	Ampara	Kuru.
Kurunegala	**Difference**	-4.34		-4.34		-4.34	
	p-value	0.001		0.002		0.001	
Moneregala	**Difference**	-4.79	-0.45	-4.79	-0.45	-4.79	-0.45
	p-value	0	1	0	0.93	0	0.974

Appendix 14. Multi-level analyses between individual school actions and student outcomes at baseline

Table 1. Results of models using the count of policy actions for all dietary outcomes at baseline

	1 Univariable	2 With fixed school characteristics	3 With student demographics	4 With student dietary characteristics
Total DQI-I Score				
Constant	58.42	58.87	61.99	60.89
Co-efficient for NFSI actions variable	0.66	0.93	1.02	1.03
95% CI	-1.15, 2.46	-0.97, 2.84	-0.84, 2.89	-0.9, 2.95
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	27.88	26.07	21.06	23.09
95% CI	12.87, 42.89	11.83, 40.3	9.07, 33.06	10.32, 35.86
Calcium (mg)				
Constant	506.32	500.53	797.84	781.29
Co-efficient for NFSI actions variable	1.96	12.81	13.03	11.79
95% CI	-46.83, 50.76	-39.19, 64.82	-33.62, 59.68	-36.18, 59.77
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	19522.27	18625.84	11365.39	12487.11
95% CI	8546.24, 30498.3	8034.01, 29217.66	3942.38, 18788.4	4616.32, 20357.91
Fibre (g)				
Constant	24.08	23.83	34.77	34.70
Co-efficient for NFSI actions variable	-0.13	0.36	0.37	0.37
95% CI	-1.95, 1.69	-1.57, 2.29	-1.44, 2.18	-1.47, 2.21
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	25.68	23.86	16.34	17.32
95% CI	10.39, 40.97	9.36, 38.37	5.18, 27.5	5.77, 28.86

Protein (g)				
Constant	55.88	55.27	80.89	78.75
Co-efficient for NFSI actions variable	0.56	0.86	1.26	1.05
95% CI	-3.24, 4.37	-3.24, 4.96	-2.3, 4.81	-2.73, 4.82
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	123.27	121.57	70.70	84.76
95% CI	56.61, 189.94	55.62, 187.52	27.55, 113.85	35.74, 133.78

Table 2. Results of models using the count of capacity building actions for all dietary outcomes at baseline

	1 Univariable	2 With fixed school characteristics	3 With student demographics	4 With student dietary characteristics
Total DQI-I Score				
Constant	58.91	59.21	61.45	60.50
Co-efficient for NFSI actions variable	0.53	0.63	1.16	1.15
95% CI	-1.58, 2.64	-1.57, 2.83	-0.93, 3.25	-1.01, 3.31
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	28.46	26.97	21.89	24.03
95% CI	13.19, 43.73	12.34, 41.61	9.56, 34.23	10.85, 37.22
Calcium (mg)				
Constant	504.49	498.41	774.39	759.42
Co-efficient for NFSI actions variable	7.26	21.17	27.97	26.90
95% CI	-49.39, 63.9	-38.29, 80.62	-23.73, 79.67	-26.36, 80.17
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	19574.98	18809.98	11418.13	12541.28
95% CI	8575.14, 30574.82	8135.11, 29484.86	3989.04, 18847.22	4671.99, 20410.56
Fibre (g)				
Constant	23.76	23.76	34.16	34.19
Co-efficient for NFSI actions variable	0.60	0.60	0.73	0.69
95% CI	-1.6, 2.79	-1.6, 2.79	-1.28, 2.74	-1.36, 2.73
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	24.02	24.02	16.44	17.40
95% CI	9.44, 38.59	9.44, 38.59	5.24, 27.65	5.88, 28.93
Protein (g)				
Constant	55.86	55.04	79.29	77.06
Co-efficient for NFSI actions variable	1.22	1.60	2.22	2.29
95% CI	-3.21, 5.64	-3.08, 6.29	-1.74, 6.18	-1.91, 6.49

Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	123.98	122.36	72.56	85.98
95% CI	56.98, 190.97	56.48, 188.24	28.57, 116.56	36.42, 135.54

Table 3. Results of models using the count of environment actions for all dietary outcomes at baseline

	1 Univariable	2 With fixed school characteristics	3 With student demographics	4 With student dietary characteristics
Total DQI-I Score				
Constant	56.93	57.23	59.97	58.84
Co-efficient for NFSI actions variable	1.36	1.53	1.93	1.92
95% CI	-0.75, 3.46	-0.54, 3.59	-0.03, 3.88	-0.11, 3.95
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	27.41	25.58	19.76	22.00
95% CI	12.6, 42.22	11.56, 39.59	8.37, 31.15	9.71, 34.29
Calcium (mg)				
Constant	405.77	412.87	689.37	667.59
Co-efficient for NFSI actions variable	60.90	64.42	78.05	76.48
95% CI	6.74, 115.06	10.84, 118	34.56, 121.55	31.08, 121.87
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	16738.07	15755.36	7043.34	8241.44
95% CI	6977.11, 26499.03	6417.96, 25092.76	1529.08, 12557.59	2240.31, 14242.56
Fibre (g)				
Constant	20.19	20.50	30.53	30.28
Co-efficient for NFSI actions variable	2.21	2.42	2.96	2.85
95% CI	0.17, 4.26	0.43, 4.41	1.27, 4.65	1.1, 4.61
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	22.32	19.90	9.94	11.40
95% CI	8.5, 36.14	7.11, 32.7	1.6, 18.29	2.47, 20.33
Protein (g)				
Constant	52.00	51.52	75.99	73.78
Co-efficient for NFSI actions variable	2.70	2.88	3.93	3.75
95% CI	-1.69, 7.1	-1.53, 7.3	0.30, 7.56	-0.14, 7.63
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	118.67	116.82	60.77	75.13
95% CI	53.99, 183.35	52.92, 180.72	21.8, 99.73	30.22, 120.05

Table 4. Results of models using the count of supportive service actions for all dietary outcomes at baseline

	1 Univariable	2 With fixed school characteristics	3 With student demographics	4 With student dietary characteristics
Total DQI-I Score				
Constant	60.07	61.09	63.98	58.84
Co-efficient for NFSI actions variable	-0.60	-0.96	-0.76	1.92
95% CI	-2.98, 1.77	-3.38, 1.47	-3.25, 1.74	-0.11, 3.95
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	28.14	26.33	22.07	22.00
95% CI	13.02, 43.27	11.99, 40.67	9.66, 34.47	9.71, 34.29
Calcium (mg)				
Constant	523.92	544.93	826.01	824.96
Co-efficient for NFSI actions variable	-10.75	-21.73	-10.35	-19.16
95% CI	-74.65, 53.15	-87.44, 43.97	-72.14, 51.45	-82.85, 44.52
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	19394.40	18506.24	826.01	12632.48
95% CI	8473.87, 30314.92	7964.94, 29047.55	-10.35	4697.21, 20567.75
Fibre (g)				
Constant	24.50	25.65	36.07	36.45
Co-efficient for NFSI actions variable	-0.41	-0.96	-0.59	-0.83
95% CI	-2.8, 1.98	-3.39, 1.46	-2.99, 1.8	-3.27, 1.61
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	25.51	23.52	16.58	17.48
95% CI	10.3, 40.73	9.16, 37.88	5.37, 27.79	5.87, 29.08
Protein (g)				
Constant	56.93	56.94	81.41	80.35
Co-efficient for NFSI actions var.	-0.26	-0.65	0.27	-0.38
95% CI	-5.26, 4.74	-5.86, 4.55	-4.47, 5.01	-5.42, 4.67
Level 1 n =	421	421	421	421
Level 2 n =	38	38	38	38
Unexplained school level variance	123.92	122.22	73.60	87.41
95% CI	56.97, 190.87	55.99, 188.46	29.17, 118.04	37.24, 137.59

Appendix 15. Analysis of change in fat and food-group servings consumption over time

This thesis focuses on diet quality scores, calcium, protein and fibre, but here is a brief description of students' diets in terms of fat consumption, sources of protein, sources of carbohydrates and sources of foods high in fat, sugar and salt, over time.

The average daily fat consumption (in grams) is provided in Table 1, and shows an overall increase across districts. This increase was due to changes in Moneregala; in Ampara daily fat consumption actually decreased and it was relatively stable in Kurunegala over time.

Table 1. Fat consumption, by district, baseline and follow-up

	Phase			
	Baseline		Follow up	
District	Avg. Fat G	Std. dev. of Fat G	Avg. Fat G	Std. dev. of Fat G
Ampara	53.40	34.18	48.05	30.10
Moneregala	40.28	24.93	47.96	27.58
Kurunegala	46.35	21.03	46.55	26.43
Grand Total	46.29	28.30	47.60	28.22

As a percentage of total energy, the percent of calories coming from fat was low and remained relatively stable over time at around 17%.

Table 2. Description of the proportion of total dietary energy coming from fat, by district, baseline

	Phase			
	Baseline		Follow up	
District	Avg. Fat Pct	Std. dev. of Fat Pct	Avg. Fat Pct	Std. dev. of Fat Pct
Ampara	18.25%	5.96%	17.43%	4.04%
Moneregala	15.99%	5.24%	16.82%	5.23%
Kurunegala	16.94%	4.37%	17.40%	4.40%
Grand Total	17.00%	5.41%	17.21%	4.58%

Description of food groups and servings

The foundation of the diet for participants was rice, with the average student consuming between eight to nine servings per day at baseline. At follow-up, rice consumption increased in both groups. There were also increases in consumption of foods high in fat, sugar and salt. Consumption of fruit, vegetables and beans—foods that are high in fibre and micronutrients—decreased over time, while consumption of meat and fish increased. Consumption of milk and egg products remained low in both groups over time and relatively unchanged.

Table 3. Average servings from various food groups, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Total servings from rice and bread	8.41	3.82	9.25	7.92
Total servings from vegetables	6.76	4.92	3.63	4.21
Total servings from foods high in fat, sugar, and salt	5.03	4.97	5.46	8.52
Total servings from fruit	2.36	2.37	1.71	1.68
Total servings from meat	1.57	1.64	2.15	3.24
Total servings from beans	1.22	1.29	0.94	0.97
Total servings of fish	1.07	1.26	1.77	3.03
Total servings from milk products	0.64	0.85	0.61	0.84
Total servings from eggs	0.25	0.54	0.23	0.84

Sources of protein

Meat and beans

The average daily servings of protein-containing foods at baseline and follow-up are detailed in Table 9.36. The most common source of protein at baseline and follow-up was dry fish sprat (small, dry oily fish) and dhal curry. On average, a serving was around 40 grams of beans and around 70 grams of meat.

Table 4. Average daily servings of protein foods by source of protein, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Dry fish sprat servings	0.60	0.98	0.65	1.09
Dhal curry servings	0.31	0.55	0.19	0.34
Fish servings	0.29	0.44	0.23	0.28
Samaposha servings	0.22	0.44	0.27	0.56
Egg and boiled omelet servings	0.25	0.54	0.23	0.84
Soya curry servings	0.19	0.34	0.15	0.21
Chicken servings	0.14	0.19	0.13	0.17
Chickpeas servings	0.12	0.32	0.07	0.14
Salmon servings	0.11	0.20	0.30	0.46
Meatballs, sausages servings	0.07	0.47	0.00	0.00
Greengrams servings	0.07	0.22	0.06	0.14
Prawn, cuttlefish, and crab servings	0.07	0.23	0.59	2.55
Beef, Pork, Mutton servings	0.03	0.14	0.01	0.05

Between baseline and follow-up, consumption of dhal curry, soya curry and chick peas dropped and consumption of samaposha increased. Samaposha is a pre-cooked cereal brand that is made from corn, soya, green grams and rice, and which is often eaten as a breakfast food.

Over the same time-frame, consumption of dry fish sprat increased. Fish (type not specified) decreased slightly while salmon (a term to describe canned fish in Sri Lanka) increased among both control and intervention groups. The most dramatic change was in consumption of prawns, cuttle-fish and crabs, which increased from less than one tenth of a serving per day to more than half of a serving per day.

Dairy

Overall, the consumption of dairy foods was low among all groups. The most common source of dairy came from full-cream milk (around a fifth of a serving per day at baseline), followed by yoghurt. Consumption of full-cream milk dropped over time, but there was an almost two-fold increase in consumption of cheese.

Table 5. Average daily servings of milk-based foods, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Full cream milk servings	0.21	0.48	0.17	0.38
Yoghurt servings	0.16	0.22	0.16	0.21
Nonfat milk servings	0.07	0.26	0.05	0.22
Curd servings	0.06	0.24	0.05	0.12
Cheese servings	0.06	0.18	0.11	0.38
Fresh milk servings	0.08	0.37	0.06	0.22

Summary of protein-containing foods

The number of servings from various protein sources have been grouped in Table 6. This shows that overall, there was an increased consumption of meat and fish among all groups but a decrease in consumption of beans/legumes. Dairy, milk and eggs, when presented by groups, were relatively stable over time.

Table 6. Summary of protein-containing foods, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Total servings from meat	1.57	1.64	2.15	3.24
Total servings from beans	1.22	1.29	0.94	0.97
Total servings of fish	1.07	1.26	1.77	3.03
Total servings from dairy	0.64	0.85	0.61	0.84
Total servings from milk products	0.64	0.85	0.61	0.84
Total servings from eggs	0.25	0.54	0.23	0.84
Total servings from foods high in fat, sugar, and salt	5.03	4.97	5.46	8.52

Sources of carbohydrates

Rice and bread

Table 7 summarises the number of servings from rice and bread sources over time. Polished rice was the most common source of food from this group, with pupils consuming around four servings per day. Over time, this increased by almost an additional serving over time. There were also increases in manioc, breadfruit and jackfruit between baseline and follow up, while consumption of bread, potatoes, milk rice and roti decreased.

Table 7. Summary of daily servings of carbohydrate based foods, by source of carbohydrate, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Polished rice servings	3.76	1.85	4.69	2.51
String hoppers servings	0.92	1.44	0.85	5.80
Potato servings	0.58	0.94	0.35	0.62
Bread servings	0.47	0.78	0.00	0.02
Unpolished rice servings	0.39	1.13	0.21	0.94
Milkrice servings	0.33	0.67	0.19	0.37
Hoppers servings	0.36	0.63	0.27	0.50
Bun and Bakery products servings	0.28	0.47	0.20	0.37
Roti servings	0.23	0.38	0.13	0.23
Manioc servings	0.18	0.43	0.68	1.73
Jak servings	0.20	0.45	0.74	1.84
Noodles, Macaroni, Pasta servings	0.17	0.26	0.11	0.22
Thosai servings	0.12	0.39	0.06	0.20
Ashplantain servings	0.12	0.53	0.09	0.33
Kolakanda or ricekanji servings	0.09	0.15	0.09	0.25
Breadfruit servings	0.09	0.29	0.49	2.23
Boiled sweet potato servings	0.08	0.26	0.07	0.16
Pittu servings	0.05	0.18	0.03	0.10

Vegetables

Table 8 summarises the source of vegetables that were observed in the pupil diets. The variety of foods listed illustrates the diversity of vegetables available in the Sri Lankan diet. At baseline, coconut sambol, pumpkin curry, leak curry, beetroot curry and cabbage curry contributed to a high level of vegetable intake. However, consumption of all vegetables dropped dramatically over time.

Table 8. Summary of daily servings of vegetables, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Coconut sambol servings	1.17	1.21	0.51	0.65
Commonmallum servings	0.58	0.79	0.30	0.47
Pumpkin curry servings	0.58	0.81	0.31	0.53
Leaks curry servings	0.57	0.87	0.24	0.37
Beetrootcurry servings	0.51	0.77	0.28	0.57
Cabbage curry servings	0.46	0.67	0.24	0.49
Cucumber Kakiricurry servings	0.41	0.86	0.23	0.66
Beans, longbeans curry servings	0.29	0.35	0.13	0.19
Mushroom curry servings	0.25	0.58	0.16	0.31
Bitter gourd curry servings	0.28	0.68	0.25	2.85
Ladies fingers curry servings	0.24	0.41	0.10	0.17
Radish Nohkol servings	0.18	0.44	0.10	0.21
Brinjol curry servings	0.22	0.32	0.11	0.19
Tomato curry servings	0.21	0.43	0.15	0.56
Carrot curry servings	0.20	0.35	0.10	0.22
Polos curry mallum servings	0.19	0.32	0.10	0.24
Kehelmuwa curry servings	0.14	0.23	0.07	0.23
Snakegourd Ridgegourd servings	0.12	0.26	0.05	0.12
Kohila curry servings	0.11	0.31	0.11	0.44
Vegetable soup servings	0.06	0.17	0.06	0.19

Fruit

As with vegetables, there was a decrease in fruit consumption among both groups over time. The most common sources of fruit at baseline and follow up was from bananas, followed by other tropical fruits including guava, papaya and mango. At baseline, the average consumption was more than two servings per day, but at follow-up, this had dropped to less than two.

Table 9. Summary of daily servings of fruit, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Banana servings	0.84	1.30	0.63	0.85
Guava servings	0.41	0.69	0.29	0.53
Mango servings	0.33	0.71	0.22	0.49
Papaya servings	0.24	0.57	0.15	0.24
Orange servings	0.17	0.41	0.15	0.37
Dried fruits, Dates and Resins servings	0.11	0.43	0.09	0.31
Apple servings	0.11	0.20	0.10	0.18
Pineapple servings	0.10	0.19	0.09	0.20
Fruit salad servings	0.05	0.12	0.00	0.00

Sources of foods high in fat, sugar and salt

Change in consumption of foods high in fat, sugar and salt are showed below. Toffee, unsweetened biscuits, sweets, ice cream, cake, jam, tomato sauce, cordial and pudding servings dropped slightly, while consumption of sugar increased (Table 10).

Table 10. Summary of daily servings of foods high in fat, sugar and salt, baseline and follow-up

	Time			
	Baseline		Follow-up	
	Servings	Std. dev. of Servings	Servings	Std. dev. of Servings
Toffee servings	1.29	2.38	1.00	2.00
Cream Sweet biscuits servings	0.86	1.67	0.67	1.81
Unsweetened Biscuits servings	0.76	1.56	0.64	1.32
Nestamalt, Viva, and Milo servings	0.53	0.68	0.37	0.55
Sweets servings	0.37	0.79	0.32	1.00
Chocolate servings	0.38	0.71	0.46	5.00
Ice cream servings	0.25	0.58	0.21	0.52
Fizzy drinks servings	0.12	0.24	0.14	0.38
Cake servings	0.13	0.23	0.01	0.26
Jam servings	0.10	0.31	0.08	0.29
Tomato sauce servings	0.07	0.40	0.00	0.00
Sugar servings	0.04	0.31	1.06	2.45
Cordial servings	0.05	0.17	0.04	0.20
Butter and Margarine servings	0.04	0.15	0.05	0.18
Watalappam Pudding servings	0.03	0.13	0.01	0.06

Appendix 16. NFSI Validation Checklist

NFSI Component	Criteria	Objective verification?	
		Yes	No
Q2.1	Did you receive a canteen policy or a policy related to school food from the education authorities? (Check the document)		
Q2.2	Does your school have any other policies on healthy eating? (Check the written document)		
Q4.8	Which of the following facilities for physical education does the school have *Changing rooms* *Washing facilities* *Outdoor space* *Indoor space available specifically for physical activities* *Sport equipment* *Audio/video equipment*		
Q4.9	Does the school have areas available for active play outside of physical education lessons (Check the facilities available)		
Q5.1	During the school hours, where can pupils obtain food outside of the school premises: *Newsagent* *Street -Vendors* *Tea shops/hotels* *Supermarkets* *Other- places*		
Q5.2	Where can pupils obtain food from within school? *School provide meals for free* *On-site school canteen* *Food vendors* *Snack bars* *Other*		
Q5.7	What foods are available for pupils within the school? *Fresh fruits and* *Curry/rice/roti/hoppers* *Short eats (cutlets, patties, Chinese roles)* *Sweets/chocolates/ice-cream* *Bottles sweet soda drink (e.g cola. Sprite, Pepsi, elephant house)* *Fruit juice* *Milk* *Other*		

Q6.1	Are the children in your school measured to monitor their grown and development?
Q6.3	Which of the following grade are measured? (Check the records)
Q6.4	How often are these measurements taken? (Check the records)
Q6.5	What measurements are taken in monitoring growth and development? (Check the records)
Q6.8	Which of the following does your school have in relation to health services in the school? *School based health staff such as a nurse or doctor* *Visiting public health worker, such as a PHM or MOH* *A room with first aid facilities* *A room where sick children can rest* *Other*

Appendix 17. Comparison of anthropometric results to national results and other Southeast Asian country results

Comparison between 2008 and 2014 GSHS in Sri Lanka

In this section, I describe how my sample's anthropometric results compared to results from a national GSHS survey that was conducted in 2008. The GSHS was administered in 2008 to a nationally-representative sample of 2,611 students with a school response rate of 100% and a student response rate of 89% [1]. My sample varied from the 2008 sample in several important ways. Aside from the six year difference, the populations varied considerably; our study was based on a rural, relatively low socio-economic population, while the 2008 sample included both urban and rural participants from a range of socio-economic backgrounds. Additionally, the surveys categorized age in different ways. The 2008 GSHS listed the youngest category as '11 years old or younger' and the oldest category as '16 years old or older,' while the GSHS in 2014 listed responses ranging from '11 years old or younger' to '18 years or older'. To compare between study years, I merged my 2014 sample of 16-18 year olds into a single category. Another difference was that the 2008 sample had only self-reported height and weight, while my sample had both self-reported and measured height and weight.

Table 1. Description of GSHS study participants in the 2008 National Survey and the 2014 Baseline INPARD survey

	2008 National Survey				2014 Baseline INPARD		
	N	%	Cum.		N	%	Cum.
Male	1,132	43.36	43.36		607	46.51	46.5
Female	1,459	55.88	99.23		671	51.42	97.9
Age (Years)							
≤11	17	0.65	0.65		1	0.08	0.08
12	244	9.38	10.03		46	3.59	3.67
13	894	34.36	44.39		190	14.83	18.5
14	844	32.44	76.83		451	35.21	53.7
15	522	20.06	96.89		549	42.86	96.6
≥16	81	3.11	100		44	3.44	100
Total	2,602	100			1,281	100	

Comparing self-reported between 2008 and 2014 GSHS Samples

For both samples, I calculated age- and sex-adjusted BMI z-scores from the self-reported height and weight (based on International Obesity Taskforce criteria). I compared the z-scores from the two samples using Analysis of variance (ANOVA) (Table 2). For both males and females, the 2008 BMI-Z scores were significantly ($p<.05$) lower than the 2014 measures.

Self-reported height and weight is an unreliable estimate. In my sample, when I compared BMI-Z scores from the self-reported values to the BMI Z scores that were based on measured height and weight, the measured scores were significantly ($p<.001$) lower than self-reported scores for both males and females.

Table 2. Age- and sex-adjusted BMI categories and mean BMI z-scores from the 2008 national survey and the 2014 baseline INPARD survey.

	Self-reported Height and Weight								Measured Height and Weight			
	2008 (no outliers)				2014 (no outliers)				2014 (no outliers)			
	N	%	Cum.		N	%	Cum.		N	%	Cum	
BMI category												
Thinness grade 3	165	7.3	7.3		131	13.02	13.02		85	6.72	6.72	
Thinness grade 2	320	14.16	21.46		81	8.05	21.07		147	11.63	18.35	
Thinness grade 1	619	27.39	48.85		177	17.59	38.67		328	25.95	44.3	
Normal weight	1,059	46.86	95.71		481	47.81	86.48		636	50.32	94.62	
Overweight	87	3.85	99.56		94	9.34	95.83		52	4.11	98.73	
Obesity	10	0.44	100		42	4.17	100		16	1.27	100	
Total	**2,260**				**1,006**				**1,264**			
Mean BMI z-score												
	Mean	**SE**	**(95% CI)**		**Mean**	**SE**	**(95% CI)**		**Mean**	**SE**	**(95% CI)**	
Male	-1.00*	0.04	-1.07	-0.93	-0.48**	0.07	-0.62	-0.33	-0.82	0.06	-0.94	-0.71
Female	-0.81*	0.03	-0.87	-0.74	-0.32**	0.07	-0.45	-0.19	-0.61	0.05	-0.71	-0.50

*Significant differences between 2008 and 2014 BMI Z scores (p<.05);

**Significant differences between 2014 BMI-Z score (from self-reported height and weight) and 2014 BMI-Z score (from measured height and weight) (p<.001)

Comparing results to other GSHS surveys from Southeast Asia

Table 3 features prevalence rates of underweight according to GSHS results from Bangladesh, Bhutan, Myanmar, Indonesia, Nepal, Thailand and Timor-Leste. The range (3.1-21.8) was much lower than the proportion in my sample, which was around 40%. Some of this difference may have been due to the fact that the results below come from nationally-representative samples, while my survey was taken exclusively from a rural population, which was poorer. Additionally, the GSHS results in the table below come from self-reported values, which are likely to be less accurate than my results, which come from measured values.

Table 3. Prevalence of underweight according to self-reported height and weight from Global-School-Based Surveys from other Southeast Asian countries

Country	Prevalence	95% CI	Sample Size
Bangladesh (2014)	13.9	10.0-19.0	2,989
Bhutan (2014)	3.1	1.7-2.7	7,576
Myanmar (2016)	18.0	14.7-21.8	2,838
Indonesia (2015)	8.7	7.8-9.8	11,142
Nepal (2015)	11.0	8.7-13.8	6,529
Thailand (2015)	8.4	7.1-10.1	5,894
Timor-Leste (2015)	21.8	15.7-29.4	3,704

Reference

1. World Health Organization, *Global school-based student health survey: Sri Lanka.* 2008.

Appendix 18. Publications and presentations arising from this thesis

Peer-reviewed papers (in press, under review)

Williams J, Allen L, Wickramasinghe K, Mikkelsen B, Roberts N, Townsend N, A review of non-communicable diseases and socio-economic status within low- and middle-income countries, Commissioned by WHO Headquarters, Geneva (In press, Journal of Global Health, December 2017).

Williams J, Townsend, N, Jayawardena R, Manoharan S, Katulunda P, Rayner M, Wickramasinghe K. Diet quality of adolescents in rural Sri Lanka based on the Diet Quality Index-International: findings from the 'Integrating Nutrition Promotion and Rural Development Project'. Public Health Nutrition (Under review, October 2017).

Williams J, Wickramasinghe K, Jayawardena R, Rayner M, Katulunda P, Manoharan S, Townsend N, Weight perception and measured body weight categories among adolescents in rural Sri Lanka. Body Image (Under review, October 2017).

Williams J, Wickramasinghe K, Pathirana, A, Rayner M, Katulunda P, Manoharan S, Townsend N, Examining school approaches to promoting healthy diets and adolescent diet quality in rural Sri Lanka, Global Health Promotion (Under review, October 2017).

Peer-reviewed papers

Allen L, Williams J, Townsend N., Mikkelsen B, Roberts N, Wickramasinghe K. Socioeconomic status and non-communicable disease behavioural risk factors in low- and lower-middle income countries: a systematic review, Lancet Global Health, Volume 5, No. 3, e277–e289, March 2017.

Townsend, N., Williams, J., Wickramasinghe, K., Karunarathne, W., Olupeliyawa, A., Manoharan, S., & Friel, S. Barriers to healthy dietary choice amongst students in Sri Lanka as perceived by school principals and staff. Health promotion international, 32 (1): 91-101, 2015.

Reports

Williams J, Townsend N, Engseveen K, Wickramasinghe K, A scoping review of the Nutrition-Friendly Schools Initiative, Commissioned by WHO Headquarters, Geneva, 2015.

Wickramasinghe K, Williams J…..& Townsend N. Integrating Nutrition Promotion and Rural Development. World Bank (Internal Report), 2017.

Invited Oral Presentations

Implementing Public Health Interventions: a case study from rural Sri Lanka, University of Oxford, Nuffield Department of Population Health, BHF CPNP Research Seminars, Oxford, 22 February 2017.

Evaluation of findings from schools involved in the 'Integrating Nutrition Promotion and Rural Development' project, A Workshop with National-level Policy Makers, Colombo, Sri Lanka, 7 October 2016.

School environments and nutrition outcomes among secondary students in rural Sri Lanka, Nuffield Department of Population Health DPhil Seminar, University of Oxford, Oxford, UK, 14 July 2016.

Evaluating the relationship between school environments and student nutrition outcomes in low- and middle-income countries, 22nd International Union of Health Promotion and Education World Conference on Health Promotion, Curitiba, Brazil, 22-26 May 2016.

Developing a tool to evaluate the school food environment in Sri Lanka, Sri Lanka Medical Association Conference, Workshop with multi-sectoral policy makers, Colombo, Sri Lanka, 8 July 2015.

Schools as sites for health promotion in low- and middle-income countries. St Edmunds Hall Research Expo. University of Oxford. 28 February 2014.

Integrating the Nutrition-Friendly Schools Initiative into the INPARD intervention: A Workshop with National-level Multi-sectoral Policy Makers, Colombo, Sri Lanka, June 2014.

Conference Abstracts

Williams J, Wickramasinghe K, Jayawardena R, Manoharan S, Friel S, Rayner M, Townsend N. Describing the diet quality of adolescents in rural Sri Lanka over time using a modified version of the Diet Quality Index-International (Conference Abstract). International Society for Behavioral Nutrition and Physical Activity, Victoria, June 2017.

Williams J, Wickramasinghe K, Friel S, Rayner M, Seenithmaby M, Townsend N. (2015). Weight Perception And BMI Among Adolescents In Rural Sri Lanka, A Lower-Middle Income Country Facing A Double Burden Of Under- And Over-Nutrition. 13th International Congress on Obesity, Vancouver, Canada, 1-4 May 2016.

Williams J, Wickramasinghe K, Friel S, Rayner M, Seenithmaby M, Townsend N. (2015) Ethnic differences in fast food and soft drink consumption among secondary school-children in rural Sri Lanka. Poster presentation, 2nd International Conference on Global Food Security, Cornell University, Ithaca, NY, 11– 14 October 2015.

Townsend N, Williams J, Wickramasinghe K, Karunarathne W, Olupeliyawa A, Friel S (2015) Overcoming food insecurity amongst school students in rural Sri Lanka, the perceptions of school principals. Poster presentation, 2nd International Conference on Global Food Security, Cornell University, Ithaca, NY, 11– 14 October 2015.

Williams J, Townsend N, Wickramasinghe K, Liyanage I, Senaviratne C, A Pathirana A, Friel S. (2015) Evaluating the diets and school environments of secondary school pupils in rural Sri Lanka. Poster presentation, International Society of Behavioural Nutrition and Physical Activity 2015, Edinburgh Scotland, May 2015.