“Even ben ik oud en grijs

Omdat ik de moed verloor

Even koud, dan smelt het ijs

En komt de zon weer door”

Toon Hermans

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DEVELOPMENT OF A SCHOOL-BASED HEALTH PROMOTION INTERVENTION IN ECUADORIAN ADOLESCENTS AND ITS CLUSTER RANDOMISED-CONTROLLED EVALUATION DESIGN

Thesis submitted in fulfillment of the requirements for the degree of Doctor (PhD) in Applied Biological Sciences

Dutch title: Ontwikkeling van een gezondheidspromotie interventie in schoolgaande adolescenten in Ecuador en haar cluster gerandomiseerde-gecontroleerde evaluatiestudie

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List of abbreviations

ASE-model	Attitude, Social influences and Self-efficacy model
BMI	Body Mass Index
C	Control
CI	Confidence Interval
CNMI	Commonwealth of the Northern Mariana Islands
CPPE	Comprehensive Participatory Planning and Evaluation
CT	Controlled trial
CTh	Control Theory
DALYs	Disability Adjusted Life Years
EG	Education Group
ES	Effect Size
GDP	Gross Domestic Product
HICs	High-Income Countries
HP	Pender's health promotion model
I	Intervention
ICC	Intra-class Correlation Coefficient
IM	Intervention Mapping
IMB	Information-Motivation Behavioural skills model
IO	Intervention Objective
IQR	Inter Quartile Range
LMICs	Low- and Middle-Income Countries
LOA	Limits of Agreement
LPA	Low Intensity Physical Activity
MET	Metabolic Equivalent
MPA	Moderate Intensity Physical Activity
MVPA	Moderate-to-Vigorous Intensity Physical Activity
NA	Not Applicable
NEG	No Education Group
NR	Not Reported
NS	Non-Significant
PA	Physical Activity

PABAK	Prevalence-Adjusted and Bias-Adjusted Kappa
PO	Performance Objective
RCT	Randomised-Controlled Trial
RDA	Recommended Dietary Allowance
SCogT	Social Cognitive Theory
SD	Standard Deviation
SED	Sedentary Intensity Physical Activity
SEM	Structural Equation Modelling
SES	Socio-Economic Status
THP	Trans-theoretical model integrated with Pender's health promotion model
TPB	Theory of Planned Behaviour
TTM	Trans Theoretical Model
VPA	Vigorous Intensity Physical Activity
Y	Years

Summary

Driven by economic and societal changes, obesity levels and chronic diseases have surged in many low- and middle-income countries (LMICs) in recent years. An estimated 25% (51.8 million) of Latin American children and adolescents are considered overweight or obese. Poor dietary and physical activity (PA) behaviours fuel these developments. Considering their impact on overall health, well-being and quality of life, preventive actions and informed policies are needed to tackle chronic diseases effectively. Preventive interventions promoting a healthy diet and an active lifestyle are promising means of improving child and adolescent health, and curbing the rise of this disease burden. Most of the available evidence, however, originates from high-income countries (HICs). In addition, a number of key conceptual and methodological concerns hamper their potential to alleviate the disease burden of chronic diseases and obesity.

This research targets school-going adolescents in Ecuador, a Latin American country with a high incidence of obesity and chronic diseases. The purpose of this research was to provide evidence at different levels of the systematic and stepwise planning and development processes of preventive interventions. In this context, a preventive school-based health promotion intervention, aiming to improve dietary and PA behaviours among 11 to 15-year old adolescents was developed as a case study.

To facilitate the development of an intervention, existing evidence on the effectiveness of school-based obesity prevention interventions was evaluated using a systematic review. This review focused on interventions targeting dietary and/or PA behaviour in children and adolescents aged 6 to 18 years in LMICs. Most of the identified interventions (82%) had a positive effect on dietary and PA behaviour but few decreased Body Mass Index (BMI). Effective interventions targeted both diet and PA, involved multiple stakeholders, and integrated educational activities into the school curriculum. However, to reach their full potential, the current interventions need to address important methodological and conceptual issues. In general, more and better quality research is needed that examines contextual influences of PA and eating behaviours and uses theory, rigorous evaluation designs, valid evaluation tools and methods that are not prone to reporting bias.

To address the latter, the validity and reliability of a PA record as a tool for PA measurement was evaluated in a sample of 302 adolescents. The PA record provided acceptable estimates for reliability and validity within a group and showed an overall fair measurement agreement for validity. There

was modest reliability for assessing PA in each intensity level. Sex and setting were associated with better validity, whereas perceived difficulty in filling out the record was associated with better reliability estimates for low PA.

Additional insights are needed into factors determining young adolescents' food and PA choices to develop the intervention. Focus groups with adolescents, parents and school staff were conducted for this purpose. Financial autonomy, perceived food safety, lack of self-control, habit strength, changes in both the socio-cultural (increased workload, changed food patterns, new transport modes) and the built environment (traffic and crime perceptions, distances) were identified as culture-specific factors. Measures that recognise environmental changes are thus needed to complement health education activities. Interestingly, various factors differed between settings and socio-economic groups. As a consequence, two composite conceptual frameworks were proposed. Both conceptualised adolescent eating or PA behaviour as a function of the identified individual and environmental influences. The usefulness of a multi-level, interactive framework for understanding and explaining the drivers of dietary behaviour was also evaluated. The framework is a comprehensive and valid model that specified the inter-relationships of individual and environmental factors and their influence on key components of adolescents' eating behaviour (i.e., sugary drink intake, breakfast intake, unhealthy snacking, and fruit and vegetable intake). The framework confirmed that factors varied with reference to the different components of eating behaviour and socio-economic status (SES) and provides valuable entry points for developing future interventions and contributes to the evidence-base of theory development in LMICs.

Based on the above and using theory, local evidence and a participatory approach, a school-based health promotion intervention was developed. It involved a comprehensive, culturally-appropriate intervention package, with intervention strategies consisting of an individual classroom-based and environment-based (school and family level) component. A pair-matched cluster randomised-controlled trial was conducted in 20 schools (1430 adolescents) to assess effectiveness. An in-depth process evaluation was also carried out. Primary outcomes assessed were dietary and PA behaviour and their influencing factors. Secondary outcomes were anthropometric measurements including BMI and the prevalence of overweight and obesity in the adolescents. The transparent and stepwise planning provides clear and detailed insights into the processes of intervention development in LMICs. This will help identify both effective and ineffective intervention strategies, and subsequently allow for the replication, adoption and/or dissemination of the identified strategies in LMICs.

In conclusion, this PhD research adds to the available evidence on health promotion interventions in the wider context of obesity and chronic diseases in LMICs. This work has resulted in further insights into the current evidence-base for preventive measures in schools in LMICs, validation studies for PA measures, and the identification and conceptualisation of influencing factors of adolescents' dietary and PA behaviours. It also delivers detailed information on the systematic processes associated with intervention development through the use of local evidence, theory, and participation. Lastly, it provides a niche exploration of further implications in the progress of understanding and implementing school-based interventions in LMICs.

Samenvatting

Gedreven door economische en sociale veranderingen, zijn obesitas en chronische ziekten de laatste jaren zeer snel toegenomen in ontwikkelingslanden. Naar schatting wordt 25% (51,8 miljoen) van de Latijns-Amerikaanse kinderen en adolescenten beschouwd als zwaarlijvig. Slechte voedings- en beweeggewoontes voeden deze ontwikkelingen. Gezien hun invloed op de maatschappelijke gezondheid, welzijn en levenskwaliteit, is er dan ook een geïnformeerd beleid nodig om chronische ziekten effectief aan te pakken. Preventieve interventies voor het bevorderen van een gezonde voeding en een actieve levensstijl zijn veelbelovend om de gezondheid van kinderen en adolescenten te verbeteren en de ziektelast te beperken. Het grootste deel van de beschikbare wetenschappelijke gegevens is echter afkomstig uit de geïndustrialiseerde landen. Daarnaast werden er een aantal belangrijke conceptuele en methodologische problemen geïdentificeerd die de vooruitgang belemmeren om deze ziektelast van obesitas en chronische ziekte te verlichten.

Dit doctoraatsonderzoek richt zich op schoolgaande jongeren in Ecuador, een Latijns-Amerikaans land met een hoge incidentie van obesitas en chronische ziekten. Met dit onderzoek willen we bewijs leveren voor de verschillende niveaus van de systematische en stapsgewijze plannings- en ontwikkelingsprocessen. In deze context werd er een preventieve gezondheidspromotie interventie in scholen ontwikkeld als *case* studie welke gericht is op het verbeteren van voedings- en bewegingsgedrag bij adolescenten (11 tot 15 jaar oud).

Om de interventie te ontwikkelen, werden eerst de bestaande gegevens over de effectiviteit van schoolinterventies voor preventie van obesitas geëvalueerd door middel van een systematische evaluatie. Deze evaluatie richtte zich op interventies die voedings- en beweeggewoontes wilden veranderen bij kinderen en adolescenten van 6 tot 18 jaar in ontwikkelingslanden. De meeste van de geïdentificeerde interventies (82%) hadden een positief effect op deze gewoontes, maar slechts enkele op BMI. Effectieve interventies waren gericht op zowel voeding als fysieke activiteit, betrokken verschillende belanghebbenden, en integreerden educatieve activiteiten in het schoolprogramma. Om hun volledige potentieel te bereiken, moeten de huidige interventies belangrijke methodologische en conceptuele problemen aanpakken. In het algemeen is er meer en beter onderzoek nodig naar de contextuele invloeden van fysieke activiteit en voedingsgedrag. Daarnaast is het belangrijk om gebruik te maken van theorie, rigide evaluaties, valide instrumenten en methodes die niet gevoelig zijn voor *reporting bias.*

Om dit laatste aan te pakken, werd de validiteit en betrouwbaarheid van een dagboekje dat het bewegingsgedrag meet, geëvalueerd in een steekproef van 302 adolescenten. Het dagboekje gaf een adequate inschatting voor betrouwbaarheid en validiteit op groepsniveau en toonde een goede overeenkomst voor de validiteit. Voor de verschillende intensiteiten, was er een bescheiden betrouwbaarheid om de fysieke activiteit juist in te schatten. Geslacht en locatie werden geassocieerd met een betere validiteit, terwijl de ervaren moeilijkheid om het boekje in te vullen werd geassocieerd met betere en betrouwbare inschattingen voor activiteiten die aan een lage intensiteit worden uitgevoerd.

Er is meer inzicht nodig in de factoren die de voedings- en fysieke activiteit keuzes van adolescenten beïnvloeden om de interventie te ontwikkelen. Daarom werden er focusgroepen met jongeren, ouders en schoolpersoneel uitgevoerd. Financiële autonomie, gepercipieerde voedselveiligheid, gebrek aan zelfbeheersing, gewoontes, veranderingen in zowel de sociaal-culturele (toegenomen werkdruk, veranderde voedingspatronen, nieuwe vormen van vervoer) als de omgevingsinfrastructuur (verkeers- en criminaliteitspercepties, afstanden) werden geïdentificeerd als cultuurspecifieke factoren. Maatregelen die veranderingen in het milieu doorvoeren zijn dus nodig om gezondheidsvoorlichtingsactiviteiten aan te vullen. Interessant is dat de verschillende factoren verschilden tussen locatie en sociaaleconomische groepen. Bijgevolg werden twee samengestelde conceptuele modellen voorgesteld. Beide conceptualiseren voedings- en bewegingsgedrag als een functie van de geïdentificeerde individuele en omgevingsinvloeden. Het nut van het interactieve model voor het begrijpen en verklaren van de verschillende invloeden op voedingsgedrag werd geëvalueerd. Het model is een allesomvattend en valide model dat de onderlinge relaties van de individuele en omgevingsfactoren en hun invloed op belangrijke onderdelen van adolescenten hun eetgedrag (dit wil zeggen, suikerhoudende drank inname, ontbijt inname, ongezonde tussendoortjes en fruit en groente) specificeerde. Het model bevestigt dat factoren over de verschillende componenten van het eetgedrag en de sociaaleconomische status heen varieerden. Daarnaast biedt het waardevolle toegangspunten voor het ontwikkelen van toekomstige interventies en draagt het bij aan de basis van theorievorming in ontwikkelingslanden.

Op basis van het bovenstaande en met behulp van theorie, lokale gegevens en een participatieve aanpak, werd een gezondheidspromotie interventie ontwikkeld in scholen. Het ging om een uitgebreid cultureel specifiek aangepast pakket, met interventies die bestaan uit een klassikale en omgeving-gebaseerde (school- en gezinsniveau) component. Er werd ook een grondige procesevaluatie uitgevoerd. Een gepaarde, cluster gerandomiseerde-gecontroleerde studie werd

uitgevoerd in 20 scholen (1430 jongeren) om de doeltreffendheid te beoordelen. Voedings- en bewegingsgedrag en hun invloedfactoren werden geëvalueerd als primaire effecten. Secundaire effecten waren antropometrische metingen zoals BMI en de prevalentie van overgewicht en obesitas. Het transparante en stapsgewijze proces zorgt voor duidelijke en gedetailleerde inzichten in het proces om een interventie te ontwikkelen in ontwikkelingslanden. Deze zullen helpen bij het identificeren van zowel effectieve als ineffectieve interventiestrategieën, en zorgen vervolgens voor de mogelijkheid tot replicatie, adoptie en/of verspreiding van de geïdentificeerde strategieën in ontwikkelingslanden.

Kortom, dit doctoraatsonderzoek draagt bij tot de beschikbare wetenschappelijke gegevens op vlak van gezondheidspromotie in de bredere context van obesitas en chronische ziekten in ontwikkelingslanden. Dit werk heeft geleid tot meer inzicht in de actuele kennis over preventieve maatregelen op scholen in ontwikkelingslanden, in validatie studies voor fysieke activiteit metingen, en de identificatie en conceptualisering van factoren die het voedings- en bewegingsgedrag van adolescenten beïnvloeden. Dit onderzoek levert ook gedetailleerde informatie over de systematische processen die samenhangen met de ontwikkeling van de interventie door het gebruik van lokale gegevens, theorie, en participatie. Tot slot biedt het een niche verkenning van verdere implicaties in de inzichten in en de implementatie van schoolinterventies in ontwikkelingslanden.

Content

Chapter 1:
Introduction, objectives and outline of the thesis

1 Defining and understanding the problem of childhood obesity and chronic diseases in low- and middle-income countries

Chronic diseases are now the leading cause of morbidity and mortality in low- and middle-income countries (LMICs) (1), and are expected to increase in prevalence over the next two decades (2;3). Although 80% of the overall chronic disease burden occurs in LMICs (4;5), chronic diseases remain underappreciated as a public health concern in these countries (6;7). Key determinants of chronic diseases are poor diets, physical inactivity, smoking, excessive alcohol use and obesity (2). Obesity rates have more than doubled over the last few decades in many high-income countries (HICs) (5;8;9). Comparable trends in LMICs (10) have been associated with both rapid economic political, cultural, and societal changes (*for a visualisation see* **Figure 1**) (11;12). This staggering increase in unhealthy body weights has been observed in both urban and rural settings, and across all levels of SES, including the poorest (13-15).

Of great concern is the worldwide rise in obesity levels among children and adolescents. One tenth of 5 to 17-year olds (150–160 million) are overweight; of these, 2 to 3% (35–40 million) are obese (16). The rapid increase in unhealthy body weight in schoolchildren has led to prevalence levels in some LMICs that are equivalent to if not higher than those of HICs (8;17;18). A recent systematic review categorized 25% (51.8 million) of Latin American children and adolescents as overweight or obese (19). Excess body weight during childhood is associated with a range of chronic conditions in adulthood, including type 2 diabetes, hypertension, dyslipidaemia, cardiovascular diseases, and various cancers (20-23), all of which have subsequent adverse effects on quality of life (24) and overall life expectancy (1;25-27). Obese children are more likely to become obese adults (28-30) and to suffer from psychosocial problems (e.g. poor self-image) and social stigmatization (31).

Prevention is of utmost importance to curb the rise in obesity and chronic diseases, particularly in LMICs as treatment is expensive and will eventually drain the already limited health resources (32). Poor dietary patterns and low physical activity (PA) levels are key factors in the onset of obesity and global burden of disease (2). As such, the reinforcement of healthy diets and PA is necessary and should be at the basis of any preventive strategy directed at children and adolescents (33;34).

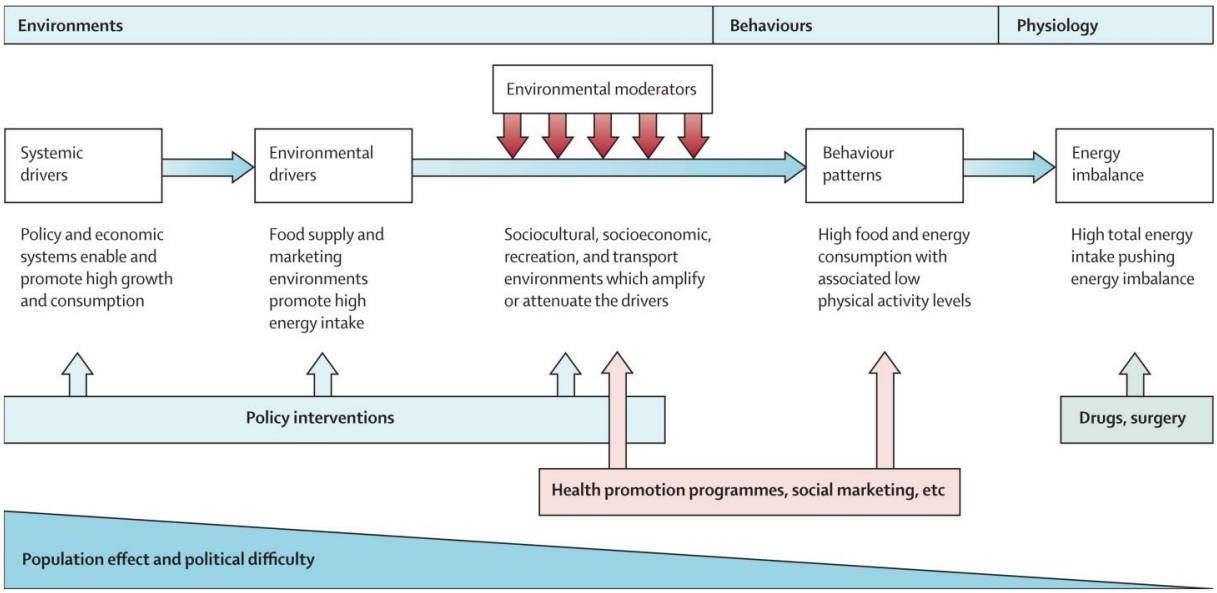

Figure 1 A framework to categorise obesity determinants and solutions (35)

2 Prevention as an answer to the problem of childhood obesity and chronic diseases in low- and middle-income countries

Increasingly, new evidence suggests that a predisposition to obesity may start in the womb (36;37), and is affected by a a wide range of internal and external risk factors (for a review see (38)). Preventive efforts therefore need to start early in life and must be continued throughout the life cycle. However, there are a number of reasons, including physiological, psychosocial and strategic reasons, to prioritise preventive efforts in adolescents. Firstly, adolescence is a period of rapid growth and therefore critical to the aetiology of overweight and obesity (39). Obesity during adolescence has a tendency to persist and continue into adulthood (40-42), and is, as previously mentioned, associated with morbidity and premature mortality (20-23). Second, during adolescence refinements in cognitive, emotional and psychosocial development take place (43;44). Adolescence is a period of transition in which increasing independence is experienced, namely the extent of parental support declines and the desire to fit in with peer norms increases. Associated with this growing independence and a search for self-identity is an increase in novelty- and sensation-seeking behaviour which can result in excessive risk-taking (43;44). This makes adolescents a vulnerable

population for adopting unhealthy lifestyles. Behavioural patterns, such as healthy eating and PA patterns, acquired during adolescence can last a lifetime (45). Hence, adolescence is a unique opportunity to positively promote and adopt a healthy lifestyle that could be sustained throughout life. Third, there are strategic arguments for primary prevention in adolescents. Young childbearing adolescents are future mothers and a healthy lifestyle is vital to ensuring that they enter their first pregnancy in an optimal state of health. The importance of adolescent health in LMICs is further supported by the size of this population group; there are 1.2 billion young people (10 to 19 years old) worldwide and the majority of these live in LMICs (46). Current coverage of adolescent health in LMICs is patchy and the reasons for improving adolescent health in LMICs are stronger than ever (47). Lastly, preventive efforts can potentially have positive effects on the mental and physical health of future generations (47), and reduce the detrimental social and economic effects on LMIC governments.

School-based interventions in which healthy dietary and PA behaviours are promoted have become an important and promising public health strategy (48;49). There is however a concern that such complex interventions do not reach their full potential as the quality of existing studies is poor, follow-up periods are short, study designs and analyses used are inappropriate, and interventions are not always guided by a systematic approach using theory and evidence-based processes (50;51). The overall lack of detailed information on intervention development, strategies and implementation processes is hindering the identification of effective and ineffective pathways for interventions, thus limiting our ability to replicate or adopt effective strategies. Furthermore it leads to ineffective use of research evidence and waste of resources (52). Despite the high burden of obesity and chronic diseases in LMICs, the evidence for preventive actions in these countries remains poor (51;53). Best practice and evidence-based recommendations are urgently needed to assist decision-makers in LMICs when designing national preventive strategies.

3 Programmatic context and framework of the Food, Nutrition and Health Project

3.1 Context

Ecuador is a Latin American country bordering the Pacific Ocean at the Equator between Colombia and Peru. It has an estimated population of 15,654,411 (July 2014, *estimate*), and languages spoken

there are Spanish (Castilian), Quechua and Shuar. Two-thirds of the population lives in urban areas (67%) and approximately half the population is under the age of 25. Quito (capital), Guayaquil and Cuenca are the three largest cities. Ecuador is classified as an upper middle-income country (54) with 4.6% of its population having a purchasing power parity below the international poverty line ($1.25/day) (55). Ninety-two per cent of its adults are educated, and in 2010 the Ecuadorian government spent 1.3% of its GDP on health (55).

Geographically, Ecuador constitutes three continental regions: the coastal plains (Costa), the Andean mountains (Sierra), the Amazon forest (Oriente), and one insular region (The Galapagos Islands). Each of these regions has different cultural identities and the main ethnicities are Mestizo (mixed Spanish and white: 72%), Indigenous (7%), Montubio (7.3%), Afro-Ecuadorian (7%), and White (6%) (56). The study was carried out in two cantons in the Azuay province: Cuenca, the third largest city in the country, and Nabón, a surrounding rural area experiencing high levels of poverty (**Figure 2**). Both are located in the South of Ecuador, in the Sierra region, at an altitude of 2550m.

Figure 2 Provinces in Ecuador and the location of the study area

3.2 Programme framework

This PhD research was integrated into a programme that aimed to improve food intake, nutrition and health in Ecuadorian adolescents, i.e. the Food, Nutrition and Health Project. The latter was implemented through an inter University Collaboration (http://www.vliruos.be/en/) between Ghent University/University of Leuven (Belgium) and Cuenca University (Ecuador) (from 2008 to 2018). Based on literature, expert opinions, and meetings with the local research team, the programme identified unhealthy body weight in young adolescents (11 to 15 years old) as a major health problem. It consequently aimed to tackle this problem using a school-based intervention to prevent unhealthy body weight within this population group.

A stepwise and systematic approach for intervention development has been advocated to ensure meaningful and sustainable changes in health behaviour (57). Health promotion has adopted rigorous planning processes, and different models can be used to guide this process (58-60). To reach the objectives of the programme, a framework was developed using the stepwise approach described by Green and Kreuter in the simple Model for Planned Health Promotion and Education (**Figure 3**) (61). This framework involved a thorough epidemiological analysis of the health problem and needs assessment (Phase A-C). As this framework does not provide detail on how to develop a complex intervention to achieve behaviour change, both the Intervention Mapping (IM) and the Comprehensive Participatory Program and Evaluation (CPPE) protocols were used to guide the development, implementation, evaluation and dissemination processes of the intervention (Phase D) (62;63). Phase E involves the implementation of the intervention. Using the findings from phases A - E, an evaluation study design was developed. Responding to obesity and chronic diseases requires in each society proper understanding of the local context and factors involved. Local data on the prevalence of unhealthy body weights and current dietary and PA patterns and their determinants were collected to account for the different contexts in a LMIC. *Theory, local evidence and participation* were the three main pillars of this programme framework. The following paragraphs detail each step of this programme framework.

3.2.1 Phase A: Analysis of the health problem in Ecuadorian adolescents

Dietary risk factors such as diets low in fruit, vegetables, and whole grains and physical inactivity collectively accounted for 10% of global DALYs in 2010 (2). These dietary risk factors and high Body Mass Index (BMI) have increased in relative importance over the past decades and are now leading risks of disease in Latin America (2;64). Obesity affects a large amount of Latin American adolescents

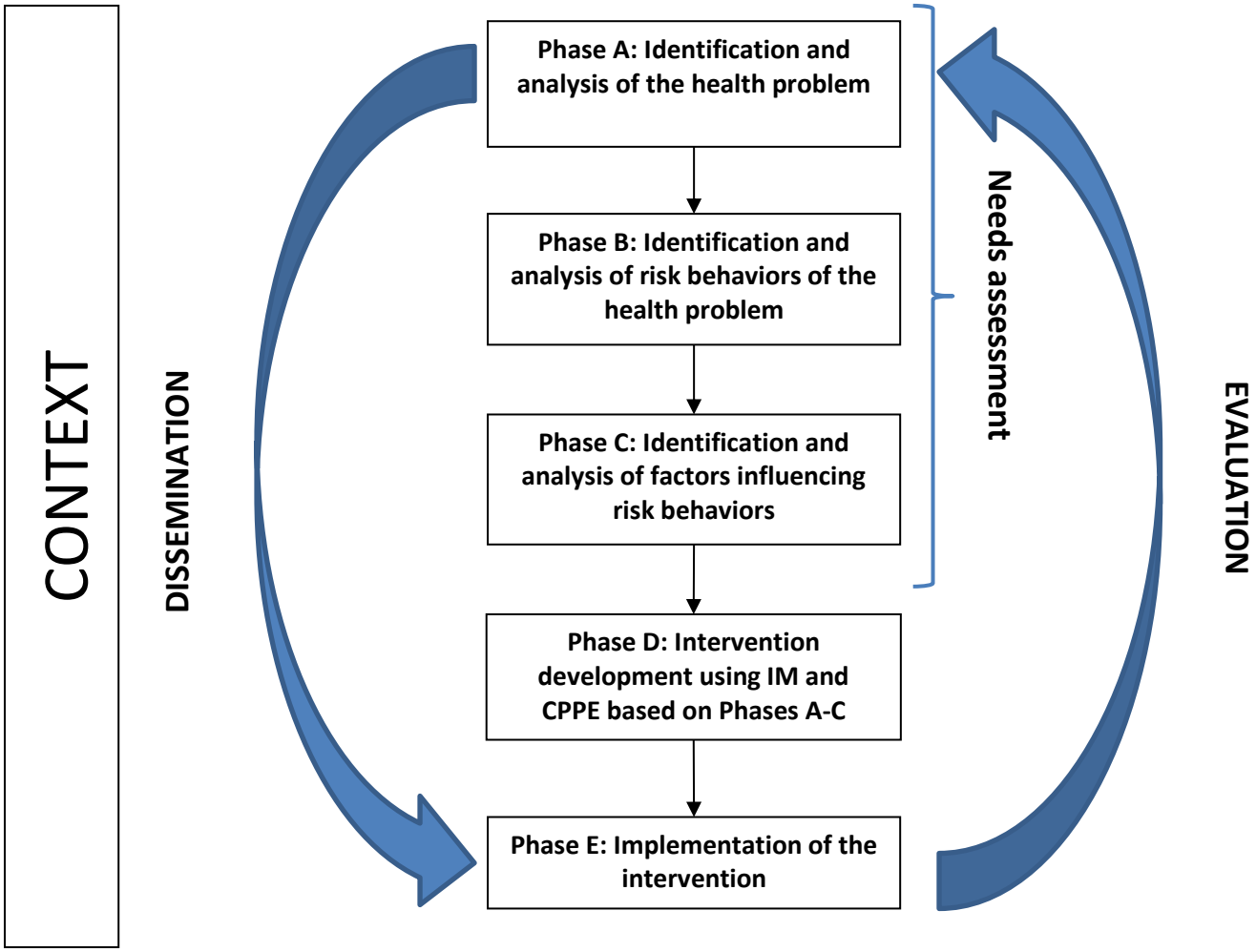

Figure 3 Programme framework for a school-based intervention in Ecuadorian adolescents (after Green and Kreuter, 1999 (61)). IM: Intervention Mapping and CPPE: Comprehensive Participatory Planning and Evaluation.

with national prevalence estimates ranging from 16.6% to 35.8% (16.5 to 21.1 million) (19). Obesity and chronic diseases are complex multifactorial problems with genetic, lifestyle, cultural, medical, social and moral causes (65). Hence, adequate and culturally-appropriate evidence on its current prevalence and clear insight into its behavioural causes are needed.

A cross-sectional study was carried out as such data were lacking for the Ecuadorian adolescent population (in 2008). This study included 770 school-going adolescents (aged 10-16 years old) from an urban (Cuenca) and rural area (Nabón). Data on anthropometry, blood pressure, socio-demographics, and current dietary and PA patterns and their driving factors were collected. The study also assessed fasting blood glucose and lipid profiles in a subsample of 334 adolescents. The study protocol was approved by both Ecuadorian and Belgian Ethical Committees (no. 2008100-97/ no. B67020084010). Detailed information on the design and results of this study has been published elsewhere (66-68).

The findings of the cross-sectional study indicated that 18.0% and 2.1% of the adolescents (both Cuenca and Nabón) were classified as being overweight and obese, respectively. Other important risk factors were dyslipidemia (34.2%) and high levels of blood pressure (6.2%). Importantly, a considerable share (19.7%) of adolescents in this study were diagnosed with central obesity (67). Children living in the rural area were 2.8 times (P = 0.002) more likely to have dyslipidemia than those from the urban area. Boys were found to have a lower BMI than girls, and the difference in overweight prevalence was marginal between socio-economic groups (67). With similar obesity prevalence as for example Mexico (69), these figures clearly show that Ecuador is in full epidemiologic transition. Such findings justify spending time, money and resources on the development, implementation and evaluation of preventive interventions as proposed by the programme. Recent data from the “Encuesta Nacional de Salud y Nutrición 2011-2013” further support such investments (**Figure 4**); The Azuay Province (34.5%) has the highest childhood obesity prevalence.

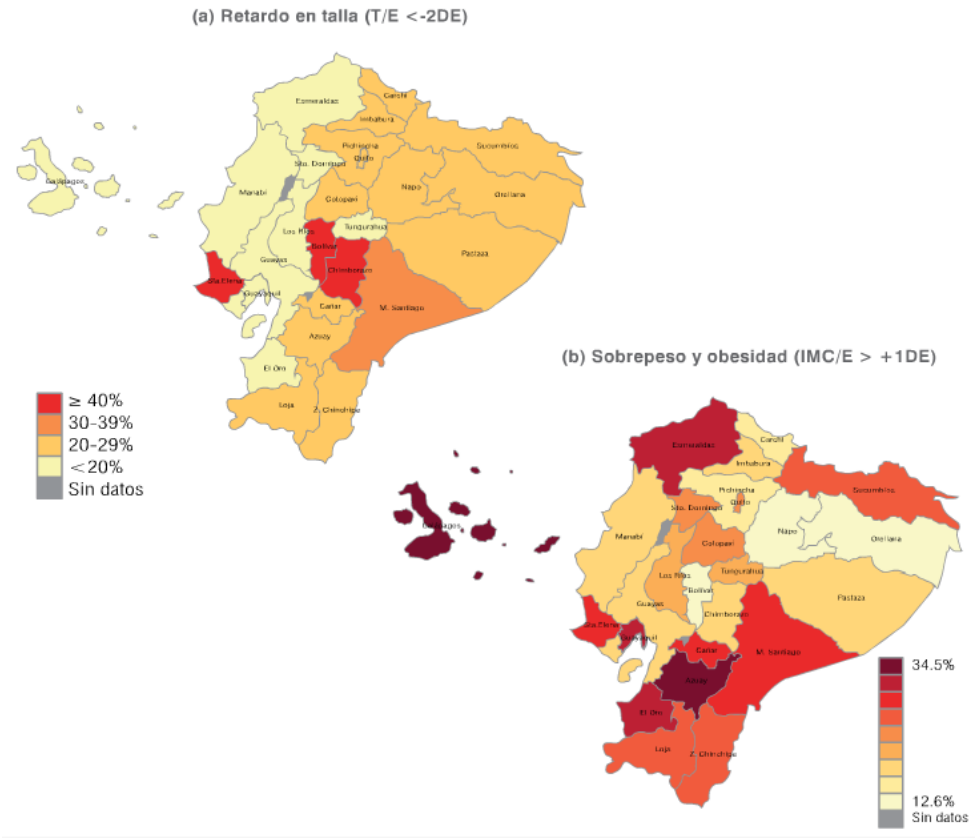

Figure 4 Prevalence of underweight, overweight and obesity in adolescents (12-19 years old) per province (70)). (a) Stunting (height for age< -2SD), (b) Overweight and obesity (BMI per age > +1SD)

3.2.2 Phase B: Risk behaviours associated with the health problem in Ecuadorian adolescents

The following dietary and PA behaviours have been (independently) associated with a high risk of obesity and/or chronic diseases: over-consumption of energy-dense foods (71), high intakes of specific foods such as sugary drinks (72) and processed foods (73), erratic behaviours such as skipping breakfast (74), diets low in fruit and vegetables and whole grains, nuts and seeds, and seafood omega-3 fatty acids (2), and an increasing sedentary lifestyle and low PA levels (2;71). Behavioural influences on obesity can differ between cultures, and specific dietary and PA behaviours need to be identified prior to designing interventions. Additionally, a valid and feasible assessment of these behaviours is crucial to examine the risk for chronic diseases.

Validity and reliability of a PA record to measure sedentary and PA behaviour was examined (*see* Chapter 3); dietary behaviour was evaluated using a 24-hour dietary recall during which a validated food recall kit was used. The cross-sectional study conducted in the adolescent population identified

several specific risk behaviours. Intake of unhealthy snacks, sugary drinks, and processed foods was found to be high, while fruit and vegetables, fibre, and fish consumption was low. It also showed that sodium, added sugar, and refined cereals were important constituents of the diet. Some erratic behaviour such as skipping breakfast was highly prevalent (68). Moreover, the adolescents were highly involved in sedentary behaviour and had low PA levels. The majority of the adolescents (59%) exhibited unhealthy levels of physical fitness (66).

The question rises what approaches are effective in preventing such risky behaviours in adolescents in LMICs? What are the possible successful pathways of change and thus potentially interesting for future interventions in LMICs? To provide an answer to these questions, the current evidence-base on implementing school-based interventions in LMICs was analysed and evaluated using a systematic review (*see* Chapter 2).

3.2.3 Phase C: Factors influencing the identified risk behaviours in Ecuadorian adolescents

It has been argued that acquiring an insight into the drivers of adverse behaviours is an integral part of the systematic process of developing interventions (75-77). Unhealthy diets and physical inactivity are influenced by inter-related factors reflecting the environment and personal, social and cultural experiences (78-81). These influences, including facilitators and barriers of change, on dietary and PA patterns are culture-specific and context-dependent. Unfortunately, most of the studies investigating such influences have been conducted in HICs, and are often focusing on a restricted set of influences (78). Adequate knowledge of potential culturally-specific influences on dietary and PA patterns is currently missing in LMICs. This is unfortunate as this is crucial to preventing non-recognition of health problems, understanding discrepancies in food intake and activity, guiding the intervention formulation and increasing the intervention's effectiveness, and finally in avoiding incorrectly formulated policies in these countries. A theory-based approach to identify influences on (un-) healthy eating and PA patterns has been recommended (76) and has been adopted by this programme. A qualitative study identified such influences from the perspective of parents, school staff and adolescents using the 'Attitude, Social influences and Self-efficacy' ASE-model and socio-ecological model. It also allowed to develop comprehensive conceptual frameworks for adolescents' eating and PA choices to guide the development of health promotion interventions in the context of systematic obesity prevention (*see* Chapter 4 and 5).

3.2.4 Phase D: Intervention development

The previous three phases (A to C) involve an in-depth needs assessment of the health problem and its causes in Ecuadorian adolescents. The results of these phases should be used for the development of an intervention. To minimize methodological and conceptual problems, a theory- and evidence-based approach, such as the Intervention Mapping (IM) protocol, has been recommended (57). Using partnerships and co-operative approaches have also shown to be key in developing successful interventions (82;83), particularly in LMICs (84). Therefore, interventions promoting dietary and PA behaviours require the use of theory and local participation to help account for cultural characteristics and requirements. As mentioned above, theory, local evidence and a participatory approach were the three pillars of the programme framework and were used as a basis for the intervention development in Ecuadorian adolescents (*see* Chapter 6).

3.2.5 Phase E: implementation of the intervention

The last phase of the framework concerns the implementation of the intervention. Participatory research methods have been advocated to enhance applicability of intervention strategies (85). The CPPE protocol can be used intensively during the implementation of an intervention to enhance communication, judge the acceptability of the intervention, and help identify opportunities and barriers.

3.2.6 Evaluation and Dissemination

Rigorous evaluations are needed and process evaluations need to be performed. An evaluation study design should follow the CONSORT statement (86), a checklist for Randomised Controlled Trials (RCTs). Built in process evaluations provide a way to evaluate if a programme is accomplishing what it is expected to accomplish. It also helps to monitor and evaluate intervention strategies of a programme in a transparent way. Finally, the use of a systematic programme framework may enhance the potential for future dissemination of the intervention. Understanding contextual elements and enabling pathways is key to evaluate, not only the current, but also the potential impact of an intervention (85).

4 Research question, hypothesis and objectives of the thesis

This PhD research aimed to improve dietary and PA behaviour in Ecuadorian adolescents within the context of the epidemic increase in childhood obesity, and its related chronic diseases. Within the presented programme framework, it focuses on the development of a school-based health promotion intervention in Ecuadorian adolescents (aged 11 to 15 years old) and its evaluation design. Practically, additional results for studies on the PA behaviour and of the intervention will not be presented in this thesis as these are the subject of other PhD researches being conducted within the overall programme framework. “School-based promotional activities improve dietary and PA behaviour among Ecuadorian adolescents” was the underlying hypothesis of this research question.

The study objectives of this PhD research were to:

- Produce a critical review of the literature on school-based interventions for obesity prevention and identify successful strategies in LMICs;
- Develop a methodologically sound tool to evaluate PA behaviour;
- Explore and identify the factors influencing adolescents’ dietary and PA behaviour at an individual as well as an environmental level;
- Validate the resulting conceptual framework for drivers of dietary behaviour;
- Provide insight in the planning, development, and implementation processes of the evaluation study of a school-based intervention aiming to improve dietary and PA behaviour in Ecuadorian adolescents.

5 Thesis outline

This doctoral dissertation is a compilation of original articles that have been published, accepted and/or submitted as contributions to international peer-reviewed journals. These articles vary by type of research, including evidence synthesis, epidemiological validation studies, qualitative and quantitative research, and the evaluation design of intervention studies. The present section provides an overview of the chapters included in this thesis. **Figure 5** illustrates how these chapters are related to the programme framework; this PhD research particularly addresses a section of the needs assessment and the development of the intervention.

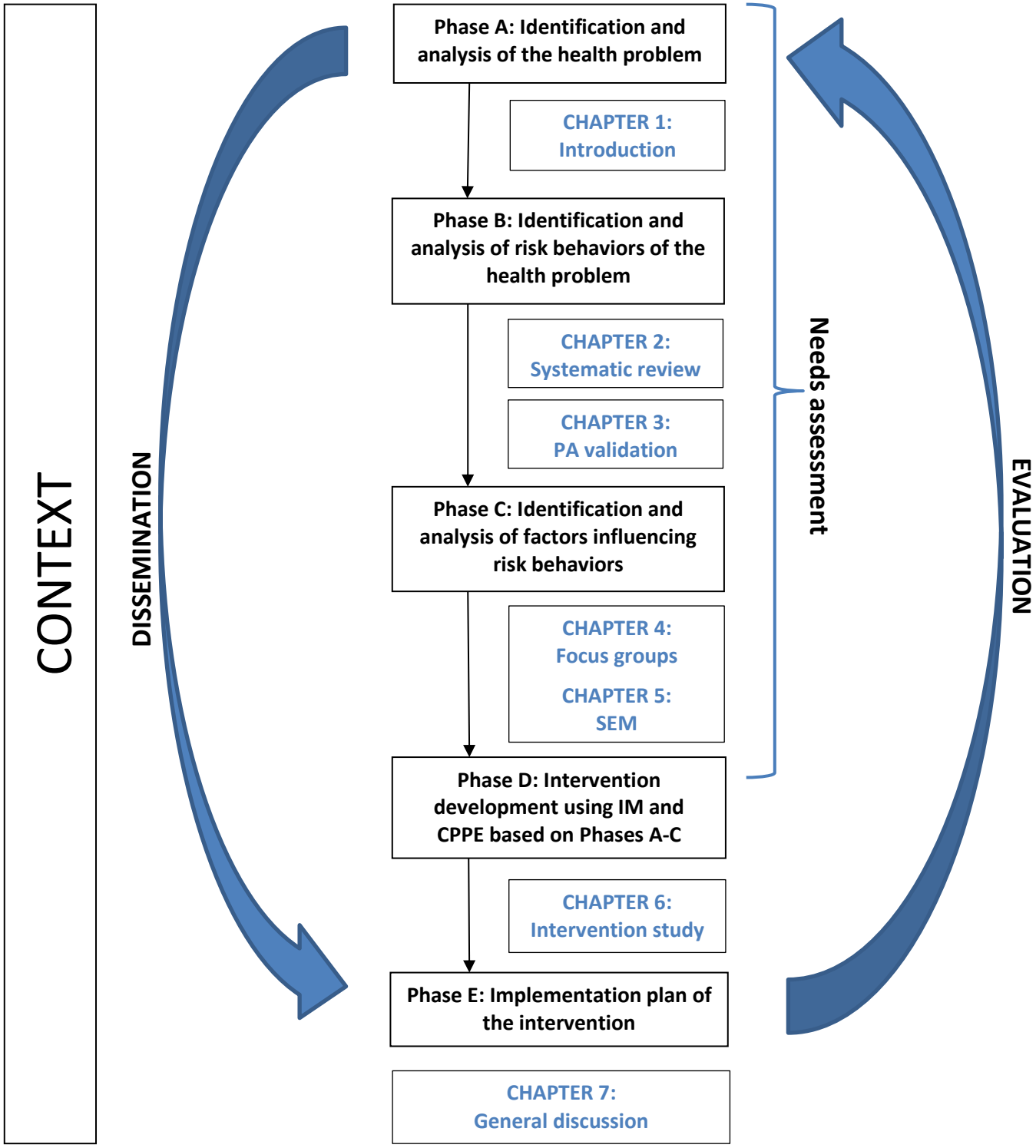

Figure 5 Chapters of this PhD related to the Programme Framework for a school-based intervention in Ecuadorian adolescents (after Green and Kreuter, 1999 (61)). PA: Physical Activity; IM: Intervention Mapping; CPPE: Comprehensive Participatory Planning and Evaluation; SEM: Structural Equation Modelling

A more detailed description of the relevant literature, study participants and applied methodologies are included in the methods section of the relevant chapters.

Chapter 1 introduces the reader to the theoretical background and programmatic framework of this PhD research.

Chapter 2 presents a systematic review of the literature on school-based obesity prevention interventions in young people in LMICs. This review summarizes the current evidence-base of such interventions on dietary and PA habits, and BMI. It also identifies what defines the most successful studies, which intervention components or strategies are effective, and the challenges and research gaps in this field.

A valid and feasible assessment of lifestyle-related behaviours is crucial to examine the risk for chronic diseases and evaluate the effectiveness of preventive interventions. However, no such tool is available to evaluate PA behaviour in adolescents within the context of an LMIC. Hence, this research further aimed to assess the validity and reliability of a PA record as an instrument used in estimating PA at a group level in the Ecuadorian adolescent population (**Chapter 3**). After reviewing the literature, further information was gathered on factors influencing diet and PA behaviour to inform the operationalization of theory constructs and selection of strategies. Focus groups were carried out to identify conceptual factors that influenced behaviour. A conceptual framework for both eating and PA behaviour was thus identified. The conceptual framework for eating behaviour was validated before it was used as a framework for intervention development, and formative and process evaluation research as outlined in **Chapter 4** and **5**.

Chapter 6 highlights the intervention development. It describes the systematic planning, and development of the implementation and evaluation design of a school-based health promotion intervention to improve adolescent health. These processes were guided by theory and local evidence, and complemented by a participatory approach. It also provides extensive background information on the application of the IM and CPPE protocols to develop the intervention programme, the cluster randomised-controlled evaluation design, and its objectives, recruitment of participants, and outcome measures. The experiences accumulated in the development of this intervention are analysed and their possible contribution to more comprehensive interventions is also discussed.

Chapter 7 summarizes the main findings of this thesis and critically discusses policy, development, practical, and public health issues. Additionally, implications for future research are discussed.

Chapter 2:

Effectiveness of preventive school-based obesity interventions in LMICs: a systematic review

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Redrafted after:

Verstraeten R, Roberfroid D, Lachat C, Leroy JL, Holdsworth M, Maes L, and Kolsteren PW. Effectiveness of preventive school-based obesity interventions in LMICs: a systematic review. Am J Clin Nutr 2012; 96(2): 415 – 438

Summary

Background: The prevalence of childhood obesity is increasing rapidly in LMICs, and informed policies to tackle the problem must be defined.

Objective: We systematically reviewed the evidence on the effectiveness of school-based interventions targeting dietary behaviour and/or PA for the primary prevention of obesity in children and adolescents aged 6–18 y in LMICs.

Design: We searched the MEDLINE, EMBASE, Web of Science, CENTRAL, ERIC, Cochrane Library, and Centre for Reviews and Dissemination databases for peer-reviewed controlled studies published in English, Spanish, French, German, or Dutch between January 1990 and July 2011. The quality of the included studies was appraised independently by 2 authors who used the Effective Public Health Practice Project tool.

Results: From a total of 7218 unique references, we retained 22 studies. Most of the interventions (82%) had a positive effect on dietary behaviour and PA behaviour (effect size ranged from −0.48 to 1.61). BMI decreased in 8 studies (effect size ranged from −0.7 to 0.0). Effective interventions targeted both diet and PA, involved multiple stakeholders, and integrated educational activities into the school curriculum.

Conclusions: School-based interventions have the potential to improve dietary and PA behaviour and to prevent unhealthy body weights in LMICs. To reach their full potential, interventions should conduct process evaluations to document program implementation. The effect and the pathways through which interventions have this effect need to be better documented through rigorous evaluation studies.

1 Introduction

Appropriate public health strategies to tackle the childhood obesity epidemic in LMICs are urgently needed. School-based intervention programs have emerged increasingly as an important strategy in obesity prevention. Most of the available evidence, however, originates from studies conducted in HICs (50;87). The only 2 systematic reviews linked to LMICs either focused on only one region (i.e., China) or had a narrow focus on one specific intervention (i.e., PA) (88;89). Moreover, a comprehensive and systematic synthesis of study results, including both anthropometric and behavioural outcome measures, is currently lacking (87). Given the differences in contextual and cultural factors between HICs and LMICs (90), the public health challenges they are facing, and the importance of basing actions on sound evidence, we conducted a systematic review to identify effective pathways that alter behaviour and/or BMI in schoolchildren in LMICs.

2 Methods

We conducted a systematic review of the effect of school-based interventions in LMICs aimed at the primary prevention of obesity through changes in dietary behaviour, PA behaviour, or both in children and adolescents 6–18 y of age. To avoid biased post hoc decisions, the inclusion criteria and analytic methods were specified in the review protocol before the review was conducted and were based on the Cochrane handbook (91). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was followed as a guideline to report this systematic review (92;93).

2.1 Search strategy

The following electronic databases were searched: MEDLINE (PubMed; http://www.ncbi.nlm.nih.gov/pubmed), EMBASE (http://www.embase.com), Web of Science (http://www.webofknowledge.com), CENTRAL (http://www.thecochranelibrary.com/), Education Resources Information Center (ERIC) (http://www.eric.ed.gov/), The Cochrane Library (http://www.thecochranelibrary.com/), and the Centre for Reviews and Dissemination (http://www.crd.york.ac.uk/crdweb/SearchPage.asp). The initial search string was developed in MEDLINE by using the Population, Intervention, Comparison and Outcome model (94), combining population (healthy children and adolescents in LMICs), intervention (school-based primary prevention for PA and/or nutrition), comparison (controlled trial), and outcome (anthropometric and/or behavioural change outcomes) terms (*see* **Supplementary Table 1**). The search string was

further refined for use in the different databases. It included both text words and thesaurus terms, which were adapted for each of the databases searched. Searches were conducted in April 2010 and updated in July 2011 for all databases except EMBASE and ERIC because of difficulty accessing them. Additional eligible studies were identified from the bibliographies of published reviews and included articles.

2.2 Eligibility criteria

The review was limited to studies published in English, French, Spanish, Dutch, and German between January 1990 and July 2011. This time frame was chosen because it covers the worldwide trend of increasing childhood obesity prevalence over the past decades. To be eligible for inclusion, studies had to *i*) be conducted in a school setting in a LMIC, based on the World Bank classification (95); *ii*) include healthy children and adolescents 6–18 y of age; *iii*) use a controlled trial design (with or without randomization); *iv*) focus on primary prevention of overweight or obesity through dietary and/or PA behaviour; and *v*) include both baseline and post-intervention measurements of dietary and PA behaviour outcomes and/or anthropometric outcomes. Studies targeting parental or teacher behaviour were eligible if outcome data could be extracted for children and/or adolescents. The following studies were excluded: *i*) correspondence letters, book chapters, dissertations, conference proceedings, and abstracts; and *ii*) secondary prevention interventions targeting only overweight, obese, or underweight subjects.

2.3 Study selection

First, the title and abstracts of the identified references were screened to select relevant studies based on the inclusion criteria. If insufficient information was available from the title and abstract, the full text was read. The full text of the selected studies was then retrieved and read to determine whether the inclusion criteria were met. The selection process was performed independently by 2 reviewers (RV and CL). Disagreement between reviewers was resolved by discussion until a consensus was reached. In cases of a disagreement, a third reviewer was consulted (PWK).

2.4 Data extraction

Data extraction of the following study characteristics was performed by one reviewer (RV): study design, study setting (urban/rural), characteristics of participants (including number, number of

schools, age, sex, and socio-economic status (SES)), type of intervention (including type, intervention duration, length of follow-up, and focus), adverse effects, and theoretical framework of the intervention. Data extraction sheets were pilot-tested on 4 papers before applying them to all included studies. Study results (i.e., the impact estimates) and the information necessary to evaluate study quality appraisal were extracted independently by ≥2 reviewers. Disagreements were resolved by discussion until a consensus was reached. If necessary, a third reviewer was consulted to obtain a final decision. If ≥2 articles presented data from the same study, the results were included only once in the tables, but all the references linked to the original study were noted.

2.5 Summary measures

To the extent that they were reported in the articles reviewed, 2 types of impact estimates were tabulated for each study: *i*) the double difference effect, i.e., the difference in the change of means over time (i.e., from baseline to follow-up) between the intervention group and the control group; and *ii*) the baseline-adjusted effect, i.e., the comparison between the means of the intervention and control groups at follow-up, adjusted for values of the outcome at baseline. After these data were extracted, it became apparent that some studies did not report statistical tests between the intervention and control groups. Consequently, studies for which no statistical tests were provided or outcomes for which no significance levels were reported were not included in the result tables. In addition, the effectiveness of studies estimating the effect of the intervention on at least one proximal (i.e., PA or dietary behaviour) and a distal outcome (i.e., BMI or overweight/obesity prevalence) was evaluated. The authors were contacted to obtain further information when needed.

2.6 Quality appraisal

Methodological quality was assessed by using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies 2008 (96). This standardized quality-assessment tool evaluates study quality in 8 domains: selection bias, allocation bias, control for confounding, blinding, data-collection methods, loss to follow-up, statistical analysis, and intervention integrity. The tool assigns ratings of 1 (lowest quality), 2 (moderate quality), or 3 points (highest quality) to each of the 6 first domains. The overall quality score is then calculated for each study by adding these ratings.

2.7 Data synthesis

Because of heterogeneity in the studies in terms of participants, types of intervention, and outcome measures, a meta-analysis was not appropriate. When possible, effect size (ES) was computed to allow comparison of the effectiveness of the interventions across studies:

ES = (mean for I – mean for C) ÷ [average SD for I and C (pooled SD)]

where I is the intervention group and C is the control group. ES was calculated for the following outcomes: dietary and PA behaviour, BMI, and the prevalence of obesity and/or overweight. They were categorized as trivial (<0.2), small (0.2 to <0.5), medium (0.5 to <0.8), or large (≥0.8) (97). The ES of interventions was presented by outcome and grouped into 3 categories depending on the type of intervention: *i*) diet, *ii*) PA, and *iii*) diet and PA.

3 Results

3.1 Description of included studies

The systematic search strategy identified 7218 unique references, of which 104 articles were included for full-text review. After full-text screening of these articles, 25 studies (presented in 29 publications) were found to meet the inclusion criteria and were included for quality appraisal and analysis (**Figure 6**). The characteristics of these studies are presented in **Table 1**. Overall, 13 interventions involved school staff, communities, parents, children, and/or families and are referred to as multicomponent interventions in the remainder of this review. Four of the 25 interventions provided an individual counselling component (98-101).

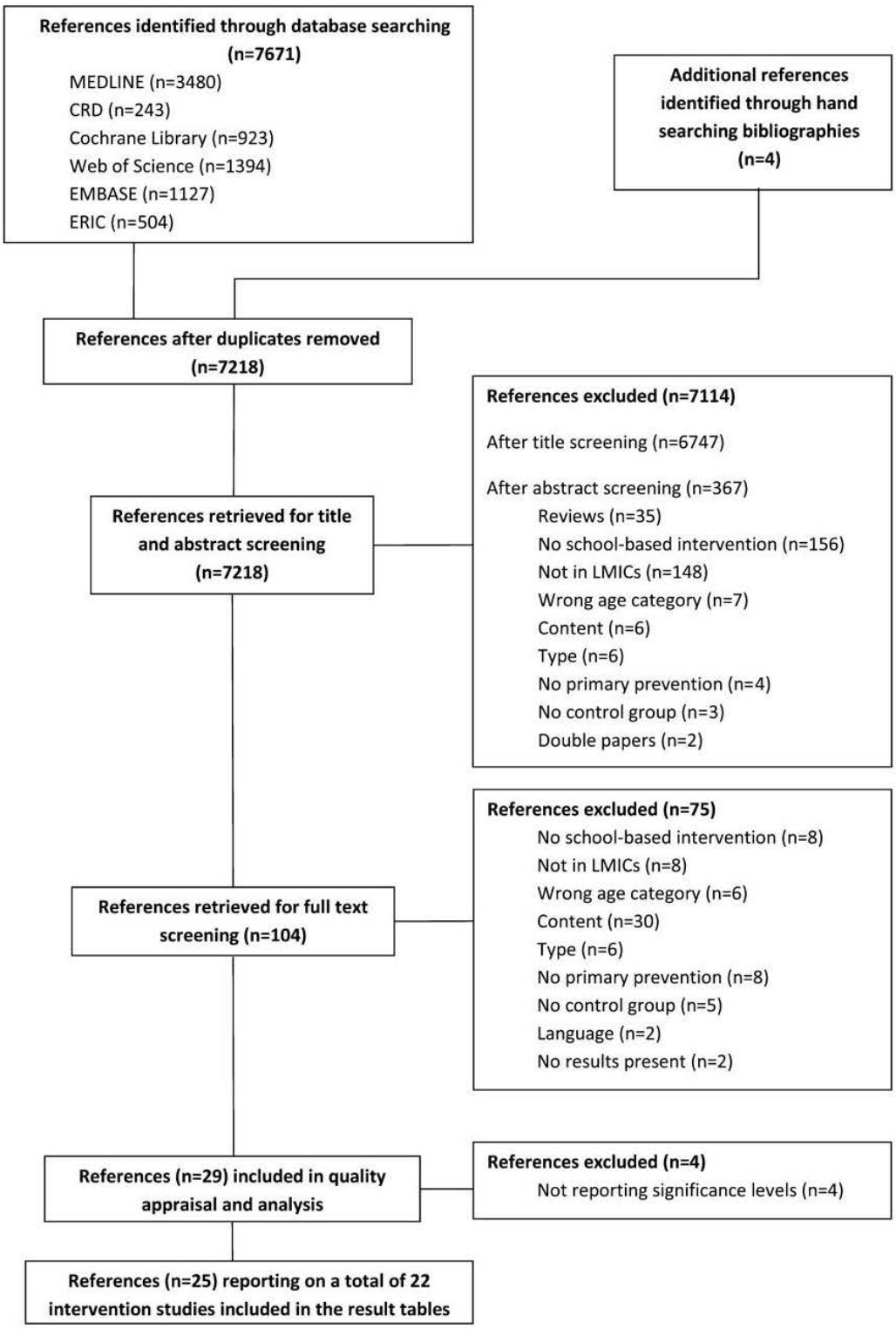


Figure 6 Flowchart for the inclusion of studies MEDLINE: http://www.ncbi.nlm.nih.gov/pubmed; CRD: http://www.crd.york.ac.uk/crdweb/SearchPage.asp; Cochrane Library: http://www.thecochranelibrary.com/; Web of Science: http://www.webofknowledge.com; EMBASE: http://www.embase.com; ERIC: http://www.eric.ed.gov/. CRD, Centre for Reviews and Dissemination; ERIC, Education Resources Information Centre; LMICs, LMICs.

Four studies were diet only interventions (102-105), 10 studies were PA only interventions (101;106-115) and 11 studies involved both diet and PA interventions (referred to as combined interventions in this review) (98-100;116-126). Diet only interventions mainly used nutrition education promoting healthy diets as a key intervention strategy (102;103;105); one study was a breakfast program (104). Eight out of 10 PA interventions provided additional physical-education sessions ranging from 50 to 315 minutes extra per week (106-108;110-114). Except for one study not reporting these data (101), these studies integrated their additional sessions into the existing curriculum. The remaining two PA interventions compared programmed PA with a regular physical-education curriculum (109) and provided tailored education according to the different stages of the Health Action Process Approach (115). Most (*n*=9) of the combined interventions used diet and PA education as their key strategy (99;100;116;119-126), which was accompanied by environmental or organizational changes in the schools in 5 of them (100;116;119;120;123-125). The remaining 2 interventions provided lectures and group counselling on cardiovascular disease prevention (98) and trained primary caregivers of children in healthy nutrition and activity (117;118).

Most of the studies were conducted in Latin America (*n*=13) and Asia (*n*=8). Only 6 studies based the intervention design on a theoretical framework. Two-thirds of the studies were conducted in major urban areas (*n*=16), 2 studies included a rural area and the remaining studies did not report this information. The number of participants ranged from 135 to 4700, and participants' mean age ranged from 6.5 to 18.4 years. The median intervention duration was 9 months (range: 1 h to 4 y) and the median length of follow-up was 11 months (range: 4 weeks to 4 years). Except for 3 studies including only boys (98;113) or girls (101), all interventions targeted both sexes. Thirteen studies reported on the SES of the area, students and/or parents. Few studies (*n*=3) reported data on adverse effects (114;121;123).

3.2 Effectiveness and effect sizes of interventions

The results are presented by outcomes. Anthropometric outcomes such as waist circumference and skinfold thickness were evaluated in too few studies to be reported in this review. Surprisingly, 3 studies did not report significance levels on any outcome of interest (102;115;119;120) and therefore were not included in the result tables. Six additional studies did not report significance testing on some of their outcomes; likewise, these outcomes are not reported in the tables (99;100;109;112;116;121). Of the 22 studies (presented in 25 publications) included in the result tables, only 12 studies reported the information required to calculate the ES. Of the 16 authors

contacted to provide additional information, 4 responded but only 2 were able to provide the required information.

3.2.1 Dietary behaviour

Five studies (2 diet and 3 combined interventions) reported significant effects on one or more dietary behaviours (**Table 2**). The diet interventions reported a positive effect on preferences for healthy food (103) and a decrease in daily consumption of sweetened carbonated drinks (105). A significant decrease in the fast food eating behaviour score (116), in the frequency of fast food consumption in general (121) and in schools (126), and in fried food consumption, soda intake and snacks high in fat, sugar and salt (121) were observed in favour of the combined interventions. The only study for which ES could be calculated had a small effect (116).

Except for one study, only multicomponent studies were effective in changing behaviour. Most provided nutrition education or nutrition and PA education as the intervention strategy, which were implemented by the teachers. All but one study had a low quality level (103).

3.2.2 PA behaviour

Nine studies (7 PA interventions and 2 combined interventions) reported on physical fitness (*n*=5) and/or PA time (*n*=4) (**Table 3**). With regard to the PA interventions only, those measuring physical fitness (*n*=3) as an outcome showed a significant increase in performance on most fitness indicators (106;108;113). Of those interventions evaluating time spent being physically active (*n*=4), all but one (112) found a significant increase in the intervention group (101;107;110;111). Overall, the ES of the PA interventions ranged from trivial to large (range: −0.48, 1.61) (101;107;108;112). The effective PA interventions were provided by teachers and included additional PA sessions or healthy PA education integrated into the existing curriculum. Two of them were multicomponent interventions (101;107). The 2 combined interventions showed a beneficial effect on all fitness tests for both boys and girls (123-125); the ES varied from small to medium (123). Also worthy of note, the study with the highest quality score was also the one that reported the largest ES.

3.2.3 BMI

Eight of the 12 studies with BMI data reported a statistically significant effect for the intervention (**Table 4**). The 2 dietary behaviour interventions did not have a significant effect on mean BMI (104;105). All PA studies, except for one (109), found a significant effect on BMI or BMI z score for

the overall sample (113;114) or for girls (110;111). No ES could be calculated for these studies. Five of 6 combined interventions reported a beneficial effect on BMI or BMI z score for the overall sample (98;117;118;122;124;125) or for boys only (123). The largest ES was for the 2 best-rated studies in terms of quality, which were both conducted in children (mean age: <12 y), were both combined diet and PA interventions, and found significant positive effects on BMI or BMI z score (117;118;122). In both studies, the key intervention strategies were an integrated curriculum delivered by teachers/school staff accompanied by regular nutrition education of parents.

3.2.4 Overweight and obesity prevalence

Three of the 7 studies reporting on this outcome significantly decreased obesity prevalence in the intervention group (99;122;124;125) by 0.8–32.5 percentage points (**Table 5**). All 3 studies reported on combined multicomponent interventions. Of the 7 studies, 2 were of moderate quality.

Table 1 Characteristics of studies (n=25) included in quality appraisal targeting diet only, PA only, or both[1]

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Diet intervention									
Fernandes et al, 2009 (102), Brazil, Florianopolis	Cluster CT	I = 1 school C = 1 school *n* = 135[2] 8.15 y[3] 47.4%	Duration: 8 meetings of 50 min Follow-up: 5 mo	Aim: A nutrition education program to improve dietary intake among 2nd grade students of primary school to prevent obesity/overweight Intervention: Teachers provided 8 meetings of 50 min about healthy diets, healthy snacks and PA Control: The control group did not receive any nutrition education	No	Low	x		x
Gaglianone et al, 2006 (103), Brazil, Sao Paulo	Cluster RCT	I = 3 schools C = 5 schools *n* = 637[2] 8.5 y[3] NR	Duration: 14 wk Follow-up: 12 mo	Aim: A nutrition education program 'Reducing Risks of Illness and Death in Adulthood' (RRIDA), to improve knowledge and attitudes associated with healthy eating habits of first- to second-grade students in primary schools to prevent obesity Intervention: Overall 22 hours of nutrition education were provided by conducting 3 weekly activities of 30 min each; teachers were trained twice a week for 6 wk Control: The control group did not receive any nutrition education	Yes	Moderate	x		
Ramírez-López et al, 2005 (104), Mexico, Sonora state	Quasiexperimental prospective study	NR *n* = 360[2] 8.5 y[3] NR	Duration: 9 mo Follow-up: 9 mo	Aim: A breakfast program to prevent obesity and cardiovascular risk factors amongst first- to fifth-grade students in primary schools Intervention: Breakfast was consumed 30 min prior to the start of the school day over a 9-mo period Control: The control group did not receive breakfast	No	Low			x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Sichieri et al, 2009 (105), Brazil, Niteroi, Rio de Janeiro	Cluster RCT	2 schools: I = 23 classes C = 24 classes *n* = 1134 10.9 y 47.1%	Duration: I = 7.96 mo, C = 8.24 mo Follow-up: 1 school year	Aim: An educational program to prevent excessive weight gain by reducing the consumption of sugar-sweetened beverages of fourth-grade students in primary schools Intervention: Research assistants provided ten 1-h sessions about water (classroom quizzes and games, song and drawing competitions); water bottles and banners promoting water were distributed Control: The control group received two 1-h sessions on health issues	No	Low	x		x
PA intervention									
Bonhauser et al, 2005 (106), Chile, Santiago	Cluster CT	I = 2 classes C = 2 classes *n* = 198 15.5 y[3] 48.4%	Duration: 10 mo Follow-up: 10 mo	Aim: A PA program on physical fitness and mental health status aimed at chronic disease prevention among adolescents Intervention: Teachers provided 4 units of PA sessions. Each unit comprised 10 consecutive weeks of lecture in which 3 PA sessions of 90 min each were provided every week; the sessions were included in the curriculum and consisted of 3 steps: minimum activity, weight-transfer activities and sports practice Control: The control group received one standard session of 90 min of PA	Yes	Moderate		x	

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
De Barros et al, 2009 (107), Brazil, Recife and Florianopolis	Cluster RCT (matching schools by size and location)	I = 10 schools C = 10 schools *n* = 2155 18.4 ± 2.3 y[4] NR	Duration: 9 mo Follow-up: 9 mo	Aim: A PA program 'Saude Na Boa' among high school students aimed at improving PA and nutritional behaviour to prevent obesity Intervention: The intervention included an environmental and organizational change (free fruit distribution on 1 d for 10 wk, special events, equipment), PA, healthy diet education integrated into the curriculum, and staff training and engagement (8 sessions) Control: NR	Yes	Low		x	
Draper et al, 2010 (108), South Africa, Alexandra Township	Qualitative study	I = 3 schools C = 2 schools *n* = 508 NR NR	Duration: NR Follow-up: 4 mo	Aim: A pilot study to assess feasibility and acceptability of a school-based PA intervention 'Healthnutz' to prevent chronic diseases Intervention: Teachers provided physical education integrated into the curriculum to students; 5 focus groups and a situational analysis with teachers and group monitors were conducted Control: NR	No	Low		x	
Farias et al, 2009 (109), Brazil, Porto Velho, Rondônia	Cluster CT	I = 1 school C = 1 school *n* = 383[2] 12.4 y[3] 53.2%	Duration: 10 mo Follow-up: 10 mo	Aim: A PA program introducing programmed PA to improve the body composition of adolescents in fifth to eighth grades Intervention: All adolescents had 2 weekly 60-min sessions of physical education (68 classes in total); the intervention group received programmed PA, which consisted of 3 steps: starting with aerobic activity, playing sports for 30 min and ending with stretching for 10 min Control: The control group received conventional physical education	No	Low			x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Li et al, 2010 (114) China, 2 Beijing districts	Cluster RCT	I = 10 schools C = 10 schools *n* = 4700 9.3 ± 0.7 y 52.3%	Duration: 1 y Follow-up: 2 y	Aim: A PA program 'Happy 10' to promote PA to prevent overweight in primary school students Intervention: Teachers organized and implemented 2 daily PA sessions of 10 min each; the intervention was integrated into the curriculum and did not replace any other activities; the progress of the class was shown on posters and stickers Control: The control group received the standard curriculum	No	Moderate			x
Liu et al, 2007 (111) and Liu et al, 2008 (110) China, Beijing district [pilot study of Li et al. 2010 (114)]	Cluster CT	I = 1 school C = 1 school *n* = 753 9 y[3] 47.4%	Duration: 8 mo Follow-up: 8 mo	Aim: A pilot PA program 'Happy 10' to promote PA, obesity control and prevention, growth and development of primary school students Intervention: Teachers organized and implemented 10 minutes of PA at least once a day during 2 semesters; the progress of the class was shown on posters and stickers Control: The control group received no intervention	No	Low		x	x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
McManus et al, 2008 (112), China, Hong Kong	Cluster RCT	I = 2 schools C = 1 school *n* = 210 10.44 ± 0.85 y 50%	Duration: unclear Follow-up: 6 mo	Aim: A PA program aimed to increase PA by providing heart rate feedback in fourth- and fifth-grade students in primary schools Intervention: There were 1 control group and 2 intervention groups; for 2 weeks, one intervention group received an educational program and heart-rate feedback whereas the other group received heart rate feedback with normal physical education sessions; the educational program included heart-rate monitor skills, heart health education, goal setting and role-play; it was implemented as a module within the physical education curriculum; after the educational part, children in the intervention groups completed 2 wk with heart-rate feedback and 2 wk without heart-rate feedback (counterbalanced) Control: The control group received no intervention	Yes	Low		x	x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Meszaros et al, 2009 (113), Hungary, Budapest, Gyor and Szigelszentmiklos	Cohort analytic study	I and C = 18 schools *n* = 521 Entrance age varied from 6.51 to 7.5 y 100%	Duration: 4 y Follow-up: 4 y	Aim: A physical education program to analyze differences in growth patterns, age-related changes in body fat and physical performance in children taking part in elevated physical education or normal physical education at school Intervention: Additional physical education sessions integrated into the curriculum; teachers provided 8 morning sessions of 45 min each and 2 afternoon sessions of 90 min each in 10-d cycles; afternoon sessions consisted of cardio-respiratory fitness and special skills, and the morning sessions of general requirements of the physical education curriculum Control: The control school received the obligatory 5 sessions of 45 min for each 10-d cycle	No	Low		x	x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Schwarzer et al, 2010 (115), China	RCT	2 schools: I = 9 classes C = 6 classes *n* = 534[2] 13.8 ± 1.4 y 46%	Duration: 1 h Follow-up: 1 mo	Aim: A PA intervention tailored to different stages as identified by the Health Action Process Approach to enhance PA Intervention: Two theory-guided interventions were provided to the intervention group: resource communication and strategic planning; students received one of the two interventions according to the stage they were in, ie, preintenders (resource communication), intenders (strategic planning), and actors; students in both intervention groups received tailored instructions for 1 hour and homework; teachers were trained to deliver the intervention Control: The control group received regular school instruction	Yes	Low		x	

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Taymoori et al, 2008 (101), Iran	Cluster RCT	I = 2 schools C = 1 school *n* = 161[2] 14.79 ± 0.44 y 0%	Duration: 6 mo Follow-up: 12 mo	Aim: An individually tailored PA intervention for Iranian girls in secondary schools to promote health Intervention: There were 2 intervention groups and 1 control group; 1 intervention was based on Pender's HP model, whereas the other intervention was based on an HP model integrated with constructs from the THP; both intervention groups received 45-60 min educational group sessions (4 times) and 20-25 min individual counseling sessions (4 times); the THP group received 2 additional sessions targeting the process of change; other activities included teacher training, two 60-min educational sessions with mothers, and one PA trip with teachers and mothers Control: The control group received pamphlets after the final follow-up of the intervention	Yes	Moderate		x	
Diet and PA interventions									
Alexandrov et al, 1992 (98), Russia, Moscow	Cluster CT	I = 7 schools C = 16 schools *n* = 766[2] 11.8 y[3] 100%	Duration: 1 y Follow-up: 3 y	Aim: An intervention aimed at preventing risk factors of cardio-vascular diseases Intervention: Primary prevention: all intervention children received lectures and group counseling on prevention by trained instructors.; secondary prevention: children with risk factors were invited with their parents to a single individual counseling session Control: NR	No	Low			x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Banchonhattakit et al, 2009 (116), Thailand, Saraburi Province	Quasi-experimental pretest-posttest time series design	I = 6 schools C = 6 schools *n* = 375 10.6 y[3] 48.5%	Duration: 8 mo Follow-up: 8 mo	Aim: An obesity prevention 'SNOCOP' in fifth-grade students in primary schools; it aims to improve student behaviour by means of a school network Intervention: The school network supported the implementation of the intervention, had monthly meetings, and consisted of parents, school administrators, teachers, and community leaders; a healthy diet, 30 min of daily PA, changing school policies, and improved school-lunch programs were promoted Control: NR	No	Low	x	x	x
Bruss et al, 2010 (117), and Bruss et al, 2010 (118), CNMI	Y1 = stepwise randomised trial; Y2 = stepwise nonrandomised trial	I = 6 schools C = 6 schools *n* = 407 8.55 ± 0.50 y 49.6%	Duration: 2 y Follow-up: 2 y	Aim: The cognitive behavioural lifestyle intervention 'Project Familia Giya Marianas' for caregivers of third-grade students in primary schools in CNMI to prevent childhood obesity Intervention: Community-based participatory research was used to design and evaluate the effectiveness of this obesity-prevention intervention on BMI of children; a cross-over design was used; school personnel were trained and provided 8 sessions of 90 min each for primary caregivers of students; main topics: physiological and socio cultural issues, psychosocial issues, and dietary behaviour and (in)activity Control: The control group received the intervention as delayed treatment	Yes	Moderate			x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Colin-Ramirez et al, 2009 (119), and Colin-Ramirez et al, 2010 (120), Mexico, Mexico city	cluster RCT	I = 5 schools C = 5 schools *n* = 498[2] 9.5 ± 0.7 y 53.6%	Duration: 12 mo Follow-up: 12 mo	Aim: An intervention aimed at improving dietary habits and PA to prevent cardiovascular diseases in 8-10-y-old students in primary schools (RESCATE) Intervention: The intervention had 3 components: individual level (nutrition education and exercise breaks), school environment (healthy snacks and physical-education classes delivered by health team for 30 min twice weekly), and family participation (homework, recipes, recommendations); teachers were trained to deliver the intervention Control: NR	No	Low	x	x	x
Francis et al, 2010 (121), Trinidad and Tobago, Sangre Grande	Cluster RCT	I = 5 schools C = 6 schools *n* = 472[2] 10.4 y[3] 52%	Duration: 1 mo Follow-up: 3 mo	Aim: A short-term multicomponent education intervention on dietary and PA behaviours among primary school children Intervention: A curriculum including classes on nutrition and PA was implemented by trained teachers; the nutrition curriculum focused on food groups, nutrients and types of food, whereas the PA component included exercises for 10 min Control: NR	No	Low	x	x	

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Jiang et al, 2007 (122), China, Beijing	Cluster RCT	I = 2 schools C = 3 schools *n* = 2425[2] (entrance) age = 8.3 y[3] 51.3%	Duration: 3 y Follow-up: 3 y	Aim: A school-based intervention program focusing on nutrition education and PA to prevent or reduce obesity in students from primary schools Intervention: Teachers were trained to deliver the intervention; primary prevention: nutrition lectures to all parents once per semester, and a student curriculum including 10 themes (one theme/lesson); secondary intervention: additional sessions for overweight and obese students, including 20 min/d of extra PA for 4 d/wk, and meetings with their parents and themselves (once/semester) Control: The control group received the usual curriculum	No	Moderate			x
Kain et al, 2004 (123), Chile, Santiago, Curico, Casablanca	Cluster CT	I = 3 schools C = 2 schools *n* = 3086[2] 10.6 y 53%	Duration: 6 mo Follow-up: 1 school year	Aim: A nutrition education and PA intervention in primary school children to prevent obesity Intervention: The nutrition component comprised an educational program for students (8-11h in fourth to sixth grades, 5-6h in seventh to eighth grades), 2 meetings with school kiosks encouraging them to sell healthy food, 2 meetings with parents, and special activities; the PA component comprised a behavioural PA program, 90 min additional weekly PA classes (6 mo), active recess (15 min/d for 3 mo), extra sports materials and special activities; school teachers were trained to deliver both components Control: NR	No	Low		x	x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Kain et al, 2008 (125), and Kain et al, 2009 (124), Chile, Casablanca, Quillota	Cluster CT	I = 3 schools C = 1 school *n* = 2039[2] 9.9 y[3] 53.8%	Duration: 11 mo Follow-up: 21 mo	Aim: A nutrition education and PA intervention in primary school children to prevent obesity Intervention: The nutrition component comprised an educational program for students (8-11h in fourth to sixth grades, 5-6h in seventh grade), 2 meetings with parents and special activities; the PA component comprised a behavioural PA program, 90 min additional weekly PA classes, and active recess (4 mo); school teachers were trained to deliver both components; the intervention was fully applied in year 1 and partly in year 2; in the second year, the intervention comprised only talks with parents of obese children, the educational program (4h to all grades), 90 min of additional weekly PA classes, and training to improve the quality of the physical-education classes Control: NR	No	Low		x	x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Kain et al, 2010 (99), Chile, Santiago (Macul)	Cohort before and after study	I = 4 schools C = 3 schools *n* = 649[2] children, 45[2] teachers NR 53%	Duration: 2 y Follow-up: 2 y	Aim: An intervention to prevent childhood Obesity, including nutrition education and increase in PA that involved implementing a counseling program on healthy lifestyles for teachers Intervention: The nutrition component included an educational program and teacher training; the PA component included an educational program, 2 mo training for physical-education teachers, and sport equipment; teachers in 4 of 7 schools received 3 private counseling sessions on nutrition and PA Control: The control group received same nutritional and PA components, but there were no counseling sessions for teachers	No	Low			x
Singhal et al, 2010 (100), northern India	Cluster CT (matched)	I = 1 school C = 1 school 201[2] *n* = 16 y[3] 60.2%	Duration: 6 mo Follow-up: 6 mo	Aim: A multicomponent nutrition and Lifestyle-education intervention aimed at changing knowledge, behaviour, anthropometric measures, and metabolic risk profile Intervention: The intervention included a multi-component model including promotion of PA, activities to promote healthy lifestyle, individual counseling, policy-level changes in school, involvement of teachers and parents, training of student volunteers, and focus group discussions Control: The control school did not receive any intervention	No	Low	x		x

Reference, country, province/city	Study characteristics		Intervention			Quality appraisal	Outcomes measured		
	Design	Clusters (I and C), no. of participants, average age (y), male (%)	Intervention duration, length of follow-up	Description	Based on theoretical framework		Diet	PA	BMI-related
Vargas et al, 2011 (126), Brazil, Niterói	Cohort before and after study	I = 1 school C = 1 school *n* = 331[2] 13 y[3] NR	Duration: 4 mo Follow-up: 4 mo	Aim: effects of obesity prevention program on dietary practices Intervention: Nutrition education and PA promotion were provided with a main focus on nutrition education Control: The control group received a normal curriculum	No	Low	x		

[1] C, control; CNMI, Commonwealth of the Northern Mariana Islands; CT, controlled trial; HP, Pender's health promotion model; I, intervention; NR, not reported; PA, physical activity; RCT, randomised controlled trial; RESCATE, programa de REduccio´n de rieSgo CArdiovascular Total Escolar; SNOCOP, School Network for Childhood Obesity Prevention; THP, trans-theoretical model integrated with Pender's health promotion model; Y: years; mo: months

[2] Sample included in analysis.

[3] Estimate of average age.

[4] Mean ± SD (all such values).

Table 2 Impact on dietary behaviour for studies providing significance levels (n=5)[1]

Reference and outcome	(Sub)sample	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusted for baseline values of outcome			Effect size		Quality appraisal
		ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Diet intervention											
Gaglianone et al, 2006 (103)											
Preferences for healthy foods	All	NR	NR	NR	0.012						Moderate
Sichieri et al, 2009 (105)											
Sugar-sweetened carbonated beverage intake per class (mL/d)	All	–69	–13	–56	<0.05						Low
Diet and physical-activity interventions											
Banchonhattakit et al, 2009 (116)											
Fast food eating behaviour score	All										
Y2						30.02 ± 0.25[2]	28.78 ± 2.98	0.001	0.77	Medium	Low
Y3						29.63 ± 0.27	28.9 ± 3.2	0.001	0.42	Small	Low
Francis et al, 2010 (121)											
Fruit intake ≥ 2 servings/d (%)	All	25	5.10	19.9	NR	NR	NR	NS[3]			Low
Vegetable intake ≥ 2 servings/d (%)	All	–1.8	–8.8	7.0	NR	NR	NR	NS[3]			Low
Mean soda intake 8 oz servings/wk[4]	All	0.9	4.5	–3.6	NR	NR	NR	<0.05[3]			Low
Snacks high in fat, sugar, and salt eaten in the past 24h (%)	All	–11	0.12	–11.12	NR	NR	NR	<0.05[3]			Low
Mean fried food servings/d	All	–1.3	–0.2	–1.1	NR	NR	NR	<0.05[3]			Low
Vargas et al, 2011 (126)											
Mean frequency of fast food consumption at school cafeteria	All	NR	NR	NR	0.001						Low
Mean daily consumption of fruit and vegetables	All	NR	NR	NR	NS						Low

[1] *References 48, 49, 51, 65, 67, and 72: unable to calculate effect sizes based on reported results. References 46, 48, 65, and 66: reported outcome but did not provide statistical tests between I and C. C,control; I, intervention; NR, not reported; NS: not significant; Y2, year 2; Y3, year 3; ΔC, change in outcome for control; ΔI, change in outcome for intervention; d: days; wk: week.*

[2] *Mean ± SD (all such values).* [3] *Regression analyses for overall fruit, vegetable, and soda intakes; snacks high in fat, sugar, and salt; and fried food (after intervention, controlled for confounders).*

[4] *1 oz = 29.6 mL.*

Table 3 Impact on PA behaviour for studies providing significance levels (n=9)[1]

Primary outcome and (sub)samples	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
PA interventions										
Bonhauser et al, 2005 (106)										Moderate
*V*O2 max (mL . kg^{-1} . min^{-1})										
All	+2.97	+0.65	+2.32	<0.005						
Speed performance (m/s)										
All	+0.50	+0.33	+0.17	0.001						
Jump performance (cm)										
All	+2.29	+0.53	+1.76	<0.005						
De Barros et al, 2009 (107)										
Duration MVPA > 60 (d/wk)					3.3 ± 2.1[2]	2.6 ± 2.1	<0.001	0.33	Small	Low
All										
Prevalence of individuals meeting PA recommendations (%)					33.1	23.7	0.001			
All										
Prevalence of physically inactive individuals (%)					10.59	17.30	<0.05			
All										
Draper et al, 2010 (108)										
10-m shuttle run (s)										
All					46.2 ± 4.6	48.6 ± 5.5	<0.0001[3]	–0.48	Small	Low
No. of sit ups in 30 s										
All					17.8 ± 6.1	15.5 ± 5.1	<0.02[3]	0.41	Small	
Sit and reach (cm)										
All					19 ± 6.8	14 ± 9.7	<0.001[3]	0.61	Medium	
Ball throw (cm)										
All					23.1 ± 7.5	21.8 ± 6.9	NS[3]	0.18	Trivial	
Long jump (cm)										
All					134.3 ± 25.7	135 ± 19.7	NS[3]	–0.03	Trivial	
Liu et al, 2007 (111), Liu et al, 2008 (110)										
PAEE (kcal . kg^{-1} .d^{-1})										
All	+3.1	–9.6	+12.7	<0.05						Low
PA time (h/day)										
All	+0.5	–1.5	+2	<0.05						

Primary outcome and (sub)samples	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
McManus et al, 2008 (112)										
Time spent above flex heart rate (%/d)										
All					EG: 35.3 ± 23.9	40.4 ± 23.9	NS[4]	–0.21	Small	Low
All					NEG: 38.5 ± 27.5			–0.07	Trivial	
Time moderately active (%/d)										
All					EG: 1.5 ± 1.9	1.7 ± 1.6	NS	–0.11	Trivial	
All					NEG: 1.6 ± 2.10			–0.05	Trivial	
Time vigorously active (%/d)										
All					EG: 0.50 ± 1.6	0.55 ± 0.80	NS	–0.04	Trivial	
All					NEG: 0.48 ± 0.73			–0.09	Trivial	
Peak VO2 (mL . kg^{-1} . min^{-1})										
All					EG: 45 ± 4.9	45.8 ± 6.8	NR	–0.14	Trivial	
All					NEG: 47.1 ± 6.8			0.19	Trivial	
Meszaros et al, 2009 (113)										
Physical fitness										
All					NR	NR	<0.05			Low
Taymoori et al, 2008 (101)										
Mean PA (min/d)										
All (after intervention)					THP: 60.0 ± 134.3	46.3 ± 21.9	0.000[5]	THP:0.18	Trivial	Moderate
All (after intervention)					HP: 56.8 ± 27.6			HP: 0.42	Small	
All (follow-up)					THP: 75.8 ± 27.5	37.3 ± 20.4	0.008	THP:1.61	Large	
All (follow-up)					HP: 73.6 ± 28.7			HP: 1.48	Large	
Overall time PA (min)										
All (after intervention)					THP: 310 ± 24.8	245.3 ± 101.3	0.000	THP: 1.03	Large	
All (after intervention)					HP: 285.9 ± 141.3			HP: 0.33	Small	
All (follow-up)					THP: 371.2 ± 129.6	196 ± 99.7	0.01	THP: 1.53	Large	
All (follow-up)					HP: 348.1 ± 159.0			HP:1.18	Large	
Diet and PA interventions										
Kain et al, 2004 (123)										
Lower back flexibility test (cm)										
Male	+2.3	–1.4	+3.7	<0.05	23.6 ± 8.6	22 ± 6.3	<0.001[3]	0.21	Small	Low
Female	+2.8	–1	+3.8	<0.05	25.7 ± 7.9	23 ± 6.4	0.0001[3]	0.38	Small	
Endurance (20m) shuttle run (stages)										
Male	+1.3	0	+1.3	<0.05	5.0 ± 1.9	3.9 ± 1.9	<0.001[3]	0.58	Medium	
Female	+0.7	–0.3	+1	<0.05	3.3 ± 1.4	2.6 ± 1.3	0.0001[3]	0.52	Medium	

Primary outcome and (sub)samples	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Kain et al, 2008 (125); Kain et al, 2009 (124)										
Mile test (min)										
Male	–0.84	–0.13	–0.71	0.037						Low
Female	–0.61	–0.23	–0.38	0.005						
Shuttle run (stages)										
Male	+1.15	+0.21	+0.94	<0.0001						
Female	+0.3	–0.16	+0.46	0.0007						

[1] References 52, 56, 57, 59, 61, 62, and 65–67: unable to calculate effect sizes based on reported results. References 61, 62, and 65–67: reported outcome but did not provide statistical tests between I and C. C, control; EG, education group; HP, Pender's health promotion model; I, intervention; MVPA, moderate-to-vigorous physical activity; NEG, no education group; NR, not reported; PA, physical activity; PAEE, physical activity energy expenditure; THP, trans-theoretical model integrated with Pender's health promotion model; DC, change in outcome for control; DI, change in outcome for intervention.

[2] Mean 6 SD (all such values).

[3] Interaction (group 3 time) effect.

[4] Interaction effect group after 2 wk and after 6 mo.

[5] Main effects.

Table 4 Impact on BMI for studies providing significance levels (n=12)[1]

Outcome and (sub)samples	Double difference effect: changes over time in I and C and I-C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Diet interventions										
Ramírez-López et al, 2005 (104)					17.2 ± 0.1[2]	16.9 ± 0.2	NS	2	Large	Low
BMI										
All										
Sichieri et al, 2009 (105)	+0.32	+0.22	+0.10	NS						Low
BMI										
All										
PA interventions										
Farias et al, 2009 (109)										
BMI										
Male					20.2 ± 3.2	20.8 ± 3.4	NS	–0.18	Trivial	Low
Female					19.8 ± 2.5	20.4 ± 3.3	NS	–0.21	Small	
Li et al, 2010 (114)										
BMI										
All										
Y1	+0.56	+0.72	–0.16	0.03						Moderate
Y2	+1.55	+1.67	–0.12	0.04						
BMI ʐ score										
All										
Y1	–0.05	+0.01	–0.06	0.03						
Y2	+0.03	+0.08	–0.05	0.03						
Liu et al, 2007 (111) ; Liu et al, 2008 (110)										
BMI										
Male	+0.86	+0.72	+0.14	NS						Low
Female	–0.47	+0.66	–1.13	<0.05						
Meszaros et al, 2009 (113)										
BMI										
All	NR	NR	NR	<0.05						Low
Diet and PA interventions										
Alexandrov et al, 1992 (98)										
BMI										
All										
Y1	+0.54	+0.72	–0.18	0.0063	18.0 ± 2.2	18.4 ± 2.7	<0.05	–0.16	Trivial	Low
Y2	+0.22	+0.21	+0.01	NS	19.7 ± 2.4	19.7 ± 2.6	NS	0.00	Trivial	

Outcome and (sub)samples	Double difference effect: changes over time in I and C and I-C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Bruss et al, 2010 (117); Bruss et al, 2010 (118)										
BMI ȥ score										
All					–0.04 ± 0.46	0.14 ± 0.59	<0.0001[3]	–0.34	Medium	Moderate
Jiang et al, 2007 (122)										
BMI										
All					18.2 ± 2.6	20.3 ± 3.4	<0.01	–0.70	Medium	Moderate
Kain et al, 2004 (123)										
BMI										
Male	+0.0	+0.3	–0.3	<0.05	19.5 ± 3.5	19.2 ± 3.1	<0.001[4]	0.09	Trivial	Low
Female	+0.3	+0.2	–0.1	NS	20.0 ± 3.8	19.6 ± 3.8	NS	0.11	Trivial	
BMI ȥ score										
Male	–0.12	–0.02	–0.1	<0.05	0.51 ± 0.94	0.46 ± 0.81	<0.001[4]	0.06	Trivial	
Female	–0.04	–0.07	–0.03	NS	0.59 ± 0.89	0.40 ± 0.9	NS	0.21	Medium	
Kain et al, 2008 (125); Kain et al, 2009 (124)										
BMI										
Male	+0.7	+1.2	–0.5	<0.05	19.7 ± 3.2	20.6 ± 3.7	NS	–0.26	Small	Low
Female	+0.8	+1.4	–0.6	<0.05	20.1 ± 3.5	20.8 ± 3.8	NS	–0.19	Trivial	
BMI ȥ score										
Male	–0.09	+0.05	–0.14	NR	0.53 ± 0.95	0.72 ± 1	0.031[5]	–0.19	Trivial	
Female	–0.06	+0.08	–0.14	NR	0.59 ± 0.90	0.72 ± 0.90	0.051	–0.14	Trivial	
Singhal et al, 2010 (100)										
BMI										
All	–0.07	+0.06	–0.13	NS						Low

[1] References 46, 51, 56, 57, 59, and 60: unable to calculate effect sizes based on reported results. References 45 and 58: reported outcome but did not provide statistical tests between I and C. C, control;
I, intervention; NR, not reported; PA, physical activity; Y1, year 1; Y2, year 2; DC, change in outcome for control; DI, change in outcome for intervention.
[2] Mean 6 SD (all such values).
[3] Post hoc analysis (5–8 lessons received).
[4] Interaction (group 3 time) effect.
[5] Interaction (group 3 age 3 time) effect. All values are expressed as mean 6 SD.

Table 5 Impact on the prevalence of overweight and obesity for studies providing significance levels (n=7)[1]

Reference, outcome, and (sub)samples	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Diet intervention										
Ramirez-Lopez et al, 2005 (104)										
Overweight prevalence										
All					28 ± 11[2]	8 ± 7.6	NS	2.15	Large	Low
Obesity prevalence										
All					28 ± 11	9 ± 8.5	NS	1.95	Large	
Sichieri et al, 2009 (105)										
Overweight prevalence										
All					19.2	16.0	NS			Low
Obesity prevalence										
All					4.4	4.5	NS			
PA interventions										
Li et al, 2010 (114)										
Overweight and obesity prevalence										
All										
Y1	NR	NR	NR	NS						Moderate
Y2	NR	NR	NR	NS						
Liu et al, 2007 (111) ; Liu et al, 2008 (110)										
Overweight prevalence										
Male	–3.8	+4.5	–8.3	NS						Low
Female	–3.3	+3.7	–7	NS						
Obesity prevalence										
Male	–0.4	+0.6	–1	NS						
Female	–5.6	+0.7	–6.3	NS						
Diet and PA interventions										
Jiang et al, 2007 (122)										
Overweight prevalence										
All	–26.3	+14.3	–40.6	NR	9.8	14.4	<0.01[3]			Moderate
Obesity prevalence										
All	–32.5	+15.7	–48.2	NR	7.9	13.3	<0.01[3]			
Kain et al, 2008 (125); Kain et al, 2009 (124)										
Obesity prevalence										
Male	–4.7	–0.2	–4.5	<0.05	12.3	21.4	<0.001			Low
Female	–3.8	+0.5	–4.3	<0.05	10.3	15.2	<0.01			

Reference, outcome, and (sub)samples	Double difference effect: changes over time in I and C and I - C				Baseline adjusted effect: I and C at follow-up adjusting for baseline values of outcome			Effect size		Quality appraisal
	ΔI	ΔC	ΔI - ΔC	*P* value	I	C	*P* value	Estimate	Classification	
Kain et al, 2010 (99)										
Obesity prevalence										
All	–0.8	–4.2	+3.4	<0.05	11.3	18.9	0.001			Low

[1] References 45, 48, 55–57, 60, 62, 65, 68, 70, and 71: unable to calculate effect sizes based on reported results. References 48, 55, 62, 65, and 66: reported outcome but did not provide statistical tests between I and C. C, control; I, intervention; NR, not reported; PA, physical activity; Y1, year 1; Y2, year 2; DC, change in outcome for control; DI, change in outcome for intervention.

[2] Mean 6 SD (all such values).

[3] Calculated for ORs.

3.3 Effectiveness of studies measuring at least one proximal and one distal outcome

Five of the 22 studies included in the results tables (**Table 2-Table 5**) measured both a proximal outcome, i.e., PA (110;111;113;123-125) or diet (105), and a distal outcome such as BMI or overweight/obesity prevalence (105;110;111;113;123-125). All 5 studies showed a significant effect on the proximal outcomes they measured. Four interventions (2 PA and 2 combined interventions) showed an effect on both the proximal and the distal outcomes for at least one subgroup (110;111;113;123-125). Only the intervention evaluating diet as an intermediate outcome did not have an effect on the distal outcome (105). All 5 studies were of low quality, and ES could only be calculated for 2 of them (123-125).

3.4 Quality appraisal

The key methodological limitations encountered were lack of randomization (*n*=10) or unclear/inappropriate randomization methods (*n*=8), inexistent or unclear description of intention-to-treat analysis (*n*=13), unblinded assessors (*n*=25), absence of reporting on dropout numbers and/or reasons (*n*=10), and absence of reporting on intervention integrity (*n*=25) and on process evaluation (*n*=23). In 2 studies, contamination between groups was likely because the intervention and control groups were within the same school, or the same teachers taught both the intervention and the control group (106;119). Finally, only half of the studies with a cluster design (*n*=17) applied an appropriate data analysis method, which resulted in likely overestimation of the statistical significance of the results. The overall quality evaluation for each study is shown in **Table 1.** Many of the studies did not evaluate the outcome that the intervention was intended to change. One of the 4 diet interventions did not report the effect on dietary outcomes, and 2 of the 10 PA interventions did not report on PA. Of the 11 combined interventions, 4 did not evaluate the effect on either diet or PA, and 4 studies evaluated only one of either.

4 Discussion

This was the first systematic review of school-based interventions aimed at the primary prevention of obesity in children and adolescents in LMICs. Twenty-five studies met the inclusion criteria. Of the 22 studies reporting useful statistics on the outcomes of interest, 18 had a positive effect on one or

more of the outcomes (82%). Two of the 3 diet interventions that measured the adolescents' diet significantly improved this outcome; however, the diet interventions did not have an effect on any of the BMI-related outcomes. The 9 PA interventions were successful at increasing PA (6 of 7 measuring PA) and lowering BMI in at least one of the studied subgroups (3 of 4 evaluating BMI), but did not have an effect on the prevalence of overweight or obesity (0 of 2 evaluating this outcome). The 10 combined interventions had a significant effect on all outcomes: diet (3 of 3 measuring diet), PA (2 of 2 measuring PA), BMI (5 of 6 in at least one subgroup), and the prevalence of overweight or obesity (3 of 3 evaluating this outcome). Even though the ES for BMI was classified as small or trivial (range: −0.7, 0.0), the public health effect at a population level can be substantial if implemented in large groups of children and when sustained over longer periods (51). We had expected the combined interventions to have a larger effect on BMI than interventions addressing only diet or PA, but no differences were found when the ES was compared between these types of studies. Even though studies were limited in number to draw firm conclusions, combined interventions are more likely to decrease BMI. Understanding the potentially synergistic effects of combined diet and PA interventions through evaluation studies with a 2-by-2 factorial design would produce relevant knowledge for policy makers.

A key question relates to which intervention characteristics are associated with higher effectiveness. Interventions that positively changed both proximal and distal outcomes were generally multicomponent, education-based interventions delivered by teachers and providing additional PA sessions or integrated classes about healthy foods, nutrition, or PA to encourage children to adopt a healthy lifestyle. Similar characteristics were found for interventions improving dietary or PA behaviour only. Those studies reducing BMI only were generally multicomponent interventions targeting both diet and PA. In addition, these intervention characteristics generally coincide with those identified in reviews of intervention studies conducted in China and Latin America (88;89). We specifically evaluated the relationship between intervention duration and effectiveness as a potential characteristic of effectiveness. Studies evaluating both proximal and distal outcomes lasted between 6 and 48 months and generally had a long-term follow-up. Interestingly, all effective studies evaluating BMI only lasted longer than 12 mo. This is a surprising finding because previous studies showed that effective interventions tended to be short term (<12 months) (51;90).

The effectiveness of multicomponent interventions, and especially those that involve parents, is not surprising. As role models, parents shape the eating behaviours of their children and play an important role in the aetiology and prevention of weight-related problems (127). In many LMICs,

caregivers and families are present more prominently in the daily life of children and adolescents, underscoring the importance of their involvement in these school-based interventions. Recently, Hingle *et al.* (128) reported that direct methods (e.g., education or workshops on healthy eating) that involve parents in diet interventions were more likely to be effective than were indirect methods (e.g., information leaflets and assignments). However, motivating and sustaining parental or family involvement in interventions remain challenging (128;129). Key barriers identified by parents were limited time availability and an unwillingness to be tutored by schools (129). These limitations may help to explain why, despite its importance, only half of the studies included in this review were multicomponent interventions involving parents or families. Notwithstanding this multicomponent nature, the scope of the strategies used by the interventions was surprisingly narrow. Only 2 of the school-based interventions targeted sedentary behaviours such as television viewing or gaming. These behaviours are increasingly observed in societies in transition (130) and have been shown to be associated with higher BMI (131;132). Previous research in HICs has shown that these sedentary behaviours can be effectively addressed (133;134) and indicate the need to include these types of interventions as obesity-prevention strategies (135). Similarly, few interventions targeted the school environment, for instance with respect to the types and nutritional value of the foods sold in and around schools or as related to school policies. Exposure to unhealthy energy-dense food in schools, which often competes with healthier choices in terms of taste, price, and supply, was not assessed. It is likely that changing the nutritional environment in schools poses a challenge for preventive interventions in LMICs because the type and complexity of changes required is different from those in HICs at times, e.g., at schools, street food vendors intermingle with privately owned food tuck shops in the schools.

A potential limitation of this review was the exclusion of studies based on language. We believe, however, that it is improbable that important studies were left out. In our experience, it is very unlikely to find methodologically sound studies meeting the inclusion criteria in languages other than English, Spanish, or French. We acknowledge that grey literature may have been an additional contribution to this review. However, as recommended by Doak *et al.* (136), only peer-reviewed literature was included. The general limited quality of the included studies is a second possible limitation. The lack of information, lack of blinding of assessors to the intervention, and lack of adjustment in the analysis for clustering were the main quality-related issues. We believe, however, that the methodological limitations present did not alter the main conclusion of our review, i.e., that school-based interventions in adolescents can successfully improve diet, PA, and BMI. First, the

positive effects found in the reviewed studies were consistent across a variety of settings. Second, and most importantly, the largest effects were found in the studies with the highest quality score (101;117;118;122).

Apart from the methodological issues outlined, the studies included in the review had many other limitations. First, several studies (*n*=11) did not evaluate the proximal outcome(s) that the intervention targeted for change, and only 5 studies evaluated the effect on both proximal and distal outcomes. Ideally, future intervention studies should evaluate the effect on diet and/or PA and on BMI (87). This would considerably strengthen the evidence and allow one to quantify to what extent improvements in these proximal outcomes are translated into changes in BMI and to potentially understand the bottlenecks in these pathways.

In addition, only 2 studies conducted a process evaluation, i.e., documented how and to what extent the intervention was implemented as planned and adopted by the beneficiaries in a particular setting. We believe that this was a missed opportunity for LMICs because this will provide the crucial information that is needed to adapt the program for implementation in other settings and to scale up, especially because large differences in school settings and nutritional and PA environments may exist.

A further limitation was that only 3 of the interventions investigated adverse effects. Obesity-prevention interventions may aggravate social stigmatization or psychosocial problems of the already overweight or obese children or could lead to or exacerbate underweight or eating disorders (90). Even though a recent meta-analysis concluded that preventive interventions are potentially harmless (51), future interventions should still include these outcomes and report them by BMI category to provide a more complete view of the intervention effects for the whole target population.

A striking omission, given its importance when considering scaling up, was the lack of information on cost-effectiveness in all of the studies. Given the limited resources available in LMICs, solid cost-effectiveness estimates would be of tremendous help to policy makers. Also related to scaling up is the need to understand to what extent SES and urban/rural settings within LMICs modify the effectiveness of interventions (50). This is especially important in light of the shift of the obesity epidemic to poorer population groups and from urban to rural settings (13-15).

A further issue that emerged was that the outcome measures in most studies were limited to BMI and self-reported behaviour. In future studies it would be valuable to include waist circumference as

an outcome measure because this would enable identification of the effect of the intervention on central adiposity and body composition in children (137). Furthermore, to overcome the limitations of self-reported behavioural outcome measures, studies should consider methods not prone to reporting bias, such as the use of accelerometers and the measurement of physical fitness. A final limitation was that only 6 studies used a theoretical framework to develop their intervention, which is surprisingly few when compared with the recent findings of Waters et al (51). Contextual influences, such as social values and cultural norms, bring about changes in lifestyles that largely contribute to shaping behaviour in children and adolescents. In particular, behavioural and environmental determinants of physical inactivity and unhealthy eating (e.g., food safety, time spent watching television, availability of playgrounds, and financial autonomy) need to be taken into account. The use of theoretical frameworks for the development of interventions will ensure that intervention activities aimed at changing the relevant proximal and distal outcomes are tailored to the participants' context (138).

In conclusion, stronger evaluation designs would contribute considerably to increasing the effectiveness of interventions aimed at preventing obesity. Although conducting these interventions in school-based settings is challenging (58), other complex programs have shown that rigorous evaluations can be implemented successfully (139).

Finally, we reviewed to what extent our findings are comparable with those from reviews of intervention studies conducted in HICs. Two similarities stand out. First, and notwithstanding the large cultural and socioeconomic differences between HICs and LMICs, intervention studies conducted in HICs identified similar intervention characteristics to be associated with effectiveness, i.e., multicomponent, combined interventions that integrate educational activities in the curriculum (50;51;87;127). Second, until recently (51), detailed process evaluations documenting the implementation of the intervention have been mostly lacking (50;87). An important difference, however, is that the use of theoretical frameworks for the development of interventions is much more common in HICs (51).

In conclusion, school-based interventions have the potential to improve dietary and PA behaviour and to prevent unhealthy body weights. However, there is a need for more well-conducted evaluation studies to strengthen the evidence base. These studies should use the strongest possible evaluation designs to allow researchers to unequivocally attribute the effect to the intervention. In addition, they need to carefully document the pathways through which the interventions have their

effect. Finally, process evaluations are needed to learn from program implementation and adoption to identify which intervention components are effective and feasible. Only with this strong evidence base will school-based interventions be able to reach their full potential of addressing unhealthy body weight in school-age children in LMICs.

Box 1 Methodological and conceptual key messages for intervention development

- Combined (PA and diet) interventions are more likely to decrease BMI;
- Multicomponent (e.g. school staff, parents, children) interventions which integrated educational activities into the school curriculum are intervention characteristics associated with higher effectiveness;
- The direct involvement of parents, caregivers or families may enhance effectiveness;
- The nutritional and PA environment in schools and sedentary behaviour are promising venues to intervene for obtaining behavioural change;
- Adverse effects, cost-effectiveness and objective outcome measures have to be addressed by interventions;
- Theory-based interventions that examine influencing factors of behaviour may increase effective intervention development and help in identifying pathways of behaviour change;
- Intervention studies should evaluate the effect on both diet and PA and BMI as it would allow one to quantify to what extent improvements in diet and PA are translated into changes in BMI and to potentially understand the bottlenecks in these pathways;
- Aside of theory, a basis needs to be created to support intervention development to render interventions sustainable;
- Rigorous evaluation designs that carefully document the pathways through which the interventions have their effect are needed;
- Built in process evaluations are needed.

Chapter 3:

Predictors of validity and reliability of a physical activity record in Ecuadorian adolescents

Redrafted after:

Verstraeten R, Lachat C, Ochoa-Aviles A, Hagströmer M, Huybregts L, Andrade S, Donoso S, Van Camp J, Maes L, Kolsteren P. Predictors of validity and reliability of a physical activity record in adolescents. BMC Public Health 2013;13:1109

Summary

Background: Poor to moderate validity of self-reported PA instruments is commonly observed in young people in LMICs. However, the reasons for such low validity have not been examined in detail.

Objective: We tested the validity of a self-administered daily PA record in adolescents and assessed if personal characteristics or the level of perceived difficulty (PD) of reporting PA modified the validity estimates.

Design: The study comprised a total of 302 adolescents from an urban and rural area in Ecuador. Validity was evaluated by comparing the record with accelerometer recordings for seven consecutive days. Test-retest reliability was examined by comparing registrations from two records administered three weeks apart. Time spent on sedentary (SED), low (LPA), moderate (MPA) and vigorous (VPA) intensity physical activity was estimated. Bland Altman plots were used to evaluate measurement agreement. We assessed if age, sex, urban or rural setting, anthropometry and PD of completing the record explained differences in validity estimates using a linear mixed model.

Results: Although the record provided higher estimates for SED and VPA and lower estimates for LPA and MPA compared to the accelerometer, it showed an overall fair measurement agreement for validity. There was modest reliability for assessing PA in each intensity level. Validity was associated with adolescents' personal characteristics: sex (SED: $P = 0.007$; LPA: $P = 0.001$; VPA: $P = 0.009$) and setting (LPA: $P = 0.000$; MPA: $P = 0.047$). Reliability was associated with the PD of completing the PA record for LPA (low PD: $P = 0.014$; high PD: $P = 0.045$).

Conclusions: The PA record provided acceptable estimates for reliability and validity on a group level. Sex and setting were associated with validity estimates, whereas PD to fill out the record was associated with better reliability estimates for LPA. This tendency of improved reliability estimates for adolescents reporting higher PD merits further consideration.

1 Introduction

The benefits of PA on health and its role in disease prevention are widely acknowledged (140;141). Adequate levels of PA are associated with a reduced risk of chronic diseases and all-cause mortality (140;142;143). An estimated three million deaths each year could be prevented if people were sufficiently active (144). In particular, regular PA at a young age can prevent chronic diseases and improve mental well-being during childhood and later in life (145;146). However, recent data on self-reported PA suggests that only 30% to 40% of young people are sufficiently active worldwide (147). In young people in LMICs physical inactivity rates are high, particularly among girls in countries in Latin America (140;148), and already constitute one of the leading causes for morbidity (148;149) and premature death (150).

To determine the risk for chronic diseases and effectiveness of preventive interventions, a valid and feasible assessment of PA is crucial (151). However, PA assessment in young people is challenging, regardless of whether objective or subjective measures of PA are used (147;152). Accelerometer registrations are now widely implemented for objective assessment of PA in children and are recognized as an appropriate measure for PA surveillance on a population level (151). Nonetheless, to estimate PA behaviour in large epidemiological studies, self-reported measures remain common. Before such subjective instruments can be applied, they should first be validated against an objective criterion method such as accelerometers. The majority of validation studies in LMICs were performed in adults and report low to moderate measurement agreement for questionnaires (153-155). The very few validation studies in young people using questionnaires and other self-reported instruments have shown poor to moderate validity (156-158). However, none of these studies explored or identified possible reasons for this low validity thereby hampering a better understanding of PA assessment and validity of the instruments used in these settings.

As the socio-cultural and physical environment in Ecuador is distinct from HICs and adopting existing tools cannot guarantee validity of the proposed measures in this population (159), a validation study of a PA record (also called diary) was conducted. The accelerometer was chosen as an objective instrument to validate the record. The choice for using both these instruments was based on the existing evidence, the age category under investigation, the study design, resources and staff available (160). The aim of the present study was to i) assess the validity and reliability of a PA record as an instrument to estimate PA on a group level in an Ecuadorian adolescent population, and ii) explore which factors are associated with this validity and reliability.

2 Methods

The recently published Hagströmer-Bowles Physical Activity/Sedentary Behaviour Questionnaire Checklist (161) was followed to report this study. It provides key methodological quality criteria for validation studies of instruments examining self-reported PA and/or sedentary behaviour.

2.1 Participants

A convenience sample of 302 school-going adolescents, aged 11-15 years, was recruited from a rural (Nabón; *n*=70) and an urban (Cuenca; *n*=232) area in the Azuay province of the Ecuadorian Andes region (**Figure 1**). Seven mixed gender schools, four urban and three rural, were selected for the study. Except for one private urban school, all were public schools. All children aged 11-15 years (from grade 7 to 11) in the schools were invited to participate. The exclusion criteria used were having a medical condition that hampered PA or being pregnant. Parental informed consent forms were distributed to the children that were eligible for the study. Those who returned signed parental consent forms (*n*=302) and completed individual assent forms (*n*=302) were included in the study. The study took place from April to July in 2008 and was approved by the Ethics Committee of the Ghent University Hospital (B67020084010).

2.2 Design and procedures

The overall validity of the PA record was assessed by *i*) comparing it with the accelerometer recordings (validity) and *ii*) comparing the two administrations of the record (test-retest reliability). In addition, we used a socio-demographic and Likert scale questionnaire to explore whether overall validity was affected by factors at individual (age, sex, BMI and PD to complete the PA record) and environmental (setting) level.

Data collection was organized during school hours on three occasions: *i*) on the first day of the study, *ii*) after one week of accelerometer measurement, and *iii*) after three weeks. On the first day, we provided classroom demonstrations and instructions on how to wear the accelerometer and complete the PA record to both the participants and their teachers. All participants were instructed to complete the PA record for seven consecutive days and wear the accelerometer during the same time period, i.e. both instruments were temporally matched. During the measurement period, teachers and researchers regularly reminded the participants in class of the importance of

completing the record as soon as possible after activities had ended. In addition, socio-demographic data (age, sex and setting) and anthropometry were collected for each participant on the first day. On the second visit, i.e. after one week, both accelerometers and the completed PA record were collected from the participants. The data from those students who *i*) were absent, *ii*) were not wearing the accelerometer or *iii*) did not have their PA record with them on this day, were collected during additional visit(s) to the schools. Finally, three weeks after the first visit, the PA record was administered a second time to assess reliability. To maximize comparability of both PA record administrations, the same procedures were applied (i.e., use of the same measuring instrument, the same researcher explaining the PA record) under the same conditions at school (e.g. no holidays or special activities). During this second administration, a Likert scale questionnaire was administered to examine PD as a predictor of validity and reliability.

2.2.1 Anthropometric measurements

Anthropometric measurements were carried out in duplicate by two independently trained researchers whilst ensuring optimal privacy. Adolescents wore light clothing but no shoes during the measurements. Body height was measured and recorded to the nearest 0.1 cm with a portable stadiometer and body weight to the nearest 0.1 kg using a digital calibrated balance (model SECA 803, Seca GmbH & CO, Hamburg, Germany). Adolescents were classified, based on age and sex, into BMI categories for 11-15 year old adolescents (underweight, normal weight, overweight and obese) (162;163).

2.2.2 PA record

To assess PA levels, a simplified version of a previously validated PA record was used (164). The list of pre-defined common activities and related numerical codes present in the original PA record were omitted in our study. On the form, each day was divided into 96 intervals of 15 min with space available to report performed activities. The instrument and related instructions were provided in Spanish. To limit recall bias, participants were instructed to record all types of activities performed during 24 hours for 7 consecutive days either directly after finalizing the activities or as soon as possible after the activities had ended.

For the analysis, each 15 min activity interval of the PA record was converted to a MET-value using the compendium of energy expenditure values for young people (165), and classified into durations by multiplying the estimated MET value of the activity by the time engaged in it. Due to logistical

constraints at the schools, the first and the last measurement day started and ended at 12:00 noon and were therefore omitted from analysis. To ensure comparability of total estimated time of the record and the accelerometer registrations, only the daily active time reported by the record was included. In addition, all days with less than nine hours (540 min) were omitted from analysis. Time (MET-min/day) spent on sedentary PA (SED) (≤ 1.5 METs), low intensity PA (LPA) (≥1.5 and < 3 METs), moderate intensity PA (MPA) (≥ 3 and < 6 METs) and vigorous intensity PA (VPA) (≥ 6 METs) were computed as outcome variables (166;167).

2.2.3 Accelerometers

An objective assessment of PA levels was obtained using the uniaxial GT-256 and GT1M ActiGraph accelerometers (Actigraph Manufacturing Technology Incorporated, Fort Walton Beach FL, USA). These accelerometers are appropriate to measure PA behaviour in adolescents and are considered comparable for the evaluation of intensity levels (168). On the first day of the study and after measuring anthropometry, pre-initialized accelerometers were distributed and placed on the right side of the hip using an adjustable elastic belt. Participants received a demonstration from a trained researcher on how to wear the accelerometer. Instructions provided were for example "accelerometers could only be removed when sleeping, showering or engaging in other water activities", "do not clean the accelerometer with a solvent", "always wear the accelerometer on the same place on your waist". In accordance with the protocol of the PA record, the accelerometers were programmed to initialize at 12:00 noon on the first measurement day and were set to register 1-minute epoch cycles.

2.2.4 Possible predictors of validity and reliability estimates

A Likert scale questionnaire was developed based on two focus groups (results not included in this study). Focus groups were conducted with participants that were different from those who participated in this study. These focus groups explored the factors that might compromise or promote the validity of any self-reported PA assessment. The focus groups allowed us to use appropriate language and tailor the questionnaire to this specific age group. This questionnaire assessed the degree of perceived difficulty for the adolescents to complete the record by including questions on: i) their time perception, ii) recall bias and iii) social norms/desirability (*see* **Supplementary Table 2**). We used the following Likert scale response categories: 1 "strongly disagree", 2 "disagree", 3 "neutral", 4 "agree", 5 "strongly agree" and 6 "I don't know". A PD-indices (Cronbach's $\alpha = 0.59$) combining these questions was used to provide a comprehensive assessment

of the degree of difficulty of completing the PA record. Children with a higher score on this scale were those who provided answers reflecting the most favourable conditions for completing the PA record. To explore the association of PD with reliability and validity, tertiles from this scale were created. Finally, tertiles of participants who found it respectively the least, more or less, and the most difficult to complete the PA record were compared with one another.

2.2.5 Accelerometer data reduction *(i.e. reduction of multitudinous amounts of raw data into a more useful, ordered, and simplified form)*

The Actilife Software (Actigraph Manufacturing Technology Incorporated, Fort Walton Beach FL, USA) was used to process the accelerometer data and computed both total registered time and time spent in different intensity levels of PA. Non-wearing time for the accelerometers was defined as 60 min of continuous zero values, allowing for 1-2 min registrations of less than 10 counts (169). Accelerometers were considered malfunctioning if no counts were registered or when a constant number of counts were recorded during the whole day (n=62) (**Figure 7**). As with the PA record, both the first and the last day of the administration period were excluded and all days with less than nine hours (540 min) were omitted from analysis (*n*=2). The following cut-off points were adopted from other studies in this age-group to determine the time spent on different intensity levels of PA: SED (≤ 100 counts) (170;171), LPA (101 - 759 counts) (171), MPA (760 - 4011 counts) (171;172) and VPA (≥ 4012 counts) (172). The cut-off point for MPA was chosen to detect moderate intensity non-ambulatory and ambulatory activities with high sensitivity and specificity (171). The cut-off point for VPA was chosen to detect ambulatory vigorous intensity activity with high specificity for the age-group (176).

2.2.6 Data analysis

Data from the PA record were entered in double using Epidata (Version 3.14, Odense Denmark) and analysed using Stata (Intercooled Stata version 10.1 Statacorp, college station, TX, USA). PA registrations were included if subjects had at least two days of corresponding accelerometer and PA record recordings. This inclusion criterion was chosen as the study aimed to estimate PA on a population level with as many subjects as possible. In this case, our criterion is acceptable even though this means having fewer valid days and higher individual variance (160). As measurement agreement might vary with the total time captured, the measured time for each intensity level was standardized to 900 min, which corresponds to the assumption of nine hours of sleep a day. All analyses were performed using these standardized outcome measures for both the accelerometers

and PA record. Descriptive data were reported as mean and SD. We tested differences in means between methods (validity) and repeated measures (reliability) using linear mixed effects models with the levels *school* and *individual*. Standard errors were estimated using the Huber-White sandwich estimator that relaxes distributional assumptions of homoscedasticity of the model residuals (173). Statistical significance was set at an alpha level of 0.05 and all tests were two-sided.

The measurement agreement between the duration of each PA intensity level was examined for both validity and reliability using the Bland Altman diagnostic plots. The plots visualize the difference between the PA measurements (validity: PA record 1 – accelerometer ; reliability; PA record 1 – PA record 2) against their average values. In case plots showed a tendency for the differences to increase as the magnitude of measurement increased, data were log-transformed and re-plotted (174). In the latter case, the mean difference and Limits Of Agreement (LOA) were back transformed by taking the antilog and values were presented as percentages. In case of a linear trend between the differences and the mean of two measurements, the differences were regressed over the means to obtain LOA that are a linear combination of the mean of the two measurements (A) (174). Lowess curves were used to visualize any group differences in validity and reliability. Classification agreement for both validity and reliability was further examined using linear weighted Kappa statistics and its 95% CI, based on groups defined by tertiles of SED, LPA, MPA and VPA. Strength of agreement for the kappa coefficient was evaluated using the standards as proposed by Landis and Koch (175). To account for prevalence and bias effects the prevalence-adjusted and bias-adjusted kappa (PABAK) is presented alongside the kappa statistics (176). Finally, we assessed the association between gender, level of PD (in tertiles), age, setting (urban vs. rural) and BMI with reliability and validity. For this purpose we used the differences (validity: PA record 1 – accelerometer ; reliability; PA record 1 – PA record 2) for each PA intensity level between 2 measurements as an outcome variable. These analyses were performed separately for each intensity level using linear mixed effects models with robust estimation for SE to account for clustering of estimates at the school level (173).

3 Results

3.1 Characteristics of participants

Figure 7 visualizes the number of adolescents included and analysed in the study. After data reduction, a total of 140 adolescents (52.1% male) provided valid data for the first administration of the PA record and the accelerometer (**Table 6**).

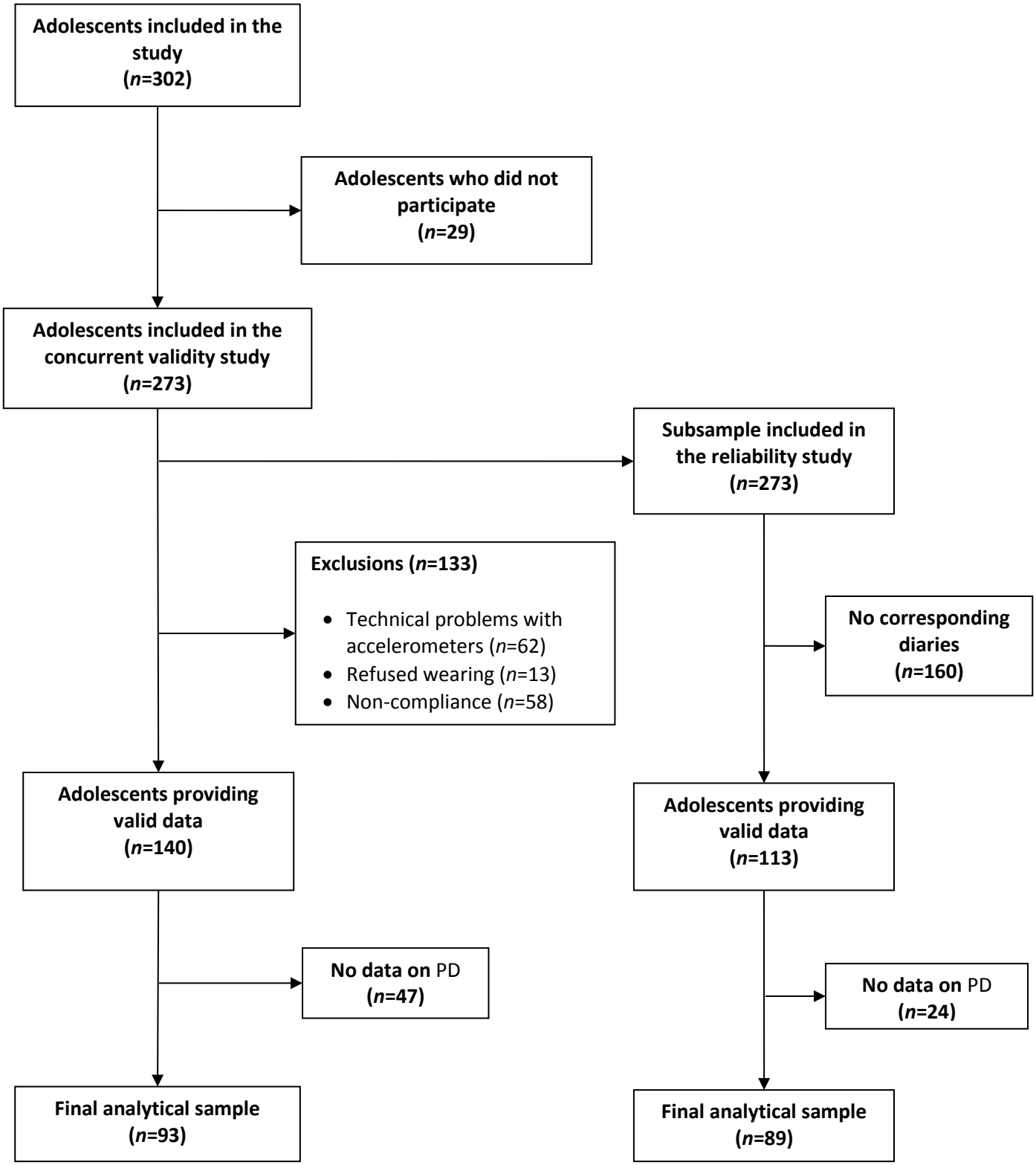


Figure 7 Flow chart of the study design

The sample included 101 adolescents (72%) from an urban and 39 from a rural area (28%). Mean age of the participants was 13.4 ± 1.3 years and mean BMI was 20.6 ± 3.7 kg/m². On average, 6.7%, 13.4% and 1.5% of the adolescents were obese, overweight and underweight respectively. A subsample of 113 adolescents (48.7% male) provided data for both PA records (**Figure 7**). There was no difference between the adolescents that provided data for both PA records and those who had data on the first PA record and accelerometer in terms of mean age (*P*=0.54), weight (*P*=0.68), height (*P*=0.22) and BMI (*P*=0.97). Finally, there was no significant difference in the PD score between those participants included in the final sample and those participants initially recruited (*P*=0.84).

Table 6 Participant characteristics

	n	Total		*n*	Urban		*n*	Rural		*P* value[1]
		Mean	SD		Mean	SD		Mean	SD	
Age (year)	140	13.4	1.3	101	13.3	1.2	39	13.6	1.6	0.760
Weight (kg)	140	46.0	11.9	101	47.6	12.2	39	41.9	10.1	0.216
Height (cm)	134	148.8	9.1	95	150.3	8.6	39	145.1	9.2	0.217
BMI (kg/m^2)	134	20.6	3.7	95	20.9	4.0	39	19.6	2.8	0.251

[1] *P values for urban-rural differences*

3.2 Descriptive PA estimates

On average, 871 min (14 h 31 min) were captured by the first PA record, and 792 min (13 h 12 min) by the accelerometer, indicating a higher mean total reported time for the PA record than for the accelerometer. For those providing repeated measures of the PA record (*n*=113), the first PA record (866 min) provided lower total time estimates compared to the second (892 min) PA record. The PA estimates after standardization are shown in **Table 7**. On average, half of the reported time measured by the first PA record and the accelerometer was spent as SED. The PA record gave significantly higher estimates than the accelerometer for SED and VPA, and significant lower estimates for LPA. Only for MPA similar estimates were provided by both instruments. When looking at repeatability, the first PA record reported less SED and consequently more LPA, MPA and VPA compared to the second record. However, only a significant difference was found for SED and LPA.

Table 7 Average standardized time (minutes per day) of activity reported for validity and reliability

PA intensity (min/d)	Validity					Reliability				
	PA record 1 (*n*=140)		Accelerometer (*n*=140)		*P* value	PA record 1 (*n*=113)		PA record 2 (*n*=113)		*P* value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
SED	488	109	432	90	0.001	482	120	550	136	0.002
LPA	192	88	265	48	0.011	201	99	158	83	0.023
MPA	175	104	188	64	0.351	170	104	155	111	0.501
VPA	45	69	15	16	0.003	46	65	37	57	0.127

PA, Physical Activity; SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical activity

3.3 Validity

Results for validity are provided for those participants with data on both the PA record and accelerometers (*n*=140) (**Figure 8**). On average, the PA record estimated 57 min (95% CI: [36;77] and LOA [-189;303]) more time spent on SED. For LPA, differences between both methods increased when more LPA was reported (β = 1.22; CI [0.91; 1.54]; lower LOA: -426.7+0.8A; upper LOA: -278.4+1.7A). Log transforming MPA showed that record estimates were on average 17% (CI [-26%; -8%]) lower than the accelerometers, but LOA were wide [-77.5%; 205%]. For lower mean MPA, adolescents tend to under report whilst for higher mean MPA they over report. For VPA the measurement disagreement between the PA record and accelerometer increased with increasing time measured. After log transforming, it is clear that the record reported more time spent on VPA (224%; CI [145%; 327%]) compared to the accelerometer. For VPA, the wide LOA [-84%; 6390%] indicated large discrepancies between both methods for some individuals. Kappa statistics analysing the classification agreement between the accelerometer and the first PA record showed fair to moderate agreement. The kappa coefficient improved for all categories when adjusted for prevalence and bias (**Table 8**).

3.4 Reliability

Results for reliability are provided for those participants with data on both PA records (*n*=113) (**Figure 9**). After log transformation, the first PA record reported significantly less time spent on SED (mean difference -14%, CI: [-19%, -9%] and LOA [-53%; 58%]) than the second PA record. The SED plot showed fair agreement as both mean difference and LOA were within acceptable limits. For LPA the first record significantly exceeded the second with 25 % (CI: [11%, 42%]) with LOA [-66%; 367%]. The plots of MPA and VPA also showed how the mean bias was acceptable for the different intensities of PA. For MPA and VPA the mean differences of the first PA record were respectively 19% (CI: [-3%; 46%] and 12% (CI: [-23%; -52%]) higher than the registrations of the second PA record. Even though these mean differences were acceptable, the LOA for MPA [-87%; 933%] and VPA [-94%; 1889%] indicated large discrepancies between both records in individuals. The differences between the repeated measures decreased with higher mean estimates of MPA.

When comparing both PA records, an overall moderate classification agreement was found. The kappa statistics improved when taking into account the impact of prevalence and bias in determining the magnitude of the kappa coefficient (**Table 8**).

Table 8 Cohen's kappa, 95%CI and prevalence-adjusted and bias-adjusted Cohen's kappa (PABAK) for each activity category

Activity level	Cohen's Kappa	95% CI	PABAK
Validity (accelerometer vs. PA record 1)			
SED	0.45	0.33 – 0.57	0.52
LPA	0.36	0.25 – 0.48	0.44
MPA	0.46	0.34 – 0.58	0.53
VPA	0.45	0.33 – 0.57	0.52
Reliability (PA record 1 vs. PA record 2)			
SED	0.58	0.44 – 0.72	0.63
LPA	0.61	0.47 – 0.75	0.66
MPA	0.49	0.35 – 0.63	0.55
VPA	0.36	0.21 – 0.48	0.50

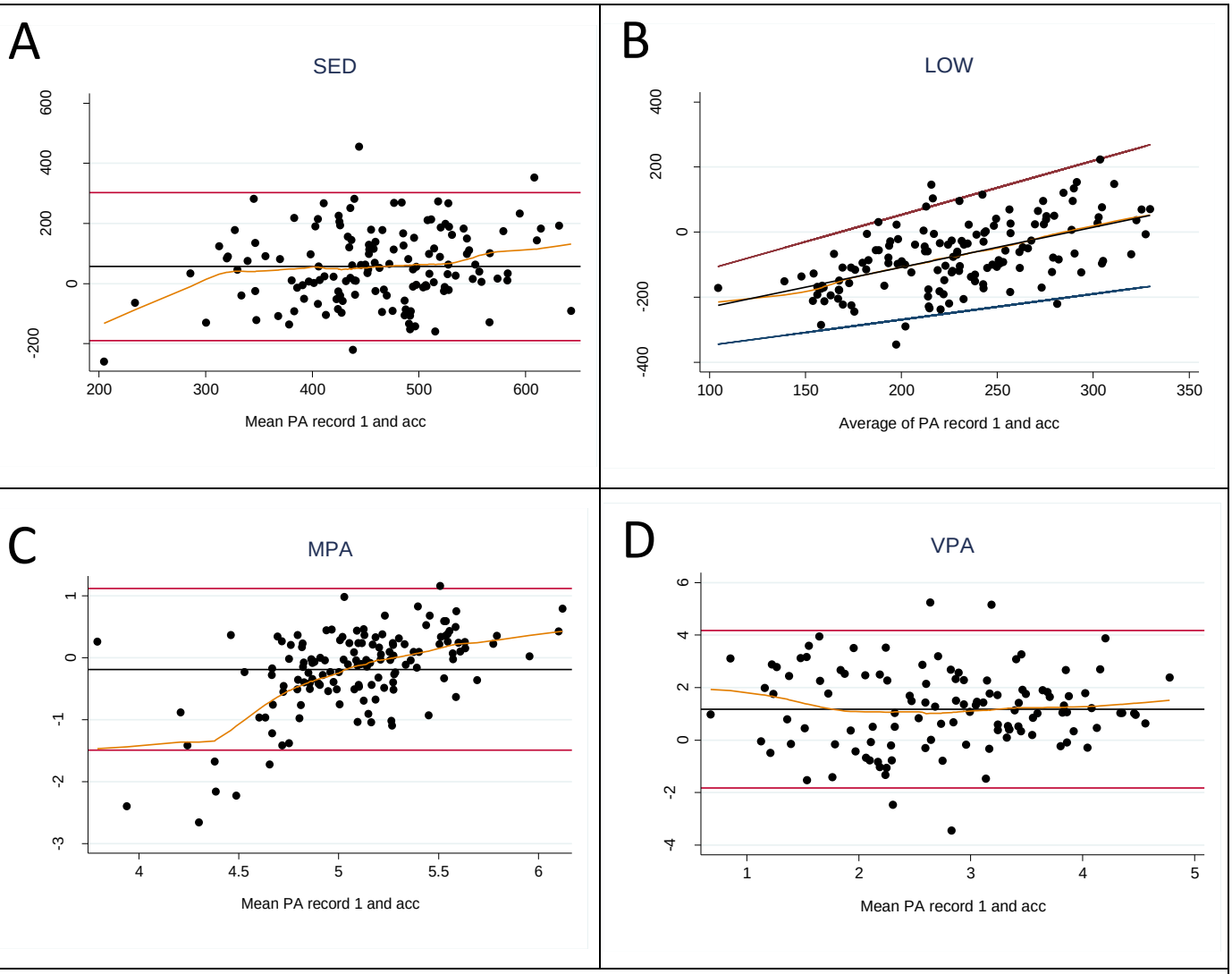
SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical activity

3.5 Predictors of validity

For validity (**Table 9**), sex was significantly associated with SED, LPA and VPA. Girls reported more LPA time (73 min) and less SED time (73 min) and VPA time (33 min) than boys. Setting was significantly associated with LPA and MPA. Rural participants reported on average more LPA time (100 min) and less VPA time (52 min) than their urban peers. Adolescents who reported higher PD to complete the PA record did not produce a different validity compared to peers reporting lower PD. Importantly, those adolescents with the highest PD level complied better with the protocol for wearing the accelerometers and had more registered days.

3.6 Predictors of reliability

Reliability was not associated with adolescents' individual characteristics such as age, sex, and BMI and environmental characteristics, such as setting (**Table 10**). However, the measurement agreement improved significantly for adolescents who reported a higher PD of completing the record compared to their peers who reported more difficulties for MPA. Compliance with the PA protocol did not differ between the different PD levels. There was no difference in number of registered days between the PD groups.



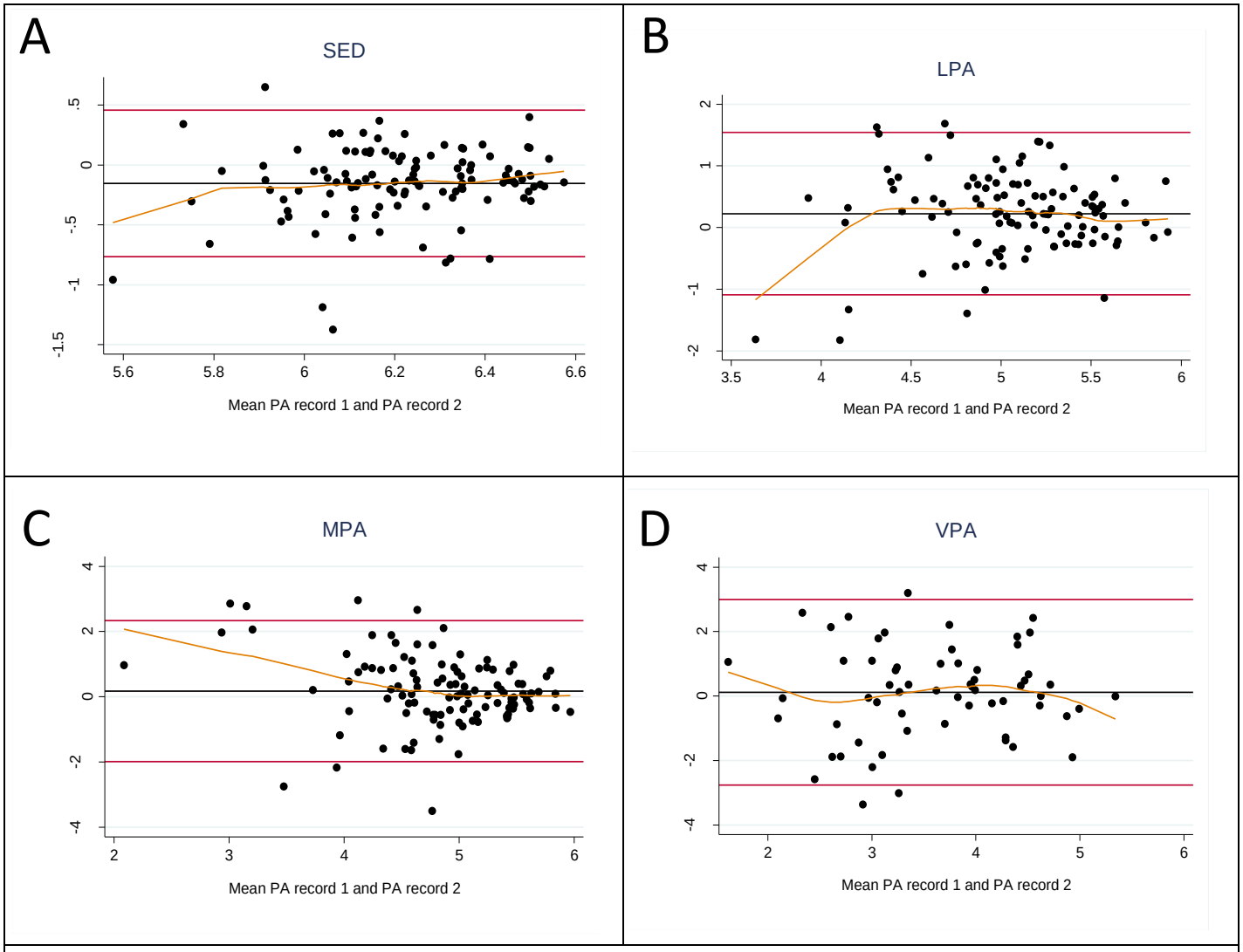
A: Difference between SED measured by PA record and accelerometers against the mean of the two methods

B: Difference between LPA measured by PA record and accelerometers against the mean of the two methods by means of regression (Upper LOA: -278.4 + 1.7A; lower LOA: -426.7 + 0.8A)

C: Difference between log-transformed MPA measured by PA record and accelerometers against the log transformed mean of the two methods. Difference between methods (-17% - antilog) and the lower and upper LOA (-77% and 205%)

D: Difference between log-transformed VPA measured by PA record and accelerometers against the log-transformed mean of the two methods. Difference between methods (224% - antilog) and the lower and upper LOA (-84% and 6390%)

Figure 8 Validity of the PA record versus accelerometer for adolescents (n=140); PA, Physical Activity; LOA, 95% Limits of Agreement; SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical Activity



A: Difference between log-transformed SED measured by PA records against the log-transformed mean of the two records. Difference between methods (-14% - antilog) and the lower and upper LOA (-54% and 58%)

B: Difference between log-transformed VPA measured by PA records against the log-transformed mean of the two records. Difference between methods (25% - antilog) and the lower and upper LOA (-66% and 367%)

C: Difference between log-transformed VPA measured by PA records against the log-transformed mean of the two records. Difference between methods (19% - antilog) and the lower and upper LOA (-87% and 933%)

D: Difference between log-transformed VPA measured by PA records against the log-transformed mean of thetwo records. Difference between methods (12% - antilog) and the lower and upper LOA (-94% and 1889%)

Figure 9 Reliability of the PA record for adolescents (n=113)
PA, Physical Activity; LOA, 95% Limits of Agreement; SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical Activity

Table 9 Predictors of measurement agreement for standardized PA record and accelerometer recordings

Predictors	Full model PA record 1 – accelerometer[1]							
	SED		LPA		MPA		VPA	
	β	*P* value	β	*P* value	β	*P* value	β	*P* value
Female	–72.6	0.007	73.4	0.001	32.6	0.146	–33.4	0.009
Age	–6.1	0.590	2.6	0.782	5.5	0.553	–2.1	0.689
Rural	–49.6	0.115	99.9	<0.001	–51.8	0.047	1.6	0.916
BMI	–6.3	0.094	3.4	0.285	2.1	0.492	0.7	0.688
PD_1[2]	–30.4	0.374	27.4	0.347	–6.1	0.829	9.1	0.574
PD_2[2]	3.2	0.918	14.8	0.575	–37.9	0.139	20.1	0.171

[1] Linear mixed model with school as random effect
[2] PD categories using the lowest PD category as reference
SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical Activity

Table 10 Predictors of measurement agreement for both standardized PA records

Predictors	Full model PA record 1 – PA record 2[1]							
	SED		LPA		MPA		VPA	
	β	*P* value	β	*P* value	β	*P* value	β	*P* value
Female	–19.8	0.521	22.9	0.317	0.6	0.982	–5.4	0.701
Age	–7.7	0.612	–3.8	0.766	8.0	0.596	10.2	0.142
Rural	28.0	0.441	23.9	0.595	–58.0	0.356	–19.3	0.246
BMI	–3	0.489	2.11	0.513	1.5	0.673	–1.0	0.615
PD_1[2]	34.9	0.377	–73.3	0.014	12.3	0.715	26.2	0.147
PD_2[2]	82.5	0.027	–57.3	0.045	–40.1	0.216	16.8	0.322

[1] Linear mixed model with school as random effect
[2] PD categories using the lowest PD category as reference
SED, Sedentary Intensity Physical Activity; LPA, Low Intensity Physical Activity; MPA, Moderate Intensity Physical Activity; VPA, Vigorous Intensity Physical Activity

4 Discussion

We evaluated the validity and reliability of a PA record for its application to assess PA at a group level in Ecuadorian adolescents and examined factors at individual and environmental level that might modify this. Our results showed that measurement agreement for validity and reliability was satisfactory at a group level, and classification agreement was fair to moderate. There was no trend of over or under reporting for repeatability and validity at the different intensity levels, except for MPA. Participants' age, BMI and PD to fill out the form did not modify validity. However, sex (for SED, LPA and VPA) and setting (for LPA and MPA) were associated with validity. In addition, we found that only PD was associated with higher reliability for LPA whilst sex, setting, BMI and age had no influence on the reliability estimates.

On average, the record measurements were substantially higher for SED and VPA compared to the accelerometer's measurements, whilst these were lower for LPA and MPA. The differences were significant except for MPA. These observations are consistent with previous findings that LPA or MPA were underestimated during self-reporting. VPA was consistently overestimated, suggesting a misclassification of MPA as VPA (152;177). In our study, LPA was underestimated and its mean difference surprisingly increased with higher reported LPA, as observed by Krishnaveni *et al.* (156). Furthermore, the underestimation of MPA by the record is possibly explained by the fact that the time spent at lower intensity levels is not as easily remembered, quantified and subsequently accurately reported as structured PA, like exercise and sports. LPA and MPA are thus less likely to be included when using self-reported measures (152). Finally, our results for VPA showed a difference between both methods, which increased with higher mean time reported. Anderson *et al.* (178) identified several factors that could contribute to such higher estimates of VPA. Firstly, children generally do not engage in sustained VPA. Their PA pattern is characterized by very short outbursts of intense PA alternated with varying intervals of LPA and MPA (179). Children might intuitively, but wrongly, acknowledge the majority of this period as VPA, which likely influences record estimates. Secondly, accelerometers have limited ability to detect some vigorous activities such as swimming, cycling, and movements of the torso or locomotion on a gradient (180). Particularly walking uphill or carrying heavy loads are examples of such activities performed by the study population which could have been underestimated by the accelerometer. In addition, children could have removed the accelerometers during vigorous activities out of fear of damaging the device.

Next to our validity, the observed reliabilities were satisfactory except for MPA. A previous study reporting reliability using the Bland Altman method showed fair agreement for all intensity levels (158). The wide LOA and their tendency to increase with higher PA intensity however, indicate that the validity of our PA record is limited for individual observations, in particular those at higher intensity. Despite these large differences in individual observations, we consider the measurement agreement for validity and reliability satisfactory at a group level.

We expected that personal factors at individual (i.e., age, sex, BMI and self-reported PD) and environmental level (i.e., setting) could alter both reliability and validity. For validity our hypothesis was not confirmed statistically for PD, age and BMI, but it was significantly different for sex and setting at specific intensity levels. Our findings did not show any age effect on validity, which is in contrast to a previous study where younger adolescents had a larger median difference in total time spent in PA than their older peers (181). A previous study examining the associations of validity between a self-reported 7-day PA questionnaire and accelerometers in children showed that sex and body fat did not affect the validity estimates (182). Whilst the former study reported no effect of sex on validity, a systematic review on PA measures in children showed that female participants were likely to overestimate their activity (177). Our results indicated that female participants over reported LPA, but under reported SED and VPA. Poor validity in rural areas, as observed in our study for LPA and VPA, has been reported in a study evaluating validity of a questionnaire in Vietnamese adolescents (157). We also note that only for LPA the highest PD group had better reliability estimates compared to the other groups. A previous study that investigated self-reported confidence in recalling PA as a predictor of validity showed that participants in the high-confidence group had higher validity and repeatability coefficients than those in the low-confidence group for most comparisons (183).

The current study has a number of strengths. First, the PA record was validated against an objective measure of PA, Furthermore, we used cut-off points for MPA that include both ambulatory and non-ambulatory moderate intensity activities (171). Other studies generally used cut-off points based upon walking and running at different intensities for MPA (152). Second, PA records or activity diaries were previously reported to estimate PA accurately at population level in adolescents (178). However, using this type of self-reported measure does not come without disadvantages. It imposes a higher participant burden, which might in turn affect their behaviour (Hawthorne effect). Third, as mentioned previously, the frequent activities of short duration might provide lower estimates then accelerometers, as only the major activity of each 15 min time interval will be reported (184).

However, introducing even shorter time-intervals would render completing the PA record even more burdensome. Fourth, we did not present correlation coefficients in this study. Not doing so may limit comparability with other similar studies. We believe however that this is irrelevant as they are inappropriate to assess measurement agreement as they only measure the strength of linear association between variables (185). Lastly, this study provided a first attempt at explaining lower validity and/or reliability in an LMIC setting. Future research should invest in improving the conceptualisation and operationalisation of the indices of perceived difficulty in completing the PA record

5 Conclusion

The PA record provided acceptable estimates on a group level. Sex and setting were the characteristics associated with differences in validity for SED, LPA, and VPA and LPA and MPA, respectively. PD was associated with lower differences in reliability. However, the interesting finding of better validity for the highest PD group when reporting LPA merits further exploration. Adequately powered longitudinal studies combined with direct observation examining PD are needed. As such, new insights into poor validity estimates might be achieved and would contribute to a better understanding of PA assessment and validity of the instruments used in LMICs.

Box 2 Key messages on using a PA record to evaluate PA behaviour

- Despite large differences in individual observations, measurement agreement for validity and reliability was satisfactory at a group level, and classification agreement was fair to moderate;
- Sex and setting were associated with validity; poor validity of the PA record in rural areas was observed;
- The PA record imposes a high burden on participants;
- It is strongly recommended to combine the self-reported PA record with an objective assessment of PA.

Chapter 4:
Culture-specific influences for healthy eating and PA behaviour in Ecuadorian adolescents: a qualitative study

Redrafted after:

Van Royen K, Verstraeten R, Andrade S, Ochoa-Avilés A, Donoso S, Maes L, Kolsteren P. Factors affecting physical activity in Ecuadorian adolescents: A focus group study. Journal of Physical activity and Health. In Press

Verstraeten R, Van Royen, Ochoa-Avilés A, Penafiel D, Holdsworth M, Donoso S, Maes L, Kolsteren P. A conceptual framework for healthy eating behaviour in Ecuadorian adolescents: a qualitative study. Plos One. 2014: e87183. doi:10.1371/journal.pone.008718.

Summary

Background: Insight is needed into factors determining young adolescents' food and PA choices to guide the development of health promotion interventions in the context of systematic obesity prevention.

Objective: The objective of this study was to identify factors influencing eating and PA behaviour of Ecuadorian adolescents - from the perspective of parents, school staff and adolescents - to develop a conceptual framework for adolescents' eating and PA behaviour.

Design: Twenty focus groups (*N*=144 participants) were conducted separately with adolescents aged 11-15y (*n* (focus groups)=12, *N* (participants)=80), parents (*n*=4, *N*=32) and school staff (*n*=4, *N*=32) in rural and urban Ecuador. A semi-structured questioning route was developed based on the 'Attitude, Social influences and Self-efficacy' model and the socio-ecological model to assess the relevance of behavioural and environmental factors in LMICs. Two researchers independently analysed verbatim transcripts for emerging themes, using deductive thematic content analysis. Data were analysed using NVivo 8.

Results: All groups recognized the importance of eating healthily and key individual factors in Ecuadorian adolescents' food choices were: financial autonomy, food safety perceptions, lack of self-control, habit strength, taste preferences and perceived peer norms. Environmental factors included the poor nutritional quality of food and its easy access at school. In their home and family environment, time and convenience completed the picture as barriers to eating healthily. Participants acknowledged the impact of the changing socio-cultural environment on adolescents' eating patterns. Availability of healthy food at home and financial constraints differed between settings and socio-economic groups.

Factors influencing PA choices included preferences for sedentary activities, poor knowledge, time constraints and laziness, as well as a lack of opportunities at home and school, unsupportive parental rules and lack of role models. Similarly as for healthy eating, some factors differed between settings and socio-economic groups. In the rural groups farming and norms for girls impeded leisure-time PA, whereas urban groups emphasized traffic and crime concerns. Fear of injuries and financial constraints were more a concern in low socio-economic groups.

Conclusion: Our findings endorse the importance of investigating behavioural and environmental

factors that influence and mediate healthy dietary and PA behaviour prior to intervention development. Several culture-specific factors emerged that were incorporated into conceptual frameworks for dietary and PA behaviour for developing health promotion interventions in Ecuador.

1 Introduction

Obesity and chronic diseases are no longer exclusive to affluent societies, but are now the leading cause of morbidity and mortality in LMICs (4). A staggering rise in unhealthy body weight has been observed in children in LMICs across all levels of SES (13;14). This rise is associated with rapid economic and societal changes which have been paralleled with large shift in dietary and PA patterns (11;12). The current dietary and PA patterns in Ecuadorian adolescents are worrisome (66;67) and insight is needed in why they engage in such risky behaviours to guide interventions to change these behaviours.

School-based interventions targeting physical inactivity and unhealthy eating are an important strategy in obesity prevention (33). However, evidence is needed from LMICs of the pathways through which school-based interventions mediate PA and dietary behaviour (186). To increase our understanding, intervention studies incorporating theoretical models to address population-specific behavioural and environmental influences on dietary and PA behaviour are required (187). Current models may not be transferable to LMICs because culture-specific influences on these behaviours, such as social values/norms and physical environment may be different from HICs.

To develop a conceptual framework for health promotion interventions in Ecuadorian adolescents that accounts for its cultural context, we solicited opinions of adolescents, parents and school staff, using focus groups to explore factors of adolescents' eating and PA behaviour.

2 Methods

2.1 Ethics statement

Focus groups were conducted between April - September 2008. They were framed within a larger research study and the study protocol was approved by both the Ethics Committees of Quito and the Ghent University Hospital (CBM/cobi-001; B67020084010). The different audiences included in these focus groups were asked for their consent. Adolescents who returned signed parental consent forms and gave written assent to participate were included in the study; parents and school staff needed to provide written consent. The 'Consolidated criteria for reporting qualitative research checklist' was used to report the results (188).

2.2 Theoretical framework

Dietary and PA behaviour in young people is determined by the complex interplay of factors at both individual and environmental level. To better understand these factors in Ecuadorian adolescents, we used a theoretical framework (**Figure 10**) to conceptualize and analyse the findings of focus group discussions. To ensure the cultural appropriateness of this framework, the cognitive variables from the 'Attitude, Social influences and Self-efficacy' ASE-model (189) were nestled within the socio-cultural and physical context of adolescents' environment, as elaborated by the socio-ecological model (190). The ASE-model poses that behaviour is a function of the intention to perform the behaviour that, in turn, can be explained through 3 cognitive factors: attitudes, social influence (including subjective norms, modelling and support) and self-efficacy. Additionally, barriers and lack of skills might limit the possibility to put the intention into practice (191). As adolescents' dietary and PA behaviour is strongly influenced by their environments (45;192), we complemented our framework with a socio-ecological perspective. In this model, behaviour is viewed as the interaction between, and interdependence of, factors within and across multiple levels of influence. In other words, it highlights people's interactions with their physical and socio-cultural environments (190). Both models have been used extensively to study dietary (193-195) and PA (196;197) behaviours in young people.

2.3 Focus groups

The protocol incorporated theoretical and practical guidelines (198;199). A double layer design using setting (urban/rural) as the first layer and different audiences (adolescents, parents and school staff) as the second layer, allowed for comparison and/or verification of results between these different layers (199). The number of focus groups was defined prior to the start of the survey (199) and considered sufficient as data saturation was reached. We conducted 20 focus groups, of which 12 were with adolescents separated by age group (6 for grade 8-9; 6 for grade 10-11) to produce homogenous groups, since ability and level of comprehension differs substantially with age (198). In addition, 4 focus groups with parents and 4 with school staff were conducted. Participants received healthy refreshments (e.g. fruit and semi-skimmed milk) as an incentive to participate and completed a socio-demographic questionnaire; a verbal record was taken in case of illiteracy. Audio-recorded focus groups, lasting 46 minutes on average, were conducted in Spanish and led by a trained interviewer (AO).

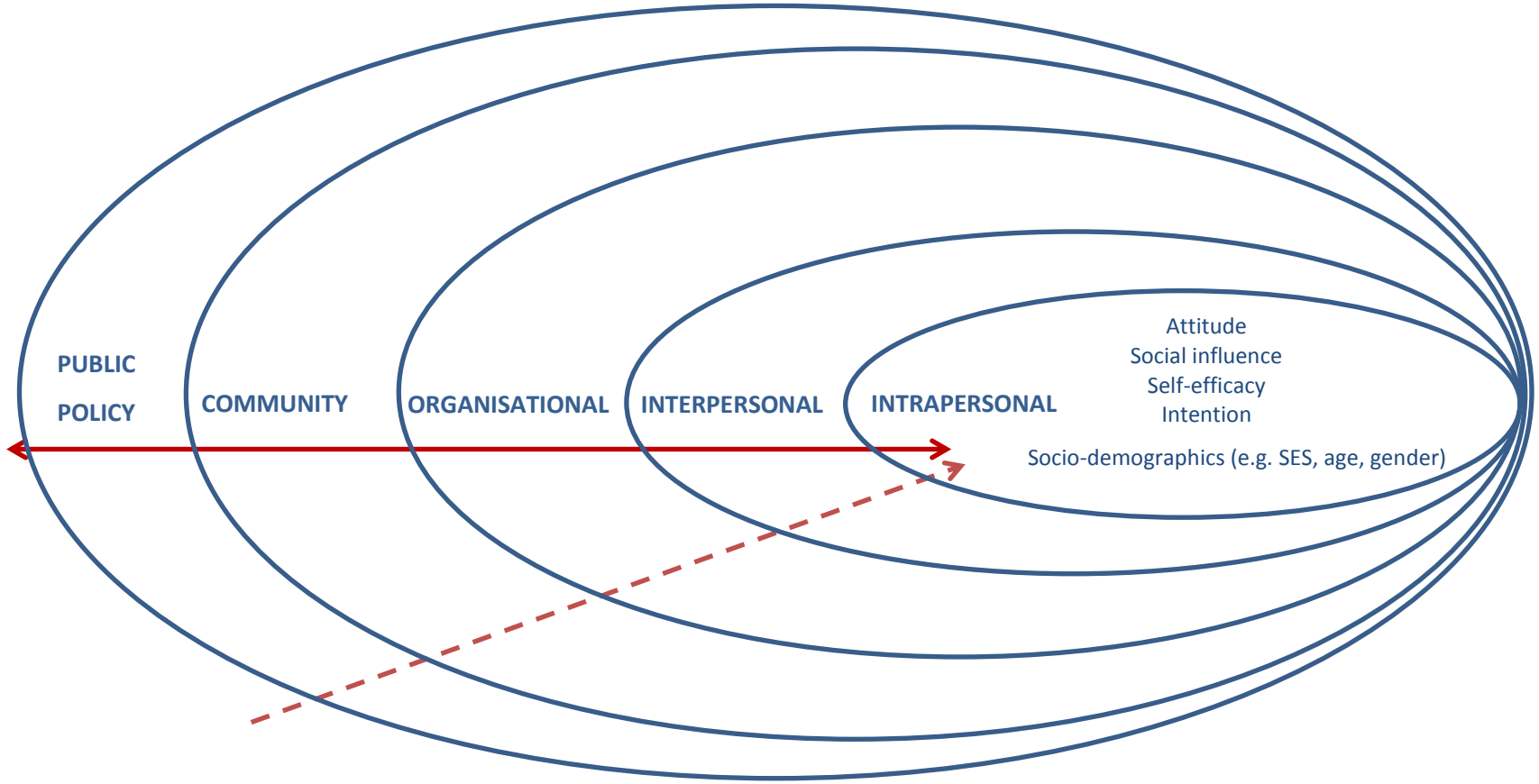


Figure 10 Theoretical framework (ASE-model and socio-ecological model) used to conceptualize and analyse the findings of focus group discussions. The dotted arrow stands for the external influences that may have an impact on intrapersonal factors. The red line represents the fact that behaviour is viewed as the interaction between, and interdependence of, factors within and across multiple levels of influence.

A silent observer (RV) was present to take notes on non-verbal individual behaviour and group interactions (198;199). Using the theoretical framework, a semi-structured questioning route was developed, pre-tested and refined. A focus group was performed with each target audience to pilot the full focus group procedure (e.g. explaining the purpose of the study, the topic of the focus group study) and the questioning route. Some questions did not yield a sufficient flow of conversation and were refined when needed. The issues addressed were designed to solicit information about the individual, physical and social eating environment of adolescents, consistent with the models selected. Open-ended questions were followed by more specific probes to clarify and extend responses. Adolescent focus groups on diet opened with a visual listing of healthy and unhealthy foods which was then referred to during the group discussion. A definition of PA was provided by the moderator after soliciting participants' views during the group discussion on PA. After each focus group, a debriefing was held with the moderator and observer.

2.4 Participants

Focus groups were conducted in 5 schools, 3 from Cuenca (urban) and 2 from Nabón (rural), which were selected by convenience sampling. Each of the 3 schools in Cuenca represented a distinct socio-economic level, i.e. low, middle, and high. There were only schools of low socio-economic level in Nabón. Schools were categorized into these different levels based on the type of school (public/private) and school fees. From each of these 5 schools, 20 adolescents (grade 8-11) were randomly selected. Convenience sampling was used to recruit participants to the parent and school staff focus groups. To be eligible, parents needed to have a child (aged 11-15y) at one of the participating schools and school staff had to be employed at one of the schools.

2.5 School setting

Schools had either contact hours in the morning (7 am-1 pm; *n*=4) or in the afternoon (12 am-6 pm; *n*=1) and both had one break of approximately 30 minutes. Food service was provided through a privately owned tuck shop, i.e. a small food-selling retailer, based either in school (urban) or outside school (rural). Adolescents have easy access to street foods nearby school and sometimes street food vendors enter the school premises.

2.6 Data coding and analyses

Records were transcribed verbatim, translated into English and cross-checked by 3 researchers. We used a deductive thematic content analysis (200) which was based on both the literature and the theoretical framework of this study. This enabled us to identify themes and factors influencing dietary behaviour of adolescents. The purpose of identifying these themes and factors was to build up a model, i.e. a conceptual framework explaining the dietary behaviour of our participants. Using this analysis, 2 investigators independently read the transcripts and identified emergent themes. For each participant group, a codebook based on these factors was developed independently by 2 researchers. If no agreement was reached on coding, a third researcher was consulted. The codebook was further validated on different transcripts. NVivo software (QSR international – version 8.0) was used to code, manage and analyse the data. Summary reports were written for each participant group according to identified factors and themes. Moreover, focus group attributes, such as SES and school setting were cross-linked with constructs and themes for each participant group. For triangulation of the data we took into account the non-verbal behaviour, group interactions and data from multiple sources i.e. adolescent, parent and school staff groups. Findings from the focus groups were grouped into individual and environmental factors influencing eating and PA behaviour, which were subdivided into specific factors according to the literature and the theoretical framework used. Inclusion of factors was based on the frequency, specificity, emotion and extensiveness of the quotes related to the factor (199). Data from all participant groups are presented for each selected factor and related quotes are shown in **Supplementary Table 3–6.** The differences in these factors among the socio-economic levels and settings are only presented where relevant.

3 Results

Twelve adolescent focus groups (*N*=80) were conducted and group size ranged from 6-8 individuals. In addition, 4 parent (*N*=32) and 4 school staff groups (*N*=32) with an average group size of 8 were performed (**Table 11**). The results are presented according to the two broad levels of individual and environmental influences, identified in the analysis. Furthermore, environmental influences are presented according to the influences at school, family, societal and built environment level.

Table 11 Participant characteristics

	Total	Urban	Rural	*P* value[1]
Adolescents (*n*=80)				
Gender (% male)	47.9	46.1	50.0	0.63
Age (mean (SD) y)	13.7 (1.2)[1]	13.7 (1.3)[2]	13.8 (1.1)[2]	0.67
School (% public)	62.5	31.2	68.8	<0.01
Socio-economic level based on schools				
Low (%)	67.5	35	100	<0.01
Medium (%)	17.5	35	0	<0.01
High (%)	15	30	0	<0.01
Parents (*n*=32)				
Gender (% male)	25	11	43	0.04
Age (mean (SD) y)	41.2 (10.7)	38.5 (6.5)	44.6 (14.1)	0.16
No. of children (mean (SD))	2.9 (1.4)	2.7 (0.9)	3.1 (1.8)	0.39
Education				
Illiterate (%)	6.5	5.5	5.6	0.001
Primary (%)	45.2	84.6	16.6	0.001
Secondary (%)	32.3	0	55.6	0.001
University (%)	16.1	7.7	22.2	0.001
School staff (*n*=32)				
Gender (% male)	58.1	41.2	78.5	0.04
Age (mean (SD) y)	36.7 (11.0)	39.6 (12.6)	33.1 (7.4)	0.09
Experience (mean (SD) y)	7.0 (8.7)	9.6 (11.6)	4.6 (4.0)	0.15

[1] *P values for urban-rural differences (two sample t-test, Chi square or Fisher Exact test)*
[2] *Date of birth was missing for 5 adolescents*

3.1 Individual influences on eating behaviour

3.1.1 Awareness

Adolescents mainly discussed healthy eating by identifying stereotype foods or food groups they perceived as (un)healthy, naming many more “unhealthy” than “healthy” foods. Fruit and vegetables were perceived as healthy, whilst French fries, potato chips, candies and ‘junk food’ (referred to as such by participants) were most frequently mentioned as “unhealthy foods”. On the other hand they mentioned, but less frequently, that eating healthily includes a balanced diet with a low amount of fat and lots of vitamins. Adolescents reported that they were aware of the general health benefits of

eating healthily. They believed that traditional and home-grown foods are 'always' healthy as these were hygienically prepared at home. In contrast, street or restaurant foods and food out-of-home in general were perceived as unhealthy because preparation methods were unknown.

Parent and school staff groups reported that a healthy diet includes balanced and varied dietary practices in which moderate portion sizes, having breakfast, and eating regularly at set times are important. Like adolescents, they associated eating healthily with traditional, home-grown and hygienically prepared food and not necessarily with nutritional quality. Parents expressed their concerns about food safety in school tuck shops.

3.1.2 Attitudes

Overall, adolescents reported positive attitudes towards healthy eating, with some of them associating healthy eating with a positive body image and health benefits, such as looking good and being healthy. Nevertheless, they reported liking "unhealthy food" so much that they could not resist it, even though they were aware of its poor nutritional value. Parents and school staff in the study generally had positive attitudes towards healthy eating but anticipated that adolescents would hold negative attitudes.

3.1.3 Self-efficacy

Many adolescents felt they would not succeed in eating healthily and associated this inability with lack of self-control and the abundance of tasty, yet "unhealthy food" at school and/or at home. Only a few adolescents indicated that they are or would be capable of eating healthily.

School staff groups acknowledged their responsibility in educating adolescents about healthy eating, but also stressed the importance of parental responsibility. Surprisingly, parents did not recognize their responsibility for their children's dietary behaviour, but placed it with school, the environment or their children themselves.

3.1.4 Habit strength

Most adolescent groups noted that their food consumption was influenced by habit, which they reported has become less healthy since moving to secondary school. They identified the increased availability of "unhealthy food" and (financial) autonomy as main influences on their habits. A strong habitual pattern was reported with regard to eating out at weekends.

Parents and school staff groups also saw habit strength as a key influence. They expressed concern about the changes adolescents face, such as increased (financial) autonomy and less parental control, and the transition from primary to secondary school accentuated the changes that have occurred in the socio-cultural environment over recent years.

3.1.5 Subjective norm

Views on the pervasiveness of subjective norms on healthy eating varied among adolescent groups. Most adolescents reported being afraid of what others might think if they ate healthily, such as embarrassment, being called “freaky”, “weird” or “not willing to spend money” or the possibility of being mocked by their peers. Positive perceptions were reported less often and generally these adolescents felt confident and did not care what their peers or other people thought.

Parents and school staff groups also emphasized the fear of embarrassment held by adolescents regarding eating healthily, indicating some strong social norms were operating in the peer environment.

3.1.6 Perceived barriers

Adolescents from low socio-economic schools described the cost of healthy food as a barrier to eating healthily, which was also stressed by parents. Furthermore, rural adolescents reported that availability was a barrier to eating healthily. These 2 key factors were distinct for urban adolescents who reported (as did parents) that food is readily available and cost was not an issue. Some adolescents reported lack of time as a barrier for eating breakfast at home; this view was shared by parents. All school staff and parent groups described the impact of the changing society and environment on lifestyles. Significant barriers to eating healthily at home were: having less time to prepare (healthy) meals, challenges of organizing their schedules around family meals, and choosing convenient ready-to-eat dishes which are preferred over “healthy foods”.

3.1.7 Taste

Overall, adolescents were enthusiastic when talking about the taste of sweet and fatty foods, whilst vegetables or salads were associated with unpleasant and negative taste experiences, particularly in the school environment. As such taste had an important impact on their preferences and consumption. This was re-iterated by parents and school staff.

3.1.8 Financial autonomy

Adolescents reported having financial autonomy to choose food, generally originating from pocket money received from parents/grandparents or money earned by them. This pocket money was mainly used to purchase foods of poor nutritional quality at school. Even though no differences were noted among adolescents from different socio-economic groups, parents from low socio-economic groups reported that their children did not receive any/much money and mostly took food from home to eat at school.

3.2 Environmental influences on eating behaviour

3.2.1 Family environment: parental rules, role modelling and availability

Three key factors - parental rules, availability and role modelling – were identified. Some parents reported they try to be a good role model for their children and include rules about healthy eating. Nevertheless, they confirmed that they inconsistently enforced rules about healthy eating and do not always set a good example for their children. They acknowledged that it is difficult to expect their children to eat healthily if they do not do so themselves. Parent groups reported that these inconsistencies arose from the fact that preparation and consumption of healthy food at home is very often a negotiation process with adolescents. Due to this constant struggle to encourage their children to eat healthily, parents reported often giving in and adapting meals to children's wishes. These inconsistencies were reflected in adolescents' responses who stated that they tend to disobey rules on healthy eating, particularly away from home. Nevertheless, adolescents indicated that the availability of healthy food at home had an influence on their eating pattern, because they eat what is served and available at home. Rural parents were most likely to evoke their dependency on their own food production to ensure that healthy food is available at home, whereas for urban participants this was more related to availability in shops.

3.2.2 School environment: school rules and availability

At school level, rules and availability were the 2 most important factors. Urban adolescents reported food restrictions at school, e.g. soft drinks and French fries. However, some adolescents did not feel constrained by these school rules and purchased their preferred food outside school. This was different for rural adolescents, where no restrictions on food were in place, as the tuck shop was external to the school. School staff confirmed adolescents' views on food restrictions at school and

stated that these were guided by food hygiene and safety practices, rather than by nutritional quality. Food availability at school was viewed by adolescents as a key factor influencing their consumption, i.e. they eat what is available. Parent and school staff groups confirmed the abundance of 'junk food' and poor availability of fresh fruit at school. However, they explained that food available in the tuck shop is a reflection of adolescents' preference for processed food. Even when fresh fruit was available at the school tuck shop, it was not sold to adolescents as it was often seen as unpalatable to them. However, all participant groups believed that if fresh fruit looked appealing, was ready-to-eat and sold at an acceptable price then adolescents would be more willing to buy it. These tuck shops typically sell confectionery food, such as sweets, crisps, ice cream and soft drinks. In addition to these foods, some of them offered warm snacks or meals during the break such as 'salchipapas' (French fries with sausage), fried 'empanada' (deep-fried pastry snack) or rice with chicken/meat.

3.2.3 Environment outside home and school: socio-cultural changes and availability

Parents frequently stated that 'junk food' is available everywhere, not only at school, but also outside school. In addition, parents from higher socio-economic groups emphasized that media has a large impact on their children's eating habits, as food advertisements are specifically targeted towards children. Parents and school staff believed that the availability of sweets and processed foods had increased since they were young. Both evoked the impact of the changing socio-cultural environment on traditional diets, food availability and family meal patterns. All these factors have led to increased portion sizes and a variety of palatable foods with poor nutritional quality.

3.3 Individual influences on PA behaviour

3.3.1 Awareness

All participant groups had generally poor knowledge about PA and its importance; they were aware of the health benefits of PA, but did not know how much PA (and at which level) is needed to meet the PA recommendations. Importantly, most of them were not able to describe the difference between performing sports and PA. Different opinions prevailed: sports were referred to as a 'hobby', 'game', 'play' or 'done for a purpose', whereas PA was seen more as training or exercise to be in shape and to be more fit. Others identified PA by naming specific sports such as using weights, exercising, jogging, running or playing football.

3.3.2 Attitudes

Overall participant groups reported a positive attitude towards PA. For the adolescent groups, this was mainly related to enjoyment or having fun and to the perceived health benefits associated with PA. In addition, their positive attitude towards PA was expressed by how they perceived active people: 'good', 'cool', 'healthy' and 'strong people'. Many adolescents perceived themselves as active, but stated that they would like to be more active. Nevertheless, sedentary activities were their preferred activities.

Parents confirmed the positive attitude of their children towards PA but stressed that variation in PA, such as new sports and seasonal hypes, was vital to keep them motivated. They praised the health benefits, social contact and prevention of boredom of PA. In addition, most parent and school staff groups recognized the popularity of sedentary activities amongst adolescents as an important barrier for PA, thereby confirming the view of adolescents. School staff from the high SES schools reported that adolescents at their school don't like PA, whereas those from the low SES schools mentioned positive attitudes of adolescents towards PA.

3.3.3 Self-efficacy

The majority of adolescents felt able to perform PA or sports, but they often reported feeling tired and/or lazy. Few rural adolescents reported that they would not succeed in performing PA or sports. This feeling of inability was related with 'lack of energy', 'no one to play with', 'simply forgetting to be active' or specifically to rural girls 'not allowed to do sports'.

3.3.4 Habit strength

Adolescents reported changes in their PA compared to when they were younger; the majority thought they were more active now than before. Reasons mentioned for being more active were 'feeling stronger', 'more skilled' and 'less falling whilst running'. Some school staff and parents reported a habitual pattern of being active in weekends with their family.

3.3.5 Subjective norm

In the rural area some adolescents and parents mentioned that leisure-time PA is inappropriate for girls, and they need to help and cook at home; parents simply don't allow girls to play.

3.3.6 Perceived barriers

Perceived barriers for PA by adolescents were primarily the lack of time and energy. Going to school, doing homework and helping at home required a lot of time and energy, which made them feel tired and lazy. In particular, adolescents from low SES schools felt additionally constrained to perform sports by fear of injuries and lack of skills; a few of them even felt embarrassed, mainly the younger adolescents (11-13 years).

Parents confirmed that their children lacked time or friends to play or do sports with. Perhaps not surprisingly, this barrier of perceived lack of time by adolescents due to school and related homework was not confirmed by the school staff.

3.4 Environmental influences on PA behaviour

3.4.1 Family environment: opportunities at home, parental rules, role modelling and support, and financial constraints

PA at home was limited due to the lack of opportunities and adolescents' preference for media use. However, some adolescents (as did parents) reported playing with pets as a pleasurable activity. Nonetheless, at home often household chores such as cleaning the house are done, which was surprisingly not seen as PA by the adolescents. In the rural area, adolescents felt more limited to be physically active at home, since they usually have to help with farming. Parents emphasized that children are also active during farming, whilst adolescents reported to be only active during farming activities by playing football.

Adolescents reported a wide variety of rules for PA: some adolescents reported they can choose the sports they like but only after doing their homework, some reported not being allowed to practice every sport they would like to, and some faced restrictions regarding TV-viewing and playing videogames. These restrictions were confirmed by parent groups. Parents did not allow every sport as some children want to do too many activities at the same time. Many parents, from both rural and urban areas, had rules on helping in household chores and this was mainly over the weekend; PA was only allowed after homework and household chores. In rural areas, PA was also secondary to farming activities.

Adolescents mentioned that they are encouraged by their family to be active. However, only few mentioned their parents as those that are engaging them in PA; generally other family members

were perceived to be more influential. Parents perceived their role in motivating their children to be active as important, but admit that it is difficult to actually do this. Parents mentioned it requires a lot of energy as children's PA preferences change rapidly, but when their children are active they do feel satisfied. A few parents explicitly stated that they support their children. Parents from the rural area recognized the need to motivate their children to be physically active, but felt constrained to do so as the help from their children is needed in farming activities. According to parents, peers can have a supportive role in engaging in PA together, though it's mainly to have social contact with friends.

Financial constraints to engage in PA activities, such as the fees to pay in sports academies or buying a bike, were mentioned a few times by parents with a low SES. Also one high SES parent mentioned that he was not being able to pay for the child's preferred activities.

3.4.2 School environment: opportunities at school, school rules, role modelling and support, and financial constraints

Adolescents mentioned several settings for PA such as the home environment, sport centres, courts and academies, but the main place where they performed PA was at school. Half of the adolescents reported they were active during school breaks, whilst the others admitted to prefer sitting and chatting. In general, adolescents reported that schools had sufficient material for sports and PA. Nevertheless, adolescents from low SES schools suggested that more materials or better infrastructure was needed, such as volleyball nets and balls, whilst adolescents from high SES schools suggested a need to improve the existing infrastructure, such as more balls, more space and more courts. They also mentioned a lack of parking space for bikes which prohibited them from coming to school by bike. School staff from low SES schools confirmed these limitations on materials due to the financial cost involved. In addition, they acknowledged the importance of school to perform PA, confirming what adolescents stated. In some schools footballs and basketballs were available during the break. Many afternoon/morning activities are organized in schools such as dance, activities through academies, but also championships. Nevertheless participation rates vary for both rural and urban schools and school staff stressed that generally only a minority participates.

Rules at school were limited. In one school it was mentioned that kids cannot play with big balls and play in trees as these were activities associated with previous injuries. At Ecuadorian schools a fixed curriculum for PA lessons determined by the Ministry needs to be followed. Adolescents receive two

hours of PA lessons each week, mainly team sports like football, basketball and volleyball as well as running and gymnastics.

All parents perceived the school as successful in promoting PA. They admitted they should do more PA themselves and stated that some of the teachers should support the adolescents more in being physically active. Whilst they were all motivated to do so, including those who weren't supporting them at the moment, they admitted that it was difficult to actually do this. Some school staff members referred to the indispensable and important role parents play, but stated that parents not always fulfil this role. School staff from rural areas said to encourage the parents to support their children being active.

School staff from both low and high SES mentioned to be limited by the schools' economic reality and the associated financial constraints. In low SES schools, financial constraints impede providing PA opportunities, facilities or even PA teachers, whilst in high SES additional activities organized outside the curriculum need to be covered by parents and is not included in the school fee, as they would prefer. For low SES schools financial constraints were mentioned more.

3.4.3 Societal environment: popular media, new transport modes, and role modelling

Adolescents and parents mentioned adolescents' preferences for media use, but didn't relate this directly to changing PA patterns. Nonetheless, school staff reported that PA patterns of adolescents have become unhealthy and related this to the increased interest of adolescents in sedentary activities such as TV, computers and videogames. These new and highly available technologies capture the interest of children stimulating sedentary behaviour and distracting them from being active. However, these changes were not only associated with adolescents' behaviour, as everybody likes these media.

Moreover, a decline in walking was mentioned by school staff due to new transport modes such as cars and busses, large distances to go to school and safety concerns. In the rural area, this change was related to improved roads and cars becoming more available, whilst in the urban area, increased insecurity and robberies enhanced car use. Some rural parents mentioned that farming activities require less strength due to the technology available now than when they were young and adolescents are nowadays less tough.

At the societal level, all participant groups referred to a famous Ecuadorian athlete as an important role model.

3.4.4 Built environment: traffic and crime concerns, geographical distances

Some adolescents mentioned safety concerns, but referred more to their parents' fears than their own. Parents and school staff mentioned safety concerns to a higher extent. In urban areas, parents and school staff expressed their worries about the dangerous traffic situation, as well as high crime rates in certain areas. They agreed that the road is too dangerous for adolescents to walk or bike.

Geographical aspects such as long distances to walk or bike to school were mentioned by all three participant groups as a reason to use the car instead. In addition, it was reported that there are no bike lanes.

3.5 Conceptual frameworks

Based on our findings two composite conceptual frameworks were proposed, in which adolescent eating (**Figure 11**) or PA (**Figure 12**) behaviour is conceptualized as a function of the identified individual and environmental influences. The framework emphasizes the interaction of factors within and across these levels of influence. All of these factors may directly or indirectly influence adolescents' dietary or PA behaviour. In addition to the more traditional influencing factors, the following culture-specific key factors were identified for our population: perceived food safety, lack of self-control, financial autonomy, habit strength, and changes in socio-cultural (increased workload, changed food patterns, new transport modes), and built environment (traffic and crime perceptions, distances). Furthermore, as acknowledged previously (187), our findings indicated that the influence of these factors on behaviour may differ according to SES and setting. This multilevel, interactive framework is useful for understanding and explaining the factors influencing dietary and PA behaviour in Ecuadorian adolescents.

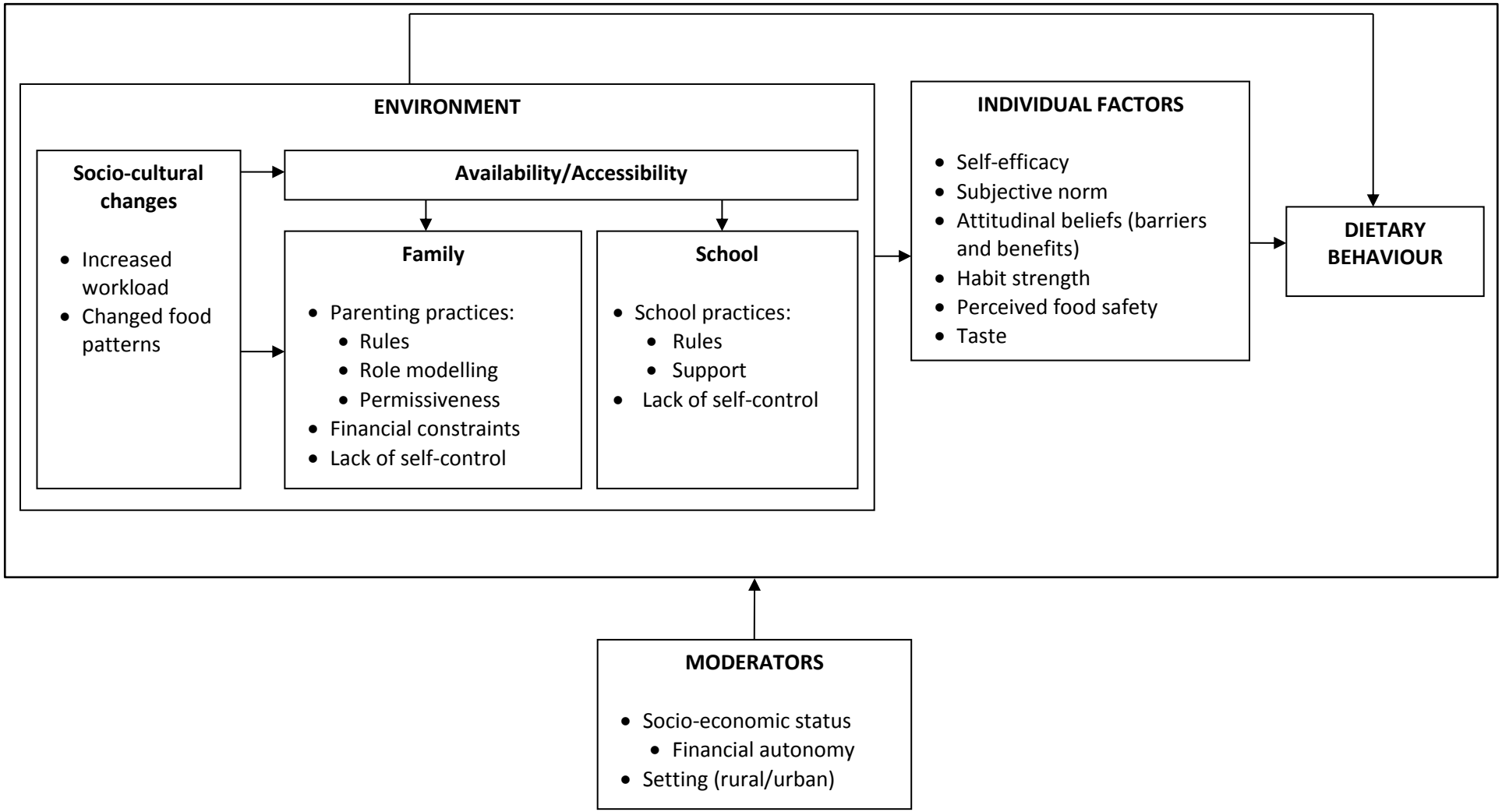


Figure 11 Conceptual framework for healthy eating behaviour in an Ecuadorian population

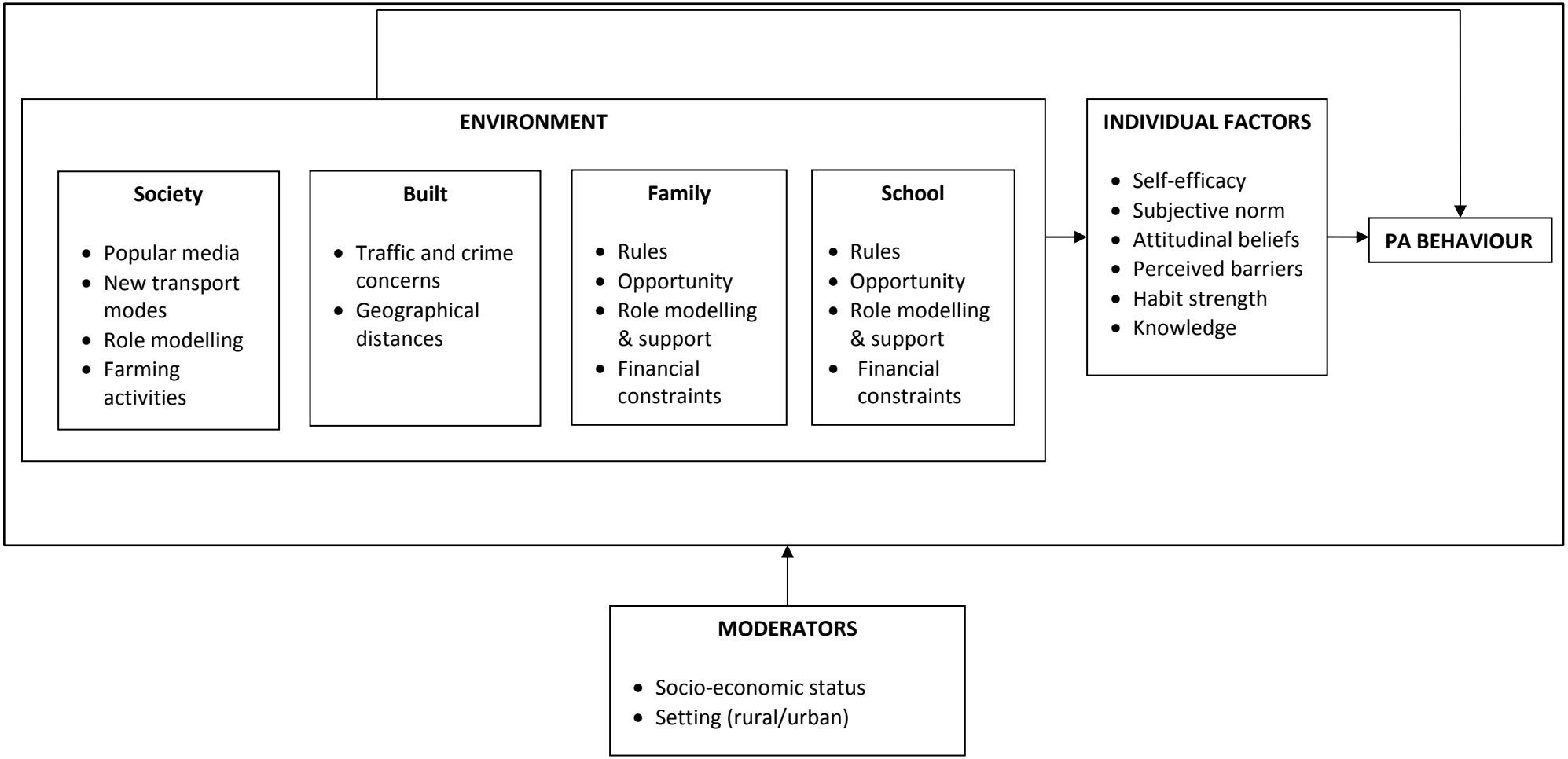


Figure 12 Conceptual framework for PA behaviour in Ecuadorian adolescents

4 Discussion

4.1 Dietary behaviour

Eating behaviour is influenced by inter-related factors reflecting ones' personal, social and cultural experiences and environment (79;81). In addition, the reasons for choosing particular foods are closely associated with concerns over identity, image and social belonging (81) which is ubiquitous in adolescence. Several culture-specific key factors - perceived food safety, lack of self-control (attribution error), financial autonomy, habit strength and changes in socio-cultural environment - emerged from focus groups endorsing the importance of the development of a conceptual framework in this population for future interventions.

First, participants often associated eating healthily with food safety issues and home-grown or -prepared food rather than with nutritional quality of their diet as a whole, which had an impact on which foods were prohibited at school and on adolescents' food choices. The importance of food safety in defining eating healthily has been noted in previous research as an important factor for LMICs (201).

Whilst school staff recognized their role in shaping adolescents' dietary behaviour, they minimized their responsibility. They saw parents as gatekeepers of adolescents' poor eating habits, suggesting that parents need to act as positive role models. However, parents evoked their work commitments, the changing socio-cultural environment, schools and their children's food preferences as key influences on food choice. This concept of attribution error, i.e. blaming situational factors when justifying one's behaviour, has been demonstrated previously (202).

Increasing financial autonomy, which coincides with the transition from primary to secondary school, played a large part in adolescents' food choices. This confirms previous findings in Vietnamese adolescents, where pocket money increased eating out frequency (203). Starting secondary school is a critical period of increasing independence as the extent of parental support for eating healthily decreases and the desire to fit in with peer norms increases (45). This process, in conjunction with easy access and constant exposure to tasty and unhealthy food in schools, explains the adolescents' indication of their deteriorating eating habits. This deterioration is accentuated further by the increasing difficulty adolescents have to eat healthily within the rapidly changing socio-cultural environment, which has impacted on family life and food availability, mirroring the ongoing nutrition

transition in Ecuador (67) and other LMICs. Ready-to-eat meals in large portion sizes are now the norm, due to busy family work schedules. A similar pattern has occurred in other countries where women's roles have changed, leading to a loss of cooking skills and an increasing reliance on convenience foods (204). A daunting prospect, as eating out and relying on convenience foods has been associated with poor dietary intake in LMICs (205).

In line with previous findings from HICs, taste (206), availability and accessibility (201;207), self-efficacy, financial constraints, time and convenience (79;207) emerged as important features in adolescents' food choices. In addition, strong subjective peer norms were present - choosing to eat healthily was often associated with an untrendy image leading to teasing from others and marginalization - supporting the preferences for unhealthy foods of adolescents. Similarly, Stead *et al.* (2011) found that *"it's emotionally and socially risky to be seen to be interested in healthy eating"* for adolescents in school and peer contexts (81). To conclude, rules at home and at school were inconsistent, so adolescents were likely to receive contradictory messages that they regarded as marginal and they developed strategies for buying their preferred food elsewhere. This might be an indirect indication that parental influence is less important in this group than peer influence. Similar associations between mixed messages and adolescent eating preferences have been found in previous research (208). Nevertheless, the impact of parents might differ across behaviours (e.g. fruit and vegetable consumption versus sugary drink intake) (209).

Few socio-demographic differences emerged. Availability and financial constraints clearly differed between the rural and urban area and the socio-economic groups, supporting findings from previous focus groups in LMICs (201). These differences might explain why participants from rural and low socio-economic schools reported lower availability of healthy food at home and could not afford to buy "healthy foods". The importance of socio-demographic factors as moderating factors or effect modifiers of behaviour has been established previously (210;211). This means that influencing factors may have differential effects on behaviour with respect to SES (75;187;212) and setting (213), which therefore supports the inclusion of these as moderating factors in the conceptual framework.

4.2 PA behaviour

Key individual and environmental factors in shaping Ecuadorian adolescents' PA behaviour emerged from focus group discussions with adolescents, parents and school staff. Based on the identified factors and influencing relationships, a conceptual framework was developed. This framework

provides points of leverage for developing a health promotion intervention and can provide valuable insights to identify possible mechanisms of behaviour change. Factors at different levels played a role in influencing PA which indicates the need for multicomponent interventions, i.e. the involvement of school, family and community level, which has been shown to be an effective strategy to increase PA (186;214;215).

Several factors identified in this study were similar to those from previous studies (80;127;187;216). Time constraints and laziness were perceived as barriers to PA. Moreover, even though adolescents reported positive attitudes towards PA and expressed the will to be more active, all three participant groups expressed the adolescents' preferences for sedentary activities (e.g. TV viewing, listening to music, play station). For many adolescents, media use was even the most preferred activity. Although adolescents themselves related lack of time for PA mainly to overload of homework and household tasks, media use has also been found to be an important factor interfering with time for PA (217). Objective data from the global school-based student health survey demonstrated that 32.2% (±2.0) of adolescents in urban Ecuador and 28.5% (±5.0) of rural Ecuadorian adolescents are engaging in sedentary activities for three or more hours per day (218). This calls for a decrease in media use, in addition to efforts to increase PA. Reducing time spent on sedentary activities was previously suggested as one plausible strategy, among others, to reduce physical inactivity among youth (145;146;219). Given that sedentary behaviour is distinct from physical inactivity and reducing sedentariness does not simply result into more PA (220), efforts focusing on sedentary behaviours must go along with actions to increase PA. However, very few school-based interventions in LMICs target sedentary behaviours (186). This is particularly concerning in the light of the ongoing shift toward more sedentary lifestyles in LMICs (71).

Furthermore, farming or household activities and the economic situation appeared to have an impact on PA. Rural parents reported encouraging their children to be active, although they found it difficult due to assistance required from their children in farming. Similarly, urban parents required the need for help in household chores. Surprisingly adolescents did not perceive farming or household chores as PA, even though PA was explicitly defined as covering various domains (leisure-time, home-based activities, transport etc.) (221) in the beginning of the focus group discussions. Greater awareness among adolescents and parents that lack of time is not necessarily a barrier and that PA can be integrated into simple daily routine activities, such as farming or household activities seems to be vital. In addition, forms of intangible support like encouragement have been proven to have positive

effects on the PA behaviour of adolescents (222;223). Even though this association has not been found for LMICs (78), it seems important to motivate parents for encouraging their children.

Rural adolescents have been observed to be more physically fit than their urban counterparts but at the same time they engaged more in sedentary activities and rural males less in moderate to vigorous PA at weekends (224). Except for time constraints for rural adolescents to engage in leisure-time PA due to household and farming activities, this may be partly associated with perceived low self-efficacy and fear of injuries observed among lower SES adolescents in general. Even though in this study self-efficacy did not seem to be important, previous studies show strong evidence for a positive association between PA and self-efficacy (216;223).

An important finding of this study was the crime and traffic safety concerns of parents in urban areas. The high impact of environment on PA levels has been established previously (187;225) and in particular for neighbourhood safety concerns (226). However, most of these associations are based on perceptions of environment rather than on objective measures in LMICs (78). Nevertheless for instance in regard to crime concerns, objective data on crime in Ecuador confirmed that this can be potentially influential (227).

Moreover, adolescents referred to their parents' fears when it came to safety concerns, rather than their own. It has been previously shown that associations between built environment and PA levels are less strong for adolescents than for adults (228) and that parents' concerns about neighbourhood safety have stronger influences on children's PA than children's own views (226;229). Combined with the limited opportunities to be active at school and at home, and the expressed need by both parents and adolescents for variety in terms of PA, this offers a window of opportunity for intervention strategies. Several strategies such as providing access to school facilities, providing equipment, and identifying ways to promote encouragement for PA have been found to be associated with an increase in PA levels during recess periods (230).

4.3 Strengths, challenges, and recommendations

Adolescent participants might have experienced difficulties in sharing their views within the focus groups due to social desirability and peer pressure. Yet, we do not believe this influenced our results to a great extent, as the moderator tried to establish a friendly and comfortable environment encouraging active participation and secondly, and more importantly, findings did not differ across adolescent groups. We aimed at minimizing bias by using triangulation and standardized data

collection procedures. Since parents and school staff re-iterated the findings of the adolescent focus groups we can assume these findings are valid. Furthermore, despite the accumulating evidence of unhealthy dietary and PA practices (2;140), both behaviours remain poorly understood in young people in LMICs. Few attempts have been made to use theory to guide the development and evaluation of interventions (186). Additionally, testing the validity of these theories, i.e. their appropriateness to specific cultures and local contexts, is rarely undertaken (231). This study adds to the current evidence-base, by identifying key factors influencing Ecuadorian adolescents' eating and PA behaviour and developing composite conceptual frameworks accordingly. The factors identified within these frameworks should be investigated using culturally appropriate scales with good psychometric properties. Doing so would allow these frameworks to be tested by evaluating the inter-relationships and association of these factors with dietary behaviours. Additionally, it facilitates tailoring of intervention strategies towards these factors, and could be used to identify pathways of behaviour change when evaluating interventions (231).

Our conceptual frameworks indicate that future interventions should not only consider individual, peer and family influences when aiming to change adolescent eating and PA habits, but should target the physical school, social and built environment as well, which is consistent with findings from other studies (232). A particular focus on school policies including regulation on food sold at the tuck shop based on its nutritional value, control of food practices and changing the PA opportunities is needed. Such strategies need to be tailored to the specific settings and socio-economic conditions, even though this might be challenging (186). Specifically, the intervention should take into account the issue of attribution error amongst parents and school staff. Despite the possible relative importance of parents, they still play an important role in the daily life and dietary behaviour of adolescents and should be included when designing interventions (211), particularly in LMICs (186). On a positive note, all participant groups requested practical advice on how to eat healthily and develop skills for being active.

5 Conclusion

Focus groups provided a clear insight into the factors that are perceived to influence adolescents' dietary and PA behaviour. Adolescents, parents and school staff identified financial autonomy, food safety, self-efficacy, habit strength, the built environment and socio-cultural changes as key cultural factors in adolescent's food and PA choices. As a consequence, two conceptual frameworks for adolescents' eating and PA behaviours emerged, which highlights points of leverage for developing

future interventions. Interactions between the identified factors in the conceptual framework and eating behaviours should be studied using structural equation or mediation analysis.

Box 3 Key messages on individual and environmental influences on eating and PA behaviour for intervention development

- Financial autonomy, food safety perceptions, lack of self-control, habit strength, peer norms, built environment and socio-cultural changes were identified as key factors in adolescent's food and PA choices;
- Two composite conceptual frameworks for Ecuadorian adolescents' eating and PA behaviour were developed and the inter-relationship and association of these factors with dietary behaviour should be evaluated using good psychometric scales;
- The frameworks should be used to facilitate tailoring of intervention strategies towards the identified factors and further identify pathways of change when evaluating interventions;
- Future interventions should combine individual influences with influences from the physical school and social environment. They should also focus on school policies, including regulation on food sold at the tuck shop and PA opportunities;
- It is recommended to include parents when designing interventions despite their possible relative impact which might differ across behaviours;
- SES and setting should be measured to evaluated their possible role as effect modifier of behaviour.

Chapter 5:

Individual and environmental factors influencing adolescents' eating behaviour in LMICs: a structural equation modelling analysis

Summary

Background: Given the public health importance of improving dietary practices in chronic disease prevention in LMICs it is crucial to better understand dietary behaviour and its influencing factors in these settings.

Objective: This study tested the validity of a conceptual framework to explore differences in influence of individual and environmental factors on eating behaviour amongst adolescents aged 11 to 16 years, and to assess socio-economic variations.

Design: A cross-sectional survey was conducted in 784 school-going Ecuadorian adolescents in urban and rural Southern Ecuador. Participants provided data on SES, anthropometry, eating behaviour and factors influencing it. The relationships between individual (attitudinal beliefs, self-efficacy, habit strength and perceived food safety) and environmental (accessibility, parenting and school practices) factors and their influence on key components of eating behaviour were modelled using structural equation modelling. Key components examined were fruit and vegetable, sugary drink, breakfast and unhealthy snack intake. We performed a multiple group analysis to examine whether these relationships differed according to SES.

Results: The conceptual model performed well for each component of eating behaviour, indicating acceptable goodness-of-fit for both the measurement and structural model. Models for vegetable intake and unhealthy snacking showed significant and direct relationships between individual factors and the behaviour. Estimates for the association between perceived benefits and vegetable intake and unhealthy snacking were similar, although worked in opposite directions. For breakfast and sugary drink consumption there was a direct and positive association between environmental factors (school support and parental permissiveness) and these eating behaviours. Except for sugary drink intake, accessibility of a healthy diet indirectly influenced dietary behaviour, mediated through school support. Habit strength and self-efficacy were associated with sugary drink intake and unhealthy snacking for poor adolescents but not for those who were better-off, respectively.

Conclusion: This is a comprehensive and valid model which specified the inter-relationships of individual and environmental factors and their influence on key components of adolescents' eating behaviour. The results indicate that the influence of these factors varied with reference to the different components of eating behaviour and SES. Different interventions for SES are warranted.

1 Introduction

The prevalence of childhood obesity has reached alarmingly high levels in low-and middle-income countries (LMICs) (8;19). Poor dietary behaviour is a key factor in the onset of obesity and an important contributor to the global disease burden (2). Despite the accumulation of evidence illustrating unhealthy food practices among young people in LMICs (233;234), their dietary behaviour remains poorly understood. To further the evidence-base for LMICs, insight is needed in why young people engage in dietary risk behaviours. Behavioural theories and conceptual frameworks have been recommended to identify and better understand influences on dietary behaviour (235). However, this comes with a number of conceptual and methodological challenges.

Firstly, the majority of these theories so far have been developed for American or European adults (236) and testing their validity, i.e. their appropriateness to specific cultures and local context, has rarely been undertaken (186;231). Furthermore, it has not been specified at what ages these models apply (237). As such, they may not be applicable nor transferable to young people living in LMICs. Secondly, much of what is known about the individual (e.g. self-efficacy and habit strength) and environmental (e.g. parental permissiveness and availability) factors influencing dietary behaviour originates from qualitative studies (238;239). Few attempts have been made to use theory to select and operationalize such factors (192). Ideally, qualitative studies would select factors (guided by theory) associated with dietary behaviour and generate a thorough understanding of how these factors vary according to gender, age, geographic location or SES within a specific population (57;192). The latter is particularly important, as obesity and other diet-related chronic diseases disproportionally affect the poor (13-15) and thereby further contribute to inequality (240). The subsequent conceptualization and operationalization of these factors should, similarly as for selecting factors, adequately reflect ones' personal, social and cultural experiences and environment (79;81). This is ensured by gathering data from the participant population to i) build a conceptual framework that examines the relationship between factors and behaviour and ii) develop culturally appropriate and valid psychometric scales to operationalize these factors, reflecting the cultural and social reality of young people in LMICs (236). Lastly, well-articulated, i.e. evidence- and theory-based, conceptual models that can examine the pathways by which individual and environmental influences interact and affect eating behaviours are lacking (76;192). These influences can act both directly, but also indirectly, via a number of hypothesized mediating pathways (76).

A recent qualitative theory-based study we undertook in Ecuadorian adolescents showed that fruit and vegetable intake were perceived as vital to healthful eating. The adolescents also understood the concept of healthful eating to encompass a limited intake of nutritionally poor foods and erratic behaviour such as skipping breakfast. This study resulted in a composite conceptual framework, where eating behaviour was conceptualized as a function of individual and environmental influences (241). We sought to further the evidence of conceptual models (theory- and evidence-based) by determining and quantifying relationships (direct and indirect) between factors and their influence on key components of eating behaviour. These key components (fruit and vegetable, sugary drink, breakfast, and unhealthy snack intake) tied in well with how adolescents viewed healthy eating (241) and reflected important problems with their current eating behaviour (68). Furthermore, each of these components has been independently associated with a high risk of chronic diseases (2;72-74;242). We also explored if there was a differential effect on eating behaviour with respect to SES, as has been suggested by the qualitative study (241).

2 Methods

2.1 Design and study population

This study used data from a cross-sectional survey that was conducted in Ecuador from January 2008 to April 2009. Participants were 10-16 year old adolescents (*n*=784) from an urban (Cuenca) and rural (Nabón) area in Ecuador. Two different sampling frames were used for each area: all school-going children willing to participate were included in Nabón, whilst a two-stage cluster design was used (with schools as primary and classes as secondary sampling units) in Cuenca. Adolescents were excluded if they were pregnant, followed a special diet or suffered from a severe medical or physical disorder. A detailed description of the sample and study procedures is given elsewhere (67).

The study protocol was granted ethics approval from the Ecuadorian and Belgian Ethical Committees (CBM/cobi-001; FWA00002482). Informed assent was obtained from all participants whose respective parents/guardians provided written informed consent.

2.2 Measurements

Data were collected at school during class time by a research team trained according to the defined protocol and training manual.

2.2.1 Socio-demographic attributes

Data on age, gender, geographic location and SES were collected. The latter was assessed using a method developed by the Integrated Social Indicator System for Ecuador (243), based on World Bank recommendations (244). This method measures poverty using the "Unsatisfied Basic Needs" criteria and classifies a household as poor when one or more serious deficiencies in access to basic needs (such as education, health, nutrition, housing, urban services and employment opportunities) are present. Using this method, participants were classified into two groups: "Poor" and "Better off" (i.e. if no deficiency was reported).

2.2.2 Anthropometric measurements

Anthropometric measurements were carried out in duplicate by two trained researchers who ensured optimal privacy. Adolescents wore light clothing but no shoes during the measurements. Height was measured to the nearest 0.1 cm with a portable stadiometer (model PORTROD, Health O Meter, USA) and body weight to the nearest 0.1 kg using a digital calibrated balance (model SECA 803, Seca GmbH & CO, Hamburg, Germany). Adolescents were then classified into age- and sex-specific BMI categories (162;163).

2.2.3 Eating behaviour

Dietary intake was measured using two interview-administered 24h dietary recalls on a randomly selected weekday and weekend day. Local measures were calibrated and used by the trained interviewers to quantify the amount of food consumed. A food composition database was compiled using databases from the US (USDA, 2012), Mexico (INNSZ, 1999), Central America (INCAP/OPS, 2012) and Peru (CENAN/INS, 2008). When detailed information on the ingredients and/or cooking methods of recipe was not available, recipes were prepared in triplicate by local volunteers. The ingredients used, and their weights, were measured and averaged to obtain a final estimate for the recipe. For locally processed and pre-packed food items, food labels were used to obtain the food composition.

Data for the identified key components of dietary behaviour were extracted from both the 24h recalls. Fruit and vegetable intake were examined individually and combined. Sugary drinks included all soft drinks, fizzy drinks, energy drinks, and juices with added sugar. Breakfast was defined as a meal consumed between 5:00 – 7:00 am and 5:00 – 8:00 am for schools with a morning and afternoon schedule, respectively. Unhealthy snacks were defined as processed foods (e.g. sweets,

salty snacks, and any other packaged food) eaten as a morning, afternoon or evening refreshment. Sugary drinks and fruit and/or vegetable intake were calculated as an average daily intake (g/day) over both days to best represent habitual intake. Breakfast and unhealthy snacking intake were expressed as a percentage of daily energy intake averaged over both days (E %/day).

2.2.4 Conceptual framework: assessment of individual and environmental factors influencing eating behaviour

The conceptual framework including key individual and environmental factors for dietary behaviour is illustrated in **Figure 11** (241). To enable quantification of the inter-relationships of these factors and their influence on key components of dietary behaviour, factors were operationalized using a self-administered questionnaire. The socio-demographic attributes were assessed using quantitative measures. As no culturally appropriate and validated psychometric scales to measure these factors existed, a questionnaire was developed using qualitative data from this population (241), relevant literature (245) and the experience of the research team. The questionnaire was piloted for understanding and readability using cognitive interviewing (a qualitative process encompassing two main techniques: think aloud interviewing and verbal probing) (246). The questionnaire was administered twice with a four week interval to 202 participants. Both single and multiple items were used to measure all factors (i.e. constructs) in the framework, except for socio-cultural changes and lack of self-control for family and school. Items in the questionnaire were measured using 5-point interval scales (agree/disagree; hard/easy; always/never). Items were recoded into the same direction so that higher construct scores corresponded to the most favourable conditions for healthy dietary practices (e.g. a high score on barriers indicates fewer barriers). Sum scores were made for each construct. Construct validity, i.e. internal consistency and repeatability of the questionnaire was assessed using Cronbach's alpha and Intraclass Correlation Coefficients (ICC), respectively.

2.3 Statistical analysis

Anthropometric, socio-demographic and questionnaire data were entered in duplicate in Epidata (Version 3.14, Odense Denmark) by two researchers. Food intake was entered using an online software package designed for 24h dietary recalls (Lucille software 0.1, 2010, Ghent University; http://www.foodscience.ugent.be/nutriFOODchem/foodintake). Data on food intake, anthropometry, socio-demographics, questionnaire and construct validity were analysed using Stata (Intercooled Stata version 12 Statacorp, college station, TX, USA). Descriptive data were reported as

percentages or as mean and SD for normal and as median and IQR for non-normally distributed variables. Statistical significance was set at an alpha level of 0.05 and all tests were two-sided. Differences in means or proportions of variables were assessed using OLS regression accounting for clustering. When necessary, continuous variables were transformed to a normal distribution.

2.3.1 Construct validity analyses

A comprehensive assessment of the scale quality was performed (247). First, an exploratory factor analysis to determine the presence of latent constructs in the questionnaire was conducted. Item distribution and variation was examined using descriptive analyses. Internal consistency of each construct was examined using Cronbach's alpha; values of alpha > 0.50 were considered acceptable as *i*) it was a newly developed questionnaire and *ii*) some constructs included only a few items (248). Repeatability (test-retest) of the questionnaire was examined using the ICC to assess absolute agreement between single items or the sum scores of the constructs; values of ICC < 0.30 were considered as poor.

2.3.2 Structural equation modelling analyses

Structural equation modelling (SEM) was conducted to allow statistical testing of the inter-relationships of constructs and their relationship with the key components of dietary behaviour in our participant population. SEM is a multivariate technique that allows for the modelling of a series of hypothesized relationships simultaneously. It combines aspects of factor analysis and multiple regression and allows for the inclusion of observed and unobserved (latent) variables (i.e., theoretical constructs) to determine whether the hypothesized associations are consistent with data of the participant population (249;250). Prior to modelling any relationship between latent variables, a measurement model was evaluated for each component of dietary behaviour. This step involves a confirmatory factor analysis to confirm the relationship between the latent variables (constructs) and their indicator variables (items). The following step, i.e. the testing of the structural model, estimates the strength of the relationships between these latent variables. It also allows for examining the direct and indirect effects among the constructs in the model. Data were examined prior to modelling to ensure they met assumptions of performing a SEM and analysed using the robust maximum likelihood procedure in LISREL 8.72 (251). Although a cluster sampling design was used, multi-level techniques were not used for the SEM analysis. It has been shown that using this technique when there's limited between cluster variability, that is when ICC < 0.25 (in our case: all ICC's < 0.1) and the number of clusters < 100 (in our case: n=34) results in improper results (252).

Correlation coefficients were calculated between the variables of interest. All correlations were below 0.70, thus multi-collinearity was not a concern in the present data (253). Path coefficients were then estimated and the general fit of the model was assessed for each component of dietary behaviour. To evaluate the goodness of fit of the model, the χ^2-value together with degrees of freedom are reported, as well as four other indices: the root mean square error of approximation (RMSEA), the normed fit index (NFI), the non-normed fit index (NNFI) and the comparative fit index (CFI). The χ^2-value has traditionally been used to test the hypothesis that the relationships suggested in the model provide a plausible explanation of the data, i.e. how well the proposed model structure fits the structure in the observed data set. It is however sensitive to sample size; a large sample size increases the power to reject the models. Other fit indexes have been proposed to compensate for this problem. The RMSEA is a measure of discrepancy between the true population model and the hypothesized model with unknown but optimally chosen parameter estimates. In other words, it favours a more parsimonious model with fewer parameters. It is relatively insensitive to sample size, since it is a population-based index (254). The CFI and NNFI both compare the fit of the hypothesized model to that of a baseline or null model, where all parameters are assumed to be independent. Values below 0.08 for RMSEA (255) and above 0.90 for NFI, NNFI and CFI (249) indicate an acceptable fit of the data to the hypothesized model. One requirement for using SEM for model testing is complete data with no missing values. To minimize exclusion of observations from the analyses, imputation of missing data values of constructs was performed using the expectation-maximization algorithm (1000 interactions) for those included in SEM analysis (256).

Separate SEM analyses were first conducted for each of the dietary behaviours. We then examined if SES modified the effect of the influencing factors by fitting the model for each of the dietary behaviours separately for poor and better-off adolescents. The sugary drink model did not run for these different groups. When a sensitivity analysis, excluding outliers (*n*=11), was performed the model did run for both SES groups.

3 Results

3.1 Participant characteristics

Of the 784 recruited adolescents, 751 adolescents (50.4% male) were included in the final SEM analysis. Those excluded had no data on anthropometry (*n*=5), dietary behaviour (*n*=5), socio-demographic factors (*n*=5) or questionnaire on factors (*n*=18). Excluded adolescents represented

4.2% of the initial sample. They did not differ in terms of mean age (*P*=0.87) and sex (*P*=0.81), but excluded adolescents tended to be poorer (*P*=0.03). Characteristics of the participants are shown in **Table 12**. Mean age of the included participants was around 14 years; 20.1% of the adolescents were overweight or obese and 4.5% were underweight. More than half of the participants (55%) had a low SES; nearly all poor adolescents came from rural areas. BMI was significantly lower in poor adolescents when compared to their peers who were better-off. Whereas age and gender did not differ according to SES.

3.2 Key components of eating behaviour

Overall, median fruit and vegetable intake was rather low, whilst median sugary drink intake was substantial in our population. Over one-fifth of daily energy intake came from unhealthy snacking, similar to the E% originating from breakfast. Only differences in sugary drink and breakfast intake were significant between poor and better-off adolescents. For breakfast intake the median was significantly higher in poor vs. better-off adolescents. The median of sugary drink intake in better-off adolescents was twice as high as in poor adolescents (**Table 13**).

3.3 Construct validity

Constructs were examined to specify the conceptual framework and the subsequent model for structural equation modelling. Internal consistency (Cronbach's alpha) and repeatability (ICC) were acceptable to good for most of the items. However, the following constructs had an alpha < 0.50 or an ICC <0.30 and were not retained in the model: subjective norm; parental rules, parental modelling, school rules and taste. The retained constructs and their items, ICC and Cronbach's alpha are presented in **Table 14**. The resulting framework, which was further validated using SEM analysis is shown in **Figure 13**.

Table 12 Participant characteristics

Variables	Total (*n*=751)	Poor (*n*=415)	Better-off (*n*=336)	*P* value
Gender (% male)	50.4	47.2	54.1	0.25
Age (mean (SD) y)	13.6 (1.2)	13.7 (1.3)	13.6 (1.1)	0.82
Setting (% urban)	79.0	64.3	97.3	<0.001
BMI (mean (SD) kg/m²)	20.3 (3.1)	20.0 (2.9)	20.6 (3.3)	0.04

SD, standard deviation; y, years; BMI, Body Mass Index

Table 13 Key components of dietary behaviour as measured by two 24h dietary recalls

Dietary behaviour	Total (*n*=751)		Poor (*n*=415)		Better-off (*n*=336)		Δ[1]	*P* value
	Median	IQR	Median	IQR	Median	IQR		
Fruit (g/d)	121.8	156.6	126.2	154.8	114.6	158.6	11.6	0.83
Vegetables (g/d)	49.7	56.7	50.3	62.2	49.4	50.0	0.9	0.48
Fruit and vegetables (g/d)	180.8	177.0	186.1	175.6	174.4	181.3	11.7	0.48
Sugary drinks (g/d)	150.0	300.0	99.0	237.5	201.6	346.2	–102.6	0.03
Breakfast (E%/d)	21.6	13.6	23.1	13.6	19.4	12.1	3.7	0.002
Unhealthy snacking (E%/d)	22.2	31.0	20.0	30.9	24.6	30.8	–4.6	0.13

IQR, Inter Quartile Range; [1] Poor - Better-off

Table 14 Cronbach's alpha and Intra-class Correlation Coefficient for retained constructs in the model at individual and environmental level

Constructs	Items	Cronbach's alpha	ICC sum score
Individual level			
Self-efficacy	Suppose you want to eat healthily. How hard is it for you to eat healthy every day? Suppose you want to eat healthily. How hard is it for you to eat healthy at home? Suppose you want to eat healthily. How hard is it for you to eat healthy at school?	0.66	0.58
Attitudinal beliefs			
Perceived benefits	If I eat healthily it helps me to control my body weight If I eat healthily it makes me feel better	0.64	0.31
Perceived barriers	Unhealthy food is cheaper Healthy food is not available when I am eating Healthy foods don't taste good I've been eating fast food since I was young My parents don't have time to cook healthy food My body needs unhealthy food Breaks at school are too short to eat healthily I eat unhealthily because I want to eat the same as my friends	0.71	0.44
Habit strength	I eat snacks or fast food when I watch TV I eat snacks or fast food when I go out with friends I eat snacks or fast food when I am going to sports training I eat snacks or fast food when I go on a family trip	0.56	0.46
Perceived food safety	Eating healthily is eating food without chemicals	NA	0.22
Environmental level (home and school environment)			
Parental permissiveness	My parents let me eat fast food ("Pitty's", French fries, hamburgers, etc) and snacks (ice cream, jelly, candies, etc.) whenever I want to My parents let me drink sodas whenever I want to	0.51	0.53
School support	How often does your school/teachers encourage you to eat healthily? How often do your teachers/school give you information regarding healthy eating?	0.76	0.40

Constructs	Items	Cronbach's alpha	ICC sum score
Accessibility to healthy food	My family can't afford to buy healthy food	0.62	0.47
	There is no weekly market in my neighbourhood		
	Healthy food that is sold around my place is spoiled		
	The places selling healthy food are far from my house		

ICC, Intraclass Correlation Coefficient; NA, Not Applicable

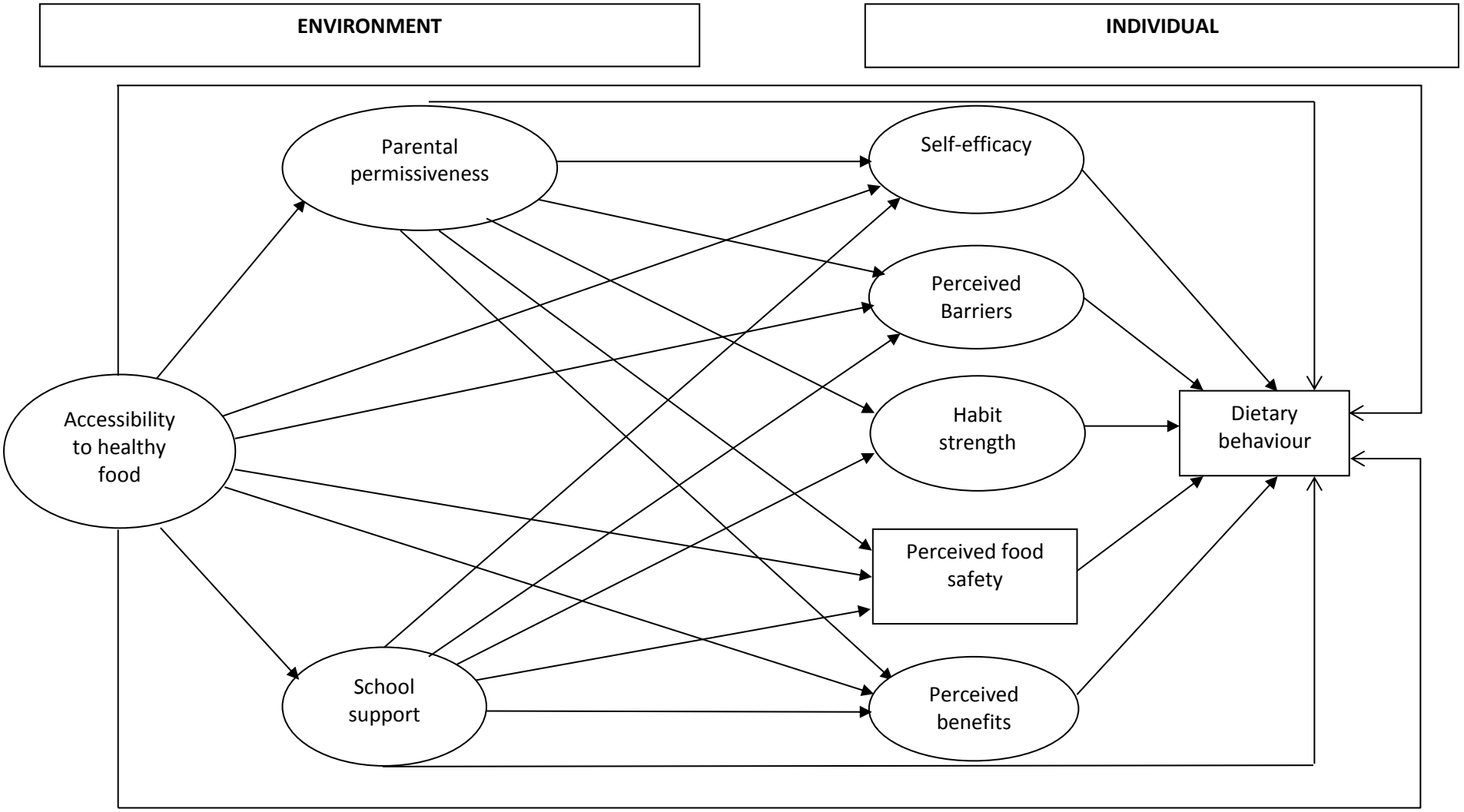


Figure 13 Specification of a SEM for predicting dietary behaviour, including mediation effects. Rectangles indicate observed variables, and ellipses latent variables

3.4 Structural equation modelling: conceptual framework

3.4.1 Goodness-of-fit of the models

The confirmatory factor loadings were significant at the 0.05 level and ranged from 0.4 to 0.86. The overall fit of the measurement model was adequate according to standard criteria ($\chi^2(271) = 503,72$, $p< 0.001$; RMSEA = 0.034; NNFI = 0.94; CFI = 0.95, GFI = 0.95). Using these same fit criteria, the overall fit of the structural models predicting fruit, vegetable, fruit and vegetable, unhealthy snacking, sugary drink, and breakfast intake was also adequate (*See* **Figure 14-16** for more details).

3.4.2 Interrelationships of the constructs

The majority of the hypothesized inter-relationships of individual and environmental factors were confirmed and appeared to be similar for each examined component of dietary behaviour (*See* **Figure 14-16** for more details). Greater accessibility to healthy food was associated with fewer perceived barriers to eating healthily and lower perceived food safety, and inversely associated with support from the school to eat healthily. Having less permissive parents was directly associated with higher self-efficacy, fewer perceived barriers and less strong unhealthy eating habits. Furthermore, greater school support was associated with higher perceived benefits of eating healthily and negatively associated with habit strength. The relationship between parental permissiveness and habit strength was the strongest in the model, suggesting that adolescents with more permissive parents had stronger unhealthy eating habits. A second strong and obvious relationship in the model was the link between greater accessibility to healthy food in the environment and fewer perceived barriers to eating healthily.

3.4.3 Sugary drink intake

Parental permissiveness had a negative direct effect on sugary drink intake, indicating that adolescents of more permissive parents consumed more sugary drinks. None of the individual factors were related with sugary drink intake (**Figure 14**).

3.4.4 Breakfast consumption

School support to eat healthily predicted breakfast consumption, meaning that a more supportive environment at school to eat healthily increased the consumption of breakfast in adolescents. Additionally, the perceived accessibility to healthy foods in the environment influenced breakfast consumption indirectly through its effect on school support (**Figure 15**).

3.4.5 Fruit, vegetable, and fruit and vegetable intake

In contrast to both previous models, none of the environmental factors were directly associated with fruit, vegetable or fruit and vegetable intake (**Figure 16**). Adolescents having high perceived benefits of eating healthily were eating more vegetables, though significant, the strength of this association was rather low. This association was not significant for fruit intake or fruit and vegetable intake. The indirect effect of school support on vegetable intake operated through perceived benefits and in its turn, school support was influenced by accessibility. Thus, adolescents' perception on the accessibility to healthy food in the environment indirectly influenced their vegetable intake.

3.4.6 Unhealthy snacking

Perceived benefits of eating healthily were directly associated with unhealthy snacking, and the indirect relationship between accessibility to healthy food and unhealthy snacking was likewise facilitated by school support and perceived benefits (**Figure 17**). This indicates that a better understanding of the importance of healthy eating (perceived benefits) is associated with higher intake of unhealthy (processed) snacks. Furthermore, the perception of healthy foods being safe was inversely and directly associated with the consumption of unhealthy snacks. This perceived food safety mediated the relationship between the accessibility to healthy foods and consuming unhealthy snacks. Thus, adolescents reporting low access to healthy foods feel less that healthy foods are safe and as a result have a higher consumption of unhealthy snacks.

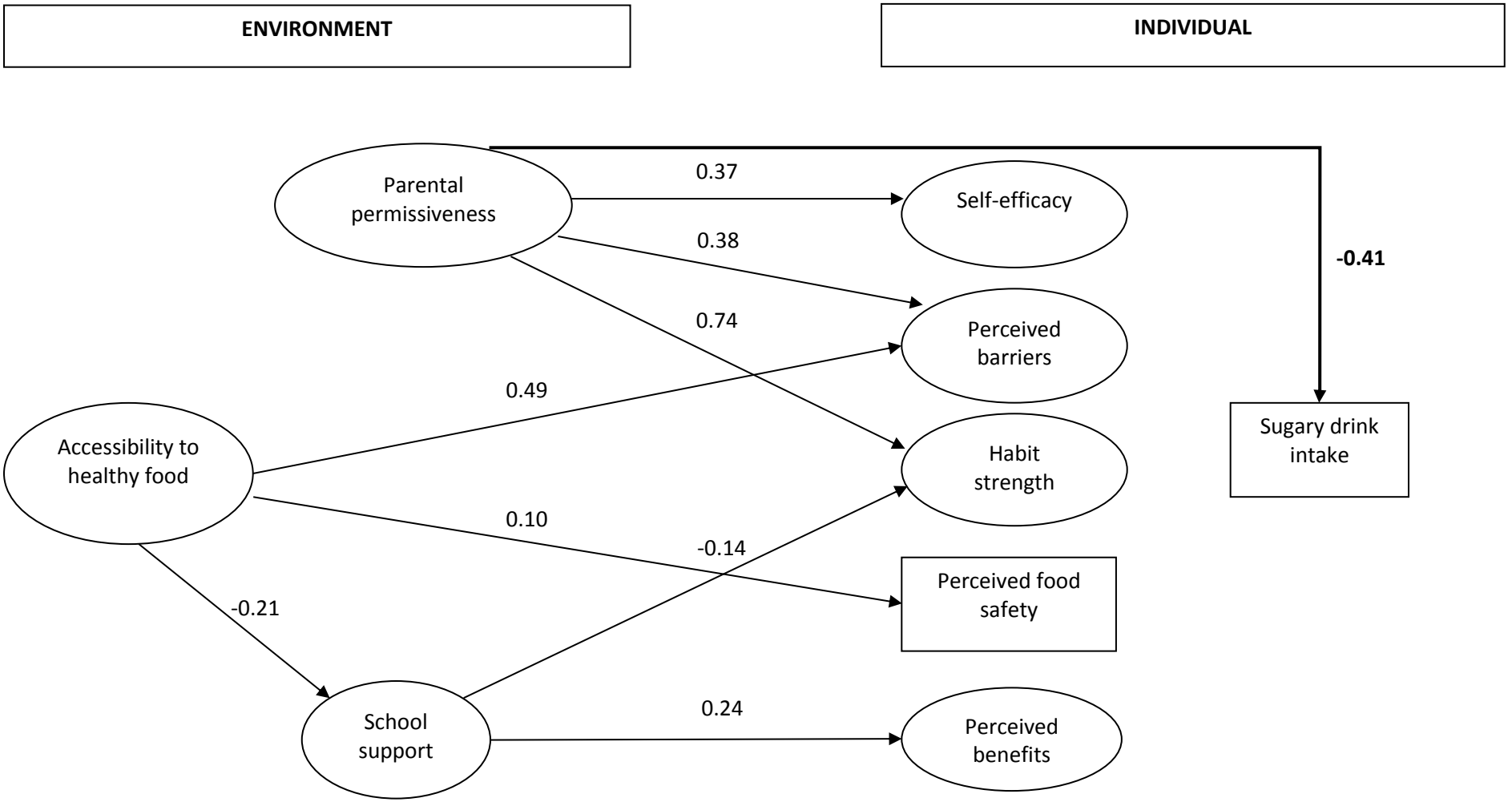


Figure 14 Individual and environmental influences on sugary drink consumption. Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(303) = 630.18$, $p< 0.001$; RMSEA = 0.038; NNFI = 0.92; CFI = 0.93, GFI = 0.93.

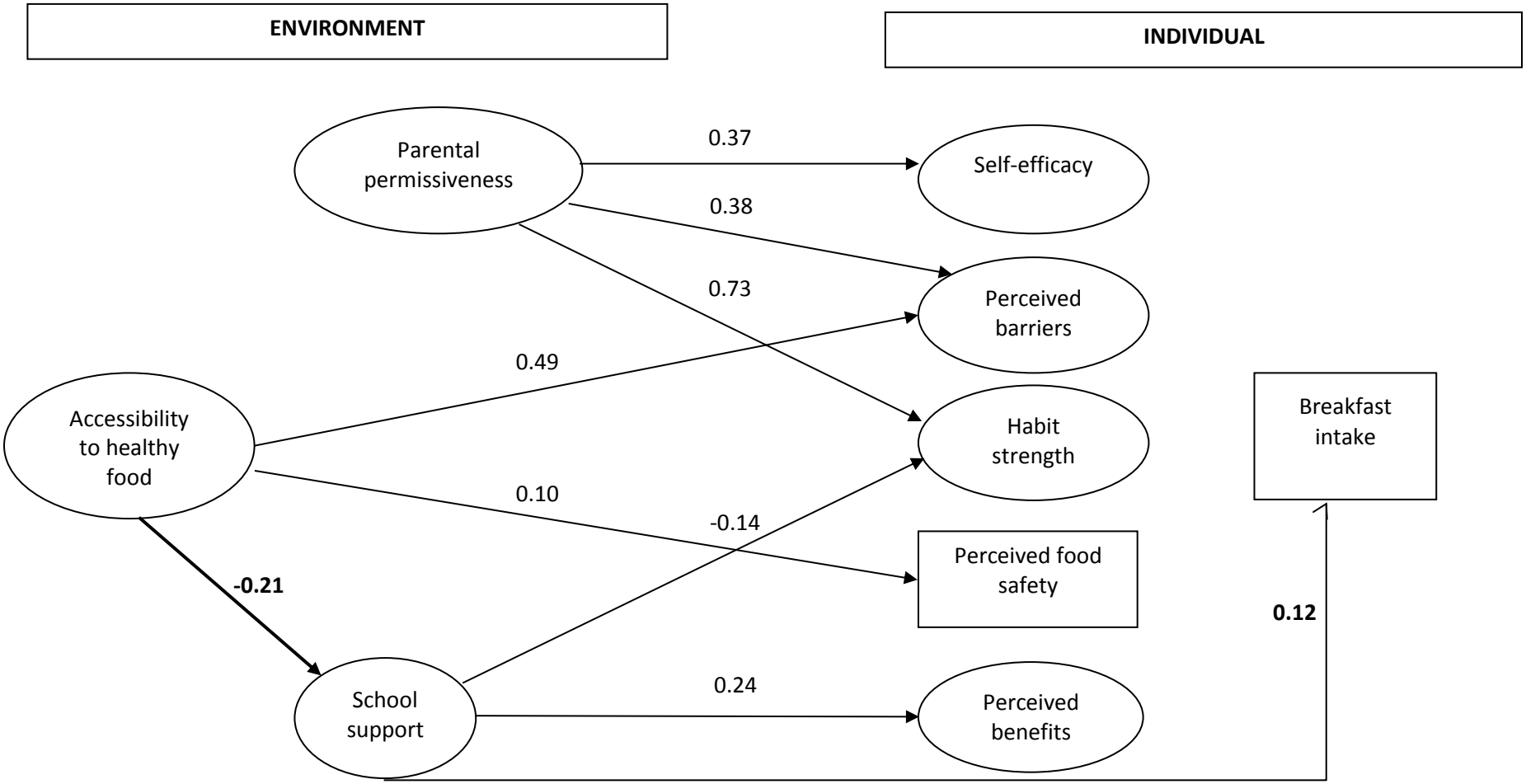


Figure 15 Individual and environmental influences on breakfast consumption. Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(303) = 630.50$, $p< 0.001$; RMSEA = 0.038; NNFI = 0.92; CFI = 0.93, GFI = 0.94.

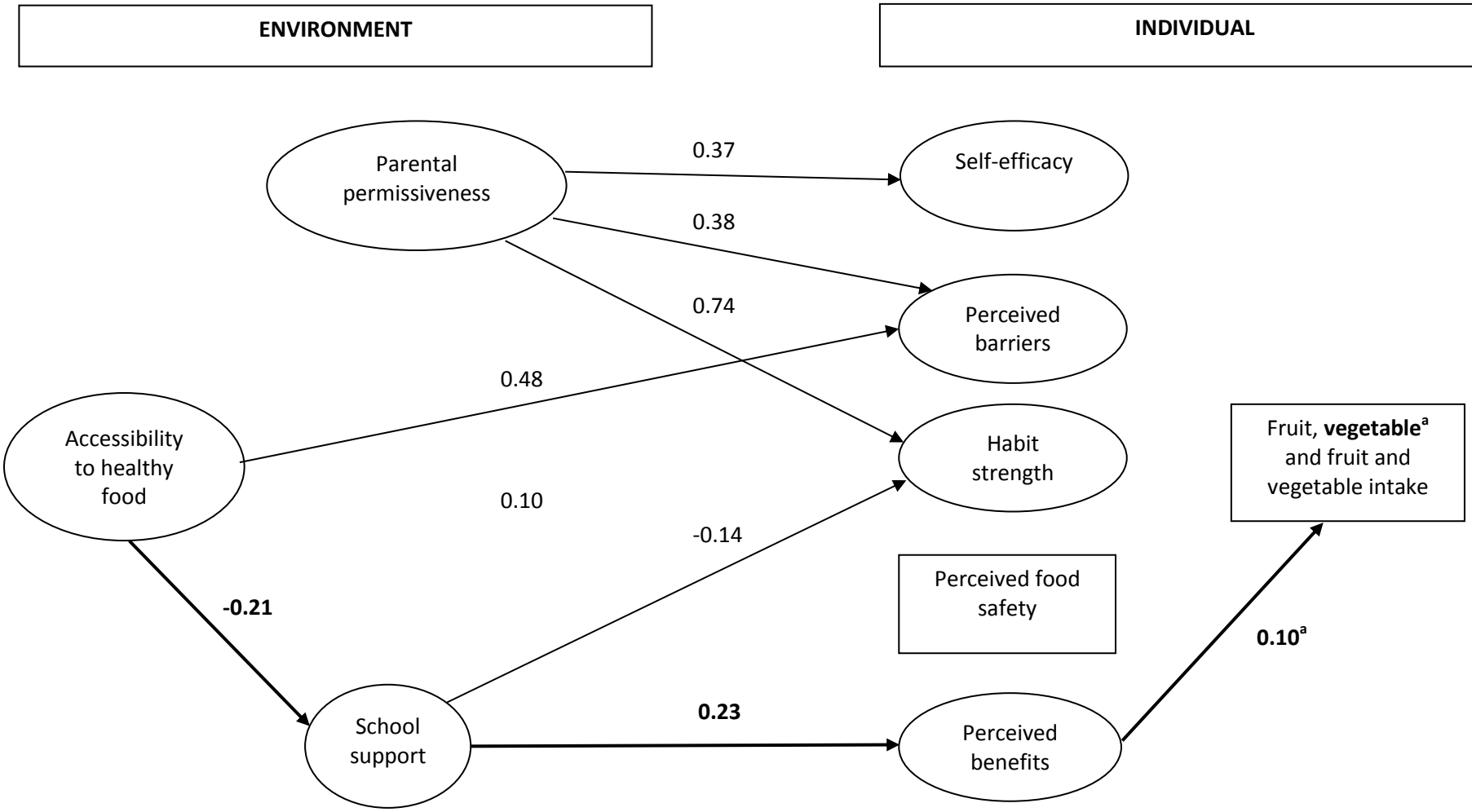


Figure 16 Individual and environmental influences on fruit, vegetable and fruit and vegetable consumption. Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(303) = 623.69$, p< 0.001; RMSEA = 0.038; NNFI = 0.92; CFI = 0.93, GFI = 0.94.[a] significant pathway for vegetable intake only

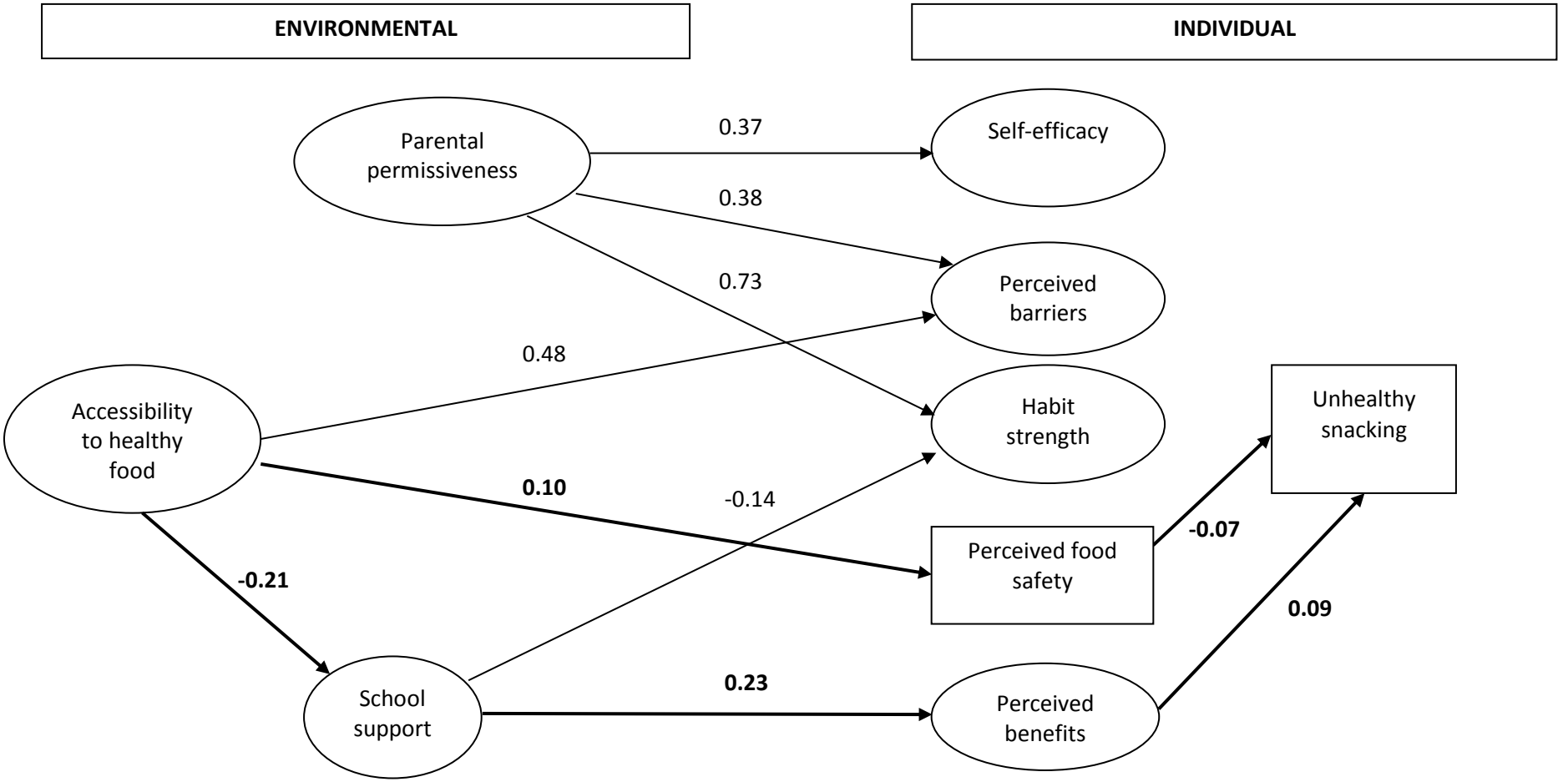


Figure 17 Individual and environmental influences on unhealthy snacking. Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(303) = 619.19$, p< 0.001; RMSEA = 0.037; NNFI = 0.92; CFI = 0.93, GFI = 0.94.

3.5 Multiple group analysis according to SES

We fitted each model separately for poor and better-off adolescents (**Figure 18-19**). All coefficients had the same sign as for the full model. However, poor adolescents exhibited relationships among the constructs that were absent in better-off adolescents. The relationships between accessibility to healthy food and school support, and school support and habit strength were only significant for poor adolescents. An additional relationship between school support and perceived food safety appeared to be important for poor adolescents only. In contrast, the following relationships were only found for better-off adolescents: accessibility to healthy food was associated with both perceived benefits and parental permissiveness. In its turn, parental permissiveness was related to perceived benefits.

Significant associations were found between constructs and unhealthy snacking (**Figure 18**) and sugary drink intake (**Figure 19**) in poor adolescents only. No association between any of the constructs and the other dietary behaviours were found and they are consequently not shown. A negative direct relationship existed between habit strength and unhealthy snack intake, suggesting that stronger habits for unhealthy eating predicted a higher consumption of unhealthy snacks in poor adolescents. Furthermore, both lower parental permissiveness and lower perceived school support predicted less strong habits for unhealthy eating, which in turn predicted low intake of unhealthy snacks. For sugary drink intake it was found that those with a higher level of self-efficacy have a lower consumption of sugary drinks. In its turn a higher level of self-efficacy is determined by having less permissive parents and indirectly affects sugary drink intake.

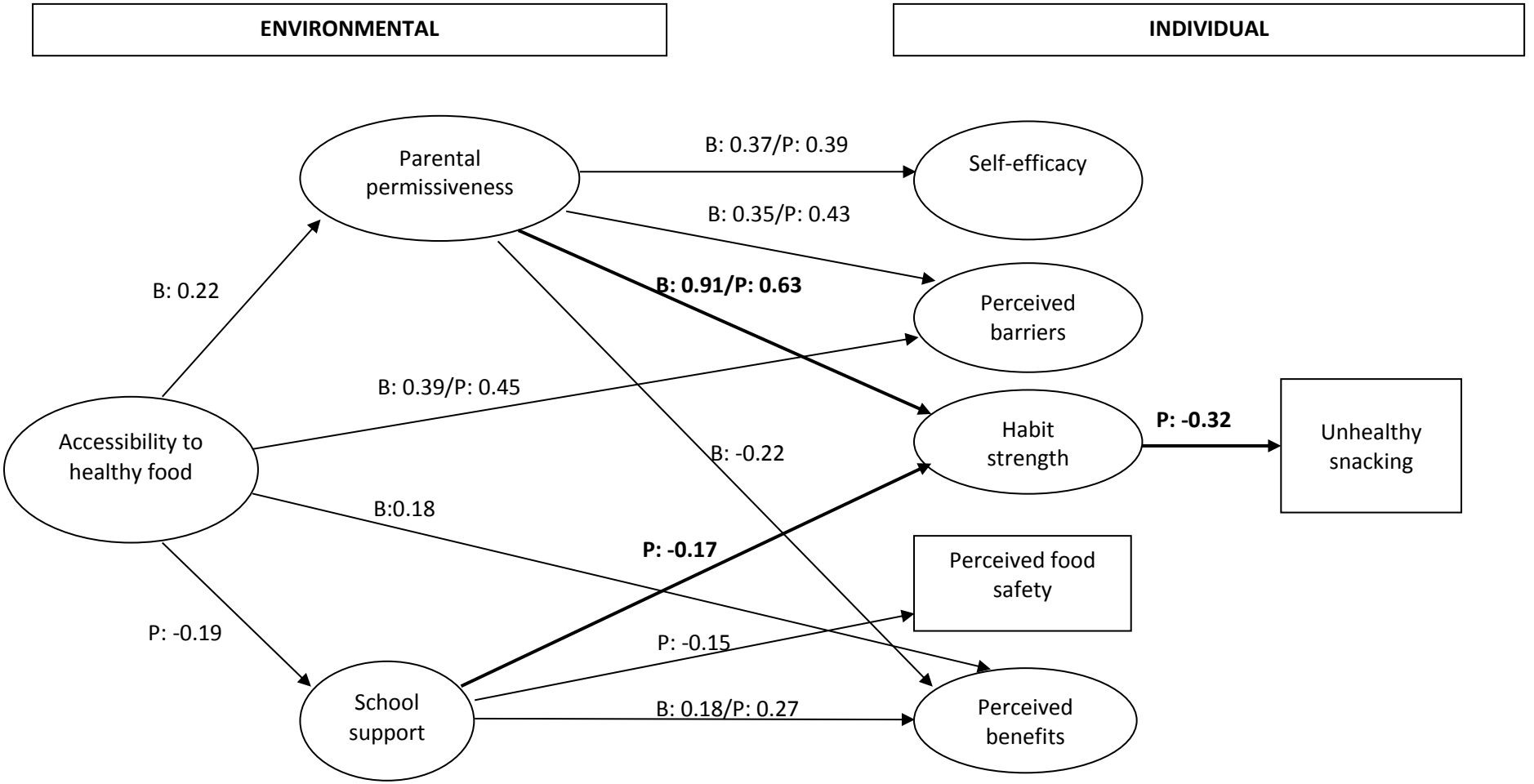


Figure 18 Multiple group structural model for unhealthy snacking. Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(303) = 619.19$, p< 0.001; RMSEA = 0.037; NNFI = 0.92; CFI = 0.93, GFI = 0.94. B: Better-off adolescents; P: Poor adolescents

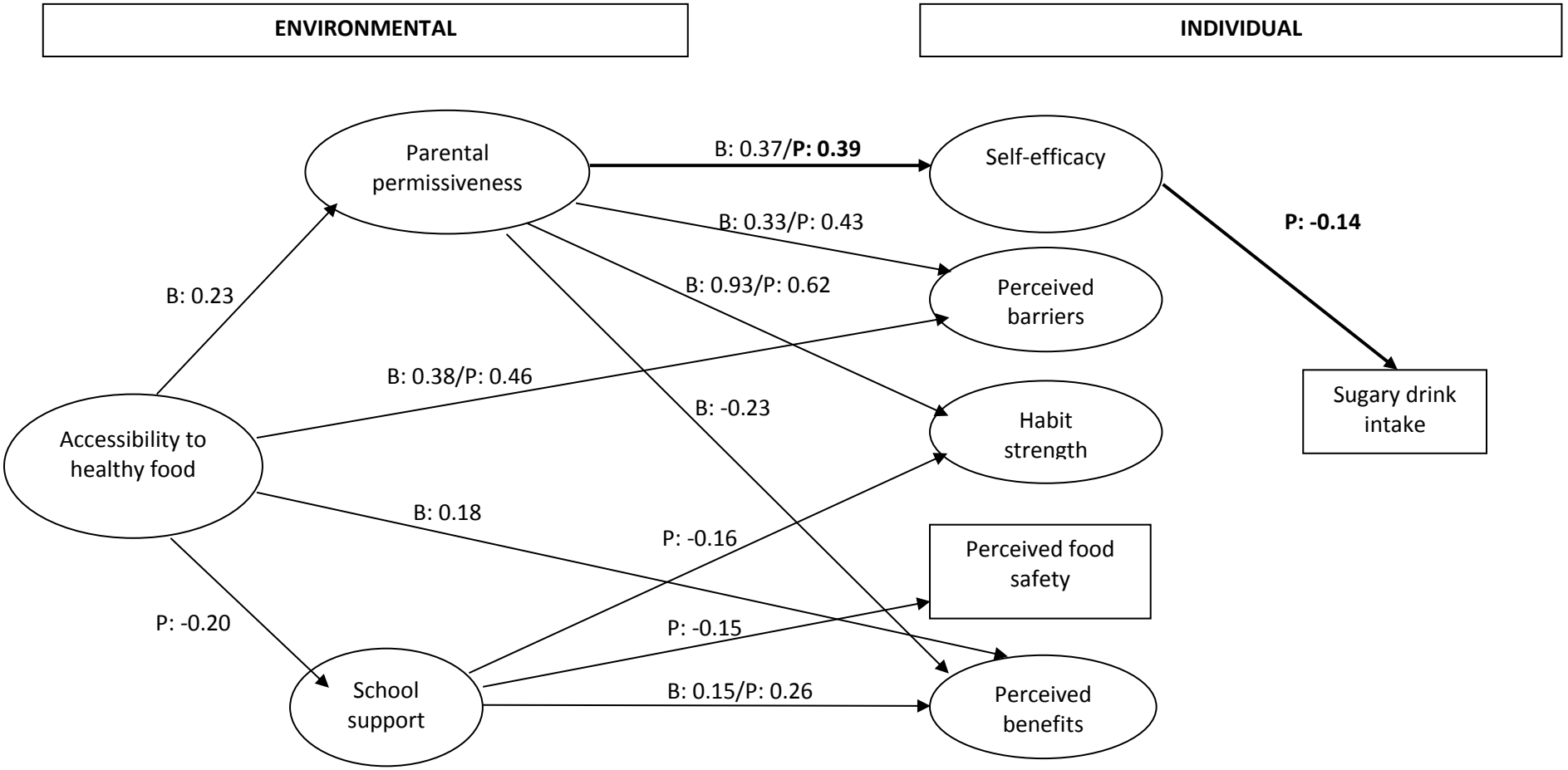


Figure 19 Multiple group structural model for unhealthy snacking in a subsample (Better off (n=329); Poor (n=411)). Only statistically significant paths at P < 0.05 are shown. Goodness of Fit-statistics: $\chi^2(624)= 932,35$; p< 0.001; RMSEA 0.037; NNFI = 0.92; CFI = 0.93, GFI = 0.92. B: Better-off adolescents; P: Poor adolescents

4 Discussion

To our knowledge, this is the first study examining the validity of a conceptual model for healthy eating behaviour in young people from LMICs. By using SEM we were able to quantify and determine the relationships between constructs and their influence on key components of eating behaviour. There were several key findings. First, the models tested for each of these components performed well indicating validity of the conceptual model for our population and results support an interplay of individual and environmental factors. Second, factors affecting food intake differed among eating behaviours. Third, these relationships were found to be modified by SES.

The behavioural change models (ASE and socio-ecological model) underlying our conceptual model suggest synergistic effects between individuals and their social and physical environment (257). The separate models tested for each key component of behaviour confirmed the interdependence of factors within and across individual and environmental levels. The fact that these relationships were comparable, both in strength and direction, across behaviours suggests that the interrelationship between environmental and individual factors for each eating behaviour were very near-identical. How these factors affected dietary behaviour, however, varied according to the component of eating behaviour studied. This differential outcome by behaviour is in line with the previous finding that factors affecting eating behaviour differ by type of behaviour (209;258-260);(192).

For vegetable intake and unhealthy snacking only individual level factors were found to be directly related to these dietary behaviours. Interestingly, perceived benefits of eating healthily was directly associated with both an increased vegetable and unhealthy snack intake. This somewhat puzzling result could have different explanations. In our adolescent population, choosing to eat healthily (e.g. vegetables) was found to be associated with an untrendy image leading to teasing and marginalization (241). To those adolescents, eating unhealthy snacks might thus help with peer acceptance. Peer group membership and the sense of belonging has been shown to positively affect the emotional well-being in adolescents (261). Another explanation might be that those that have higher perceived benefits of eating healthily, eat more vegetables and thus think they can afford to eat unhealthy snacks or are “allowed (as a reward)” by parents as an encouragement to eat healthier (262). Using food as a reward, however, is a parenting practice that has been shown to increase the risk for childhood overweight (75). Furthermore, it could also be explained by the fact that these perceived benefits are not strong enough to counter unhealthy snack intake. Additionally, perceived food safety of healthy foods was a direct and inverse predictor of unhealthy snack intake.

Adolescents who less perceive healthy foods as safe have an apparent preference for unhealthy snacks, as these are usually highly processed or packaged and thus not contaminated (241). Similarly, food safety was a key barrier in eating healthily in a study from Benin (201) and this finding argues for strategies tackling food safety to support healthier food choices.

Only environmental factors were directly associated with sugary drink and breakfast intake. Parental permissiveness directly predicted sugary drink intake whilst school support directly predicted breakfast intake. Prior studies have similarly reported evidence of parental permissiveness and social support as significant predictors of soft drink and breakfast consumption respectively in children aged 10 – 12 years old (211). In our previous work in this population, the adolescents indicated that their parents or school staff have little influence over their food choices (241). Yet, the associations between parental permissiveness and sugary drink intake and school support and breakfast intake were the strongest direct relationships in our model. Furthermore, these results confirm the hypotheses that environmental factors exert a direct influence on behaviour (187) and that the importance of parents or schools differ across behaviours (241).

We also found that access to healthy food was associated indirectly with all eating behaviour (except for sugary drink intake) and this effect operated through socio-environmental (i.e. parental permissiveness and school support) and individual factors. As would be expected, greater accessibility to healthy food increased consumption of healthy food. For instance, the perception of healthy foods being safe mediated the relationship between high accessibility to healthy food and a decreased intake of unhealthy snacks. Conversely, the other indirect relationships found for accessibility are not that straightforward to interpret. For breakfast intake, the relationship between accessibility and the consumption of breakfast was mediated through a supportive school environment. Thus, school support to eat healthily depends on the accessibility to healthy foods. Accessibility operating through school support was found for vegetable and unhealthy snack intake too, but the effect of school support on the behaviour operated through perceived benefits of healthy eating. Thus, one can conclude that individual influences and social environment are stronger predictors of behaviour than the physical environment (i.e. availability and accessibility of foods) in our population. Other literature further supports this finding (75;192). As a consequence, simply improving accessibility to healthy food may be insufficient to improve dietary behaviour; strategies to address the individual and socio-environmental influences would be required.

SES was found to modify the relationships, but only for poor adolescents. Surprisingly, the individual factors (habit strength and self-efficacy) that had a direct impact on eating behaviour differed from those in the overall model. Both, however, have been previously shown to play an important role in eating behaviour (45;263-266) and were also affected by parental or school influences (266). The fact that self-efficacy was only important for sugary drink intake in poor adolescents, confirms the hypothesis that self-efficacy could be more related to specific behaviours and act only in specific situations (194;267).

This study is unique in the sense that we validated a comprehensive conceptual model that was guided by theory and evidence; the relative contribution of the different levels of factors and their interactions was examined for multiple dietary behaviours. Moreover, it used local evidence to do so and a good fit was achieved for the model. Despite its strengths there are some potential limitations. The reader should be conscious about the cross-sectional nature of the data. Intervention studies are needed to understand the extent to which changes in constructs lead to actual changes in eating behaviour. Another possible limitation is the problem of incompletely assessed or omitted variables due to poor psychometric properties (268;269). However, we think that this effect is limited as most of these variables were integrated in other constructs. Furthermore, an indicator of habit strength assessing a variety of situations regarding soft drink and snack consumption was used. “Habit is a key automaticity-based determinant of action, and are behavioural patterns learned through context-dependent repetition” (263). Focusing on two behaviours only, might have impacted results. Future studies could include the Self-Report Index of Habit Strength as developed and validated by Verplanken *et al.* (270) to examine habit strength in a more complete manner. Finally, SES was highly correlated with urban/rural residence and findings of the multiple group analyses should be interpreted with caution.

This study also has implications for health promotion interventions. Based on the different findings for dietary behaviours it seems like simple logic to differentiate intervention strategies according to the behaviour. For instance, an intervention aimed at reducing sugary drink intake in Ecuadorian adolescents would have to develop intervention strategies for dealing with parental permissiveness. This example illustrates how literature has often dealt with one dietary behaviour at a time. However, we have to make different dietary choices in daily life and decreasing sugary drink intake is likely resulting in changes in other aspects of one’s diet. We therefore argue for a more pragmatic and comprehensive form of promoting healthy eating behaviour in which multiple dietary behaviours are included, but intervention strategies are differentiated according to the behaviour. Furthermore,

previous recommendations for multi-component interventions including different stakeholders (e.g. parents, adolescents) still hold (186). Additionally, interventions need to recognize the complexities of young people's eating behaviour and should develop strategies accounting for its environmental (physical and social) and individual influences. We recommend further proof of concepts, i.e. testing evidence- and theory-based models, in LMICs to investigate in-depth the inter-relationships of these influences and their relationship with dietary behaviour. This would facilitate tailoring of interventions towards these factors, and could be used to identify pathways of behaviour change when evaluating interventions (192;231).

5 Conclusion

Application and testing of a conceptual model identified interactions between factors influencing food choices in Ecuadorian adolescents. Our model performed well, and support was gained that the investigated dietary behaviours are each influenced by a similar complex interplay of individual and environmental factors. However, the hypothesized pathways of these variables towards dietary behaviour did vary with reference to the different types of behaviour. In addition, inter-relationships and pathways were not consistent across SES. Further research is recommended to consider this model as a basis to assess change mechanisms in dietary interventions, which is essential to enhance cost-effectiveness and context specific program implementations to improve dietary behaviours in LMICs.

Box 4 Key messages for intervention development

- Investigated dietary behaviours are each influenced by a similar complex interplay of individual and environmental factors;
- The pathways of these variables towards dietary behaviour varied with reference to the different types of behaviour, and thereby these deserve priority in intervention design;
- Inter-relationships and pathways were not consistent across SES;
- The framework contributes to the evidence-base of theory development in LMICs;
- This framework may guide research towards the identification of causal mechanisms linking individual and/or environmental factors with behavioural change in LMICs;
- Measures are warranted to realize environmental changes in addition to health education.

Chapter 6:

The participatory, theory- and evidence-based planning and development processes of ACTIVITAL, a school-based health promotion intervention

Trial identifier: ClinicalTrials.gov NCT01004367

Financial support: Institutional University Cooperation Programme (IUC) VLIR-UOS (http://www.vliruos.be/en/project-funding/programdetail/institutional-university-cooperation_3948/) and Nutrition Third World (http://www.nutrition-ntw.org/)

Summary

Background: Childhood obesity and its comorbidities constitute some of the biggest public health concerns in LMICs today. Only limited data are available on the systematic development, implementation and evaluation of health promotion interventions in LMICs. Such data are urgently needed to ensure these interventions can reach their full potential in tackling childhood obesity.

Objective: This chapter describes the participatory, theory- and evidence-based development and implementation processes of the evaluation design of the ACTIVITAL programme; a school-based health promotion program aimed at improving dietary and PA behaviour in Ecuadorian adolescents (11-15 years old).

Design: Both the Intervention Mapping protocol and the Comprehensive Participatory Program and Evaluation protocol were used to guide all stages of the intervention development. The combined application of these models resulted in a comprehensive, culturally-appropriate intervention package tailored to the needs of the participants.

Results: Intervention strategies consisted of an individual classroom-based and environment-based (school and family level) component. The intervention was evaluated using a pair-matched cluster randomised-controlled trial in 20 schools (1430 adolescents) for which an in-depth process evaluation was conducted. Primary outcomes assessed were dietary and PA behaviour and its influencing factors. Secondary outcomes were anthropometric measurements (BMI, overweight and obesity prevalence). The intervention was implemented between 2009 and 2012 and was evaluated mid-term (17 months) and at the end of the intervention (28 months).

Conclusion: The present chapter demonstrates that combining a participatory with a theory- and evidence-based approach is useful in developing a complex health promotion intervention and provides a clear insight into the processes of its development. Furthermore, it will help identify effective and ineffective intervention strategies, and allow for the replication, adoption or dissemination of these strategies in LMICs.

1 Introduction

Child obesity and its comorbidities constitute some of the biggest public health concerns in LMICs today (1;2). A recent systematic review categorised 25% (51.8 million) of Latin American children and adolescents as overweight or obese (19). Poor dietary patterns and low PA levels underlie this high prevalence, and are key contributing factors to the global burden of disease (2).

School-based interventions in which healthy dietary and PA behaviours are promoted have become an important public health strategy in LMICs, as they have the potential to improve child and adolescent health (186). There is however a concern that these interventions do not reach their full potential due to inadequate designs, lack of valid and reliable instruments, and the incomplete or inappropriate evaluation of behaviours targeted for change (186). These interventions are rarely developed in a true evidence- and theory-based manner. Moreover, they lack detailed information on development, intervention strategies and implementation processes (186). This "black box" in intervention development hinders the identification of effective and ineffective pathways for interventions, thus limiting our ability to replicate or adopt effective strategies.

The risk for such methodological and conceptual problems can be minimized by using a stepwise theory- and evidence-based approach in designing interventions (57). Using partnerships and co-operative approaches have also shown to be key in developing successful interventions (82;83), particularly in LMICs (84). Therefore, interventions promoting dietary and PA behaviours require the use of theory, local evidence, and a participatory approach to help account for cultural characteristics and requirements. The Intervention Mapping (IM) protocol and the Comprehensive Participatory Program and Evaluation (CPPE) protocol can both be used as tools in intervention development thereby helping fulfil the above requirements. The IM protocol provides a useful framework to systematically develop, implement and evaluate a theory- and evidence-based health promotion intervention (271). The CPPE protocol is an approach which develops and evaluates complex interventions in a more comprehensive and participatory manner (63). This protocol includes the participants' views, thereby ensuring the intervention strategies are relevant and aimed at meeting the needs of the target population.

This chapter provides detailed insight in the planning, development and implementation processes of the evaluation design of a school-based health promotion intervention aiming to improve dietary and PA behaviour in Ecuadorian adolescents (aged 11 – 15 years old). These processes were guided by

theory, local evidence and a participatory approach. The experiences accumulated in the development of this intervention are analysed; their possible contribution to more comprehensive interventions is also discussed.

2 Methods

2.1 Programme framework

A theoretical programme framework, using the stepwise approach described by Green and Kreuter in the simple Model for Planned Health Promotion and Education (61), was developed to guide the different processes of intervention development (Figure 3). This framework was developed using local evidence to account for the different contexts of LMICs. The first phases of the intervention development involved an in-depth assessment of needs (Phase A – C). This included identifying and analysing the health problem, i.e. unhealthy body weight, and a subsequent study on dietary and PA risk behaviours and their influencing factors (*see* Chapter 4 and 5). This allowed for intervention strategies matching the participants' social and cultural realities. The next phase of the programme framework involved developing the intervention (Phase D); by integrating the IM and CPPE protocols we translated the identified needs into possible means of change through various intervention strategies. The last phase of the framework involved the implementation of these intervention strategies (Phase E). Using the findings from the above phases, an evaluation study design was developed. All of these phases were conducted between January 2008 and January 2013. Finally, the use of this systematic development of the programme framework may also enhance the potential for future dissemination of the intervention.

2.1.1 Needs assessment (Phases A – C)

The needs assessment involved the following sub-studies:

- An in-depth analysis of unhealthy body weight in young Ecuadorian adolescents;
- An evaluation of possible risk behaviours associated with unhealthy body weight;
- A systematic review which analysed and evaluated the current evidence-base on implementing school-based interventions in LMICs and provided conceptual and methodological recommendations for intervention development (*see* Box 1*,* Chapter 2);
- A qualitative study identifying the relevant factors influencing risk behaviours from the viewpoints of adolescents, parents and school staff. A conceptual framework was developed

from these findings and included the influencing factors and their relation to dietary behaviour (*see* Chapter 4);

- This was further examined through structural equation modelling (*see* Chapter5).

The qualitative and quantitative data gathered from the needs assessment were used to design, implement and evaluate a culturally-appropriate intervention which aimed to prevent unhealthy body weight during early adolescence.

2.2 Intervention development (Phase D)

This phase combined the IM and CPPE protocol to facilitate the development of the intervention. These protocols were applied conjointly as illustrated in **Figure 20**. The evidence- and theory-based approach of IM was strengthened with the participatory analysis of CPPE. The latter involved a causal model to gain insight into participants' views on the underlying causes of the health problem with a subsequent identification of possible interventions. This process resulted in the final selections of intervention objectives, relevant factors influencing diet and PA, and intervention strategies. Results were combined to detail the intervention programme.

2.2.1 CPPE

2.2.1.1 Procedure and participants

A protocol specifying the practical guidelines was developed for the CPPE workshop (63). The workshop was carried out with adolescents and school staff groups in the intervention. Workshops were conducted in each intervention school prior to the start of the intervention. An additional two workshops were run with adolescents. Each group consisted of 6 to 10 participants, selected by convenience sampling. Before the start of a workshop participants received a detailed explanation of the exercise. The workshop comprised two sections: the causal model and identification of intervention strategies.

The causal model is a visual exercise in which the problem at hand is broken down step by step in order to identify its root causes. In theory, this involves listing potential influencing factors and determinants (e.g. political, social, biological, etc.) relating to unhealthy body weight. This is followed by linking the identified causal factors in hierarchical order. Horizontal links are ignored and the

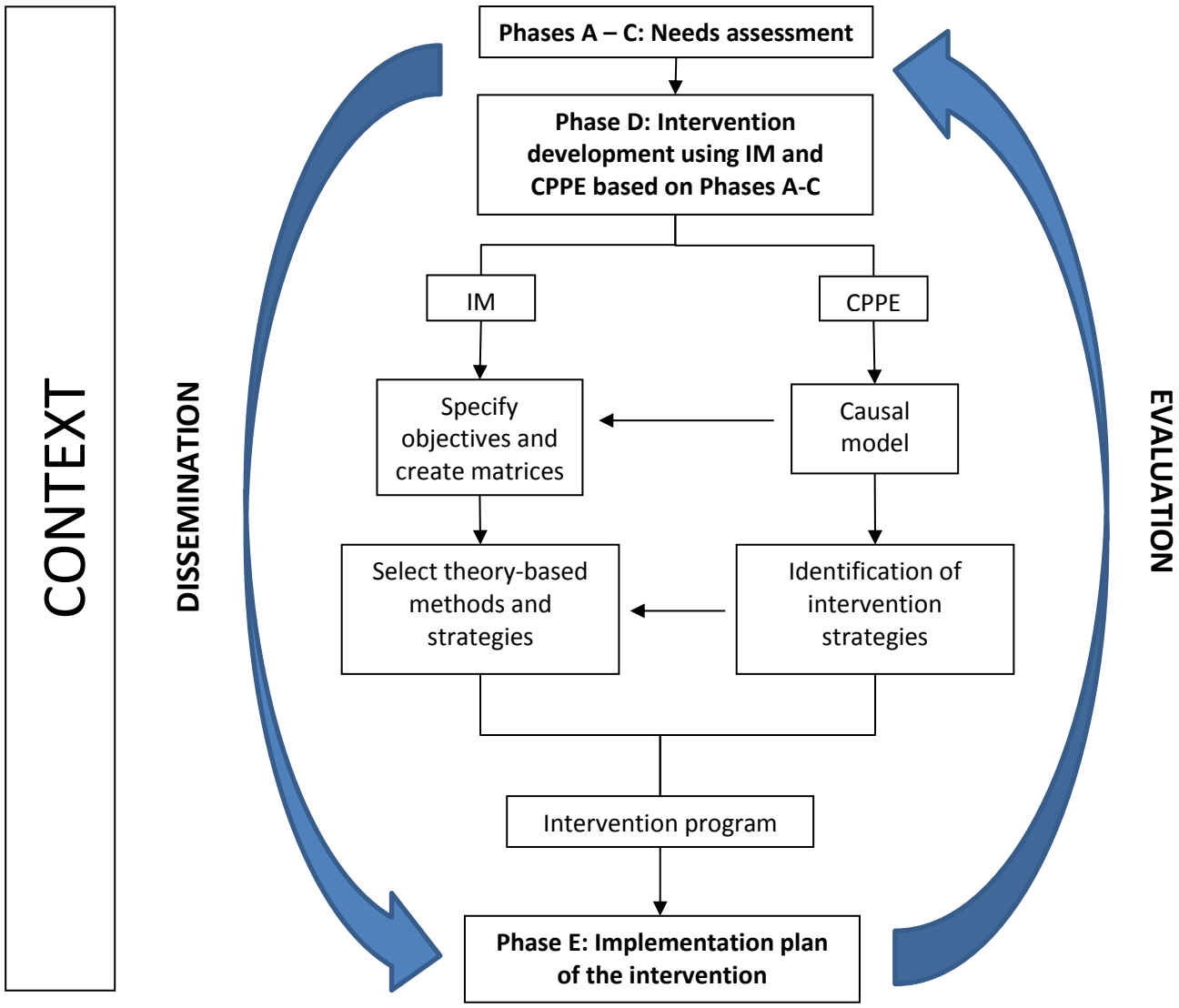


Figure 20 Programme framework for a school-based intervention in Ecuadorian adolescents. Phase D: development process of the intervention based on the IM and CPPE protocol (after Green and Kreuter, 1999 (61)).

repetition of factors is permitted. In practice, participants, individually and anonymously, noted down their ideas on separate pieces of papers. These were then compiled and organized into similar themes. The identified themes were then discussed until consensus was reached on inclusion amongst the group. Finally, these themes were visually connected on a large sheet of paper. For the adolescent group we used this approach in a more flexible way, allowing peers to work together.

Following the causal model exercise, possible interventions for the identified causes were evaluated within each group. The selection process used different criteria as identified by the group such as, for example, feasibility and operationalization within the school. Potential opportunities and barriers for implementation were also identified through this selection process. A consensual and provisional selection of interventions that responded best to the criteria set by the group was made.

2.2.1.2 Analysis

Cross-cutting themes and factors influencing unhealthy body weight were identified and were grouped into individual and environmental factors. The purpose of this identification was to inform the IM process on the participants' views on important influences on unhealthy body weight. In addition, summary reports were written for the intervention strategies as identified by the different groups.

2.2.2 IM

The results of the CPPE workshops were used during the IM process to tailor and fine-tune the objectives of the intervention, to map theory-based methods to these objectives, and to translate these methods into intervention strategies.

2.2.2.1 Identification of objectives and matrices

The first step in IM involved detailing the objectives of the intervention. This included:

- Identifying a set of performance objectives for each intervention objective. These specified the exact behaviour expected from participants from the intervention;
- Identifying the most important and changeable factors influencing these performance objectives. This is vital, as it allows for the identification of factors that need to change to have the desired impact on the performance objective, and ultimately the intervention objective (62). This process is typically performed by reviewing existing literature (271). It was argued that this is insufficient, as factors determining behaviour can be very different

across cultures and populations (57). Hence, evidence for these factors was based primarily on local evidence collected during the needs assessment and causal model, and partly on existing literature;

- Matrices of change objectives were created by crossing the performance objectives with these factors. A change matrix of this sort states exactly what needs to be addressed in order to influence performance objectives.

2.2.2.2 Theory-based methods and intervention strategies

Change matrices functioned as the backbone for selecting theoretical methods and intervention strategies. Theoretical methods are general techniques describing the association between an intervention action and the change in behavioural determinants; intervention strategies operationalize them into practical applications (271). Guidance from literature (271;272) was used to map theoretical methods to identified influencing factors (e.g. social influences, skills). These methods were then translated into practical intervention strategies, taking into account the preferred strategies of adolescents and school staff. This process was undertaken separately from the identified performance objectives for selected dietary and PA risk behaviours.

2.2.3 Intervention programme

Once the intervention strategies were created, a structured intervention programme was developed. The precise content and mode of delivery for each intervention strategy was designed using the CPPE feedback to ensure that the proposed content was context-specific. Furthermore, a training manual, workshops, training sessions, and intervention materials were developed and pre-tested in schools that did not take part in the intervention. Focus groups and cognitive interviewing were used to pre-test the tools, and the identified flaws and/or mistakes were adapted. This step also included selecting a name for the programme, developing an appropriate and attractive design, and a website for the intervention.

2.3 Implementation

Following the development of intervention strategies, the implementation of these strategies was scheduled. Feedback sessions were organized with schools to fine-tune and adopt the overall implementation schedule, taking into account the identified barriers and opportunities in each

school from the CPPE workshop. Agreements were reached on the strategy of programme implementation with the principal of each intervention school.

2.4 Design of the evaluation study

An evaluation design was made in agreement with the CONSORT statement (86), a checklist for RCTs. This involved an impact and process evaluation. The outline for public health interventions proposed by Saunders (273) was followed for the process evaluation in which recruitment, dose delivered and received, reach, fidelity, environment, and barriers and facilitators of the programme were examined. For both evaluations a detailed protocol comprising objectives, methods and outcome measurements was written.

2.5 Dissemination

The designed school-based intervention for Ecuadorian adolescents may prove to be an effective means of yielding a public health benefit, as a small change in behaviour can have a large impact by reaching large number of adolescents. Understanding contextual elements and enabling pathways is key to evaluate, not only the current, but also the potential impact of the intervention (85). In addition to the process and outcome evaluation, we intended to collect information on the costs of various aspects of the intervention and possible adverse effects. This included costs of outcome assessments, intervention staff and other personnel, logistics (e.g. transport and equipment), materials, intervention delivery, and follow-up. We also collected benefits for the adolescents, schools, families, and tuck shops, allowing us to perform a cost-benefit analysis.

3 Results

3.1 Needs assessment (Phase A – C)

The needs assessment was conducted in 2008 and 2009. In phase A, unhealthy body weight in Ecuadorian youth was identified as an important health problem; dietary and PA behaviours were identified as key factors in this population. In phase B, a local cross-sectional study identified adolescents as having a high intake of unhealthy snacks and sugary drinks, a low fruit and vegetable intake, and erratic behaviour such as skipping breakfast (68). They were also highly involved in sedentary behaviour and had low PA and fitness levels (66). Furthermore, the following successful

intervention strategies were identified for LMICs (*see* Chapter 2, *Box 1*): combined (PA and diet) interventions integrated into the existing school curriculum, involving parents and/or guardians, and enabling dietary and PA changes in the school environment. Moreover, these should be theory-based and document development and implementation processes (186). Phase C identified perceived food safety, habit strength, lack of self-control, perceived peer norms, built and socio-cultural environment as some of the key individual factors in Ecuadorian adolescents' food and PA choices (*see* Chapter 4, *Box 3*). Further testing revealed that the identified dietary risk behaviours are each influenced by a similar interplay of individual and environmental factors. However, the hypothesized pathways of these variables towards dietary behaviour did vary with reference to the different types of behaviour. In addition, inter-relationships and pathways were not consistent across SES (*see* Chapter 5*, Box 4*).

Combining these data resulted in an aim to design, implement and evaluate a school-based culturally-appropriate health promotion intervention geared at improving dietary and PA patterns in Ecuadorian adolescents (aged 11-15 years old). We also decided that this intervention should integrate young adolescents, their parents and school staff using intervention strategies at both individual and environmental level. School teachers would deliver part of the intervention to the adolescents. The use of teachers could provide a number of benefits: *i*) they are familiar with the adolescents thereby ensuring that the intervention is tailored to the needs of the adolescents, and *ii*) the intervention could be delivered through the schools' own resources, increasing adolescent participation and its sustainability. School tuck shops would receive particular attention as they are the final arbiters in deciding what food is actually served to children. Their individual work ethics and beliefs would also influence the food available and sold.

3.2 Intervention development (Phase D)

3.2.1 CPPE

In addition to the epidemiological analysis performed in the previous phases, it is important to also examine the perception of the target groups on the health problem. Twelve CPPE workshops were conducted and group size ranged from 6 to 10 individuals. School staff groups (*n*=10) included school directors, managers of the tuck shop, PA instructors, teachers of life sciences, nutritionists and/or medical staff. Adolescent groups (*n*=2) included adolescents from 11 to 15 years of age. The output of a CPPE workshop with an adolescent group is used to illustrate the process.

3.2.1.1 CPPE workshop with an adolescent group

The first stage of the workshop (causal model) with the adolescent groups resulted in a simple model that included food intake and PA as the causal factors for unhealthy body weight (**Figure 21**). According to these adolescents, all influencing factors of unhealthy body weight could be summarized into two categories: those that influence the food intake of an adolescent, and those that influence the PA level of an adolescent. In turn, factors that affected food intake and PA could be divided into other categories. Following this, the adolescent group built a series of sub-models to elaborate on each of the different influencing factors.

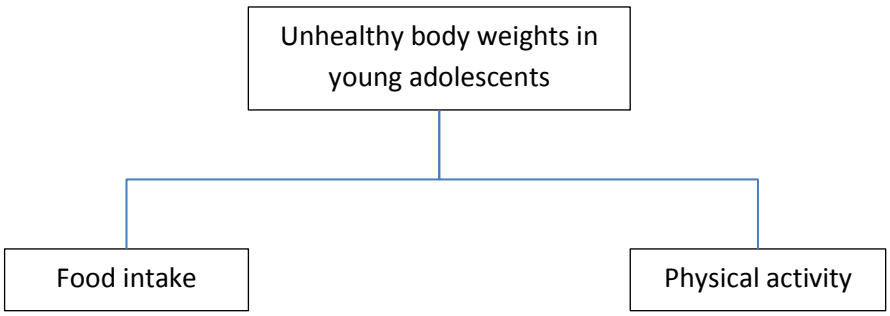


Figure 21 Schematic representation of the simple model for unhealthy body weight in young Ecuadorian adolescents

The food intake sub-model (**Figure 22**) included 4 important influencing factors: food balance, food quality, food quantity and psychological elements. For each of these factors further sub-models were developed. Adolescents emphasized the influence of satiety (e.g. "*you have no borders to eat"*), food cravings (e.g. *"you can't control hunger and yearn for food")* and portion sizes on the amount of food one eats. Moreover, food balance was found to be influenced by three underlying factors: food processing (e.g. *" they (industry) put a lot of fat and salt in it"*), food addiction (e.g. *"we can't stop eating once we tasted it"),* and taste (e.g. *"we like the taste of fatty foods").* Adolescents associated psychological aspects with forced eating by their parents, emotions (e.g. *"eating a lot when you feel depressed or anxious"*), mental problems, and social influences (e.g. *"the world criticizes you for who you are and you go out and eat until you drop"*). Finally, the sub-model for food quality calls for particular attention as it illustrates the impact of the adolescents' individual food preferences and environmental aspects on poor nutrition. The following influencing factors were identified: cooking skills, palatability, time, convenience, availability, food safety, taste and education.

Similarly, a sub-model was built for PA (**Figure 23**). It uncovered several key themes: exercise, sedentary activity, psychological aspects (e.g. *"I don't feel happy when doing sports"*), safety (e.g. *"It is not safe to walk"*), and social influence. The sub-model developed for exercise revealed similar results to that of the PA focus groups (274). Adolescents talked about factors related to sports or doing exercise but did not necessarily relate them to daily activities such as cleaning their rooms or herding the cattle. Time, preferences, and skills appeared to be important; adolescents had no time to exercise, preferred watching TV, were too tired or lacked the skills to be active (e.g. *"I can't play ball very well"*). Social influence was an additional important factor as other people's opinions would limit adolescent participation in sports (e.g. *"They tell us we are not worth to be active or do sports", "The trainer said we are good-for-nothing and we don't want to participate anymore").*

3.2.1.2 CPPE output: all workshops combined

The number, scope and hierarchical position of factors somewhat differed between school staff and adolescent groups. Cross-cutting themes identified by all groups for food intake were psychological problems, taste, skills, food preferences, peer and social influence, habits, time and convenience at an individual level, and availability and accessibility at an environmental level. School staff drew attention to the availability of food in school tuck shops which is influenced by national legislation and not by the schools. They also identified the financial autonomy (i.e., purchasing power) of the adolescents and the issue of anorexia as contributing factors to unhealthy body weight. Moreover, they added the problem of immigration to the sub-model of psychological factors. Some of the adolescents are from immigrant families and often have grandparents or other relatives as their legal guardian. However, in reality these are often latchkey children with high financial autonomy, resulting in an irregular and unhealthy eating pattern.

For PA, peer and social influence, skills, injury, and time at an individual level, and availability and accessibility at environmental level, were identified as influencing factors by all groups. School staff groups added traffic and crime concerns, and opportunities available at school as important factors to the model.

Following the causal model exercise, possible intervention strategies to improve dietary and PA behaviours (as these were the main causal influences) were proposed. This step was based on the various identified factors and pre-set criteria by the group, and included the identification of opportunities and barriers of each school including the non-cooperating people. Adolescents suggested the following as the intervention: i) clean, fresh and palatable fruit at an acceptable price

at school, ii) additional PA opportunities, and iii) their parents receiving advice on how to prepare and serve healthy and tasty foods at home. School staff groups also emphasized the need to be educated about healthy and adequate nutrition before they could teach the children. They emphasized the challenges of environmental influences on the eating behaviour of adolescents when developing an effective intervention. Additionally, teachers had little faith that they would be able to engage in additional activities due to time limitations and school tuck shops expressed the fear that if they would change the offer, they would lose profit.

3.2.2 IM

3.2.2.1 Identification of objectives and matrices

Eight intervention objectives were identified (**Table 15**). Using input from the needs assessment ensured that the objectives were achievable as they were adapted to the local context and daily reality of adolescent life. Additionally, by using the results of the causal model, it was decided that the intervention would focus on the improvement of diet and PA behaviours rather than obtaining an ideal body weight. We aimed to reduce the chance of stigmatization and to avoid contributing to eating disorders or distorted perceptions of body image (275).

Table 15 Intervention objectives for identified dietary and PA risk behaviours

Dietary behaviour	IO1: Adolescents decrease their sugary drink intake to meet RDA
	IO2: Adolescents increase their daily fruit and vegetable intake to meet RDA
	IO3: Adolescents decrease their unhealthy snack intake to meet RDA
	IO4: Adolescents increase their healthy breakfast intake up to meet RDA
	IO5: School tuck shops offer more healthy foods
PA behaviour	IO6: Adolescents decrease daily screen time (1-2 hours/day)
	IO7: Adolescents increase daily PA levels to reach 60 min/day
	IO8: The school offers more opportunities for being active

IO: Intervention Objective; P:, Physical Activity; RD: Recommended Dietary Allowance

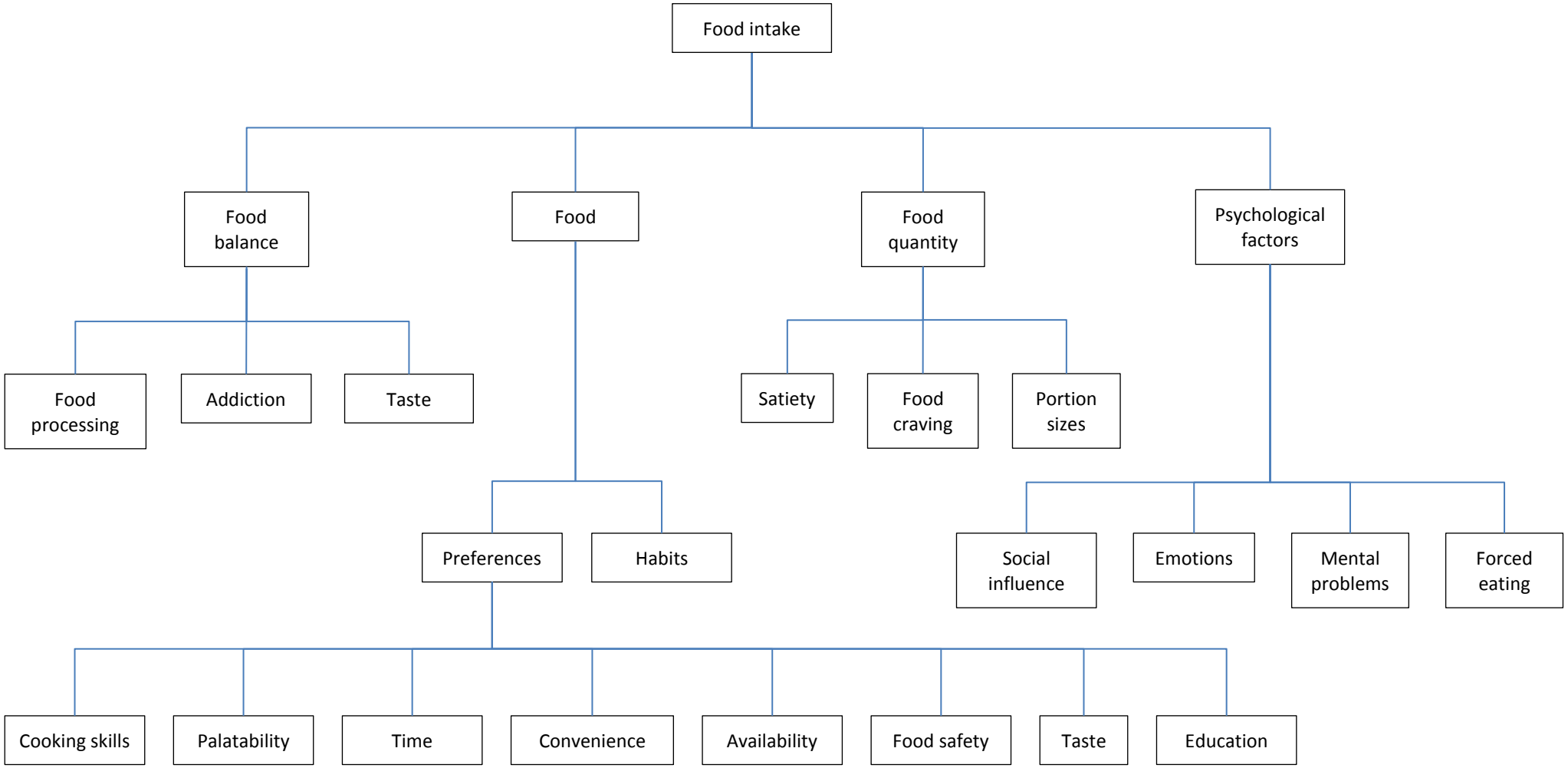


Figure 22 Schematic representations of the sub-models for food intake

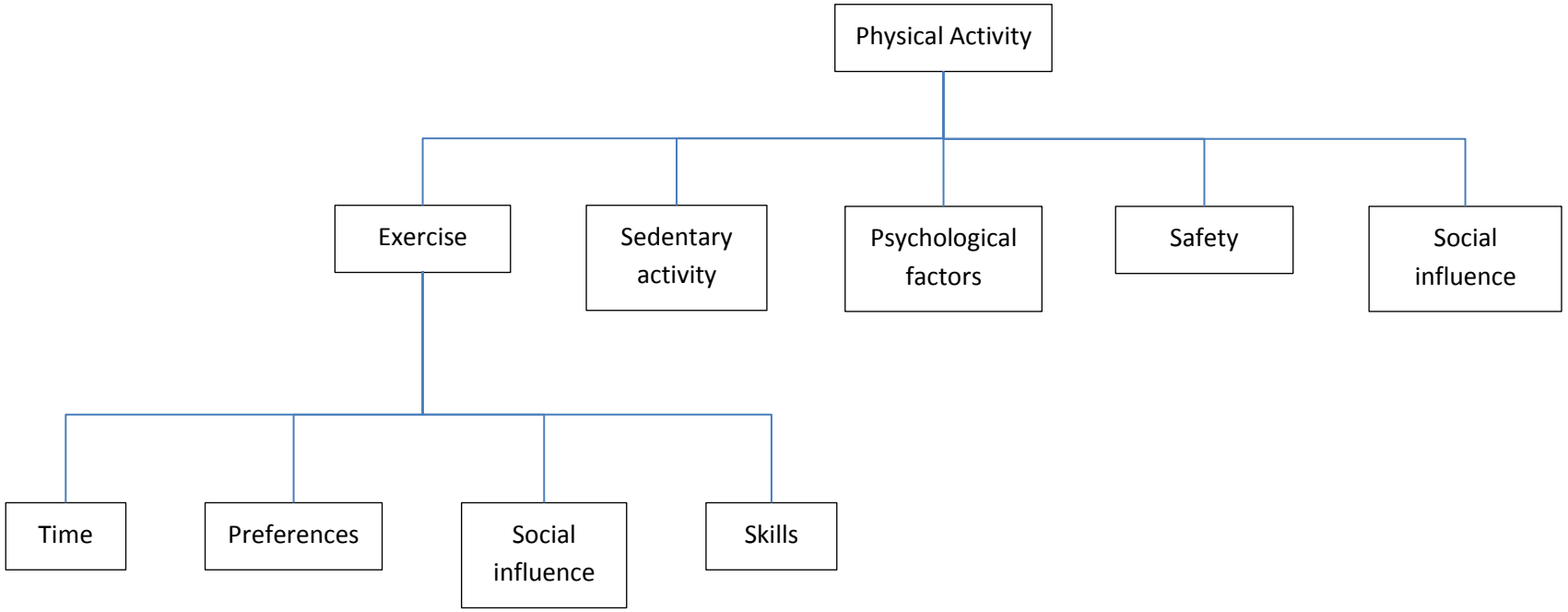


Figure 23 Schematic representations of the sub-models for PA

Performance objectives were subsequently identified for each of these intervention objectives. The selection of performance objectives for each intervention level (adolescents, parents, school staff, and school tuck shops) was informed by the needs assessment and the CPPE workshop. **Table 16** illustrates the performance objectives for the intervention objective of increasing breakfast intake (IO4). After finalizing the performance objectives, factors influencing the selected dietary and PA risk behaviours were identified. We applied methodological triangulation by *i*) using focus groups to identify and conceptualise these influencing factors (*see* Chapter 4), *ii*) using SEM to evaluate the strength of the associations between the factors and the identified behaviours (*see* Chapter 5), and *iii*) using the causal model which helped generate new ideas for influencing factors in our population. Combining the results of these qualitative and quantitative studies, the presence of these factors and their relative importance in influencing changes in the diet and PA behaviour of adolescents was estimated.

Table 16 Performance objectives for breakfast intake

Intervention objective: Adolescents increase their healthy breakfast intake	
Adolescent	
PO1	Adolescent chooses to eat a healthy breakfast
PO2	Adolescent prepares a healthy breakfast
PO3	Adolescent buys a healthy breakfast for 1$ or 2$
Parents or other guardian(s)	
PO4	Parent/other guardian(s) encourages and motivates the adolescent to eat regularly a healthy breakfast
PO5	Parent/other guardian(s) ensures the adolescent has the opportunity to eat a healthy breakfast
School staff	
PO6	School staff uses the strategies and new resources to increase healthy breakfast intake
PO7	School staff encourages and motivates adolescents to eat a healthy breakfast
School tuck shops	
PO8	Tuck shop offers a safe, palatable and healthy breakfast alternative
PO9	Tuck shops share experiences
PO10	Tuck shop uses the new resources and recipes to provide a healthy breakfast

PO: Performance Objectives

Table 17 illustrates a comprehensive overview of the identified factors of performance objectives for dietary risk behaviour. One should note that not all of these identified factors were relevant for each dietary behaviour. A similar table was constructed for PA behaviour. Interestingly, this table showed that not all factors were confirmed by the different methodologies. Some of these that were identified in the conceptual framework, such as parental rules, were not confirmed by the causal model and/or the SEM and vice versa. It became clear that outcome expectations, for instance, were important for school staff (tuck shop managers and teachers) during the causal model exercise.

In a following step, the change matrices were constructed in which the performance objectives are crossed with selected factors. This created the change objectives which specified exactly what the adolescent or environmental agent (i.e. school tuck shops, parents and school staff) needed to change in order to achieve the performance objective.

Table 17 Relative importance and changeability of factors influencing dietary behaviour in Ecuadorian adolescents

Factors	Importance	Changeability	Source
Knowledge/awareness	++	+++	CF/CM
Skills/self-control	++	+++	CF/CM/SEM
Taste	+++	+	CF/CM
Perceived food safety	+++	++	CF/CM/SEM
Attitudinal beliefs:			
Perceived benefits	+++	++	CF/CM/SEM
Perceived barriers	+++	++	CF/CM/SEM
Habit strength	++	+	CF/CM/SEM
Financial autonomy	++	+	CF/CM/SEM
Emotional factors	++	+	CM
Subjective norm	++	+	CF/CM
Parenting practices:			
Rules	++	+	CF
Role modelling	++	++	CF
Permissiveness	+++	++	CF/SEM
School practices:			
Rules	++	+	CF
Support	+++	++	CF/SEM
Availability/accessibility at home	+++	++	CF/CM/SEM
Availability/accessibility at school	+++	++	CF/CM/SEM
Socio-cultural changes:			
Increased workload	++	+	CF
Changed food patterns	+++	+	CF
Immigration	++	+	CM
Outcome expectations	+++	++	CM

Importance = the importance of the relationship between the influencing factors and dietary behaviour; changeability = how feasible it is to change this factor by an intervention; +: not very important/not easy to change; ++: important/changeable; +++: very important/easy to change. CF, Conceptual Framework (see chapter 3.1); CM, Causal Model (see chapter 4); SEM, tested by means of structural equation modelling (see chapter 3.2).

Table 18 shows an example of such change objectives. A full matrix was constructed for the adolescents, and since we expected school staff and parents to create environmental changes to influence the breakfast behaviour of the adolescents we also created separate matrices for parents, school staff and tuck shops. **Supplementary Table 7-10** illustrate an example of these matrices for breakfast intake.

Table 18 Example of change objectives for a performance objective related to breakfast intake - adolescents

Breakfast intake	Knowledge/awareness	Skills/Self-control	Attitudinal beliefs: benefits and barriers	Subjective norm
PO1: Prepare a healthy breakfast	Describe why a nutritious and healthy breakfast is important for them Describe what a healthy breakfast should consist of Are aware of different healthy breakfast preparations	Develop skills to identify what a healthy breakfast is Develop skills and feel confident they can prepare a healthy breakfast	Express short term benefits (e.g. feeling good, body image) when eating a healthy breakfast	Express confidence in sharing experiences in preparing a healthy breakfast and its taste with their peers

3.2.2.2 Identification of theory-based methods and intervention strategies

Matrices with change objectives served as the backbone for identifying appropriate theoretical methods and intervention strategies (**Supplementary Table 11**). Theoretical methods (i.e. behavioural change techniques) were considered effective in changing the influencing factors identified from literature (271;272). These methods were then mapped against each factor, and change objectives were finally translated into an intervention strategy by operationalizing the selected theoretical method.

The translation of methods into strategies was performed using input from the CPPE exercise. Therefore, on one hand applications were underpinned by theory whilst on the other hand a realistically implementable programme was developed from the participants' views. This lead to a final selection of intervention strategies. **Table 19** illustrates the results for knowledge/awareness in adolescents for the breakfast intake example.

Table 19 Theoretical methods and related intervention strategies mapped towards knowledge/awareness for breakfast intake – adolescents

Factor	Theoretical methods	Intervention strategies
Knowledge/Awareness	Active learning (IMB model)	The ACTIVITAL toolkit: providing information, facts about a healthy breakfast through an interactive session (games, visual exercises, etc.)
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current habits are discussed (quiz) and new goals are set
	Rehearsal	Throughout the intervention, knowledge is repeated and evaluated
	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills (breakfast event/athletes sharing their experiences) on how to overcome these

3.3 Intervention programme

The intervention programme was developed by operationalizing the intervention strategies. During the CPPE workshop, a partnership was established with all the intervention schools. Part of the intervention was designed to be delivered by school teachers (e.g. biology or life sciences), whilst another part was delivered by research staff. The intervention programme was designed for over 3 years. In the first year, the working partnership with schools was developed, using the CPPE with adolescents and school staff, in order to guarantee the full cooperation of schools throughout the execution of the intervention. Also, an introduction to the intervention was delivered and basic workshops on healthy eating and PA were conducted. Considerations were made regarding budget, time and resources, sustainability, safety (no harm or adverse effect) and feasibility of the intervention strategies. Taking these criteria into consideration, some of the intervention strategies were fine-tuned whilst others were discarded. For example, from the matrices developed using IM and CPPE, a school food and PA policy was identified as a possible intervention strategy. However, it was not deemed feasible by the schools as the food service is provided through privately owned tuck shops and they fall under the legislation of the government. Over the following 2 years the final

intervention programme was delivered; it included strategies targeting both individual and environmental levels (physical and social environment at school and at home) (**Table 20**).

The individual classroom-based component included an interactive educational toolkit on dietary and PA risk behaviours, and consisted of 12 sessions. The toolkit included workbooks for teachers and adolescents with detailed instructions on how to deliver each session. They were accompanied by different resources developed especially for these sessions including puzzles, bingo, games, etc. This allowed teachers to implement the toolkit with minimum effort. The intention was to integrate this package into the existing curriculum through the Ministry of Education. However, this appeared to be a challenge. Instead, we obtained a letter of support from the Ministry of Education requesting intervention schools to temporarily include the intervention into their current curriculum. The toolkit was hence delivered during regular school hours.

The environmental component of the intervention included a parenting and a school programme. The parenting programme covered 6 interactive sessions with parents and/or legal guardians for which sheets with tips, flyers and activities were developed. The school programme involved school tuck shops, changes in the physical environment and social events. Professional development and training was delivered for tuck shop managers and/or their employees by the research staff. In total, 10 training sessions and 3 workshops were carried out. The training sessions were developed in a participatory manner and content was adapted to their needs. This enabled us to develop the sessions as per individual characteristics and the potential of each tuck shop. In addition, school events targeting dietary and PA behaviour were implemented in each intervention school, and included preparing a healthy breakfast and talks from famous young athletes. Finally, in all intervention schools participants were introduced to a walking trail of 10,000 steps and a number of promotional materials such as posters and leaflets.

The content of the intervention strategies delivered to tuck shop managers, employees and parents or guardians was matched to the content of the toolkit delivered to the adolescents. They were also scheduled to run simultaneously in order to reinforce the positive behaviours. If adolescents were working on the breakfast chapter, parents would receive their session on healthy breakfasts around the same time, tuck shops would receive a training session on how to offer a healthy breakfast, and an event in which a healthy breakfast was prepared was organized at school.

The name ACTIVITAL (“actividad y vitalidad”) was chosen as it encompassed the possible outcomes of adhering to healthy dietary and PA habits, as recommended by the intervention, without any

stigmatizing. A mature and hip logo was chosen to match the materials (**Figure 24**). A website (http://199.217.116.151/activital/) was also created for the project. All educational material, including the logo, posters, manuals and workbooks were pre-tested with representatives from each target group. This revealed the need for simple language, and identified mistakes and flaws in the materials. It also showed that the participants liked the practical and interactive aspect of the toolkit.

Figure 24 Logo of the intervention and the ACTIVITAL toolkit

Table 20 Detailed overview of the ACTIVITAL intervention

Timing	Intervention strategy	Content	Resources	Providers
Year 1	CPPE	Discussing intervention with school staff, adolescents and their parents	CPPE material	Research staff
	Workshops	Healthy eating and PA behaviours	Leaflets	Research staff
Year 2	ACTIVITAL toolkit	Five chapters: 1. Introduction 2. Food pyramid 3. Move (60/7 rule and sedentary activity) 4. Microscope (breakfast, snacks, sugary drinks) 5. Financial autonomy (game)	Workbooks for teachers and adolescents Resources such as bingo, games, puzzles.	Teachers
	Parents	Three workshops: 1. Food pyramid 2. Move (60/7 rule and sedentary activity) 3. Microscope (breakfast, snacks, sugary drinks)	Leaflets, quizzes and workshop material	Research staff
	Tuck shops	Ten training sessions: 1. Identification of needs and problems 2. Prioritization of needs and problems 3. Introduction to food safety 4. HACCP and recipe development 5. Food pyramid 6. Cooking skills	Recipe book, leaflets, practical working sheets, food	Research staff

Timing	Intervention strategy	Content	Resources	Providers
		7. Food preparation 8. Breakfast, snacks, sugary drink alternatives and fruit and vegetable preparation 9. National legislation: adaptation and implementation 10. Management of the tuck shop		
	Social events	Workshops with famous athletes Breakfast event Posters	Food and auditorium	Athletes School staff Research staff
Year 3	ACTIVITAL toolkit	Seven chapters: 1. Your food under the microscope - Nutrients 2. Food labels – your food scanned! 3. Less is more - Portion sizes 4. Colour your plate 5. Lunch and dinner 6. Why do we buy? 7. A groove move	Workbooks for teachers and adolescents Resources such as nutrient cards, wooden blocks, game materials	Teachers in life sciences or biology
	Parents	Three workshops: 1. Portion sizes 2. Food labels and advertisement 3. PA: barrier identification and playground markings	Leaflets, workshop material, food and playground markings	Research staff

Timing	Intervention strategy	Content	Resources	Providers
	Tuck shops	Three themes: 1. Portion sizes and nutritional guidelines 2. Healthy menu planning and cooking healthy alternatives 3. Analysis, evaluation and discussion of implementing healthy menu	Healthy menu plan, leaflets, practical working sheets	Research staff
	Physical environment	Walking trail of 10000 steps	Playground markings Promotional material	School staff

3.4 Implementation

After finalizing the development of the intervention, the next stage was to ensure its adoption and implementation into each school. The CPPE workshop identified the opportunities and barriers of each school which were taken into account for implementation. For example, in some schools the medical doctor was responsible for following up on implementation, whilst in others it was the life sciences teacher. The implementation schedule was discussed in detail with these identified supervisors.

4 Design of the evaluation study

4.1 Study objectives and outcomes

The ACTIVITAL programme aimed to improve dietary and PA behaviour of young Ecuadorian adolescents in schools, using a pair-matched cluster RCT, by implementing an individual classroom-based component and an environmental element.

A considerable amount of time is needed before improvements in diet and PA (they represent the most immediate results of health promotion interventions) can result in BMI changes. For this reason we advocated the use of behavioural outcomes for diet and PA, and the factors influencing these behaviours as primary outcomes. Secondary outcomes measured were anthropometric and blood pressure measurements. The study was conducted from 2009 to 2012 in Cuenca, an urban area in Southern Ecuador.

4.2 Ethics statement

The study protocol was approved by the Ethics Committees of Quito (Ecuador) and Ghent University Hospital in Belgium (CBM/Cobi-001; B67020084010; FWA00002482). The study is registered with clinicaltrials.gov, number NCT01004367. The different participants included in the intervention programme provided consent. Adolescents who returned signed parental consent forms and gave written assent to participate in the study were included; parents and school staff needed to provide written informed consent. Control schools were offered guidance or help in topics other than diet and PA, such as sexual intercourse or drug use, and a pledge was made that the intervention material

would be freely available to them for use after evaluation. The CONSORT guidelines were followed to report this study (86).

4.3 Study design

4.3.1 Sample size, recruitment and randomization

The intervention was performed in Cuenca, the third largest city located in Southern Ecuador. Based on previous experiences in Cuenca, a substantial risk of non-participation was assumed, school characteristics differed substantially, and it became clear that randomizing within schools would be limited. For these reasons, a pair-matched cluster RCT was used to evaluate the intervention. Matching may increase power due to a significant reduction in between cluster variance, provided that an effective set of matching factors can be identified (276-278). Potentially important confounders correlating with the main study outcomes were taken into account ensuring that the clusters receiving the intervention were more likely to resemble the control clusters. This allowed us to ensure the effects are a consequence of the intervention and not due to heterogeneity of the clusters in the intervention.

Sample size was calculated using the formula from Hayes and Bennett (276) for paired-matching studies for the different dietary and PA outcomes, with an α of 0.05, a power of 80%, and a variation in cluster means of K_m = 0,15. When incorporating the outcome generating the highest sample size, the cost and logistical reasons, 10 pairs of clusters (65 children per cluster) were included. Using a dropout rate of 10% the sample size was estimated to be 1430 adolescents. We predicted the following reasons for drop outs: school transfer, school absence and adolescent refusal to participate. This sample size provided the ability to detect a 10% reduction in energy originating from fat intake, from 40 to 30%.

Figure 25 presents the flow diagram of the recruited population. Within Cuenca, 108 schools were registered at the local Direction of Education. Of these schools, only 49 fulfilled the eligibility criteria of i) schools have at least 90 students enrolled in 8^{th} and 9^{th} grade (11 to 13 years old) to ensure there are enough students per cluster and ii) schools are located in the urban area of Cuenca. We excluded schools from rural areas because their context is very different to that from urban areas, and would therefore require a different set of interventions (68;241). The remaining schools were

matched with one another before randomization. This was done based on similarities in total number of students enrolled in schools, type of school (private or public), student gender (single-gender or co-ed schools), monthly fee as a proxy for the SES of school, and school hours (morning: 7 am – 1 pm or afternoon:12 am – 6 pm). Based on these criteria, 28 schools were matched into 14 pairs and the 10 "best matches" were selected. In each pair, one school was randomly assigned to the intervention group using random number generation (with schools as unit of randomization) in Stata (version 12.0, Stata Corporation, Texas, USA). The first school drawn from the pair was assigned to the intervention. Thus, the unit of randomization was the cluster of schools. Recruitment of participants commenced in August/September 2009 and ended in October 2009.

4.3.2 Recruitment of schools

Invitational visits were made to each school in which the project leader would meet the school principal and/or vice-principal. Project leaders explained the objective of the study, the expectations from the school and the duration of the study. A follow-up meeting was organized to obtain class lists after principals agreed to participate in the study. None of the schools refused participation at this stage (participation rate 100%). In each school, a contact person for the intervention period was assigned, relevant teachers were identified to deliver the intervention, and managers/employees of the food tuck shops were invited to participate.

4.3.3 Recruitment of adolescents

Size of classes ranged from 16-46 students. Hence, we randomly selected two classes from the 8^{th} and two from the 9^{th} grade in each school. Within these classes all adolescents were invited to participate in the study. Adolescents with a co-morbidity, following a special diet, or pregnant were excluded at all times during the programme. Written consent from a parent or guardian and informed assent from adolescents themselves was obtained. Participation rate was respectively 92% and 95% in year 1 and year 2 of the intervention.

4.3.4 Recruitment of parents

Parents were invited to attend the workshops through the school; a letter was sent out by the school principal which said it was mandatory to participate in these workshops. Participation rate was respectively 21% and 12.5% in year 1 and year 2 of the intervention.

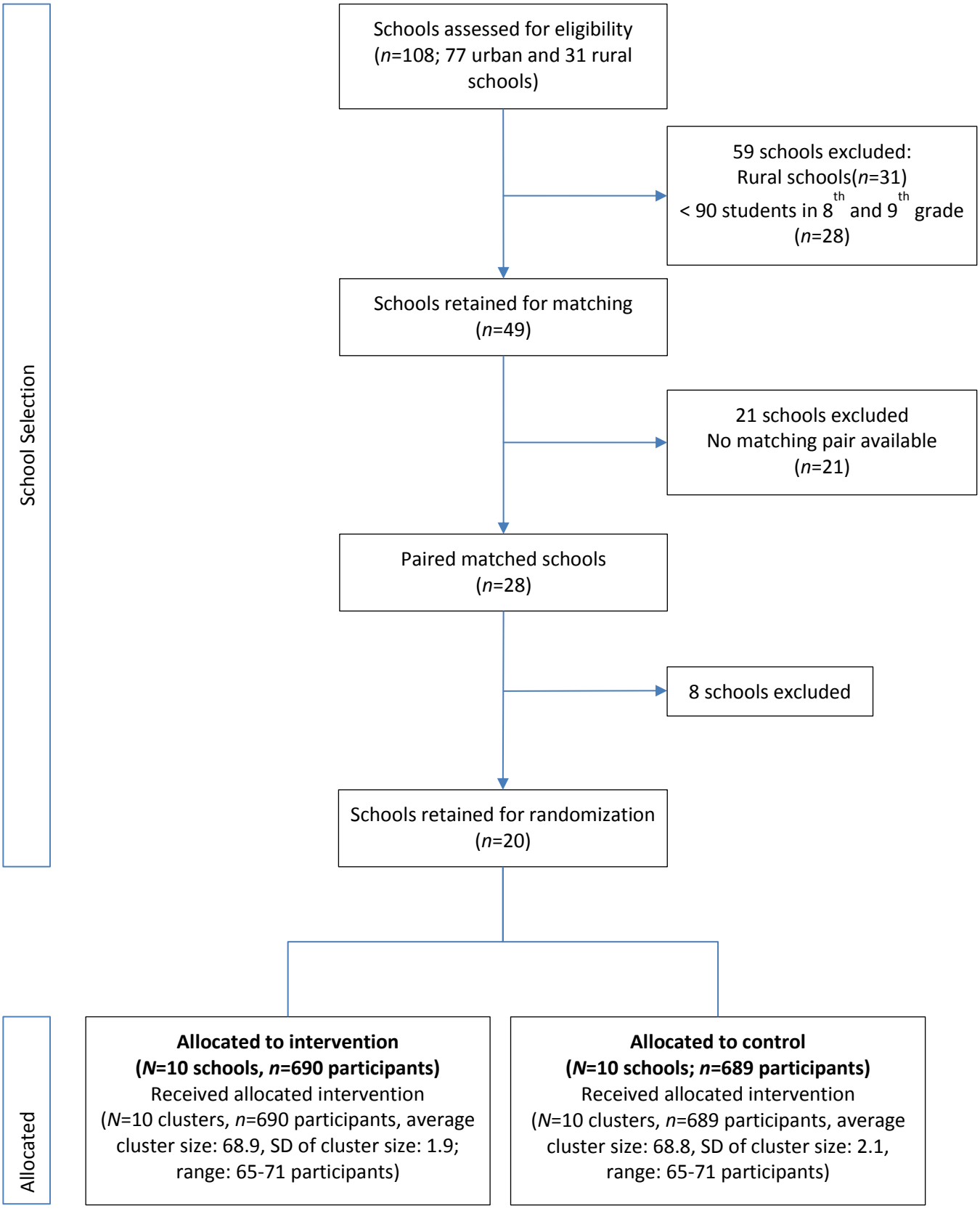


Figure 25 Flow chart of recruitment

4.4 Intervention implementation and duration

The intervention was planned for three years, between 2009 and 2012, and implemented in two stages: *i*) the preparatory phase (September 2009 - June 2010) and *ii*) the programme implementation (September 2010 - June 2012). To assess progress, monitor potential adverse effects and coordinate the intervention activities, research staff met with school teachers and school boards every two to three weeks. The frequency of meetings depended on phase of implementation and on problems encountered.

4.5 Measurements

Data on all outcomes were collected at baseline (when students entered the 8th and 9th grade), after 17 and after 28 months. Physical fitness was the exception and was only measured at baseline and after 28 months. Each measurement period involved a research team of medical doctors, nutritionists and health professionals. This team had field experience and received a 40-hour training session prior to the measurement period. Reliability and repeatability were assessed to ensure precision and accuracy of the measurements. Validated tools to evaluate PA, physical fitness, nutritional status and behavioural factors were used.

Efforts were made to obtain a complete set of measurements on each participant. However, during the implementation of the intervention adolescents were exposed to an important academic transition in year 3 where they changed schools and/or classes according to their preferred specialization (e.g. general science, technical production, arts, etc.). Due to the vast amount of children and limited resources it was difficult to track children who had left or changed school at this stage.

4.5.1 Socio-demographic attributes

Age, gender, and SES were measured. The latter was assessed using a method developed by the Integrated Social Indicator System for Ecuador (243), based on World Bank recommendations (244). This method measures poverty using the “Unsatisfied Basic Needs” criteria and classifies a household as poor when there are one or more serious deficiencies in access to basic needs (e.g. education, health, nutrition, housing, urban services and employment opportunities) t. Using this method, participants were classified into two groups: “Poor” and “Better off” (i.e., if no deficiency was reported).

4.5.2 Dietary and PA behaviour

Dietary intake was measured using two interview-administered 24-hour dietary recalls on a randomly selected weekday and weekend day. Local measures of intake were calibrated and used by the trained interviewers to quantify the amount of food consumed. A food composition database was compiled using databases from the US (USDA, 2012), Mexico (INNSZ, 1999), Central America (INCAP/OPS, 2012) and Peru (CENAN/INS, 2008). When detailed information on the ingredients and/or the cooking methods of a recipe was not available, recipes were prepared in triplicate by local volunteers. The ingredients used, and their weights, were measured and averaged to obtain a final estimate for the recipe. For locally processed and pre-packed food items, food labels were used to obtain the food composition.

Screen time was assessed using a validated self-reported questionnaire (279). Adolescents reported the number of hours spent per typical week and weekend day watching television, playing videogames or using the computer. In a sub-sample of the study population, an objective assessment of PA levels was obtained using the uniaxial GT-256 and GT1M ActiGraph accelerometers (Actigraph Manufacturing Technology Incorporated, Fort Walton Beach FL, USA). These accelerometers are suitable for measuring PA behaviour in adolescents and are comparable to evaluating PA intensity levels (168). These participants were selected using a random number in Stata. Accelerometers were worn for 5 consecutive school days. Pre-initialized accelerometers were distributed and placed on the right side of the hip using an adjustable elastic belt. Participants received a demonstration and instructions from a trained researcher on how to wear the accelerometer. Accelerometers could only be removed when sleeping, showering or engaging in other water activities. Accelerometers were set to register 1-minute epoch cycles.

4.5.3 Physical fitness

Physical fitness was assessed using the EUROFIT test battery (280) which measured: cardio-respiratory endurance (20m shuttle run test), strength (handgrip and vertical jump test (281)), muscular endurance (bent arm hang and sit-ups test), speed (speed shuttle run and plate tapping), flexibility (sit-and-reach) and balance (flamingo balance test). This battery has been previously validated (282) and used in various Latin American countries to assess physical fitness (283).

4.5.4 Influencing factors of dietary and PA behaviour

Factors influencing dietary and PA behaviour were assessed using a questionnaire. This questionnaire is considered a reliable and valid tool to measure individual and environmental factors in Ecuadorian adolescents (*see* chapter 4). It includes questions on attitudinal beliefs, subjective norm, perceived barriers, parental influence, etc.

4.5.5 Anthropometry

Anthropometric measurements were carried out in duplicate by two trained researchers who ensured optimal privacy. Adolescents wore light clothing and no shoes during the measurements. Height was measured to the nearest 0.1 cm with a portable stadiometer (model PORTROD, Health O Meter, USA) and body weight to the nearest 0.1 kg using a digital calibrated balance (model SECA 803, Seca GmbH & CO, Hamburg, Germany). Adolescents were then classified into age- and sex-specific BMI categories (162;163) and the prevalence of obesity was thus estimated. Waist circumference Waist circumference was measured at the mid-point between the last rib and the iliac crest. Abdominal obesity was defined as having a waist circumference higher than the 80th percentile for age and sex.

4.5.6 Blood pressure

Systolic and diastolic blood pressures were measured and recorded after a 10-min seated rest using a portable sphygmomanometer. Measurements were carried out by trained staff, on-site and in triple. In order to avoid any false positives, a fourth measurement was taken after a period of rest when initial values were above 120/80 mmHg. When a child was diagnosed with high blood pressure, he/she was referred to a specialist for a final diagnosis and treatment. Normal blood pressure was defined as average systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) below the 90th percentile for sex, age and height. Pre-hypertension and hypertension were classified together as a high risk level of blood pressure, when the average SBP and/or DBP was greater than or equal to the 90th percentile for sex, age and height (284).

4.5.7 Knowledge questionnaire

The adolescent's knowledge on recommendations and the importance of healthy PA and dietary behaviour for their health and well-being was assessed using a questionnaire before and after the

ACTIVITAL toolkit was implemented. This knowledge questionnaire was developed based on the educational content applied in the ACTIVITAL toolkit.

4.5.8 Nutrition and PA environment

To measure the nutrition and PA environment, validated questionnaires were used and slightly modified or adapted to the context (285;286). Questionnaires assessed key elements of the physical environment inside and outside schools for nutrition and PA as well their related policies. We examined what was available, both inside school and in their nearby surroundings, and the nutrition and PA policy of schools.

4.5.9 Process evaluation

In order to understand the process of change of the proposed outcomes a full pre-specified process evaluation was carried out. It included monitoring delivery, reach and dose of the intervention, and the evaluation of the programme by key stakeholders. This was done through observations, focus groups, face-to-face interactions, and questionnaires for all participant groups. This information will serve to identify facilitating factors and barriers for intervention effectiveness, and for further dissemination.

4.6 Data management and analysis

Data was entered and processed using Epidata and specifically developed software for the food intake. Data is being analysed using STATA 12 (Statacorp, college station, Texas USA). In case of severe deviation from normality the difference in medians are tested using non-parametric statistics. All analysis are carried out with a significance level of 5%. Analysis are by intention-to-treat and adjusted for the clustering effect.

Differences at baseline between intervention groups as well as differences between dropouts and remainders groups are assessed; using a t-test for continuous variables adjusted for the pair-matched allocation, and the χ^2 test for categorical variables. To estimate the effect of the intervention a difference in differences approach is used.

5 Dissemination

Currently, the evaluation study is being analysed. The possibility of disseminating or scaling up the ACTIVITAL intervention will be evaluated based on its effectiveness, costs and possible adverse effects. For the time being, only the costs of the intervention can be presented. **Table 21** details the costs of all activities included in the intervention. The total amount spent from 2008 to 2012 is €155,988.

Table 21 Costs of all activities in the intervention

Item	Needs assessment	ACTIVITAL study		
	Costs in 2008-2009 (€)	Costs in 2009-2010 (€)	Costs in 2010-2011 (€)	Costs in 2011-2012 (€)
Investment costs (ethical committee, accelerometers, etc.)	2440	718	0	1000
Supplies (printing material intervention)	3605	15358	0	636
Personnel (research staff and service contracts)	23030	20625	57248	16897
Transport	3390	1925	0	0
Miscellaneous (trainings, purchasing foods, refreshments, etc.)	552	6989	0	1572
Subtotal	33017	45616	57248	20106
Total	155988			

6 Discussion

This chapter describes the use of a theory and evidence-based approach and a participatory approach in developing a multi-component school-based health promotion intervention, aimed at improving dietary and PA behaviour of Ecuadorian adolescents. This is a unique intervention as it incorporates epidemiological and psychosocial evidence from Ecuadorian adolescents, and involves all the participant groups from the beginning to ensure the cultural appropriateness of the intervention. Intervention strategies were developed using both the IM and CPPE processes. This systematic and stepwise process led to the development of an intervention delivered by both the research team and the school staff. The intervention addressed key barriers in the dietary and PA risk behaviours of adolescents, by targeting changes in adolescent behaviour using an interactive educational toolkit and by targeting changes in the environment at school (in school tuck shops, social events, and physical environment) and at home (parental workshops). The intervention was delivered during school hours to ensure the efficient use of resources (except for the school tuck training sessions and parental workshops). To assess effectiveness of the study, a pair-matched RCT was implemented and evaluated over 3 years. Additionally, an in-depth process evaluation was performed to evaluate (in) effective pathways of the intervention.

6.1 Strengths, challenges and limitations

A perceived strength and the most novel aspect of this intervention, is the use of the participatory approach which feeds the development of the intervention. The possible advantage of using a participatory approach over other approaches is that it allows for a better understanding of how people perceive realities whilst encouraging communication and avoiding the implementation of irrelevant strategies. This approach also contributed to the motivation of the participant groups, a feeling of ownership, and identified possible barriers and opportunities in each school which were then taken into account when developing the implementation strategies. By combining it with the IM we were able to provide a transparent process. Additionally, the intervention development used local evidence and sought confirmation of behavioural change theories used for the targeted population. All materials were readily available and easy-to-use. Therefore, they did not require a high level of expertise, reduced the workload, enhanced the sustainability of the intervention, and facilitated adoption and implementation.

There are, however, a number of challenges associated with our approach. Both IM and CPPE are resource-intensive and were not implemented completely. IM requires a considerable amount of time and expertise in revisiting and fine-tuning objectives and theories. CPPE relies heavily on strong partnerships, the enthusiasm of one person or a group of persons and their commitment to the project. Both processes complemented each other's weaknesses.

The qualitative research revealed the importance of the macro-environment (i.e. policies, cultural changes, built environment). Unfortunately these could not be addressed in the ACTIVITAL programme. Attempts were made to change for example diet and PA policies in schools, but proposals were not supported by the schools nor by the tuck shops. They argued that the structure was too complicated since tuck shops are private companies located within schools. This would be an exciting challenge though for future intervention studies.

7 Conclusion

This chapter describes the development of a comprehensive school-based health promotion programme in Ecuadorian adolescents. The use of CPPE and IM lead to a transparent and culturally-appropriate intervention with the potential to provide information to other researchers in the same field, and enabled identification of effective and ineffective intervention strategies. The intervention has been implemented and its impact on behaviour change is being analysed through a pair-matched clustered RCT.

Box 5 Methodological and conceptual key messages addressed in the development of ACTIVITAL

- Influencing factors on both dietary and PA behaviour were examined in this population and conceptualised in a framework and validated;
- ACTIVITAL was a theory-based intervention based on local evidence and the use of a participatory approach;
- ACTIVITAL was a combined intervention addressing both PA and dietary behaviour;
- ACTIVITAL was a multicomponent (i.e. school staff, parents, and adolescents) intervention which integrated educational activities into the school curriculum to the extent possible;
- Parents and/or caregivers and school staff were directly involved in the development of ACTIVITAL;
- Both the individual influences and the influences imposed on adolescents by the nutritional and PA environment in schools were addressed by ACTIVITAL;
- Adverse effects, costs and objective outcome measures have been addressed by ACTIVITAL;
- A rigorous evaluation design, including both process and impact evaluations, was used to examine the effect of ACTIVITAL;

Chapter 7:
General discussion

The outcome of this research is positioned within the wider context of rapid increases in unhealthy body weights and chronic diseases in LMICs (*see* Chapter 1). In an attempt to reverse and/or halt this trend, the present research was directed at improving dietary and PA behaviours in adolescents in Cuenca, Ecuador. Different studies were conducted to address this objective, and the three main pillars throughout this work were local evidence, theory and a participatory approach. A total of five studies were performed:

1. An evidence synthesis for school-based interventions in LMICs;
2. A validation study of a tool measuring PA behaviour;
3. A qualitative study identifying and conceptualising factors influencing adolescents' dietary and PA behaviours;
4. A quantitative study to validate the conceptual framework for dietary behaviour influences; and
5. An intervention study aiming to improve dietary and PA behaviours in adolescents through the use of a school-based health promotion intervention. Findings from the above studies were used to develop this intervention.

This final chapter provides an overview of the key findings and conclusions in relation to the programme framework presented in Chapter 1. It also valorises obtained results towards findings from the evidence synthesis and provides a niche exploration of further implications of similar interventions in Ecuador and other LMICs.

1 Overview of main findings

1.1 Needs assessment (Phase A-C)

A systematic review (Chapter 2) examined the effectiveness of school-based obesity-preventions interventions in LMICs to guide the development of a new intervention. This review showed that these interventions have the potential to improve dietary and PA behaviour and thus prevent unhealthy body weight in LMICs. From this information, intervention characteristics associated with higher effectiveness were identified. The review subsequently called for more and better quality research using valid evaluation tools and methods that use theory, are not prone to reporting bias and examine contextual influences of physical activity and eating behaviours.

In response to this, the validity and reliability of a PA record as a tool for measuring PA was evaluated (Chapter 3). The PA record provided acceptable estimates for reliability and validity at a group level.

The influences on PA and eating behaviour were also studied (Chapter 4 and 5). Several culture-specific factors emerged that were incorporated into the conceptual frameworks for diet and PA behaviour. These frameworks allowed for the development of a suitable intervention promoting both these behaviours, and contributing to the evidence-base of theory development in LMICs. The results also highlighted that measures to recognising environmental changes were warranted in addition to health education.

1.2 Intervention development (Phase D)

A school-based intervention was developed from the above findings and through the use of theory, local evidence, and a participatory approach (Chapter 6). The IM and CPPE protocols were used to develop these intervention strategies. This overall approach resulted in a comprehensive, culturally-appropriate intervention package tailored to improve PA and dietary habits in young adolescents. The intervention strategies consisted of individual classroom-based and environment-based components. This study provided new insight into the processes of intervention development in LMICs. Furthermore, it would help identify and differentiate between effective and ineffective strategies, and allow for the replication, adoption or dissemination of useful strategies.

2 Evidence synthesis: valorisation of obtained results

The evidence synthesis performed within this PhD research made both methodological and conceptual recommendations for the planning and development of preventive interventions in LMICs (*see* Box 1). Valorisation of the acquired results towards these recommendations is further discussed.

2.1 Conceptual recommendations

Resulting from the conceptual recommendations, a stepwise and systematic approach using theory or conceptual underpinnings (61;62) was followed for the planning and development of the ACTIVITAL programme. The initial systematic review also highlighted that aside from the theory, a basis for cooperation needs to be created to support intervention development in order to ensure

the sustainability of these interventions. This confirmed the three pillars, local evidence, theory, and a participatory approach used throughout the ACTIVITAL programme's planning and development.

2.1.1 Toward a conceptual framework for eating and PA behaviour

The *local evidence pillar* provided information on what was likely to work in LMICs (*see* Chapter 2). Targeting both dietary and PA behaviours in a combined fashion and involving multiple stakeholders (e.g. parents and school staff) appeared to be effective intervention characteristics (*see* Box 1) (186). Local evidence provided details on which dietary and PA behaviours needed to be targeted for change to contextualise the intervention (67;68). It also demonstrated that when addressing these behaviours in adolescents, contextual influences such as social values and cultural norms must be acknowledged, as well as the environment contributing to the shaping of behaviours. These influences are likely to differ within and between countries (57).

Influences on dietary and PA behaviours in Ecuadorian adolescents were examined using a qualitative study design. This study accounted for social, cultural and environmental influences from the perspective of parents, school staff and adolescents. A multitude of influences can be considered important in determining food and PA choices of adolescents; to select and prioritize these influences, a theoretical framework (ASE-model and Socio-Ecological model) was used (*see* Chapter 4). The findings of this study resulted in a framework in which the examined individual and environmental influences explaining eating (*see* chapter 5) and PA behaviours were set forth. The findings of chapter 4 and 5 confirmed the importance of using local data to inform interventions rather than relying on existing international evidence. This was evident at different stages of this PhD research and for a number of reasons.

The usefulness of local evidence was showcased at the level of influences on dietary and PA behaviour. Several culture-specific influences such as perceived food safety and socio-cultural changes were uncovered, while other influences such as availability were identical to those found from studies in HICs (241). These findings highlight the importance of context in the development of behaviour change interventions. On another note, these results supported the hypothesis put forward in the systematic review: interventions should target changes in the nutritional and PA environment of schools, and parents play an important contributory role (in some behaviour but not all).

Local evidence played an important role regarding the theories used for identifying behavioural influences. To quote an expert:*" interventionists need theories that are accurate and applicable; that specify not only the relation between two constructs, but also whether that relation does or does not change across contexts"* (287). The conceptual framework for eating behaviour exemplifies this statement by examining the relationships between constructs, across different eating behaviours and SES, and within the particular context Ecuadorian adolescents live in. Not all constructs were associated with the different eating behaviours and some that were expected to be important, such as self-efficacy, were not. Also, the associations of constructs with diet varied according to the particular eating behaviour studied, and with SES level. It is important to note here that the absence of an association can be explained by a number of reasons: *i*) inadequate measures to detect associations, *ii*) associations hold for some target groups and not for others, and *iii*) there is an association, but it appears to be not that important within the sample population. Considering these reasons, the variation in influencing drivers across eating behaviours and SES highlight the importance of using the conceptual rationale to investigate these associations. Furthermore, the conceptual framework contributes to the evaluation of existing theories and their further refinement (287), particularly for this age group in LMICs. Additionally, it also reflects the cultural and contextual interactions of these influencing factors at individual and environmental level. This is vital as there is a lack of strong conceptual models theorizing these pathways (192). Few behaviour change studies have tried to examine such multiple relationships in a comprehensive model (187). Considering the complex set of factors that place an adolescent at risk for unhealthy body weight or chronic diseases, solutions for tackling their disease burden must not only look at the different factors per se, but should also look at how they interact. Addressing these relationships between the environment and the individual is exactly what is needed to advance health behaviour interventions (288).

2.1.2 A systematic development of a preventive intervention

Theory as a pillar in the present research had multiple uses. First, it played an important role in developing the systematic programme framework used for planning and developing the ACTIVITAL programme (*see* Chapter 1). Different types of models (58;61;62;289) have been used over the past years and have shown to be useful as general systematic approaches for intervention development. As these do not provide an explanation on how behaviour change is induced, the framework was complemented with the IM protocol. Second, as detailed above, the use of theory allowed us to understand influences at individual and environmental levels, and their interactions with specific dietary and PA behaviours. Third, a range of behaviour change techniques was used to characterize

the content of the intervention with precision and specificity. Using such standardized descriptions of intervention content facilitates the fidelity of intervention operationalization in studies aiming to replicate intervention strategies (62;272;290). It will also help reveal effective or ineffective pathways of change and intervention strategies.

The present research also confirmed that the *participatory approach* (CPPE) used to develop the ACTIVITAL programme was an appropriate and useful strategy. This pillar helped in determining what strategies were feasible with the available resources, identified barriers and opportunities for implementation, and increased the acceptance of strategies in the target population during intervention development.

2.2 Methodological recommendations

One of the key methodological recommendations made by the systematic review concerned the rigorous evaluation of intervention designs (*see* Box 1). As the ACTIVITAL programme was a complex intervention, both impact and process evaluations were planned. The editorial by Baranowski associated with the evidence synthesis of the present research (291) argues (as before (235)) in favour of evaluations which first test for efficacy and later for effectiveness. Efficacy trials evaluate the effect of the intervention under ideal circumstances or in other words they look upon internally valid estimates of programme effects. Effectiveness trials look to see if the intervention was effective under "real life" circumstances and thus examine its external validity (292). In reality, however, such a stepwise process requires time, resources and a large budget. The stepwise development of the ACTIVITAL programme could be interpreted as following a similar way. During the first year, a thorough preparatory and participatory phase was conducted in which the target population was both logistically and emotionally invested. The second year could be viewed as an efficacy study given the highly-controlled, observed and optimal conditions assuring accurate programme implementation. In the third year of implementation, the setting was less controlled with less focus on participation representing an example of an effectiveness study. These different steps were rigorously evaluated using process and impact evaluation.

3 Implications

Implications of this PhD research for Ecuador and other LMICs take on different dimensions (**Figure 26**), which will be further explained in the paragraphs hereafter.

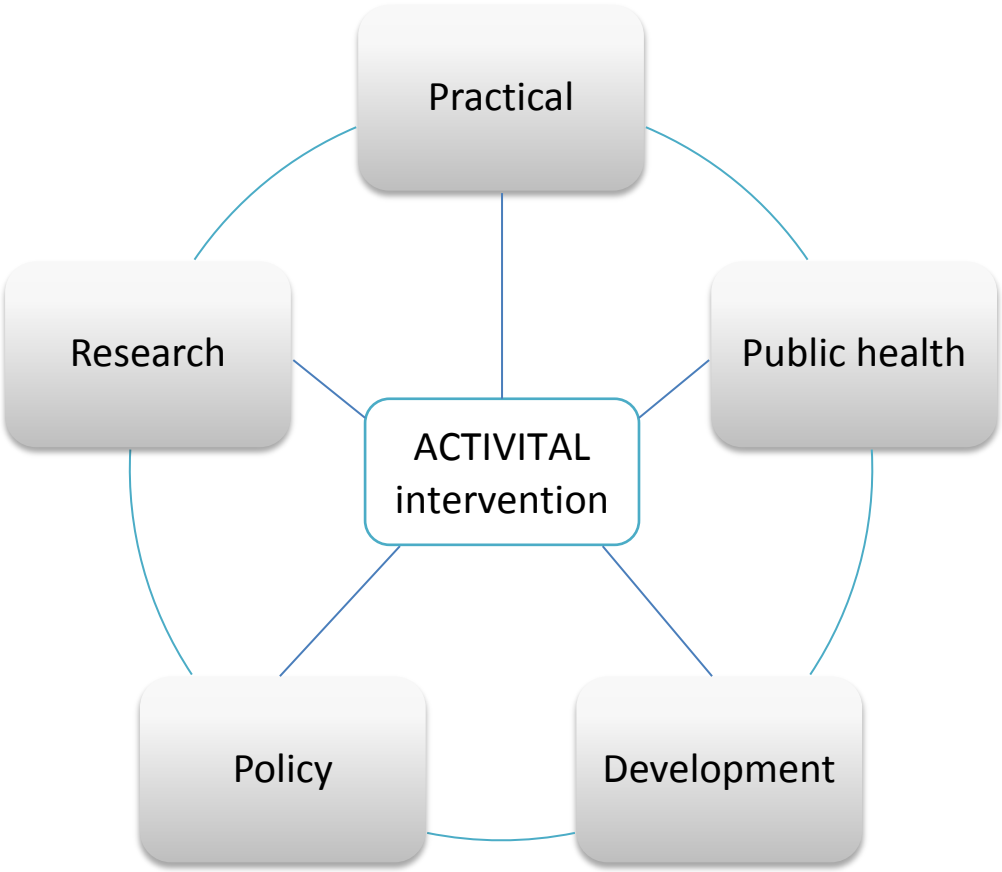


Figure 26 Implications of this PhD research for Ecuador and other LMICs

3.1 Practical implications

Global disease burden has evolved from infectious diseases to chronic diseases (1;2). This epidemiologic transition has been the greatest in LMICs, particularly among young people as they are the most socially and economically vulnerable (293). Governments in these countries have to formulate timely actions and policies. Such policies are currently lacking a firm evidence-base to allow for robust conclusions for preventive efforts in adolescents to be drawn. The rigorous approach and in-depth processes followed in this PhD research adds to the existing evidence-base on preventive health promotion interventions. A question however rises on whether following a systematic and stepwise methodology as shown in the present research is an efficient and feasible approach, particularly in light of the many years and resources needed to demonstrate their full potential. The answer to this feasibility question takes on a number of different dimensions. A simple 'yes' would answer the question if a *one-size-fits-all* approach is used in the prevention efforts.

However, such an approach assumes all equal contexts, which is not in fact the case as shown by the findings of this PhD research. As discussed extensively in the above paragraphs, differences do exist in contextual influences, even within a sample population group. Therefore it can be concluded that intervention strategies working in context A will not necessarily do so in context B. Clearly, a *one-size-fits-all* approach would be a premature action and result in ineffective interventions that risk wasting the limited resources of LMICs, also leading to the loss of public confidence in community interventions.

To firmly conclude that the approaches used in ACTIVTAL were successful, they need to be replicated in different contexts by a battery of multiple proof-of-concepts. Such contexts include areas with diverse subjects living in different geographic regions and from different cultural and socio-economic backgrounds. This pool of proof-of-concepts will increase insight into how cultural differences affect the effectiveness of strategies until generalization to a larger target group becomes more plausible. Practically, these proof-of-concepts need to *i*) target multiple behaviours, as behavioural risks for obesity and chronic diseases are clustered in adolescents (76;294;295); *ii*) acknowledge the context in which they are implemented by using local evidence to identify contextual influences; *iii*) characterize the content of the intervention with precision and specificity using behavioural change techniques, *iv*) use a theory-based development process; *v*) use a participatory approach to the greatest extent possible; and *vi*) develop a rigorous design for evaluation, including process evaluation. The challenge for such proof-of-concepts is to develop sustainable, effective, and cost-effective approaches. These processes should be well-documented and transparent to allow for the accurate replication of interventions, facilitate faithful implementation of a proof-of-concept, and form a robust conclusion on whether or not these interventions are ideal for LMICs. On a positive note such a pool of proof-of-concepts could equally contribute to the evaluation and refinement of behaviour change theory as mentioned previously (287).

In order to achieve this, concerted action is needed from both policy-makers and researchers in LMICs. Considering the current fragmentation of health promotion efforts and the multiple causes related to obesity and chronic diseases, researchers from multiple disciplines need to join forces. A crossover of multiple disciplines to evaluate proof-of-concepts would be useful in avoiding researchers from different backgrounds independently yet inefficiently addressing the same issue from different perspectives (296), particularly as developing such complex interventions can be challenging in LMICs (58).

3.2 Public health impact

Health promotion interventions can help halt, or stabilise, the upsurge of obesity and chronic diseases in LMICs. The ACTIVITAL programme, can be a means of reaching large parts of the adolescent population in Ecuador with little effort. The preliminary results of the impact evaluation (part of the parallel PhD research) showed improvements in dietary and PA risk factors. Adolescents from the intervention group consumed fewer harmful food groups such as added sugars, soft drinks, fast food, salty snacks and sweets. On the other hand, more vegetables, fruits and fiber were consumed as a result of the ACTIVITAL intervention. The intervention also improved physical fitness and minimized the decline in physical activity levels. These small, but positive effects on both dietary and PA risk factors, can yield substantial health gains when disseminated widely (297).

Before scaling-up, however, data on adverse effects, cost-effectiveness, and sustainability of the intervention are needed. The intervention may aggravate social stigmatisation of psychosocial problems in obese adolescents or could lead to or exacerbate underweight or eating disorders (90). Costs related to obesity or chronic diseases are predicted to soar the next two decades; in the USA for example, costs will increase by US$66 billion per year for treatment of obesity-associated diseases (298). Moreover, the economic toll of chronic diseases in LMICs is estimated to reach US$21 trillion by 2030 (299). A mere 1% reduction in BMI would substantially reduce the number of obesity-related diseases and their costs (298). The planned cost-benefit analysis for the ACTIVITAL programme will identify whether the intervention is an effective tool from a public health perspective or not. This analysis will be important given the paucity of such data for interventions in LMICs (186). A process evaluation of the ACTIVITAL programme will provide more detailed data on the sustainability of the intervention, e.g. ease of implementation and dependence on external factors.

3.3 Development implications

A large body of evidence shows that the burden chronic diseases imposed upon LMICs is large and associated with high treatment costs and lost labour units (4;300). An inevitable burden is placed on countries that can least afford this major health drawback in relation to their social and economic development. The poorest populations in these societies are especially vulnerable (301;302) as they are most likely to be exposed to the risk factors of chronic diseases, yet they are less able to cope with the financial burdens of treating chronic diseases (240). Chronic diseases consequently

contributes to further health inequalities (303). Surprisingly, chronic diseases have been underappreciated as development issues as witnessed by their absence in the Millennium Development Goals. Preventive efforts should ensure that all population groups benefit from the implemented measures.

The ACTIVITAL programme could be one of many initial steps towards designing programmes that are aimed at the alleviation of the chronic disease burden in Ecuador. The participatory approach used for developing the intervention encouraged the involvement of all relevant stakeholders, creating more awareness among adolescents, school-staff, parents, and local policy-makers. A recent review on the effect of obesity prevention interventions stratified by SES identified that individual level interventions may be less successful in low SES than structural changes in the environment. This evidence, however, is derived solely from HICs (304). ACTIVITAL targeted changes in the individual and the environment, and accounted for socio-economic differences during the development processes and the operationalization of intervention strategies. A subgroup analysis combined with the process evaluation will further evaluate the ability of the intervention to indiscriminately reach all SES groups. The experience of this study serves as an important evidence-base for local and national authorities in Ecuador to undertake action.

3.4 Policy implications

Previous paragraphs have made a compelling case for the need of multicomponent interventions. The Ecuadorian adolescent population studied in this PhD research presented high-risk behaviours related to chronic diseases and obesity; under nutrition played a secondary role in this. Influences on these risk behaviours were identified but were complex and present at both individual and environmental levels (*see* chapter 4). Preventing these risk behaviours from an early stage, and through the use of informed policies, is of extreme importance. Decision makers need to know whether behaviour change interventions to promote diet and PA are effective or not, together with reasons and context for their effectiveness. Recent evidence from a systematic review on school-based nutrition and PA policies for children suggests that vertical policies implemented in isolation are less likely to be effective than those that are comprehensive and incorporate wider stakeholder and family involvement (305). The ACTIVITAL programme makes an important contribution to the development of the evidence-base of such preventive efforts, crucial to policy-making.

In addition to adequate intervention strategies, multi-sectoral (e.g. food industry, catering, government, sport organisations) public health policies accounting for the complexity of chronic diseases and obesity are needed (306). Lachat *et al*. reported that only 82 (out of 140) LMICs currently have policies in place to tackle at least one risk factor of chronic diseases (307). Ecuador does not any have such a policy plan in place. While sustaining the successes in control of infectious diseases and under nutrition, Ecuador must recognize the urgency in addressing the growing burden of obesity and its chronic diseases. An analysis of current Ecuadorian policy plans using the *intervention ladder (*a ranking based on potential infringement of free choice associated with legislation) (308) showed that policies have so far been largely situated at the level of choice enabling or information provision actions (309). In addition, these policies were either at a premature stage or have been developed from a poor evidence-base (309). The Ecuadorian government needs to move from a free choice of action into a more structural, regulatory or fiscal change on this public health matter (306). On a positive note, political processes prioritising chronic diseases and the obesity crisis in Ecuador are beginning to emerge (http://www.siicsalud.com/acise_viaje/ensiicas-profundo.php?id=118636). Examples of these recent efforts are to mandate the traffic light system (a system of food labelling in which green, amber, and red symbols are used to indicate whether the food contains low, medium, or high amounts of sugar, fat, salt, etc. on food packages, respectively) and the addition of a daily hour of physical education in school curricula (**Figure 27**).

3.5 Further research

The findings of this PhD research contribute to the evidence-base of preventive efforts to promote healthy living in young people. Even though the ACTIVITAL programme was planned and developed under the best of circumstances there are some limitations (*see* discussion sections in previous chapters for more detail). Future research should build on the strengths of this study but take into account these identified limitations.

During conceptualisation and operationalization of concepts across chapters in this PhD research, some limitations were identified. Firstly, some psychosocial variables were assessed with a limited number of items. The use of such limited number or single items was mainly due to practical reasons as data were collected during school hours. However, studies have shown that this is not only practical, but also theoretically plausible.

Estudiantes tendrán una hora de ejercicios

Tras el anuncio del Ministro de Educación, Augusto Espinosa, los estudiantes tendrán más tiempo para la actividad física, como parte de sus actividades académicas. Diego Cáceres | EL TIEMPO

Un partido de fútbol, charlas con profesores y padres de familia y la firma de convenios fueron, entre otras, las actividades cumplidas ayer, por el ministro de Educación, Augusto Espinosa, en esta ciudad.

Figure 27 Press release of the addition of a daily hour of physical education in schools in Cuenca (Source: El Tiempo, Ecuador, 20th of March 2014)

Recent research illustrated that the predictive validity of single-item measures for constructs are as predictive as multi-item measures (310). Moreover, no specific rule of thumb on the number of items to be considered exists. Secondly, some variables were omitted due to poor psychometric properties. The different social and cultural context, and cognitive background of Ecuadorian adolescents could have played a role in the low reliability of questionnaires; it showed to be challenging to respond to questions using a Likert response format or anchor points (e.g. always – never). However, recent research illustrated that evaluating reliability/internal consistency using merely Chonbach's alpha is insufficient. They argue for a more comprehensive assessment of scale quality including "i) computation of omega, the greatest lower bound, and Cronbach's alpha, preferably with confidence intervals, ii) conduct a factor analysis, iii) inspect means, medians, and varances for each item, iv) generate a correlation matrix, v) inspect scatterplots of associations between items, and vi) inspect histograms of each item's distribution" (247). Practically, further studies, in both LMICs and HICs, should invest in validating the psychometric properties of scales while reflecting the socio-cultural context of the target population (311).

Through the triangulation of methods, influences on behaviour, psychological and emotional factors emerged. Anxiety, depression, sadness or loneliness, and forced eating by parents are some of the examples of these factors, all of which may lead to excessive eating. Eating is seen as displacement behaviour for negative feelings. (312). These identified factors were not addressed in the ACTIVITAL program, but future studies may choose to develop subscales that address them. An interesting road to follow here is the system thinking as proposed by Kahneman (313). Kahneman divided thinking into two systems which interact with one another. System 1 represents fast thinking. It includes automatic responses and is informed by subconscious natural drivers such as the instinct for danger. System 2 on the other hand characterises slow thinking, which is a deliberate and conscious process (e.g. “what shall we have for dinner tonight” or a “mathematical calculation”). One could use this theory to evaluate and better understand food choices resulting in excessive eating. Emotions such as fear, anger, and hatred, can explain the majority of occasions on which people depart from rational eating behaviour.

An important area of investigation is the emerging need to have age-appropriate and updated theories that can be used for intervention development in LMICs. The proposed conceptual frameworks for eating and PA behaviours in Ecuadorian adolescents from the present research should be elaborated further by other proof-of-concept studies. When combining evidence of such proof-of-concepts for LMICs existing theories can be evaluated and refined, and subsequent new theories can be developed using an evidence-induced approach (57;287). In addition, this would allow for conceptual development to catch up with analytical advances (192).

Partnerships among LMICs of researchers, practitioners, policy-makers, and other stakeholders within the obesogenic environment (e.g. food industry, sports organisations) need to be created. Such partnerships can undertake combined actions to address the burden of chronic diseases and obesity to move forward the agenda. The importance of such a collaborative approach and a greater alignment between researchers and policy-makers was reinforced by the experiences gained from the ACTIVITAL programme.

Appendices

Supplementary Table 1 Search strategy MEDLINE (MeSH)

Category	Search terms
Countries	(Afghanistan OR Afghan OR Albania* OR Algeria* OR "American Samoa*" OR Angola* OR Argentin* OR Armenia* OR Azerbaijan* OR Bangladesh* OR Barbad* OR Belarus OR Belorussian OR Beliz* OR Benin* OR Bhutan* OR Bolivia* OR Bosnia and Herzegovina OR Botswan* OR Brazil* OR Bulgaria* OR "Burkina Faso" OR Burkinabe OR Burund* OR Cambodia* OR Cameroon* OR "Cape Verde" OR "Cape Verdean" OR "Central African Republic" OR Chad* OR Chile* OR Chin* OR Colombia* OR Comoros OR Comorian OR "Democratic Republic of Congo" OR "Republic of Congo" OR Congo OR Congolese OR "Costa Rica" OR "Costa Rican" OR "Côte d'Ivoire" OR "Republic of Côte d'Ivoire" OR "Ivory Coast" OR Ivorian OR Croatia* OR Croat OR Cuba* OR "Czech Republic" OR Czech OR Djibouti* OR Dominica* OR "Dominican Republic" OR Ecuador* OR Egypt* OR "Arab Republic of Egypt" OR "El Salvador" OR Salvadorian OR "Equatorial Guinea" OR Guinean OR Eritrea* OR Estonia* OR Ethiopia* OR Fiji* OR Gabon* OR Gambia* OR Georgia* OR Ghana* OR Grenad* OR Guatemala* OR Guinea OR "Guinea-Bissau" OR Guyan* OR Haiti* OR Hondura* OR Hungar* OR India* OR Indonesia* OR Iran* OR "Islamic Republic of Iran" OR Iraq* OR Jamaica* OR Jordan* OR Kazakh* OR Kenya OR Kenyan OR Kiribati OR Korea* OR "Democratic Republic of Korea" OR "Kyrgyz Republic" OR Kyrgyzstan* OR Lao* OR Latvia* OR Lebanon OR Lebanese OR Lesotho OR Liberia* OR Libya* OR Lithuania* OR Macedonia* OR "republic of Macedonia" OR Madagasca* OR Malawi* OR Malaysia* OR Maldives OR Maldivian OR Mali* OR "Marshall Islands" OR Mauritania* OR Mauritius OR Mauritian OR Mayotte OR Mexic* OR Micronesia* OR "federal states of Micronesia" OR Moldov* OR Mongolia* OR Morocc* OR Mozambique OR Mozambican OR Myanmar OR Namibia* OR Nepal* OR Nicaragua* OR Niger* OR Nigeria* OR "Northern Mariana Islands" OR Oman* OR Pakistan* OR Palau* OR Panama* OR "Papua New Guinea" OR Paraguay* OR Peru* OR Philippine* OR Poland OR Polish OR Romania* OR "Russian Federation" OR Rwanda* OR Samoa* OR "Sao Tome and Principe" OR Sao Tomean OR Senegal* OR "Serbia and Montenegro" OR Serbia* OR Montenegr* OR Seychell* OR "Sierra Leone" OR "Sierra Leonian" OR "Slovak Republic" OR Slovakia* OR "Solomon Islands" OR Somali* OR "South Africa" OR "South African" OR "Sri Lanka" OR "Sri Lankan" OR "Saint Kitts and Nevis" OR "Saint Lucia" OR "Saint Vincent and the Grenadines" OR Sudan* OR Suriname* OR Swaziland Or Swazi OR "Syrian Arab Republic" Or Syria* OR Tajikistan OR Tajik OR Tanzania* OR Thailand OR Thai OR "Timor-Leste" OR Togo* OR Tonga* OR "Trinidad and Tobago" OR Trinidadian OR Tobagonian OR Tunisia* OR Turk* OR Turkmenistan OR Uganda* OR Ukrain* OR Uruguay* OR Uzbekistan OR Uzbek OR Vanuat* OR Venezuela* OR Vietnam* OR "West Bank and Gaza" OR Yemen* OR "Republic of Yemen" OR Zambia* OR Zimbabwe*) **AND**

Setting	(school OR school*) **AND**
Intervention	(overweight OR obesity OR nutrition* OR food intake OR food consumption OR diet OR exercise OR physical activity OR physical fitness OR sport*) **AND**
Study design	(intervention* OR controlled clinical trial OR evaluation studies OR process evaluation OR evaluation* OR comparative studies OR comparison* OR randomised controlled trial OR random allocation OR non randomised or nonrandomised or non-randomised or pseudo randomised OR Quasi experimental OR pseudo experimental OR experiment* OR matched communities OR matched schools OR matched pairs OR matched populations OR outcome study or outcome studies OR "controlled before and after study" OR "uncontrolled before and after study" OR cohort study OR cohort studies OR "interrupted time series study" OR Qualitative study) **NOT**
Type	editorial **NOT** comment **NOT** letter

Limits used in MEDLINE: Age category: Child: 6-12 y, Adolescent: 13-18 y; Subjects: *Restricted to studies on humans;* Language restrictions: *English, German, Spanish, Dutch and French.*
**Search terms expanded.*

Supplementary Table 2 Items included in the perceived difficulty indices

Perceived difficulty indices
I easily remembered all my activities
It was difficult to give one specific name for the activities
I found it easy to complete the PA record
I understood the reasons why the study was conducted
I did not understand how to complete the PA record
I always carried the PA record with me
It was easy for me to separate my activities in 15 minutes
I didn't report some activities because I was embarrassed to write them down
I normally wear a watch
I used a tool that indicates time when filling out the PA record

Supplementary Table 3 Quotes on individual factors influencing eating behaviour in adolescents, parents and school staff

Factor	Quotes
Awareness	A1: "To have a better life and be able to live longer." A2: "£That we are strong, sexy£." A3: "I think that it is unhealthy because the preparation is not hygienic, the food could be contaminated." P1: "To have at least 5 meals per day…for their age. To have a good breakfast and always include a dairy product, and a cereal, cheese, eggs. And to vary the food and don't have all the time the same. Something for snack in the morning, a healthy snack…for lunch…always a healthy lunch that includes vegetables, salad, protein, meat, fruits…and in the afternoon fruits and…like…a good dinner…to don't skip meals, as a habit to eat every day in the same way, at the same time." P2: "… but I am also worried about how things are done here. Because potatoes are fried in the same oil, they reuse the oil for a week. I have discussed this with the teachers, because one person has to go and check every day that the oil has been changed. I am really worried." S1: "We have assessed reintroducing our traditional foods like barley, quinoa, potatoes, machica … it would be important for the students to eat that." S2: " 'Gatorade [energy drink]' is forbidden because we received information that some substances affect the kidneys. Thus the director at that time met with the parents and asked to stop giving Gatorade to the kids, also and other things… because this information has popped up."
Attitudes	A1: "Once in a whilst it is also good to eat a bit healthy …because if you eat only meat … you can get sick." A2: "It is not healthy but tasty §§." P1: "With the vegetables, we have to explain to them, over and over… they never say 'oh this is tasty' . Never. Like tasty broccoli or spinach... nooooo." P2: "How can we be completely sure that the children eat what we give them? That is not real. I used to give him fruit for school, he used to sell it and with that money bought foods at the grocery." S1: "Well, the youngsters … drink a glass of soft drink, … they prefer that." S2: "The adolescents think that they don't need to eat breakfast."
Taste	A1: "I don't … I prefer … the salads at home they taste different, here I don't like them, I prefer the tasty ones, here they taste different." A2: "I don't like eggplant … wuuuak ((he makes a noisy gesture referring to nasty))" P1: "£ They always drink soft drinks, but I also like it huffff £" S1: "Yes, they don't like it because it's healthy food."

Self-efficacy	A1: "I wouldn't do it because it is difficult as there are a lot of places and stores in which I can buy unhealthy food." A2: "I mean, I eat healthily because I … I like it, I don't like to be fat, I don't know… for that reason I control myself… I don't drink soft drinks… nothing like that… I don't like mayonnaise." P1: "As I mentioned they are influenced by others…" S1: "It would be important to motivate healthy eating at home. Because it depends on themselves, in my case my daughters … it depends on them that they come to school having breakfast. Doesn't it. They have had this habit since they were little, thus I know they will keep on doing it, and for the next generations. It really depends on how we, the parents, have taught them." S2: "Well, I think we can provide some things, but adequate nutrition is most feasible at home."
Financial autonomy	A1: "When we are paid, when we work … Friday I will have a party and get well paid… I entertain parties for kids, and I get money that I use to buy all that I want." A2: "When I get money, I go and buy French fries." P1: "My children do not eat in the school break, because we give them 50 or 60 cents per day, but they save that … especially the girl, but the little boy spends all his money buying hot dogs, pizza at the bar. But the girls do it once in a whilst." P2: "I give them money for food on the break."
Habit strength	A1: "When we go to feed the cattle, we chew gum, lollipops." A2: "…when we were little our parents used to control what we ate or not, we used to eat mostly at home. But now we go out with friends and nobody checks if we eat fat." P1: "Some kids are used to drinking soft drinks, and they complain. It is difficult for a kid to drink juice when he has been used to drink soft drinks…that is difficult to handle. It is a lifestyle, they are used to it." P2: "… we don't eat together anymore. We used to eat together at the same time. It has changed when they started secondary school, the academies… I think there will be negative results." S1: "At school the kids decide, more or less, what to eat…[…..] This does not happen at primary school, because there, they receive their meal…that is …controlled. But at secondary school it's a little bit more difficult, because the adolescents don't receive a meal. Therefore, what they should eat is a bit more fruit, but they don't like it, they don't eat it."
Subjective norm	A1: "They would make fun of me, they would say that we are tight… that we do not want to spend money." A2: "Because, I get embarrassed of eating rice in front of my classmates." A3: "I don't think they would say anything, it is my life and I choose what to eat, can't I?"

	P1: "She brings …carrots, milk or fruit … she is seen as a freak." P2: "I tried to give them ((fruit)) when they were little, for example apples … but they say they get embarrassed… I never did it again." S1: "When she is seen thin, and we haven't seen her in this condition from the beginning…or when she's getting fat … We ask them … what happened to you? Aren't you doing enough exercise? Are you eating a lot? Or something like that… We intervene making comments like these, that is our relation… we have to take care of our students..." S2: "… She said 'no', that she felt embarrassed of eating that (('junk food')), then it was very difficult, because it is quite popular and cool to eat 'junk food'."
Perceived barriers	A1: "Because we don't buy the food we don't like…or because sometimes it is not at the stores." A2: "Because there is no money to buy it." A3: "Because sometimes it ['junk food'] is the easiest and fast to cook." P1: "They don't think, they just eat what is available and convenient. We don't know if that is good or bad." P2: "The convenience of the new things ((foods))." S1: "Because before … I am not sure but, it could be that parents used to care more about eating than now…and now it is easier to get ready-to-eat food, which can be bought and eaten. Hamburgers and all these things make kids fat…and don't let them grow. They eat less vegetables…etc. I think it's the convenience of frozen foods, because before mothers used to be at home cooking and sometimes stay at the table for half an hour to wait until the kid eats everything. Therefore, habits have changed…for time limitation and convenience. These are the reasons why things have changed a lot."

A, adolescents; P, parents; S, school staff; …, short silence; […], overlapping speech; __, emphasis; ££, smiley voice; §§, laughing; / /, irony; ((), transcribers' comments

Supplementary Table 4 Quotes on environmental factors influencing eating behaviour in adolescents, parents and school staff

Factor	Quotes
Family environment	
Parental rules	A1: "At lunch, they tell me that I have to eat at the school tuck shop, and a milk at the break, something like that, healthy, but £I don't do it £." A2: "My mother advises me, but she doesn't oblige me." P1: "… and we are used to letting them eat what they want on the weekends." P2: "When we are at home, they ((children)) decide on what to eat."
Availability	A1: "I eat healthy at home because my parents buy or cultivate this kind of food." A2: "When my mother goes to the market I eat lots of fruit." P1 "Well, we give them breakfast, and at school... sometimes they get school lunch… otherwise they buy at the grocery shop here… French fries, these things." P2: "Well, some of us, we do not have plants ((growing)), but if we have… for example apples, we eat them all the time. We carry them in our pockets, it depends …well we cannot say we have them and the others don't… but we haven't dedicated ourselves to cultivate…for example, I have, but this season is ending… but from February until May, three months, they eat when they want. After the season we have to buy, that is how it is."
Modelling	A1: "On the other hand my grandparents teach me, but they eat more dessert and things like that." A2: "If I see other people eating unhealthy I want to do it too." P1: "If the mother cannot stop drinking soft drinks, the kids won't neither." P2: "… I think that the environment is affecting her a lot, I don't know why she is obsessed controlling her weight, and she is thin. That is something I am very worried about, I think she sees the models on TV, she sees her friends. But for example, I give them rice in the afternoon but at night I always gave them chocolate milk, but now … she doesn't want the chocolate, just pure milk. She is the only one that asks for pure milk, but I noticed that it's to avoid the sugar and the cocoa. So I see that should come from her environment… The boy on the other hand, wants treats and to eat what all the friends eat, like plantains, Goudies ((potato chips)), Cachitos ((potato chips)).. thus he is not going to ask for an apple … even if I send him fruit from home, or because I said that fruits are healthy."
School environment	
School rules	A1: "Bubble gum, bubble gum is not sold anymore." A2: "… almost everything can be found at the tuck shop." P1: "From last year French fries and sausages… because they use a lot of saturated fats"

	P2: "That is good, they used to use the same oil. They kept it in bottles and reused it and with that they used to make the sauce." S1: "I am sure that school is the only high school in Cuenca that does not sell saturated fatty foods, [yes]. In that sense we are novel, we have avoided color additives consumption in drinks, there is no Manzana drink ((Ecuadorian soft drink)), only Sprite is being sold and juices… fruit juices such as blackberry juice, orange juice… The children have got used to drink juices or yogurt. We also broke the contract with Coca Cola… because it is not drunk anymore."
Availability	A1: "At school we eat unhealthily because we can only buy this type of food and because we like it." P1: "They tend to buy treats, thus it wouldn't be worth the bar selling fruit or healthy foods… it's not worth. They like potato chips, cassava, plantains… all fried." S1: "What is sold on the school grocery are sandwiches, tacos with avocado and tomato, French fries and sausage, hamburgers, French fries, hot dogs, Cuban sandwiches, and always potato chips, cookies, chips."
Outside home and school	
Availability	A1: "Sometimes when we are out, and we are at the grocery …and there are chocolates." P1: "Unfortunately, not all of us do that ((serve balanced meals)). Even if we want and do our best, we can't. Specially due to all kinds of 'junk food' around these days" P2: "Other problem is that when we were little, there was not too many treats compared with now. There were, but not as much as today. And I see that the children eat it a lot." S1: "Ahhh yes, sure here in front of the school… hamburgers are sold for one dollar [with fries and everything]… § well all that has fats §."
Socio-cultural changes	P1: "I think the publicity is aggressive and directed towards them…" P2: "I think, bad feeding comes from the media, the TV etc. P3: ""It is a lifestyle, they are used to it. It's not the lifestyle …as we were used to, we used to sit to eat at 1pm and have time to calm down" S1:"Now with modernization, the microwave … now everybody comes, put in the microwave and … runs. The cooking habit has been lost" S2: "Unfortunately, we are driven by a consumer society where lots of fast products are offered and sold…"

A, adolescents; P, parents; S, school staff; …, short silence; […], overlapping speech ; __, emphasis; £ £, smiley voice; §§, laughing; / /, irony; ((), transcribers' comments

Supplementary Table 5 Quotes on individual factors influencing PA behaviour in adolescents, parents and school staff

Factors	Quotes
Awareness	A1: "With PA you can make your legs stronger, all that, to be more fit, on the other hand sport is just like a hobby, not so much training" P1: "I believe …it can be around 3 or 4 times a week. It can be the ideal to exercise" S1: "They are also active when they are studying or listening to music"
Attitudes	A1: Moderator: "What do you like to do the most when you are not at school?" Participants: "Watch TV"; "Play with the computer"; "Play videogames" A2: "Good attitudes, I mean, one always thinks positive about sportive people" P1: "I get crazy, now she wants to golf …" P2: "My son does everything but he likes to hang in front of the TV or the Nintendo…" S1: "Well, If talk about PA most of them are always active, some are hyperactive and they run, jump … well they are always active" S2: "They don't like to sport … they don't want to have physical education class"
Self-efficacy	A1: Moderator: "If you decide to perform PA, would you succeed?" "Yes" (All participants agree)
Habit strength	A1: "Yes, when we were younger, we used to play more …and now not" A2: "Because when we were little we did not engage in too much activities …we were not allowed. They say that we fell and then cried"
Perceived Barriers	A1: "At home there is not too much time to do things, we have a lot of school work and that is what we do the most." A2: "Before I used to feel lazy for running, and now … I feel more lazy" A3: "I am shy, to be seen doing exercise" P1: "There is sometimes a lot of school work, but it is important that they study" P2: "It depends, they like to play and do things like that, they do something every afternoon…, depending on the time…they help their parents…to check the cattle"
Subjective norm	A1: "Because you are men … for women it is not allowed to play, they say women have to £ play by cooking £ , that is what they say" P1: "Boys can play…But the girls, have to help at home"

Supplementary Table 6 Quotes on environmental factors influencing PA behaviour in adolescents, parents and school staff

Factors	Quotes
School environment	
Opportunities	A1: "A net to play volleyball … they only put a rope" S1: "Sure, here there is no physical space, for example to play football or indoor. Kicking a ball can hit a classmate. There is no volley court"
Support and role modelling	P1: "The school influences a lot … to perform sports every day. They promote dances to perform at school. Yes, this school helps. Teachers are good, and they influence enormously. All my children graduate from this school and they are good people." S1: "Personally I feel … how can I say? I would like to perform more PA but unfortunately … and here we have to be honest…some teachers support so, but some teachers do not support it, they see it as wrong. Only because they make noise… and that is true, they make noise … our infrastructure is not the optimal for the students to play."
Financial constraints	S1: "Just by affinity ... to have a PA teacher a salary is needed, a professional can be hired if the salary would be available … so all the students can receive training" S2: "Therefore it obviously implies an economic cost of trainers, directors, facilitators, sport gear, infrastructure, and this is difficult for us due to our obvious economic crisis, and the school fee…especially for parents"
Family environment	
Opportunities	A1: "At home, I sometimes play football … I break the windows …" P1: "Something that is fascinating is the pets, it should be a sport."
Rules	A1: "In weekdays I must cook, clean the house" A2: "My daddy doesn't let me because they say it is exhausting, and that it takes my time for school work, or that we finish late and I sleep little" A3: "I do what I want, but first I have to do school work" P1: "We say, please fix this and after that you can go and play" P2: "From Monday to Thursday they cannot use the play station … they cannot even see it"
Support and role modelling	P1: "I used to push them….until last year, this year I decided to let them do whatever they want…. I don't…Now I am relaxed" P2: "We like them to help at home, we don't ask them to play…we need help at the farm…with anything. It would be good that after school they can go to play, but nooo…they have to help us."

Financial constraints	P1: “My daughter loves to dance but … I cannot afford a dance academy. She really loves that… she dances in front of the TV .. she brings her friends and they all dance …but I cannot register on that dance school.”
Society	
Popular media	A1: “I think … not at home. Because people rarely do it at home, they play with the computer, they watch TV or things like that” S1: “Also, yes, It is not a game anymore, now everything is electronic, the cell phones, and play station, all that. That is how it has changed, in terms of activities for leisure time. Spare time is not well used, it should be used by sport activities and physical exercise.”
New transport modes	P1 “When I was younger I used to walk 14 km and I never got sick. I never had any problem …and I used to be thin … well not that thin, but healthy. And now… I am fat because I don’t walk. Walking is the healthiest thing especially in the morning .. this is my own experience. Nowadays we move on buses, cars … etc.”
Role modelling	A1: “We would like to be like him…” *(about sportsman)*
Built environment	
Traffic and crime concerns	A1: “They are afraid that we have an accident” P1: “We walk when we go out together these days they cannot walk around alone. I feel that we cannot let them out … alone. I feel really scared.”
Geographic distances	S1: “And about the walking …it is also unsafe because they can be attacked … and it is too far”

A, adolescents; P, parents; S, school staff; …, short silence; […], overlapping speech ; __, emphasis; £ £, smiley voice; §§, laughing; / /, irony; (()), transcribers’ comments

Supplementary Table 7 Change objectives for performance objectives related to breakfast intake - adolescents

Breakfast intake	Knowledge/awareness	Skills/Self-control	Attitudinal beliefs: benefits and barriers	Subjective norm
PO1: Choose to eat a healthy breakfast	Is aware of and evaluate their own current breakfast habits Recognize that a variety of healthy breakfasts exists	Express confidence in making a healthy breakfast choice Develop skills on how to overcome difficulties in eating a healthy breakfast	Identify and understand what makes it difficult to eat a healthy breakfast (barriers) Expresses positive attitudes to choose healthy alternatives when unhealthy food is more available	Express confidence to not care what others think about them if they eat a healthy breakfast
PO2: Prepare a healthy breakfast	Describe why a nutritious and healthy breakfast is important for them Describe what a healthy breakfast should consist of Are aware of different healthy breakfast preparations	Develop skills to identify what a healthy breakfast is Develop skills and feel confident they can prepare a healthy breakfast	Express short term benefits (e.g. feeling good, body image) when eating a healthy breakfast	Express confidence in sharing experiences in preparing a healthy breakfast and its taste with their peers
PO3: Buy a healthy breakfast for 1 or 2$	Recognize and evaluate current purchasing power for breakfast Are aware of how they can eat a healthy breakfast for a limited amount of money	Express confidence in the ability to buy a healthy breakfast for 1 or 2$.	Express positive attitudes to choose healthy alternatives when unhealthy food is more available at a better price	

Supplementary Table 8 Change objectives for performance objectives related to breakfast intake – parents/other guardian(s)

Breakfast intake	Knowledge	Skills/Self-control	Attitude
PO4: Encourage and motivate the adolescent to eat regularly a healthy breakfast	Describe why a nutritious and healthy breakfast is important for health and well-being of adolescents Recognize and evaluate their families' current breakfast habits	Express confidence to encourage and motivate their children	Expresses positive feelings about being a role model for the adolescent. Express positive feelings towards encouraging and motivating the adolescent Express their appraisal when their adolescents are eating a healthy breakfast
PO5: Ensure the adolescent has the opportunity to eat a healthy breakfast	Describes what a healthy breakfast consist of Are aware of different healthy breakfast preparations for a limited budget Recognize reasons why their children are not eating a healthy breakfast	Expresses confidence in their own skills to provide a healthy breakfast Develop skills on how to overcome difficulties in providing a healthy breakfast	Express positive feelings about making a healthy breakfast available

Supplementary Table 9 Change objectives for performance objectives related to breakfast intake – school staff

Breakfast intake	Knowledge/awareness	Skills/self-control	Attitude	Outcome expectations
PO6: Use the strategies and new resources to increase healthy breakfast intake	List the different strategies described in the materials Describe why a nutritious and healthy breakfast is important for health and well-being of adolescents	Express confidence in their ability to use the different strategies in the classroom	Have a positive attitude towards the materials developed	Expect these resources to reinforce adolescents' demand for a healthy breakfast Expect these resources to be readily implementable without training Expect adolescents appreciate and have fun with the material
PO7: Encourage and motivate adolescents to eat a healthy breakfast	Describe what a healthy breakfast consists of	Express confidence in ability to encourage and motivate adolescents to eat a healthy breakfast	Express positive feelings to stimulate the adolescents to eat a healthy breakfast Express positive feelings to Provide positive feedback when adolescents eat a healthy breakfast	Expect that motivating adolescents will increase their healthy breakfast consumption

Supplementary Table 10 Change objectives for performance objectives related to breakfast intake – school tuck shops

Breakfast intake	Knowledge/awareness	Skills/self-control	Attitude	Outcome expectations
PO9: Offer a safe, palatable and healthy breakfast alternative	Identify and understand food safety issues Are aware of how foods, e.g. fruits are best preserved Know how to plan a healthy breakfast menu	Develop skills to get, keep and prepare healthy breakfast considering food safety issues Express confidence in providing a safe, palatable and healthy breakfast	Have a positive attitude to offer healthy breakfast alternatives	Expect that adolescents no longer avoid buying healthy breakfast because of food safety issues Expect that adolescents will buy the palatable healthy breakfast alternative
PO10: Share experiences	Identify which healthy breakfast recipes are popular amongst adolescents		Have a positive attitude to share experiences with group members	Expect that they can learn from other tuck shop owners
PO11: Use the new resources and recipes to provide a healthy breakfast	Describe why a nutritious and healthy breakfast is important for health and well-being of adolescents Describes what a healthy breakfast consist of	Develop different skills to offer a healthy breakfast at a good price Feel confident they can prepare a healthy breakfast		Expect that trainings reinforce and support the demand of adolescents for healthy breakfast Expect that their revenue is not lowered by making changes to their offer in the tuck shops

Supplementary Table 11 Matrix: theoretical methods and related intervention strategies mapped towards behavioural and environmental factors

Factors	Theoretical methods	Intervention strategies
Adolescents		
Knowledge/Awareness	Active learning (IMB model)	The ACTIVITAL toolkit: providing information, facts about a healthy breakfast through an interactive session (games, visual exercises, etc)
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current habits are discussed (quiz) and new goals are set
	Rehearsal	Throughout the intervention, knowledge is repeated and evaluated
	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills (breakfast event/athletes sharing their experiences) on how to overcome these
Attitudinal beliefs	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills (breakfast event/athletes sharing their experiences) on how to overcome these
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
	Modelling (SCogT)	Famous young athletes share their experiences on breakfast, attention, remembrance and show them how they can improve
Skills/Self-control	Guided practice (SCogT)	A session in which a “real life game” is played in which they get money to buy a healthy breakfast and evaluate what they bought for a limited amount of money
	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience	Events, workshops in which they prepare a healthy breakfast and share experiences and receive practical tips
Subjective norm	Shifting the focus (TPB) Information about other’s approval (TPB)	Focusing on e.g. better performance at school, a healthy skin, rather than on healthy weight, etc.

Factors	Theoretical methods	Intervention strategies
	Modelling Prompt identification as role models (SCogT)	Famous athletes share their experience, and increase acceptance of eating a healthy breakfast. Workshops
	Plan social support and change (social support theories)	Workshops
Parents		
Knowledge/Awareness	Active learning (IMB model)	Workshops providing information, facts about a healthy breakfast through an interactive session
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current habits are discussed (quiz) and new goals are set
Attitude	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and skills training on how to overcome these (breakfast recipes)
	Prompt identification as role models (SCogT)	Their exemplary role for their children is discussed in an interactive session
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
Skills/Self-control	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience (Theories of learning)	Workshops in which they receive breakfast recipes for different budgets, share experiences and receive practical tips
School staff		
Knowledge/Awareness	Active learning (IMB model)	The ACTIVITAL toolkit: providing information, facts about a healthy breakfast through an interactive session (games, visual exercises, etc.). Each chapter provides details on how to deliver sessions within the toolkit.

Factors	Theoretical methods	Intervention strategies
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
Attitude	Prompt identification as role models (SCogT)	They are encouraged to be an exemplary role for the adolescents throughout the ACTIVITAL toolkit, use of leaflets, and informal meetings
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
Skills/Self-control	Guided practice (SCogT)	A session in which a "real life game" is played in which they get money to buy a healthy breakfast and evaluate what they bought for a limited amount of money. The teachers first models the good behaviour and then the adolescents are asked to play the game themselves.
	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
Outcome expectations	Enactive mastery experience (SCogT)	Participatory development and problem-solving: including recommendations in the toolkit, technical assistance in problems in implementing the toolkit, generating solutions, and obtaining feedback after implementation
	Persuasive communication	Benefits of protecting children from diseases by having a healthy breakfast
Tuck shops		
Knowledge/Awareness	Active learning (IMB model)	Workshops providing information, facts about a healthy breakfast, food safety issues, planning healthy breakfasts through interactive session
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current practices are discussed (quiz) and new goals are set

Factors	Theoretical methods	Intervention strategies
Skills/Self-control	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience (Theories of learning)	Workshops in which they receive breakfast recipes for different budgets, share experiences and receive practical tips
Attitude	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills on how to overcome these
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
	Direct experience (Theories of learning)	Sharing experiences
Outcome expectations	Structural redesign (organizational development theory)	Trainings with manager or employees of tuck shops on providing healthy breakfasts
	Guided practice (SCogT)	Tuck shops with positive experiences on healthy recipes shared these with the other tuck shops
	Enactive mastery experience (SCogT)	Participatory problem-solving: including technical assistance in diagnosing problem, generating solutions, developing priorities, making action plan, obtaining feedback after implementation

SCogT, Social Cognitive Theory; CTh, Control Theory; TTM, Trans Theoretical Model; IMB, Information-Motivation Behavioural skills model; TPB, Theory of Planned Behaviour

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Education

2008 - 2014	PhD in Applied Biological Sciences – Faculty of Bioscience Engineering, Ghent University *PhD:* "A school-based health promotion intervention in adolescents in Ecuador and its cluster randomized-controlled evaluation design" (27th of June, 2014) *Doctoral training:* Completed within the Doctoral School of (Bioscience) Engineering
2007	Pre-doctoral training in Applied Biological Sciences – Faculty of Bioscience Engineering, Ghent University *Thesis: "*Effects of an increased accessibility of fruits and vegetables in a canteen lunch; a control intervention study"
2004 - 2005	Master in Food Science and Nutrition - Faculty of Bioscience Engineering, Ghent University, graduated with great distinction *Thesis*: "Influence of local alcoholic beverages on body weight in developing countries"
2000 - 2004	Master of Science in Industrial Engineering –biochemistry, KaHo St.-Lieven Ghent, department of Industrial Engineering, graduated with distinction *Thesis*: "Microbial degradation of structurally diverse organo-phosphonates". This thesis was executed in Poland at the University of Technology, Wrocław

1993 - 2000	Sciences – Mathematics (6h), Sint-Lodewijkscollege, Lokeren

Additional training and certificates

2008 – 2013	*Doctoral training:* Completed within the Doctoral School of (Bioscience) Engineering
2013	Junior faculty in the "19th European Nutrition Leadership Platform (ENLP) Seminar, Luxemburg"
2012	Participant in the "18th ENLP Seminar, Luxemburg"
2008-2012	Spanish courses: • Level 1 and 2 at the University Centre of Languages, Ghent University • Intensive private courses in Ecuador
2007	Summer course of EU basics in Public Health
2006	Certificate of the course "Basic security in the field, staff safety, health and welfare" - United Nations Office for Project Service (UNOPS)
2005	Certificate of the course "General Information Cycle" - Belgian Technical Cooperation (BTC-CTB) - Brussels, Belgium

Professional Experience

2013 - Current	Scientific Officer for the Institute of Tropical Medicine (ITM), Antwerp, Belgium
2008-2014	PhD in Applied Biological Sciences – Faculty of Bioscience Engineering, Ghent University *PhD:* "A school-based health promotion intervention in adolescents in Ecuador and its cluster randomized-controlled evaluation design" (27th of June, 2014) Promoter: Prof. dr. Patrick Kolsteren – Institute of Tropical Medicine, Antwerp Co-promoter: Prof. dr. Lea Maes – Ghent University
2007	Coordinator for the "European Nutrition and Health Report 2009" for Belgium and Luxemburg

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2006-2007	Design and development of a PhD proposal
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Scientific contributions

International A1 publications

Van Royen K, **Verstraeten R,** Andrade S, Ochoa-Avilés A, Donoso S, Maes L, Kolsteren P. Factors affecting physical activity in Ecuadorian adolescents: A focus group study. Journal of Physical activity and Health. *In press*

Andrade S, Ochoa-Avilés A, Lachat C, Escobar P, **Verstraeten R**, Van Camp J, Donoso S, Rojas R, Cardon G, Kolsteren P. Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study. BMC pediatrics. *2014*; 14:106

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Lachat CK, **Verstraeten R**, Khanh LNB, Hagstromer M, Khan NC, Van NDA, Dung NQ, Kolsteren P. Validity of two physical activity questionnaires (IPAQ and PAQA) for Vietnamese adolescents in rural and urban areas. International Journal of Behavioral Nutrition and Physical Activity *2008*;5.

Verstraeten R, De Winter AM, Kolsteren P. The European nutrition and health report (ENHR) 2009 : the Belgian experience. Forum of Nutrition *2009*;258-62.

Books

Verstraeten R and Ochoa-Avilés A. Educational leaflets on physical activity and nutrition to promote health in school-going adolescents in Ecuador (aged 11-15 yrs old).

MSc dissertations and internships supervised

Diana Andrade (2014) Process evaluation of a school-based health promotion intervention, ACTIVITAL. Master thesis to obtain the degree of Maestría en Gestión de la Calidad y Seguridad Alimentaria, 2013-2014

Marta Jiménez Carillo (2013) A stakeholder analysis: policy options for responding to obesity in Ecuador. Internship in the "Food, Nutrition and Health project", a collaboration between Cuenca University and Ghent University, 2012-2013

Luca Florizoone (2011) Validity and reliability of a healthy eating determinant questionnaire for adolescents in Ecuador. Master thesis to obtain the degree of Master of Science in Health Education and Health Promotion, 2010-2011

Kathleen Van Royen (2011) Implementation of a school-based health promotion intervention in Cuenca, Ecuador. Internship in the "Food, Nutrition and Health project", a collaboration between Cuenca University and Ghent University, 2010-2011

Huynh Thi Thanh Tuyen (2010) Statistical analysis of baseline data of a school-based health promotion intervention in Cuenca, Ecuador. Internship in the "Food, Nutrition and Health project", a collaboration between Cuenca University and Ghent University, 2010-2011

Lara van Steenwege (2010) Development of nutrition education guides II in Cuenca, Ecuador. Internship in the "Food, Nutrition and Health project", a collaboration between Cuenca University and Ghent University, 2009-2010

Eveline Panis (2010) Development and evaluation of nutrition education guides I in Cuenca, Ecuador. Master thesis to obtain the degree of Master in Biosciences: Food Industry, 2009-2010.

Ellen Huizinga (2009) Development and piloting questionnaires on the nutritional and PA environment in and around schools. Internship in the "Food, Nutrition and Health project", a collaboration between Cuenca University and Ghent University, 2009-2010

Dolores Daniela Penafiel Anchundia (2009) Determinants of healthy eating and physical activity behaviour of Ecuadorian adolescents: A qualitative study using focus groups. Master thesis to obtain the degree of Master of Human Nutrition and Rural Development, 2008-2009.

MSc students or interns for whom input was provided

Anna Maria Garcia solorzano (2013) Evaluation of the changes in the nutritional quality of the meals offered by nine school food tuck shops in Cuenca, Ecuador after the ACTIVITAL school-based intervention, 2012-2013

Sophie Etienne (2012) Development and evaluation of a physical activity strategy in a school-based intervention in Cuenca, Ecuador. Master thesis to obtain the degree of Master in Health Education and Health Promotion, 2011-2012

Lourdes Jerves (2011) Capacitacion para una alimentacion saludable en los bares de diez colegios en la ciudad de cuenca. Report, 2011-2012

Maria-Cecilia Vintimilla (2011) Capacitacion para una alimentacion saludable a padres de familia de diez colegios en la ciudad de cuenca. Master thesis to obtain the degree of Licenciado en

Gastronomía y Servicios de Alimentos y Bebidas". Master thesis to obtain the degree of Master of Human Nutrition and Rural Development, 2011-2012

Awards

The 'Young Investigators Award for outstanding oral communication' for the presentation: "Can school-based interventions prevent childhood obesity in low- and middle-income countries?" This price was rewarded by the Belgian Nutrition Society on its "Third Annual Congress on Behaviour and Nutrition, new insights for better solutions." – Brussels, 2012