WARWICK

MEDICAL SCHOOL

Malnutrition among South Asian adolescents: a mixed methods study

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ACADEMIC SUPERVISORS

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Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

The work presented (including data generated and data analysis) was carried out by the author. See section 1.7. Research team members for collaborations.

Parts of this thesis have been published by the author in several academic journals. See next section, Published work and dissemination for list of publications.

Sara Estecha Querol

30/03/2022

Dedication

I dedicate this thesis to my beloved friend and colleague Maxwell Larweh.

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I want to thank Paramjit Gill, Lena Al-Khudairy and Romaina Iqbal, who were my supervisors throughout my PhD journey. Thanks to Paramjit and Romaina for making me a resilient researcher. Thanks to Lena for challenging me by providing constructive insights.

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Abstract

Malnutrition is a highly prevalent and persistent problem in developing countries, and its consequences for chronic disease management come at a high human and economic cost. While undernutrition and micronutrient deficiency rates remain highly concerning in South Asia, this region faces the new challenge of overnutrition. Adolescence provides a window of opportunity for improving nutrition. Yet, the burden of malnutrition among adolescents remains unattended and insufficiently investigated. This doctoral thesis aimed to produce a nuanced understanding of malnutrition among South Asian adolescents and identify factors improving or worsening malnutrition among Pakistani adolescents attending schools.

A mixed-methods approach was used to address the overall aim of the thesis. The pragmatic paradigm underpins the current thesis. Pragmatism was suitable for this research because malnutrition is a complex global health issue, and using a mixed-methods approach enabled a richer understanding of the relationship between adolescent malnutrition and its drivers. In addition, a conceptual framework was developed and a scoping review was conducted to guide this research.

The quantitative and qualitative data were collected in parallel and analysed separately. In this thesis, the secondary quantitative data analysis calculated the burden of malnutrition among schooled adolescents living in the eight South Asian countries: stunting was 13%, thinness 11% and overweight 11% at the South Asian level. Factors associated with malnutrition were age, hygine behaviours, social support, tobacco and sedentary behaviours. The qualitative study used photodiaries and interviews to explore awareness and perspectives of malnutrition among schooled adolescents living in a slum in Pakistan. Food consistently underpinned participants' narratives and photodiaries which was reflected in how they made sense of malnutrition: overnutrition was an excess of food and undernutrition was a lack of food. Finally, the findings from both approaches were interpreted and connected by discussing to what extent and in what ways they relate to each other and produce a complete understanding of adolescent malnutrition in South Asia.

The thesis suggested future work addressing adolescent malnutrition in South Asia, some of which are relevant to Pakistan and slum settings. Ultimately, this thesis developed several recommendations for policymakers and healthcare organisations delivering adolescent health and nutrition actions in South Asia.

Published work and dissemination

Peer-reviewed journal articles:

- Estecha Querol S, Iqbal R, Kudrna L, Al-Khudairy L, Gill P. The Double Burden of Malnutrition and Associated Factors among South Asian Adolescents: Findings from the Global School-Based Student Health Survey. *Nutrients*. 2021; 13(8):2867. doi.org/10.3390/nu13082867
- Estecha Querol S, Gill P, Iqbal R, Kletter M, Ozdemir N, Al-Khudairy L. Adolescent undernutrition in South Asia: A scoping review. *Nutrition Research Reviews*. 2021; 1-11. doi:10.1017/S0954422421000068
- Estecha Querol S, Al-Khudairy L, Iqbal R, Johnson S, Gill P. Adolescent undernutrition in South Asia: a scoping review protocol. *BMJ Open*. 2021; 10:e031955. doi:10.1136/bmjopen-2019-031955

Conference publications:

- Estecha Querol S, Al-Khudairy L, Kudrna L, Iqbal R, Gill P. The double burden of malnutrition and associated factors among South Asian adolescents. Oral presentation presented at: 12th European Congress on Tropical Medicine and International Health; 28 September 2021; online. doi.org/10.1111/tmi.13632 (page 157)
- Estecha Querol S, Zehra Zaidi S K, Al-Khudairy L, Iqbal R, Gill P. Exploring malnutrition in Pakistani adolescents living in slums through photodiary and interviews. Oral presentation presented at: 8th International Conference on Nutrition and Growth; 26 August 2021; online. Abstract here (page 54)
- Estecha Querol S, Gill P, Iqbal R, Al-Khudairy L. Adolescent undernutrition in South Asia: a scoping review. Poster presented at: 8th International Conference Nutrition & Growth; 26 August 2021; online. Poster here Abstract here (page 89)
- Estecha Querol S, Al-Khudairy L, Iqbal R, Gill P. Application of the photovoice method to promote partnerships and engagement with the community in a slum in Pakistan. Poster presented at: Fundación Iberoamericana de Nutrición (FINUT) Conference 2020. Poster publisheh at: Ann Nutr Metab 76(suppl 4), Page 105; October 2020. 10.1159/000511826

Conference disseminations:

- Estecha Querol S, Zehra Zaidi S K, Al-Khudairy L, Nazish A, Gill P, Iqbal R. Exploring malnutrition in Pakistani adolescents living in slums through photodiary and interviews. Oral presentation presented at: 2nd Pakistani Nutrition and Dietetics Society International Conference; 12nd March 2022; online.
- Estecha Querol S, Zehra Zaidi S K, Al-Khudairy L, Iqbal R, Gill P. Exploring malnutrition in Pakistani adolescents living in slums through photodiary and interviews. Oral presentation presented at: Midlands Graduate School DTP Annual Conference; 23rd June 2021; online.
- Estecha Querol S. Malnutrition among Pakistani adolescents: A mixed-methods study. Oral presentation presented at: WMS PGR Symposium 2021; 26th May 2021; online.
- Estecha Querol S, Al-Khudairy L, Kudrna L, Iqbal R, Gill P. Poster presented at: WMS PGR Symposium 2021; 30th September 2020; online.

Seminars:

- "Malnutrition is all about (good or bad) food": A mixed-methods study exploring malnutrition among South Asian adolescents. Oral presentation at: the Growth, Exercise, NUtrition and Development (GENUD) research group seminar; 6th April 2022; Zaragoza (Spain).

Awards:

- Recognition Award in Natural Life Science category at the 10th UK Doctoral Research Awards competition 2021; 11th September 2021.
- Award Certificate Transferable Skills in Science - University of Warwick; March 2022.
- Scholarship for Conference Registration at the 2nd PNDS International Conference; March 2022.

Public Engagement activities:

- International Day of Women and Girls in Science – I am a scientist and I am from your village. Public Engagement Workshop delivered at: Matarraña High School, Valderrobres (Spain); 11th February 2022.
- What does malnutrition mean for you? Public Engagement Workshop delivered at: Matarraña High School, Valderrobres (Spain); 6th May 2022.

Abbreviations

AESAN	Association of Southeast Asian Nations
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CHW	Community Health Worker
DHS	Demographic and Health Surveys
FAO	Food and Agriculture Organization
GAGE	Gender and Adolescence: Global Evidence
GSHS	Global School-Based Student Health Survey
IAP	Indian Academy of Pediatrics
LMIC	Low and/or Middle Income Countries
NCD	Non-Communicable Diseases
NCHS	National Center for Health Services
NIHR	National Institute for Health Research
NHANES	National Health and Nutrition Examination Survey
PCC	Population Concept Context
PRISMA-ScR	Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews
RA	Research Assistant
RCT	Randomized Controlled Trial
SDG	Sustainable Development Goal
TA	Thematic Analysis
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organisation
WIE	Warwick Institute of Engagement

Covid-19 impact statement

This thesis and specially, the qualitative strain of it have been hugely impacted by the COVID-19 pandemic. As a consequence, the candidate applied for a funded COVID Extension for doctoral students at the University of Warwick and she was awarded with five months funded extension.

The candidate planned to travel to Karachi (Pakistan) to collect the data herself with the help of a local research assistant. Ethical approval was obtained to start data collection from September to December 2020. When COVID-19 irrupted, the research team decided to pause this phase of the thesis. As it was not feasible to continue with the original plan, an alternative approach for data collection was developed.

The methods of the qualitative project had to be remarkably modified and adapted to the new rules of social distancing. Since the candidate could not undertake the fieldwork due to travel restrictions, a local research assistant was comprehensively trained to collect the data on the candidate's behave. Consequently, substantial amendments in the two previously approved ethics aplications had to be submitted in order to accommodate all the new changes. Despite these adjustements, recruitment and data collection experienced considerable delays due to the two lockdowns in the city of Karachi. Further delay on transferring the data to the candidate occurred meaning that the candidate received the data on December 2021.

Thesis overview

Chapter 1: Introduction

Chapter 1 provides a literature review on adolescent malnutrition in South Asia that justifies the need for this thesis. It presents the thesis research design and structure.

Chapter 2: Conceptual framework on adolescent malnutrition

Chapter 2 explains the conceptual framework on adolescent malnutrition which provides background to the thesis.

Chapter 3: Review on adolescent malnutrition in South Asia

Chapter 3 summarises evidence on adolescent overnutrition in South Asia informed by two systematic reviews and justifies the need for a scoping review on undernutrition.

Chapter 4: Scoping review on adolescent undernutrition in South Asia

Chapter 4 covers the methods, results and discussion of the scoping review.

Chapter 5: Quantitative analysis on the double burden and associated factors among South Asian adolescents

Chapter 5 explores the burden of malnutrition and its associated factors among South Asian adolescents using a public dataset.

Chapter 6: Qualitative study on malnutrition perspectives and awareness among Pakistani adolescents living in a slum

Chapter 6 explores awareness, meanings and perceptions of adolescent malnutrition among schooled individuals living in a slum in Pakistan through photodiaries and interviews.

Chapter 7: Mixed-methods discussion and implications

Chapter 7 concludes by synthesising the quantitative and qualitative findings, and stating the implications for policy and future research based on the thesis findings.

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1. Chapter 1: Introduction

Chapter summary

The research conducted for this PhD project was based at Warwick Medical School in Coventry (United Kingdom) and was funded by the National Institute for Health Research (NIHR) Global Health Research Unit on improving Health in Slums.

The introduction provides the reader important background information to understand the context of the current PhD thesis. Chapter 1 starts with a literature review on the three key elements of this doctoral thesis: adolescents, malnutrition and South Asia. It also outlines how these key elements are defined for the current thesis. Further information on the Unit in which this PhD is located with a particular focus on the existing collaboration with the Aga Khan University is introduced. Next, the importance of investigating adolescent malnutrition in South Asia is highlighted, unfolding a unique opportunity for this doctoral thesis. Subsequently, the overall aim and objectives of this thesis are presented. The research design of this mixed-methods thesis is explained by stating the research paradigm, epistemological and ontological approaches, and theoretical foundations underpinning this doctoral thesis. Following this, an overview of the thesis structure is presented. Finally, the research team members who supported the conduct of this project are introduced.

1.1. Literature review: the three key elements of this thesis

A literature review could be seen "as casting a broad net around an area to explore the topic" (Rocco & Plakhotnik, 2009). The following literature review aims to state the importance of researching adolescent malnutrition in South Asia and provide the foundations for designing the research questions and the methods of this doctoral thesis.

1.1.1. Adolescent health and nutrition

Adolescents (10-19 years old) represent 1.2 billion individuals worldwide, mostly clustered in low-income and middle-income countries (LMIC) (Lansford & Banati, 2018). This period of social and biological change bears a substantial proportion of disease and injury burden (Mokdad et al., 2016). Between 1990 and 2013, the top causes of death among adolescents were HIV/AIDS, infections, self-harm and road injuries; and the leading risk factors were unsafe water and sanitation, alcohol use, unsafe sex and anaemia. Other factors such as mental disorders, early marriage, child labour, sexual orientation, bullying, social support and sexual violence were acknowledged as key to adolescent health but scantily captured in surveys (Mokdad et al., 2016).

Adolescence has traditionally been neglected in global health and health measurement (Christian & Smith, 2018; Mokdad et al., 2016). Whilst the large health and nutrition surveys have mainly collected household data starting from the age of 15 years, the 10 -14 year old age group, unmarried adolescents, unschooled adolescents, and male adolescents have been unconsidered in global health surveys (Mokdad et al., 2016). Although adolescent health and nutrition have been overlooked in health services, policies and programs (WHO, 2005), it is now getting more recognition in the global agendas.

Adolescence was added in 2016 into the Global Strategy report as an essential component to achieve the Sustainable Development Goals (SDG) (WHO, 2015). This updated report entitled *The Global Strategy for Women's, Children's and Adolescents' health (2016-2030)* recognises that there was a need to include adolescents "because they are central to everything we want to achieve, and to the overall success of the 2030 Agenda, (pg. 5)". This Global Strategy takes a life-course approach acknowledging that nutrition, education, water, clean air, sanitation, hygiene and infrastructure are key factors to accomplishing the SDGs. Building on the momentum, the newly established Lancet Commission on Adolescent Health and Wellbeing published a report concluding that "investments in adolescent health and wellbeing bring a triple dividend of benefits now, into future adult life, and for the next generation of children" (Patton et al., 2016).

The *Global Accelerated Action for the Health of Adolescents (AA-HA!): guidance to support country implementation* is a call for setting priorities and implementing key actions across countries that respond to the health needs of adolescents (WHO, 2017b). Adolescent participation becomes core in this guide where adolescents' views are considered to develop and implement health interventions and policies targeting this group. The *AA-HA! guidance* has developed a motto to engage adolescents and has claimed their participation in health programming: "nothing about us, without us". Complementing and expanding on this guidance, the World Health Organization (WHO) published another document summarising evidence-informed recommendations more nutrition-focused with the purpose of ensuring well-being and a healthy life among this age group (WHO, 2018b).

Adolescents bear a great nutritional burden and are at particular risk of malnutrition in all its forms due to their high nutritional requirements for growth, characteristic eating behaviours and great susceptibility to environmental influences (WHO, 2016b). Macronutrient and micronutrient requirements increase during adolescence. In particular, iron, vitamin A, calcium, zinc and vitamin D are essential to support pubertal and physical growth as well as psychological development (WHO, 2018b). Adolescents are more likely to eat outside their home, skip breakfast, snacking, and consume sugar sweetened beverages and junk food. These unhealthy eating behaviours are mostly influenced by peers, parents, food availability and accessibility, food preferences, cultural beliefs, mass media, body image, cost and convenience (PAHO et al., 2017).

Despite adolescents' nutritional vulnerability, a growing body of evidence suggests that this period of life presents a unique window of opportunity to catch up with growth, shape health and eating behaviours that persist into adulthood, address nutrition deficiencies, prevent non-communicable diseases (NCDs), and tackle the consequences of intergenerational malnutrition (Patton et al., 2012; WHO, 2005). Yet, the burden of malnutrition among adolescents remains unattended and insufficiently investigated (Caleyachetty et al., 2018).

1.1.2. The burden of malnutrition

Malnutrition refers to deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients (WHO, 2016b). Focusing on early stages in life, the term malnutrition covers several conditions affecting child growth patterns such as stunting, wasting, underweight, micronutrient deficiencies and overweight/obesity.

Growth reference data and indicators are different between children and adolescents. As this thesis focuses exclusively on adolescents, the forms of malnutrition investigated are illustrated

in Figure 1: undernutrition (stunting and thinness), overnutrition (overweight/obesity) and micronutrient deficiencies. The WHO recommends to use Body Mass Index (BMI) for age (thinness and overweight/obesity) and height for age (stunting) to explore adolescent growth patterns (WHO, 2007).

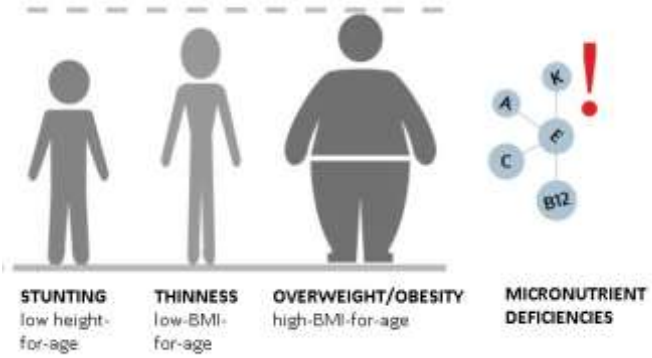

Figure 1. Forms of adolescent malnutrition

Undernutrition (stunting and thinness) is assessed by measuring height and weight (UNICEF, 2013). Stunting reflects chronic undernutrition, and it is associated with poor cognitive development, lower school performance and reduced economic productivity (Cashin & Oot, 2018). Thinness or underweight in adolescents is associated with a higher risk of infectious diseases, delayed maturation, reduced muscular strength, work capacity and bone density later in life. In addition, thinness in adolescent girls is associated with adverse pregnancy outcomes and intrauterine growth retardation (FAO et al., 2018). Overnutrition (overweight/obesity) is another form of adolescent malnutrition that generally increases morbidity and mortality later in life, involving the development of non-communicable diseases such as type 2 diabetes, hypertension, cardiovascular diseases and cancers (WHO, 2016b). The WHO growth reference for school-aged children and adolescents is commonly used to calculate stunting, thinness, overweight and obesity in adolescents (Table 1).

Table 1. Adolescent undernutrition and overnutrition using the WHO growth reference for school-aged children and adolescents (de Onis et al., 2007)

	Adolescent growth indicators	Cut-offs
Undernutrition	Stunting	height-for-age <2 SDs below the WHO Child Growth Reference median
	Thinness	BMI-for-age <2 SDs below the WHO Growth Reference median
Overnutrition	Overweight	BMI-for-age >1 SD above the WHO Growth Reference median
	Obesity	BMI-for-age >2 SD above the WHO Growth Reference median

Micronutrient deficiencies or insufficiencies, also called “hidden hunger”, indicate a lack of important vitamins and minerals (WHO, 2016b). The main micronutrient deficiencies in adolescents globally are iron deficiency, iodine deficiency and vitamin A deficiency (Christian & Smith, 2018). Iron and iodine deficiency rates are higher among adolescent females than males (WHO, 2006). However, there is limited micronutrient status data globally, and the impact of micronutrient deficiencies on health, development, and survival is not well investigated yet (Osendarp et al., 2020).

The definition of the burden of malnutrition changes depending on the reference used. In the literature, both the double burden and triple burden definitions can be found. The WHO (WHO, 2018a) and the Lancet’s Series on the Double Burden of Malnutrition (Hawkes et al., 2020; Nugent et al., 2020; Popkin et al., 2020; Wells et al., 2020) describe the double burden of malnutrition as the coexistence of overweight/obesity along with undernutrition –which refers to stunting, wasting and micronutrient deficiency – at country, household, and individual levels. However, Food and Agriculture Organization (FAO) experts and other authors such as Meenakshi and Pinstrup-Andersen (FAO, 2014; Meenakshi, 2016; Pinstrup-Andersen, 2007), refer to the triple burden of malnutrition as the coexistence of undernutrition, micronutrient deficiencies and overnutrition. Essentially, the inclusion or exclusion of micronutrient deficiency to the undernutrition definition results in the double or triple burden of malnutrition term, respectively. Nevertheless, if micronutrient deficiencies are included under the undernutrition term, there is no acknowledgement that micronutrient deficiency can also be present in normal-weight and overweight populations (Osendarp et al., 2020). For this reason, the current thesis will present undernutrition, micronutrient deficiencies and overnutrition as different forms of malnutrition.

The growing challenge of populations experiencing multiple forms of malnutrition has drawn special attention from the global health community in the last three decades (Davis et al., 2020a). The *2018 Global Nutrition Report* highlights that the global burden of malnutrition remains unacceptably high, affecting every country in the world (Independent Expert Group of the Global Nutrition Report, 2018). This health issue is especially prevalent and persistent in LMICs (WHO, 2020b), where one in three are affected by the double burden of malnutrition (Hawkes et al., 2020; Nugent et al., 2020; Popkin et al., 2020; Wells et al., 2020).

As a result of the global nutrition transition, larger numbers of people are expected to experience it across the life course, typically suffering from undernutrition in childhood to overnutrition in adulthood (Wells et al., 2020). Early life undernutrition and micronutrient

deficiencies may result in increased odds of childhood mortality, reduced capacity for physical work, lower school performance, and greater susceptibility to infectious diseases (Shrimpton & Rokx, 2012). Adult overweight/obesity has been extensively associated with a higher risk of non-communicable diseases such as hypertension, diabetes, cancer, stroke, and ischemic heart disease (Shrimpton & Rokx, 2012). These diverse forms of ill health contribute to lower wages, loss of productivity and higher medical costs (Nugent et al., 2020). Thus, the global burden of malnutrition introduces considerable health challenges that need to be urgently addressed (Hawkes et al., 2020).

The World Health Assembly formulated six global nutrition targets aiming to tackle the burden of malnutrition worldwide by 2025 (WHO, 2014a). These targets plan to decrease stunting and wasting in children, reduce anaemia in women, decrease the rates of low birth weight, increase the rates of exclusive breastfeeding in the first 6 months, and ensure that there is no increase in childhood overweight. In 2015, the United Nations (UN) established the 2030 Agenda for Sustainable Development with 17 goals and 169 associated targets for sustainable growth and equal resource distribution (United Nations General Assembly, 2015). All countries worldwide are included and expected to work towards achieving the SDGs by 2030. More specifically to malnutrition, the SDG 2 aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture", and the SDG 2 target 2 aims to "end all forms of malnutrition" by 2030. Despite SDG 2's focus on addressing malnutrition, other SDGs have the potential to influence malnutrition determinants and improve the global nutrition agenda (Sabbahi et al., 2018). Going forward, the UN Decade of Action on Nutrition 2016–2025 supports the objectives set forth by the SDGs and aims to mobilise action and accelerate progress towards ending malnutrition in all its forms (United Nations General Assembly, 2017). Despite all these global actions and commitments, the world is not on track to meet SDG 2 by 2030 (United Nations, 2020). Currently, the COVID-19 pandemic has affected food systems profoundly and threatened people's access to food, distancing the achievement of the SGD 2 even more (Committee on World Food Security, 2020).

Although all forms of malnutrition have traditionally been addressed as separate public health issues, innovative ways of designing, targeting, and implementing programmes and policies are required to address it (Popkin et al., 2020). In the last five years, evidence has revealed that all forms of malnutrition are interconnected (The Lancet, 2020). Moving away from siloed approaches, double-duty actions (also called triple-duty or multi-duty actions) seek to tackle all forms of malnutrition simultaneously (WHO, 2017a). These actions have the potential to improve nutrition globally and promote health at all life stages (Hawkes et al., 2020).

1.1.3. South Asia context

South Asia has been considered the world's fastest-growing region since 2014. Despite the decrease in the poverty rate and the improvements in health and education, there is considerable social exclusion, significant infrastructure gaps, and insufficient job creation (The World Bank, 2019).

The name to define the same area and the countries included in this geographic region vary among classifications due to geographical or political issues. In this thesis, South Asia will include Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka (The World Bank, 2019; UNICEF, 2019c).

Three hundred and forty million adolescents live in South Asia, accounting for 30% of the world's adolescent population (UNICEF, 2019b). South Asian adolescents are still widely invisible with minimal access to evidence-based information and restricted decision-making on issues affecting their lives, especially girls (UNICEF, 2019a). Adolescent girls are more likely to be anaemic, experience gender discrimination, have a poor education and health, and suffer exploitation and violence. The United Nations Children's Fund (UNICEF) reports that 11% of South Asian adolescent girls aged 15-19 years are stunted, 39% are thin, and 55% are anaemic (UNICEF, 2019a).

1.2. NIHR Global Health Research Unit on Improving Health in Slums

This PhD project is located within the NIHR Global Health Research Unit on improving Health in Slums. The UN defines a slum as "a heavily populated urban area characterized by substandard housing and squalor", that is, high population density with low-quality standards of housing and social deprivation. Slums are mostly informal urban settlements facing poverty in developing world cities where access to water, electricity, sanitation, and other basic services and infrastructure is usually limited. Health issues such as child mortality or infectious diseases are a major problem among people living in slums (UN-HABITAT, 2003).

This NIHR research Unit aims to improve health services in slums by mapping current health services and usage, collecting data on disease prevalence and health care provision, exploring health service delivery, and working with decision-makers and slum communities in designing the models of health service delivery. It focuses on seven slums across Asia and Africa: Nairobi (Kenya), Karachi (Pakistan), Dhaka (Bangladesh), Lagos (Nigeria), and Ibadan (Nigeria). The project team at the University of Warwick works with academic institutions in Nigeria (University of Ibadan), Kenya (African Population and Health Research Center), Pakistan (Aga

Khan University), and Bangladesh (Independent University Bangladesh), policy organizations and slum communities. To find out more about the Unit and its research topics, visit https://warwick.ac.uk/fac/sci/med/about/centres/cahrd/slums/

One study in this PhD thesis stemmed from a collaboration between the University of Warwick and the Aga Khan University. The research team in the Aga Khan University's Faculty of Health Sciences in Karachi is led by Dr Romaina Iqbal, Associate Professor, Department of Community Health Sciences. Malnutrition in adolescents living in slums was an area of shared interest and an identified gap for this PhD project, which was deliberated and approved by both research teams. The study site of this PhD research project was in a slum located in the city of Karachi (Pakistan). More details about the study site are in Chapter 6.

1.3. Rationale for this thesis

As demonstrated in the literature review above, malnutrition is a highly prevalent and persistent problem in developing countries, and its consequences for chronic disease management come at a high human and economic cost (Wells et al., 2020). Every country in the world is affected by one or more forms of malnutrition, making this health issue one of the greatest global challenges nowadays (Popkin et al., 2020). Despite the international actions to end malnutrition, it is predicted that prevalence will soon increase due to the current global pandemic (Osendarp et al., 2021). While the prevalence of undernutrition in South Asia remains highly concerning, this region is currently facing the new challenge of overnutrition (Hossain et al., 2020).

Health and nutritional surveys in South Asia have mainly focused on malnutrition among children under five years old and women of reproductive age (Mokdad et al., 2016). Although adolescence provides a window of opportunity for improving nutrition (WHO, 2005), the burden of malnutrition among adolescents remains unattended and insufficiently investigated (Caleyachetty et al., 2018). A need exists in the literature to not only obtain quantitative results on adolescent malnutrition but also to explain such results in more depth. Adolescents' perspectives on malnutrition could be valuable to gain a better understanding of the problem. This provides a unique opportunity to explore adolescent malnutrition in South Asia in this doctoral thesis.

1.4. Thesis aim and objectives

1.4.1. Aim

- To produce a nuanced understanding of malnutrition among South Asian adolescents and identify factors contributing to improving or worsening malnutrition among schooled Pakistani adolescents.

1.4.2. Objectives

- Objective 1: To summarise what is known about adolescent malnutrition in South Asia and identify gaps in the literature using a scoping review to synthesise the evidence.
- Objective 2: To calculate the burden of malnutrition and its determinants among South Asian adolescents using a large publicly available school-based survey dataset: the Global School-based student Health Survey (GSHS).
- Objective 3: To explore awareness and perspectives of malnutrition among schooled Pakistani adolescents living in a slum using a qualitative method to capture their understandings on malnutrition.
- Objective 4: To integrate findings from the scoping review, quantitative data analysis and qualitative study and discuss associations to produce a more comprehensive understanding of adolescent malnutrition in Pakistan and develop implications for health policies and future research.

1.5. Research design

To achieve the overall research aim and objectives of this thesis, mixed methods research was undertaken. This method consists of collecting and analysing quantitative and qualitative data, integrating both approaches, and interpreting the findings to better understand the research problem (Creswell & Plano Clark, 2011). Combining both approaches will enhance the understanding of adolescent malnutrition more than either form of data alone.

Hence, the research question of this thesis is the following:

- To what extent do both quantitative and qualitative findings produce a more complete understanding of malnutrition among South Asian adolescents?

In this thesis, a parallel-databases variant design was used to address adolescent malnutrition in South Asia with a special focus on Pakistani adolescents living in slums (Figure 2). The purpose of the parallel design is “to obtain different but complementary data to best understand the research problem” (Creswel & Plano Clark, 2011, p.77). In a parallel mixed

methods design, the two strands have equal importance in addressing the research problem. Quantitative and qualitative data are collected at the same time during the research process and analysed independently. Then, the results are merged into an overall interpretation. When the two parallel strands are only brought together at the end (mixing during interpretation), the design is called parallel-databases variant (Creswell & Plano Clark, 2011).

The set of criteria for Good Reporting of A Mixed Methods Study (GRAMMS) developed by O'Cathain et al. guided this mixed-methods thesis (O'cathain et al., 2008). As suggested by Creswell & Clark (2011), further checklists and guidance for reporting research studies were used in the several phases of this thesis as they serve to assess the quality of a particular study application and its design (Creswell & Plano Clark, 2011).

A theoretical orientation is positioned at the beginning of a mixed-methods study and it provides a framework or theory from health sciences that guides the nature of the research questions, shapes the direction of the research projects and helps to explain what the researcher seeks to find (Creswell & Plano Clark, 2011). Literature review, conceptual framework and systematic and scoping reviews were used to build the theoretical foundations of this thesis (see Figure 2). Although there is a clear distinction between these terms in this thesis, they usually serve similar functions (Rocco & Plakhotnik, 2009). The definitions of literature review, conceptual framework and systematic and scoping reviews are further explained in their respective chapters. In this thesis, they serve the following purposes: 1) to build the thesis foundations, 2) to conceptualize the thesis projects, 3) to assess research design of the thesis projects, and 4) to provide a reference point for interpretation of the results (Merriam & Simpson, 2000 in Rocco & Plakhotnik, 2009).

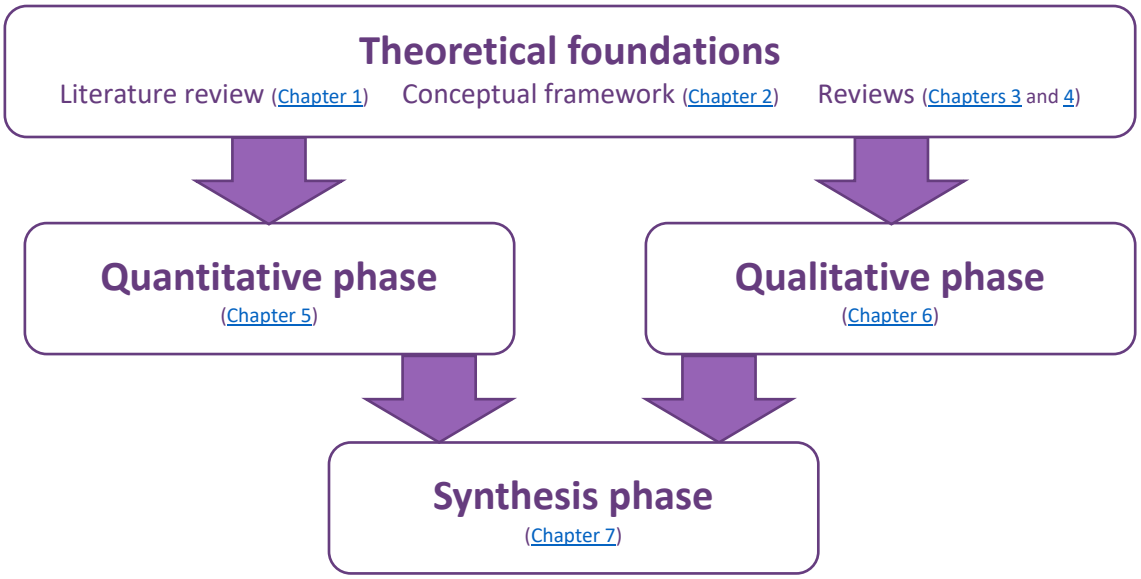

Figure 2. Mixed methods parallel design.

The type of mixed methods design should determine the guiding assumptions of worldviews and therefore inform theoretical foundations and shape research procedures (Creswell & Plano Clark, 2011). Creswell & Clark (2011) recommend situating a parallel design within a pragmatism paradigm. Pragmatism is oriented towards "what works" which "enables researchers to adopt a pluralistic stance of gathering all types of data to best answer the research questions" (p. 46). Pragmatism rejects traditional dualism, going beyond the choice between postpositivism and constructivism (Teddlie, 2009). Within a pragmatism worldview, the researcher makes decisions to address an actual real-world problem offering policy recommendations or other practical actions (Salkind, 2010). Then, the researcher develops a holistic approach that aims to better understand a health problem considering its broadest context (Salkind, 2010).

Ontologically, pragmatism accepts a chaotic and complex nature of the phenomena under investigation and therefore seeks to understand singular and multiple truths (Kaushik & Walsh, 2019). Epistemologically, pragmatism avoids abstract and focuses instead on tangible, practical, real-world solutions. In other words, pragmatism "prefers actions to philosophizing" (Teddlie, 2009). As a paradigm, pragmatism offers a value-oriented approach to addressing research health problems (i.e. democratic values, equality values or cultural values) (Kaushik & Walsh, 2019; Teddlie, 2009). All these elements allow pragmatic studies to be flexible in selecting their best means for gaining knowledge, that is, the methods (Kaushik & Walsh, 2019; Salkind, 2010).

The pragmatism paradigm is compatible with both a quantitative approach and a qualitative interpretivist approach (Kelly & Cordeiro, 2020). Hence, in this thesis, the quantitative phase used closed-ended data to test hypotheses following a deductive process (Table 2). In the qualitative phase, by contrast, the candidate collected open-ended data to explore and gain a broad understanding of the phenomena by following an inductive process (Table 2).

Table 2. Characteristics of the quantitative and qualitative phases in this mixed-methods study.

	Quantitative phase	**Qualitative phase**
Theoretical foundations	Literature review, conceptual framework, and systematic and scoping reviews	Literature review, conceptual framework, and systematic and scoping reviews
Investigative strategy	Deductive	Inductive
Possible bias	Ideally none. Checks to eliminate bias	Actively reporting researcher's bias and preconceptions
Nature	Hypothesis testing	Exploratory
Researcher-research subject relationship	Practicality (usage of a publicly available survey)	Practicality (researcher conducted fieldwork)
Type of data	Closed-ended (numbers)	Open-ended (images and words)
Methods of data collection	Survey	Photodiary and interviews
Data analysis	Descriptive and inferential statistics	Reflexive thematic analysis

Given the theoretical underpinnings of this mixed-methods thesis, the candidate sought to understand malnutrition within the South Asian context better to improve adolescent health and nutrition ultimately.

1.6. Thesis structure

The current thesis consists of seven chapters, including this introductory chapter. Figure 3 provides an overview of the thesis structure. It illustrates in which chapter the mixed-methods stages (the theoretical foundations, qualitative phase, qualitative phase and synthesis phase) are discussed. It shows in which chapter the four thesis objectives are addressed.

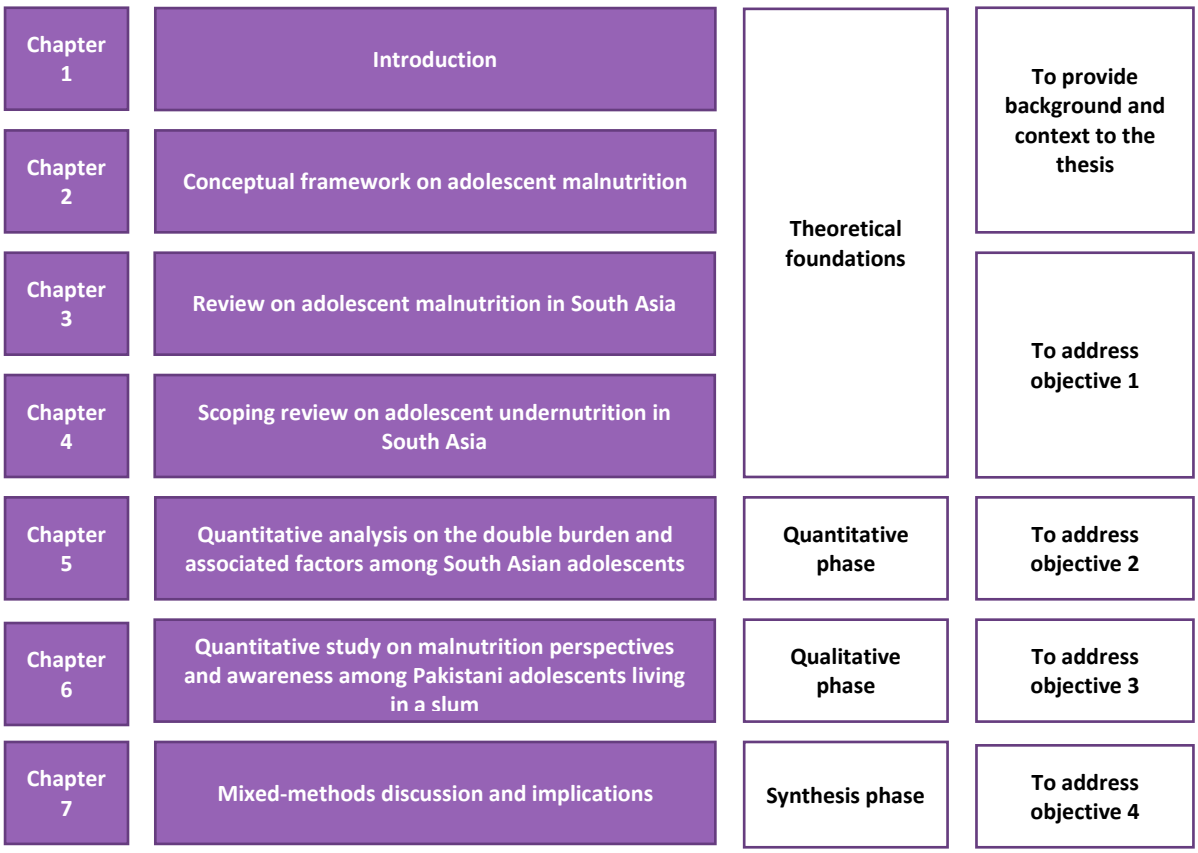

Figure 3. PhD thesis structure.

Chapter 1 provides a literature review on adolescent malnutrition in South Asia that justifies the need for this thesis. It briefly presents how the problem will be addressed by introducing the thesis design. Chapter 1 also gives context to this thesis by introducing the Research Unit and the research team members that shaped this project.

Chapter 2 explains the conceptual framework on adolescent malnutrition created for this thesis. This proposed framework provides background to the thesis and informs subsequent chapters.

Chapter 3 and Chapter 4 report systematically the literature on malnutrition among South Asian adolescents and identify gaps in knowledge. Chapter 3 justifies the need of conducting a scoping review on undernutrition which is presented in Chapter 4. This chapter covers the methods, results and discussion of the scoping review.

All the mentioned chapters (Chapter 1, Chapter 2, Chapter 3 and Chapter 4) inform the subsequent quantitative phase (Chapter 5) and qualitative phase (Chapter 6) of this thesis. Chapter 5 is a secondary quantitative data analysis that uses data from the Global School-based Student Health Survey to calculate the burden of malnutrition and its associated factors

among South Asian adolescents. Chapter 6 is a qualitative study that explores awareness and perspectives of malnutrition among Pakistani adolescents living in a slum. Both Chapter 5 and Chapter 6 provide a rationale, methods, results and discussion of the findings.

Chapter 7 concludes by synthesising the quantitative and qualitative findings. This chapter provides a final discussion, implications based on the synthesis, and future research and dissemination plans.

1.7. Research team members

Several research team members supported this PhD project. The individual contributions of the research team members are acknowledged below.

Both academic supervisors, Prof Paramjit Gill (PG) and Dr Lena Al-Khudairy (LAK) supported the conduct of the whole project.

Samantha Johnson (SJ), an experienced research librarian at the University of Warwick, helped to develop the search strategy of the scoping review. The review was further supported by two reviewers, Dr Maartje Kletter (MK) and Neslihan Ozdemir (NO), who screened evidence according to eligibility criteria.

The formal analysis of the quantitative study was supported by Dr Laura Kudrna (LK), Research Fellow at the Institute of Applied Health Research, University of Birmingham.

The research team at the Aga Khan University supported the qualitative project. As a Principal Investigator of the research team at the Aga Khan University and Associated Professor, Dr Romaina Iqbal (RI) supervised all qualitative project-related activities. Dr. Ahsana Nazish (AN), Senior Instructor, facilitated project activities in the study site. Abidali Muhammad (AM), Assistant Manager, arranged transportation, admin and logistics of the project. Syeda Kisa Zehra Zaidi (SKZZ), Research Assistant, conducted the data collection. Ali Raza (AR), Community Health Worker, assisted the data collection.

The qualitative project was further supported by Iman Ghosh, Research Assistant at Warwick Medical School.

2. Chapter 2: Conceptual framework on adolescent malnutrition

Chapter summary

Chapter 2 illustrates a conceptual framework on the determinants and consequences of adolescent malnutrition in all its forms. The need for a conceptual framework on adolescent malnutrition is firstly justified. The characteristics of four frameworks related to child and adolescent nutritional status and their limitations are detailed. Ultimately, a new conceptual framework combining and reorganising the previous four is proposed.

2.1. Rationale for using a conceptual framework in this thesis

Along with a literature review (section 1.1. in Chapter 1) and a systematic and scoping reviews (Chapter 3 and Chapter 4, respectively), a conceptual framework on adolescent malnutrition was used as the theoretical foundations of this mixed-methods thesis (see 1.5. Research design).

Imenda (2014) suggests that usually, in social and health science research, "there is no one theory that can adequately direct the researcher to sufficiently answer the research questions being pursued". Hence, adolescent malnutrition as a research problem cannot meaningfully be investigated in reference to concepts resident within one theory (Imenda, 2014). Instead, both relevant theoretical and empirical work concerning adolescent malnutrition will be synthesised in this thesis (Imenda, 2014; Rocco & Plakhotnik, 2009). This synthesis is called a conceptual framework, which essentially helps define the main variables and their relationships (Rocco & Plakhotnik, 2009). A conceptual framework can be located in both quantitative and qualitative research paradigms; its use is also recommended in mixed-methods approaches (Imenda, 2014). A conceptual framework is typically limited to the specific research problem for which it was developed (Imenda, 2014). This means that the proposed conceptual framework (below) can only be applied to adolescent malnutrition, and its application to, for instance, child malnutrition may be limited.

A conceptual framework in global health research is employed to group concepts, summarize knowledge, display causality or association, and facilitate the creation of research questions (Paradies & Stevens, 2005). More specifically, it is helpful for deciding which variables are relevant to include in quantitative research, making decisions about how to define variables during data analysis, and ultimately interpreting statistical results (Population Survey Analysis, 2014). In qualitative research, a conceptual framework aims to classify relevant concepts and map relationships among them (Imenda, 2014). On reflection, a conceptual framework in qualitative research may enable researchers to focus on investigating critical areas and tailor the topic guide avoiding unnecessary questions and meaningless participant answers. Similarly, it could be essential to be disciplined in including only essential questions that provide usable data in health surveys and questionnaires. After an initial investigation of a research health problem, a conceptual framework could assist to target, develop, and evaluate public health interventions. Ultimately, a conceptual framework should be informative, visually appealing, comprehensible and provide a descriptive narrative with it (Paradies & Stevens, 2005).

Conceptual frameworks have been recommended by the United States Agency for International Development (USAID) when conducting research on adolescents (USAID Advancing Nutrition, 2021); however, there is no reference framework for adolescent malnutrition as there is for maternal and child malnutrition (UNICEF, 2013). Therefore, there is a need to develop a conceptual framework on the determinants and consequences of adolescent malnutrition in all its forms that can be used in global health research regardless of geographical area and research methods.

2.2. Frameworks on adolescent malnutrition

A conceptual framework that merges and builds on four frameworks that relate to child and adolescent nutritional status is proposed in this chapter. Three frameworks captured the pathways of adolescent health and nutrition (Christian & Smith, 2018; WHO, 2005; WHO, 2018b). In addition, UNICEF's framework on maternal and child nutrition (UNICEF, 2013) informed the proposed conceptual framework due to its worldwide recognition to understand the multifactorial determinants of malnutrition. The characteristics of these four frameworks and their limitations are detailed below.

2.2.1. UNICEF conceptual framework

The UNICEF conceptual framework on the determinants and consequences of child undernutrition was developed in 1990 (UNICEF, 1998) as part of the UNICEF Nutrition Strategy. This distinguishes basic, underlying, and immediate causes of undernutrition and demonstrates the interconnection of these causes moving from a macro to a micro level (Reinhardt & Fanzo, 2014). The basic causes consist of systemic challenges, such as social, economic, cultural and political factors that neglect human rights and perpetuate poverty by distributing unfairly global resources. The underlying causes include household food security, adequate care and feeding practices, access to quality health services, and a healthy household environment. Both the basic and underlying causes influence the immediate causes. The immediate causes are the influence of both basic and underlying causes on the individual, including dietary intake and illnesses. The framework also includes short- and long-term consequences of malnutrition which could be perpetuated throughout generations. The framework has been refined to include new information and evidence since its creation. In 2013, adequate maternal nutrition was incorporated into the framework as crucial to prevent child undernutrition (UNICEF, 2013).

The UNICEF's framework has increased international attention and action towards improving child health and nutrition outcomes. Its ultimate goal is to guide in the assessment of nutrition-related determinants and thus plan effective actions to address malnutrition in all geographical contexts (Sabbahi et al., 2018). Unfortunately, it does not fully apply to adolescents because it excludes crucial determinants of malnutrition in this stage of life, such as working status, health behaviours or early pregnancy, which are very important in this stage of life. However, UNICEF's framework has been used to guide malnutrition research on adolescents (Caleyachetty et al., 2018; Vogt et al., 2016). Despite being children- and mother-focus, this framework was taken into consideration for the proposed conceptual framework because of its importance, universality and comprehensiveness. In addition, there are some levels in the UNICEF's framework that could apply to the adolescent population, such as basic causes and short- and long-term consequences.

2.2.2. WHO conceptual framework 2005

The WHO conceptual framework on nutritional problems and casual factors in adolescence appears in the WHO report entitled *Nutrition in adolescence –issues and challenges for the health sector* (WHO, 2005). This report identifies adolescence as a period of nutritional vulnerability when lifestyle, eating behaviours, underlying psychosocial factors and socioeconomic factors are key to adolescent health. Its conceptual framework, which was "loosely adapted" from UNICEF's framework 1990, focuses on critical nutritional problems in adolescence, such as undernutrition, micronutrient deficiency, obesity, and chronic health diseases, regardless of geographic area or income level. The concurrence of different forms of malnutrition is recognized in this framework along with underlying factors that compromise adolescent nutritional status, such as lifestyle factors, dietary inadequacies, early pregnancy, infection and other health conditions. Socioeconomic factors and food systems are also acknowledged in this framework and "regarded as major threats to adequate nutrition in adolescence, along with lifestyles" (WHO, 2005). This WHO conceptual framework highlights that fetal or childhood malnutrition increases the likelihood of chronic disease risk during adolescence or later on during adulthood.

The WHO conceptual framework of nutritional problems and casual factors in adolescence (WHO, 2005) includes malnutrition in all its forms and considers essential underlying causes of malnutrition during this life stage, such as lifestyle and early pregnancy. However, the interrelationship of these causes is not organised into distinct levels of malnutrition drivers apart from the underlying causes. This framework overlooks basic factors such as political context and access to health services as well as environmental factors such as family and peers

relationship. It steers a life-span approach when mentioning the impact of fetal or childhood malnutrition, but it does not note adulthood health and nutritional consequences.

2.2.3. Comprehensive framework by Christian and Smith (2018)

The comprehensive framework on adolescent health by Christian and Smith (2018) was informed by WHO framework 2005 and considers both the life course and social determinants of health (Christian & Smith, 2018). Adolescent health policies, health systems and food systems are the wider socioeconomic and political context governing the whole framework. Cultural and gender norms are considered essential structural determinants of health and nutrition, which regulate energy intake, work, education, leisure activities, and mortality causes during adolescence. Dietary intake, physical activity, infection and early pregnancy are physiological determinants of adolescent health. The life course approach becomes relevant in this framework when considering poor nutrition during gestation and childhood as a critical determinant of adolescent health.

This framework is the first and only one including work and education as important structural determinants for adolescent health at the individual level, but it omits determinants at the household or community level such as household food security or sanitation services. Similar to the WHO conceptual framework 2005, Christian and Smith's framework sustains a life course approach until adolescence, but it does not go beyond adolescence, disregarding the consequences of malnutrition later in life. This framework simplifies the so-called physiological determinants missing out on several health behaviours and psychosocial factors such as alcohol use, mental health and smoking habit.

2.2.4. WHO conceptual framework 2018

The WHO framework of interventions and determinants of adolescent nutrition appears in the WHO guideline titled *Implementing effective actions for improving adolescent nutrition* (WHO, 2018b). This guideline presents a framework that unifies eight evidence-based nutrition interventions and determinants of adolescent nutrition. This WHO framework adapts the three underlying causes of malnutrition from UNICEF's framework to three corresponding solutions for adolescents to enjoy health and improved nutrition, i.e. adolescents should be able to access a nutritious diet; they should be able to contribute to their health through positive behaviours; and they should be able to access essential health services. In order to achieve improved adolescent health and nutrition, adolescents should be well-nourished and protected from disease, injury, infection and early pregnancy. Ultimately, this framework points out the intergenerational outcomes of addressing adolescent health: low probability of

malnutrition in adolescence and adulthood, prevention of NCDs, better maternal and birth outcomes, and increased work capacity and productivity.

Despite including determinants of adolescent health and nutrition, the WHO framework 2018 focuses on evidence-based interventions. As a result of these interventions, a positive narrative describes the determinants that enable improved adolescent health and nutrition. This framework adds the social aspect surrounding adolescents by acknowledging peers, interpersonal networks, families and communities, but other wider determinants are missing, such as socioeconomic context, food systems and health care services. Opposite to the WHO conceptual framework 2005 and Christian and Smith's framework, this framework highlights the outcomes in adolescence and adulthood but forgets the fetal and child growth and nutrition status.

In summary, all four frameworks are highly regarded and well-established. They are informed by previous literature serving different purposes and applications. However, none of the four frameworks listed above has focused exclusively on determinants and outcomes of adolescent malnutrition in all its forms considering a life course approach. Hence, the importance of developing a new conceptual framework to address adolescent malnutrition in all its forms.

2.3. The proposed conceptual framework for this thesis

As discussed above, adolescent malnutrition is a complex global health issue with multiple and interrelated levels of determinants involved in its development and continuation. The following conceptual framework on adolescent malnutrition considers both the life course and macro and micro determinants of health (Figure 4). The conceptual framework proposed combines and reorganises the determinants of adolescent malnutrition of the above frameworks.

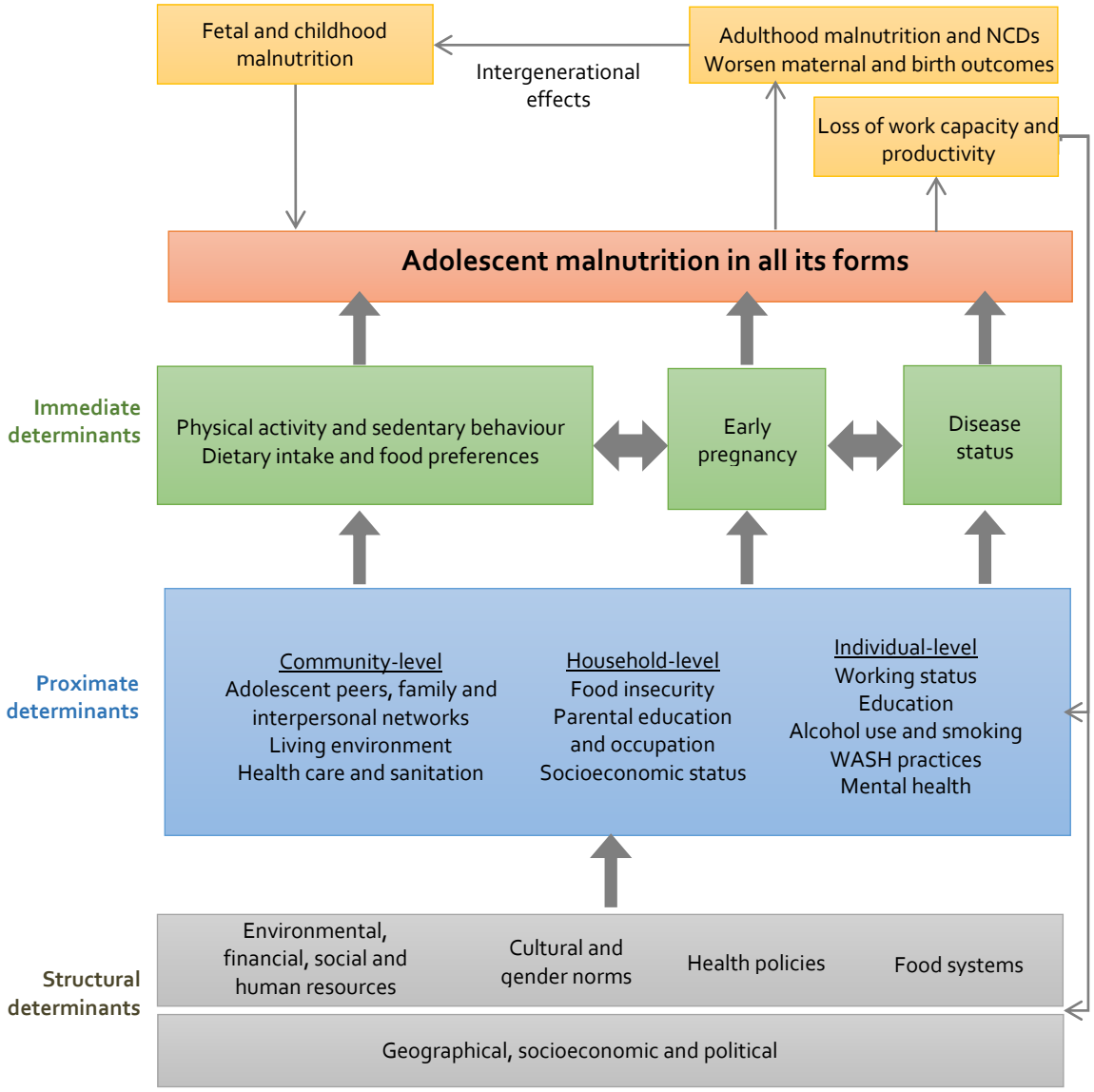

Figure 4. Conceptual framework on the determinants and outcomes of adolescent malnutrition in all its forms. Adapted from: (UNICEF, 2013), (WHO, 2005), (Christian & Smith, 2018), and (WHO, 2018b).

In this conceptual framework, the determinants for adolescent malnutrition are classified into three categories: structural, proximate and immediate. The structural determinants are widespread among the overall society and refer to the macro context involving geographical, socioeconomic and political challenges influencing global resources, cultural and gender norms, health policies, and food systems. The proximate determinants are organised from community to household and individual levels of focus. At the community level, peers, family, and social networks influence adolescent nutrition but also local health care and sanitation services, and safe living environments that enable physical activity and healthy diets as schools or local playgrounds. Food insecurity, parental education and occupation, and socioeconomic status are key factors for adolescent nutrition at the household level. At the individual level, personal contributing factors are working status, education, alcohol and tobacco use, hygiene

practices, and emotional health. Both structural and proximate determinants impact the immediate determinants, which have a more direct influence on the nutritional status of the adolescent leading to undernutrition, micronutrient deficiencies or overnutrition. The immediate determinants involve early pregnancy, disease status, and health behaviours such as physical activity, sedentary behaviour, dietary intake, and food preferences. Ultimately, adolescent malnutrition outcomes transcend generations and become a cyclical global health problem. The economic effects of adolescent malnutrition imply reduced human capital formation, which can have a further impact on proximate and structural determinants. From a life-course approach, all forms of adolescent malnutrition have intergenerational effects: stunted, thin, overweight and/or micronutrient deficient adolescents become underweight, overweight, micronutrient deficient and/or with risk of NCDs adults who give birth to stunted, underweight, wasted, overweight and/or micronutrient deficient children.

Although it is essential to examine the complexity of adolescent malnutrition, it will not be feasible to investigate all its determinants and relationships in a single doctoral thesis. This thesis is focused on the immediate and proximate determinants as they are in line with the scope of this thesis.

3. Chapter 3: Review on adolescent malnutrition in South Asia

Chapter summary

Chapter 3 summarises evidence on adolescent overnutrition in South Asia informed by two systematic reviews (Mazidi et al., 2018; Mistry & Puthussery, 2015). Methods, findings, discussion, future areas of research and implications of these reviews are presented. This chapter also introduces adolescent undernutrition and micronutrient deficiencies in South Asia by identifying the need for conducting a review on the topic and justifying the method applied for this project.

3.1. Background on adolescent malnutrition in South Asia

This chapter and the following (Chapter 4) respond to objective 1 of this thesis:

- To summarise what is known about adolescent malnutrition in South Asia and identify gaps in the literature using a scoping review to synthesise the evidence.

In order to facilitate the presentation and understanding of evidence looking at adolescent malnutrition in South Asia, the topics are divided into two parts: Chapter 3 focuses on overnutrition, and Chapter 4 focuses on undernutrition and micronutrient deficiencies.

The conceptual framework (Chapter 2) produced a synthesis of the evidence that "set the scene" for exploring adolescent malnutrition and shows broadly what determinants connect with adolescent malnutrition worldwide. Since this PhD thesis is focused on South Asian countries, it becomes essential to be familiar with what is known and identify what has been and has been not studied up-to-date in this context. Hence, a review was found to be the most suitable methodology for this purpose (Noble & Smith, 2018).

3.1.1. Background on adolescent overnutrition in South Asia

Two systematic reviews have synthesised the evidence on childhood and adolescent overnutrition in South Asia (Mazidi et al., 2018; Mistry & Puthussery, 2015). These reviews included the eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka), focused on adolescence, reported recent publications and used a systematic design to search and summarise the evidence (Table 3). Therefore, it was considered that further reviews on adolescent overnutrition in South Asia would not add additional value to the current evidence. This thesis reports and reflects on the findings of these two reviews to address objective 1. A summary of the methods, results and discussion from both reviews is presented below.

Table 3. Reviews on child and adolescent overnutrition in South Asia.

	(Mazidi et al., 2018)	**(Mistry & Puthussery, 2015)**
Type of review	Systematic review and meta-analysis	Systematic review
Date of the included publications	1999-2017	1990-2013
Context of the included publications	Asia (including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka)	South Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka)
Age sample of the included publications	Children (5-12 years) and adolescents (12-19 years)	Children and adolescents aged from 0 to 18 years old

Forms of malnutrition	Overnutrition (overweight and obesity)	Overnutrition (overweight and obesity)

Mistry and Puthussery (2015) systematic review aimed to systematically synthesise the evidence on factors associated with overweight and obesity among children and adolescents in South Asian countries (Table 3). In other words, this review focused on risk factors that were linked to increased risk of overweight and obesity. Quantitative and qualitative primary studies were retrieved from electronic databases. Mazidi et al. (2018) conducted a systematic review and meta-analysis with the aim to estimate the prevalence of childhood and adolescent overweight and obesity in Asian countries (Table 3). Authors searched for population-based cross-sectional or cohort studies in electronic databases as well as grey literature databases. Quality appraisal was conducted in both reviews.

Mistry and Puthussery (2015) included 11 studies, of which all were school-based and quantitative (mostly using a cross-sectional design). Seven out of 11 studies were located in India. For overnutrition classification, CDC growth charts were employed in four studies, the WHO growth standards in three, IAP in one, IOTF in one and two studies did not report the growth reference. The prevalence of overweight ranged from 3.1% to 19.7% and obesity from 1.2% to 14.5% among children and adolescents. Prevalence of overnutrition was higher among boys than girls, but the difference was generally statistically not significant. This review pointed out several contributors to child and adolescent overweight and obesity: lack of physical activity, long hours of screen time, frequent consumption of fast food, frequent consumption of calorie-dense foods, higher household socioeconomic status and family history of obesity.

In Mazidi et al. (2018) review, 41 studies were included. Of these, five studies were from India and one from Pakistan. Different references for calculating overnutrition were employed. The most frequently used growth reference for calculating overnutrition were WHO (n=16), IOTF (n=11), CDC (n=7) and Cole criteria (n=6). The overall prevalence of overweight among Asian adolescents was 14.6% (95% CI: 12.5-17.1) and obesity was 8.6% (95% CI: 7.2-10.2). These prevalence varied depending on the criteria used. The overall prevalence of overweight and obesity in adolescent boys (15.9% and 10.1%, respectively) was significantly higher than in adolescent girls (13.7% and 6.2%, respectively).

It is important to note that the aim and the target population was different in both reviews, but their findings can enhance the understanding of adolescent overnutrition in South Asia.

While Mistry and Puthussery (2015) identified various determinants of overweight and obesity among children and adolescents in South Asian countries, Mazidi et al. (2018) estimated the prevalence of overweight and obesity among children and adolescents in the Asian continent. From the 41 studies included in Mazidi et al. (2018), only six were from South Asian countries (five from India and one from Pakistan), making it challenging to generalise this review findings to the South Asian context. Despite using a systematic review methodology, both reviews acknowledged the heterogeneity of different study designs, classifications, and outcomes of the included studies. Interestingly, Mazidi et al. (2018) found that the pooled prevalence of overweight and obesity in adolescents statistically differed by sex, whereas Mistry and Puthussery (2015) reported that the difference between boys and girls was mostly non-significant among the studies included. Both reviews pointed out the importance of the findings for a range of stakeholders to prevent and address the uprising overnutrition epidemic in this context. In addition, Mistry and Puthussery (2015) identified several areas for future research. The authors recommend collecting nationally representative data from all South Asian countries, exploring potential determinants of overnutrition with a qualitative approach and conducting interventional studies.

3.1.2. Background on adolescent undernutrition and micronutrient deficiencies in South Asia

Child and adolescent undernutrition and micronutrient deficiencies in South Asia have been previously reviewed (Akhtar, 2016; Khan et al., 2007; Mak & Tan, 2012; Pasricha & Biggs, 2010). Some literature reviews (Akhtar, 2016; Khan et al., 2007; Pasricha & Biggs, 2010) were focused on children, while Mak's systematic review (2012) provided evidence on both children and adolescents. However, this last systematic review exclusively focused on studies examining the prevalence of underweight status in the last two decades without including other undernutrition indicators or micronutrient deficiencies (Mak & Tan, 2012). A comparison of these reviews (Table 4) revealed the need for a more systematic approach to synthesise up-to-date evidence on adolescent nutritional status, including stunting, thinness and micronutrient deficiencies. Hence, this review includes a large pool of evidence from all South Asian countries by following a broad search strategy including all forms of undernutrition as well as including grey literature without restrictions on date of publication.

Table 4. Reviews on child and adolescent undernutrition and micronutrient deficiencies in South Asia.

	(Akhtar, 2016)	(Mak & Tan, 2012)	(Pasricha & Biggs, 2010)	(Khan et al., 2007)	This PhD review
Type of review	Literature review	Systematic review	Literature review	Literature review	Scoping review
Date of the included publications	Restrictions on date of publication not specified	1990 - 2010	Restrictions on date of publication not specified	Restrictions on date of publication not specified	Up to 2019
Context of the included publications	South Asia (India, Pakistan, Bangladesh, Sri Lanka and Nepal)	East Asia (China, Hong Kong, Japan, South Korea, and Taiwan), South Asia (Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, Singapore, Thailand, and Vietnam), and West Asia (Bahrain and Iran).	South and South-East Asia (no countries are listed)	South Asia (no countries are listed)	South Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka)
Age sample of the included publications	Children under 5 years and school children (up to 12 years)	Children and adolescents	Children under 5 years	Children under 5 years	Adolescents 10 – 19 years
Forms of malnutrition	Stunting, wasting, underweight and micronutrient deficiencies	Underweight	Stunting, wasting, underweight and micronutrient deficiencies	Stunting, wasting, underweight and micronutrient deficiencies	Stunting, thinness and micronutrient deficiencies

3.2. Rationale for using a scoping review methodology to synthesise evidence on adolescent undernutrition in South Asia

Grant & Booth, in 2009, identified and characterised 14 types of reviews (Grant & Booth, 2009). The methods used (search, appraisal, synthesis and analysis) for all different types of reviews were evaluated in order to select the most appropriate type of review to answer objective 1 (Grant & Booth, 2009). Other factors considered at this stage were resources, nature of evidence (quantitative and qualitative studies as well as grey literature), and potential heterogeneity of the design and outcomes among potentially included studies, as pointed out by previous studies (Mak & Tan, 2012; Mazidi et al., 2018; Mistry & Puthussery, 2015) that were discussed in section 3.1. Background on adolescent malnutrition in South Asia.

Literature review, rapid review, scoping review and systematic review are used to summarise the knowledge around a specific question or health research topic (Noble & Smith, 2018). Literature reviews examine recent evidence on a topic but do not typically include a

comprehensive search strategy and rigid selection criteria (Grant & Booth, 2009). Authors may be selective with the included evidence resulting in reviewing bias. Rapid reviews assess the literature on a policy or practice issue needed for evidence-based decisions (Grant & Booth, 2009). Despite using systematic search methods, rapid reviews abbreviate particular stages of the systematic review process, which consequently increases the risk of introducing bias. Systematic reviews search for, appraise and synthesise research evidence in a systematic approach that should be reproducible by other researchers (Grant & Booth, 2009). Scoping reviews examine the potential size and the nature of available research evidence using a broad, replicable and systematic search (Arksey & O'Malley, 2005). A formal assessment of the methodological quality of evidence is not typically conducted in scoping reviews (Arksey & O'Malley, 2005). In some cases, a scoping review assesses the feasibility of undertaking a full systematic review (Arksey & O'Malley, 2005; Munn et al., 2018). Both scoping reviews and systematic reviews highlight gaps in knowledge to help guide future research (Munn et al., 2018). While systematic reviews require a highly focused research question that restricts studies for inclusion, the research question in scoping reviews is more broadly defined to allow for more flexibility in the quality and type of included studies (Arksey & O'Malley, 2005).

Since providing evidence to inform practice, critically appraising the evidence, and answering the feasibility or effectiveness of a treatment or health procedure goes beyond objective 1, a systematic review was not deemed as feasible to address this thesis objective (Munn et al., 2018). Therefore, a scoping review was considered the most suitable method to summarise the literature on adolescent undernutrition and micronutrient deficiencies in South Asia and identify gaps in the literature. This scoping review focuses on undernutrition and micronutrient deficiencies status because adolescent overnutrition in South Asia has been sufficiently summarised and investigated in previous reviews (Mazidi et al., 2018; Mistry & Puthussery, 2015) (see 3.1.1. Background adolescent overnutrition in South Asia).

4. Chapter 4: Scoping review on adolescent undernutrition in South Asia

Chapter summary

Chapter 4 reports the results of the scoping review, mapping the evidence on adolescent undernutrition and micronutrient deficiencies in South Asia and highlighting gaps in knowledge. This chapter begins with the review's aims before moving on to report the method and results of the review. It finally provides a discussion and interpretation of the findings presenting the strengths and limitations. This review and the protocol have been published in Nutrition Research Reviews and BMJ Open, respectively. The methods, results and discussion have been adapted from the published journal articles (see below). The last section of this chapter provides an integration of the findings from two reviews on overnutrition (Chapter 3) and my scoping review on undernutrition and micronutrient deficiencies.

Peer-reviewed journal articles:

- Estecha Querol S, Al-Khudairy L, Iqbal R, Johnson S, Gill P. Adolescent undernutrition in South Asia: a scoping review protocol. *BMJ Open*. 2021; 10:e031955. doi:10.1136/bmjopen-2019-031955
- Estecha Querol S, Gill P, Iqbal R, Kletter M, Ozdemir N, Al-Khudairy L. Adolescent undernutrition in South Asia: A scoping review. *Nutrition Research Reviews*. 2021; 1-11. doi:10.1017/S0954422421000068

Conference publications:

- Estecha Querol S, Gill P, Iqbal R, Al-Khudairy L. Adolescent undernutrition in South Asia: a scoping review. Poster presented at: 8th International Conference Nutrition & Growth; 26 August 2021; online.

  Poster here

  Abstract here (page 89)

4.1. Aims of the scoping review

- To map the evidence on adolescent undernutrition and micronutrient deficiencies in South Asia.
- To identify gaps in knowledge.
- To inform the subsequent projects of this PhD thesis.

4.2. Methods

The methodology of this scoping review was informed by Arksey and O'Malley's framework (Arksey & O'Malley, 2005) and The Joanna Briggs Institute Reviewers' Manual (Peters et al., 2015). In addition, the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist was followed where applicable (Tricco et al., 2018). In order to develop this scoping review protocol, the five stages proposed in Arksey and O'Malley's methodological framework were followed (Arksey & O'Malley, 2005).

4.2.1. Stage 1: identifying the research question

The Population, Concept and Context (PCC) strategy was used to define the title, scoping review aim, scoping review question, and inclusion criteria (Peters et al., 2015). Following the PCC strategy, this scoping review aimed to answer the following question: what do we know about adolescent undernutrition and micronutrient deficiencies in South Asia from the existing literature?

4.2.2. Stage 2: identifying relevant studies

At this stage, the reviewing team (SEQ, SJ, RI, LAK, PG) discussed the keywords constituting the search strategy and the criteria for inclusion and exclusion of the studies in accordance with the PCC strategy.

Databases

An experienced research librarian (SJ) and the PhD candidate (SEQ) developed the search strategy by testing the keywords, MESH terms and databases to search. Finally, the reviewing team discussed and determined the final search strategy. The search was conducted using Medline (OVID), Embase, Cochrane, Web of Science, CINAHL, PsycInfo, Scopus, the WHO Library Information System, eLENA e-Library of Evidence for Nutrition Actions, and Opengrey. The websites of relevant agencies, academic institutions and technical bodies were also searched: WHO, UNICEF, Demographic and Health Surveys (DHS), Program, Planning and Development Department AJ&K, Global Health Data Exchange, World Food Program (WFP) and World Bank eLibrary.

Search strategy

Searches were carried out from inception to 11 March 2019. The search strategy included South Asia AND adolescents AND undernutrition. Related terms to undernutrition were also considered in the search strategy, such as stunting, thinness, underweight, and micronutrient deficiency. The search strategy was tailored to the specific requirements of each database. No restrictions on language were made. The final search strategy for all databases can be found in Appendix 1.

Eligibility criteria

Given the broadness of the proposed scoping review research question, the eligibility criteria were clearly defined to thoroughly guide the reviewers' decisions. The inclusion criteria listed below were based upon the PCC strategy:

- Population: adolescents mean age 10 – 19 years old (WHO, 2019a).
- Context: South Asia. The World Bank limits the South Asia region to Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka (The World Bank, 2019).
- Concept: in this scoping review, only undernutrition (stunting, thinness or underweight) and micronutrient deficiencies indicators for adolescents were used (WHO, 2016b). Studies also needed to investigate undernutrition and micronutrient deficiencies as its primary outcome.
- Adolescent nutritional status was assessed quantitatively using the following WHO indicators: 1) thinness or underweight (low BMI-for-age); 2) stunting (low height-for-age); and 3) micronutrient deficiencies (lack of essential vitamins and minerals required in small amounts by the body for proper growth and development (Ritchie & Roser, 2020)). Studies were included regardless of the growth references or cut-off values followed.
- Adolescent nutritional status in South Asia was also assessed qualitatively, therefore, qualitative studies exploring perspectives, experiences or opinions around adolescent undernutrition were included.
- Type of studies: quantitative and qualitative studies as well as grey literature, e.g. primary research studies, reviews, government reports and guidelines.

Studies were excluded if they included:

- Only overnutrition indicators (obesity and overweight).
- Pregnant or breastfeeding adolescents.

- Adolescent athletes.
- Adolescents with long term conditions such as diabetes, tuberculosis or HIV.
- Hospitalised adolescents.
- Intervention studies targeting treatment of a specific illness or condition such as diarrhoea.

4.2.3. Stage 3: study selection

The screening process of this proposed scoping review comprised two phases. Firstly, titles and abstracts were reviewed by two independent reviewers (SEQ and MK) following a broad inclusion criterion, that is, studies looking at adolescent undernutrition and micronutrient deficiencies in South Asia. Papers identified by either or both reviewers were included in the next phase. Secondly, two reviewers independently (SEQ and NO) screened full-text studies using the eligibility criteria mentioned above and reasons for exclusion were documented. At this stage, disagreements were resolved by either discussion or referral to a third reviewer (LAK).

4.2.4. Stage 4: charting the data

A form was developed and piloted to extract relevant information from the included studies (Table 5). One reviewer (SEQ) extracted data. A second reviewer (LAK) reviewed the results of data charting to resolve any conflict and ensure consistency. For all included studies, key characteristics were charted using an Excel sheet.

Table 5. Key information extracted from the studies included in the scoping review.

Study details
Author(s) / Organization Year of publication Province and city (where the study was published or conducted) Study design Aims Sample size
Data relevant to the PCC term
Population: target population characteristics (age, sex and setting) Context: country Concept: outcome quantitative measures (stunting, thinness or underweight, and micronutrient deficiencies) including growth references or the cut-off values. Concept: qualitative outcomes (experiences, opinions and perspectives). Undernutrition outcomes (e.g. prevalence) Recommendations of the author(s)

4.2.5. Stage 5: collating, summarising and reporting the results

The results are reported as a data map presented in a tabular form displaying the distribution of publication year, location, characteristics of the target population, study design, and outcomes. Additionally, a narrative synthesis accompanied the descriptive presentation of the results by grouping the data into meaningful summaries for a better exposition of the findings. Evidence was therefore divided into publications that included an intervention component and publications that did not include an intervention component.

4.2.6. Ethics

Since a scoping review involves a methodical integration and presentation of available resources, this study does not require ethics approval.

4.3. Results

4.3.1. Results of the search:

The search located 6972 records from databases and 1103 records from grey literature such as websites of agencies, academic institutions and technical bodies (Figure 5). De-duplication resulted in a total of 6181 records that were screened. Title and abstract screening excluded 5640 records. Out of the 541 full-text records assessed for eligibility, 401 did not meet the inclusion criteria. A total of 140 records (131 publications) met the inclusion criteria of this review. Records were grouped under publications if they belonged to the same research project, reporting the group of records as one publication. Three systematic reviews were screened for relevant publications. No further evidence was identified from these systematic reviews. Therefore, a total of 128 publications were formally included in this review constituting 108 original articles, ten letters to the editor, six reports from international agencies, three conference abstracts, and one communication.

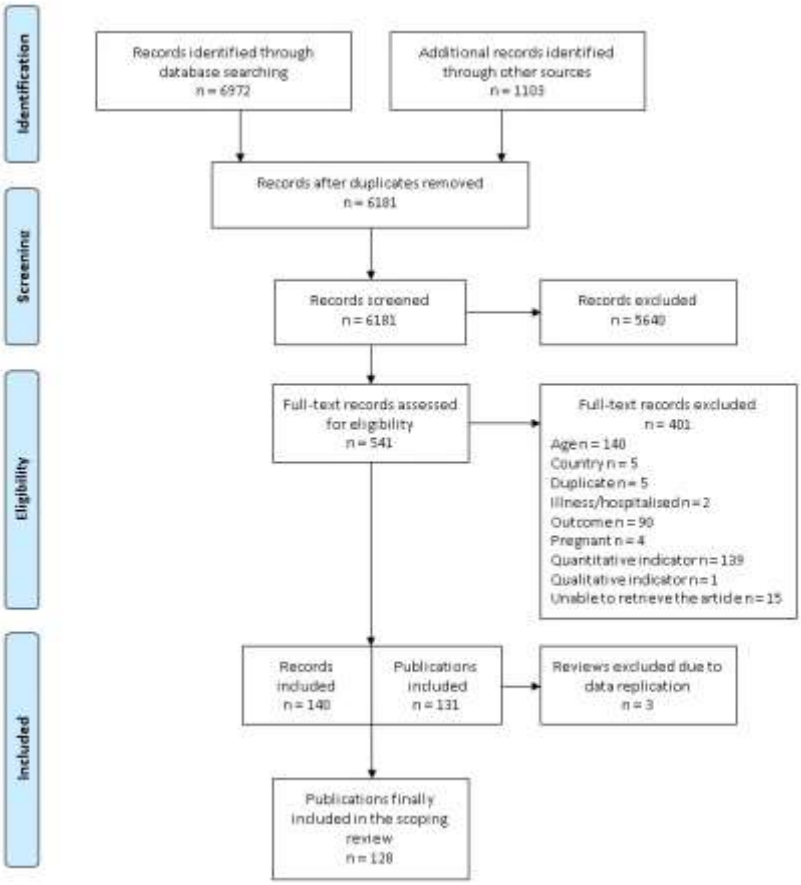

Figure 5. Selection of sources of evidence in this review using the original PRISMA statement (Moher et al., 2009)

4.3.2. Characteristics of the included studies:

Information of the author, year of publication, study title, age and sex of the target population, location, malnutrition indicator(s), classification, growth standards and main findings are provided for the 128 eligible publications (see Appendix 2). Appendix 2 table categorises the literature into two main groups: one where an intervention component is present (n=12) and one where it is not (n=116).

The majority of the eligible evidence was published in the last 15 years (Table 6). The first publication measuring micronutrient deficiencies was in 1975 (Tandon et al., 1975), the first publication measuring stunting was in 1996 (PanterBrick et al., 1996), and the first publication measuring thinness was in 2002 (Venkaiah, 2002). All included publications reported quantitative outcomes (Table 6). Eligible evidence involved nine randomised controlled trials, two longitudinal studies, one non-randomized prospective trial, one pre-post interventional study, and 115 cross-sectional studies (Table 6).

Table 6. Characteristics of the included studies.

	n	% out of 128 publications included
Year of publication		
Before 2000	7	5%
2000-2004	5	4%
2005-2009	37	29%
2010-2014	40	31%
2015-2019	39	30%
Type of data		
Quantitative	128	100%
Qualitative or mixed methods	0	0%
Study design		
RCT	9	7%
Longitudinal studies	2	2%
Non-randomized prospective trial	1	1%
Pre-post interventional study	1	1%
Cross-sectional studies	115	90%
Country		
Afghanistan	1	1%
Bangladesh	17	13%
Bhutan	1	1%
India	86	67%
Maldives	1	1%
Nepal	4	3%
Pakistan	6	5%
Sri Lanka	9	7%
Multinational	3	2%
Community		
Multi-setting (nationally representative)	12	9%
Rural	32	25%
Slum	8	7%
Urban	14	11%
Urban and rural	10	8%
Unknown	52	40%
Setting		
Community-based	34	27%
School-based	69	53%
Both	3	2%
Unknown	22	17%
Gender		
Girls	45	35%
Boys	6	5%
Both	77	60%
Nutritional status indicator		
Stunting	16	13%
Underweight	30	23%
Micronutrient deficiency	40	31%
Stunting & underweight	27	21%
Stunting & micronutrient deficiency	2	2%
Underweight & micronutrient deficiency	4	3%
Stunting & underweight & micronutrient deficiency	9	7%

Geographical distribution of the evidence

The majority of publications (67%) were conducted in India (Table 6). The geographical distribution of the literature was aggregated in some of the states or provinces of Bangladesh, India, Nepal, Pakistan and Sri Lanka (Figure 6). Evidence from Bhutan, Afghanistan and

Maldives was obtained solely from the Global School-based Student Health Survey (WHO, 2014b; WHO, 2014c; WHO, 2016a). The setting was only reported in 76 publications (60%) (Table 1), of which 32 were conducted in rural areas (25%), 8 in slum areas (7%), 14 in urban areas (11%), 10 in both urban and rural areas (8%), and 12 were nationally representative samples (9%). Sixty-nine of the included publications were school-based (53%), and 34 were community-based (35%) (Table 6).

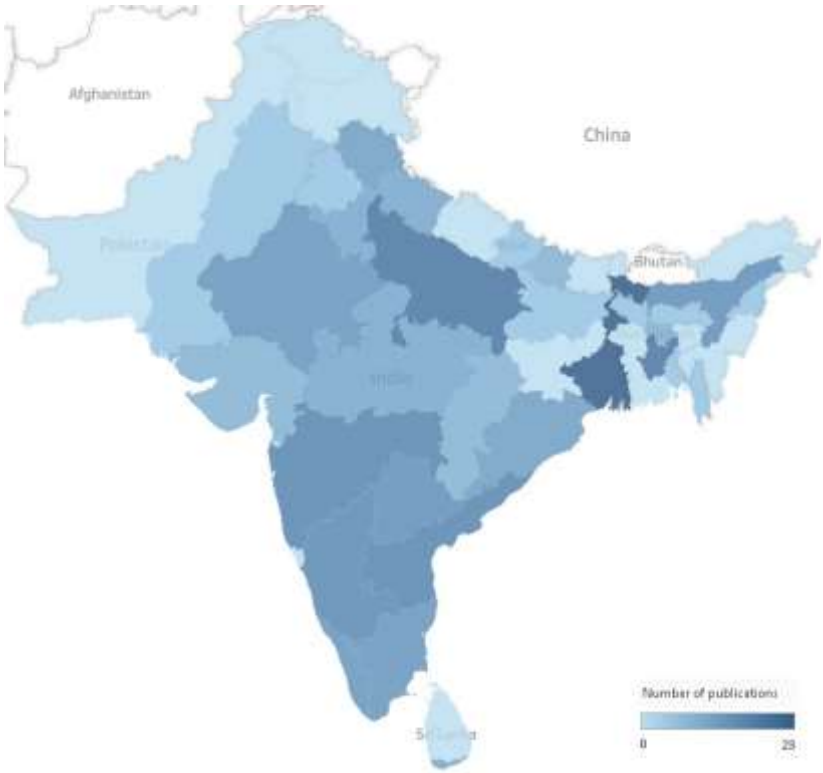

Figure 6. Geographical distribution of the literature across South Asian countries. The total number does not equal the total number of publications included in the scoping review as some publications focused on more than one country, state or province.

Target population

Gender stratified analysis was provided in 77 publications (60%) (Table 6). Forty-five publications reported data on girls only, and six publications included boys only. In terms of participants' age, 82 publications focused exclusively on the age range between 10 to 19 years. Sixteen publications had a mean age of 10 to 19 years. In publications where the mean age was greater than 10 to 19 years, data regarding adolescents was only extractable in 30 publications. The sample size was extracted from 122 publications (95%). The sample size ranged from 41 to 16245, with a mean of 1704 adolescents. In six publications, it was not possible to extract the sample size because it was not reported. Adolescents were anaemic at baseline in four publications (Ahmed et al., 2005; Ahmed, 2010; Ahmed, 2008; Prakash et al., 2010).

Undernutrition indicators

Thinness (low BMI-for-age) was frequently (n=70) used to measure adolescent malnutrition. Stunting (low height-for-age) was used as a malnutrition indicator in 54 publications, and micronutrient deficiency was also reported in 55 publications (Table 6).

Twenty-seven publications categorised adolescent nutritional status using age and sex-specific anthropometric measures using NCHS growth charts (Appendix 2). Other growth references were considered to assess BMI-for-age or height-for-age: WHO reference 2007 (n=22), CDC growth charts (n=11), NHANES (n=11), WHO reference 1995 (n=9), and IAP growth charts (n=5). Ten publications used IOTF criteria on sex-age-specific BMI cut-offs for thinness, and three publications used Waterlow's classification of stunting. The citations of the listed growth references are provided in Appendix 2.

Anaemia was the most reported sign of a micronutrient deficiency (Table 7). It was reported in 38 publications, of which 20 referenced the WHO classification of low haemoglobin concentration. Other micronutrient deficiencies examined were vitamin A (n=13), folic acid (n=9), vitamin B12 (n=7), vitamin D (n=6), vitamin C (n=5), zinc (n=5), vitamin B2 (n=3), iodine (n=3), iron (n=2).

Table 7. Reported micronutrient deficiencies and indicators.

Micronutrient	Number of publications
Anaemia	
Low haemoglobin	34
No indicator reported	4
Vitamin A deficiency	
Clinical signs (i.e. Bitot's spots)	5
Low serum retinol	7
Low plasma retinol	1
Folic acid deficiency	
Low RBC folate	4
Low serum folic acid	5
Vitamin B12 deficiency	
Low serum vitamin B12	7
Vitamin D deficiency	
Low serum 25(OH)D	6
Vitamin C deficiency	
Low plasma vitamin C	5
Zinc deficiency	
Low serum zinc	3
Low plasma zinc	1
No indicator reported	1
Vitamin B2 deficiency	
High EGRAC	3
Iodine deficiency	
Low urinary iodine	3
Iron deficiency	
Low serum ferritin	2

Publications that included an intervention component

Results of publications that include an intervention component (n=12) are presented in Appendix 2. A brief on the findings of these publications is summarised below.

Among the publications that include an intervention component, supplementation was the most prevalent type of intervention using food fortification in six publications and capsules in five. In addition, there was one school feeding program that provided daily balanced meals to a cohort of tribal students attending a school in rural south India (Thomas et al., 2013). The authors of this publication classified the students according to attendance: 'new' students less than a year and 'old' students more than a year of attendance. Comparison of thinness prevalence in these groups showed that 50% of 'new' and 37.5% of 'old' students were thin; however, the difference was not significantly different between the two groups.

In Sri Lanka, iron and zinc capsules consumed daily on school days for 24 weeks showed improvements in the prevalence of anaemia and zinc deficiency but did not decrease the rate of stunting among adolescents (Hettiarachchi et al., 2008). Various publications compared the efficacy of different micronutrient supplementation combinations among anaemic adolescents (Ahmed et al., 2005; Ahmed, 2010; Prakash et al., 2010) and vitamin D deficient adolescents (Garg et al., 2013a).

A sample of 178 anaemic adolescent schoolgirls in Bangladesh received either iron and folic acid (IFA) - 30 mg Fe and 400 µg folic acid - tablets or multiple micronutrients (MMN) tablets (15 micronutrients, including iron and folic acid) (Ahmed et al., 2005). The findings showed that even though the effect of IFA and MMN tablets on reducing anaemia and iron deficiency was similar, MMN supplementation demonstrated a significant enhancement of other micronutrients status. The team examined the relative efficacy of long-term (52 weeks) once-weekly and twice-weekly MMN supplementation (Ahmed, 2010). Both supplementation frequencies were equally efficacious in decreasing anaemia, however, twice-weekly MMN was more efficacious than one-weekly MMN in improving vitamin A, riboflavin, and folic acid status.

Another randomised control trial studied the effect of non-iron containing Ayurvedic preparations to treat nutritional anaemia in adolescent students in India (Prakash et al., 2010). The authors found that a daily dose of two non-iron containing Ayurvedic preparations improved anaemia in the study participants. An intervention providing 60000 IU/week doses of vitamin D to vitamin D deficient adolescents revealed that 4, 6, and 8 weeks supplementation regimens were equally efficacious in achieving vitamin D sufficiency (Garg et al., 2013a).

Micronutrient fortified biscuits were confirmed to be effective in improving not only micronutrient deficiencies but also thinness and stunting among Indian adolescent girls (Goyle, 2012). Evidence showed that food fortification is a cost-effective and sustainable strategy to improve micronutrient deficiencies among adolescents in Bangladesh (Rahman et al., 2015) and India (Vir et al., 2008), respectively. School-based interventions showed that vitamin D fortification (Khadgawat et al., 2013) and iron fortification (Muthayya et al., 2012) were an effective strategy for wider use in school feeding programs. School-based supplementation programs also resulted in higher adherence due to supervision (Hyder et al., 2007). However, a project providing weekly iron–folic acid tablets to adolescent girls did not find any difference in the impact on anaemia prevalence between school girls (supervised) and non-school girls (unsupervised) (Vir et al., 2008).

Publications that did not include an intervention component

One hundred sixteen publications assessed nutritional, that is, the prevalence of undernutrition and micronutrient deficiencies. Among these, six publications compared stunting and/or thinness prevalence using different growth references and 38 publications assessed risk factors such as age, sex, demographic determinants and socioeconomic status. Results of publications that did not include an intervention component are displayed in Appendix 2, and a narrative summary is provided below.

The prevalence of stunting, thinness and micronutrient deficiencies was challenging to compare because the included publications followed different growth references. Prevalence varied widely and is presented in Appendix 2. Prevalence of stunting ranged from 7% (Agrahar-Murugkar, 2005) to 90% (Durrani et al., 2007) and prevalence of thinness varied from 1.3% (WHO, 2016a) to 63% (Bharthi et al., 2017). Some publications determined the prevalence of stunting and/or thinness with different growth references (Agrahar-Murugkar, 2005; Garg et al., 2013b; Mandot et al., 2009; Medhi et al., 2007; Prashant et al., 2009; Sikdar, 2012). On the one hand, the prevalence of nutritional status varied greatly with the growth reference employed. Agrahar-Murugkar (2005) showed that stunting prevalence in Indian schoolgirls was 46% using Waterlow's classification and 7% using <-2SD from median of CDC 2000 (Agrahar-Murugkar, 2005). On the other hand, variability of thinness was found to be smaller by Garg et al. (2013), ranging from 6.6% (using <5th percentile of IAP reference) to 17% (using <-2SD from median of CDC 2000) among adolescent boys in India (Garg et al., 2013b). Four publications comparing different references reported that nutritional status prevalence measured by IAP reference was lower compared to prevalence measured by other growth references such as

CDC, WHO and NCHS (Garg et al., 2013b; Mandot et al., 2009; Medhi et al., 2007; Prashant et al., 2009).

Gender, age, socio-economic, demographic, dietary and other associated factors were evaluated in relation to stunting and thinness among South Asian adolescents. Four publications reported that stunting in adolescent girls was more common than in adolescent boys (Mondal & Sen, 2010; Pal et al., 2017; Rao et al., 2006; Vashist & Goel, 2009) but the difference was statistically significant in one publication (Pal et al., 2017). In contrast, the prevalence of stunting was found to be significantly higher among boys than girls in North-East India resulting in 1.55 times greater risk of being stunted for boys as compared to girls (Rengma, 2016). Prevalence of thinness was found to be higher among boys than girls in eight publications (Bose & Bisai, 2008; Chakrabarty & Bharati, 2008; Das et al., 2007; Johnson et al., 2015; Khan et al., 2013; Mondal, 2014; Mondal & Sen, 2010; Vashist & Goel, 2009) reporting significance in five (Bose & Bisai, 2008; Chakrabarty & Bharati, 2008; Das et al., 2007; Mondal, 2014; Mondal & Sen, 2010). The overall prevalence of thinness was slightly higher among girls than boys in two publications from India but there was no gender-specific significant difference (Bharthi et al., 2017; Mondal & Terangpi, 2014).

Indian adolescents showed a significantly higher prevalence of stunting with increased age (Pal et al., 2017; Rengma, 2016). The results of these two publications also showed that the risk of stunting in late adolescence was approximately two (Rengma, 2016) to four times (Pal et al., 2017) higher than in early adolescence. Prevalence of thinness was greater among early adolescents compared to older counterparts (Ameer et al., 2018; Bose & Bisai, 2008; Das et al., 2007; Pal et al., 2017; Radhika et al., 2018). However, age-specific trends in thinness prevalence were absent in six publications (Bharthi et al., 2017; Das, 2005; Debnath et al., 2016; Mondal, 2014; Mondal & Sen, 2010; Mondal & Terangpi, 2014).

While stunting was more common amongst adolescents residing in rural areas in India (Choudhary, 2016; Maiti et al., 2011; Rao et al., 2006; Vashist & Goel, 2009), thinness was found to be more prevalent in both urban (Choudhary, 2016) and rural settings (Vashist & Goel, 2009). Low socioeconomic status was significantly associated with stunting (Pal et al., 2017; Rengma, 2016) and thinness (Niranjala, 2011; Pal et al., 2017) among South Asian adolescents. Thinness was significantly higher in adolescent girls living in households with unimproved water sources (Niranjala, 2011; Radhika et al., 2018). Parent's education (Das, 2005; Khan et al., 2013; Rengma, 2016), birth order and family size (Debnath et al., 2016; Pal et al., 2017; Venkaiah, 2002), as well as dietary determinants such as energy intake (Ameer et al.,

2018; Hettiarachchi et al., 2006a), micronutrient intake (Hettiarachchi et al., 2006a; Radhika et al., 2018), vegetarianism (Ameer et al., 2018), dietary diversity (Niranjala, 2011) and food availability (Niranjala, 2011) were found to be significantly contributing to adolescent undernutrition.

Anaemia (low haemoglobin concentration) ranged between 1% (Allen et al., 2017) and 98.3% (Shridevi, 2015). Prevalence of micronutrient deficiency varied (Appendix 2); vitamin A deficiency from 0.3% (Jayatissa & Ranbanda, 2006) to 65.4% (Kawade, 2012), folic acid deficiency from 1.5% (Gupta et al., 2017) to 54.6% (Hettiarachchi et al., 2006b), vitamin B12 deficiency from 0.44% (Thoradeniya et al., 2006) to 68.3% (Kapil & Sareen, 2014), vitamin D deficiency from 70% (Kapil et al., 2018) to 96.3% (Kapil et al., 2017), vitamin C deficiency from 2% (Ahmed, 2008) to 10.8% (Kawade, 2012), and zinc deficiency from 28.8% (de Lanerolle-Dias et al., 2012) to 72.4% (Kawade, 2012). Prevalence of iodine deficiency was 23.6% (Pandav et al., 1997) and 38.4% (Harun-Or-Rashid et al., 2009), prevalence of vitamin B2 deficiency was 89% (Ahmed, 2008), and prevalence of iron deficiency was 55% (Kapil & Sareen, 2014).

Prevalence of micronutrient deficiencies and associated factors were studied among South Asian adolescents. Association between the prevalence of vitamin A deficiency and gender was not significant in two publications (Agrawal et al., 2013; Jayatissa & Ranbanda, 2006); however, another publication found that xerophthalmia, as defined by Bitot spots and/or night blindness, was significantly associated with adolescent boys (Sinha et al., 2011). While iron deficiency (Allen et al., 2017) and vitamin D deficiency (Kapil et al., 2017; Kapil et al., 2018) were significantly higher among females, vitamin B12 deficiency was significantly more common among males (Chakraborty et al., 2018).

On age-wise categorisation, two publications did not find a significant difference in the prevalence of anaemia among Indian adolescent girls (Laxmaiah et al., 2013; Selvarani, 2017). The increase in age with the increase in the prevalence of vitamin A deficiency (Agrawal et al., 2013) and iron deficiency (Allen et al., 2017) were found to be statistically significant. Vitamin B12 deficiency (Chakraborty et al., 2018) and anaemia (Selvarani, 2017) were significantly higher among rural adolescents compared to their urban counterparts. Ethnicity (Allen et al., 2017), occupation of the father (Gupta & Gupta, 2018) and mother education (Lamba et al., 2014) were associated with anaemia. When categorised based on working status, working adolescent girls from Sri Lanka were at nearly twice the risk of having folic acid deficiency and twice the risk of having zinc deficiency when compared with non-working adolescents (de Lanerolle-Dias et al., 2012).

4.4. Discussion

There are limited reviews on adolescent undernutrition and micronutrient deficiencies in South Asia (Akhtar, 2016; Khan et al., 2007; Mak & Tan, 2012; Pasricha & Biggs, 2010). To the author's knowledge, this study is the first scoping review mapping the available evidence. The search strategy involved seven electronic databases and grey literature. From 6181 records matching the search, 128 met the selection criteria and were therefore included in this scoping review.

Firstly, this scoping review aimed to map the evidence on undernutrition and micronutrient deficiencies in South Asia. Several characteristics of the included publications were examined. The evidence was considerably recent as there were only 12 publications before 2004. There was available literature on adolescent micronutrient deficiencies since the 1970's, however, the oldest evidence calculating BMI-for-age and height-for-age was published after WHO guidance (1995) on measuring and classifying thinness and stunting in adolescents. Evidence included in this scoping review is comprised exclusively of quantitative methods employing mostly cross-sectional study design.

Most publications were conducted in India. This scoping review additionally examined the regional allocation of the literature within South Asian countries finding that the evidence was clustered in certain states or provinces. Rural areas were the most reported communities. These findings show an uneven geographical distribution of the literature across countries and within countries in South Asia. Half of the publications were school-based, while 35% were community-based. Despite the large numbers of out-of-school adolescents in South Asia (UNICEF, 2014), recruiting participants from madrassahs, schools, and high schools was possibly more accessible than a household survey or door to door approach.

In this scoping review, nutritional status was more studied among adolescent girls than boys, and thinness was more studied than stunting or micronutrient deficiencies. In addition, anaemia was the most evaluated micronutrient deficiency.

This scoping review found only 12 publications that included an intervention component, one of which was a school feeding program and the rest were supplementation programs. The age limitation in this scoping review might have excluded some interventions targeting children from birth to adolescence. It is worth noting that the effectiveness of these programs in reducing adolescent malnutrition was not assessed as this falls outside our scoping review aims. However, all publications were successful in improving at least one form of adolescent malnutrition. Recommendations from these publications can be inferred. The authors of the

school feeding program (Thomas et al., 2013) suggested that noting the exact length of attendance time to the program and quantifying meal intake by each student could be key to examining more accurately the nutritional benefits of school meals and developing detailed nutritional school programs. Recommendations resulting from the supplementation programs highlighted the need to explore long-term efficacy, dose and intake frequency of supplements to enhance adolescent micronutrient status.

A considerable number of publications that did not include an intervention component were available. These publications assessed the prevalence of stunting, thinness and micronutrient deficiencies in South Asia, which varied greatly. This may be due to the usage of different growth references, classifications and cut-offs as well as differences in characteristics of the target population such as age range and setting. Hence, comparisons across publications cannot be made. It is important to note that this scoping review did not assess the quality of malnutrition indicators measured in the included publications; consequently, prevalence could have been overestimated or underestimated. Six publications nevertheless assessed and compared the prevalence of stunting and/or thinness using different growth references (Agrahar-Murugkar, 2005; Garg et al., 2013b; Mandot et al., 2009; Medhi et al., 2007; Prashant et al., 2009; Sikdar, 2012). The review findings showed that prevalence depended substantially on the growth reference used. The lowest thinness and stunting rates were given by IAP reference (Garg et al., 2013b; Mandot et al., 2009; Medhi et al., 2007; Prashant et al., 2009). The applicability of different growth references to Indian schoolchildren was recently examined (Singh et al., 2020). Similarly to our findings, Singh et al. (2020) observed that IAP reference classified fewer children as stunted and thin than WHO reference 2007. The authors suggested using IAP reference over WHO reference 2007 to evaluate growth in Indian schoolchildren. Further research on applicability of different growth references to South Asian adolescents should be conducted, in order to enable undernutrition and micronutrient deficiencies prevalence to be compared across South Asian countries and worldwide.

Undernutrition and micronutrient deficiencies associated factors were evaluated in 38 of the included publications in this scoping review. The findings were presented with raw prevalence, p values and odds ratios, impeding comparison across publications. In addition, the findings were inconsistent for some of the associated factors. For instance, stunting was found to be more prevalent among girls, but evidence also suggested boys were at greater risk of being stunted. The findings on thinness were slightly more dependable, with boys being thinner than girls. Gender association varied greatly with the micronutrient deficiency studied. Stunting, thinness and micronutrient deficiencies were also associated with age, rural and urban areas,

socioeconomic status, sanitation, parent's education and occupation, birth order, individual working status, family size and dietary determinants.

Secondly, this scoping review aimed to identify gaps in knowledge. Much of the available literature covers the prevalence of adolescent undernutrition and micronutrient deficiencies in the South Asian context using a cross-sectional design. This indicates that additional research on nutritional status using other study designs is needed to explore causality during adolescence instead of association. In addition, this scoping review did not locate any qualitative or mixed-methods publications. These approaches could contribute to better understanding adolescent malnutrition as well as evaluating if experiences from adolescents match with malnutrition associated factors given by quantitative research.

This scoping review also identified that there is a lack of adolescent undernutrition and micronutrient deficiencies literature in Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka as nearly 70% of the evidence included was conducted in India. Moreover, some publications were less systematic than others in reporting method and target characteristics such as the age of the sample, community, setting or growth reference. As a consequence, this information was difficult to extract, and so it is missing. Reporting the community (rural, slum, urban or nationally representative sample) was a clear example, as this could not be identified in 40% of the publications. It was noteworthy the greater evidence scarcity from slums and national representative samples as well as research targeting out-of-school adolescents.

This review suggests that supplementation and school feeding programs research on South Asian adolescents seldom evaluated cost-effectiveness and impact on undernutrition rates in the long term on a large scale. Therefore, future research should aim to be implemented at a national level, also incorporating other types of interventions such as nutrition promotion, weight gain treatment, regulatory interventions (i.e. marketing) or health-related actions (i.e. deworming) to tackle adolescent undernutrition and micronutrient deficiencies.

This scoping review found that thinness (BMI-for-age) was more widely used to measure adolescent nutritional status than stunting (height-for-age) or micronutrient deficiencies. However, all three indicators should be measured since they assess different forms of malnutrition. Finally, existing literature did not appropriately determine whether some undernutrition and micronutrient deficiencies associated factors such as gender or age are risk or protective determinants. In addition, little is known about other factors such as dietary

intake or sanitation in relation to adolescent undernutrition and micronutrient deficiencies in South Asia.

4.4.1. Limitations and strengths

Our scoping review has some limitations. The evidence in this scoping review was clustered in certain geographic areas or countries (e.g. India), resulting in the need for caution in the generalisation of the findings to the South Asian region as a whole. Although our search strategy and selection process followed systematic methods, the challenges of searching for grey literature might have obstructed the inclusion of some relevant unpublished evidence (Paez, 2017). Due to time constraints and a large number of included publications, the research team did not search additional resources by hand searching the evidence reference list as it is suggested in Arksey and O'Malley's methodological framework (Arksey & O'Malley, 2005). Since assessing rigour and quality was not an aim in this scoping review, a critical appraisal of the included studies was not undertaken. Hence, it is important to note that the base for conclusions in this study is the nature and extent of the existing literature on malnutrition among South Asian adolescents rather than the intrinsic quality of the literature on this topic (Grant & Booth, 2009). In other words, the knowledge gaps identified in this scoping review do not necessarily identify research gaps where the research itself is of poor or high quality (Arksey & O'Malley, 2005).

Despite these limitations, this scoping review provides a wide perspective on adolescent undernutrition and micronutrient deficiencies in South Asia, including a large pool of evidence from all South Asian countries. It follows a broad and systematic search strategy incorporating stunting, thinness and micronutrient deficiencies as well as including grey literature without restrictions on language or date of publication. Based on the identified gaps in knowledge, this scoping review can inform areas for future research and can potentially provide a useful overview of the topic for policymakers and researchers working on the topic. Since scoping review language is often narrative and free of complicated statistical language, the findings of this scoping review are more accessible and comprehensible to policymakers and the general public (Peterson et al., 2017).

Due to the heterogeneity of the included evidence, meaningful comparison across studies was difficult to make. As a consequence, conducting a systematic review aiming to summarise the literature on adolescent undernutrition and micronutrient deficiencies appears unfeasible and inadvisable (Arksey & O'Malley, 2005; Munn et al., 2018). However, a systematic review may be suitable if the aim is to measure merely prevalence (Mak & Tan, 2012; Mazidi et al., 2018).

4.5. Conclusion

Chapter 3 and Chapter 4 have reviewed the literature on adolescent malnutrition (undernutrition, micronutrient deficiencies and overnutrition) in South Asia as well as identified gaps in the literature and suggested areas for future research.

Previous reviews on adolescent overnutrition estimated the prevalence of adolescent overweight and obesity in Asia (Mazidi et al., 2018), summarised various determinants of overweight and obesity among children and adolescents in South Asia (Mistry & Puthussery, 2015) and identified several areas for future research (Mistry & Puthussery, 2015). This scoping review on adolescent undernutrition and micronutrient deficiencies in South Asia located a broad range of publications on the topic and identified noteworthy gaps in the evidence (Estecha Querol et al., 2021).

Literature was exclusively quantitative and predominantly used a cross-sectional design (Estecha Querol et al., 2021; Mazidi et al., 2018; Mistry & Puthussery, 2015). The majority of publications came from India, showing an uneven geographical distribution of the literature (Estecha Querol et al., 2021; Mazidi et al., 2018; Mistry & Puthussery, 2015). Prevalence of nutritional status varied widely due to differences in classifications, target population characteristics (e.g. age range, setting), study design, and sample sizes (Estecha Querol et al., 2021; Mazidi et al., 2018; Mistry & Puthussery, 2015).

Knowledge gaps on adolescent malnutrition in South Asia were identified (Estecha Querol et al., 2021; Mistry & Puthussery, 2015). Future research should investigate adolescent malnutrition in South Asia using nationally representative data, interventional studies and qualitative methods. Regarding target sample characteristics, more studies are required to investigate malnutrition among adolescents living in slums, out-of-school adolescents and adolescents living in Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka. In terms of malnutrition indicators, consensus about the classification criteria for all forms of malnutrition becomes crucial, so prevalence can be compared not only across South Asian countries but also globally. In order to address malnutrition among South Asian adolescents, all forms should be measured and monitored, and risk / protective factors should be further investigated.

By finding what is known about adolescent malnutrition in South Asia and identifying gaps in knowledge, Chapter 3 and Chapter 4 inform the quantitative and qualitative phases of this parallel mixed-methods thesis. Hence, it was considered that this PhD thesis should investigate the prevalence of malnutrition and associated factors in all South Asian countries by using a

national representative sample (Chapter 5: secondary data analysis) as well as explore malnutrition in this context from a qualitative perspective (Chapter 6: photodiary and interviews).

To sum up, further exploration of adolescent undernutrition, micronutrient deficiency and overnutrition in South Asia and its associated factors using additional methods targeting overlooked adolescent populations is necessary in order to tackle the burden of malnutrition and improve adolescent health and nutrition.

5. Chapter 5: Quantitative analysis on the burden of malnutrition and associated factors among South Asian adolescents

Chapter summary

Chapter 5 explores the burden of malnutrition and its associated factors among South Asian adolescents by conducting a secondary data analysis using data from the Global School-based Student Health Survey. This chapter begins with a background on the burden of nutrition in South Asia, explains the rationale for conducting quantitative analysis using the Global School-based Student Health Survey and lists the aims of the secondary data analysis. In the methods section, details about the survey design and how data analysis was conducted are provided. This chapter finalises with a results section, a discussion section including strengths and limitations and a conclusion. This secondary data analysis has been published in Nutrients. This chapter has been adapted from the published journal article (see below).

Peer-reviewed journal articles

- Estecha Querol S, Iqbal R, Kudrna L, Al-Khudairy L, Gill P. The Double Burden of Malnutrition and Associated Factors among South Asian Adolescents: Findings from the Global School-Based Student Health Survey. *Nutrients*. 2021; 13(8):2867. doi.org/10.3390/nu13082867

5.1. Background and rationale

This chapter responds to objective 2 of this thesis:

- To calculate the burden of malnutrition and its determinants among South Asian adolescents using a large publicly available school-based survey dataset: the Global School-based student Health Survey (GSHS).

The findings from the reviews on malnutrition among South Asian adolescents (see Chapter 3 and Chapter 4) point out the gaps in knowledge, introducing suggestions for future research that can be explored in this thesis. Previous literature has calculated the prevalence of malnutrition and identified some risk factors (see Chapter 3 and Chapter 4); however, studies typically used data from samples that were not nationally representative of a certain country as well as used different classifications to define malnutrition. In that regard, the use of a nationally representative sample and a standardised methodology across all South Asian countries was deemed essential to reliably assess the burden of malnutrition and its associated health and psychosocial factors among adolescents.

Global health surveillance in this population presents several challenges, such as international comparability of the data, ethical considerations on obtaining consent, high rates of absenteeism in schools, and undefined adolescent health indicators (Patton et al., 2012). The Global School-based student Health Survey (GSHS) provides good quality data on adolescent nutritional status and health behaviours. The GSHS is a cross-sectional school-based survey conducted with a national representative sample of students living in LMIC that uses standardised procedures to collect weight, height, health behaviours and protective factors (CDC, 2018). Further details on the GSHS are explained in section 5.3.1. Global School-based student Health Survey. Despite the suitability of the GSHS data to address objective 2, the survey does not collect nutritional biomarkers data, thus, micronutrient deficiency as a form of malnutrition cannot be assessed, and only undernutrition and overnutrition adolescent indicators can be calculated in this study. The DHS is also a nationally-representative survey providing data on population health and nutrition, but it was considered to be unsuitable for this analysis for two main reasons: it does not collect data on adolescent boys and collects limited potential malnutrition associated factors such as education, wealth and urban/rural status (Harding et al., 2019).

In the South Asian context, the prevalence of undernutrition in children and adolescents remains considerably high compared to other regions, despite a decline over the past three decades (Black et al., 2013; NCD Risk Factor Collaboration, 2017; UNICEF, 2013). In addition,

South Asia is currently facing the challenge of overnutrition which is exacerbating the double burden of malnutrition (Harding et al., 2019; Popkin et al., 2020). Recent epidemiological studies on the double burden of malnutrition (coexistence of undernutrition and overnutrition) in South Asia have focused on women of reproductive age (Biswas et al., 2020; Gao et al., 2020; Hashan et al., 2020; Herter-Aeberli et al., 2016; Kulkarni et al., 2017; Sengupta et al., 2014; Shafique et al., 2007) and mother-child pairs (Anik et al., 2019; Das et al., 2019; Sunuwar et al., 2020). However, only a few studies quantified the double burden of malnutrition among adolescents in India (Ahmad et al., 2018; Bhargava et al., 2020; Darling et al., 2020; Faizi et al., 2017; Schott et al., 2019), overlooking the rest of the South Asian countries.

Lifestyle, eating behaviours, underlying psychosocial factors and socioeconomic determinants are key to adolescent health and nutrition (WHO, 2005). Factors associated with adolescent malnutrition are complex and involve determinants at individual, household, and population levels. The WHO identifies some causes of adolescent undernutrition such as diet, diseases, infections and early pregnancy (WHO, 2018b) as well as causes of adolescent overnutrition such as diet, physical activity levels and sedentary time (WHO, 2020c). Among Indian adolescents, previous studies identified factors contributing to the double burden of malnutrition which were socioeconomic status (Ahmad et al., 2018; Bhargava et al., 2020; Darling et al., 2020; Faizi et al., 2017; Schott et al., 2019), hygiene behaviour (Darling et al., 2020), maternal education (Ahmad et al., 2018; Faizi et al., 2017; Schott et al., 2019), physical activity (Ahmad et al., 2018) and urban/rural residence (Ahmad et al., 2018; Schott et al., 2019). Thus, a more comprehensive picture of the double burden of malnutrition and its associated factors in all South Asian countries is essential to eventually improve adolescent health and nutritional status in this context.

5.2. Aims of the quantitative analysis

- To calculate the prevalence of the burden of stunting, thinness and overweight (adolescent malnutrition indicators) among South Asian schooled adolescents at regional and country level.
- To investigate potential malnutrition associated factors among South Asian schooled adolescents at regional and country level.
- To investigate the relationship between malnutrition indicators and potential associated factors among South Asian schooled adolescents at regional and country level.

5.3. Methods

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cross-sectional studies was followed to report this secondary data analysis where applicable (Vandenbroucke et al., 2007).

5.3.1. Global School-based student Health Survey

The GSHS is a global cross-sectional school-based survey created by WHO in collaboration with UNICEF, UNESCO, and UNAIDS; and with technical assistance from CDC (CDC, 2018; WHO, 2019b). This surveillance project uses a standardized scientific sample selection process which is conducted among students aged 11–17 years to assess health behaviours and protective factors such as alcohol use, dietary behaviours, drug use, hygiene, mental health, physical activity, other protective factors, sexual behaviours, tobacco use, and violence and unintentional injury. The rationale for the inclusion of each health behaviour and protective factor can be found elsewhere (WHO, 2009). The GSHS samples are representative of all students in a given country.

Before the GSHS databases are publicly available, some data edits are performed for each country to ensure comparability across countries (WHO & CDC, 2013). Data are checked for out of range responses, multiple responses to a single question, and logical consistency between related questions. Height, weight and BMI are edited to ensure results are biologically plausible. Data are checked to ensure that each question has valid data for at least 60% of all students once all other edits have been completed. Finally, data are checked to ensure that each student has at least 20 valid responses once all other edits have been completed. Data are also checked to ensure that there are no cases of too many of the same response in a row.

The GSHS surveys from the eight South Asian countries were: Pakistan 2009, Afghanistan 2014, Bangladesh 2014, India 2007, Maldives 2009 and 2014, Nepal 2015, Sri Lanka 2008 and 2016, and Bhutan 2016.

5.3.2. Preparing the database

The above databases were merged using Stata v16. In order to calculate the prevalence of adolescent malnutrition indicators (stunting, thinness and overweight), the exact age of the individual is required (measured in years or months). Consequently, the 12, 13, 14 and 15 years old participants were kept and participants in the categories “11 years old or young” and “16 years old or older” were removed for this analysis. Other studies exploring adolescent malnutrition prevalence using the GSHS have also removed these categories in their analysis

(Caleyachetty et al., 2018; Yang et al., 2019). In total, 366 participants belonging to the "11 years old or young" category and 11,953 participants belonging to the "16 years old or older" category were removed.

Maldives and Sri Lanka had two surveys. For analysis purposes and comparison across countries, one of the two surveys was removed from the final database, as in similar studies (Caleyachetty et al., 2018; Yang et al., 2017; Yang et al., 2019). When comparing the two surveys from Maldives, in 2014 the student response rate was 60%, whereas in 2009 was 80%. Maldives 2009 had more health behaviours variables available than Maldives 2014. The total sample in both surveys was similar (3,157 in 2009 and 3,479 in 2014). The 2014 survey was removed and the 2009 survey was kept for analysis. When comparing the two surveys from Sri Lanka, the response rate was 89% in both surveys. Sri Lanka 2016 had more health behaviours variables available than Sri Lanka 2008. The total sample was 2,611 in 2008 and 3,262 in 2016. Therefore, the 2008 survey was removed and the 2016 survey was kept for analysis. None of the surveys included in this analysis had a participant response rate of less than 70%.

Hence, the surveys included in this study were Pakistan 2009, Afghanistan 2014, Bangladesh 2014, India 2007, Maldives 2009, Nepal 2015, Sri Lanka 2016, and Bhutan 2016.

5.3.3. Two-stage sample design

In order to account for the GSHS sample design, this analysis considered the weighting, clustering, and stratification using the *svy* command in Stata (StataCorp, 2013). GSHS surveys employ two-stage sample design where the first sampling units are clusters and the second sampling units are elements of those clusters. More specifically, the GSHS variable s*tratum* reflects the first level of the GSHS sample selection process which is schools and the GSHS variable *PSU* reflects the second level of the GSHS sample selection process which is classrooms (WHO & CDC, 2013). Explained in other words, in the first stage of the GSHS, schools were independently selected within each country. In the second stage, classrooms were selected within each chosen school. Within each chosen classroom, a questionnaire was filled out by every attending student.

In addition to the GSHS sampling units, the sampling weight is also required when analysing GSHS data to appropriately represent the weighting process and the two-stage sample design. In this analysis, stratification was also taken into consideration. As stratification consists of dividing the population into different (demographic) groups, this analysis used the variable *country,* which includes the eight South Asian country surveys.

5.3.4. Study variables

Explanatory variables

The GSHS uses core questionnaire modules, core-expanded questions, and country-specific questions that are combined to form a questionnaire that the students completed during one regular class period. Fifty-six health behaviours and protective factors (note that throughout this Chapter these variables will be named health behaviour variables) were collected, but not all of these variables are included in the South Asian surveys. In this analysis, variables were included if they were: 1) collected across all South Asian countries, and 2) relevant within existing established frameworks on adolescent nutritional status (Christian & Smith, 2018; UNICEF, 2013; WHO, 2005; WHO, 2018b), specifically the conceptual framework on Chapter 2.

In total, 16 health behaviour variables were identified as potential predictors of adolescent malnutrition and included in the analyses. Dichotomous variables were created regardless of the number of responses to simplify the analyses and interpretation. Table 8 provides detailed information on the definitions and coding of these variables. The cut-offs found in previous studies using the GSHS informed the creation of cut-offs in this analysis (Appendix 3).

Table 8. Survey questions from the Global School-based student Health Survey (GSHS) datasets used in this study.

Survey question	Coding[1]	Variable name
During the past 30 days, how many times per day did you usually eat fruit? During the past 30 days, how many times per day did you usually eat vegetables?	<5 fruits and vegs per day (0) 5 fruits and vegs or more per day (1)	5 fruits and vegs
During the past 12 months, how often have you felt lonely?	Never/rarely/sometimes (0) Often/always (1)	Loneliness
During the past 12 months, how often have you been so worried about something that you could not sleep at night?	Never/rarely/sometimes (0) Often/always (1)	Anxiety
During the past 30 days, on how many days did you smoke cigarettes?	0 days (0) 1 or more days (1)	Tobacco
During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?	<7 days per week (0) 7 days per week (1)	Physical activity
During the past 7 days, on how many days did you walk or ride a bicycle to or from school?	<3 days per week (0) 3 or more days per week (1)	Active transportation
How much time do you spend during a typical or usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities?	<3 hours per day (0) 3 or more hours per day (1)	Sedentary behaviour
During the past 30 days, how many times per day did you usually clean or brush your teeth?	<2 times per day (0) 2 times or more per day (1)	Tooth brushing
During the past 30 days, how often did you wash your hands before eating?	Never/rarely (0) Sometimes/often/always (1)	Washing hands before meals
During the past 30 days, how often did you wash your hands after using the toilet or latrine?	Never/rarely (0) Sometimes/often/always (1)	Washing hands after toilet
During the past 30 days, how often did you use soap when washing your hands?	Never/rarely (0) Sometimes/often/always (1)	Washing hands with soap
How many close friends do you have?	No friends (0) 1 or more friend (1)	Friendships
During the past 30 days, how often were most of	Never/rarely/sometimes (0)	Peer support

the students in your school kind and helpful?	Often/always (1)	
During the past 30 days, how often did your parents or guardians check to see if your homework was done?	Never/rarely/sometimes (0) Often/always (1)	Parental involvement in school
During the past 30 days, how often did your parents or guardians understand your problems and worries?	Never/rarely/sometimes (0) Often/always (1)	Parental understanding
During the past 30 days, how often did your parents or guardians really know what you were doing with your free time?	Never/rarely/sometimes (0) Often/always (1)	Parental bonding

[1] The cut-offs applied here were used in previous GSHS publications

Outcome variables

Anthropometric measurements (height in cm and weight in kg) were collected by trained GSHS survey staff. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Adolescent malnutrition indicators were assessed based on the WHO growth reference for school-aged children and adolescents (de Onis et al., 2007) and the WHO macro was used to calculate z-scores (WHO, 2007). Stunting was defined as height-for-age <2 SDs below the WHO Child Growth Reference median. Thinness was defined as BMI-for-age <2 SDs below the WHO Growth Reference median. Overweight/obesity (referred to as overweight in this Chapter) was defined as BMI-for-age >1 SD above the WHO Growth Reference median. Participants with missing information (age, sex, weight or height) or biologically implausible values (defined by WHO as extreme z-scores for weight, height and BMI (WHO, 2007)) were excluded from this analysis.

5.3.5. Missing values

The literature considers that more than 10% of missing data is problematic, and therefore, sensitivity analysis should be considered (Madley-Dowd et al., 2019). In this analysis, the explanatory variables reported between 0.7% and 4.1% of missing values, so no further analysis were conducted.

Variables	Missing values	
	n	%
5 fruits and vegs	439	1.53
Loneliness	399	1.39
Anxiety	203	0.71
Tobacco	440	1.53
Physical activity	594	2.07
Active transportation	699	2.44
Sedentary behaviour	638	2.22
Tooth brushing	208	0.73
Washing hands before meals	330	1.15
Washing hands after toilet	336	1.17
Washing hands with soap	293	1.02

Friendships	391	1.36
Peer support	878	3.06
Parental involvement in school	786	2.74
Parental understanding	966	3.37
Parental bonding	1,166	4.07

5.3.6. Statistical analysis

To account for the GSHS two-stage sample design, this analysis applied the sampling weights, clustering, and stratification using the *svy* command in Stata v16 (StataCorp, 2013). Prevalence of the three forms of malnutrition and health behaviour variables were calculated at the country level and South Asian level (pooled sample). A chi-square test of independence was conducted to examine the associations between sex and adolescent malnutrition indicators. In addition, the association between country and each health behaviour variable was evaluated also using chi-squared tests. Statistical significance of the chi-square statistic was set at $p < 0.05$. Maps displaying prevalence of stunting, thinness and overweight among South Asian students were created using Tableau.

Bivariate analysis checked the independent association of each health behaviour variable to the outcome ($p < 0.05$, using chi-squared test). Collinearity was assessed to identify pairs of health behaviour variables that were correlated ($r > 0.5$, using Pearson's correlation test). In addition, I computed other collinearity diagnostic measures (VIF > 10, tolerance value < 0.1 and condition index > 10) using *collin* command in Stata. None of the covariates were identified to be strongly collinear. Regression was used to examine the associations between malnutrition indicators and health behaviour variables. Binary logistic regression was applied to predict the outcome variable informed by a set of health behaviour variables – potential associated factors – calculating odds ratios (ORs). Multivariable logistic regression models of predictors of nutritional status in South Asian students were built adjusting for sex, age, and geographical region. Manual backward stepwise regression was used to develop multivariable logistic regression models of the predictors of malnutrition in South Asian students aged 12-15 years. Only significant health behaviour variables ($\alpha < 0.05$, using the Wald test) were retained in the reduced model, except for age, sex and country, which were considered traditional confounders. Full and reduced models (only including explanatory variables identified as significant using backward stepwise regression) of stunting, thinness and overweight at the South Asian and country level were examined. The bootstrap resampling method was used for a more accurate estimation of the standard errors in logistic regression.

5.3.7. Ethics

The GSHS surveys are publicly available (https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/global-school-based-student-health-survey), and they were approved by the national government's administrative body and the corresponding institutional ethics board review (CDC, 2018). This study is a post-hoc analysis of the eight South Asian countries' GSHS surveys, and as such, no ethical approval was required.

5.4. Results

The characteristics of the GSHS datasets included in this study are shown in Table 1. The response rate ranged from 69% (Nepal) to 91% (Bangladesh). The sample size varied from 1,493 participants in Afghanistan to 7,327 in India. A total of 24,053 adolescents completed height, weight, sex and age measurements. The average age of students was 13.99 years (SD ± 0.89).

Table 1. Descriptive characteristics of South Asian schooled adolescents aged 12-15 years of the Global School-based student Health Survey.

Country	Survey year	Response rate (%)[1]	Sample size	Girls (%)
Pakistan	2009	76	4,998	25.1
Afghanistan	2014	79	1,493	63.2
Bangladesh	2014	91	2,753	61.6
India	2007	83	7,327	45.3
Maldives	2009	80	1,977	56.2
Nepal	2015	70	4,615	54.9
Sri Lanka	2016	89	2,228	56.6
Bhutan	2016	95	3,287	58.1

[1] Response rate from countries' fact sheet (WHO, 2019b)

5.4.1. Prevalence of stunting, thinness and overweight

The overall prevalence of adolescent stunting in South Asia was 13% – this ranged from 3.9% in Pakistan to 28.2% in Afghanistan (χ^2= 1023.11, p<0.001) (Figure 7). Table 9 shows that stunting prevalence was 11.6% in boys and 14.8% in girls in the pooled sample (p=0.06). There was no significant association between sex and stunting in any of the South Asian countries except from Pakistan where stunting in girls was more likely than in boys (p<0.001).

Table 9. Prevalence* of stunting among South Asian schooled adolescents aged 12-15 years old.

Country	**Stunting (height-for-age <2 SDs)**			
	All students (%)	**Boys (%)**	**Girls (%)**	**χ^2 (p-value)[1]**

Pakistan	3.90	2.32	6.34	49.43 (0.000)
Afghanistan	28.15	35.97	19.82	38.44 (0.071)
Bangladesh	13.52	12.53	15.14	3.42 (0.460)
India	9.65	8.60	11.07	10.45 (0.198)
Maldives	13.33	12.13	14.39	1.26 (0.543)
Nepal	24.09	24.45	23.77	0.25 (0.592)
Sri Lanka	24.99	25.49	24.57	0.11 (0.843)
Bhutan	7.58	7.90	7.32	0.37 (0.662)
South Asia	12.97	11.64	14.80	51.60 (0.059)

[1] χ^2 represents test between sex and stunting
*following WHO growth reference

Figure 7. Stunting (height-for-age <2 SDs) prevalence of adolescents by South Asian country, GSHS data.

The overall prevalence of adolescent thinness in South Asia was 10.8% – this ranged from 1.5% in Bhutan to 18.6% in Sri Lanka (χ^2=159.5, p=0.04) (Figure 8). Table 10 shows that thinness prevalence was 11.8% in boys and 9.3% in girls in the pooled sample (p=0.11). The proportion of students who were thin did not differ by sex in Pakistan, Afghanistan, Bangladesh, India, Maldives and Sri Lanka. However, there was a significant effect of sex on thinness in Nepal (p=0.03), and Bhutan (p=0.001) with boys being thinner than girls (p=0.001).

Table 10. Prevalence* of thinness among South Asian schooled adolescents aged 12-15 years.

Country	**Thinness (BMI-for-age <2 SDs)**			
	All students (%)	**Boys (%)**	**Girls (%)**	**χ^2 (p-value)[1]**
Pakistan	9.09	9.51	8.43	1.59 (0.575)
Afghanistan	2.51	2.34	2.69	0.15 (0.781)
Bangladesh	11.43	12.83	9.13	7.89 (0.262)
India	12.82	13.48	11.92	3.26 (0.263)
Maldives	17.86	16.73	18.86	0.89 (0.521)
Nepal	8.25	9.78	6.93	10.84 (0.029)
Sri Lanka	18.56	20.14	17.22	1.41 (0.369)

Bhutan	1.49	2.02	1.05	5.07 (0.001)
South Asia	10.78	11.85	9.29	39.80 (0.109)

[1] χ^2 represents test between sex and thinness
*following WHO growth reference

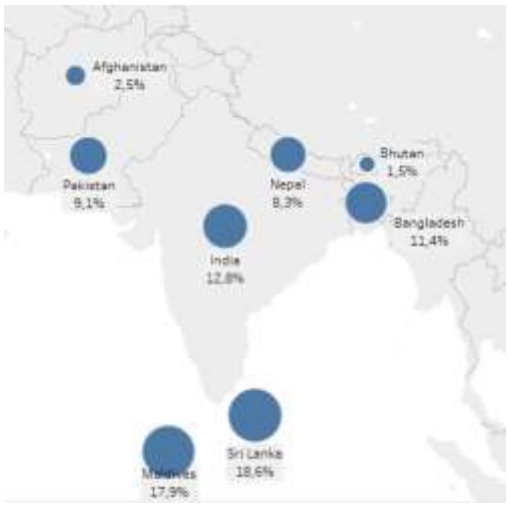

Figure 8. Thinness (BMI-for-age <2 SDs) prevalence of adolescents by South Asian country, GSHS data.

The overall prevalence of adolescent overweight in South Asia was 10.8% – this ranged from 8% in Pakistan to 19% in Afghanistan (χ^2=109.14, p=0.2) (Figure 9). Table 11 shows that overweight prevalence at the South Asian level was 11.4% in boys and 9.9% in girls (p=0.3). The association between sex and overweight was not significant in Afghanistan, Bangladesh, Nepal, and Sri Lanka. In contrast, results indicated a significant difference between sexes in the remaining countries. Boys were more likely to be overweight in India (p=0.01) and Maldives (p=0.02), while girls were more likely to be overweight in Pakistan (p=0.001) and Bhutan (p=0.002).

Table 11. Prevalence* of overweight among South Asian schooled adolescents aged 12-15 years.

[1] χ^2 represents test between sex and overweight

Country	Overweight (BMI-for-age >1SDs)			
	All students (%)	Boys (%)	Girls (%)	X2 (p-value)[1]
Pakistan	7.98	6.48	10.31	22.96 (0.001)
Afghanistan	19.04	21.25	16.69	4.01 (0.333)
Bangladesh	11.3	12.71	8.99	8.03 (0.292)
India	12.96	14.36	11.05	14.57 (0.010)
Maldives	13.77	18.33	9.74	17.80 (0.020)
Nepal	9.53	10.81	8.43	6.63 (0.151)
Sri Lanka	13.22	13.94	12.6	0.39 (0.580)
Bhutan	16.34	12.89	19.16	22.84 (0.002)
South Asia	10.77	11.43	9.87	14.84 (0.352)

*following WHO growth reference

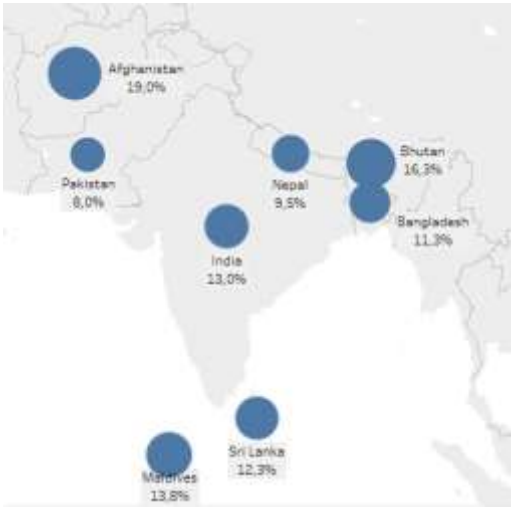

Figure 9. Overweight (BMI-for-age >1 SDs) prevalence of adolescents by South Asian country, GSHS data.

5.4.2. Prevalence of health behaviours

Table 12 shows the prevalence of health behaviours at the country level and regional level. Around 14% of adolescents in the pooled sample consumed the recommended amount of 5 portions of fruits and vegetables per day (WHO & FAO, 2003). Feeling frequently lonely or worried was reported by 10.1% and 5.9% of adolescents, respectively. The overall prevalence of tobacco use was 6.3%. Recommended levels of physical activity were met by 27.1% of adolescents in this sample (WHO, 2020a). More than 60% of the schooled adolescents in South Asia reported active transportation such as walking or riding a bicycle. The overall prevalence of sedentary behaviour was 15.8%. Over half of the respondents (54%) brushed their teeth twice a day following American Dental Association recommendations (American Dental Association, 2013). Washing hands frequently was reported in more than three out of four adolescents. Nine in ten adolescents had one or more close friends. Feeling supported by parents was reported in around half of the sample. There was a significant association between country and all health behaviour variables ($p<0.05$) apart from washing hands before meals and after toilet.

Table 12. Stratified prevalence of health behaviours among South Asian schooled adolescents aged 12-15 years, GSHS datasets.

	Pakistan (%)	Afghanistan (%)	Bangladesh (%)	India (%)	Maldives (%)	Nepal (%)	Sri Lanka (%)	Bhutan (%)	South Asia (%)	χ^2 (p-value)[1]
5 fruits/vegs per day	9.84	15.35	16.32	14.81	11.39	9.01	23.67	23.53	14.33	401.75 (0.000)
Loneliness	11.87	28.83	10.90	8.23	13.87	5.89	7.49	11.38	10.07	337.99 (0.000)
Anxiety	8.21	21.84	4.47	7.61	13.22	3.83	3.87	6.88	5.91	413.56 (0.000)
Tobacco use	6.30	6.52	6.90	1.22	8.99	4.90	2.49	19.29	5.33	273.97 (0.004)
Physically activity	11.57	9.64	41.24	30.07	21.61	14.42	17.36	15.54	27.14	2,385.96 (0.000)
Active	61.48	70.16	67.86	56.70	52.41	57.94	60.79	45.94	62.93	259.43 (0.004)

transportation										
Sedentary behaviour	8.19	23.34	14.93	22.84	42.45	9.78	35.08	28.06	15.83	1,199.93 (0.000)
Tooth brushing	30.18	41.08	64.09	55.58	77.06	49.61	71.19	42.96	53.97	2,151.41 (0.000)
Washing hands before meals	96.55	93.97	96.90	94.08	91.46	96.00	97.33	96.19	96.25	88.10 (0.066)
Washing hands after toilet	96.59	94.38	98.06	96.68	95.32	95.59	97.08	95.71	97.05	90.24 (0.213)
Washing hands with soap	91.97	88.37	95.04	87.02	92.76	95.15	92.94	94.71	92.93	359.35 (0.001)
Friendships	91.89	86.25	91.20	89.83	90.48	95.57	94.75	90.46	91.94	150.86 (0.000)
Peer support	39.36	63.09	55.41	41.53	51.41	53.46	49.89	39.98	49.38	562.33 (0.000)
Parental involvement in school	52.36	45.55	53.70	47.66	31.60	50.16	68.45	30.50	52.98	308.76 (0.000)
Parental understanding	54.64	51.97	47.67	62.39	35.16	53.75	63.17	42.44	53.44	377.37 (0.000)
Parental bonding	50.47	54.72	43.54	57.38	48.77	50.47	70.29	39.46	50.33	647.34 (0.000)

[1] χ^2 represents test between country and each health behaviour

5.4.3. Factors associated with malnutrition indicators

The bivariate analysis showed that anxiety (p=0.03) and tobacco use (p=0.04) were significantly associated with stunting in the pooled sample (Appendix 4 Table 1). Sedentary behaviour was significantly associated with thinness (p=0.01) (Appendix 4 Table 2). The following factors were significantly associated with overweight (Appendix 4 Table 3): tobacco use (p=0.001), sedentary behaviour (p=0.009), and tooth brushing (p=0.005).

The multivariable logistic regression reduced model of the pooled sample (Table 13) showed that age and country of residence were associated with stunting. Students aged 13, 14 and 15 years had more than two times the odds of being stunted than students aged 12 years (p<0.001). Students living in Afghanistan (OR 10.67, 95% CI 6.00-19.00, p<0.001), Bangladesh (OR 4.29, 95% CI 2.61-7.07, p<0.001), India (OR 2.73, 95% CI 1.78-4.19, p<0.001), Maldives (OR 3.24, 95% CI 1.90-5.54, p<0.001), Nepal (OR 8.99, 95% CI 5.79-13.97, p<0.001), Sri Lanka (OR 8.30, 95% CI 5.41-12.73, p<0.001), and Bhutan (OR 2.21, 95% CI 1.48-3.29, p<0.001) exhibited a greater risk of being stunted than students living in Pakistan. Peer support was negatively associated with stunting (OR 0.75, 95% CI 0.64-0.88, p<0.001).

In the reduced model for thinness (Table 14), several factors were associated with this malnutrition indicator at the South Asian level: being 13 years old (OR 1.65, 95% CI 1.19-2.28, p=0.003) versus being 12 years old; living in Afghanistan (OR 0.29, 95% CI 0.17-0.50, p<0.001), India (OR 1.71, 95% CI 1.24-2.37, p<0.001), Maldives (OR 3.09, 95% CI 2.07-4.62, p<0.001), Sri

Lanka (OR 2.99, 95% CI 2.02-4.42, p<0.001) and Bhutan (OR 0.18, 95% CI 0.11-0.30, p<0.001) versus living in Pakistan; sedentary behaviour (OR 0.62, 95% CI 0.46-0.82, p<0.001); and tooth brushing (OR 0.72, 95% CI 0.56-0.92, p=0.01).

In the reduced model for overweight (Table 15), South Asian schooled adolescents being 13 years (OR 0.61, 95% CI 0.42-0.87, p=0.006), 14 years (OR 0.53, 95% CI 0.37-0.76, p<0.001) and 15 years old (OR 0.48, 95% CI 0.31-0.78, p<0.001) were less likely to be overweight than their peers aged 12 years old. Students living in Afghanistan (OR 2.64, 95% CI 1.81-3.86, p<0.001), India (OR 1.46, 95% CI 1.06-2.02, p=0.02), Maldives (OR 1.65, 95% CI 1.06-2.57, p=0.03), Sri Lanka (OR 1.59, 95% CI 1.03-2.44, p=0.03), and Bhutan (OR 2.23, 95% CI 1.65-3.01, p<0.001) versus those living in Pakistan had significantly greater odds of being overweight than students living in Pakistan. Several factors were also associated with overweight: tobacco use (OR 0.44, 95% CI 0.27-0.71, p<0.001), tooth brushing (OR 1.43, 95% CI 1.13-1.82, p=0.003), washing hands with soap (OR 1.58, 95% CI 1.07-2.33, p=0.02), and parental involvement in school (OR 0.80, 95% CI 0.66-0.98, p=0.03).

Table 13. Multivariable logistic regression model for adolescent stunting in South Asia, GSHS datasets.

	Stunting FULL MODEL					Stunting REDUCED MODEL				
	OR	Boot strap std.err.	p	95% conf. interval		OR	Boot strap std.err.	p	95% conf. interval	
Age										
12 years	1.00					1.00				
13 years	1.93	0.35	0.000	1.35	2.75	1.96	0.36	0.000	1.37	2.80
14 years	2.71	0.61	0.000	1.75	4.20	2.66	0.59	0.000	1.72	4.11
15 years	3.33	0.70	0.000	2.21	5.03	3.27	0.66	0.000	2.20	4.87
Sex										
Boy	1.00					1.00				
Girl	1.15	0.20	0.416	0.82	1.60	1.19	0.18	0.254	0.88	1.61
Country										
Pakistan	1.00					1.00				
Afghanistan	11.80	3.89	0.000	6.18	22.53	10.67	3.14	0.000	6.00	19.00
Bangladesh	4.85	1.31	0.000	2.86	8.23	4.29	1.09	0.000	2.61	7.07
India	2.97	0.67	0.000	1.91	4.61	2.73	0.60	0.000	1.78	4.19
Maldives	3.62	1.13	0.000	1.96	6.68	3.24	0.89	0.000	1.90	5.54
Nepal	9.01	2.05	0.000	5.77	14.08	8.99	2.02	0.000	5.79	13.97
Sri Lanka	8.96	2.00	0.000	5.79	13.87	8.30	1.81	0.000	5.41	12.73
Bhutan	2.39	0.52	0.000	1.57	3.65	2.21	0.45	0.000	1.48	3.29
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.90	0.16	0.548	0.63	1.27					

Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.85	0.17	0.417	0.58	1.26					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.93	0.18	0.704	0.63	1.36					
Tobacco use										
0 days	1.00					1.00				
1 or more days	0.54	0.22	0.132	0.24	1.21	0.52	0.18	0.058	0.26	1.02
Physically activity										
<7 days per week	1.00									
7 days per week	0.85	0.12	0.257	0.64	1.13					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.00	0.14	0.978	0.76	1.30					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.78	0.14	0.176	0.55	1.12					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.90	0.07	0.201	0.77	1.06					
Washing hands before meals										
Never/rarely	1.00					1.00				
Sometimes/often/always	1.46	0.29	0.059	0.99	2.17	1.33	0.24	0.118	0.93	1.89
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.10	0.27	0.708	0.67	1.79					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.05	0.18	0.767	0.76	1.46					
Friendships										
no friends	1.00									
1 or more friend	0.85	0.15	0.358	0.59	1.21					
Peer support										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.76	0.07	0.002	0.64	0.90	0.75	0.06	0.001	0.64	0.88
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	0.95	0.10	0.656	0.78	1.17					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.09	0.12	0.426	0.88	1.34					
Parental bonding										
Never/rarely/sometimes	1.00									

Often/always	1.03	0.15	0.825	0.78	1.36					

OR= Odds ratio

Table 14. Multivariable logistic regression model for adolescent thinness in South Asia, GSHS datasets.

	Thinness FULL MODEL					Thinness REDUCED MODEL				
	OR	**Boot strap std.err.**	**p**	**95% conf. interval**		**OR**	**Boot strap std.err.**	**p**	**95% conf. interval**	
Age										
12 years	1.00					1.00				
13 years	1.86	0.33	0.000	1.31	2.64	1.65	0.27	0.003	1.19	2.28
14 years	1.36	0.25	0.090	0.95	1.94	1.25	0.22	0.218	0.88	1.77
15 years	1.26	0.26	0.259	0.84	1.88	1.16	0.21	0.433	0.81	1.66
Sex										
Boy	1.00					1.00				
Girl	0.79	0.13	0.143	0.58	1.08	0.76	0.11	0.070	0.57	1.02
Country										
Pakistan	1.00					1.00				
Afghanistan	0.27	0.09	0.000	0.14	0.51	0.29	0.08	0.000	0.17	0.50
Bangladesh	1.57	0.51	0.165	0.83	2.97	1.48	0.46	0.211	0.80	2.73
India	1.93	0.34	0.000	1.36	2.73	1.71	0.28	0.001	1.24	2.37
Maldives	3.21	0.72	0.000	2.06	4.99	3.09	0.63	0.000	2.07	4.62
Nepal	1.10	0.20	0.622	0.76	1.58	0.99	0.17	0.956	0.71	1.39
Sri Lanka	3.25	0.68	0.000	2.16	4.88	2.99	0.60	0.000	2.02	4.42
Bhutan	0.18	0.05	0.000	0.11	0.30	0.18	0.05	0.000	0.11	0.30
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.86	0.13	0.309	0.65	1.15					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.19	0.21	0.332	0.84	1.68					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.99	0.16	0.942	0.71	1.37					
Tobacco use										
0 days	1.00									
1 or more days	1.37	0.34	0.203	0.84	2.21					
Physically activity										
<7 days per week	1.00									
7 days per week	0.92	0.13	0.567	0.71	1.21					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.15	0.10	0.111	0.97	1.35					
Sedentary behaviour										

<3 hours per day	1.00					1.00				
3 or more hours per day	0.63	0.10	0.004	0.46	0.86	0.62	0.09	0.001	0.46	0.82
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	0.70	0.12	0.031	0.50	0.97	0.72	0.09	0.009	0.56	0.92
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.02	0.27	0.945	0.61	1.70					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.07	0.29	0.802	0.63	1.81					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.14	0.30	0.606	0.69	1.90					
Friendships										
no friends	1.00									
1 or more friend	0.98	0.20	0.918	0.66	1.45					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.94	0.07	0.467	0.81	1.10					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	0.95	0.11	0.684	0.76	1.19					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.09	0.11	0.356	0.90	1.32					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.89	0.08	0.202	0.74	1.07					

OR= Odds ratio

Table 15. Multivariable logistic regression model for adolescent overweight in South Asia, GSHS datasets.

	Overweight FULL MODEL					**Overweight REDUCED MODEL**				
	OR	**Boot strap std.err.**	**p**	**95% conf. interval**		**OR**	**Boot strap std.err.**	**p**	**95% conf. interval**	
Age										
12 years	1.00									
13 years	0.58	0.10	0.001	0.42	0.81	0.61	0.11	0.006	0.42	0.87
14 years	0.53	0.09	0.000	0.38	0.75	0.53	0.10	0.001	0.37	0.76
15 years	0.47	0.10	0.000	0.30	0.71	0.48	0.10	0.001	0.31	0.73
Sex										
Boy	1.00									

Girl	0.72	0.14	0.091	0.49	1.05	0.74	0.13	0.094	0.52	1.05
Country										
Pakistan	1.00									
Afghanistan	2.63	0.57	0.000	1.72	4.03	2.64	0.51	0.000	1.81	3.86
Bangladesh	1.27	0.36	0.401	0.73	2.22	1.31	0.38	0.356	0.74	2.32
India	1.45	0.26	0.039	1.02	2.06	1.46	0.24	0.020	1.06	2.02
Maldives	1.45	0.35	0.123	0.90	2.32	1.65	0.37	0.026	1.06	2.57
Nepal	0.96	0.19	0.835	0.65	1.41	0.97	0.19	0.886	0.66	1.42
Sri Lanka	1.53	0.33	0.051	1.00	2.33	1.59	0.35	0.035	1.03	2.44
Bhutan	2.23	0.37	0.000	1.60	3.10	2.23	0.34	0.000	1.65	3.01
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.84	0.17	0.384	0.57	1.24					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.07	0.19	0.688	0.76	1.52					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.63	0.09	0.002	0.47	0.85					
Tobacco use										
0 days	1.00					1.00				
1 or more days	0.45	0.12	0.003	0.27	0.76	0.44	0.11	0.001	0.27	0.71
Physically activity										
<7 days per week	1.00									
7 days per week	0.93	0.19	0.734	0.63	1.38					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.01	0.14	0.925	0.77	1.34					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.29	0.21	0.118	0.94	1.78					
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	1.50	0.21	0.003	1.15	1.97	1.43	0.17	0.003	1.13	1.82
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.11	0.26	0.648	0.71	1.74					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.13	0.28	0.612	0.70	1.83					
Washing hands with soap										
Never/rarely	1.00					1.00				
Sometimes/often/always	1.59	0.32	0.021	1.07	2.37	1.58	0.31	0.021	1.07	2.33
Friendships										
no friends	1.00									

1 or more friend	0.85	0.16	0.375	0.59	1.22					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.00	0.12	0.996	0.79	1.26					
Parental involvement in school										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.80	0.10	0.081	0.63	1.03	0.80	0.08	0.027	0.66	0.98
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.00	0.15	0.982	0.75	1.34					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.99	0.09	0.891	0.83	1.17					

OR= Odds ratio

In addition to the pooled sample models, full and reduced models of the three forms of malnutrition at the country level were also examined. Factors associated with malnutrition indicators varied across countries and no clear trend was identified (Appendix 5 Table 1 - 24). The significant associations of these regression country-specific models are summarised in Table 16.

Table 16. Summary of the statistically significant associations in the country-specific regression reduced models* for adolescent malnutrition, GSHS datasets.

Country	Positively associated	Negatively associated
Pakistan	Sex For stunting (OR=2.8) For overweight (OR=1.6) Tooth brushing For overweight (OR=1.5)	Parental understanding Against overweight (OR=0.7)
Afghanistan	Active transportation For stunting (OR=1.5) Sedentary For stunting (OR=2.0) Tooth brushing For thinness (OR=2.4)	Sex Against stunting (OR=0.4) Peer support Against thinness (OR=0.4) Tooth brushing Against stunting (OR=0.4)
Bangladesh	Age For stunting (OR=1.6) Wash before meals For stunting (OR=4.8) Tooth brushing For overweight (OR=1.9)	Peer support Against stunting (OR=0.6) Sedentary Against thinness (OR=0.4) Tooth brushing Against thinness (OR=0.6) Tobacco use Against overweight (OR=0.2)
India	Age For stunting (OR=1.3) Active transportation For stunting (OR=1.6) For thinness (OR=1.2)	Age For overweight (OR=0.8) Sedentary Against stunting (OR=0.8) Against thinness (OR=0.8) Peer support Against thinness (OR=0.7) Sex

		Against overweight (OR=0.7)
Maldives	Age For stunting (OR=1.7) For thinness (OR=1.3) Parent involvement For overweight (OR=1.6)	Age Against overweight (OR=0.7) Peer support Against stunting (OR=0.6) Sex Against overweight (OR=0.5)
Nepal	Age For stunting (OR=1.3)	Age Against overweight (OR=0.7) Active transport Against stunting (OR=0.7) Washing with soap Against stunting (OR=0.7) Sex Against thinness (OR=0.7) Against overweight (OR=0.6) Parental involvement Against overweight (OR=0.7)
Sri Lanka	Fruit and veg intake For stunting (OR=1.6) Sedentary behaviour For overweight (OR=1.6)	Tobacco Against stunting (OR=0.2) Physical active Against overweight (OR=0.4) Friendships Against stunting (OR=0.6) Parental understanding Against stunting (OR=0.8)
Bhutan	Fruit and veg intake For stunting (OR=1.6)	Tobacco Against stunting (OR=0.2) Friendships Against stunting (OR=0.6) Parental understanding Against stunting (OR=0.8) Physical active Against overweight (OR=0.4)

* In-detail results of country-specific regression models can be found in Appendix 5 Table 1 - 24.

5.5. Discussion

In this secondary data analysis of the GSHS, the prevalence of the double burden of malnutrition among in-school adolescents in South Asian countries was calculated (Pakistan, Afghanistan, Bangladesh, India, Maldives, Nepal, Sri Lanka and Bhutan). This study showed that the overall prevalence of stunting in South Asia was 13%, thinness was 10.8% and overweight was 10.8%, with significant geographical variations in stunting and thinness. Sex was not associated with adolescent malnutrition indicators in the pooled sample; however, it was within some countries (stunting in Pakistan; thinness in Nepal and Bhutan; and overweight in Pakistan, India, Maldives, and Bhutan). Prevalence of health behaviours was calculated, showing substantial differences across South Asian countries. Factors associated with malnutrition at the South Asian level were identified: age, hygiene behaviours, social support, sedentary behaviour, and tobacco use.

Firstly, the prevalence of stunting, thinness and overweight in South Asia was calculated. The present findings suggest that adolescents in South Asia are affected by the double burden of malnutrition, consistent with global trends (Caleyachetty et al., 2018; Schott et al., 2019), and other studies from South Asia (Ahmad et al., 2018; Darling et al., 2020). Pakistan showed the lowest rate for stunting (3.9%) and overweight (8%). Afghanistan presented the highest prevalence across South Asia of stunting (28.2%) and overweight (19%), contrasting with a low thinness rate (2.5%). Sri Lanka reported the highest rate for thinness (18.6%), co-existing with relatively high rates of stunting (25%) and overweight (13.2%). The lowest prevalence of thinness in South Asia was found in Bhutan (1.5%) as opposed to overweight prevalence (16.3%). It is important to point out that the prevalence of the double burden of malnutrition cannot be reported as high, medium or low in this study because malnutrition prevalence thresholds in adolescents have not yet been established. Since malnutrition thresholds of public health significance have been defined for children under 5 years of age (de Onis et al., 2019), future research should aim to develop these thresholds for adolescent populations. Classifying the prevalence of stunting, thinness and overweight in adolescents may contribute to improving monitorization, identifying priorities, mobilising action and tailoring interventions addressing malnutrition.

This study demonstrates some significant associations between sex and adolescent malnutrition indicators. Pakistani girls were more likely to be stunted and overweight in comparison to boys. There was a significant relationship between malnutrition indicators and sex in Bhutan with boys being thinner than girls and girls being more overweight than boys. Findings also showed a significant effect for sex in India, Maldives and Nepal. Despite these associations in our sample, there is no distinct sex disparity trend. This is consistent with findings from previous reviews on underweight (Estecha Querol et al., 2021) and overweight (Mistry & Puthussery, 2015) among South Asian adolescents. Although sex may not be a malnutrition risk factor, gender inequalities in health should be acknowledged in this population. Adolescent girls in South Asia are disproportionately affected by early marriage and pregnancy, sexual violence, reproductive morbidity and mortality, and deprived educational and employment opportunities; while adolescent boys suffer from injury, violent death, suicide, harmful drinking and tobacco smoking (Fikree & Pasha, 2004; Kennedy et al., 2020).

To our knowledge, no previous analyses have calculated adolescent malnutrition indicators at a country level in the eight South Asian countries. Our results are not directly comparable with previous publications (Caleyachetty et al., 2018; NCD Risk Factor Collaboration, 2017; UNICEF,

2016; UNICEF, 2019a; Yang et al., 2019). It is problematic to compare regional malnutrition prevalence from previous studies (Caleyachetty et al., 2018; Yang et al., 2019) to our analyses because of different geographical classifications (WHO vs. World Bank classification). Although previous evidence (NCD Risk Factor Collaboration, 2017; UNICEF, 2016; UNICEF, 2019a) applied the same geographical classification, the age ranges of the target population differed. For instance, findings from NCD-RisC showed that more than a quarter of children and adolescents aged 5-19 were underweight and less than a tenth were overweight (NCD Risk Factor Collaboration, 2017). Nevertheless, this publication found that thinness prevalence in South Asia to be the highest worldwide. UNICEF reported that 11% of South Asian adolescent girls aged 15-19 years were stunted and 39% were thin (UNICEF, 2019a). Prevalence in children under 5 years of age living in South Asia was 30% for underweight, 37% for stunting and 4% for overweight (UNICEF, 2016). This study adds to this information by reporting the overall prevalence of stunting, thinness and overweight among adolescents aged 12 to 15 years using a standardised methodology across eight South Asian countries.

Secondly, the prevalence of health behaviours was examined in this study. These results were compared with other GSHS publications where possible (i.e. variables' cut-offs are the same as ours). Only 14.3% of South Asian adolescents consumed the recommended fruit and vegetable intake (5/day). A study using GSHS datasets in 65 low-income and middle-income countries reported a higher percentage (25.7%) of adolescents who met the recommendations of daily fruit and vegetable intake (Caleyachetty et al., 2015). Feeling lonely and anxious was reported by 10.1% and 5.9% of respondents in our pooled sample, respectively. Other GSHS studies found loneliness and anxiety to be 10.0% and 10.4% in Seychelles (Alwan et al., 2011), and 7.5% and 6.2% in sub-Saharan Africa countries (Shayo & Lawala, 2019). Psychological distress in this study was particularly outstanding among Afghan adolescents with 28.8% in loneliness and 21.84% in anxiety. It may be worth noting that at the time that the GSHS survey was conducted in Afghanistan, a war was impacting the country, which may help to explain the high percentages of in-school adolescents suffering from anxiety and loneliness. Previous literature found that Afghan adolescents suffer distress, trauma, violence, and war-related experiences affecting their mental health greatly (Panter-Brick et al., 2009).

This study reported a lower overall prevalence of tobacco use (5.3%) in comparison to previous GSHS publications in Seychelles (22%) (Alwan et al., 2011), Thailand (14.1%) (Pengpid & Peltzer, 2019a), African countries (10.2%) (Pengpid & Peltzer, 2011), and 68 low-income and middle-income countries (13.6%) (Xi et al., 2016). Similarly, findings from the Global Youth Tobacco Survey showed that 5.4% of South Asian adolescents were cigarette smokers (Rao et

al., 2014). We hypothesise that relatively low tobacco use rates in South Asia are linked with strong social stigma and religious unacceptability, which may reduce the smoking rate in this population. Additionally, these are subjective measures to reporting bias.

The prevalence of physically active adolescents at the South Asian level was 27.1% in this study. However, findings from the Africa region (16.6%), the Americas region (16.2%) and the Western Pacific region (13.8%) (Xu et al., 2020) indicated lower rates of physical activity. More than 60% of the schooled adolescents in the present study reported active transportation such as walking or riding a bicycle, while adolescents in Africa (41.3%), America (40.4%), and Western Pacific (44.1%) regions reported lower rates of active transportation (Xu et al., 2020). On the other hand, our study found a lower overall prevalence of sedentary behaviour (15.8%) compared to schooled adolescents living in Africa (41.3%), America (40.4%), and Western Pacific (44.1%) regions (Xu et al., 2020).

Results from the pooled sample showed that 54% of the adolescents reported brushing their teeth twice a day, with large country variations ranging from 30.2% in Pakistan to 77.1% in Maldives. Pengpid and Peltzer (2014) found that daily brushing recommendations were met by 77.6% of adolescents from four Southeast Asian Countries (Peltzer & Pengpid, 2014). The prevalence of frequent hand hygiene behaviour was lower in our study (washing hands before meals, after toilet use and with soap was 89.5%, 92.8%, and 79.9%, respectively) compared to another GSHS publication that analysed data on hand-washing practices across 80 countries (washing hands before meals, after toilet and with soap was 93.6, 94.4%, and 91.2%, respectively) (Smith et al., 2020).

The prevalence of students reporting that they had at least one close friend in our pooled sample was 91.9%, similar prevalence was reported in Latin America and the Caribbean (92%) (Sauter et al., 2020) and in Africa (87.6%) (Peltzer, 2009). Adolescents in our pooled sample reported a slightly higher rate of peer support (49.6%) compared to findings from Africa (39%) (Peltzer, 2009) and the Association of Southeast Asian Nations (ASEAN) Member States (40.4%) (Peltzer & Pengpid, 2017).

Half of the adolescents in this sample reported the presence of supportive parental figures (53% reported that their parents were involved in their academic activities, 53.4% reported that their parents understood their problems, and 50.3% reported that their parents monitor their leisure time activities). Maldives and Bhutan presented the lowest levels of parental support, whereas the highest rates of perceived parental support were found in Sri Lanka. One in three adolescents in the Caribbean (Abdirahman et al., 2012) reported that their parents

often check their homework, while less than half of adolescents reported parent involvement in school activities in a GSHS publication analysing data from 52 countries (Kushal et al., 2021). One in three adolescents had parents who understood their problems in sub-Saharan Africa (Shayo & Lawala, 2019), the Caribbean (Abdirahman et al., 2012) and in another GSHS study from 52 countries (Kushal et al., 2021). Half of the adolescents from these two last studies (Abdirahman et al., 2012; Kushal et al., 2021) reported that their parents monitored their leisure time.

Thirdly, several health behaviours were found to be associated with adolescent malnutrition indicators (stunting, thinness and overweight) in multivariable logistic regression models of the pooled sample. Variables representing hygiene behaviours were found to be associated with malnutrition. Tooth brushing was associated with two forms of malnutrition (thinness and overweight). In other South Asian studies, poor oral health predicted overweight (Chakravathy et al., 2013; Karki et al., 2019; Kumar et al., 2017) and underweight (Karki et al., 2019). This study shows that handwashing practices were associated with nutritional status among adolescents living in South Asia. Likewise, inadequate handwashing practices had a significant association with poor nutritional status in adolescent girls living in eastern India (Chattopadhyay et al., 2019) and lack of toilet facilities was associated with an increased risk for stunting among adolescents living in rural West Bengal (Darling et al., 2020).

Interestingly, this study did not find a significant association between sedentary behaviour and overweight. By contrast, previous research from Sri Lanka found an association between sedentary behaviour and being overweight among school children (Godakanda et al., 2018). Nevertheless, sedentary behaviour was negatively associated with thinness. Sedentary behaviour implies a low energy expenditure which may lead to an increase in BMI, hence its protective effect against thinness.

In this analysis, tobacco use was found as a significant predictor for overweight. It is difficult to contextualise this finding because no studies were found on the association between smoking and nutritional status in South Asia, possibly due to a predominantly smokeless society and social taboos. Pengpid & Peltzer (2016) confirmed an association between tobacco use and overweight among girls in the AESAN member countries (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam).

Peer support and parental involvement in school were associated with malnutrition at the South Asian level. Peer support was a protective factor against stunting while parental involvement in school protected against being overweight. Peers and parents have a great

impact on adolescent food choices (Shepherd & Dennison, 1996; Wouters et al., 2010), especially on those who are overweight (Watts et al., 2015). For example, Pengpid and Peltzer a reported positive association between peer support and overweight among school-going adolescent girls in the AESAN member countries (Pengpid & Peltzer, 2016) and a negative association between peer support and underweight (Pengpid & Peltzer, 2019b). Parental supervision was positively associated with underweight and parental bonding increased the odds for overweight or obesity among schooled adolescents in AESAN countries (Pengpid & Peltzer, 2019b). Although this is the first study that investigates the relationship between the double burden and peer influence in the South Asian context, these findings suggest that the double burden of malnutrition may be reduced with social support.

Fruits and vegetable consumption, psychological distress and physical activity have previously been associated with nutritional status, especially overweight, among South Asian adolescents (Ahmad et al., 2018; Choudhuri & Balaram, 2020; Fernandes et al., 2015; Jayawardena et al., 2017). However, these factors did not appear significant in the pooled sample. Additionally, traditional confounders such as sex and age were explored. The multivariable analysis did not provide evidence that sex was a risk factor for malnutrition at the South Asian level. This coincides with recent reviews (Estecha Querol et al., 2021; Mistry & Puthussery, 2015) that reported an inconsistent association between nutritional status and sex within the literature. Older age was associated with a higher stunting probability. Previous evidence from India also found that the risk of stunting in late adolescence was higher than in early adolescence (Darling et al., 2020; Pal et al., 2017; Rengma, 2016). On the other hand, age was negatively associated with overweight in this study.

In the country-specific regression models, several health behaviours were associated with different forms of malnutrition. Sex disparity was significant in Pakistan, Afghanistan, India, Maldives, and Nepal. Adolescent girls exhibited less risk of being affected by stunting, thinness and overweight than adolescent boys, apart from Pakistan, where girls had a greater risk of being stunted and overweight. Older age seemed to be a risk factor for stunting and thinness in Bangladesh, India, Maldives, Nepal and a protective factor against overweight in India, Maldives, and Nepal. Adequate toothbrushing findings were inconsistent across countries. It was either a risk or a protective factor being significant in Pakistan, Afghanistan and Bangladesh. Hand hygiene behaviour practice was found to be a protective factor against stunting in Nepal, but it was a risk factor for stunting in Bangladesh.

As expected, being physically active was negatively associated with overweight in Bhutan and Sri Lanka, and being sedentary was positively associated with overweight in Sri Lanka. Accordingly, sedentary behaviour was a protective factor against thinness and stunting in India and Bangladesh. However, sedentary behaviour was found to be a risk factor for stunting in Afghanistan. Regarding active transportation, it was found as a risk factor for stunting and thinness in India, while it was a protective factor against stunting in Afghanistan and Nepal.

Peer and parental support variables were found as significant predictors of all forms of malnutrition. Peer support and friendships were negatively associated with thinness and stunting in Bangladesh, Afghanistan, India, Maldives and Bhutan. Parental support seemed to be negatively associated with overweight (Pakistan, Nepal) and stunting (Sri Lanka and Nepal). However, it was positively associated with overweight in Maldives. Surprisingly, psychological distress (loneliness and anxiety) was not significant for nutritional status. Adolescents meeting the recommendations of daily fruit and vegetable intake were significantly more likely to be stunted in Sri Lanka and Bhutan. Tobacco was negatively associated with stunting in Bhutan and Sri Lanka and overweight in Bangladesh.

The statistical significance and direction of the association (positive or negative association) in the regression models did not show clear patterns of health behaviours associated with the three forms of malnutrition, e.g. fruit and vegetable intake was statistically associated with stunting in only two countries (Sri Lanka and Bhutan). Moreover, some findings were contradictory (e.g. frequent tooth brushing was a risk factor for thinness in Afghanistan but a protective factor against thinness in Bangladesh) or illogical (e.g. washing hands before meals was a risk factor for stunting in Bangladesh). These findings suggest that malnutrition is a large-scale and complex health problem that needs additional explanation using other research approaches. A qualitative study will potentially enhance the understanding and help to explain the quantitative results.

The double burden of malnutrition introduces considerable challenges for policy and programming in global health (Hawkes et al., 2020). Governments in LMIC and the research community have traditionally focused on undernutrition (Hawkes et al., 2020). Yet, childhood and adolescent overnutrition is predicted to rise globally in the next years, beating underweight prevalence among this population (NCD Risk Factor Collaboration, 2017). Effective interventions, programmes and policies (double-duty actions) should address the immediate, proximate and structural determinants of adolescent malnutrition in all its forms, carefully tackling one form without worsening the other. Nevertheless, further studies are

needed to better understand what determinants worsen or mitigate the double burden of malnutrition in adolescents across all South Asian countries.

5.5.1. Strengths and limitations

The use of the GSHS is both a strength and a limitation. Regarding the strengths of the GSHS, there are no other global quality health surveys on South Asian adolescents up to date in which data is nationally representative, and methodology is standardised across countries. This survey collects height, weight and BMI which are anthropometric measurements widely used to calculate malnutrition indicators and monitor prevalence at the population level. This study is the first, to our knowledge, to examine the relationship between the double burden of malnutrition and associated factors among South Asian adolescents using a large pool of nationally representative data, although more research is needed to confirm these associations.

In terms of limitations, the cross-sectional, non-interventional design limits any causal interpretation, although the observed prevalence and associations could be used to generate hypotheses. Second, data on certain aspects of adolescents' circumstances were not available in the GSHS, such as household socioeconomic status, ethnicity, religion, and rural/urban setting, so adjusting and stratifying the analysis to explore further inequalities among these subgroups was not possible. Third, GSHS does not collect micronutrient deficiency data, thus, this form of malnutrition was not included in this analysis, potentially leading to underrate its impact on the adolescent malnutrition burden (Osendarp et al., 2020). Fourth, the breadth of GSHS has been questioned due to its restriction to adolescents who are attending school as rates of absenteeism are high in LMIC (Patton et al., 2012). The estimates of the double burden of malnutrition in this analysis apply only to adolescents who attend school, therefore, findings cannot be generalised to all adolescent populations living in South Asia. Fifth, the reliability and validity of the GSHS questionnaire adapted for South Asian countries have not been investigated yet; however, two studies on schooled adolescents from Fiji (Becker et al., 2010) and Iran (Ziaei, 2014) found acceptable reliability and validity concluding that the questionnaire can serve as a reliable instrument for obtaining data on adolescent health behaviours.

This particular analysis also has limitations. Some important variables such as frequency of hunger, carbonated soft drink consumption and frequency of eating at fast-food restaurants were not included in this analysis due to the inclusion criteria, that is, only explanatory

variables collected in the eight South Asian countries. Survey data were collected between 2008 and 2016, so comparisons between South Asian countries should be made with caution.

5.6. Conclusions

Global health and nutrition surveillance is a relatively low-cost method to obtain representative information from a certain population in which countless statistical analyses can be performed. For this study, the GSHS provided a suitable source of data on adolescent nutritional status and health behaviours that answered objective 2 of this thesis. However, GSHS should collect participants' sociodemographic information (for instance, rural/urban status and wealth) as well as collect all health behaviours variables in all country surveys in order to allow cross-country comparisons. In addition, collecting nutritional biomarkers would be essential for health and nutrition surveys aiming to investigate the burden of malnutrition.

This study reveals that the prevalence of the double burden of malnutrition at the population level among schooled adolescents living in South Asia is a nutritional problem of public health importance. This study highlights the urgent need to address the double burden of malnutrition in South Asian schooled adolescents and further investigate malnutrition risk and protective factors. Determining the magnitude of the double burden among adolescents is important for the development of appropriate double-duty actions to accelerate progress toward ending malnutrition in all its forms.

6. Chapter 6: Qualitative study on malnutrition perspectives and awareness among Pakistani adolescents living in a slum

Chapter summary

Chapter 6 explores awareness, meanings and perceptions of adolescent malnutrition among schooled individuals living in a slum using photodiaries and interviews. This chapter begins by providing background on slum environments as well as introducing the particular slum where this project was conducted. After situating the under-researched topic of malnutrition within slums, this qualitative research project aims are listed. The process of photodiaries and interviews as data collection methods are explained. How the candidate and the research assistant shaped this project is considered and reflected in this chapter. Insights and challenges of the recruitment, conducting interviews, and the study's nature are also acknowledged. Reflexive thematic analysis was used to analyse the data and interpret the findings. This chapter finalises with a discussion section including strengths and limitations and a conclusion. This qualitative study has not been published but it will be soon submitted for publication in a peer-review journal.

6.1. Background and rationale

This chapter responds to objective 3 of this thesis:

- To explore awareness and perspectives of malnutrition among schooled Pakistani adolescents living in a slum using a qualitative method to capture their understandings on malnutrition.

Previous work presented in this thesis (Chapter 2, Chapter 3, and Chapter 4) shaped, informed, and helped develop this qualitative study. The conceptual framework acknowledged (Chapter 2) several malnutrition determinants in the adolescent populations. The findings from the reviews on adolescent malnutrition in South Asia (Chapter 3 and Chapter 4) highlighted the need for studies employing qualitative methods among adolescents living in slums and adolescents living in Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka.

UN-Habitat estimates that approximately one billion people live in slums (UN-HABITAT, 2016). In Southern Asia, nearly 30% of the urban population lives in slums. UN-Habitat defines slums as informal settlement that lacks one or more of the following five conditions: access to clean water, access to improved sanitation, sufficient living area (not overcrowded), durable housing and security of tenure (UN-HABITAT, 2003). Despite the UN-Habitat slum definition, there is no agreement on a standardised definition for slums (Lilford et al., 2019). However, it is essential to differentiate these areas from non-slums areas for scientific, policy and monitoring purposes. People living in slums are more exposed to health problems, have less access to education, social services and employment, and most live in poverty (UN-HABITAT, 2003). Improving the lives of slum dwellers is on the 2030 Agenda for Sustainable Development. Goal 11 of the Sustainable Development Agenda aims to make cities and human settlements inclusive, safe, resilient and sustainable by 2030. More specifically, target 11.1 aims to ensure access to adequate, safe and affordable housing and basic services in slums, and target 11.7 aims to provide access to safe, inclusive and accessible, green and public spaces for those in vulnerable situations. Thus, guaranteeing good quality sanitation, infrastructure, and health care in slums are key to ending poverty worldwide (UN-HABITAT, 2016).

Children living in slums are at high risk of malnutrition (Goudet et al., 2017a; Srivastava et al., 2012). However, there is limited knowledge of adolescents living in slums across South Asia (Chapter 3 and Chapter 4). Appendix 2 of this scoping review (Chapter 4) shows that a few studies investigated undernutrition among adolescents living in slums (Bisai et al., 2009; Bose & Mukhopadhyay, 2004; Gupta & Gupta, 2018; Gupta Bansal et al., 2015; Prashant et al., 2009; Rawat et al., 2015; Singh & Mishra, 2001). These studies were exclusively located in India and

found alarming undernutrition (over 40%) and anaemia prevalence (over 60%). A very recent study estimated the magnitude of the double burden of malnutrition among school-going children in a slum area in India (Bhattacharyya et al., 2021). The prevalence of stunting was 9.4%, thinness was 23.6%, and overnutrition was 11%. In addition, the authors found that boys were more stunted and thin than girls, and poor parental education was significantly associated with all forms of malnutrition.

As described in section 1.2. NIHR Slum Unit, this PhD project forms part of the NIHR Global Health Research Unit on Improving Health in Slums, a multi-partner, multimethod collaboration exploring healthcare and access in seven slums in Bangladesh, Kenya, Nigeria and Pakistan (Bakibinga et al., 2019). The candidate's PhD project is embodied more precisely in a slum the city of Karachi (Pakistan) (Figure 10) which is a centrally located, well-established neighbourhood in Karachi East district (Ahmed et al., 2020). The religion is mixed, but this neighbourhood probably has one of the largest proportions of Christians in the city (40%). There are several ethnic groups in this slum, including Muhajirs, Punjabis, Sindhis, Kashmiris, Seraikis, Pakhtuns, Balochis, Memons, Bohras, Ismailis. Approximately 0.1 million people live there, and the population is mostly settled, working in blue-collar jobs. Structures are permanent and multistory, with high levels of new construction underway. Residents have variable access to basic services and sanitation (Ahmed et al., 2020).

Figure 10. Photos from the study site - Karachi (Pakistan) - were taken by the candidate in January 2020.

The research team in the Aga Khan University conducted a household survey in the study site back in 2019 and collected data on phone ownership and health service use of 988 households. They found that 54% of the respondents (adults) owned a mobile phone while 19% owned other devices such as computers or tablets. Moreover, 51% had daily access to internet data on at least one digital device (unpublished data). Based on this information, there were probably very few adolescents living in this slum with internet access or smartphones. Therefore, it was sensible to design a project without relying on an internet connection or ownership of digital devices. In addition to the local context, the research team also took into consideration the literacy levels, cultural sensitivities and Covid-19 context when designing this cross-cultural, cross-language study.

Malnutrition has been traditionally investigated using quantitative approaches despite the efforts of USAID Advancing Nutrition (USAID Advancing Nutrition, 2021) and the GAGE consortium (Jones, 2018) in highlighting the importance of conducting qualitative methodologies in adolescent populations. Health care providers' and caregivers' perspectives on childhood malnutrition have been investigated in LMIC (Abaasa et al., 2021; Kismul et al., 2015; Lindberg et al., 2021; Vaezghasemi et al., 2020) and slum settings (Goudet et al., 2011; Goudet et al., 2017b). Yet, a qualitative approach exploring adolescent malnutrition is missing in these particular contexts. This study could potentially challenge this purely quantitative definition of adolescent malnutrition and reveal a new conceptualisation of malnutrition, including “how it feels” and “how it is understood”. Furthermore, a qualitative approach could potentially contribute to better understanding malnutrition-associated factors given by quantitative research (Chapter 5).

Considering all of the above, a qualitative study was conducted to answer objective 3 by exploring malnutrition among adolescents living in a slum in Karachi.

6.2. Aims of the qualitative study

- To explore awareness and understanding of malnutrition among adolescents living in a slum in Karachi.
- To explore perceptions of malnutrition among adolescents living in a slum in Karachi.
- To explore determinants of malnutrition among adolescents living in a slum in Karachi.

6.3. Methods

6.3.1. Qualitative approach and research paradigm (rationale)

This qualitative study used pragmatic theoretical assumptions to understand malnutrition in a given context. The conceptual underpinnings of the research (ontological, epistemological and

methodological assumptions) are explained in detail in section 1.5. Research design. The reviews (1.1. Literature review, Chapter 3 and Chapter 4) and conceptual framework (Chapter 2) framed the development of the research aims and design. This preexisting theory was used as "a lens through which to interpret the data" rather than hypothesis or (quantitative) theory testing (Braun & Clarke, 2021a). Hence, this research study draws on an interpretive approach in which the candidate is interested in understanding how adolescents living in a slum in Pakistan make meaning of malnutrition. It is exploratory in nature and uses an inductive strategy that moves from open-ended data to patterns. A thick narrative of the data extracts is presented and discussed, moving from a descriptive to an interpretative level and bringing in existing literature (Braun & Clarke, 2006; Merriam, 2019).

6.3.2. Data collection methods and instruments

Engaging, fun, interactive and creative data collection methods are most appropriate for conducting research with young children and adolescents (USAID Advancing Nutrition, 2021). Considering participants' age and context (i.e. literacy level, cultural sensitivities, limited access to the internet or mobile devices), a qualitative method including images or visual data was perceived as suitable. Given the cross-cultural nature of this project, visual data have the potential to transcend any language barriers.

Images could offer the possibility to see the world through the eyes of adolescents and find out what the adolescents have to tell us about their perceptions of malnutrition (Banks, 2008). For instance, photo-elicitation is a visual method that employs images to study society. Photo-elicitation involves "using photographs to invoke comments, memory and discussion in the course of a semi-structured interview" (Banks, 2008) (p. 76). Photo-elicitation is helpful when there is a wide social or cultural gap between researcher and participants because its use could overcome these gaps or misunderstandings in communication. On the same line, an advantage of photo-elicitation is that the images provide something to talk about, so possible discomfort can be eased by focusing on the photographic content (Banks, 2008). Recently, this method was originally used for nutrition research in adolescents without pre-existing health conditions by Green et al. (Green et al., 2021).

As mentioned in the Covid-19 impact statement, this thesis and especially this qualitative study were profoundly affected by the Covid-19 pandemic. The initial qualitative study involved a visual participatory action research method to explore malnutrition and the candidate travelling to Pakistan to collect the data in September 2020. For this purpose, a project protocol was designed using photovoice method (see Appendix 6). Exploring

malnutrition among adolescents through photovoice appears to be a novel approach that could be carried out as a future research study (Estecha Querol et al., 2020).

The planned participatory action research method involved frequent interaction among community leaders, school staff, participants, and researchers; hence, the research team decided against its use during the Covid-19 pandemic. However, both using an appealing visual method for adolescents and maintaining research subjects' involvement and collaboration in the production of the research data - to the extent possible - were still considered essential for the design of a new qualitative study. After extensive discussion on re-planning this qualitative phase, an alternative instrument for data collection was developed: photodiary and interviews. This adjustment enabled addressing objective 3 using a more 'Covid-19 friendly' method.

Photodiary and interviews

The photodiary method was initially developed to investigate Muslim and African Caribbean teenagers' experiences on parenting in Hirst's study in 2003 (Hirst et al., 2006). In photodiaries, participants take pictures over a determined period of time following prompts or instructions given by the researcher as well as writing a diary recording their thoughts, feelings or experiences about the given research topic. The researcher initiates and facilitates the assignment (Clarke & Braun, 2013) but the research subject generates the material and therefore chooses what to capture and record in the photodiary (Carter & Mankoff, 2005). The participant-generated visual images and diary are used to elicit conversation, enrich the interview method, and/or add further forms of data (Allen, 2008; Clarke & Braun, 2013). Both diaries and interviews are perfectly suited to explore experiences offering a unique perspective of participants' lives that may be otherwise unavailable to the researcher (Clarke & Braun, 2013).

In this study, participants snapped and wrote about the meaning of malnutrition and subsequently were asked in the interview to talk about the content of their photodiaries as well as questions on the concept and perceptions of malnutrition and how this affects the participants and their community. It was our hope that this project would challenge schooled adolescents living in a slum to contemplate malnutrition and its associated factors on a local level and potentially encourage them to think very carefully about finding images that somehow defined or evoked malnutrition.

Since the candidate could not travel to Pakistan to undertake the fieldwork, a local Urdu speaking research assistant (RA) was hired by the Department of Community Health Sciences, Aga Khan University and was trained on the methods and research aims of the project by the

candidate. A male community health worker (CHW) from the Aga Khan University team accompanied the RA to the field for safety purposes. The RA and CHW followed local guidelines on minimising the COVID-19 spread amongst themselves and the participants. The process of photodiary and interviews is explained below:

1- Partnership with the school. To effectively carry out this project, the research team gained access to the schools by developing a research consensus with the collaborating schools. The aims and the procedures involved in this research project were explained to the school principals. Once the research team gained access to the schools, the recruitment and taking consent from participants took place (see section 6.3.4. Recruitment).

2- Research material distribution. Participants received a notebook, colour pens, glue, scissors, a Polaroid camera (INSTAX® Mini 11), detailed photodiary instructions to complete the research project (Appendix 7) and information about the research study (Figure 11). Polaroid cameras contain a self-developing film to create a print shortly after taking the picture. This type of camera was considered the most suitable for this project because it prints the image instantly without requiring any additional electronic devices or the internet. Participants were expected to take photos of anything related to undernutrition, micronutrient deficiencies and overnutrition and paste these pictures into the diary along with a written note explaining the content of the image.

Figure 11. Research materials were given to the participants: school supplies (on the left) and instructions document in Urdu (on the right)

The study protocol, the photodiary instructions (Appendix 7) and the interview topic guide (Appendix 8) were informed by the framework (Chapter 2) as well as the reviews (Chapter 3 and Chapter 4). Malnutrition associated factors from these chapters were prompted in both photodiary instructions and the interview topic guide. Since this study aimed to explore awareness of malnutrition as well as malnutrition associated factors, the photodiary instructions were divided into two parts: the first part asked for the meaning of malnutrition

(undernutrition, micronutrient deficiencies and over-nutrition), and the second part asked for factors that could worsen or improve malnutrition. This distribution allowed the participants to focus first on one aim at a time and not feel overwhelmed by the newness of the 'task'.

3- Photodiary production. Participants were given two weeks to complete their photodiary. In order to ease the use of the camera and the production of the photodiary, the RA explained to the participants how to use the camera and what they were expected to do when the materials were handed over. She also contacted the participants via phone call to check if any problems or questions arose during the process.

4- Collection of the photodiaries. Photodiaries were scanned and returned to the participants.

5- Semi-structured interviews. Informed by the literature and in line with the aims of the study, a topic guide was prepared (Appendix 8). The topic guide had two clear parts: 1) questions about the content of the photodiary (this part was tailored for each participant, see an example in Appendix 8) and 2) questions on the concept and perceptions of malnutrition and how this affected the participant and their community. The RA conducted the interviews in Urdu, the local language. Interviews were conducted face to face because of cultural preferences and unreliable phone signal in the slum area. The usage of Personal Protective Equipment and maintaining distance at all times was essential to keep RA and participants safe. Previous consent (verbal) was given by the participant before starting the audio recording. At the beginning of the interview, the RA explained the research study again and asked a couple of icebreaker questions as well as basic sociodemographic information such as sex, religion and age in order to build rapport with the participant. The interviews lasted from 15 to 37 minutes. After each interview, both the RA and the candidate reflected on how the interview went. Finally, RA transcribed the photodiaries and audios verbatim in Urdu. Then, she translated them from Urdu into English. To ensure the quality of transcripts, six interviews were independently translated by a second researcher (Iman Ghosh) after training on the study aims. Quotes from the photodiaries are in Urdu unless indicated otherwise.

6.3.3. Sample characteristics

Study participants were schooled adolescents aged 13 to 16 years old living in a slum in Karachi. A slum area in Karachi was chosen because of two main reasons: 1) the existing collaboration and research interest of the NIHR Global Health Research Unit on Improving Health in Slums (see section 1.2. NIHR Global Health Research Unit on Improving Health in Slums) and 2) knowledge scarcity on adolescents living in slums (Goudet et al., 2017a; Srivastava et al., 2012). The eligibility criteria of this study are described below.

Inclusion criteria:

- Adolescents aged 13 to 16 years old
- Attending school
- Living in the study site slum
- Cognitively competent
- Voluntary (chooses to participate)

Exclusion criteria:

- Pregnant / breastfeeding adolescents
- Adolescents with serious illnesses such as HIV, tuberculosis or diabetes.

Braun and Clarke have recently discussed how the claim of achieving "data saturation" to determine sample size is inherently problematic in qualitative research, especially in more interpretative forms of qualitative research (Braun & Clarke, 2021d). Considering this study's approach and its method for data analysis (see section 6.3.7. Data analysis), the sample size was not determined by seeking data saturation but rather by making pragmatic decisions around sampling (Braun & Clarke, 2021d). Hence, the sample size of this study was determined by taking into account the research question, the purpose of the project, the methods of data collection, the homogeneity of the sample, the COVID-19 pandemic, the expected depth of data generated from adolescent participants, and the time and resources available. In total, 14 participants (five boys and nine girls) were recruited, see Table 17. Photo-elicitation studies among the adolescent population have used a similar sample size (Chakraborty, 2009; Fournier et al., 2014; Nayriro, 2018).

Table 17. Participants characteristics.

Participant's name*	Age	Sex	Religion	Recruitment
Jon	13	Male	Christian	Door-to-door
Mary	15	Female	Christian	Door-to-door
David	14	Male	Christian	Door-to-door
Sunny	13	Male	Christian	Door-to-door
Sakina	16	Female	Muslim	Door-to-door
Ali	16	Male	Muslim	School D
Sulman	15	Male	Christian	School D
Qirat	16	Female	Muslim	School D
Zainab	16	Female	Muslim	School D
Ashi	16	Female	Muslim	School D
Rimsha	15	Female	Muslim	School E
Mahi	14	Female	Muslim	School E
Jannat	16	Female	Muslim	School E
Laraib	15	Female	Muslim	School E

*These names are not participants' real names

6.3.4. Recruitment

The fieldwork took place from March to August 2021. Covid-19 and subsequent lockdowns made the recruitment extremely challenging (see section 6.3.6. Insights and challenges of this study: Challenges of the recruitment). To maximise the chances to recruit participants, two approaches were used: door-to-door and school-based recruitment. The RA and a CHW followed a door-to-door recruitment approach involving in-person contact with the study site community. Five schools were approached, but participants were only recruited from two schools (School D and School E). The RA and a CHW ensured collaboration with School D and School E, and then the school principal searched for potential participants. Figure 12 shows the process of both door-to-door and schooled-based recruitment. Reasons for refusal and other insights from the recruitment process are further explained in section 6.3.6. Insights and challenges of this study: Challenges of the recruitment. In total 14 participants were included in this study: 5 participants from door-to-door recruitment, 5 participants from School D and 4 participants from School E took part in this study (Table 17). This study, therefore, involved convenience and purposive sampling where the selected sample was accessible and could potentially contribute with rich data (Clarke & Braun, 2013).

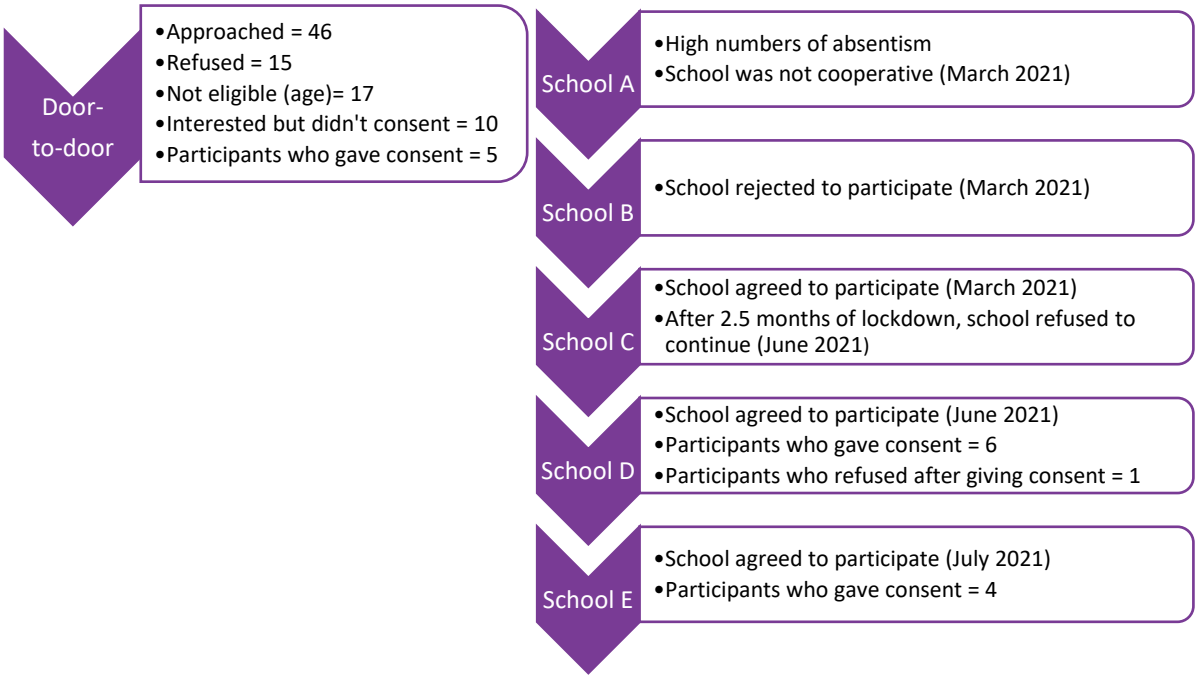

Figure 12. Recruitment process

Informed consent

Informed consent was obtained from adolescents and one parent/guardian. High illiteracy levels were expected among parents of potential participants. In order to ensure compliance

with the highest ethical standards, as well as participants' and parents' understanding of the aims and process of the project, a phone-based verbal consent (Appendix 9) as well as a written consent form (Appendix 10) was taken. Consent forms were translated into Urdu by the research team in Pakistan and produced in lay language for the target audience considering their age and sociocultural characteristics. Verbal consent of the adolescent and their parent/guardian giving consent was audio recorded. The RA explained the project and made sure that both the participant and parents understood it. In addition, the CHW acted as a witness and was present during the explanation and the consent taking.

Participants were encouraged to take photos with no faces or identifying characters. However, if the participant wanted to actively and purposively take a picture of a person, written consent was needed from the model (Appendix 11). If a participant took a picture of a person and there was no written consent, the model's face was faded from the image. All data were pseudo-anonymized, with the removal of identifiers.

Adolescent participants were free to withdraw from the study at any point and data could be removed until one month after collection. Adolescent participants were given a local phone number from the RA. Adolescent or his/her parent/guardian could call this number and request to remove the data. Alternatively, the school principal could contact the RA to ask for participants' data removal.

6.3.5. Reflexivity

Two main individuals shaped the making of this cross-cultural, cross-language research project: Kisa (as the research assistant) and I (as the researcher).

As a researcher and PhD candidate, I am aware that my persona, PhD goals and expectations, previous experiences, and assumptions would (and did) influence the research process. In order to establish rigour and transparency, a critical reflection about my role in the study, a personal statement of the RA, and a contextual consideration of Kisa - I relationship are provided.

Starting with my persona, I am a Spanish citizen born in 1991 (she/her). I have a background in Nutrition and Public Health, and my research interests include adolescent health, global health nutrition, health policy agenda and participatory action research methods. In this PhD program, I planned to develop my research skills in mixed-methods and critical qualitative research. One of my PhD goals (and expectations) was to work together with adolescents living in a slum to understand adolescent malnutrition and trigger some social change rather than merely collecting data to explore adolescent malnutrition and construct an interpretation (my

interpretation vs. our [their+my] interpretation). However, the COVID-19 pandemic started after designing the PhD project but before carrying out the qualitative study. This meant loads of frustration, removing the participatory aspect and consequently re-planning the project. As a visual learner, I am inclined to visual methods, especially when it comes to a cross-cultural, cross-language research project because I believe that images are a powerful mean of communication and have the potential to minimise the language barrier ("a picture is worth a thousand words"). Hence, it is very likely that my interest in visual and participatory methods influenced the selection of the qualitative research method.

Indeed, I aimed to minimise the language barrier to some extent by using images and working with a research assistant as a translator. However, I did not aim to minimise cultural differences. Instead, I tried to acquire cultural sensitivity and competence by reading books, research papers, asking and actively listening to Kisa, and keenly observing the dynamics within the research team to learn about the culture, religion, history and politics of the country and the particular study site. Immersing in a culture (i.e. long stay within the group) may provide a researcher with an in-depth and accurate understanding of a linguistically and culturally distant community (Liamputtong, 2010). However, a long stay in Karachi was not an option at that time. This could be a limitation of this study.

The role of research assistants or interpreters has been hardly investigated as usually, the researcher claims full ownership of the research process and the findings (Stevano & Deane, 2017). Unquestionably, the research assistant had a crucial role in this project which came with great responsibility towards the research process. From my perspective, it was crucial that authority and power asymmetries rooted in both the employment relationship and our foundational knowledge were reviewed. Only then Kisa could also own the project so we (Kisa and I) could ensure the success of *our* project (Kisa referred to this project with the possessive pronoun "our").

Providing quality training on the study's aims and methods to Kisa as well as staying closely in contact with her was critical and had a very positive impact on the research process and quality of the outcomes. While she provided me with local and cultural knowledge, I taught her from qualitative theoretical foundations and methodology to practicalities on how to navigate academia. The contextual intersecting relationship between Kisa and I went beyond a hierarchic professional relationship where I was a mentor to her and she was my trusted eyes, mouth and ears in the field. Kisa was the only person through whom I could live the experience of undertaking this study, so I asked her to document her trips to the field in great detail for

not only quality data collection purpuses but also for my own learning. Kisa also wrote a self-reflection on her performance during the interviews so she could improve her interviewing skills next time.

Reflecting on how Kisa and I shaped the project, I realised that this reflection not only needs to come from my lens but also from Kisa's perspective, so I asked her to share some lines with her views to be copied in this thesis.

"I am Syeda Kisa Zehra Zaidi; I acted as a Research Assistant (RA) in this research. I am a Public Health Nutritionist by profession and currently pursuing my MS degree in Public Health. I am a citizen of Karachi (Pakistan), where this study was carried out. When I got hired as an RA for this research, I was in my final semester of BS-Public Health Nutrition; I had a 4months of internship experience in various PH organizations.

Initially, I was ambiguous regarding the execution of cross-cultural research. I had an assumption that it might be challenging for Sara to relate with the kids from a slum in a developing country. But as we progressed, we found different ways to explain and understand these cultural differences. My socio-demographic background supported me a lot throughout the research. My education and experience served as a bridge between Sara and the participants, and these also helped me absorb the photo-diary method and research topic. The food myths that participants mentioned during the interview or within the photo diary, I was aware of them all. However, I noticed a significant gap between Sara and the participant's culture, a lot of these foods myths were novel findings for Sara.

Like any other researcher, we had also encountered plenty of issues: COVID lockdowns, alternate schooling days, travel restrictions, and connectivity issues. As per my assumption, this study might have been executed way more smoothly in a pre-COVID era in the presence of Sara. I absolutely enjoyed the participants' excitement for participating in this study, capturing pictures, designing diaries, and giving interviews, which, unfortunately, Sara missed witnessing. Being a female, communicating with parents and recruiting the participants (especially females) was more feasible due to parents' safety concerns. As observed, Pakistani parents trust females more in a scenario where interview recording and camera involves. The lesser age gap between the participants and me made it easier for me to explain the study."

The fact that the age gap between Kisa and participants was not more than ten years might have made the adolescents feel comfortable and not see her as a researcher 'examining' them. Her cultural similarity and familiarity (vs mine) with participants, their families and the school staff facilitated trust and rapport. At this point, it may be very apparent the duality of insider

versus outsider in this qualitative project. Kisa, as the local researcher, was linguistically and culturally close to the participants, while I was distant from all (Kisa and the research participants). From her insider perspective, it is important mentioning that Kisa had no previous contact with the study site community. From my outsider perspective, I was an external researcher who was not present in the data collection. I am very aware of my condition as a Western white woman leading a cross-cultural research project, and I question if my writing legitimates and interprets the people whom I researched. It is obvious that I shaped the making of this research study but tried that these characteristics did not influence the research process, participants or research assistant. On the bright side, being an outsider has "its own usefulness, such as providing different perspectives on cultural and community norms, and asking questions that require more detailed explanations" (Coloma, 2008 cited in Liamputtong, 2010). Additionally, being a remote outsider could be advantageous too, as the flow of the recruitment and data collection was not being disturbed by my whiteness and womanness.

6.3.6. Insights and challenges of this study

Challenges of the recruitment

The COVID-19 pandemic has transformed how research is conducted, forcing a switch to online recruitment and data collection on a worldwide scale (Hlatshwako et al., 2021). However, this study rests within a slum in Pakistan, where online research methods were not an option in this context. This made recruiting participants a long and time-consuming process. The recruitment was put on hold for more than three months in total due to multiple lockdowns in the city of Karachi. In addition to the lockdowns, there were times when the Aga Khan University advised the fieldworkers not to go to the study site, for instance, when COVID-19 cases in the area were high, or there was a positive case among the fieldworkers' team.

To further adapt to the COVID-19 pandemic without using online research methods, the research team decided to recruit participants using both a door-to-door approach and recruiting from schools. As expected, we identified that adolescents were more likely to take part in the study if they were contacted through school as opposed to using a door-to-door approach. The school guaranteed an atmosphere of trust and convenience where the principal introduced the RA and CHW to potential participants and facilitated school spaces for the meetings or interviews with the participants (Figure 13). In contrast, schooled adolescents being contacted door-to-door might have decided against the project after an initial conversation because they or their parents might have been unsure of the study.

Figure 13. Potential participant boys (left) and girls (right) from School C attending the first meeting with the research assistant where the project and its aims were explained.

We experienced low rates of participation from door-to-door recruitment. The main reasons for refusal were due to inconvenient timing (i.e. exams period) and the head of household not understanding the project or being unsure about it. The research assistant reflects on this issue in her field diary: "the main reason behind the refusal is that adolescents are having their exams and this project can distract them from their studies. […] Sometimes, the household member does not want to listen or they may listen half heartedly. Explaining this study is a challenge and the majority of people that we have approached in here are illiterate and do not understand what I am saying even if I explain it in the easiest way possible. The study is not based on a questionnaire and it also includes a camera and pictures, so some of the parents hesitated. The participants that we did recruit using door-to-door seemed to come from a more literate family".

Regarding school recruitment, there was low attendance due to the COVID-19 pandemic. Since producing a photodiary was a time-consuming task and it was exam season, the principals selected their most successful and reliable students to participate in this project. For the same reason, participants with good performance at school had to be conveniently and purposely selected in the door-to-door recruitment.

Although adolescents recruited in schools showed interest in the research project, this was not translated into the rapid recruitment that we expected. On the 26th March 2021, RA writes in her diary before going to the field: "I expect that students will show excitement towards our project, and we will hopefully get a nice response from students as well as their parents. I am guessing that around 80% of students will show interest in the study and will give us positive feedback". Same day, after the fieldwork she writes: "at the end of the session, I asked if they would be willing to participate in this study and I got 100% positive response". This was the same case for door-to-door recruitment. On the 26th May 2021, RA writes in her diary: "I hope

we will be able to recruit all 14 participants in a week or half". Next day, she writes: "although we got a cold response today, both CHW and I are hoping to get a better response in the upcoming visits".

In conclusion, this recruitment experienced considerable delays due to unfortunate and uncontrollable circumstances such as exam period, lockdowns and offline design.

Surroundings and rapport in the interviews

The RA conducted five interviews at the participants' homes (doo-to-door recruitment), eight interviews at school and one over the phone (Table 17). When interviews took place at the participants' homes, families were welcoming but the room facilitated for the interview was not always quiet - family members were around, distracting little siblings or noisy ceiling fan. The RA asked for a more private and quiet space for the interviews when possible. It is important to mention that all 13 face-to-face interviews were conducted following COVID-19 safety measures.

Face-to-face interviews were widely preferred by school principals, research team and participants. In this way, connexion issues and misunderstandings were avoided. In addition, this method was more convenient and friendly to participants allowing them to build more rapport before starting the malnutrition-related questions. After conducting the second interview, RA noted "I will try to make the participant more comfortable before the interview and will ask them more ice-breaker questions". While some participants answered the questions very confidently, others were "nervous, confused, shy or didn't know what to reply" during the interview.

Nature of the research project: topic and methods

The research team in Pakistan informed that the topic of malnutrition is not a sensitive issue in the country, and people talk about it naturally. In this sense, the research team did not anticipate any negative consequences to the participants regarding safety and entitlement to privacy caused by the display of the photodiaries and interviews data.

Potential participants and their parents may have seen this project as something completely 'alien' to them, owing to the (abstract) nature of the topic and the method. This could have contributed to refusing to participate or being confused during the interviews. It is worth mentioning here that the photodiary instructions (Appendix 7) were designed to prompt reflection on the meaning of malnutrition and how malnutrition and its associated factors affect participants and their community. However, we recognise that snaping these reflections could have been challenging for participants. In the same way, a study using photodiaries to

promote critical language awareness among Spanish language learners asked "what is Spanish-speaking culture?" (Schwartz & Terry, 2017).

Since the 'task' was not easy to comprehend and perform, we implemented strategies to mitigate potential misunderstandings and technical problems with the Polaroid camera. RA did regular follow-up calls and visits to the schools or households to not only offer practical support but also to aid memory and motivation. When research materials were handed over, RA asked the participants to tell her what the project was about and if they had any questions regarding the process. RA also checked in with the participants during the two weeks of photodiary production and answered questions: "another student asked me if they could paste a picture of an apple and write about its nutritional components and its benefits, so I told them that they are free to paste anything and explain things according to their choice". While two participants encountered technical issues with the camera, which were resolved at the moment by the RA, another participant asked for more camera training to make the most of his photodiary.

Benefits of taking part in this study

Participants received a notebook, some school materials and a Polaroid camera in order to complete the research project. Completing a photodiary is a very time-consuming task, so the research team wanted to recognise the participants' time and energy commitment by allowing them to keep all the research materials. The research team acknowledges that the Polaroid camera may have boosted interest in taking part of the study, but the RA was careful to manage expectations and excitement. Despite this, we did not identify any participant who wanted to take part in this project merely to own a Polaroid camera. Instead, we noticed an interest in the creativity and novelty of this project.

6.3.7. Data analysis

Reflexive thematic analysis (TA) was used as a method for data analysis in this study. TA was named and developed by Braun and Clarke in 2006 as a fluid, evolving and flexible method for identifying, analysing and reporting patterns (themes) across a dataset (Braun & Clarke, 2006; Clarke & Braun, 2013). TA groups similar data patterns, which help the researcher make sense of the data. It can be used to answer a large range of research questions as well as used to analyse various kinds of data and a range of dataset sizes (Braun & Clarke, 2006; Clarke & Braun, 2013). This approach has evolved and recently been redefined by the authors as reflexive TA (Braun & Clarke, 2019; Braun & Clarke, 2021a). Reflexive TA "emphasises the

importance of the researcher's subjectivity as an analytic resource, and their reflexive engagement with theory, data and interpretation" (Braun & Clarke, 2021b).

Reflexive TA was used for two main reasons: 1) its suitability to explore people's experiences, perspectives, and understandings as well as explore the influencing factors that shape a particular phenomenon; and 2) its flexibility to be applied in different datasets and within a huge range of theoretical frameworks (Braun & Clarke, 2021a). This analysis followed a more inductive and semantic approach shaped by previous theoretical foundations and a pragmatic perspective and researcher background (see section 6.3.5. Reflexivity). The development of codes and themes was directed by the content of the data (inductive) and reflected the explicit or manifest meanings of the data (semantic) (Braun & Clarke, 2021b). In reflexive TA, these explicit meanings require the researcher's interpretation, so knowledge is generated or constructed rather than discovered (Braun & Clarke, 2021a).

Reflexive TA follows six phases for analysis (Braun & Clarke, 2021c). Firstly, the candidate became familiar with the data by actively reading the field notes, transcribed interviews and transcribed photodiaries while writing down some first ideas about coding and items of potential interest using annotations and memos in Nvivo 12. Notes were taken from individual data items (e.g. an interview or a photodiary) and in relation to the entire dataset. As emerging into the data, corrections of the transcriptions were made by the RA when the candidate noted grammatical, lexical or semantic potential errors. Data were coded by the candidate using Nvivo 12. After re-reading all codes, some were renamed, some broken into more codes and others transferred to another code due to their similarity. In total, 206 codes were identified. Next, the candidate generated seven initial themes. At this phase, a visual thematic map was built to sort the codes into themes, and a flow chart was created to represent the relationship between themes (see Figure 1 in Appendix 15). The central organising concept and its boundaries were written down as a 'story' or 'abstract' for each theme. Further reviewing and defining the themes resulted in three themes (see Figure 2 in Appendix 15). The central idea and the boundaries of these new three themes were written. All the phases, especially these themes, were shared and reviewed with LAK to construct a richer reading of the data and, consequently, themes were refined.

Braun and Clarke's checklists for reporting reflexive TA were followed (Braun & Clarke, 2006; Braun & Clarke, 2021b). Lincoln and Guba (1985) also established strategies to guarantee quality. The following techniques were used in this study 1) prolonged engagement in the field with participants and during the data familiarisation process; 2) methodological triangulation

by gathering data with different collection methods (participant's diary, interviews, research assistant's diary and candidate's diary); 3) investigator triangulation by interpreting and reviewing sessions with the research team; 4) "thick description" of the research process; 5) audit trail by transparently describing the decisions made and steps taken during the research process; and 6) reflexive diary from both researcher and RA on roles, performance, preconceptions and values. This study did not check the analysis with participants (member check); however, using photo-elicitation allowed participants to explain the meaning of their photographs, and therefore the significance of the visual data was somewhat not exclusively interpreted by the researcher.

6.3.8. Ethics

This research complied fully with the ethical practice guidelines laid out by three institutions: the University of Warwick (reference number BSREC 74/19-20 AM02, see Appendix 12), the Aga Khan University (reference number 2021-3717-16861, see Appendix 13) and the National Bioethics Committee Pakistan (reference number 4-87/NBC-630/21/1578, see Appendix 14).

Due to the changing development of the COVID-19 pandemic, ethics amendments had to be resubmitted and aligned on two different occasions. Keeping the methods more flexible or creating several data collection alternatives would have helped avoid additional amendments.

6.4. Results

The analysis produced three final themes. The first theme described the role of (good or bad) food in health and nutrition status. The second theme focused on the participants' social context influences concerning their dietary intake and food choices. The third theme explored participants' preconceptions of being healthy.

6.4.1. Theme 1: malnutrition is all about (good or bad) food

Food, specifically, what participants understood by good or bad food, recurred throughout the dataset. In photodiaries, there was a common intention to capture a variety of food items and classify them into two distinct categories, as Sakina's title diary illustrates: "merits and demerits of food" [written in English]. Generally, participants identified vegetables and fruits as "healthy" or "good", and a diet based on those items would be "good for health", "balanced", "right", or "proper". However, junk food, sugar, fried food, soft drinks, and snacks were classified as "unhealthy", "bad", or "harmful", and individuals consuming those would have a "poor quality diet", which would be "bad for health". The 'good' and the 'bad' continuously emerged from the interviews and photodiaries (Figure 14). Food and beverages

were viewed as either good or bad for health, with no middle ground with the exception of meat, bread, potato and rice. There was some controversy and confusion about the healthiness of these products amongst participants. Interestingly, the first pages usually showed good food items and their "benefits", while the last pages contained bad items (including alcoholic drinks, tobacco and smokeless tobacco) and their "side" or "adverse effects". Participants' (almost exclusive) focus on snapping pictures of good or bad food suggests that their understanding of malnutrition was in some way limited to the relationship between both. Rimsha's interview provides an example of this:

> Interviewer: the pictures you have pasted [in your diary] are mostly food items. So, how food items are related to undernutrition and overnutrition?
>
> Rimsha: if we eat good food there will be a good effect on our body and if we eat bad food there will be bad effect on our body. That is, good food causes good effect and bad food causes bad effects. It is said like that if we eat fruits, it will have a good effect. And whatever we eat good or bad, it goes into our stomach, so there must be an effect. So whatever we eat good or bad our body will get an effect of that, so good food will produce good effects and bad food will produce bad effects.

Figure 14. Rimsha's photodiary: representation of the good and the bad food

Participants photographed and wrote about the most available and consumed foods and beverages. Qirat mentioned during her interview that she had to rely on her brothers to bring her the food she wanted to capture, but by the time they brought the desired item, she had already completed her photodiary. Jannat snapped a plate containing six onions and wrote in her diary: "it [onion] is an important vegetable that is consumed in our daily life. Onions are used in Subcontinent, Pakistan and India, and all over the world". Participants displayed pictures of their favourite food items, acknowledging either the good or bad effects on health. Ashi wrote in her diary a poem about the mango – also known as "the king of fruits" among

the participants – which she copied from Youtube. On another page of her photodiary, she pasted a picture of a chocolate bar, indicating its general likeability without forgetting its unhealthiness (Figure 15).

Figure 15. Ashi's photodiary: "adverse effects of chocolate. Chocolate is something that hardly anyone dislikes. Kids, adolescents and adults all like to eat chocolate. Although it is delicious in taste, it has adverse effects too".

It is apparent participants' effort to make a colourful, well designed, thorough diary combining photos, drawings, and clippings from magazines as well as writing a few sentences about the content of the illustrations (Appendix 16). Mahi drew a dolphin on the cover of the diary, and Mary stuck some post-it page markers on the cover with words like "healthy", "sweet", "food", "unhealthy", and "fruit" [written in English]. Sakina wrote on the first page: "it's my Diary. My Diary is my most important subject. Thanks ☺" [written in English]. Many participants expressed that making the diary was "nice", "a lot of fun", and "very enjoyable". Nonetheless, Sakina commented that although she enjoyed it, she was worried about "making any mistakes". This suggests that some participants may have seen the photodiary as 'homework' since this project was embedded in a school context. Hence, their concern about making mistakes could be stemmed both from the belief of a possible evaluation like a 'school task' and the fulfilment of researchers' expectations. Even though it was a big 'task', participants appreciated the opportunity to make and learn something new:

> Ali: I was amused while colouring because I am doing this colouring activity after a long… I never had the chance or even thought to do it. I really liked that you have come [to the school] and I have worked with you on this project and I enjoyed it. I have gained more knowledge, I was not aware of so much information. I mean, I had some knowledge but it increases when a person does it by themselves.

Making this diary was recognised as a learning experience where what food is healthy or unhealthy was the main – and possibly only – takeaway: "from this [diary making experience] I learned that the food which is good for us should be taken and what is not good should be avoided" (Laraib). Moreover, there was a sense of curiosity for nutrition-related knowledge and reflection amongst the participants regarding the whole experience. For instance, Mahi commented that she will find out more information about the food that she eats from now on. Similarly, Sulman stated that he feels confident about understanding "these nutrition things", but if there is something that he does not know, he will make sure to "practise and understand it". These are vivid examples of how the photodiary enhanced their ability to reflect on their dietary choices and empowered them to keep learning.

There was an awareness that nutritious food was essential to their growth and development (Figure 16). Fruits and vegetables were the predilect energy givers amongst the participants. Statements such as "when we eat [fruit], it dissolves inside us and the energy comes into us. Our body grows, our height grows. And more energy also comes into us. As much as we eat fruits, these are so good for health" (Sunny) suggest that growth is as a recursive process that takes places not only on the outside – weight and height increase – but also on the inside. Sunny's use of the words "energy comes into us" shows how the 'power of the fruit' enters the body to subsequently make it grow from the inside to the outside. Sunny viewed 'having energy inside' as something desired and visible: "the more we take homemade meal, the more we will show that there is so much strength inside us. Others will say, 'look at yourself, how much strength is inside you'". Similar patterns were evident in the accounts of other participants when they described that unhealthy food, smoking and alcoholic drinks bring diseases and germs into the body. Perhaps this reflects an emphasis from their community and household environment to eat healthy food to grow and be in good health.

Figure 16. Jon's photodiary: "the fruit is delicious and nutritious. It helps to children's growth".

Food consistently underpinned the participants' narratives and photodiaries which was reflected in how they made sense of malnutrition. However, there was some confusion when they were asked about the meaning of undernutrition (*ghizayat ki kami*), overnutrition (*ghizayat ki ziyadti*), and vitamin and mineral deficiencies (*haya'teen or madi'niyat ki kami*). A few participants declared not knowing the answer, noted the great difficulty of the questions, or simply went silent. In the Urdu language, *ghizayat ki kami* can be literally translated as deficient in nutrients and *ghizayat ki ziyadti* as an excess of nutrients. Jannat's description of overnutrition illustrates her sense-making: "overnutrition… when eat properly, it will be fine... not having in excess of things... disadvantage of some things.. disadvantage…". All these responses probably suggest unfamiliarity and/or unawareness with malnutrition words.

Overnutrition was defined as an "excess of food" that appeared to impact people's bodies and health. There was a general acknowledgement that overnutrition "has a harmful effect on the body" (Mary), and "our body will become fat" (David) if unhealthy items were consumed. The negative impact of eating food in excess was not only limited to these "bad" items; for instance, Sulman and Rimsha commented that eating banana or mango in excess might be detrimental to health. Some participants mentioned that overnutrition was not only related to unhealthy food and beverages but also to physical activity. Physical inactivity was understood to be both the cause and the consequence of obesity. One participant (Sunny) recognised that losing weight was such a challenging and lengthy process. As opposed to overnutrition, many participants described undernutrition as a lack of (nutritious) food: "Not eating… not eating good food… eating fast food, oily food, street food, and not having vegetables, not eating fruits, not drinking milk, not drinking juice" (Rimsha). Undernutrition also appeared to have bodily connotations, which referred to insufficient weight and height.

Participants' understandings of malnutrition went beyond physical connotations to suggest emotional implications. Participants noted that experiencing emotional distress was related to nutritional status: "this [undernutrition] is due to tension" (Mary). Jon commented that people don't take care of their diet when depressed, and Sakina said that some people don't eat at all and others eat loads when depressed or stressed. Interestingly, various participants viewed junk food as particularly harmful for health and wellbeing: "many people eat fast food. People who are overweight also eat it. They do not take care of their health (…) it [fast food] affects our brain and we have depression" (Rimsha). However, they did not acknowledge experiencing any psychological distress. In the following quote, Qirat's use of the words "the children", "they", and "we" indicates detachment from these experiences. This separation is apparent throughout their narratives and will be analysed in more detail in Theme 3.

> Interviewer: you have written [in your diary] about mental health, so does mental health have anything to do with undernutrition?
>
> Qirat: Yes, if there is a fight between the parents, the children also get upset, if they go to school, they do not take interest in studies. It seems to us that they are alright but no, one knows what is going on inside them. I say that it should not be the case because we always have in our minds why this happened today. Then we do not even want to study and then we do not feel hungry. One cannot sleep at night and these thoughts continuously go on in the mind.

There was a united consensus that weakness was an undesirable consequence of malnutrition. Participants expressed that someone thin, fat or deficient in calcium or iron becomes weak and therefore falls ill and with no appetite: "when people do not take vitamins, they become weak, they also have headaches, and they do not feel hungry. They may have a fever, they will not eat anything" (Mary). Not feeling hungry seemed to be a common concern as it was understood as a sign of illness. Moreover, some participants reported that the weakness produced by being malnourished would impact productivity and physical activity: "under-nutrition… If we don't consume food, we will become weak. We will not be able to walk again, we will be completely tired. We will not be able to study well" (Mary). It is important to make here a language remark about the word weak (*kamsor*) in Urdu. In the local language, *kamsor* means low weight, but it can also indicate physical weakness, depending on the context. From the participants' accounts, it appeared that they assumed that someone underweight is inevitably weak.

Participants appeared well versed in a wide-ranging of consequences of eating unhealthy food, smoking and not exercising. They wrote in their diaries extensively about unhealthy foods affecting bones, digestive system, eyes, skin, or immune system and causing illnesses like cardiovascular disease, dental problems, kidney stones, diabetes, or cancer. In the same way, they were also aware of what foods could prevent diseases, to the extent of appointing miraculous qualities: Figure 17. For instance, Sulman wrote in his diary that lemons are good for malaria; and Mahi wrote that rubbing a slice of potato on a burned area removes the burn mark. These are examples of food myths that appeared to be developed from interactions with other people and shaped by local culture.

Figure 17. Jannat's photodiary: "banana is a blessing of God, it can treat all stomach related issues. It is also helpful in dysentery. It cures stomach pain. It treats stomach acidity. It cures dyspepsia and nausea. It is also beneficial in heartburn, and it also increases immunity."

6.4.2. Theme 2: who says what is good or bad?

The knowledge and understanding about food and health seemed to be facilitated by several influencing factors such as family, community, education, friends and media. Compelling the diary involved many participants' families giving information or even hands-on help. However, participants did not recognise families' help unless asked, probably because they perceived this project as a 'school task'. The photodiary instructions given were not specific about this, so participants could turn it into a collective project. For instance, David featured various family members while eating or smoking. Siblings appeared to be the helpers with the making; for example, Sakina's brother wrote some of the diary pages. By contrast, parents seemed to be the source of knowledge of what is good or bad: "my mother told me about it, that eating tomatoes cure anaemia. (…) When we are not eating the good things that make blood, my mother says to eat strawberries, bananas, tomatoes, chicken, mangoes" (Qirat). Parents prescribed what food must not be eaten. Some participants mentioned that they were not allowed to eat street food as it was considered unhealthy and unhygienically prepared. Yet, other parents let their children eat street food. This behaviour was found very irresponsible as parents were expected to know the adverse effects and prohibit children from eating it. Rimsha commented that parents were the ones to be blamed and responsible for their children's health since "they [kids] learn whatever they are allowed to eat, if we say this is not good for our health, they will understand and learn". It became evident that participants' understandings were influenced by family nutritional knowledge and eating behaviours. In this

regard, Sunny's father could be viewed as a role model as he encouraged healthy food choices at home:

> Sunny: my younger brother always wants to take an outdoor meal, so dad says 'no, eat a homemade meal, not the outdoor meal, these are good for health'. So my dad also does not take outdoor meal much and prefer to eat homemade food. Dad says 'eat homemade things. The more you eat homemade things, the better for your health'.

The harms of eating out versus the benefits of eating homemade food were constantly mentioned during Sunny's interview. He said that despite the harmfulness and insalubrity of street food, food vendors consciously sell these foods because they have to maintain their business. Sunny also noted that these foods are very appealing and addictive. Other participants similarly noticed that while homemade and unprocessed foods are healthy and germ-free, food from the street makes us sick. These two opposite dietary patterns appeared to be gender-specific: girls eat homemade food, and boys eat out. Mary mentioned that girls are more knowledgeable and more attentive to their diet compared to boys. This may be because girls seemed to learn more from their mothers as they spent more time at home, and mothers appeared to be more strict and controlling of their daughters. Contrastingly, boys "do not eat that much. They don't worry about hunger, they just think about going out", as Mary noted. Qirat felt that boys don't content with the food served at home and go out to eat while girls eat without complaining:

> Qirat: The first thing is that girls eat everything. Even in our house whatever is cooked, we eat quietly. But our elder brothers object that, 'what it is, what kind of vegetable it is, it is better for me to go out and eat'. All I can say is that boys should eat mostly homemade things, they should know that homemade things are more nutritious. I have two brothers in my house. If they eat lentils during the day, they do not eat the same lentils at night. They order something else from outside at night and say, 'we did eat this lentil once'. They do not know how much nutrition it will give us if we eat it twice. That is why I would say that boys should eat the same.

Participants used books from school and information acquired there to write their diaries. Formal education certainly impacted their nutritional knowledge: "we must read. Education shows what is good for us and what is not. (…) And sometimes teachers tell us, this is right for you and this is not" (David). The school was regarded as essential for their personal development and future success in life. It was not only a place to make friends but also a place where food choices needed to be made: "now as the canteen opens, the ones who bring from

home are right. Not those who eat canteen stuff, rolls, samosas, pizza, sandwiches, nuggets... This is because they are not good for health. Like buying crust, chocolate, biscuits, not these!" (Sulman). Homemade lunch was viewed as the healthiest option for eating at school as students need good nutrition to "focus on their education" (Mahi).

Friends also appeared to influence participants' food choices greatly. One participant (Mary) spoke about casual discussions with her friends about what food can be considered good or bad: "he [a friend] said 'I like pizza very much'. (…) There are green veggies in it. Let's face it. But there are many things in it that are not good. So the other one said 'I like this thing very much, we eat meat every day at home'. So we said that is also good". When Mary and other friends had seen the boy who liked pizza eating "wrong food", they advised him not to eat it because "it is not good for you" and suggested healthier alternatives instead. Peer pressure was apparent throughout the interviews. Participants mentioned that friends and neighbours insisted on eating junk food and smoking cigarettes, reassuring them that these behaviours do not cause any harm. However, the unwanted consequences of engaging in such unhealthy habits seemed clear; David alluded to gaining weight (Figure 18), and Ali noted addiction. Although having friends was considered important, many participants viewed them as bad influences. There was a general acknowledgement that adolescents become like their friends and can not be different from them:

> Mahi: If we sit in good company, it will affect our language and everything we do. If we sit with good people who eat good things and meet well, it also affects our health that I will eat what is good thing with them. If we sit with children who talk dirty, eat dirty things, use dirty language, it will affect our health negatively. We try to copy more by looking at our friends. We see them and try to be like them, so we become good, or we become bad. When we sit down with them and get up with them, we will eat what we are eating, so same effect it will have on our health.

Figure 18. David's photodiary: Friends gathering side effects. Snacks. Unwanted weight gain if portions or frequency of snacking is too much, adding excess calories. Too much snacking can reduce hunger at mealtimes or cause one to skip a meal entirely, which increases the risk of losing out on important nutrients [written in English].

Although this photodiary project was designed not to rely on the internet as limited access was supposed in the participants' context, at least half of the participants collected information for writing their diaries from the internet. Participants might have used the internet due to the complexity and novelty of the topic or their desire to create good work. As Sakina expressed: "if I make any mistakes, that is not good, isn't it?". It can be clearly seen in some participants' photodiaries that they copied entire pages from the Internet. For instance, Sunny copied the two first paragraphs from the rice entry on Wikipedia [written in English], and David copied a section on the health effects of smoking and tobacco use from the CDC website [written in English]. One participant (Mary) noticed that information from the internet or television ads could be misleading. Nevertheless, the Internet was mainly used to supplement participants' and their families knowledge of (good or bad) food.

> Sakina: I have some previous idea about what are the effects of these outside foods, what are the effects on our body. And if we have to eat outside food, what food we should eat, and how to eat. So I confirmed it from the Internet. I have some personal interests. There was no one with me at that time, so I confirmed it from the Internet.

Religion also dictated what it was to be consumed. Muslim participants wrote in their diaries that some fruits are a blessing from Allah and that Prophet said that calabash, nigella seeds and dates have healing properties. All participants, regardless of religion, labelled alcohol as very harmful for health, but Ali noticed that a "true Muslim" would never drink or touch it.

6.4.3. Theme 3: healthy like us

The majority of participants identified someone around them as overweight, thin or anaemic. Siblings, cousins, school friends were "a bit fat", "very fat", "very thin", "often sick", "with

anaemia", or "with blood sugar". However, none of the participants recognised themselves as malnourished, and declared to be healthy and eat properly. This could indicate the coexistence of different nutritional statuses within the same household. Participants were aware that thin or fat bodies were not well regarded in their culture as thin people want to put on weight to "look as good as others" (Sulman), and overweight people "get sick and do not look good" (Zainab). Both thinness and obesity were worrying and avoided due to potential stigmatisation and shame. This probably explains why participants tended to see themselves as healthy and clearly separate themselves from the 'unhealthy others'. Therefore, it was suggested that people should be "normal". In the following quote, Sulman explained what he observed from 'others' and advised eating a balanced diet:

> Sulman: I have seen that people who don't go outside and don't walk a lot, they just eat, they don't think what they eat, and they just get fat. There are some people who keep fit and even go out for a walk to lose fat. Then, you should not eat too much food, you should eat to a certain extent and you should not eat too little. Whatever you get from nutritious food, you will stay healthy and you will not suffer from any disease.

Throughout the photodiaries and interviews, all participants indicated numerous pieces of advice to be healthy (like them). Alcohol, drugs, tobacco, smokeless tobacco, fried food, non-homemade food, soft drinks, and bad influences should be certainly avoided. They suggested doing exercise and gave guidance on the frequency of consumption of some items; for instance, eating five pieces of fruit and vegetables a day, drinking one glass of milk daily, consuming chicken once per weak maximum, drinking 12 glasses of water per day, and eating an apple, banana pomegranate or tomato every day. Many participants commented that foods high in micronutrients should be consumed because they delay ageing, allow fast illness recovery, and "prevent our body from becoming weak" (Qirat). Mary used a metaphor to explain that our body has a "syllabus" of micronutrients that we should aim to "maintain". Participants also gave some hygiene recommendations, such as keeping the kitchen clean, washing fruits and vegetables before consuming, and washing hands before cooking or eating. Some participants highlighted that these recommendations were critical now to stop COVID-19 (Figure 19):

Figure 19. Sulman's photodiary: Keeping hands clean is very necessary. We can stop COVID-19 by making/spreading cleaning habits. Cleanliness is half the faith, we should stay clean at all costs. If we don't keep things clean then these germs and bacteria will make us ill. That's why we should take it as a responsibility to wash our hands before eating anything.

All these recommendations reflect comprehensive health knowledge and understanding of the importance of healthy food habits and lifestyles. Thanks to this knowledge, participants made well-informed decisions; for example, David cut down on chips. Participants mentioned that everyone, but especially adolescents, should know what should be eaten. Sakina commented that adolescents have the ability to learn about nutrition and cooking, so if they are educated on what to eat, they will put the knowledge into practice. Participants themselves and some people close to them actively learned about food and later spread the information. For instance, Ali found that milk works for preventing anaemia and told others about it; and Mahi's father read about medicine and nutrition because the doctor did not advise Mahi's ill sister what to eat. However, 'the unhealthy others' seemed not to eat mindfully and understand the harms of bad habits. Some participants felt that people were aware of the harmful effects of unhealthy products but consumed them regardless. In any case, participants considered that nutrition and health are in our own hands. As Rimsha said:

> Rimsha: undernutrition or overnutrition is caused by human itself. People should take care of their food. People should not start eating by seeing fast food oily food and not eat. And eat only vegetables, etc.

People's responsibility to eat healthily prevailed in participants' narratives. This is a vivid example of how 'the others' are to be blamed for their poor lifestyle choices. Following this responsibility discourse, most participants contemplated merely individually focused health interventions on overcoming the problem of malnutrition in their area. Informing people what to eat seemed to be the most popular measure against malnutrition. Participants suggested

nutritional counselling, informing others about the harms and benefits of the foods, displaying ads on the roads, disseminating information by word of mouth, and spreading awareness among adolescents. Jon indicated that not having stress was essential besides eating good foods. David commented that he would ask overweight children to exercise and thin children to adopt a healthy lifestyle and take medicines to put on weight. In addition, he would open clinics to treat malnourished people. Some participants viewed a straightforward solution to malnutrition: “tell them to eat and drink, don't eat these things in excess, eat properly” (Jannat). Furthermore, two participants said that if people do not eat healthily after informing them, “I can’t do anything” (Ali) and “it is their will” (Sunny). Giving food to those in need was considered by several participants to reduce malnutrition in their neighbourhood. Sulman would provide safe and healthy food and filtered safe water to the poor “so that they will be healthy like us”. Similarly, Sakina would offer food to those around her who don’t have it, but she noticed that people are not so neighbourly nowadays. As we have already noted, there appeared to be a division between the study participants and ‘others’ who needed food or information. The interventions listed by participants did not apply to them and were only for ‘others’ to become “healthy like us”.

Nonetheless, two participants indicated tackling the food environment to support healthier food choices and dietary intake. Rimsha proposed closing restaurants where fast food is sold. Ali suggested, in his own words, that health policy strategies should be evidence-based:

> Ali: I have read so much, and agreed with the chicken fact that it is harmful, it should be consumed once or twice a week. So I will allow chicken sellers accordingly, that is to sell only once or twice a week. The other shops which sell beneficial products will remain open.

6.5. Discussion

This study demonstrates adolescent sense-making, consciousness and subjective perceptions of malnutrition. Data from photodiaries and interviews generated a novel, thick conceptualisation of adolescent malnutrition and determinants of malnutrition in a slum in Pakistan.

In this study, awareness of malnutrition was embedded in participants’ food-centred understandings. Other research in LMIC has documented awareness of childhood obesity and undernutrition from parents' perspectives (Burtscher & Burza, 2015; Nguyen et al., 2021). Among Indian families, undernutrition was connected to witchcraft as well as feeding habits

such as eating age-inappropriate food, not enough food, and not drinking maternal milk (Burtscher & Burza, 2015). Similarly to our findings, Vietnamese parents related childhood obesity to unhealthy foods, and detrimental health and development (Nguyen et al., 2021). Understandings of obesity causes and consequences were investigated in a sample of children in the UK using focus groups (Fielden et al., 2011). From an early age, children seem to be aware of a broad scope of negative consequences of obesity (Fielden et al., 2011). Our participants also recognised numerous consequences of both overnutrition and undernutrition, highlighting weakness as common and severe aftermath. Unlike these children from the UK, our participants manifested physiological perceptions of growth and development. These perceptions rested on the importance of how an individual feels and is viewed (e.g. weak, ill, energetic) as well as bodily dimensions related to weight and height. Although we identified widespread malnutrition awareness among these adolescents living in a slum in Pakistan, not all participants were able to articulate a meaning for undernutrition (*ghizayat ki kami*), overnutrition (*ghizayat ki ziyadti*), and vitamin and mineral deficiencies (*haya'teen or madi'niyat ki kami*). Unfamiliarity with these terms could be due to their young age or because they did not identify themselves as thin, overweight or micronutrient deficient. While the Scaling Up Nutrition Civil Society Alliance in Pakistan (SUNCSA-Pak) reported in 2016 that malnutrition awareness spiked in the country (Scaling Up Nutrition, 2016), we argue that unawareness among adolescents could indicate that this population do not regard malnutrition as a problem in their group age. Further research should investigate the implications of malnutrition unawareness among young populations in LMIC.

Participants' sense-making around malnutrition constantly showed a pronounced dichotomy between 'the good' and 'the bad' in regards to food and lifestyle choices. This polarised reasoning may stem from culture, community and household beliefs that are internalised and incorporated into their own narratives. These results are echoed by a recent UK study exploring children's own perspectives on food choices and factors on eating behaviour (Ogden & Roy-Stanley, 2020). Shared perceptions of diet and health can also arise from cultural gender norms (Jonsson et al., 2017; Monge-Rojas et al., 2015; Núñez et al., 2015; Spencer et al., 2015). There was evidence of gendered dietary patterns in our interviews with female participants: boys tended to skip meals or eat out unhealthy food, and girls stayed at home eating homemade food and emulating their mothers. While this study resonates with evidence of the 'masculine' behaviour of eating unhealthy foods (Monge-Rojas et al., 2015) and the shared perceptions of diet between daughters and mothers (Phillips et al., 2016), it can be argued that

the effect of gender stereotype on the adoption of eating habits has to be further studied and contextualised among adolescents living in slums.

The evidence in this study suggests that participants grasped the drivers of malnutrition but did not identify malnutrition as a complex health issue involving structural determinants such as political, geographical and socioeconomic factors. Consistent with qualitative evidence in adolescents, this study identified malnutrition drivers to be sanitation (Chattopadhyay et al., 2019; Otsuka et al., 2019), exercise (Roshita et al., 2021), families (Cardel et al., 2020), peers (Watts et al., 2015), wellbeing (Hall et al., 2019; Smith et al., 2013), gender (Blum et al., 2019; Trübswasser et al., 2021b), nutritional knowledge (Banna et al., 2016), media (Watts et al., 2015), and most importantly, food (Rathi et al., 2016; Trübswasser et al., 2021b). Malnutrition appeared to be strongly linked to dietary intake and eating habits in this sample. This could be attributed to several reasons. Firstly, participants perceived that health status (feeling or being seen as weak or strong) depended greatly on what food was consumed. This understanding resembles the 'you are what you eat' principle that says "people are believed to take on the properties of the foods they eat" (Steim & Nemeroff, 1995). Secondly, they were aware of the relation between food and body weight, which aligns with previous research (Baxter et al., 2016). Thirdly, the focus of public health campaigns against malnutrition in their community. Movements such as the SUNCSA-Pak or the WFP operate with a holistic approach targeting all malnutrition determinants as well as encompassing both preventive and curative schemes. On the contrary, other campaigns against malnutrition are run by private companies that present fortified foods as the solution to children's insufficient eating patterns (e.g. https://runwaypakistan.com/morinaga-nutrition-on-toh-worries-gone/ and https://profit.pakistantoday.com.pk/2021/08/16/millions-of-children-with-malnutrition-need-your-support-sunridge-taqatwar-pakistan/). These products are widely broadcasted on television and online platforms, possibly reinforcing the understanding of 'malnutrition is all about good or bad food'. Ironically, these specific products were not targeted at people most severely affected by poverty and hence more likely to be micronutrient deficient.

By using photo-elicitation, a global health problem was revealed through the eyes of adolescents living in a slum in Pakistan. Despite the challenging nature of the topic and methods, the photodiary created by our participants provided novel insights, facilitated conversation and enriched the interview data. I did not expect the use of the internet in the photodiary making. The online search generally focused on the benefits and adverse effects of food items, as participants understood food to be related to malnutrition. Participants did not provide any meaning or explain their perceptions on malnutrition unless asked in the

interview, even though the photodiary instructions indicated “you can write your thoughts, reflections, feelings, and experiences towards undernutrition, micronutrient deficiencies and overnutrition”. Participants demonstrated an appetite for nutritional knowledge. While the photodiary appeared to provide an opportunity for gaining food literacy or reaffirming previous knowledge, the one-to-one interview seemed to evoke reflection on malnutrition meaning and offer nutritional knowledge confirmation. I noted a beneficial and empowering effect of the photodiary, as opposed to the findings from Schwartz and Terry (2017). Given the attractive and engaging nature of this method, I argue that it can open an opportunity for learning and reflection about health-related topics in adolescent populations.

Participants indicated a clear distinction between the ‘healthy us’ and the ‘unhealthy others’. Although healthy lifestyles and food habits were widely understood in this sample, it was not always evident whether they followed the theory. While food literacy allows healthier and more informed choices (Chung, 2017), knowledge does not necessarily determine behaviour, as food choices during adolescence are more motivated by factors like food safety, availability and accessibility in LMIC (Trübswasser et al., 2021a; Weller et al., 2021). There appeared to be a detachment from their narratives when talking about experiences and health behaviours. Participants expressed that they were healthy but did not exemplify their behaviour using the first person, e.g. “I do” or “I eat”. Instead, participants' narratives focused on what they observed on the unaware and irresponsible ‘others’ and what the ‘others’ should do, making them solely accountable for their poor lifestyle choices. These narratives align with norms of neoliberal discourse that place responsibility for addressing social problems on the individual. Our findings resonate with previous evidence among Pakistani communities reviling neoliberal narratives of self-critique, self-blame and self-help to resolve their social, well-being and economic issues (Khoja-Moolji, 2014; Manan, 2021; Noor et al., 2020). Ultimately, participants' narratives focused on searching for downstream interventions to address malnutrition in their community, such as providing health information and food donations. These suggested interventions appeared to be targeted only to the ‘others’. Despite the individually-focused solutions, a few participants mentioned that improving physical environments could support healthier food choices. It is necessary to better study slum environments to implement effective nutrition programs and upstream interventions to reduce malnutrition in these communities (Goudet et al., 2019).

6.5.1. Strengths and limitations

An important strength of this study was its focus on adolescents; qualitative data about adolescents was generated by them and collected from them. This present study appears to be

the first qualitative research project to explore perspectives, meanings and awareness of malnutrition among adolescents living in a LMIC and within a slum setting.

The application of photodiaries and interviews in this cross-cultural, cross-language study was useful not only to explore awareness and meanings of malnutrition among adolescents living in a slum in Pakistan but also to empower this particular community to learn about nutrition and potentially make healthier food choices. This method or other participatory research action methods using photo-elicitation could allow adolescents in LMIC to show how they experience important health issues (Estecha Querol et al., 2020; Trübswasser et al., 2021a).

However, some methodological issues need to be considered. Firstly, RA found it challenging to encourage long and elaborate responses in both photodiaries and interviews. Secondly, the researcher interpreting the data is an outsider who was not present during the fieldwork, limiting the understanding and interpretation of this highly contextual and geographically-bounded study. Thirdly, some meaning from the translated interviews and photodiaries might have been lost in backtranslation. However, the constant assistance from the wider research team in the field mitigated this.

Out-of-school adolescents were not included in this study. Since large numbers of out-of-school children and adolescents live in Pakistan (5.5 million) (UNESCO Institute for Statistics, 2015), future research should investigate how malnutrition is understood and perceived by these individuals who potentially are at higher risk of malnutrition and adverse health outcomes. Our selection criteria did not include ownership of electronic devices with internet access, minimising selection bias to higher socio-economic groups in the slum. However, the low attendance due to the COVID-19 pandemic and the student's exams period led to selecting the most reliable students. In addition, our participants had a certain interest and/or understanding of nutrition and health that enabled them to pursue this project more successfully than those students who refused to participate.

I identified some topics such as gendered dietary patterns or individual responsibility discourse that were raised during data collection. However, they could not be explored in detail as these were beyond the scope of this particular study. A slum environment has yet to be explored through a feminist and neoliberal governmentality lens to better understand adolescents' perceptions and meanings of malnutrition.

6.6. Conclusions

This study provides adolescent sense-making around malnutrition and demonstrates malnutrition awareness among 13-16 years old students living in a slum in Pakistan. In this study, malnutrition was felt as weakness and understood as a lack or excess of food. The findings demonstrated a broad range of factors influencing adolescent malnutrition in this context. The results further suggest that effective interventions for improving adolescent nutritional status need to explore their perspectives and awareness of gender norms, political, geographical and socioeconomic determinants in relation to malnutrition. Adolescents have the ability to not only participate in research but to generate insightful data. To address this global health problem, adolescents should be involved in creating research, solutions and decisions about them.

7. Chapter 7: Mixed-methods discussion and implications

Chapter summary

Chapter 7 provides an integration of the quantitative and qualitative findings. Subsequently, how the quantitative and qualitative findings apply to the framework is illustrated. The key strengths and limitations of this thesis are discussed. This chapter also provides implications for future research as well as health policy. Finally, dissemination plans are explained.

This chapter addresses objective 4 of this thesis:

- To integrate findings from the scoping review, quantitative data analysis and qualitative study and discuss associations to produce a more comprehensive understanding of adolescent malnutrition in Pakistan and develop implications for health policies and future research.

A mixed-methods approach with a parallel-databases variant design was used to address the overall aim of this thesis, which was to produce a nuanced understanding of malnutrition among South Asian adolescents. The quantitative and qualitative data were collected in parallel and analysed separately. In this thesis, the secondary quantitative data analysis calculated the burden of malnutrition and its determinants among schooled adolescents living in the eight South Asian countries. The qualitative study used photodiaries and interviews to explore awareness and perspectives of malnutrition among schooled adolescents living in a slum in Pakistan. Subsequently, the findings will be interpreted and connected by discussing to what extent and in what ways they relate to each other and produce a complete understanding of adolescent malnutrition in South Asia (Creswell & Plano Clark, 2011).

The pragmatic paradigm underpins the current thesis. Pragmatism was suitable for this research because malnutrition is a complex global health issue, and using a mixed-methods approach enabled a richer understanding of the relationship between adolescent malnutrition and its drivers.

This thesis was framed by theoretical foundations (literature review, conceptual framework, and systematic and scoping reviews), which guided the research questions and defined the study variables and measures. Literature review, conceptual framework and systematic and scoping reviews will help write the following discussion and implications to make meaningful connections between previous evidence and the results of this thesis (Rocco & Plakhotnik, 2009).

The literature review helped ground this thesis and demonstrate the importance of the topic and the need for further studying it (see 1.1. Literature review in Chapter 1). In addition, a conceptual framework was developed to guide this research (see 2.3. The proposed conceptual framework in Chapter 2). The proposed framework collected all the determinants of adolescent malnutrition and their relationship emphasised in previous frameworks (Christian & Smith, 2018; Reinhardt & Fanzo, 2014; WHO, 2005; WHO, 2018b). How the

quantitative and qualitative findings apply to the framework will be discussed later in section 7.2. Conceptual framework and mixed-methods findings.

The reviews on adolescent malnutrition in South Asia summarised what is known about the topic and identified gaps in the literature (see Chapter 3 and Chapter 4). These systematic and scoping reviews found that evidence was exclusively quantitative and predominantly used a cross-sectional design. The majority of papers were from India, showing an uneven geographical distribution of the literature. Malnutrition prevalence of the included publications varied widely due to differences in classifications, target population characteristics (e.g. age range, setting), study design, and sample sizes.

The quantitative and qualitative results have previously been summarised and interpreted separately (see 5.5. Discussion for quantitative study and see 6.5. Discussion for qualitative study). Merging the results of the two studies would be problematic because the samples of both studies are widely different, making it challenging to check for convergent or divergent results (Creswell, 2018). Instead, the following discussion demonstrates to what extent both sets of results are connected and how these results inform understanding of adolescent malnutrition in South Asia. As the qualitative study was located in Pakistan, the next section will focus on presenting the quantitative and qualitative findings from Pakistan and, additionally, bring some broader results from the South Asian context.

7.1. Mixed-methods discussion

In LMICs, undernutrition and overnutrition coexist among adolescents at the country level (Ahmad et al., 2018; Caleyachetty et al., 2018; Darling et al., 2020; Schott et al., 2019). The quantitative phase of this mixed-methods project (Chapter 5) demonstrated that the overall prevalence of stunting among South Asian schooled adolescents was 13%, thinness was 10.8%, and overweight was 10.8%, with significant geographical variations in stunting and thinness. In this secondary data analysis of the Global School-based student Health Survey (GSHS), Pakistan 2009 showed a rate for stunting at 3.9% and overweight at 8%, and reported a comparatively low prevalence of thinness (9%). Appendix 2 of the scoping review on adolescent undernutrition and micronutrient deficiency in South Asia (Chapter 4) included publications reporting higher prevalence among Pakistani adolescents compared to our findings. In these publications, stunting ranged from 12% (Jafar et al., 2008) to 90% (Durrani et al., 2007); thinness ranged from 17% (Mushtaq et al., 2011) to 25% (Kapoor et al., 2017); and anaemia was 62% (Kapoor et al., 2017). The two systematic reviews on adolescent overnutrition in

South Asia (Chapter 3) included two studies reporting overweight prevalence among Pakistani adolescents. Similarly to our findings, both studies reported that the prevalence of overweight was at 8% (Ahmed et al., 2013; Warraich et al., 2009). Although the prevalence given by our secondary data analysis appears low compared with the publications included in the mentioned reviews, these results need careful interpretation because of different study settings, age ranges, and survey years. Nevertheless, recent evidence has pointed out that child and adolescent undernutrition prevalence in South Asia remains the highest worldwide, concurring with increasing rates of overweight (NCD Risk Factor Collaboration, 2017; UNICEF, 2016; UNICEF, 2019a).

As noted in previous reviews (Chapter 3 and Chapter 4), few studies on malnutrition prevalence were conducted in Pakistan compared to other South Asian countries and no studies were located in a slum in Pakistan. The qualitative phase (Chapter 6) of the current mixed-methods study did not measure malnutrition prevalence; however, it explored malnutrition awareness among adolescents living in a slum in the city of Karachi (Pakistan). Through photodiaries and interviews, this study identified malnutrition awareness. Undernutrition was understood as a lack of food and overweight as an excess of food. Participants manifested physiological perceptions of body growth related to an increase in weight and height. According to participants, weakness was experienced by thin, overweight and micronutrient deficient individuals. It was reported as an undesired malnutrition consequence that could lead to a loss of appetite and illness. These understandings of malnutrition broaden the formal quantitative definition of undernutrition (i.e. low height or low BMI for age), overnutrition (i.e. high BMI for age) and micronutrient deficiency (i.e. lack of essential vitamins and minerals).

Food consistently underpinned participants' narratives and photodiaries which was reflected in how they made sense of malnutrition. Participants suggested that good or bad food had an impact on physical growth and health status. In the qualitative study, participants did not report their dietary intake of ‘good’ food (i.e. fruits and vegetables); however, they viewed themselves as fit and seemed to be knowledgeable about healthy lifestyles and food habits. This contrasts with the low percentage (10%) of Pakistani schooled adolescents who consumed the recommended amount of five portions of fruits and vegetables per day found in the quantitative phase. Hence, this could suggest that nutritional knowledge does not necessarily translate to healthy dietary choices.

In the quantitative phase, only 12% of schooled adolescents in Pakistan reported meeting the WHO recommended levels of physical activity. In the qualitative phase, participants suggested exercising in order to lose unwanted weight. They perceived that physical inactivity was both the cause and the consequence of overnutrition. However, sedentary behaviours were not associated with overnutrition in Pakistan in the logistic regression models.

Participants gave some hygiene recommendations such as keeping the kitchen clean, washing fruits and vegetables before consuming, and washing hands before cooking or eating. As this study was conducted a year after the outbreak of the COVID-19 pandemic, the importance of frequent hygiene practices was highlighted. Even though the GSHS in Pakistan was conducted in 2009, the habit of washing hands was already widely spread among the Pakistani sample (>92%). However, Pakistan reported the lowest rate of tooth brushing in South Asia (30%). In the logistic regression models, tooth brushing predicted overweight among schooled Pakistani adolescents.

In the secondary data analysis, in-school Pakistani adolescents reported higher rates of anxiety (8%) and loneliness (12%) than the South Asian average. Although emotional distress was not associated with nutritional status in the quantitative study, participants in the qualitative phase recognised a psychological aspect of malnutrition. In line with participants' detachment from their narratives and clear distinction from the 'others', they did not acknowledge experiencing psychological distress themselves. Some suggested that people do not mind their diet when depressed or stressed. Interestingly, various participants viewed junk food as particularly harmful for mental health, indicating that junk food could cause depression.

A chi-square test of independence was conducted in the quantitative phase to examine the association between sex and adolescent malnutrition indicators. Pakistani girls were more likely to be stunted and overweight than boys. In the qualitative phase, female participants pointed out gendered dietary patterns: girls eat homemade food without complaining while boys are not pleased with the food served at home and tend to eat out. Hence, findings from quantitative and qualitative phases may indicate that sex is a malnutrition risk factor in Pakistan.

Participants in the qualitative study suggested that having friends was important. This is in line with the high percentage of Pakistani adolescents (92%) who reported having one or more friends in the secondary data analysis. However, low peer support was found among Pakistani students (39%) compared to the South Asian average (49%). In fact, peer support was found to be a protective factor against stunting at the South Asian level, but it was not significant at the

Pakistan level. Throughout the interviews, it was evident that friends influenced lifestyle choices greatly. Our participants also viewed friends as bad influences who would insist on eating junk food and smoking. Despite peer pressure to smoke, low tobacco use rates were found at Pakistan level (6%) and South Asian level (5%) in the GSHS secondary data analysis. This could be explained by a predominantly smokeless cigarette society, religious unacceptability and strong social stigma. Ultimately, these findings evidence an apparent relationship between malnutrition and peer influence in the Pakistani context.

Parental understanding was found to be a protective factor against overweight in the logistic regression models at the Pakistan level in the GSHS sample. Descriptive analysis showed that one in two schooled Pakistani adolescents reported being supported by their parents. In the qualitative phase, we found that participants' nutritional knowledge and eating habits stemmed from family beliefs and practices, which were internalised and incorporated into their own narratives. In addition, it was evident from the interviews that formal education had also an impact on participants' nutritional knowledge and eating habits. Good nutrition was regarded as key to succeeding at school, determining working capacity and future success in life. From these findings, one may conclude that households and schools are two key environments that Pakistani adolescents observe and learn from, having the potential to impact their health and nutritional status.

The secondary data analysis did not explore interventions or health policies tackling adolescent malnutrition because it was not available in the dataset. However, in the qualitative phase, participants suggested how to address this issue. People's responsibility to eat healthily was highlighted by participants, implying that people are to be blamed for their poor lifestyle choices. Following this responsibility discourse, most participants contemplated merely individually focused health interventions on overcoming the problem of malnutrition in their area. For instance, they suggested providing health information and food donations.

The following section illustrates how the conceptual framework (Chapter 2) is relevant to this mixed-methods discussion.

7.2. Conceptual framework and mixed-methods findings: the Pakistani case

The conceptual framework presented in Chapter 2 informed this thesis by providing an evidence-based overview of adolescent malnutrition's main drivers and consequences. It also assisted in deciding which variables were relevant in the quantitative study and tailoring the qualitative study materials.

The findings discussed in the previous section enhance the conceptual framework on adolescent malnutrition. Figure 20 displays how the quantitative and qualitative findings apply to this framework, focusing on the Pakistani context.

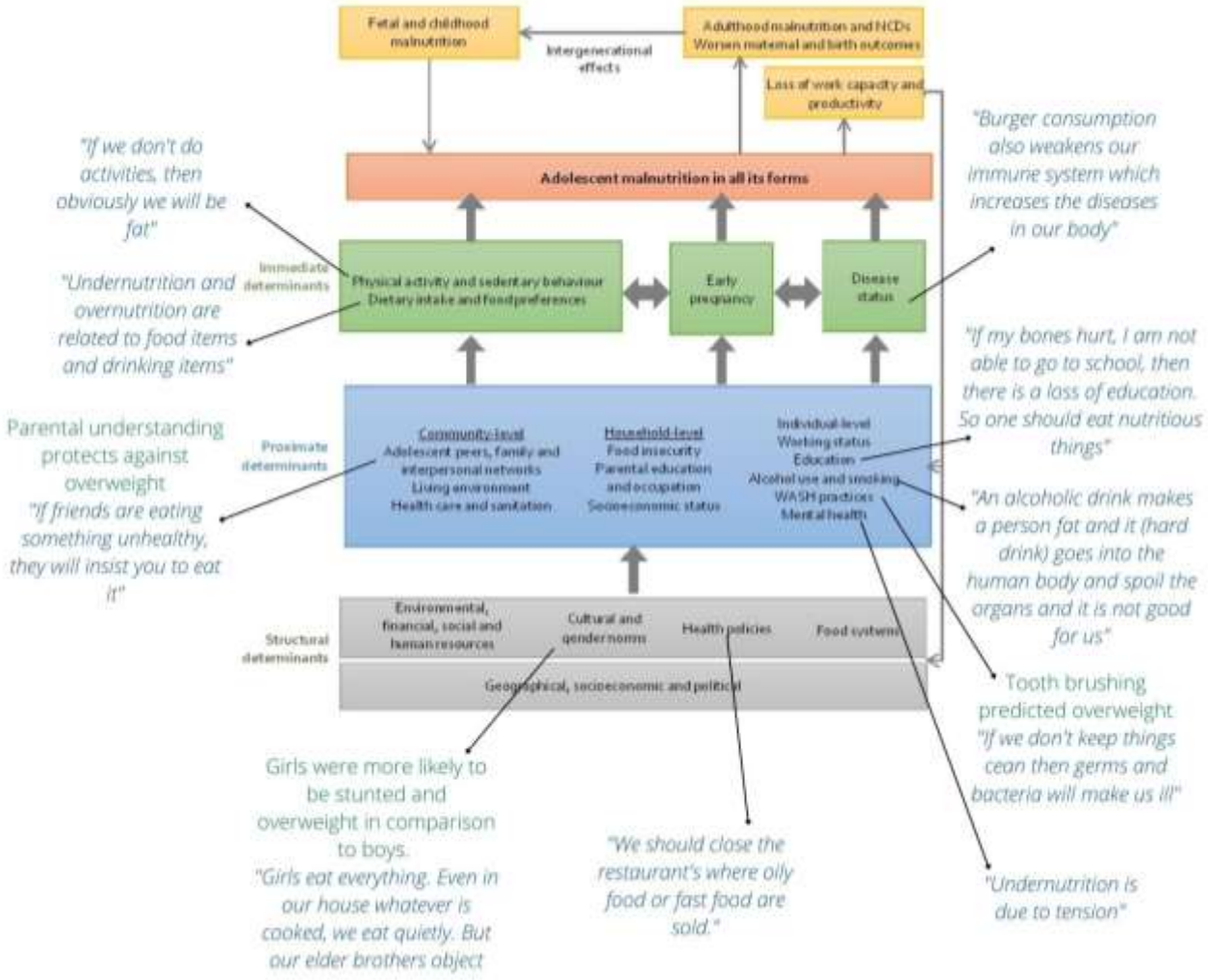

Figure 20. Conceptual framework on adolescent malnutrition fed with the quantitative and qualitative findings of the current thesis – Pakistan-focused. Findings from the quantitative phase are in green and findings from the qualitative phase are in blue.

Furthermore, in the qualitative phase of the current mixed-methods thesis, it was evident that participants' understandings were shaped by their nutritional knowledge and health consciousness. These domains – nutritional knowledge and malnutrition awareness – could potentially add value to this conceptual framework.

7.3. Strengths and limitations

The strengths and limitations of the scoping review, the secondary data analysis and the qualitative study were outlined in their respective chapters. Key strengths and limitations of this mixed-methods thesis are considered in this section.

7.3.1. Key strengths of this PhD thesis

This mixed-methods study is well positioned to better understand, in a holistic manner and from an adolescent perspective, malnutrition and influencing factors in the Pakistani context. A novel insight of this global health issue was developed by using both quantitative and qualitative data. This thesis not only extends the existing knowledge but also opens a door for new methods exploring malnutrition among adolescent populations. Hence, the findings are likely to be interesting to those conducting research with adolescents.

Applying mixed-methods allowed tackling a broader range of research questions. The current PhD thesis had four clear objectives that were addressed by using different methods (review, statistical analysis and qualitative analysis) and types of data (previous evidence, closed-ended and open-ended data). This is a strength as the resulting synthesis generated a bigger picture of the status of adolescent malnutrition in Pakistan.

The mixed-methods design and the pragmatism worldview allowed a flexible selection of the research procedures to best answer the research questions. In this sense, using a publicly available dataset and collecting qualitative data from 14 participants was practical, feasible, and COVID-19-sensible. Ultimately, the findings provide implications for policy and research, addressing public health issues with limited resources.

By using a mixed-methods study, the findings are enhanced and complemented, bringing greater insight into the problem that would be obtained by either type of data separately. Pictures and narratives were used to add insights to numbers and go beyond the quantitative definition of malnutrition. The GSHS survey added precision to the qualitative data. In this regard, one-to-one interviews could have felt like a test to the participants, and they might have clearly separated themselves from the 'others' in order not to be judged. However, survey participants might have provided frequency on health behaviours more accurately due to the survey's anonymity.

7.3.2. Key limitations of this PhD thesis

One of the limitations of this research was that the samples of the quantitative and qualitative studies vary greatly in space and time: national representative sample of schooled adolescents surveyed in 2009 vs small sample of schooled adolescents living in a slum recruited in 2021.

This made it challenging to achieve side-by-side comparison and interpretation of the findings. Nevertheless, this mixed-methods study provides in-depth insights into adolescent malnutrition gained using different methods and combining all the findings.

Important drivers of malnutrition such as food insecurity, household socioeconomic status, food systems, and early pregnancy were not investigated in this thesis. Although it is essential to examine the complexity of adolescent malnutrition, it was not feasible to investigate all adolescent malnutrition determinants in this doctoral thesis due to time and resources limitations.

A further limitation of this thesis was that the PhD candidate was not present during the qualitative data collection, so she had to rely on others for this work. This meant additional training to the RA, logistic issues, data transfer agreement, virtual monitoring and additional check points to ensure the methods were adhered to.

7.4. Implications for future research

There are several implications of the current thesis findings for future research. This section starts with implications that could be applied across the South Asian countries and ends with Pakistan- and slum-specific implications.

Results from the scoping review provide a baseline from which future research can move forward. The scoping review identified a lack of variety in study designs to explore adolescent malnutrition in South Asia. RCT, longitudinal, interventional, qualitative and mixed-methods studies could contribute to a better understanding of adolescent malnutrition by exploring causality instead of association, evaluating the cost-effectiveness of supplementation and school feeding programs, and assessing if experiences from adolescents match with malnutrition drivers given by quantitative research. There is much scope for further research investigating adolescent undernutrition and micronutrient deficiencies in Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka. In addition, further research needs to be conducted in slum settings and with out-of-school adolescents.

There is also an urgent need for research on estimating the prevalence of adolescent malnutrition at the population level using not only anthropometry but also nutritional biomarkers. The scoping review found that thinness (BMI-for-age) was more frequently used to measure adolescent nutritional status than stunting (height-for-age) or micronutrient deficiencies. Future studies should include all three indicators since they assess different forms

of malnutrition. In addition, other indicators such as dietary diversity, food insecurity and healthy diets measures could potentially complement anthropometry and nutritional biomarkers. Opportunities are wide open for further research investigating these dietary-based measures among South Asian adolescents.

Determining the magnitude of the burden of malnutrition and monitoring it is essential to develop appropriate policies and actions to accelerate progress towards ending adolescent malnutrition. However, defining the prevalence of the burden of malnutrition at the country level as high, medium or low in this population group is not possible. While malnutrition prevalence thresholds for public health significance in children are defined (de Onis et al., 2019), these have not been established for adolescents yet. Future research should aim to develop these thresholds for adolescent populations because classifying the prevalence of malnutrition in adolescents may improve monitoring, identifying priorities, mobilising action and tailoring interventions addressing malnutrition.

Furthermore, there is only one publicly available health and nutrition survey collecting quality data on South Asian adolescents, which was used for the quantitative analysis of this thesis. The GSHS samples are representative of all students in a given country, and its methodology is standardised across countries which allows for calculating malnutrition indicators at the population level across South Asian countries. However, this survey has some limitations that future global health and nutrition surveillance should consider. Firstly, basic participants' sociodemographic information such as ethnicity, religion, rural/urban setting and household socioeconomic status should be collected in health and nutrition surveys, so analysis to explore further inequalities among subgroups can be performed. Secondly, out-of-school adolescents should be included in surveys so that malnutrition prevalence can be assessed and monitored. Thirdly, the reliability and validity of the survey questionnaires across countries should be tested to ensure robust conclusions from the data. Fourthly, nutritional biomarkers data should be collected in health and nutrition surveys aiming to investigate the burden of malnutrition.

Findings from the qualitative study provide a novel insight into adolescent malnutrition; however, more in-depth qualitative research is needed across other South Asian countries. Future studies should explore different qualitative methods to collect data among adolescents with no ownership of smartphones and no access to the Internet. These methods should be engaging, creative and participatory: focus groups, mapping, workshops, photowalks, photovoice, photodiaries, graffiti walls, drawings, vignettes, zine-making, and completing the

story. Where the setting or the budget allows, technology could also enable other formats such as online diaries, videodiaries and podcasts.

Malnutrition determinants were indicated by the conceptual framework and explored further in this thesis. The findings suggest that malnutrition is a large-scale and complex health problem that needs further investigation to better understand what determinants worsen or mitigate the burden of malnutrition in adolescents across different settings in all South Asian countries. In addition, future research should investigate potential malnutrition drivers such as nutritional knowledge and awareness, which could be ultimately added to the conceptual framework.

Results from the quantitative and the qualitative studies aid in developing the following Pakistan- and slum-focused recommendations for future research:

- As dietary intake and food preferences are immediate determinants of malnutrition, future research should identify factors that prevent or support adolescents in consuming healthy foods as well as investigate perceived needs and preferences.
- More comprehensive studies are needed to examine the influences that may either enhance or impede the likelihood of physical activity among adolescents.
- Gender norms and gender-specific eating habits should be acknowledged and further investigated in order to reduce gender inequalities in health.
- Further research should reveal how malnutrition could be reduced with peer and social support.
- Further studies should investigate how community and family nutritional knowledge and beliefs impact adolescent malnutrition.
- The role of schools in educating and promoting health and nutrition should be further studied in order to support the school curriculum and teachers to guide adolescents' healthy lifestyle choices.
- Future research should explore adolescent perspectives, needs and preferences on health interventions tackling the problem of malnutrition to ensure uptake and cultural sensitivity.
- How the COVID-19 pandemic impacted malnutrition, food system, food insecurity, and hunger should be examined.

7.5. Implications for health policy

There are several implications for health policymakers. As the new COVID-19 pandemic shaped the current thesis, this section starts pointing out the additional challenge of COVID-19 for the South Asian context concerning nutrition goals and actions. Then, how efforts to improve adolescent nutrition have been introduced globally are presented. Finally, Pakistan- and slum-focused implications for policy-makers are listed.

COVID-19 has triggered global economic and nutrition crises. In South Asia, the population have experienced disruptions in health services and food systems as well as a rise in food insecurity and poverty rates. As a result of the impact of COVID-19, child and maternal mortality are predicted to increase by 15-50% in South Asia (UNICEF et al., 2021). Poorer households and slums areas are the most affected in this region (Owais, 2021). COVID-19 pandemic presents an unprecedented global threat to hunger and malnutrition (Fore et al., 2020; Headey et al., 2020; Osendarp et al., 2021) and setbacks the progress toward meeting the 2030 global nutrition goals (Committee on World Food Security, 2020; Fan et al., 2021). However, some global health and nutrition experts have pointed out the COVID-19 pandemic as an opportunity to create resilient food systems and improve health and nutrition outcomes in South Asia (Heck et al., 2020; Wilkins, 2020). In the virtual conference on *Delivering for Nutrition (D4N) in South Asia: Implementation Research in the Context of COVID-19* in December 2021, Saskia Osendarp commented: “these predictions do not have to become destiny, we still have room to reverse the numbers. If governments and societies act now, act fast and act for everyone, the nutrition impacts of COVID-19 can be mitigated”. Yet, COVID-19 mitigation responses have primarily targeted children and women (Akseer et al., 2020; FAO et al., 2020). Actions and policies to support nutrition in the context of COVID-19 should also protect and enhance the nutritional status of adolescents in South Asia.

Effective interventions, programmes and policies should address the identified immediate, proximate and structural determinants of adolescent malnutrition, carefully tackling one form without worsening the other. These actions aiming to tackle all forms of malnutrition simultaneously have been named double-duty actions (WHO, 2017a). Hawkes et al. (2020) identified ten double-duty actions that have strong potential to reduce the risk of all forms of malnutrition but acknowledged that new actions should be designed purposively to tackle malnutrition at different stages of the lifecycle, including adolescence.

Adolescent health and nutrition have been overlooked in health services, policies and interventions (Hargreaves et al., 2022; WHO, 2005). However, this trend is changing, and

adolescence is getting more recognition in global agendas and research priorities. A Lancet Series on Adolescent Nutrition was launched in November 2021 to highlight the role of nutrition in adolescent growth and the drivers of adolescent food choice (Neufeld et al., 2022; Norris et al., 2022). This Series also provides recommendations on how to achieve better adolescent nutrition outcomes, which could positively impact health through the course of life into the next generation (Hargreaves et al., 2022).

Adolescent nutrition should be made a priority in South Asian countries, where 30% of the world's adolescent population is located (UNICEF, 2019b). Global actions and governments' commitments need to be taken to address malnutrition in all its forms. Actions to address this issue are underway in Indonesia, for instance. In collaboration with UNICEF, this country identified adolescent nutrition as a priority and designed an integrated package of nutrition-specific and nutrition-sensitive interventions (Rah et al., 2021). Cambodia, Bolivia, India, Portugal provide more examples of countries where governments are at the centre to create actions and health policies directed to adolescents (Al-Jawaldeh et al., 2022). Assisted by international agencies, governments in South Asia should prioritise adolescent health and allocate more resources to develop effective interventions addressing malnutrition in this generation.

Adolescent participation is acknowledged as an essential factor to develop and implement health interventions and policies targeting this group: "nothing about us, without us" (WHO, 2017b). Researchers, governments and international agencies need to promote healthy eating habits (e.g. from Indonesia, *#CoolToEat*: https://www.wfp.org/news/wfp-and-government-launch-digital-campaign-promote-healthy-eating-among-indonesian-adolescents), collect adolescents' views (e.g. 20 countries involved, *Fix my Food*: https://www.unicef.org/documents/fix-my-food), and raise malnutrition awareness (e.g. from Indonesia, *With Good Nutrition She'll Grow Into It* https://scalingupnutrition.org/news/a-campaign-to-address-malnutrition-among-adolescent-girls-in-indonesia/). Youth is a powerful force who have already mobilised for climate and are currently advocating for nutrition in initiatives such as *Act for Food Act for Change* (https://actions4food.org/en/) or *Bite Back 2030* (https://www.biteback2030.com/). Researchers, governments and international agencies need to ensure that these youth movements are supported and heard.

Findings from this doctoral thesis aid in developing the following recommendations for policy-makers, focusing on Pakistan and slum settings:

- Data collection systems should be strengthened to allow monitoring of malnutrition prevalence and its determinants. Out-of-school adolescents should be included.
- Government should ensure that nutrient-rich foods are more available, affordable, convenient, safe, and appealing in environments that are usually visited by adolescents (e.g. schools, playgrounds).
- Education and health policy-makers should collaborate to guarantee healthy school food environments. They also should include nutritional education in the school curricula as well as provide skills for autonomy over healthy food choices.
- Raise awareness about malnutrition as well as the benefits of good diets and healthy lifestyles. However, campaigns raising awareness need to be careful not to rely on individual responsibility.
- Policies and interventions addressing adolescent malnutrition should include two key factors: families and schools.
- National and local governments should identify adolescent malnutrition as a priority in their agendas.
- There is a need for regulatory interventions to guarantee that nutrition information is accurate, available and easy to understand for adolescents.
- National and local governments should actively seek adolescent participation in health interventions and policies directed to them.
- Government and international organisations should explore ways to engage with adolescents who have no access to the Internet, or live in remote and poorly serviced areas.

7.6. Dissemination of PhD findings

The PhD findings have been and will be further disseminated to different target audiences: academics and adolescents. This section describes what has been disseminated to date and is planned to be disseminated in the future.

7.6.1. Disseminating findings to the public

Public engagement activities serve as a way for the researcher to share findings with the public. As part of the dissemination of this thesis findings, I decided to run Public Engagement workshops with adolescents. The purpose of these workshops is manifold: 1) to inspire adolescents to become the researchers of the future; 2) to raise awareness of adolescent malnutrition (social impact); 3) to share what I do; and 4) to improve my skills (professional

development). To achieve these aims, I have divided the content into two workshops. The first workshop has already been delivered (see Table 18), and the second workshop will take place on the 6th of May 2022 (see Table 19). These workshops will be run at my previous high school (IES Matarraña High School in Valderrobres, Spain) in the English language class, targeting adolescents aged 16 years.

Table 18. Public engagement activity: first workshop at IES Matarraña High School in Valderrobres.

	FIRST WORKSHOP – 11TH FEBRUARY 2022
TITLE	International Day of Women in Science - I am a scientist and I am from your village
AIMS	➢ To inspire adolescents to become the researchers of the future ➢ To improve my skills (professional development)
CONTENT	1. Evaluating and measuring impact - hands up before and after • *Who wants to be a researcher?* 2. Answer in handout and class debate • *What is science? What do you think a researcher does?* 3. Presentation of 9 women (who I know) doing science in different research fields. 4. Answer in handout, class debate and a short presentation • *What is research useful for?* • *What challenges do you think a researcher faces?* 5. Imagination exercise - answer in handout and class debate • *If you had the opportunity... what would you research about?* 6. Evaluating and measuring impact - answer in handout and class debate • *What else would you add to your definition of research?* • *What have you learned new about the role of researchers?*

Table 19. Public engagement activity: second workshop at IES Matarraña High School in Valderrobres.

	SECOND WORKSHOP – 6TH MAY 2022
TITLE	What does malnutrition mean for you?
AIMS	➢ To raise awareness of adolescent malnutrition (social impact) ➢ To share what I do ➢ To improve my skills (professional development)
CONTENT	1. Evaluating and measuring impact – post-it notes wall • *What is malnutrition?* 2. Class debate 3. Presentation of the qualitative research findings. 4. Evaluating and measuring impact – online wall using phones • *What is malnutrition?* • *What have you learned new?*

5. Class debate
    - *Have our perspectives changed?*
6. Evaluating and measuring impact – survey
7. Q&A

On the occasion of the first public engagement workshop celebrating the International Day of Women and Girls in Science, I was interviewed live by the local radio to talk about this experience (https://www.lacomarca.net/podcasts/descripcion-de-dia-de-la-mujer-y-la-nina-en-la-ciencia-la-facultad-y-sara-estecha/), and this was also featured in another local newspaper (https://matarranya.media/cultura/2022/02/16/lies-matarranya-se-suma-al-dia-de-la-dona-i-nena-a-la-ciencia/).

Furthermore, I have established contact with the Engagement Officer at Warwick Institute of Engagement (WIE), Naomi Kay. These workshops will receive WIE funding and will be shared on the WIE website.

The findings are likely to be interesting to the senior leadership team of the IES Matarraña High School, senior leadership teams in other schools and those who conduct public engagement activities with adolescents. The public engagement workshops will therefore be written up as lay report and shared with the IES Matarraña High School management team.

These workshops will be delivered following the four principles of high-quality engagement of the National Co-ordinating Centre of Public Engagement (NCCPE, 2020). The GRIPP2 reporting checklists (Staniszewska et al., 2017) will be used to write the findings that will be submitted for publication in a peer-reviewed scientific journal.

7.6.2. Disseminating findings to academic audiences

To date, several publications from this doctoral thesis have been published in peer-reviewed journals and conferences, see Published work and dissemination section. The findings of the scoping review, quantitative study and qualitative study have been presented at several national and international conferences, see Published work and dissemination section. In addition, this PhD project was submitted at the 10th UK Doctoral Research Awards Competition 2021 and was awarded in the Natural Life Science category.

At a future date, the qualitative study and the public engagement workshops will be submitted for publication in a peer-reviewed scientific journal:

- “Good food causes good effect and bad food causes bad effects”: awareness, meanings and perceptions of malnutrition among Pakistani adolescents living in slums through photodiaries and interviews. Manuscript in preparation
- Breaking the stereotype of a scientist as an old man in a lab coat: a Public Engagement workshop with high school students from a rural area in Spain.
- Meanings of malnutrition for high school students from a rural area in Spain: a Public Engagement workshop.

8. References

Abaasa, C.N., Rukundo, G.Z., Ayesiga, S., Atukunda, S.P., Campisi, S., O'Hearn, S. and MacDonald, N. (2021) Healthcare providers and caregivers' perspectives on factors responsible for persistent malnutrition of under 5 children in Buhweju district, South Western Uganda; a phenomenological qualitative study, *BMC Public Health*, 21, 1, 1495.

Abdirahman, H.A., Bah, T.T., Shrestha, H.L. and Jacobsen, K.H. (2012) Bullying, mental health, and parental involvement among adolescents in the Caribbean, *West Indian Med J*, 61, 5, 504-8.

Agrahar-Murugkar, D. (2005) Nutritional status of Khasi schoolgirls in Meghalaya, *Nutrition*, 21, 4, 425-431.

Agrawal, V.K., Agrawal, P. and Dharmendra (2013) Prevalence and determinants of xerophthalmia in rural children of Uttarpradesh, India, *Nepalese Journal of Ophthalmology : A Biannual Peer-reviewed Academic Journal of the Nepal Ophthalmic Society : NEPJOPH*, 5, 2, 226-9.

Aguilar-Farias, N., Martino-Fuentealba, P., Carcamo-Oyarzun, J., Cortinez-O'Ryan, A., Cristi-Montero, C., Von Oetinger, A. and Sadarangani, K.P. (2018) A regional vision of physical activity, sedentary behaviour and physical education in adolescents from Latin America and the Caribbean: results from 26 countries, *Int J Epidemiol*, 47, 3, 976-986.

Ahmad, S., Shukla, N.K., Singh, J.V., Shukla, R. and Shukla, M. (2018) Double burden of malnutrition among school-going adolescent girls in North India: A cross-sectional study, *J Family Med Prim Care*, 7, 6, 1417-1424.

Ahmed, F., Khan, M.R., Akhtaruzzaman, M., Karim, R., Marks, G.C., Banu, C.P., Nahar, B. and Williams, G. (2005) Efficacy of twice-weekly multiple micronutrient supplementation for improving the hemoglobin and micronutrient status of anemic adolescent schoolgirls in Bangladesh, *Am J Clin Nutr*, 82, 4, 829-35.

Ahmed, F.K., M. R.; Akhtaruzzaman, M.; Karim, R.; Williams, G.; Torlesse, H.; Darnton-Hill, I.; Dalmiya, N.; Banu, C. P.; Nahar, B. (2010) Long-term intermittent multiple micronutrient supplementation enhances hemoglobin and micronutrient status more than iron + folic acid supplementation in Bangladeshi rural adolescent girls with nutritional anemia, *Journal of Nutrition*, 140, 10, 1879-86.

Ahmed, F.K., M. R.; Banu, C. P.; Qazi, M. R.; Akhtaruzzaman, M. (2008) The coexistence of other micronutrient deficiencies in anaemic adolescent schoolgirls in rural Bangladesh, *European Journal of Clinical Nutrition*, 62, 3, 365-72.

Ahmed, J., Laghari, A., Naseer, M. and Mehraj, V. (2013) Prevalence of and factors associated with obesity among Pakistani schoolchildren: a school-based, cross-sectional study, *East Mediterr Health J*, 19, 3, 242-7.

Ahmed, S.A.K.S., Ajisola, M., Azeem, K., Bakibinga, P., Chen, Y.-F., Choudhury, N.N., Fayehun, O., Griffiths, F., Harris, B., Kibe, P., Lilford, R.J., Omigbodun, A., Rizvi, N., Sartori, J., Smith, S., Watson, S.I., Wilson, R., Yeboah, G., Aujla, N., Azam, S.I., Diggle, P.J., Gill, P., Iqbal, R., Kabaria, C., Kisia, L., Kyobutungi, C., Madan, J.J., Mberu, B., Mohamed, S.F., Nazish, A., Odubanjo, O., Osuh, M.E., Owoaje, E., Oyebode, O., Porto de Albuquerque, J., Rahman, O., Tabani, K., Taiwo, O.J., Tregonning, G., Uthman, O.A. and Yusuf, R. (2020) Impact of the societal response to COVID-19 on access to healthcare for non-COVID-19 health issues in slum communities of Bangladesh, Kenya, Nigeria and Pakistan: results of pre-COVID and COVID-19 lockdown stakeholder engagements, *BMJ Global Health*, 5, 8, e003042.

Akhtar, S. (2016) Malnutrition in South Asia-A Critical Reappraisal, *Crit Rev Food Sci Nutr*, 56, 14, 2320-30.

Akseer, N., Kandru, G., Keats, E.C. and Bhutta, Z.A. (2020) COVID-19 pandemic and mitigation strategies: implications for maternal and child health and nutrition, *The American Journal of Clinical Nutrition*, 112, 2, 251-256.

Al-Jawaldeh, A., Bekele, H., de Silva, A., Gomes, F., Untoro, J., Wickramasinghe, K., Williams, J. and Branca, F. (2022) A new global policy framework for adolescent nutrition?, *The Lancet*, 399, 10320, 125-127.

Allen, A., Allen, S., Rodrigo, R., Perera, L., Shao, W., Li, C., Wang, D., Olivieri, N. and Weatherall, D.J.P., A. (2017) Iron status and anaemia in Sri Lankan secondary school children: A cross-sectional survey, *PLoS ONE*, 12, e0188110.

Allen, L. (2008) Young people's 'agency' in sexuality research using visual methods, *Journal of Youth Studies*, 11, 6, 565-577.

Alwan, H., Viswanathan, B., Rousson, V., Paccaud, F. and Bovet, P. (2011) Association between substance use and psychosocial characteristics among adolescents of the Seychelles, *BMC Pediatr*, 11, 85.

Ameer, S.R., Ahmad, S.R. and Chandrasekhar, A. (2018) Assessment of underweight and its determinants among school going adolescents in Hyderabad, *Indian J Public Health Res Dev*, 9, 5, 77-82.

American Dental Association (2013) American Dental Association Statement on Regular Brushing and Flossing to Help Prevent Oral Infections <https://www.ada.org/en/press-room/news-releases/2013-archive/august/american-dental-association-statement-on-regular-brushing-and-flossing-to-help-prevent-oral> Accessed 5 November 2020

Anik, A.I., Rahman, M.M., Rahman, M.M., Tareque, M.I., Khan, M.N. and Alam, M.M. (2019) Double burden of malnutrition at household level: A comparative study among Bangladesh, Nepal, Pakistan, and Myanmar, *PLoS One*, 14, 8, e0221274.

Arksey, H. and O'Malley, L. (2005) Scoping studies: towards a methodological framework, *Int J Soc Res Methodol*, 8, 1, 19-32.

Bakibinga, P., Kabaria, C., Kyobutungi, C., Manyara, A., Mbaya, N., Mohammed, S., Njeri, A., Azam, I., Iqbal, R., Mazaffar, S., Rizvi, N., Rizvi, T., ur Rehman, H., Shifat Ahmed, S.A.K., Alam, O., Khan, A.Z., Rahman, O., Yusuf, R., Odubanjo, D., Ayobola, M., Fayehun, F., Omigbodun, A., Owoaje, E., Taiwo, O., Diggle, P., Aujla, N., Chen, Y.-F., Gill, P., Griffiths, F., Harris, B., Madan, J., Lilford, R.J., Oyobode, O.R., Pitidis, V., de Albequerque, J.P., Sartori, J., Taylor, C., Ulbrich, P., Uthman, O., Watson, S.I., Yeboah, G. and Improving Health in Slums, C. (2019) A protocol for a multi-site, spatially-referenced household survey in slum settings: methods for access, sampling frame construction, sampling, and field data collection, *BMC Medical Research Methodology*, 19, 1, 109.

Banks, M. (2008) Using Visual Data in Qualitative Research.

Banna, J.C., Buchthal, O.V., Delormier, T., Creed-Kanashiro, H.M. and Penny, M.E. (2016) Influences on eating: a qualitative study of adolescents in a periurban area in Lima, Peru, *BMC Public Health*, 16, 1, 40.

Baxter, S.L., Collins, S.C. and Hill, A.J. (2016) 'Thin people … they're healthy': young children's understanding of body weight change, *Pediatric Obesity*, 11, 5, 418-424.

Becker, A.E., Roberts, A.L., Perloe, A., Bainivualiku, A., Richards, L.K., Gilman, S.E. and Striegel-Moore, R.H. (2010) Youth health-risk behavior assessment in Fiji: the reliability of Global School-based Student Health Survey content adapted for ethnic Fijian girls, *Ethn Health*, 15, 2, 181-97.

Bhargava, M., Bhargava, A., Ghate, S.D. and Rao, R.S.P. (2020) Nutritional status of Indian adolescents (15-19 years) from National Family Health Surveys 3 and 4: Revised estimates using WHO 2007 Growth reference, *PLoS One*, 15, 6, e0234570.

Bharthi, K., Ghritlahre, M., Das, S. and Bose, K. (2017) Nutritional status among children and adolescents aged 6-18 years of Kolam tribe of Andhra Pradesh, India, *Anthropological Review*, 80, 2, 153-163.

Bhattacharyya, M., Roy, S., Sarkar, A., Sinha, R.N., Mallick, A.K. and Bandyopadhyay, S. (2021) Burden of malnutrition among school-going children in a slum area of Kolkata: A matter of concern, *J Family Med Prim Care*, 10, 8, 2940-2946.

Bisai, S., Bose, K. and Dikshit, S. (2009) Underweight and stunting among slum children of Midnapore, India, *J Paediatr Child Health*, 45, 3, 161-2.

Biswas, T., Magalhaes, R.J.S., Townsend, N., Das, S.K. and Mamun, A. (2020) Double Burden of Underweight and Overweight among Women in South and Southeast Asia: A Systematic Review and Meta-analysis, *Adv Nutr*, 11, 1, 128-143.

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. and Uauy, R. (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries, *Lancet*, 382, 9890, 427-451.

Blum, L.S., Khan, R., Sultana, M., Soltana, N., Siddiqua, Y., Khondker, R., Sultana, S. and Tumilowicz, A. (2019) Using a gender lens to understand eating behaviours of adolescent females living in low-income households in Bangladesh, *Matern Child Nutr*, 15, 4, e12841.

Bose, K. and Bisai, S. (2008) Prevalence of underweight and stunting among school children in West Bengal, *Indian J Pediatr*, 75, 12, 1272.

Bose, K. and Mukhopadhyay, A. (2004) Nutritional status of adolescent Bengalee boys, *Indian Pediatr*, 41, 6, 633.

Braun, V. and Clarke, V. (2006) Using thematic analysis in psychology, *Qualitative Research in Psychology*, 3, 2, 77-101.

Braun, V. and Clarke, V. (2019) Reflecting on reflexive thematic analysis, *Qualitative Research in Sport, Exercise and Health*, 11, 4, 589-597.

Braun, V. and Clarke, V. (2021a) Conceptual and design thinking for thematic analysis.

Braun, V. and Clarke, V. (2021b) One size fits all? What counts as quality practice in (reflexive) thematic analysis?, *Qualitative Research in Psychology*, 18, 3, 328-352.

Braun, V. and Clarke, V. (2021c) *Thematic Analysis: A Practical Guide*, London: SAGAE Plublications Ltd.

Braun, V. and Clarke, V. (2021d) To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales, *Qualitative Research in Sport, Exercise and Health*, 13, 2, 201-216.

British Dental Association (2020) Brushing: top tips for your patients <https://bda.org/toptips#:~:text=Brushing%20your%20teeth%20twice%20a,a%20good%20oral%20hygiene%20routine.> Accessed 5 November 2020

Burtscher, D. and Burza, S. (2015) Health-seeking behaviour and community perceptions of childhood undernutrition and a community management of acute malnutrition (CMAM) programme in rural Bihar, India: a qualitative study, *Public Health Nutr*, 18, 17, 3234-43.

Caleyachetty, R., Echouffo-Tcheugui, J.B., Tait, C.A., Schilsky, S., Forrester, T. and Kengne, A.P. (2015) Prevalence of behavioural risk factors for cardiovascular disease in adolescents in low-income and middle-income countries: an individual participant data meta-analysis, *Lancet Diabetes Endocrinol*, 3, 7, 535-44.

Caleyachetty, R., Thomas, G.N., Kengne, A.P., Echouffo-Tcheugui, J.B., Schilsky, S., Khodabocus, J. and Uauy, R. (2018) The double burden of malnutrition among adolescents: analysis of data from the Global School-Based Student Health and Health Behavior in School-Aged Children surveys in 57 low- and middle-income countries, *American Journal of Clinical Nutrition*, 108, 2, 414-424.

Cardel, M.I., Szurek, S.M., Dillard, J.R., Dilip, A., Miller, D.R., Theis, R., Bernier, A., Thompson, L.A., Dulin, A., Janicke, D.M. and Lee, A.M. (2020) Perceived barriers/facilitators to a healthy lifestyle among diverse adolescents with overweight/obesity: A qualitative study, *Obesity Science & Practice*, 6, 6, 638-648.

Carter, S. and Mankoff, J. (2005) When participants do the capturing: the role of media in diary studies *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Portland, Oregon, USA: Association for Computing Machinery. pp. 899–908.

Cashin, K. and Oot, L. (2018) Guide to Anthropometry: A Practical Tool for Program Planners, Managers, and Implementers <https://www.fantaproject.org/sites/default/files/resources/FANTA-Anthropometry-Guide-May2018.pdf>

CDC (2018) Global school-based student health survey (GSHS) <https://www.cdc.gov/GSHS/> Accessed 25 April 2019

Chakrabarty, S. and Bharati, P. (2008) Physical growth and nutritional status of the Shabar tribal adolescents of Orissa, India: A cross-sectional study, *Malaysian Journal of Nutrition*, 14, 1, 101-112.

Chakraborty, K. (2009) 'The good Muslim girl': conducting qualitative participatory research to understand the lives of young Muslim women in the bustees of Kolkata, *Children's Geographies*, 7, 4, 421-434.

Chakraborty, S., Chopra, M., Mani, K., Giri, A.K., Banerjee, P., Sahni, N.S., Siddhu, A., Tandon, N. and Bharadwaj, D. (2018) Prevalence of vitamin B-12 deficiency in healthy Indian school-going adolescents from rural and urban localities and its relationship with various anthropometric indices: a cross-sectional study, *J Hum Nutr Diet*, 31, 4, 513-522.

Chakravathy, K.P., Thippeswamy, H.M., Kumar, N. and Chenna, D. (2013) Relationship of body mass index and dental caries with oral health related quality of life among adolescents of Udupi district, South India, *Eur Arch Paediatr Dent*, 14, 3, 155-9.

Chattopadhyay, A., Sethi, V., Nagargoje, V.P., Saraswat, A., Surani, N., Agarwal, N., Bhatia, V., Ruikar, M.M., Bhattacharjee, S., Parhi, R.N., Dar, S., Daniel, A., Sachdev, H., Singh, C., Gope, R., Nath, V., Sareen, N., Wagt, A.d. and Unisa, S. (2019) WASH practices and its association with nutritional status of adolescent girls in poverty pockets of eastern India, *BMC Women's Health*, 19.

Choudhary, S.K., S.; Dabi, D.; Parakh, M.; Dara, P. K.; Parakh, P.; Vyas, S.; Deopa, B. (2016) Urban Rural Comparison of Anthropometry and Menarcheal Status of Adolescent School Going Girls of Jodhpur, Rajasthan, India, *J Clin Diagn Res*, 10, 10, SC8-SC12.

Choudhuri, D. and Balaram, S. (2020) Factors Associated with Nutritional Status of Adolescent Schoolchildren in Tripura, *Indian Pediatr*, 57, 2, 177-178.

Christian, P. and Smith, E.R. (2018) Adolescent Undernutrition: Global Burden, Physiology, and Nutritional Risks, *Ann Nutr Metab*, 72, 4, 316-328.

Chung, L.M.Y. (2017) Food Literacy of Adolescents as a Predictor of Their Healthy Eating and Dietary Quality, *Journal of Child and Adolescent Behavior*, 5: e117.

Clarke, V. and Braun, V. (2013) *Successful Qualitative Research: A Practical Guide for Beginners*, London: SAGE.

Committee on World Food Security (2020) Impacts of COVID-19 on food security and nutrition: developing effective policy responses to address the hunger and malnutrition pandemic <https://www.fao.org/3/cb1000en/cb1000en.pdf> Accessed 18 March 2022

Creswell, J.W. and Plano Clark, V.L. (2011) *Designing and conducting mixed methods research*, Los Angeles: SAGE Publications.

Creswell, J.W.C.J.D. (2018) *Research design : qualitative, quantitative, and mixed methods approaches*.

Darling, A.M., Fawzi, W.W., Barik, A., Chowdhury, A. and Rai, R.K. (2020) Double burden of malnutrition among adolescents in rural West Bengal, India, *Nutrition*, 79-80, 110809.

Das, D.K.B., R. (2005) Nutritional status of adolescent girls in a rural area of North 24 Parganas district, West Bengal, *Indian Journal of Public Health*, 49, 1, 18-21.

Das, P., Ray, S.K., Joardar, G.K. and Dasgupta, S. (2007) Nutritional profiles of adolescents in a rural community of Hooghly district in West Bengal, *Indian Journal of Public Health*, 51, 2, 120-1.

Das, S., Fahim, S.M., Islam, M.S., Biswas, T., Mahfuz, M. and Ahmed, T. (2019) Prevalence and sociodemographic determinants of household-level double burden of malnutrition in Bangladesh, *Public Health Nutr*, 22, 8, 1425-1432.

Davis, J.N., Oaks, B.M. and Engle-Stone, R. (2020a) The Double Burden of Malnutrition: A Systematic Review of Operational Definitions, *Current Developments in Nutrition*, 4, 9.

Davis, L.E., Abio, A., Wilson, M.L. and Shaikh, M.A. (2020b) Extent, patterns and demographic correlates for physical fighting among school-attending adolescents in Namibia: examination of the 2013 Global School-based Health Survey, *PeerJ*, 8, e9075.

de Lanerolle-Dias, M., de Silva, A., Lanerolle, P., Arambepola, C. and Atukorala, S. (2012) Micronutrient status of female adolescent school dropouts, *Ceylon Med J*, 57, 2, 74-8.

de Onis, M., Borghi, E., Arimond, M., Webb, P., Croft, T., Saha, K., De-Regil, L.M., Thuita, F., Heidkamp, R., Krasevec, J., Hayashi, C. and Flores-Ayala, R. (2019) Prevalence thresholds for wasting, overweight and stunting in children under 5 years, *Public Health Nutr*, 22, 1, 175-179.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C. and Siekmann, J. (2007) Development of a WHO growth reference for school-aged children and adolescents, *Bulletin of the World Health Organization*, 85, 9, 660-667.

Debnath, M., Tigga, P.L., Mondal, N. and Sen, J. (2016) Birth order, father's occupation and family size are strongly associated with thinness among bengalee adolescent girls of Darjeeling district, West Bengal (India), *J Nepal Paediatr Soc*, 36, 2, 115-120.

Durrani, N.U.R., Ahmad, Z. and Abbas, K.A. (2007) Nutritional and health status of school age children in Islamabad Capital Territory, *Pak Pediatr J*, 31, 4, 190-194.

Estecha Querol, S., Al-Khudairy, L., Iqbal, R. and Gill, P. (2020) Application of the photovoice method to promote partnerships and engagement with the community in a slum in Pakistan. In: Abstracts of the Fundación Iberoamericana de Nutrición (FINUT) Conference 2020, *Annals of Nutrition and Metabolism*, 76(suppl 4), 4, 105.

Estecha Querol, S., Gill, P., Iqbal, R., Kletter, M., Ozdemir, N. and Al-Khudairy, L. (2021) Adolescent undernutrition in South Asia: a scoping review, *Nutrition Research Reviews*, 1-29.

Faizi, N., Khan, Z., Khan, I.M., Amir, A., Azmi, S.A. and Khalique, N. (2017) A study on nutritional status of school-going adolescents in Aligarh, India, *Trop Doct*, 47, 3, 212-216.

Fan, S., Teng, P., Chew, P., Smith, G. and Copeland, L. (2021) Food system resilience and COVID-19 – Lessons from the Asian experience, *Global Food Security*, 28, 100501.

FAO (2014) FAO expert talks about malnutrition's 'triple burden' <http://www.fao.org/europe/news/detail-news/en/c/271772/> Accessed 15 February 2019

FAO, UNICEF, WFP and WHO (2018) The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. <http://www.fao.org/3/I9553EN/i9553en.pdf>

FAO, WFP, WHO and UNICEF (2020) Joint statement on nutrition in the context of the COVID-19 pandemic in Asia and the Pacific <https://www.unicef.org/eap/media/5211/file> Accessed 16 March 2022

Fernandes, N., Khubchandani, J., Seabert, D. and Nimkar, S. (2015) Overweight status in Indian children: prevalence and psychosocial correlates, *Indian Pediatr*, 52, 2, 131-4.

Fielden, A.L., Sillence, E. and Little, L. (2011) Children's understandings' of obesity, a thematic analysis, *Int J Qual Stud Health Well-being*, 6, 3.

Fikree, F.F. and Pasha, O. (2004) Role of gender in health disparity: the South Asian context, *BMJ*, 328, 7443, 823-826.

Fore, H.H., Dongyu, Q., Beasley, D.M. and Ghebreyesus, T.A. (2020) Child malnutrition and COVID-19: the time to act is now, *The Lancet*, 396, 10250, 517-518.

Fournier, B., Bridge, A., Mill, J., Alibhai, A., Kennedy, A.P. and Konde-Lule, J. (2014) Turning the Camera Back:A Photovoice Project With Ugandan Children who are Orphaned and Living with HIV, *SAGE Open*, 4, 2, 2158244014530997.

Gao, L., Bhurtyal, A., Wei, J., Akhtar, P., Wang, L. and Wang, Y. (2020) Double Burden of Malnutrition and Nutrition Transition in Asia: A Case Study of 4 Selected Countries with Different Socioeconomic Development, *Adv Nutr*, 11, 6, 1663-1670.

Garg, M.K., Marwaha, R.K., Khadgawat, R., Ramot, R., Obroi, A.K., Mehan, N., Gupta, N. and Madan, R. (2013a) Efficacy of vitamin D loading doses on serum 25-hydroxy vitamin D levels in school going adolescents: an open label non-randomized prospective trial, *Journal of Pediatric Endocrinology & Metabolism*, 26, 5-6, 515-23.

Garg, P., Kaur, S., Gupta, D., Osmond, C., Lakshmy, R., Sinha, S., Kapil, U. and Sachdev, H.P.S. (2013b) Variability of thinness and its relation to cardio-metabolic risk factors using four body mass index references in school-children from Delhi, India, *Indian Pediatrics*, 50, 11, 1025-1032.

Godakanda, I., Abeysena, C. and Lokubalasooriya, A. (2018) Sedentary behavior during leisure time, physical activity and dietary habits as risk factors of overweight among school children aged 14-15 years: case control study, *BMC Res Notes*, 11, 1, 186.

Goudet, S., Griffiths, P., Bogin, B. and Madise, N. (2017a) Interventions to tackle malnutrition and its risk factors in children living in slums: a scoping review, *Annals of Human Biology*, 44, 1, 1-10.

Goudet, S.M., Bogin, B.A., Madise, N.J. and Griffiths, P.L. (2019) Nutritional interventions for preventing stunting in children (birth to 59 months) living in urban slums in low- and middle-income countries (LMIC), *Cochrane Database Syst Rev*, 6, 6, Cd011695.

Goudet, S.M., Faiz, S., Bogin, B.A. and Griffiths, P.L. (2011) Pregnant women's and community health workers' perceptions of root causes of malnutrition among infants and young children in the slums of Dhaka, Bangladesh, *Am J Public Health*, 101, 7, 1225-33.

Goudet, S.M., Kimani-Murage, E.W., Wekesah, F., Wanjohi, M., Griffiths, P.L., Bogin, B. and Madise, N.J. (2017b) How does poverty affect children's nutritional status in Nairobi slums? A qualitative study of the root causes of undernutrition, *Public Health Nutr*, 20, 4, 608-619.

Goyle, A. (2012) Effect of micronutrient fortified biscuit supplementation on the weight, height and BMI of adolescent girls, *Coll Antropol*, 36, 2, 573-579.

Grant, M.J. and Booth, A. (2009) A typology of reviews: an analysis of 14 review types and associated methodologies, *Health Info Libr J*, 26, 2, 91-108.

Green, E.M., Spivak, C. and Dollahite, J.S. (2021) Early adolescent food routines: A photo-elicitation study, *Appetite*, 158, 105012.

Gupta, A. and Gupta, S. (2018) Prevalence of iron deficiency anaemia in healthy adolescent girls from low to medium socio-economic strata living in one of the fastest developing economies, *Br J Haematol*, 181, 167-168.

Gupta, A., Kapil, U., Ramakrishnan, L.P., Ravindra, Yadav, C., Pandey, R.M. and Yadav, C.P. (2017) Prevalence of Vitamin B12 and Folate Deficiency in School Children Residing at High Altitude Regions in India, *Indian J Pediatr*, 84, 4, 289-293.

Gupta Bansal, P., Singh Toteja, G., Bhatia, N., Kishore Vikram, N., Siddhu, A., Kumar Garg, A. and Kumar Roy, A. (2015) Deficiencies of Serum Ferritin and Vitamin B12, but not Folate, are Common in Adolescent Girls Residing in a Slum in Delhi, *Int J Vitam Nutr Res*, 85, 1-2, 14-22.

Guthold, R., Cowan, M.J., Autenrieth, C.S., Kann, L. and Riley, L.M. (2010) Physical activity and sedentary behavior among schoolchildren: a 34-country comparison, *J Pediatr*, 157, 1, 43-49.e1.

Hall, B.J., Garabiles, M.R., de Hoop, J., Pereira, A., Prencipe, L. and Palermo, T.M. (2019) Perspectives of adolescent and young adults on poverty-related stressors: a qualitative study in Ghana, Malawi and Tanzania, *BMJ Open*, 9, 10, e027047.

Harding, K.L., Aguayo, V.M. and Webb, P. (2019) Trends and Correlates of Overweight among Pre-School Age Children, Adolescent Girls, and Adult Women in South Asia: An Analysis of Data from Twelve National Surveys in Six Countries over Twenty Years, *Nutrients*, 11, 8.

Hargreaves, D., Mates, E., Menon, P., Alderman, H., Devakumar, D., Fawzi, W., Greenfield, G., Hammoudeh, W., He, S., Lahiri, A., Liu, Z., Nguyen, P.H., Sethi, V., Wang, H., Neufeld, L.M. and Patton, G.C. (2022) Strategies and interventions for healthy adolescent growth, nutrition, and development, *The Lancet*, 399, 10320, 198-210.

Harun-Or-Rashid, M., Khatun, U.F., Yoshida, Y., Morita, S., Chowdhury, N. and Sakamoto, J. (2009) Iron and iodine deficiencies among under-2 children, adolescent girls, and pregnant women of Bangladesh: association with common diseases, *Nagoya journal of medical science*, 71, 1-2, 39-49.

Hashan, M.R., Das Gupta, R., Day, B. and Al Kibria, G.M. (2020) Differences in prevalence and associated factors of underweight and overweight/obesity according to rural-urban residence strata among women of reproductive age in Bangladesh: evidence from a cross-sectional national survey, *BMJ Open*, 10, 2, e034321.

Hawkes, C., Ruel, M.T., Salm, L., Sinclair, B. and Branca, F. (2020) Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms, *Lancet*, 395, 10218, 142-155.

Headey, D., Heidkamp, R., Osendarp, S., Ruel, M., Scott, N., Black, R., Shekar, M., Bouis, H., Flory, A., Haddad, L. and Walker, N. (2020) Impacts of COVID-19 on childhood malnutrition and nutrition-related mortality, *Lancet*, 396, 10250, 519-521.

Heck, S., Campos, H., Barker, I., Okello, J.J., Baral, A., Boy, E., Brown, L. and Birol, E. (2020) Resilient agri-food systems for nutrition amidst COVID-19: evidence and lessons from food-based approaches to overcome micronutrient deficiency and rebuild livelihoods after crises, *Food Security*, 12, 4, 823-830.

Herter-Aeberli, I., Thankachan, P., Bose, B. and Kurpad, A.V. (2016) Increased risk of iron deficiency and reduced iron absorption but no difference in zinc, vitamin A or B-vitamin status in obese women in India, *Eur J Nutr*, 55, 8, 2411-2421.

Hettiarachchi, M., Liyanage, C., Wickremasinghe, R., Hilmers, D. and Abrams, S. (2006a) Nutrient intake and growth of adolescents in southern Sri Lanka, *Ceylon Medical Journal*, 51, 3, 89-92.

Hettiarachchi, M., Liyanage, C., Wickremasinghe, R., Hilmers, D.C. and Abrahams, S.A. (2006b) Prevalence and severity of micronutrient deficiency: a cross-sectional study among adolescents in Sri Lanka, *Asia Pacific Journal of Clinical Nutrition*, 15, 1, 56-63.

Hettiarachchi, M., Liyanage, C., Wickremasinghe, R., Hilmers, D.C. and Abrams, S.A. (2008) The efficacy of micronutrient supplementation in reducing the prevalence of anaemia and deficiencies of zinc and iron among adolescents in Sri Lanka, *European Journal of Clinical Nutrition*, 62, 7, 856-865.

Hirst, J., Formby, E. and Owen, J. (2006) Pathways into parenthood: reflections from three generations of teenage mothers and fathers. Project Report. <https://core.ac.uk/download/pdf/99919.pdf> Accessed 8 December 2021

Hlatshwako, T.G., Shah, S.J., Kosana, P., Adebayo, E., Hendriks, J., Larsson, E.C., Hensel, D.J., Erausquin, J.T., Marks, M., Michielsen, K., Saltis, H., Francis, J.M., Wouters, E. and Tucker, J.D. (2021) Online health survey research during COVID-19, *Lancet Digit Health*, 3, 2, e76-e77.

Hossain, M.S., Ferdous, S., Raheem, E. and Siddiqee, M.H. (2020) The double burden of malnutrition; further perspective, *The Lancet*, 396, 10254, 813-814.

Hyder, S.M., Haseen, F., Khan, M., Schaetzel, T., Jalal, C.S., Rahman, M., Lonnerdal, B., Mannar, V. and Mehansho, H. (2007) A multiple-micronutrient-fortified beverage affects hemoglobin, iron, and vitamin A status and growth in adolescent girls in rural Bangladesh, *Journal of Nutrition*, 137, 9, 2147-53.

Imenda, S. (2014) Is There a Conceptual Difference between Theoretical and Conceptual Frameworks?, *Journal of Social Sciences*, 38, 2, 185-195.

Independent Expert Group of the Global Nutrition Report (2018) 2018 Global Nutrition Report <https://globalnutritionreport.org/reports/global-nutrition-report-2018/>

Jafar, T.H., Qadri, Z., Islam, M., Hatcher, J., Bhutta, Z.A. and Chaturvedi, N. (2008) Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children, *Archives of Disease in Childhood*, 93, 5, 373-378.

Jayatissa, R. and Ranbanda, R.M. (2006) Prevalence of challenging nutritional problems among adolescents in Sri Lanka, *Food & Nutrition Bulletin*, 27, 2, 153-60.

Jayawardena, R., Ranasinghe, P., Wijayabandara, M., P. Hills, A. and Misra, A. (2017) Nutrition Transition and Obesity Among Teenagers and Young Adults in South Asia, *Current Diabetes Reviews*, 13, 5, 444-451.

Johnson, A.R., Balasubramanya, B., Shaiby, S.R. and Britto, R.D. (2015) Body image perception and nutritional status of adolescents in a school in rural South India, *J Indian Assoc Child Adolesc Ment Health*, 11, 4, 260-278.

Jones, N., Camfield, L., Coast, E., Samuels, F., Hamad, B. A., Yadete, W., Amayreh, W., Odeh, K. B., Sajdi, J., Rashid, S., Sultan, M., Malachoswka, A. and Presler-Marshall, E. (2018) GAGE baseline qualitative research tools

Jonsson, L., Larsson, C., Berg, C., Korp, P. and Lindgren, E.-C. (2017) What undermines healthy habits with regard to physical activity and food? Voices of adolescents in a disadvantaged community, *International Journal of Qualitative Studies on Health and Well-being*, 12, sup2, 1333901.

Kapil, U., Pandey, R., Goswami, R., Sharma, B., Sharma, N., Ramakrishnan, L., Singh, G., Sareen, N., Sati, H., Gupta, A. and Sofi, N. (2017) Prevalence of Vitamin D deficiency and associated risk factors among children residing at high altitude in Shimla district, Himachal Pradesh, India, *Indian J Endocrinol Metab*, 21, 1, 178-183.

Kapil, U., Pandey, R.M., Sharma, B., Ramakrishnan, L., Sharma, N., Singh, G. and Sareen, N. (2018) Prevalence of Vitamin D Deficiency in Children (6-18 years) Residing in Kullu and Kangra Districts of Himachal Pradesh, India, *Indian J Pediatr*, 85, 5, 344-350.

Kapil, U. and Sareen, N. (2014) Prevalence of ferritin, folate and vitamin B12 deficiencies amongst children in 5-18 years of age in Delhi, *Indian J Pediatr*, 81, 3, 312.

Kapoor, A., Channa, N.A., Soomro, A.M., Tunio, S.A., Khand, T.U. and Memon, N. (2017) Malnutrition and clinical manifestations in school going children at district tharparkar, sindh, pakistan, *Rawal Medical Journal*, 43, 1, 115-119.

Karki, S., Päkkilä, J., Ryhänen, T., Laitala, M.-L., Humagain, M., Ojaniemi, M. and Anttonen, V. (2019) Body mass index and dental caries experience in Nepalese schoolchildren, *Community Dentistry and Oral Epidemiology*, 47, 4, 346-357.

Kaushik, V. and Walsh, C.A. (2019) Pragmatism as a Research Paradigm and Its Implications for Social Work Research, *Social Sciences*, 8, 9, 255.

Kawade, R. (2012) Zinc status and its association with the health of adolescents: a review of studies in India, *Glob Health Action*, 5, 7353.

Kelly, L.M. and Cordeiro, M. (2020) Three principles of pragmatism for research on organizational processes, *Methodological Innovations*, 13, 2, 2059799120937242.

Kennedy, E., Binder, G., Humphries-Waa, K., Tidhar, T., Cini, K., Comrie-Thomson, L., Vaughan, C., Francis, K., Scott, N., Wulan, N., Patton, G. and Azzopardi, P. (2020) Gender inequalities in health and wellbeing across the first two decades of life: an analysis of 40 low-income and middle-income countries in the Asia-Pacific region, *The Lancet Global Health*, 8, 12, e1473-e1488.

Khadgawat, R., Marwaha, R.K., Garg, M.K., Ramot, R., Oberoi, A.K., Sreenivas, V., Gahlot, M., Mehan, N., Mathur, P. and Gupta, N. (2013) Impact of vitamin D fortified milk supplementation on vitamin D status of healthy school children aged 10-14 years, *Osteoporosis International*, 24, 8, 2335-43.

Khan, A., Burton, N.W. and Khan, S.R. (2013) Double burden of overweight and underweight among school children of Dhaka city, Bangladesh, *Obes Res Clin Pract*, 1, 26.

Khan, A.A., Bano, N. and Salam, A. (2007) Child Malnutrition in South Asia: A Comparative Perspective, *South Asian Survey*, 14, 1, 129-145.

Khoja-Moolji, S. (2014) Producing neoliberal citizens: critical reflections on human rights education in Pakistan, *Gender and Education*, 26, 2, 103-118.

Kismul, H., Hatløy, A., Andersen, P., Mapatano, M., Van den Broeck, J. and Moland, K.M. (2015) The social context of severe child malnutrition: a qualitative household case study from a rural area of the Democratic Republic of Congo, *International Journal for Equity in Health*, 14, 1, 47.

Kulkarni, V.S., Kulkarni, V.S. and Gaiha, R. (2017) "Double Burden of Malnutrition": Reexamining the Coexistence of Undernutrition and Overweight Among Women in India, *Int J Health Serv*, 47, 1, 108-133.

Kumar, S., Kroon, J., Lalloo, R., Kulkarni, S. and Johnson, N.W. (2017) Relationship between body mass index and dental caries in children, and the influence of socio-economic status, *Int Dent J*, 67, 2, 91-97.

Kushal, S.A., Amin, Y.M., Reza, S. and Shawon, M.S.R. (2021) Parent-adolescent relationships and their associations with adolescent suicidal behaviours: Secondary analysis of data from 52 countries using the Global School-based Health Survey, *EClinicalMedicine*, 31.

Lamba, R., Misra, S.K., Agrawal, R. and Rana, R. (2014) To study the prevalence of anemia and related biosocial factors among college going adolescent girls in urban Agra, *Indian J Public Health Res Dev*, 5, 2, 35-38.

Lansford, J.E. and Banati, P. (2018) *Handbook of adolescent development research and its impact on global policy*, New York: Oxford University Press.

Laxmaiah, A., Arlappa, N., Balakrishna, N., Mallikarjuna Rao, K., Galreddy, C., Kumar, S., Ravindranath, M. and Brahmam, G.N. (2013) Prevalence and determinants of micronutrient deficiencies among rural children of eight states in India, *Annals of Nutrition & Metabolism*, 62, 3, 231-41.

Liamputtong, P. (2010) *Performing Qualitative Cross-Cultural Research*, Cambridge: Cambridge University Press.

Lilford, R., Kyobutungi, C., Ndugwa, R., Sartori, J., Watson, S.I., Sliuzas, R., Kuffer, M., Hofer, T., Porto de Albuquerque, J. and Ezeh, A. (2019) Because space matters: conceptual framework to help distinguish slum from non-slum urban areas, *BMJ Global Health*, 4, 2, e001267.

Lindberg, L., Nhambongo, I., Nhampossa, T., Munguambe, K. and Priebe, G. (2021) A qualitative study of mothers' health literacy related to malnutrition in under 5-year-old children in southern Mozambique, *Public Health Nutr*, 1-9.

Madley-Dowd, P., Hughes, R., Tilling, K. and Heron, J. (2019) The proportion of missing data should not be used to guide decisions on multiple imputation, *Journal of Clinical Epidemiology*, 110, 63-73.

Maiti, S., Ali, K.M., De, D., Bera, T.K., Ghosh, D. and Paul, S. (2011) A comparative study on nutritional status of urban and rural early adolescent school girls of West Bengal, India, *J Nepal Paediatr Soc*, 31, 3, 169-174.

Mak, K.K. and Tan, S.H. (2012) Underweight problems in Asian children and adolescents, *Eur J Pediatr*, 171, 5, 779-85.

Manan, S.A. (2021) 'English is like a credit card': the workings of neoliberal governmentality in English learning in Pakistan, *Journal of Multilingual and Multicultural Development*, 1-17.

Mandot, S., Mandot, D. and Sonesh, J.K. (2009) Nutritional status of tribal (Garasia) school children of Sirohi district, Rajasthan, *Indian Pediatrics*, 46, 5, 437-8.

Mazidi, M., Banach, M. and Kengne, A.P. (2018) Prevalence of childhood and adolescent overweight and obesity in Asian countries: a systematic review and meta-analysis, *Arch Med Sci*, 14, 6, 1185-1203.

Medhi, G.K., Hazarika, N.C. and Mahanta, J. (2007) Nutritional status of adolescents among tea garden workers, *Indian J Pediatr*, 74, 4, 343-7.

Meenakshi, J.V. (2016) Trends and patterns in the triple burden of malnutrition in India, *Agricultural Economics*, 47, S1, 115-134.

Merriam, S.B.G.R.S. (2019) Qualitative Research in Practice : Examples for Discussion and Analysis.

Mistry, S.K. and Puthussery, S. (2015) Risk factors of overweight and obesity in childhood and adolescence in South Asian countries: a systematic review of the evidence, *Public Health*, 129, 3, 200-9.

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G. (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, *PLoS Med*, 6, 7, e1000097.

Mokdad, A.H., Forouzanfar, M.H., Daoud, F., Mokdad, A.A., El Bcheraoui, C., Moradi-Lakeh, M., Kyu, H.H., Barber, R.M., Wagner, J., Cercy, K., Kravitz, H., Coggeshall, M., Chew, A., O'Rourke, K.F., Steiner, C., Tuffaha, M., Charara, R., Al-Ghamdi, E.A., Adi, Y., Afifi, R.A., Alahmadi, H., AlBuhairan, F., Allen, N., AlMazroa, M., Al-Nehmi, A.A., AlRayess, Z., Arora, M., Azzopardi, P., Barroso, C., Basulaiman, M., Bhutta, Z.A., Bonell, C., Breinbauer, C., Degenhardt, L., Denno, D., Fang, J., Fatusi, A., Feigl, A.B., Kakuma, R., Karam, N., Kennedy, E., Khoja, T.A., Maalouf, F., Obermeyer, C.M., Mattoo, A., McGovern, T., Memish, Z.A., Mensah, G.A., Patel, V., Petroni, S., Reavley, N., Zertuche, D.R., Saeedi, M., Santelli, J., Sawyer, S.M., Ssewamala, F., Taiwo, K., Tantawy, M., Viner, R.M., Waldfogel, J., Zuniga, M.P., Naghavi, M., Wang, H., Vos, T., Lopez, A.D., Al Rabeeah, A.A., Patton, G.C. and Murray, C.J. (2016) Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013, *Lancet*, 387, 10036, 2383-401.

Mondal, N. (2014) Thinness as major underlying problem among adolescents of northeast India, *J Nepal Paediatr Soc*, 34, 1, 39-47.

Mondal, N. and Sen, J. (2010) Prevalence of stunting and thinness among rural adolescents of Darjeeling district, West Bengal, India, *Italian Journal of Public Health*, 7, 1, 54-61.

Mondal, N. and Terangpi, M. (2014) Prevalence of undernutrition among tribal adolescents of Karbi Anglong district of Assam, Northeast India, *Sri Lanka Journalof Child Health*, 43, 3, 154-158.

Monge-Rojas, R., Fuster-Baraona, T., Garita, C., Sánchez, M., Smith-Castro, V., Valverde-Cerros, O. and Colon-Ramos, U. (2015) The influence of gender stereotypes on eating habits among Costa Rican adolescents, *Am J Health Promot*, 29, 5, 303-10.

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A. and Aromataris, E. (2018) Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach, *BMC Medical Research Methodology*, 18, 1, 143.

Mushtaq, M.U., Gull, S., Khurshid, U., Shahid, U., Shad, M.A. and Siddiqui, A.M. (2011) Prevalence and socio-demographic correlates of stunting and thinness among Pakistani primary school children, *BMC Public Health*, 11, 790.

Muthayya, S., Thankachan, P., Hirve, S., Amalrajan, V., Thomas, T., Lubree, H., Agarwal, D., Srinivasan, K., Hurrell, R.F., Yajnik, C.S. and Kurpad, A.V. (2012) Iron Fortification of Whole Wheat Flour Reduces Iron Deficiency and Iron Deficiency Anemia and Increases Body Iron Stores in Indian School-Aged Children, *Journal of Nutrition*, 142, 11, 1997-2003.

Nayriro, M. (2018) Re-Conceptualizing School Continuation & Re-Entry Policy for Young Mothers Living in an Urban Slum Context in Nairobi, Kenya: A Participatory Approach, *Studies in Social Justice*, 12, 310-328.

NCCPE (2020) About quality engagement <https://www.publicengagement.ac.uk/do-engagement/quality-engagement/about-quality-engagement> Accessed 25 March 2022

NCD Risk Factor Collaboration (2017) Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults, *Lancet*, 390, 10113, 2627-2642.

Neufeld, L.M., Andrade, E.B., Ballonoff Suleiman, A., Barker, M., Beal, T., Blum, L.S., Demmler, K.M., Dogra, S., Hardy-Johnson, P., Lahiri, A., Larson, N., Roberto, C.A., Rodríguez-Ramírez, S., Sethi, V., Shamah-Levy, T., Strömmer, S., Tumilowicz, A., Weller, S. and Zou, Z. (2022) Food choice in transition: adolescent autonomy, agency, and the food environment, *The Lancet*, 399, 10320, 185-197.

Nguyen, T., Trat, T., Tieu, N.T., Vu, L. and Sokal-Gutierrez, K. (2021) Key informants' perspectives on childhood obesity in Vietnam: A qualitative study: Research Square.

Niranjala, A.M.S.G., N. S. (2011) Nutritional Status of Adolescent Females in Estates in Haliela, Sri Lanka, *ICAN: Infant, Child, & Adolescent Nutrition*, 3, 5, 260-267.

Noble, H. and Smith, J. (2018) Reviewing the literature: choosing a review design, *Evid Based Nurs*, 21, 2, 39-41.

Noor, S., Musarrat, R. and Ansari, M.I. (2020) Perfection and Working Women: Foucauldian Discourse Analysis of a Pakistani Morning Show, *Global Political Review*, 5, 1, 135-144.

Norris, S.A., Frongillo, E.A., Black, M.M., Dong, Y., Fall, C., Lampl, M., Liese, A.D., Naguib, M., Prentice, A., Rochat, T., Stephensen, C.B., Tinago, C.B., Ward, K.A., Wrottesley, S.V. and Patton, G.C. (2022) Nutrition in adolescent growth and development, *The Lancet*, 399, 10320, 172-184.

Nugent, R., Levin, C., Hale, J. and Hutchinson, B. (2020) Economic effects of the double burden of malnutrition, *Lancet*, 395, 10218, 156-164.

Núñez, A., Robertson-James, C., Reels, S., Jeter, J., Rivera, H., Yusuf, Z. and Liu (2015) Exploring the role of gender norms in nutrition and sexual health promotion in a piloted school-based intervention: The Philadelphia Ujima™ experience, *Evaluation and Program Planning*, 51, 70-77.

O'cathain, A., Murphy, E. and Nicholl, J. (2008) The Quality of Mixed Methods Studies in Health Services Research, *Journal of Health Services Research & Policy*, 13, 2, 92-98.

Ogden, J. and Roy-Stanley, C. (2020) How do children make food choices? Using a think-aloud method to explore the role of internal and external factors on eating behaviour, *Appetite*, 147, 104551.

Osendarp, S., Akuoku, J.K., Black, R.E., Headey, D., Ruel, M., Scott, N., Shekar, M., Walker, N., Flory, A., Haddad, L., Laborde, D., Stegmuller, A., Thomas, M. and Heidkamp, R. (2021) The COVID-19 crisis will exacerbate maternal and child undernutrition and child mortality in low- and middle-income countries, *Nature Food*, 2, 7, 476-484.

Osendarp, S.J.M., Brown, K.H., Neufeld, L.M., Udomkesmalee, E. and Moore, S.E. (2020) The double burden of malnutrition-further perspective, *Lancet*, 396, 10254, 813.

Otsuka, Y., Agestika, L., Widyarani, Sintawardani, N. and Yamauchi, T. (2019) Risk Factors for Undernutrition and Diarrhea Prevalence in an Urban Slum in Indonesia: Focus on Water, Sanitation, and Hygiene, *The American journal of tropical medicine and hygiene*, 100, 3, 727-732.

Owais, A. (2021) Impact of COVID 19 on maternal and child health and nutrition: South Asia situation.

Paez, A. (2017) Grey literature: An important resource in systematic reviews, *J Evid Based Med*.

PAHO, WHO, USAID and SPRING (2017) Report of the Stakeholders Consultation on Adolescent Girls' Nutrition: Evidence, Guidance, and Gaps <https://www.spring-nutrition.org/sites/default/files/publications/reports/spring_stakeholders_consult_adol_girls_nutr_0.pdf> Accessed 3 May 2019

Pal, A., Pari, A.K., Sinha, A. and Dhara, P.C. (2017) Prevalence of undernutrition and associated factors: A cross-sectional study among rural adolescents in West Bengal, India, *Int J Pediatr Adolesc Med*, 4, 1, 9-18.

Pandav, C.S., Mallik, A., Anand, K., Pandav, S. and Karmarkar, M.G. (1997) Prevalence of iodine deficiency disorders among school children of Delhi, *Natl Med J India*, 10, 3, 112-4.

Panter-Brick, C., Eggerman, M., Gonzalez, V. and Safdar, S. (2009) Violence, suffering, and mental health in Afghanistan: a school-based survey, *The Lancet*, 374, 9692, 807-816.

PanterBrick, C., Todd, A. and Baker, R. (1996) Growth status of homeless Nepali boys: Do they differ from rural and urban controls?, *Soc Sci Med*, 43, 4, 441-451.

Paradies, Y. and Stevens, M. (2005) Conceptual diagrams in public health research, *Journal of Epidemiology and Community Health*, 59, 12, 1012-1013.

Pasricha, S.-R. and Biggs, B.-A. (2010) Undernutrition among children in South and South-East Asia, *J Paediatr Child Health*, 46, 9, 497-503.

Patton, G.C., Coffey, C., Cappa, C., Currie, D., Riley, L., Gore, F., Degenhardt, L., Richardson, D., Astone, N., Sangowawa, A.O., Mokdad, A. and Ferguson, J. (2012) Health of the world's adolescents: a synthesis of internationally comparable data, *Lancet*, 379, 9826, 1665-75.

Patton, G.C., Sawyer, S.M., Santelli, J.S., Ross, D.A., Afifi, R., Allen, N.B., Arora, M., Azzopardi, P., Baldwin, W., Bonell, C., Kakuma, R., Kennedy, E., Mahon, J., McGovern, T., Mokdad, A.H., Patel, V., Petroni, S., Reavley, N., Taiwo, K., Waldfogel, J., Wickremarathne, D., Barroso, C., Bhutta, Z., Fatusi, A.O., Mattoo, A., Diers, J., Fang, J., Ferguson, J., Ssewamala, F. and Viner, R.M. (2016) Our future: a Lancet commission on adolescent health and wellbeing, *The Lancet*, 387, 10036, 2423-2478.

Peltzer, K. (2009) Prevalence and correlates of substance use among school children in six African countries, *Int J Psychol*, 44, 5, 378-86.

Peltzer, K. and Pengpid, S. (2014) Oral and hand hygiene behaviour and risk factors among in-school adolescents in four Southeast Asian countries, *International journal of environmental research and public health*, 11, 3, 2780-2792.

Peltzer, K. and Pengpid, S. (2017) Prevalence and Correlates of Physical Fighting Among School Going Students Aged 13 - 15 in the Association of Southeast Asian Nations (ASEAN) Member States, *Iran J Pediatr*, 27, 5, e8170.

Pengpid, S. and Peltzer, K. (2011) Hygiene behaviour and associated factors among in-school adolescents in nine African countries, *Int J Behav Med*, 18, 2, 150-9.

Pengpid, S. and Peltzer, K. (2016) Overweight, obesity and associated factors among 13-15 years old students in the Association of Southeast Asian Nations Member Countries, 2007-2014, *The Southeast Asian journal of tropical medicine and public health*, 47 2, 250-62.

Pengpid, S. and Peltzer, K. (2019a) Alcohol Use and Misuse Among School-Going Adolescents in Thailand: Results of a National Survey in 2015, *International journal of environmental research and public health*, 16, 11, 1898.

Pengpid, S. and Peltzer, K. (2019b) Underweight and overweight or obesity and associated factors among school-going adolescents in five ASEAN countries, 2015, *Diabetes Metab Syndr*, 13, 6, 3075-3080.

Peters, M., Godfrey, C., McInerney, P., Soares, C., Khalil, H. and Parker, D. (2015) *The Joanna Briggs Institute reviewers' manual 2015: methodology for JBI scoping reviews*, Adelaide, SA Australia: The Joanna Briggs Institute.

Peterson, J., Pearce, P.F., Ferguson, L.A. and Langford, C.A. (2017) Understanding scoping reviews: Definition, purpose, and process, *J Am Assoc Nurse Pract*, 29, 1, 12-16.

Phillips, E.A., Comeau, D.L., Pisa, P.T., Stein, A.D. and Norris, S.A. (2016) Perceptions of diet, physical activity, and obesity-related health among black daughter-mother pairs in Soweto, South Africa: a qualitative study, *BMC Public Health*, 16, 750.

Pinstrup-Andersen, P. (2007) Agricultural research and policy for better health and nutrition in developing countries: a food systems approach, *Agricultural Economics*, 37, s1, 187-198.

Popkin, B.M., Corvalan, C. and Grummer-Strawn, L.M. (2020) Dynamics of the double burden of malnutrition and the changing nutrition reality, *Lancet*, 395, 10217, 65-74.

Population Survey Analysis (2014) Process: Conceptual Framework <http://www.populationsurveyanalysis.com/wp-content/uploads/2014/09/framework_handout.pdf> Accessed 4 October 2021

Prakash, V.B., Prakash, S., Sharma, R. and Pal, S.K. (2010) Sustainable effect of Ayurvedic formulations in the treatment of nutritional anemia in adolescent students, *J Altern Complement Med*, 16, 2, 205-211.

Prashant, K., Shaw, C., Prashant, K. and Shaw, C. (2009) Nutritional status of adolescent girls from an urban slum area in South India, *Indian J Pediatr*, 76, 5, 501-504.

Radhika, M.S., Swetha, B., Kumar, B.N., Krishna, N.B. and Laxmaiah, A. (2018) Dietary and nondietary determinants of nutritional status among adolescent girls and adult women in India, *Ann N Y Acad Sci* 1416, 1, 5-17.

Rah, J.H., Melse-Boonstra, A., Agustina, R., van Zutphen, K.G. and Kraemer, K. (2021) The Triple Burden of Malnutrition Among Adolescents in Indonesia, *Food and Nutrition Bulletin*, 42, 1_suppl, S4-S8.

Rahman, A.S., Ahmed, T., Ahmed, F., Alam, M.S., Wahed, M.A. and Sack, D.A. (2015) Double-blind cluster randomised controlled trial of wheat flour chapatti fortified with micronutrients on the status of vitamin A and iron in school-aged children in rural Bangladesh, *Maternal & Child Nutrition*, 11 Suppl 4, 120-31.

Rao, K.M., Balakrishna, N., Laxmaiah, A., Venkaiah, K. and Brahmam, G.N. (2006) Diet and nutritional status of adolescent tribal population in nine states of India, *Asia Pacific Journal of Clinical Nutrition*, 15, 1, 64-71.

Rao, S., Aslam, S.K., Zaheer, S. and Shafique, K. (2014) Anti-smoking initiatives and current smoking among 19,643 adolescents in South Asia: findings from the Global Youth Tobacco Survey, *Harm Reduct J*, 11, 8.

Rathi, N., Riddell, L. and Worsley, A. (2016) What influences urban Indian secondary school students' food consumption? – A qualitative study, *Appetite*, 105, 790-797.

Rawat, R., Kumar, S. and Anil, B.S. (2015) Sociodemographic correlates of malnutrition among school aged children in an urban slum in India: a cross sectional study, *Journal of Evolution of Medical and Dental Sciences*, 4, 1598+.

Reinhardt, K. and Fanzo, J. (2014) Addressing Chronic Malnutrition through Multi-Sectoral, Sustainable Approaches: A Review of the Causes and Consequences, *Frontiers in Nutrition*, 1, 13.

Rengma, M.S.B., K.; Mondal, N. (2016) Socio-economic and demographic correlates of stunting among adolescents of Assam, North- east India, *Anthropological Review*, 79, 4, 409-425.

Ritchie, H. and Roser, M. (2020) Micronutrient Deficiency <https://ourworldindata.org/micronutrient-deficiency> Accessed 14 April 2020

Rocco, T.S. and Plakhotnik, M.S. (2009) Literature Reviews, Conceptual Frameworks, and Theoretical Frameworks: Terms, Functions, and Distinctions, *Human Resource Development Review*, 8, 1, 120-130.

Roshita, A., Riddell-Carre, P., Sjahrial, R., Jupp, D., Torlesse, H., Izwardy, D. and Rah, J.H. (2021) A Qualitative Inquiry into the Eating Behavior and Physical Activity of Adolescent Girls and Boys in Indonesia, *Food and Nutrition Bulletin*, 42, 1_suppl, S122-S131.

Sabbahi, M., Li, J., Davis, C. and Downs, S.M. (2018) Chapter Nine - The Role of the Sustainable Development Goals to Reduce the Global Burden of Malnutrition, In Barling, D. and Fanzo, J. (eds) *Advances in Food Security and Sustainability*: Elsevier. pp. 277-333.

Salkind, N.J. (2010) Pragmatic Study, In Salkind, N.J. (ed) *Encyclopedia of Research Design*, Thousand Oaks, California: SAGE Publications. pp. 1073-1075.

Sauter, S.R., Kim, L.P. and Jacobsen, K.H. (2020) Loneliness and friendlessness among adolescents in 25 countries in Latin America and the Caribbean, *Child Adolesc Ment Health*, 25, 1, 21-27.

Scaling Up Nutrition (2016) Nutrition awareness spikes with phase two of Pakistan's civil society campaign <https://scalingupnutrition.org/news/nutrition-awareness-spikes-with-phase-two-of-the-pakistans-civil-society-campaign/> Accessed 1 March 2022

Schott, W., Aurino, E., Penny, M.E. and Behrman, J.R. (2019) The double burden of malnutrition among youth: Trajectories and inequalities in four emerging economies, *Economics & Human Biology*, 34, 80-91.

Schwartz, A. and Terry, H. (2017) Seeing the Unheard: Heritage Learners of Spanish and Photo-Diary Pedagogy, *International Multilingual Research Journal*, 11, 4, 223-238.

Selvarani, P. (2017) Prevalence of anaemia and its association with demographic factors among adolescent girls in Coimbatore district, India, *Indian J Public Health Res Dev*, 8, 2, 207-211.

Sengupta, A., Angeli, F., Syamala, T.S., Van Schayck, C.P. and Dagnelie, P. (2014) State-wise dynamics of the double burden of malnutrition among 15-49 year-old women in India: how much does the scenario change considering Asian population-specific BMI cut-off values?, *Ecol Food Nutr*, 53, 6, 618-38.

Shafique, S., Akhter, N., Stallkamp, G., de Pee, S., Panagides, D. and Bloem, M.W. (2007) Trends of under- and overweight among rural and urban poor women indicate the double burden of malnutrition in Bangladesh, *Int J Epidemiol*, 36, 2, 449-57.

Shayo, F.K. and Lawala, P.S. (2019) Does food insecurity link to suicidal behaviors among in-school adolescents? Findings from the low-income country of sub-Saharan Africa, *BMC Psychiatry*, 19, 1, 227.

Shepherd, R. and Dennison, C. (1996) Influences on adolescent food choice. , *Proceedings of the Nutrition Society*, 55, 1B, 345-357.

Shridevi, K.N.R., R.; Madhavi, P.; Chandra Sekhar, K.; Deotale, P. G. (2015) A study of nutritional status of adolescent girls of social welfare hostels in and around Vijayawada city, *Indian J Public Health Res Dev*, 6, 1, 40-46.

Shrimpton, R. and Rokx, C. (2012) The double burden of malnutrition: a review of global evidence <https://documents1.worldbank.org/curated/en/905651468339879888/pdf/795250WP0Doubl00Box037737900PUBLIC0.pdf> Accessed 15 March 2019

Sikdar, M. (2012) Prevalence of malnutrition among the Mising children of Northeast India: A comparison between four different sets of criteria, *North American Journal of Medical Sciences*, 4, 7, 305-309.

Singh, N. and Mishra, C.P. (2001) Nutritional status of adolescent girls of a slum community of Varanasi, *Indian J Public Health*, 45, 4, 128-34.

Singh, P., Gandhi, S., Malhotra, R.K. and Seth, A. (2020) Impact of Using Different Growth References on Interpretation of Anthropometric Parameters of Children Aged 8-15 Years, *Indian Pediatr*, 57, 2, 124-128.

Sinha, A., Jonas, J.B., Kulkarni, M. and Nangia, V. (2011) Vitamin A deficiency in schoolchildren in urban central India: the central India children eye study, *Archives of Ophthalmology*, 129, 8, 1095-6.

Siziya, S., Muula, A.S. and Rudatsikira, E. (2007) Prevalence and correlates of truancy among adolescents in Swaziland: findings from the Global School-Based Health Survey, *Child and Adolescent Psychiatry and Mental Health*, 1, 15.

Smith, E., Sweeting, H. and Wright, C. (2013) 'Do I care?' Young adults' recalled experiences of early adolescent overweight and obesity: a qualitative study, *International Journal of Obesity*, 37, 2, 303-308.

Smith, L., Butler, L., Tully, M.A., Jacob, L., Barnett, Y., López-Sánchez, G.F., López-Bueno, R., Shin, J.I., McDermott, D., Pfeifer, B.A., Pizzol, D. and Koyanagi, A. (2020) Hand-Washing Practices among Adolescents Aged 12-15 Years from 80 Countries, *Int J Environ Res Public Health*, 18, 1.

Spencer, R.A., Rehman, L. and Kirk, S.F.L. (2015) Understanding gender norms, nutrition, and physical activity in adolescent girls: a scoping review, *International Journal of Behavioral Nutrition and Physical Activity*, 12, 1, 6.

Srivastava, A., Mahmood, S.E., Srivastava, P.M., Shrotriya, V.P. and Kumar, B. (2012) Nutritional status of school-age children - A scenario of urban slums in India, *Archives of Public Health*, 70, 1, 8.

Staniszewska, S., Brett, J., Simera, I., Seers, K., Mockford, C., Goodlad, S., Altman, D.G., Moher, D., Barber, R., Denegri, S., Entwistle, A., Littlejohns, P., Morris, C., Suleman, R., Thomas, V. and Tysall, C. (2017) GRIPP2 reporting checklists: tools to improve reporting of patient and public involvement in research, *BMJ*, 358, j3453.

StataCorp (2013) Stata: Release 13. Statistical Software. <https://www.stata.com/manuals13/svy.pdf> Accessed 9 May 2020

Steim, R.I. and Nemeroff, C.J. (1995) Moral Overtones of Food: Judgments of Others Based on What they Eat, *Personality and Social Psychology Bulletin*, 21, 5, 480-490.

Stevano, S. and Deane, K. (2017) The Role of Research Assistants in Qualitative and Cross-Cultural Social Science Research, In P., L. (ed) *Handbook of Research Methods in Health Social Sciences.* , Singapur: Springer.

Sunuwar, D.R., Singh, D.R. and Pradhan, P.M.S. (2020) Prevalence and factors associated with double and triple burden of malnutrition among mothers and children in Nepal: evidence from 2016 Nepal demographic and health survey, *BMC Public Health*, 20, 1, 405.

Tandon, B.N., Ramachandran, K., Nath, L.M., Sood, N.N., Gahlot, D.K., Gupta, M.C., Wali, J.P., Sinha, S.N., Hasteer, P.C. and Kutty, P.R. (1975) Vitamin A nutritional status of rural community of Khol block in Haryana, North India. A collaborative study, *Am J Clin Nutr*, 28, 12, 1436-42.

Teddlie, C.T.A. (2009) *Foundations of mixed methods research : integrating quantitative and qualitative approaches in the social and behavioral sciences*, Los Angeles: SAGE.

The Lancet (2020) A future direction for tackling malnutrition, *Lancet*, 395, 10217, 2.

The World Bank (2019) The World Bank in South Asia <http://www.worldbank.org/en/region/sar/overview> Accessed 28 February 2019

Thomas, R., Srinivasan, R. and Sudarshan, H. (2013) Nutritional status of tribal children and adolescents in rural south India: the effect of an NGO delivered nutritional programme, *Indian J Pediatr*, 80, 10, 821-5.

Thoradeniya, T., Wickremasinghe, R., Ramanayake, R. and Atukorala, S. (2006) Low folic acid status and its association with anaemia in urban adolescent girls and women of childbearing age in Sri Lanka, *British Journal of Nutrition*, 95, 3, 511-6.

Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Moher, D., Peters, M.D.J., Horsley, T., Weeks, L., Hempel, S., Akl, E.A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M.G., Garritty, C., Lewin, S., Godfrey, C.M., Macdonald, M.T., Langlois, E.V., Soares-Weiser, K., Moriarty, J., Clifford, T., Tunçalp, Ö. and Straus, S.E. (2018) PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation, *Ann Intern Med*, 169, 7, 467-473.

Trübswasser, U., Baye, K., Holdsworth, M., Loeffen, M., Feskens, E.J. and Talsma, E.F. (2021a) Assessing factors influencing adolescents' dietary behaviours in urban Ethiopia using participatory photography, *Public Health Nutr*, 24, 12, 3615-3623.

Trübswasser, U., Verstraeten, R., Salm, L., Holdsworth, M., Baye, K., Booth, A., Feskens, E.J.M., Gillespie, S. and Talsma, E.F. (2021b) Factors influencing obesogenic behaviours of adolescent girls and women in low- and middle-income countries: A qualitative evidence synthesis, *Obes Rev*, 22, 4, e13163.

UN-HABITAT (2003) The challenge of slums: Global Report on Human Settlements 2003 <https://www.un.org/ruleoflaw/files/Challenge%20of%20Slums.pdf> Accessed 29 April 2019

UN-HABITAT (2016) Urbanization and development: emerging futures. World Cities Report 2016 <https://www.unhabitat.org/wp-content/uploads/2014/03/WCR-%20Full-Report-2016.pdf> Accessed 27 May 2019

UNESCO Institute for Statistics (2015) Out-of-school children and adolescents in Asia and the Pacific: left behind on the road to learning opportunities for all <https://unesdoc.unesco.org/ark:/48223/pf0000247532?2=null&queryId=1f3552a8-2e19-44db-84a2-3f752222c598> Accessed 14 March 2022

UNICEF (1998) The state of the world's children <https://www.unicef.org/sowc98/sowc98.pdf> Accessed 8 April 2021

UNICEF (2013) Improving child nutrition: the achievable imperative for global progress <https://www.unicef.org/publications/files/Nutrition_Report_final_lo_res_8_April.pdf > Accessed 16 May 2019

UNICEF (2014) Global Initiative on Out-of-School Children: South Asia Regional Study covering Bangladesh, India, Pakistan and Sri Lanka <http://uis.unesco.org/sites/default/files/documents/out-of-school-children-south-asia-country-study-education-2014-en.pdf> Accessed 3 March 2022

UNICEF (2016) The state of the world's children 2016 <https://www.unicef.org/reports/state-worlds-children-2016> Accessed 4 April 2019

UNICEF (2019a) Adolescent and women's nutrition <https://www.unicef.org/rosa/what-we-do/nutrition/adolescent-and-womens-nutrition> Accessed 25 April 2019

UNICEF (2019b) Adolescents in South Asia <https://www.unicef.org/rosa/what-we-do/adolescents> Accessed 25 April 2019

UNICEF (2019c) South Asia: where we work <https://www.unicef.org/rosa/where-we-work> Accessed 25 April 2019

UNICEF, UNFPA, WHO and SickKids Center for Global Child Health (2021) Direct and indirect effects of the COVID-19 pandemic and response in South Asia <https://www.unicef.org/rosa/media/13066/file/Main%20Report.pdf> Accessed 16 March 2022

United Nations (2020) Goal 2: Zero Hunger <https://www.un.org/sustainabledevelopment/hunger/> Accessed 15 March 2022

United Nations General Assembly (2015) Transforming our world: The 2030 agenda for sustainable development <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication > Accessed 2 April 2021

United Nations General Assembly (2017) Work programme of the United Nations Decade of Action on Nutrition (2016-2025) <https://www.who.int/nutrition/decade-of-action/workprogramme-2016to2025/en/> Accessed 2 April 2021

USAID Advancing Nutrition (2021) Conducting Formative Research on Adolescent Nutrition: Key Considerations

Vaezghasemi, M., Öhman, A., Ng, N., Hakimi, M. and Eriksson, M. (2020) Concerned and conscious, but defenceless - the intersection of gender and generation in child malnutrition in Indonesia: a qualitative grounded theory study, *Global Health Action*, 13, 1, 1744214.

Vandenbroucke, J.P., von Elm, E., Altman, D.G., Gøtzsche, P.C., Mulrow, C.D., Pocock, S.J., Poole, C., Schlesselman, J.J., Egger, M. and for the, S.I. (2007) Strengthening the

Reporting of Observational Studies in Epidemiology (STROBE): Explanation and Elaboration, *PLOS Medicine*, 4, 10, e297.

Vashist, B.M. and Goel, M.K. (2009) Nutritional status of adolescents in rural and urban Rohtak, Haryana, *Health and Population: Perspectives and Issues*, 32, 4, 190-197.

Venkaiah, K.D., K.; Nayak, M. U.; Vijayaraghavan, K. (2002) Diet and nutritional status of rural adolescents in India, *European Journal of Clinical Nutrition*, 56, 11, 1119-25.

Vir, S.C., Singh, N., Nigam, A.K. and Jain, R. (2008) Weekly iron and folic acid supplementation with counseling reduces anemia in adolescent girls: a large-scale effectiveness study in Uttar Pradesh, India, *Food & Nutrition Bulletin*, 29, 3, 186-94.

Vogt, L.E., Rukooko, B., Iversen, P.O. and Eide, W.B. (2016) Human rights dimensions of food, health and care in children's homes in Kampala, Uganda - a qualitative study, *BMC Int Health Hum Rights*, 16, 10.

Warraich, H.J., Javed, F., Faraz-Ul-Haq, M., Khawaja, F.B. and Saleem, S. (2009) Prevalence of obesity in school-going children of Karachi, *PLoS One*, 4, 3, e4816.

Watts, A.W., Lovato, C.Y., Barr, S.I., Hanning, R.M. and Mâsse, L.C. (2015) A qualitative study exploring how school and community environments shape the food choices of adolescents with overweight/obesity, *Appetite*, 95, 360-7.

Weller, S., Hardy-Johnson, P., Strommer, S., Fall, C., Banavali, U., Chopra, H., Janha, R.E., Joseph, S., Reddy, K.J., Mengistie, M.A., Wrottesley, S.V., Kouakou, E. and Barker, M. (2021) 'I should be disease free, healthy and be happy in whatever I do': a cross-country analysis of drivers of adolescent diet and physical activity in different low- and middle-income contexts, *Public Health Nutrition*, 24, 16, 5238-5248.

Wells, J.C., Sawaya, A.L., Wibaek, R., Mwangome, M., Poullas, M.S., Yajnik, C.S. and Demaio, A. (2020) The double burden of malnutrition: aetiological pathways and consequences for health, *Lancet*, 395, 10217, 75-88.

WHO (2005) Nutrition in adolescence - issues and challenges for the health sector <https://apps.who.int/iris/bitstream/handle/10665/43342/9241593660_eng.pdf?sequence=1> Accessed 2 May 2019

WHO (2006) Adolescent Nutrition: A Review of the Situation in Selected South-East Asian Countries <https://apps.who.int/iris/bitstream/handle/10665/204764/B0239.pdf?sequence=1&isAllowed=y> Accessed 3 May 2019

WHO (2007) Growth reference data for 5-19 years <https://www.who.int/growthref/en/> Accessed 26 November 2018

WHO (2009) Core Module Rationale <https://www.paho.org/hq/index.php?option=com_docman&view=download&category_slug=gshs-9349&alias=44258-core-module-rationale-2018-258&Itemid=270&lang=es> Accessed 4 May 2021

WHO (2014a) Global nutrition targets 2025: policy brief series (WHO/NMH/NHD/14.2) <https://apps.who.int/iris/bitstream/handle/10665/149018/WHO_NMH_NHD_14.2_eng.pdf?ua=1>

WHO (2014b) Global School-based Student Health Survey: Afghanistan 2016 Fact Sheet <https://www.who.int/ncds/surveillance/gshs/2014-GSHS-Afghanistan-fact-sheet.pdf> Accessed 26 June 2019

WHO (2014c) Global School-based Student Health Survey: Maldives 2016 Fact Sheet <https://www.who.int/ncds/surveillance/gshs/2014-Maldives-GSHS-FS.pdf> Accessed 26 June 2019

WHO (2015) The Global Strategy for Women's, Children's and Adolescents' health <http://globalstrategy.everywomaneverychild.org/pdf/EWEC_globalstrategyreport_200915_FINAL_WEB.pdf> Accessed 1 May 2019

WHO (2016a) Global School-based Student Health Survey: Bhutan 2016 Fact Sheet <https://www.who.int/ncds/surveillance/gshs/Bhutan_gshs_fs_2016.pdf> Accessed 26 June 2019

WHO (2016b) What is malnutrition? <http://www.who.int/features/qa/malnutrition/en/> Accessed 19 November 2018

WHO (2017a) Double-duty actions for nutrition. Policy Brief <http://apps.who.int/iris/bitstream/handle/10665/255414/WHO-NMH-NHD-17.2-eng.pdf;jsessionid=237B3D3FCAD606C243CBA49C562B01DE?sequence=1> Accessed 7 October 2021

WHO (2017b) Global accelerated action for the health of adolescents (AA-HA!): Guidance to support country implementation <https://apps.who.int/iris/bitstream/handle/10665/255415/9789241512343-eng.pdf;jsessionid=2AF6F2A88F14BF4477B909D53DBFA07A?sequence=1> Accessed 3 May 2019

WHO (2018a) Double burden of malnutrition <https://www.who.int/nutrition/double-burden-malnutrition/en/> Accessed 21 November 2018

WHO (2018b) Guideline: Implementing effective actions for improving adolescent nutrition <https://apps.who.int/iris/bitstream/handle/10665/260297/9789241513708-eng.pdf?sequence=1> Accessed 2 May 2019

WHO (2019a) Adolescent health and development <http://www.searo.who.int/entity/child_adolescent/topics/adolescent_health/en/> Accessed 1 February 2019

WHO (2019b) Global school-based student health survey (GSHS) <https://www.who.int/ncds/surveillance/gshs/en/> Accessed 25 April 2019

WHO (2020a) Global strategy on diet, physical activity and health website. Physical activity and young people. <https://www.who.int/teams/health-promotion/physical-activity/physical-activity-and-young-people> Accessed 5 November 2020

WHO (2020b) Malnutrition <https://www.who.int/news-room/fact-sheets/detail/malnutrition> Accessed 1 April 2020

WHO (2020c) Noncommunicable diseases: Childhood overweight and obesity <https://www.who.int/news-room/q-a-detail/noncommunicable-diseases-childhood-overweight-and-obesity> Accessed 27 October 2021

WHO and CDC (2013) Global School-based Student Health Survey Data User's Guide <https://www.cdc.gov/gshs/background/pdf/gshs-data-users-guide.pdf> Accessed 25 February 2019

WHO and FAO (2003) Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation. <https://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf> Accessed 26 April 2019

Wilkins, J.L. (2020) Challenges and Opportunities Created by the COVID-19 Pandemic, *Journal of Nutrition Education and Behavior*, 52, 7, 669-670.

Wilson, M.L., Dunlavy, A.C., Viswanathan, B. and Bovet, P. (2012) Suicidal expression among school-attending adolescents in a middle-income sub-Saharan country, *Int J Environ Res Public Health*, 9, 11, 4122-34.

Wouters, E., Larsen, J.K., Kremers, S., Dagnelie, P. and Geenen, R. (2010) Peer influence on snacking behavior in adolescence, *Appetite*, 55, 11-17.

Xi, B., Liang, Y., Liu, Y., Yan, Y., Zhao, M., Ma, C. and Bovet, P. (2016) Tobacco use and second-hand smoke exposure in young adolescents aged 12-15 years: data from 68 low-income and middle-income countries, *Lancet Glob Health*, 4, 11, e795-e805.

Xu, G., Sun, N., Li, L., Qi, W., Li, C., Zhou, M., Chen, Z. and Han, L. (2020) Physical behaviors of 12-15 year-old adolescents in 54 low- and middle-income countries: Results from the Global School-based Student Health Survey, *J Glob Health*, 10, 1, 010423.

Yang, L., Bovet, P., Liu, Y., Zhao, M., Ma, C., Liang, Y. and Xi, B. (2017) Consumption of Carbonated Soft Drinks Among Young Adolescents Aged 12 to 15 Years in 53 Low- and Middle-Income Countries, *Am J Public Health*, 107, 7, 1095-1100.

Yang, L., Bovet, P., Ma, C., Zhao, M., Liang, Y. and Xi, B. (2019) Prevalence of underweight and overweight among young adolescents aged 12-15 years in 58 low-income and middle-income countries, *Pediatr Obes*, 14, 3, e12468.

Ziaei, R., Dastgiri, S., Soares, J., Baybordi, E., Zeinalzadeh, A., Asl Rahimi, V., & Mohammadi, R. (2014) Reliability and Validity of the Persian Version of Global School-based Student Health Survey Adapted for Iranian School Students, *Journal of Clinical Research & Governance*, 3, 2, 134-140.

9. Appendices

APPENDIX 1. SCOPING REVIEW SEARCH STRATEGY

Medline: ovid

	Searches
1	South Asia*.mp.
2	South East Asia*.mp.
3	exp Afghanistan/
4	exp Bangladesh/
5	exp Bhutan/
6	exp India/
7	Maldives.mp.
8	exp Nepal/
9	exp Pakistan/
10	exp Sri Lanka/
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12	exp Thinness/
13	exp malnutrition/ or exp deficiency diseases/
14	(undernutrition or under nutrition or under-nutrition or stunting or stunted or underweight or under-weight or under weight or thinness or micronutrient deficienc*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
15	12 or 13 or 14
16	(adolescen* or teen* or youth* or student* or juvenile* or underage or young people or young person or young adult or girl or boy).mp
17	exp Adolescent/
18	16 or 17
19	11 and 15 and 18

Embase: ovid

	Searches
1	exp South Asia/
2	exp Southeastern Asia/
3	exp Afghanistan/
4	exp Bangladesh/
5	exp Bhutan/
6	exp India/
7	exp Maldives/
8	exp Nepal/
9	exp Pakistan/
10	exp Sri Lanka/
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12	exp malnutrition/
13	exp underweight/
14	exp nutritional deficiency/
15	(undernutrition or under nutrition or under-nutrition or stunting or stunted or underweight or under-weight or under weight or thinness or micronutrient deficienc*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]
16	12 or 13 or 14 or 15
17	(adolescen* or teen* or youth* or student* or juvenile* or underage or young people or young person or young adult or girl or boy).mp
18	exp adolescence/
19	17 or 18

20	11 and 16 and 19

Cochrane Library

	Searches
1.	South Asia or Afghanistan or Bangladesh or Bhutan or India or Maldives or Nepal or Pakistan or Sri Lanka
2.	malnutrition or undernutrition or under nutrition or under-nutrition or stunting or stunted or underweight or under-weight or under weight or thinness or micronutrient deficienc*
3.	adolescen* or teen* or youth* or student* or juvenile* or underage or young people or young person or young adult or girl or boy
4	#1 AND #2 AND #3

Web of Science

	Searches
1.	TS=(South Asia or Afghanistan or Bangladesh or Bhutan or India or Maldives or Nepal or Pakistan or Sri Lanka)
2.	TS=(malnutrition or undernutrition or under nutrition or under-nutrition or stunting or stunted or underweight or under-weight or under weight or thinness or micronutrient deficienc*)
3.	TS=(adolescen* or teen* or youth* or student* or juvenile* or underage or young people or young person or young adult or girl or boy)
4.	#3 AND #2 AND #1

CINAHL

	Searches
1	“South Asia”
2	(MH “Asia, Western+”)
3	“Afghanistan”
4	“Bangladesh”
5	“Bhutan”
6	“India”
7	“Maldives”
8	“Nepal”
9	“Pakistan”
10	“Sri Lanka”
11	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10
12	(MH "Malnutrition") OR "malnutrition"
13	(MH "Thinness") OR "thinness"
14	"micronutrient deficiency" OR (MH "Vitamin B6 Deficiency") OR (MH "Vitamin B12 Deficiency") OR (MH "Folic Acid Deficiency") OR (MH "Ascorbic Acid Deficiency") OR (MH "Vitamin B Deficiency") OR (MH "Riboflavin Deficiency") OR (MH "Vitamin E Deficiency") OR (MH "Thiamine Deficiency") OR (MH "Vitamin D Deficiency") OR (MH "Vitamin A Deficiency")
15	"undernutrition"
16	"stunting"
17	S11 OR S12 OR S13
18	"adolescents or teenagers or young adults" OR (MH "Young Adult") OR (MH "Adolescence")
	S10 AND S14 AND S15

Psychinfo

	Searches
1	South Asia*.mp.
2	Afghanistan.mp.
3	Bangladesh.mp.
4	Bhutan.mp.
5	India.mp.
6	Maldives.mp.
7	Nepal.mp.
8	Pakistan.mp.
9	Sri Lanka.mp.
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9
11	exp Nutritional Deficiencies/
12	(malnutrition or undernutrition or under nutrition or under-nutrition or stunting or stunted or underweight or under-weight or under weight or thinness or micronutrient deficienc*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]
13	11 or 12
14	(adolescen* or teen* or youth* or student* or juvenile* or underage or young people or young person or young adult or girl or boy).mp
15	10 and 13 and 14

Scopus

((TITLE-ABS-KEY (afghanistan) OR TITLE-ABS-KEY (bangladesh) OR TITLE-ABS-KEY (bhutan) OR TITLE-ABS-KEY (india) OR TITLE-ABS-KEY (maldives) OR TITLE-ABS-KEY (nepal) OR TITLE-ABS-KEY (pakistan) OR TITLE-ABS-KEY (sri AND lanka) OR TITLE-ABS-KEY (south AND asia*))) AND ((TITLE-ABS-KEY (youth*) OR TITLE-ABS-KEY (adolescen*) OR TITLE-ABS-KEY (student*) OR TITLE-ABS-KEY (juvenile*) OR TITLE-ABS-KEY (underage) OR TITLE-ABS-KEY (young AND people) OR TITLE-ABS-KEY (young AND person) OR TITLE-ABS-KEY (young AND adult) OR TITLE-ABS-KEY (girl) OR TITLE-ABS-KEY (boy) OR TITLE-ABS-KEY (teen*))) AND ((TITLE-ABS-KEY (malnutrition) OR TITLE-ABS-KEY (undernutrition) OR TITLE-ABS-KEY (under AND nutrition) OR TITLE-ABS-KEY (under-nutrition) OR TITLE-ABS-KEY (stunting) OR TITLE-ABS-KEY (stunted) OR TITLE-ABS-KEY (underweight) OR TITLE-ABS-KEY (under-weight) OR TITLE-ABS-KEY (under AND weight) OR TITLE-ABS-KEY (thinness) OR TITLE-ABS-KEY (micronutrient AND deficienc*))) AND (EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "ENVI") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "ARTS") OR EXCLUDE (SUBJAREA , "ECON") OR EXCLUDE (SUBJAREA , "PSYC") OR EXCLUDE (SUBJAREA , "ENGI") OR EXCLUDE (SUBJAREA , "NEUR") OR EXCLUDE (SUBJAREA , "DENT") OR EXCLUDE (SUBJAREA , "EART") OR EXCLUDE (SUBJAREA , "CHEM") OR EXCLUDE (SUBJAREA , "ENER") OR EXCLUDE (SUBJAREA , "CENG") OR EXCLUDE (SUBJAREA , "MATH") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "BUSI") OR EXCLUDE (SUBJAREA , "DECI") OR EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "MATE") OR EXCLUDE (SUBJAREA , "PHYS") OR EXCLUDE (SUBJAREA , "Undefined"))

Grey literature sources

WHOLIS – the WHO Library Information System	http://kohahq.searo.who.int/
eLENA e-Library of Evidence for Nutrition Actions	https://www.who.int/elena/en/
Opengrey	http://www.opengrey.eu/
WHO	https://www.who.int/en
UNICEF	https://www.unicef.org/
DHS program	https://dhsprogram.com/
Planning and Development Department AJ&K	https://pndajk.gov.pk/
GHDx	http://ghdx.healthdata.org/geography/pakistan
WFP	https://www1.wfp.org/
World Bank eLibrary	https://elibrary.worldbank.org/

APPENDIX 2. PUBLICATIONS INCLUDED IN THE SCOPING REVIEW

PUBLICATIONS THAT INCLUDED AN INTERVENTION COMPONENT											
Author	Title	year	country	sex	setting	study design	sample analysed	age sample analysed	quant outcome	cut-offs and reference	prevalence (%)
Ahmed, F.; Khan, M. R.; Akhtaruzzaman, M.; Karim, R.; Marks, G. C.; Banu, C. P.; Nahar, B.; Williams, G.	Efficacy of twice-weekly multiple micronutrient supplementation for improving the hemoglobin and micronutrient status of anemic adolescent schoolgirls in Bangladesh	2005	Bangladesh	girls	rural	randomized, double-blind, experimental trial	178	14-18y	Micro deficiency: anemia, iron, vit C, folic acid, vit B12, vit A, vit B2	Hb<120 g/L[13] Serum ferritin <12 ng/mL Plasma vitamin C < 0.29 mg/dL RBC folic acid < 140 ng/mL Serum vitamin B12 < 200 pg/mL Serum retinol <30.0 ug/dL[11] EGRAC >= 1.4	Multiple micronutrient tablets group: less anemic, decreased prevalences of vit A and C and riboflavin deficiencies. Iron and folic acid tablets group: less anemic.
Ahmed, F.; Khan, M. R.; Akhtaruzzaman, M.; Karim, R.; Williams, G.; Torlesse, H.; Darnton-Hill, I.; Dalmiya, N.; Banu, C. P.; Nahar, B. Ahmed, F.; Khan, M. R.;	Long-term intermittent multiple micronutrient supplementation enhances hemoglobin and micronutrient status more than iron + folic acid supplementation in Bangladeshi rural adolescent	2010	Bangladesh	girls	rural	randomized, double-blind controlled trial	324	11-17y	Micro deficiency: anemia, vit C, folic acid, vit A, B2	Hb<120 g/L[13] Plasma vitamin C <16.5 umol/L RBC folic acid <317 umol/L Serum retinol <1.05 umol/L[11] EGRAC >= 1.4	Multiple micronutrient tablets group 1: less anemic, decreased prevalences of vit A, B2 and C and folate deficiencies. Multiple micronutrient

Akhtaruzzaman, M.; Karim, R.; Williams, G.; Banu, C. P.; Nahar, B.; Darnton-Hill, I.	girls with nutritional anemia. Effect of long-term intermittent supplementation with multiple micronutrients compared with iron-and-folic acid supplementation on Hb and micronutrient status of non-anaemic adolescent schoolgirls in rural Bangladesh										tablets group 2: less anemic, decreased prevalences of vit A, B2 and C and folate deficiencies. Iron and folic acid tablets group : less anemic, decreased prevalence of folate deficiency and vit A deficiency.
Garg, M. K.; Marwaha, R. K.; Khadgawat, R.; Ramot, R.; Obroi, A. K.; Mehan, N.; Gupta, N.; Madan, R.	Efficacy of vitamin D loading doses on serum 25-hydroxy vitamin D levels in school going adolescents: an open label non-randomized prospective trial	2013	India	both	Not reported	non-randomized prospective trial	482	10-15y	Micro deficiency: vit D	Serum 25(OH)D <50 nmol/l	less vitamin D deficiency

Goyle, Goyle, A.; Prakash, S. Goyle, A.; Prakash, S. Goyle, A.; Prakash, S. Goyle, A.; Prakash, S.	Effect of micronutrient fortified biscuit supplementation on the weight, height and BMI of adolescent girls. Effect of supplementation of micronutrient fortified biscuits on haemoglobin and serum iron levels of adolescent girls from Jaipur city, India.	2012	India	girls	slum	randomised control trial 1608 & 1609) baseline data part of a randomised control trial	107	10-16y	Height-for-age	Vishveshwara Rao's classification	less stunted
									BMI-for-age	BMI Zscores of WHO reference 2007[3]	less thin

	Effect of supplementation of micronutrient fortified biscuits on serum total proteins and vitamin A levels of adolescent girls (10-16 years) of Jaipur city, India. Efficacy of multi-micronutrient fortified biscuits on urinary iodine levels of adolescent girls from Jaipur, India. Iron status of adolescent girls (10-15 years) attending a government school in Jaipur city, Rajasthan, India. Serum total proteins and vitamin A levels of adolescent girls (10-15 years) attending a government								Micro deficiency: anemia, iodine vit A	Hb<12g/dl[13] Urinary iodine <100 mg/L[19] Serum retinol <10 mcg/dl	less anemic, less iodine deficiency, less vit A deficiency. Anemia at baseline 96.3%. Vit A def at baseline 1.8%

	school in Jaipur city, India										
Hettiarachchi, M.; Liyanage, C.; Wickremasinghe, R.; Hilmers, D. C.; Abrams, S. A.	The efficacy of micronutrient supplementation in reducing the prevalence of anaemia and deficiencies of zinc and iron among adolescents in Sri Lanka	2008	Sri Lanka	both	Not reported	randomised control trial	774	12-16y	Height-for-age	<-2SD from median of CDC 2000[5]	No effect on stunting
									Micro deficiency: anemia, zinc	Not reported	less anemia and zinc deficiency

Hyder, S. M.; Haseen, F.; Khan, M.; Schaetzel, T.; Jalal, C. S.; Rahman, M.; Lonnerdal, B.; Mannar, V.; Mehansho, H.	A multiple-micronutrient-fortified beverage affects hemoglobin, iron, and vitamin A status and growth in adolescent girls in rural Bangladesh	2007	Bangladesh	girls	rural	randomised control trial	989	mean age 12y	Micro deficiency: anemia, vit A, zinc	Hb <120 g/L. Serum retinol <0.70 umol/L Serum zinc <10.7 umol/L	less anemia, less vit A deficiency. No effect on zinc deficiency
Khadgawat, R.; Marwaha, R. K.; Garg, M. K.; Ramot, R.; Oberoi, A. K.; Sreenivas, V.; Gahlot, M.; Mehan, N.; Mathur, P.; Gupta, N.	Impact of vitamin D fortified milk supplementation on vitamin D status of healthy school children aged 10-14 years	2013	India	both	Not reported	randomised control trial	713	10-14y	Micro deficiency: vit D	Serum 25(OH)D <20 ng/ml[21]	less vit D deficiency

Muthayya, S.; Thankachan, P.; Hirve, S.; Amalrajan, V.; Thomas, T.; Lubree, H.; Agarwal, D.; Srinivasan, K.; Hurrell, R. F.; Yajnik, C. S.; Kurpad, A. V.	Iron Fortification of Whole Wheat Flour Reduces Iron Deficiency and Iron Deficiency Anemia and Increases Body Iron Stores in Indian School-Aged Children	2012	India	both	urban and rural	randomised control trial	401	6-15y (mean age 10.4y)	Micro deficiency: anemia	Hb<12g/dl[13]	less anemia
Prakash, Vaidya Balendu; Prakash, Shyam; Sharma, Rajesh; Pal, Sanjoy K.	Sustainable effect of Ayurvedic formulations in the treatment of nutritional anemia in adolescent students	2010	India	both	Not reported	randomised control trial	1167	11-18y	Micro deficiency: anemia	Hb<12g/dl[13]	less anemia

Rahman, A. S.; Ahmed, T.; Ahmed, F.; Alam, M. S.; Wahed, M. A.; Sack, D. A.	Double-blind cluster randomised controlled trial of wheat flour chapatti fortified with micronutrients on the status of vitamin A and iron in school-aged children in rural Bangladesh	2015	Banglades h	both	rural	randomise d control trial	352	6-15y (mean age 10.4y)	Micro deficiency: anemia, vit A	Hb <115 g/L^{-1} for children <12 years and <120 g/L^{-1} for those 12 years Serum retinol <0.70 mmol L^{-1}	less vit A deficiency. No effect in anaemia status
Thomas, R.; Srinivasan, R.; Sudarshan, H.	Nutritional status of tribal children and adolescents in rural south India: the effect of an NGO delivered nutritional programme	2013	India	both	rural	cross-sectional	410	5-17y (mean age 12.3y)	Height-for-age	<3rd percentile of WHO reference 2007[3]	not effective on stunting
									BMI-for-age	<5th percentile of WHO reference 2007[3]	not effective on thinness

Vir, S. C.; Singh, N.; Nigam, A. K.; Jain, R.	Weekly iron and folic acid supplementation with counseling reduces anemia in adolescent girls: a large-scale effectiveness study in Uttar Pradesh, India	2008	India	girls	Not reported	pre-post interventional study	Not reported	10-19y	Micro deficiency: anemia	Hb <12 g/dL	less anemia

PUBLICATIONS THAT DID NOT INCLUDE AN INTERVENTION COMPONENT

Author	Title	year	country	sex	setting	study design	sample analysed	age sample analysed	quant outcome	cut-offs and reference	prevalence (%)
Agrahar-Murugkar, D.	Nutritional status of Khasi schoolgirls in Meghalaya, India	2005	India	girls	rural	cross-sectional	Not reported	10-12y	Height-for-age	<-2SD from median of CDC 2000[5]; 95% of the median, Waterlow's classification[7]	Stunting 7% (CDC); stunting 46% (Waterlow)

Agrawal, V. K.; Agrawal, P.; Dharmendra,	Prevalence and determinants of xerophthalmia in rural children of Uttarpradesh, India	2013	India	both	rural	cross-sectional	296	10-15y	Micro deficiency: vit A	Conjunctival xerosis when accompanied by Bitot's spots[10]	Vit A def 8.9% in 10-12y, and 11.6% in 13-15y
Ahmed, F.; Hasan, N.; Kabir, Y.	Vitamin A deficiency among adolescent female garment factory workers in Bangladesh	1997	Bangladesh	girls	urban	cross-sectional	388	12-19y	Micro deficiency: vit A	Serum retinol <0.70 mmol/l	Vit A def 14.2%
Ahmed, F.; Khan, M. R.; Islam, M.; Kabir, I.; Fuchs, G. J.	Anaemia and iron deficiency among adolescent schoolgirls in peri-urban Bangladesh	2000	Bangladesh	girls	peri-urban	cross-sectional	548	11-16y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 28%
									BMI-for-age	<5th percentile of WHO reference 1995[2]	Thinness 13.5%
									Micro deficiency: anemia	Hb<120 g/l[14]	Anemia 27%
Ahmed, F.; Khan, M. R.; Banu, C. P.; Qazi, M. R.;	The coexistence of other micronutrient deficiencies in	2008	Bangladesh	girls	rural	cross-sectional	310	14-18y	Height-for-age	<3rd percentile of WHO reference 1995[2]	Stunting 33.4%

Akhtaruzzaman, M. Ahmed, F.; Khan, M. R.	anaemic adolescent schoolgirls in rural Bangladesh Extent of multiple micronutrient deficiencies in anemic adolescent schoolgirls in rural Bangladesh								BMI-for-age	<5th percentile of WHO reference 1995[2]	Thinness 8.4%
									Micro deficiency: folic acid, vit B12, B2, vit C, vit A	Hb<120 g/l[14] RBC folate <317 nmol/l[23] Serum vitamin B12 <150 pmol/l EGRAC >=1.4 Plasma ascorbic acid <11.4 µmol/l Serum retinol <0.70 µmol/l[11]	Folic acid def 24.8%, Vit B12 def 6.8%, Vit B2 def 89%, Vit C def 2%, and Vit A def 4.1%.
Ahmed, F.; Rahman, A.; Noor, A. N.; Akhtaruzzaman, M.; Hughes, R.	Anaemia and vitamin A status among adolescent schoolboys in Dhaka City, Bangladesh	2006	Bangladesh	boys	Not reported	cross-sectional	381	11-16y	Height-for-age	<-2SD from median of CDC 2000[5]	Stunting 8%
									BMI-for-age	<-2SD from median of CDC 2000[5]	Not reported
									Micro deficiency: anemia, vit A	Hb<115g l^{-1} for 11-year-olds, <120 g l^{-1} for 12–14-year-olds and <130 g l^{-1} for 15–16-year-olds[13] Serum retinol <0.70µmol[11]	Anemia 7%, and vitamin A def 1.5%

Allen, A.; Allen, S.; Rodrigo, R.; Perera, L.; Shao, W.; Li, C.; Wang, D.; Olivieri, N.; Weatherall, D. J.; Premawardhena , A.	Iron status and anaemia in Sri Lankan secondary school children: A cross-sectional survey	2017	Sri Lanka	both	Not reported	cross-sectional	5912	11-19y	Micro deficiency: anemia	Hb <11.5 g/dl in children <12 years, Hb <12.0 g/dl in females ≥12 years and males aged 12-14 years, and Hb <13.0 g/dl in males aged 15 years and above[12]	Anemia 4.6% in girls, and 1% in boys
Amarnath, M.; Lakshmanrao, N.	Anemia among adolescent girls in tribal area of Visakhapatnam district in Andhra Pradesh	2013	India	girls	Not reported	cross-sectional	270	10-19y	Micro deficiency: anemia	Hb <12gms/dl	Anemia 89%
Amatya, B.; Shrestha, N.	Prevalence of Malnutrition in a Rural Residential Sanskrit School in Baglung, Nepal	2017	Nepal	boys	rural	cross-sectional	41	8-19y (mean age 13y)	Height-for-age	<-2SD of WHO reference 2007[3]	Stunting 53.3%
									BMI-for-age	<-2SD of WHO reference 2007[3]	Thinness 14%
Ameer, S. R.; Ahmad, S. R.; Chandrasekhar, A.	Assessment of underweight and its determinants among school going adolescents in Hyderabad, India	2018	India	both	Not reported	cross-sectional	763	13-16y	BMI-for-age	Not reported	Thinness 52.7%

Aziz, S.; Noor, W.; Majeed, R.; Amanullah Khan, M.; Qayum, I.; Ahmed, I.; Hosain, K.	Growth centile charts (Anthropometric measurement) of Pakistani pediatric population	2012	Pakistan	both	urban and rural	cross-sectional	9147	3-16y (mean age 10.9y)	Height-for-age	<-2SD from median of CDC 2000[5]	Stunting 14.4% in girls, and 15% in boys
Banerjee, S. R.; Chakrabarty, S.; Vasulu, T. S.; Bharati, S.; Sinha, D.; Banerjee, P.; Bharati, P.	Growth and nutritional status of Bengali adolescent girls, India	2009	India	girls	peri-urban	cross-sectional	527	10-18y	Height-for-age	95% of the median, Waterlow's classification[7]	Stunting 65.5%
Bansal, P. G.; Toteja, G. S.; Bhatia, N.; Vikram, N. K.; Siddhu, A.; Garg, A. K.; Roy, A. K. Bansal, P. G.; Toteja, G. S.; Suman, R.	Deficiencies of serum ferritin and vitamin B12, but not folate, are common in adolescent girls residing in a slum in Delhi. Plasma vitamin C status of adolescent girls in a slum of Delhi	2015	India	girls	slum	cross-sectional	794	11-18y	Micro deficiency: anemia, folic acid, vit B12 and vit C.	Hb <120 g/L[15] Serum folic acid <4ng/ml[17] Vitamin B12 <203pg/ml[17] Plasma vitamin C <0.2 mg/dL[18]	Anemia 58.7%, folic acid def 5%, vit B12 def 63.3%, and Vit C def 6.3%

Bharthi, K.; Ghritlahre, M.; Das, S.; Bose, K.	Nutritional status among children and adolescents aged 6-18 years of Kolam tribe of Andhra Pradesh, India	2017	India	both	Not reported	cross-sectional	571	10-18y	BMI-for-age	IOTF[6]	Thinness 63% in girls, and 55.4% in boys
Bisai, S.; Bose, K.; Dikshit, S.	Underweight and stunting among slum children of Midnapore, India	2009	India	both	slum	cross-sectional	210	10-18y	Height-for-age	<-2SD of NCHS reference[1]	Stunting 56.9% in girls, and 41.4% in boys
Bose, K.; Bisai, S.	Nutritional status of rural adolescent school children in Paschim Medinipur, West Bengal	2008	India	both	rural	cross-sectional	1094	11-18y	BMI-for-age	<5th percentile of NHANES[4]	Thinness 25.2% in girls, and 41.8% in boys
Bose, K.; Bisai, S.	Prevalence of undernutrition among rural adolescents of West Bengal, India	2008	India	both	Not reported	cross-sectional	2016	10-15y	BMI-for-age	<5th percentile of NHANES[4]	Thinness 20.2% in girls, and 45.8% in boys

Bose, K.; Bisai, S.; Chakraborty, J.; Datta, N.; Banerjee, P.	Extreme levels of underweight and stunting among pre-adolescent children of low socioeconomic class from Madhyamgram and Barasat, West Bengal, India	2008	India	both	Not reported	cross-sectional	130	10-12y	Height-for-age	<-2SD of NCHS reference[1]	Stunting 50.8% in girls, and 53.6% in boys
Bose, K.; Mukhopadhyay, A.	Nutritional status of adolescent Bengalee boys	2004	India	boys	slum	cross-sectional	502	10-16y	BMI-for-age	<5th percentile of NHANES[4]	Thinness 37.6%
Caleyachetty, R.; Thomas, G. N.; Kengne, A. P.; Echouffo-Tcheugui, J. B.; Schilsky, S.; Khodabocus, J.; Uauy, R.	The double burden of malnutrition among adolescents: Analysis of data from the Global School-Based Student Health and Health Behavior in School-Aged Children surveys in 57 low- and middle-income countries	2018	South Asia: India, Pakistan, Sri Lanka	both	nationally representative	cross-sectional	13107	12-15y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Pakistan: stunting 7.1% and thinness 11.2%. India: stunting 14.6%, thinness 15.9%. Sri Lanka: stunting 25.6%, thinness 31.5%.
									BMI-for-age	<-2SD from median of WHO reference 2007[3]	

Chakrabarty, S.; Bharati, P.	Physical growth and nutritional status of the Shabar tribal adolescents of Orissa, India: A cross-sectional study	2008	India	both	Not reported	cross-sectional	328	10-18y	BMI-for-age	<5th percentile of WHO reference 1995[2]	Thinness 35.8% in girls, and 54.4% in boys
Chakraborty, S.; Chopra, M.; Mani, K.; Giri, A. K.; Banerjee, P.; Sahni, N. S.; Siddhu, A.; Tandon, N.; Bharadwaj, D.	Prevalence of vitamin B-12 deficiency in healthy Indian school-going adolescents from rural and urban localities and its relationship with various anthropometric indices: a cross-sectional study	2018	India	both	urban and rural	cross-sectional	2403	11-17y	Micro deficiency: vit B12	Serum B12 <148 pmol L^{-1}	Vit B12 def 31% in girls, and 34.4% in boys
Choudhary, S.; Khichar, S.; Dabi, D.; Parakh, M.; Dara, P. K.; Parakh, P.; Vyas, S.; Deopa, B.	Urban Rural Comparison of Anthropometry and Menarcheal Status of Adolescent School Going Girls of Jodhpur, Rajasthan, India	2016	India	girls	urban and rural	cross-sectional	327	11-16y	Height-for-age	CDC 2000[5]	Stunting 21.2%
									BMI-for-age	CDC 2000[5]	Thinness 27%

Das, D. K.; Biswas, R.	Nutritional status of adolescent girls in a rural area of North 24 Parganas district, West Bengal	2005	India	girls	rural	cross-sectional	143	10-19y	Height-for-age	<5th percentile of WHO reference 1995[2]	Stunting 37.8%
									BMI-for-age	<5th percentile of WHO reference 1995[2]	Thinness 14.7%
Das, P.; Ray, S. K.; Joardar, G. K.; Dasgupta, S.	Nutritional profiles of adolescents in a rural community of Hooghly district in West Bengal	2007	India	both	rural	cross-sectional	204	10-19y	Height-for-age	Not reported	Stunting 52.4% in girls, and 52.4% in boys
									BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 18% in girls and 36.6% in boys
Das, S.; Bose, K.	Prevalence of thinness using new international cut-off points among Santal tribal children and adolescents of Purulia District, West Bengal, India	2011	India	both	Not reported	cross-sectional	421	7-18y (mean age 11.3y)	BMI-for-age	IOTF[6]	Thinness 44.6% in girls, and 38.2% boys
Datta Banik, S.	Menarche, nutritional status and body size in 10 to 12 year-old girls	2014	India	girls	Not reported	cross-sectional	100	10-12y	Height-for-age	WHO reference 2007[3]	Stunting 50%

	from Kashipur, Purulia, West Bengal, India								BMI-for-age	WHO reference 2007[3]	Thinness 22%
de Lanerolle-Dias, M.; de Silva, A.; Lanerolle, P.; Arambepola, C.; Atukorala, S.	Micronutrient status of female adolescent school dropouts	2012	Sri Lanka	girls	urban and rural	cross-sectional	613	15-19y	BMI-for-age	WHO reference 2007[3]	Thinness 32.8%
									Micro deficiency: anemia, zinc	Hb <120 g/L[13] Serum zinc <66µg/dl	Anemia 17%, and zinc def 28.8%
Debnath, M.; Tigga, P. L.; Mondal, N.; Sen, J.	Birth order, father's occupation and family size are strongly associated with thinness among bengalee adolescent girls of Darjeeling district, West Bengal (India)	2016	India	girls	Not reported	cross-sectional	387	9-14y (mean age 11.5y)	BMI-for-age	IOTF[6]	Thinness 23.8%
Durrani, N. U. R.; Ahmad, Z.; Abbas, K. A.	Nutritional and health status of school age children in Islamabad Capital Territory, Pakistan	2007	Pakistan	both	rural	cross-sectional	108	11-14y	Height-for-age	<-2SD from median of WHO reference 1995[2]	Stunting 89.9%

Faizi, N.; Khan, Z.; Khan, I. M.; Amir, A.; Azmi, S. A.; Khalique, N.	A study on nutritional status of school-going adolescents in Aligarh, India	2017	India	both	Not reported	cross-sectional	1456	13-15y	BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 2.6% in girls, and 2.9% in boys
Garg, P.; Kaur, S.; Gupta, D.; Osmond, C.; Lakshmy, R.; Sinha, S.; Kapil, U.; Sachdev, H. P. S.	Variability of thinness and its relation to cardio-metabolic risk factors using four body mass index references in school-children from Delhi, India	2013	India	both	Not reported	cross-sectional	16245	5-18y (mean age 11.7y)	BMI-for-age	<-2SD from median of CDC 2000[5]; IOTF[6]; <-2SD from median of WHO reference 2007[3]; 5th percentile of IAP[8]	Thinness in girls: CDC 10.3%, IOTF 9.4%, WHO 9%, IAP 6.5%; in males: CDC 17%, WHO 15%, Cole 10.5%, IAP 6.6%
Ghosh, J. R.; Bandyopadhyay, A. R.	Prevalence of thinness and overweight among urban adolescents of West Bengal, India	2009	India	both	urban	cross-sectional	1153	9-17y	BMI-for-age	5th percentile of WHO reference 1995[2]	Thinness 16.9% in girls, and 28.4% in boys

Ghosh, J. R.; Sarkar, A.	Prevalence of undernutrition among Santal children of Birbhum District, West Bengal, India	2013	India	both	rural	cross-sectional	119	10-16y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 31.1% in girls, and 17% in boys
									BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 5.8% in girls, and 16% in boys
Gupta, A.; Gupta, S.	Prevalence of iron deficiency anaemia in healthy adolescent girls from low to medium socio-economic strata living in one of the fastest developing economies	2018	India	girls	slum	cross-sectional	253	11-18y	Micro deficiency: anemia	Not reported	Anemia 86.6%
Gupta, A.; Kapil, U.; Ramakrishnan, L.; Pandey, R. M.; Yadav, C. P.	Prevalence of Vitamin B12 and Folate Deficiency in School Children Residing at High Altitude Regions in India	2017	India	both	Not reported	cross-sectional	215	6-18y (mean age 13y)	Micro deficiency: folic acid and vit B12	Serum folic acid <4ng/ml[17] Serum vitamin B12 <203pg/ml[17]	Folic acid def 1.5%, vit B12 def 7.4%

Gupta, V. K.; Maria, A. K.; Kumar, R.; Bahia, J. S.; Arora, S.	To study the prevalence of anaemia in young males and females with respect to the age, BMI, activity profile and the socioeconomic status in rural Punjab	2011	India	both	rural	cross-sectional	1824	10-19y	Micro deficiency: anemia	Hb <13g/dl in males and Hb <12g/dl in females	Anemia 87% in girls, and 88.7% in boys
Haboubi, G. J.; Shaikh, R. B.	A comparison of the nutritional status of adolescents from selected schools of South India and UAE: A cross-sectional study	2009	India	both	Not reported	cross-sectional	1200	10-16y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 36.9% in girls, and 38.8% in boys
									BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 50% in girls, and 64.6% in boys
Harun-Or-Rashid, M.; Khatun, U. F.; Yoshida, Y.; Morita, S.; Chowdhury, N.; Sakamoto, J.	Iron and iodine deficiencies among under-2 children, adolescent girls, and pregnant women of Bangladesh: association with common diseases	2009	Bangladesh	girls	nationally representative	cross-sectional	355	13-19y	Micro deficiency: anemia, iodine	Hb<12 g/dL[13] Urinary iodine <100µg/L[19]	Anemia 24.8%, iodine def 38.4%

Hettiarachchi, M.; Liyanage, C.; Wickremasinghe, R.; Hilmers, D.; Abrams, S.	Nutrient intake and growth of adolescents in southern Sri Lanka	2006	Sri Lanka	both	Not reported	cross-sectional	945	12-16y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 21.1% in girls, and 21.3% in boys
									BMI-for-age	<5th percentile of CDC 2000[5]	Thinness 35.7% in girls, and 57.6% in boys
Hettiarachchi, M.; Liyanage, C.; Wickremasinghe, R.; Hilmers, D. C.; Abrahams, S. A.	Prevalence and severity of micronutrient deficiency: a cross-sectional study among adolescents in Sri Lanka	2006	Sri Lanka	both	Not reported	cross-sectional	945	12-16y	Height-for-age	<-2SD from median of CDC 2000[5]	Stunting 17.5% in girls, and 19.5% in boys
									BMI-for-age	<-2SD from median of CDC 2000[5]	Thinness 23.8% in girls, and 43.2% in boys
									Micro deficiency: anemia, zinc, folic acid	Hb < 120.0 g/L Serum zinc <9.95 µmol/L. Serum folate <6.80 nmol/L	Anemia 58% in girls and 49.6% in boys. Zinc def 58.3% in girls, and 51.5% in boys. Folic acid def

											52.5% in girls, and 54.6% in boys.
Himaz, R.	Stunting later in childhood and outcomes as a young adult: Evidence from India	2018	India	both	Not reported	secondary data analysis of a longitudinal study	1000	children were aged 8, 12, 15 and 19.	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 30% at the age of 8. Less than half of the stunted children at 8 remained stunted at age 19
Hussain, D. A. S.; Arefin, M. S.; Hussain, B.; Sarker, A.	Prevalence of iron deficiency anemia and its biochemical parameters among the selected school-going under-priviledged children in Dhaka City, Bangladesh	2013	Bangladesh	both	Not reported	cross-sectional	164	10-18y	Micro deficiency: anemia	Hb <12.0 gm/dl	Anemia 66%

Jaacks, L. M.; Slining, M. M.; Popkin, B. M.	Recent trends in the prevalence of under- and overweight among adolescent girls in low- and middle-income countries	2015	India, Bangladesh and Nepal	girls	nationally representative	cross-sectional	Not reported	15-18y	BMI-for-age	IOTF[6]	Thinness 40% in India, 24% in Nepal and 24% in Bangladesh.
Jafar, T. H.; Qadri, Z.; Islam, M.; Hatcher, J.; Bhutta, Z. A.; Chaturvedi, N.	Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children	2008	Pakistan	both	urban	cross-sectional	NHSP n=685; Karachi survey n= 637	11-14y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 15.3% in NHSP, and 11.9% in Karachi survey
Jani, R.; Salian, N.; Udipi, S.; Ghugre, P.; Lohia, N.; Haas, J.; Boy, E.	Folate status and intake of tribal Indian adolescents aged 10 to 17 years	2015	India	both	Not reported	cross-sectional	224	10-17y	Micro deficiency: anemia, folic acid	Hb <120g/L[15] RBC folate < 340 nmol/L[16]	Anemia 43% in girls, and 31.3% in boys. Folic acid def 48% in girls and 41% in boys.
Jayatissa, R.; Ranbanda, R. M.	Prevalence of challenging nutritional problems among adolescents in Sri	2006	Sri Lanka	both	nationally representative	cross-sectional	6264	10-15y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 27.9% in girls, and 29.1% in boys.

	Lanka								BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 36.1% in girls, and 57.9% in boys
									Micro deficiency: anemia, vit A	Hb<12.0 g/dL Presence of Bitot's spots[10]	Anemia 11.2% in girls, and 11% in boys. Vit A def 0.3% in girls, and 0.4% in boys
Johnson, A. R.; Balasubramanya, B.; Jaimol,; Shaiby, S. R.; Gifty,; Britto, R. D.	Body image perception and nutritional status of adolescents in a school in rural South India	2015	India	both	Not reported	cross-sectional	118	10-19y	BMI-for-age	WHO reference 2007[3]	Thinness 26.6% in girls, and 43.6% in boys
Kabir, Y.; Shahjalal, H. M.; Saleh, F.; Obaid, W.	Dietary pattern, nutritional status, anaemia and anaemia-related knowledge in urban adolescent college girls of Bangladesh	2010	Banglade sh	girls	urban	cross-sectional	65	15-19y	Height-for-age	<95% of NCHS reference[1]	Stunting 63%
									Micro deficiency: anemia, vit C	Hb<12.0 g/dl[13] Vitamin C <0.29 mg/dl	Anemia 23%, vit C def 8%

Kanade, A. N.; Joshi, S. B.; Rao, S.	Undernutrition and adolescent growth among rural Indian boys	1999	India	boys	rural	longitudinal	473	10-18y	Height-for-age	<90% of the median, Waterlow's classification[7]	Stunting ranged from 16.7% at the age of 18y and 67.2 at the age of 13
Kapil, U.; Pandey, R.; Goswami, R.; Sharma, B.; Sharma, N.; Ramakrishnan, L.; Singh, G.; Sareen, N.; Sati, H.; Gupta, A.; Sofi, N.	Prevalence of Vitamin D deficiency and associated risk factors among children residing at high altitude in Shimla district, Himachal Pradesh, India	2017	India	both	Not reported	cross-sectional	626	6-18y (mean age 13y)	Micro deficiency: vit D	Serum 25(OH)D <20 ng/ml[20]	Vit D def 96.3% in girls, and 89.3% in boys
Kapil, U.; Pandey, R. M.; Sharma, B.; Ramakrishnan, L.; Sharma, N.; Singh, G.; Sareen, N.	Prevalence of Vitamin D Deficiency in Children (6-18 years) Residing in Kullu and Kangra Districts of Himachal Pradesh, India	2018	India	both	Not reported	cross-sectional	1222	6-18y (mean age 13y)	Micro deficiency: vit D	Serum 25(OH)D <20 ng/ml[20]	Vit D def in 91.5% in girls, and 70% in boys

Kapil, U.; Sareen, N.	Prevalence of ferritin, folate and vitamin B12 deficiencies amongst children in 5-18 years of age in Delhi	2014	India	both	Not reported	cross-sectional	Not reported	12-18y	Micro deficiency: iron, folic acid, vit B12.	Serum ferritin < 12 ng/mL Serum folate < 3 ng/mL Serum B12 < 200 pg/mL	Iron def 55.0 %, folic acid def 30.7 % and vit B12 def 68.3 %
Kapoor, A.; Channa, N. A.; Soomro, A. M.; Tunio, S. A.; Khand, T. U.; Memon, N.	Malnutrition and clinical manifestations in school going children at district Tharparkar, Sindh, Pakistan	2018	Pakistan	both	Not reported	cross-sectional	300	12-17y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 32% in girls, and 34% in boys.
									BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 16% in girls, and 34% in boys.
									Micro deficiency: anemia	Not reported	Anemia 50.6% in girls, and 70% in boys.
Kawade, R.	Zinc status and its association with the health of	2012	India	girls	Not reported	cross-sectional	630	10-16y	BMI-for-age	<5th percentile of IAP[8]	Thinness 24%

	adolescents: a review of studies in India								Micro deficiency: anemia, zinc, vit A, vit C.	Hb<12 g/dl Plasma zinc < 0.7mg/l Plasma retinol <200 mg/l Plasma vit C <0.2 mg/dl	Anemia 27.2%, zinc def 72.4%, vit A def 65.4%, vit C def 10.8%
Khan, A.; Burton, N. W.; Khan, S. R.	Double burden of overweight and underweight among school children of Dhaka city, Bangladesh	2013	Bangladesh	both	urban	cross-sectional	898	mean age 14.3y	BMI-for-age	WHO reference 2007[3]	Thinness 11.4% in girls, and 15.7% in boys
Khan, M. R.; Ahmed, F.	Physical status, nutrient intake and dietary pattern of adolescent female factory workers in urban Bangladesh	2005	Bangladesh	girls	urban	cross-sectional	1211	14-19y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 65%
									BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 17%
Khan, Z.; Khan, I. M.; Amir, A.; Azmi, S. A.; Khalique, N.	A study on nutritional status of school-going adolescents in Aligarh, India	2017	India	both	Not reported	cross-sectional	1456	13-15y	BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 2.6% in girls, and 2.9% in boys

Kini, S.; Kumar, M.; Usha Rani, S. P.	Assessment of nutritional status of school going children in rural Mangalore, south India: A cross sectional study	2016	India	both	rural	cross-sectional	290	10-16y	Height-for-age	Not reported	Stunting 21.8% in girls, and 16.6% in boys
									BMI-for-age	Not reported	Thinness 41% in girls, and 53.7% in boys
Kumar, A. K.; Siddhu, C. M.; Chandra, M. R.; Kishore, K.	Serum vitamin A level of secondary school children	1976	India	boys	Not reported	cross-sectional	409	10-16y	Micro deficiency: vit A	Clinical signs of vitamin A deficiency	Vit A def 24%
Lamba, R., Jr.; Misra, S. K.; Agrawal, R.; Rana, R., Sr.	To study the prevalence of anemia and related biosocial factors among college going adolescent girls in urban Agra	2014	India	girls	urban	cross-sectional	300	16-19y	Micro deficiency: anemia	Hb<12gm/dl[15]	Anemia 65.3%

Laxmaiah, A.; Arlappa, N.; Balakrishna, N.; Mallikarjuna Rao, K.; Galreddy, C.; Kumar, S.; Ravindranath, M.; Brahmam, G. N.	Prevalence and determinants of micronutrient deficiencies among rural children of eight states in India	2013	India	both	rural	cross-sectional	6616	12-17y	Micro deficiency: anemia	Hb<12gm/dl[13]	Anemia 69.2%
Leroy, J. L.; Ruel, M.; Sununtnasuk, C.; Ahmed, A.	Understanding the determinants of adolescent nutrition in Bangladesh	2018	Bangladesh	both	nationally representative of rural Bangladesh	cross-sectional	4093	10-20y	BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 16.7% in girls, and 22.3% in boys
Maiti, S.; Ali, K. M.; De, D.; Bera, T. K.; Ghosh, D.; Paul, S.	A comparative study on nutritional status of urban and rural early adolescent school girls of West Bengal, India	2011	India	girls	urban and rural	cross-sectional	2545	10-14y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 32.5%
									BMI-for-age	<-2SD from median of NCHS reference[1]	Thinness 23.3%

Maiti, S.; Ghosh, D.; Paul, S.	Prevalence of thinness among early adolescent in rural school girls of Paschim Medinipur, West Bengal, India	2011	India	girls	rural	cross-sectional	3693	10-14y	BMI-for-age	IOTF[6]	Thinness 58.3%
Malhotra, A.; Passi, S. J.	Diet quality and nutritional status of rural adolescent girl beneficiaries of ICDS in north India	2007	India	girls	rural	cross-sectional	209	11-21y (mean age 13.6y)	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 29.7%
									BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 30.6%
Mandot, S.; Mandot, D.; Sonesh, J. K.	Nutritional status of tribal (Garasia) school children of Sirohi district, Rajasthan, India	2009	India	both	Not reported	cross-sectional	1131	10-16y	Height-for-age	<3rd percentile of NCHS reference[1] & IAP[9]	Stunting 48.1% in girls, and 47.8% in boys (NCHS) & 30.5% in girls, and 29.2% in boys (IAP)

									BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 55.8% in girls and, 68.5% in boys
Mansur, D. I.; Haque, M. K.; Sharma, K.; Mehta, D. K.; Shakya, R.	Prevalence of underweight, stunting and thinness among adolescent girls in Kavre District, Nepal	2015	Nepal	girls	rural	cross-sectional	617	10-16y	Height-for-age	<-2SD from median of WHO reference 1995[2]	Stunting 19%
									BMI-for-age	<-2SD from median of WHO reference 1995[2]	Thinness 13%
Marwaha, R. K.; Tandon, N.; Reddy, D. R.; Aggarwal, R.; Singh, R.; Sawhney, R. C.; Saluja, B.; Ganie, M. A.; Singh, S.	Vitamin D and bone mineral density status of healthy schoolchildren in northern India	2005	India	both	urban	cross-sectional	760	10-18y	Micro deficiency: vit D	Serum 25(OH)D <20 ng/ml[21]	Vit D def 89.9%

Medhi, G. K.; Hazarika, N. C.; Mahanta, J.	Nutritional status of adolescents among tea garden workers	2007	India	both	Not reported	cross-sectional	605	10-18y	Height-for-age	<3rd percentile of NCHS reference[1] & IAP[9]	Stunting 51.9% in girls, and 47.4% in boys (NCHS). Stunting 29.1% in girls and 30.9% in boys (IAP)
									BMI-for-age	<5th percentile of NHANES[4]	Thinness 41.3% in girls, and 59.4% in boys
Mitra, M.; Kumar, P. V.; Chakrabarty, S.; Bharati, P.	Nutritional status of kamar tribal children in Chhattisgarh	2007	India	both	Not reported	cross-sectional	44	10-12y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 65% in girls, and 66.7% in boys
Mondal, N.	Thinness as major underlying problem among adolescents of northeast India	2014	India	both	rural	cross-sectional	1165	10-18y	BMI-for-age	IOTF[6]	Thinness 46.9% girls, and 51.2% boys

Mondal, N.; Basumatary, B.; Kropi, J.; Bose, K.	Prevalence of double burden of malnutrition among urban school going Bodo children aged 5-11 years of Assam, Northeast India	2015	India	both	urban	cross-sectional	268	10-11y	BMI-for-age	IOTF[6]	Thinness 13.2% in girls, and 13.6% in boys
Mondal, N.; Sen, J.	Thinness is a major underlying problem among Indian children	2010	India	both	rural	cross-sectional	929	10-12y	BMI-for-age	IOTF[6]	Thinness 60.3% in girls, and 70.1% in boys
Mondal, N.; Sen, J.	Prevalence of undernutrition among children (5-12 years) belonging to three communities residing in a similar habitat in North Bengal, India	2010	India	both	Not reported	cross-sectional	688	10-12y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 53% in girls, and 42% in boys
Mondal, N.; Sen, J.	Prevalence of stunting and thinness among rural adolescents of Darjeeling district, West Bengal, India	2010	India	both	rural	cross-sectional	726	10-17y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 50.3% in girls, and 43.1% in boys

									BMI-for-age	<5th percentile of NHANES[4]	Thinness 32% in girls, and 52.1% in boys
Mondal, N.; Terangpi, M.	Prevalence of undernutrition among tribal adolescents of Karbi Anglong district of Assam, Northeast India	2014	India	both	Not reported	cross-sectional	864	10-17y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 50.2% in girls, and 50.1% in boys
									BMI-for-age	<5th percentile of NHANES[4]	Thinness 14.9% in girls, and 12.5% in boys
Mushtaq, M. U.; Gull, S.; Khurshid, U.; Shahid, U.; Shad, M. A.; Siddiqui, A. M.	Prevalence and socio-demographic correlates of stunting and thinness among Pakistani primary school children	2011	Pakistan	both	urban and rural	cross-sectional	187	11-12y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 18.7%
									BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 17.1%
Niranjala, A. M. S.; Gunawardena, N. S.	Nutritional Status of Adolescent Females in Estates in Haliela, Sri Lanka	2011	Sri Lanka	girls	Not reported	cross-sectional	524	13-16y	BMI-for-age	<5th percentile of NCHS reference[1]	Thinness 39.1%

Padhy, G. K.; Mishra, R. N.; Das, S.; Sahu, K.	A study on assessment of health status of school children of eastern Bhubaneswar, India	2013	India	both	Not reported	cross-sectional	604	10-16y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 28% in girls, and 22.4% in boys
Pal, A.; Pari, A. K.; Sinha, A.; Dhara, P. C.	Prevalence of undernutrition and associated factors: A cross-sectional study among rural adolescents in West Bengal, India	2017	India	both	rural	cross-sectional	560	10-17y	Height-for-age	<-2SD from median of WHO reference 1995[2]	Stunting 58.4% in girls, and 48.8% in boys
									BMI-for-age	<5th percentile of NHANES[4]	Thinness 50.9% in girls, and 46.6% in boys
Pandav, C. S.; Mallik, A.; Anand, K.; Pandav, S.; Karmarkar, M. G.	Prevalence of iodine deficiency disorders among school children of Delhi	1997	India	both	Not reported	cross-sectional	1684	10-14y	Micro deficiency: iodine	Urinary iodine <100ug/L	Iodine def 23.6%
PanterBrick, C.; Todd, A.; Baker, R.	Growth status of homeless Nepali boys: Do they differ from rural and urban controls?	1996	Nepal	boys	urban and rural	cross-sectional	150	12-14y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 68%

Pasi, A. L.; Hanchate, M. S.; Pasha, M. A. M.	Study of health profile of adolescent girls in Kurnool district of Andhra Pradesh-India	2013	India	girls	rural	cross-sectional	589	10-19y	Micro deficiency: anemia	Hb < 12 gm/dl[14]	Anemia 41.9%
Patel, S. A.; Narayan, K. M.; Cunningham, S. A.	Unhealthy weight among children and adults in India: urbanicity and the crossover in underweight and overweight	2015	India	both	nationally representative	cross-sectional	Not reported	15-18y	BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 11.3% in girls, and 25.5% in boys
Prashant, K.; Shaw, C.	Nutritional status of adolescent girls from an urban slum area in South India	2009	India	girls	slum	cross-sectional	223	10-18y	Height-for-age	<3rd percentile of NCHS reference[1] & IAP[8]	Stunting 47% (NCHS) and 28.3% (IAP)
									BMI-for-age	<5th percentile of IAP[8]	Thinness 20.6%

Radhika, M. S.; Swetha, B.; Kumar, B. N.; Krishna, N. B.; Laxmaiah, A.	Dietary and nondietary determinants of nutritional status among adolescent girls and adult women in India	2018	India	girls	rural	cross-sectional	3930	10-19y	BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 27%
Rah, J. H.; Christian, P.; Shamim, A. A.; Arju, U. T.; Labrique, A. B.; Rashid, M.	Predictors of stunting and thinness in post-menarcheal adolescent girls in rural Bangladesh	2009	Bangladesh	girls	rural	cross-sectional	456	12-19y	Height-for-age	<-2SD from median of CDC 2000[5]	Stunting 47%
									BMI-for-age	<5th percentile of CDC 2000[5]	Thinness 11.9%
Rao, K. M.; Balakrishna, N.; Laxmaiah, A.; Venkaiah, K.; Brahmam, G. N.	Diet and nutritional status of adolescent tribal population in nine states of India	2006	India	both	tribal and rural	cross-sectional	12789	10-17y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 46% in tribal girls, 39% in rural girls, and 42.4% in tribal boys, 39% in rural boys.

									BMI-for-age	<5th percentile of NHANES[4]	Thinness 41.7% in tribal girls, 40.1% in rural girls, and 62.9% in tribal boys, 66.9% in rural boys
Rawat, R.; Kumar, S.; Bindhu, S. A.	Sociodemographic correlates of malnutrition among school aged children in an urban slum in India: a cross-sectional study	2015	India	both	slum	cross-sectional	217	10-14y	BMI-for-age	<5th percentile of CDC 2000[5]	Thinness 54.3%
Rengma, M. S.; Bose, K.; Mondal, N.	Socio-economic and demographic correlates of stunting among adolescents of Assam, North- east India	2016	India	both	Not reported	cross-sectional	1818	10-18y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 37.8% in girls, and 48.4% in boys
Roy, S.; Barman, S.; Mondal, N.; Sen, J.	Prevalence of stunting and thinness among adolescent girls belonging to the	2016	India	girls	Not reported	cross-sectional	500	9-18y	Height-for-age	<3rd percentile of NCHS reference[1]	Stunting 39.6%

	rajbanshi population of West Bengal, India								BMI-for-age	<5th percentile of NHANES[4]	Thinness 26%
Sahu, M.; Bhatia, V.; Aggarwal, A.; Rawat, V.; Saxena, P.; Pandey, A.; Das, V.	Vitamin D deficiency in rural girls and pregnant women despite abundant sunshine in northern India	2009	India	girls	Not reported	cross-sectional	121	mean age 14.3y	Micro deficiency: vit D	Serum 25(OH)D <50 nmol/l	Vit D def 88%
Selvarani, P.	Prevalence of anaemia and its association with demographic factors among adolescent girls in Coimbatore district, India	2017	India	girls	urban and rural	cross-sectional	605	13-16y	Micro deficiency: anemia	Hb<12gms/dl[15]	Anemia 55.7%
Shahabuddin, A. K. M.; Talukder, K.; Talukder, M. Q. K.; Hassan, M. Q.; Seal, A.;	Adolescent nutrition in a rural community in Bangladesh	2000	Banglade sh	both	rural	cross-sectional	906	10-17y	Height-for-age	Not reported	Not reported

Rahman, Q.; Mannan, A.; Tomkins, A.; Costello, A.									BMI-for-age	Not reported	Not reported
									Micro deficiency: anemia	Hb <12.0 g/dl for males 10-15 y, Hb <13.0 g/dl for males >15 y, Hb <11.5 g/dl for females 10-15 y, Hb <12.0 g/dl for females >15 y	Anemia 65% girls, and 96% boys
Shridevi, K.; Nageshwara Rao, R.; Madhavi, P.; Chandra Sekhar, K.; Deotale, P. G.	A study of nutritional status of adolescent girls of social welfare hostels in and around Vijayawada city	2015	India	girls	Not reported	cross-sectional	181	13-17y	Micro deficiency: anemia	Not reported	Anemia 98.3%
Sikdar, M.	Prevalence of malnutrition among the Mising children of Northeast India: A comparison between four different sets of criteria	2012	India	both	Not reported	cross-sectional	102	10y	BMI-for-age	<-2SD from median of WHO reference 2007[3] & IOTF[6] & <5th percentile of NHANES[4] & <5th percentile CDC 2000[5]	Thinness 24% (WHO), 20% (IOTF), 34% (NHANES) and 34% (CDC) in girls. Thinness 7.6% (WHO) 17.3% (IOTF), 25% (NHANES), and 28.8% (CDC) in boys.

Singh, N.; Mishra, C. P.	Nutritional status of adolescent girls of a slum community of Varanasi, India	2001	India	girls	slum	cross-sectional	70	13-18y	Height-for-age	Not reported	Stunting 10%
Singh, R. K.	Lifestyle behavior affecting prevalence of anemia among women in EAG states, India	2013	India	girls	nationally representative	cross-sectional	7863	15-19y	Micro deficiency: anemia	Hb <12 g/dl	Anemia 66%
Sinha, A.; Jonas, J. B.; Kulkarni, M.; Nangia, V.	Vitamin A deficiency in schoolchildren in urban central India: the central India children eye study	2011	India	both	urban	cross-sectional	11601	7-21y (mean age 13y)	Micro deficiency: vit A	Bitot spots and/or subjective night blindness	Vit A def 6.5%
Siva, P. M.; Sobha, A.; Manjula, V. D.	Prevalence of anaemia and its associated risk factors among adolescent girls of central Kerala	2016	India	girls	Not reported	cross-sectional	257	10-19y	BMI-for-age	WHO reference 2007[3]	Thinness 17.2%
									Micro deficiency: anemia	Hb <12 gm/dl[15]	Anemia 21%

Sunethra Atukorala, T. M.; De Silva, L. D. R.	Iron status of adolescent females in three schools in an urban area of Sri Lanka	1990	Sri Lanka	girls	urban	cross-sectional	93	14-18y	Micro deficiency: anemia	Hb<12 g/dl	Anemia 7.5%
Tamanna, S.; Rana, M. M.; Ferdoushi, A.; Ishtiyaq Ahmad, S. A.; Rahman, M.; Rahman, A.	Assessment of nutritional status among adolescent Garo in Sherpur district, Bangladesh	2013	Bangladesh	both	Not reported	cross-sectional	384	10-18y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 17.7% in girls, and 12.9% in boys
Tandon, B. N.; Ramachandran, K.; Nath, L. M.; Sood, N. N.; Gahlot, D. K.; Gupta, M. C.; Wali, J. P.; Sinha, S. N.; Hasteer, P. C.; Kutty, P. R.	Vitamin A nutritional status of rural community of Khol block in Haryana, North India. A collaborative study	1975	India	both	rural	cross-sectional	555	10-19y	Micro deficiency: vit A	Night blindness and Bitot's spots	Night blindness 11.2% and Bitot's spots 7.6%
Thoradeniya, T.; Wickremasinghe, R.; Ramanayake, R.; Atukorala, S.	Low folic acid status and its association with anaemia in urban adolescent girls and women of childbearing age in Sri Lanka	2006	Sri Lanka	girls	urban	cross-sectional	276	15-18y	Height-for-age	5th percentile of WHO reference 1995[2]	Thinness 18%

									Micro deficiency: anemia, folic acid, vit B12	Hb<120 g/l Serum folic acid <3 ng/ml Serum vitamin B12 <150 pg/ml	Anemia 31.1%, folic acid def 45.1%, and vit B12 def 0.44%
Toteja, G. S.; Singh, P.; Dhillon, B. S.; Saxena, B. N.; Ahmed, F. U.; Singh, R. P.; Prakash, B.; Vijayaraghavan, K.; Singh, Y.; Rauf, A.; Sarma, U. C.; Gandhi, S.; Behl, L.; Mukherjee, K.; Swami, S. S.; Meru, V.; Chandra, P.; Chandrawati,; Mohan, U.	Prevalence of anemia among pregnant women and adolescent girls in 16 districts of India	2006	India	girls	Not reported	cross-sectional	4337	11-18y	Micro deficiency: anemia	Hb<120 g/L[14]	Anemia 90.1%
Vashist, B. M.; Joyti, ; Goel, M. K.	Nutritional status of adolescents in rural and urban Rohtak, Haryana	2009	India	both	urban and rural	cross-sectional	2000	13-16y	Height-for-age	NCHS reference[1]	Stunting 11.7% in girls and 10.8% in boys

									BMI-for-age	NCHS reference[1]	Thinness 14.4% in girls, and 26.9% in boys
Vaze, N.; Gandhe, B.	Prevention of anemia in adolescent school girls of Nagpur, India	2015	India	girls	Not reported	cross-sectional	3153	13-17y	Micro deficiency: anemia	WHO classification (Not reported)	Anemia 90.6%
Venkaiah, K.; Damayanti, K.; Nayak, M. U.; Vijayaraghavan, K.	Diet and nutritional status of rural adolescents in India	2002	India	both	rural	cross-sectional	12124	10-17y	Height-for-age	<-2SD from median of NCHS reference[1]	Stunting 39%
									BMI-for-age	5th percentile of NHANES[4]	Not reported
Vijaya Kumar, U.; Budaya Kiran, M. S.; Lakshmana Rao, N.	A community study on prevalence and knowledge regarding anaemia among adolescent girls in a rural area of Rajahmundry, Andhra Pradesh	2015	India	girls	rural	cross-sectional	215	11-18y	Micro deficiency: anemia	Hb<12gm/dl	Anemia 63.7%

Demographic and Health Surveys Demographic and Health Surveys	ADOLESCENT NUTRITION 2000-2017: DHS DATA ON ADOLESCENTS AGE 15-19. Adolescent Nutrition in Demographic and Health Surveys	2018	South Asia: Bangladesh, India, Maldives, Nepal, Pakistan	both	nationally representative	cross-sectional	Not reported	15-19y	Height-for-age	<-2SD from median of WHO reference 2007[3]	Stunting 35.9% in South Asian girls
									BMI-for-age	<-2SD from median of WHO reference 2007[3]	Thinness 10.9% in South Asian girls and, 21.6% in South Asian boys
									Micro deficiency: anemia	Hb <12 gm/dl[15]	Anemia 54% in South Asian girls, and 30.2% in South Asian boys
GSHS	Global School-based Student Health Survey Bhutan 2016 Fact Sheet	2016	Bhutan	both	nationally representative of all students	cross-sectional	7576	13-17y	BMI-for-age	<-2SD from median	Thinness 1.3% in girls, and 3.1% in boys
GSHS	Global School-based Student Health Survey Maldives 2014 Fact Sheet	2014	Maldives	both	nationally representative of all students	cross-sectional	3493	13-17y	BMI-for-age	<-2SD from median	Thinness 18.6% in girls, and 20.7% in boys

GSHS	Global School-based Student Health Survey Nepal 2015 Fact Sheet	2015	Nepal	both	nationally representative of all students	cross-sectional	6529	13-17y	BMI-for-age	<-2SD from median	Thinness 7.7% in girls, and 14.4% in boys
GSHS	Global School-based Student Health Survey Afghanistan 2014 Fact Sheet	2014	Afghanistan	both	nationally representative of all students	cross-sectional	2579	13-17y	BMI-for-age	<-2SD from median	Thinness 3.9% in girls, and 3% in boys
GSHS	Global School-based Student Health Survey Pakistan 2009 Fact Sheet	2009	Pakistan	both	nationally representative of all students	cross-sectional	5192	13-15y	BMI-for-age	<-2SD from median	Thinness 9% in girls, and 12.3% in boys

[1] Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF. NCHS growth curves for children birth-18 years. United States. Vital Health Stat 11. Nov 1977;(165):i-iv, 1-74.

[2] World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser. 1995 1995;854:1-452.

[3] de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bulletin of the World Health Organization. 2007;85(9):660-667. doi:10.2471/BLT.07.043497

[4] National Center for Health Statistics. NHANES I (1971-1974). https://wwwn.cdc.gov/nchs/nhanes/nhanes1/Default.aspx

[5] Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. Adv Data. Jun 8 2000;(314):1-27.

[6] Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. Bmj. Jul 28 2007;335(7612):194. doi:10.1136/bmj.39238.399444.55

[7] Waterlow JC, Buzina R, Keller W, Lane JM, Nichaman MZ, Tanner JM. The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. Bull World Health Organ. 1977;55(4):489-98.

[8] Agarwal DK, Agarwal KN, Upadhyay SK, Mittal R, Prakash R, Rai S. Physical and sexual growth pattern of affluent Indian children from 5 to 18 years of age. Indian Pediatr. Oct 1992;29(10):1203-82.

[9] Joint WHO/USAID Meeting. Vitamin A deficiency and xerophthalmia : report of a Joint WHO/USAID Meeting [held in Jakarta from 25 to 29 November 1974]. Geneva: World Health Organization; 1976.

[10] Joint WHO/UNICEF/USAID/Helen Keller International/IVACG Meeting. Control of vitamin A deficiency and xerophthalmia : report of a Joint WHO/UNICEF/USAID/Helen Keller International/IVACG Meeting [held in Jakarta from 13 to 17 October 1980]. Geneva: World Health Organization; 1982.

[11] World Health Organization. Nutrition Unit. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. Geneva: World Health Organization; 1996.

[12] Joint World Health Organization/Centers for Disease Control. Assessing the iron status of populations: including literature reviews: report of a Joint World Health Organization/Centers for Disease Control and Prevention Technical Consultation on the Assessment of Iron Status at the Population Level, Geneva, Switzerland, 6-8 April 2004. 2nd ed ed. World Health Organization; 2007.

[13] UNICEF & United Nations University & World Health Organization. Iron deficiency anaemia : assessment, prevention, and control : a guide for programme managers. Geneva: World Health Organization; 2001.

[14] World Health Organization. Nutritional anaemias : report of a WHO group of experts [meeting held in Geneva from 11 to 15 October 1971]. Geneva: World Health Organization; 1972.

[15] World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva: World Health Organization; 2011.

[16] World Health Organization. Serum and red blood cell folate concentrations for assessing folate status in populations. Vitamin and Mineral Nutrition Information System. . Geneva: World Health Organization; 2012.

[17] de Benoist B. Conclusions of a WHO Technical Consultation on folate and vitamin B12 deficiencies. Food Nutr Bull. Jun 2008;29(2 Suppl):S238-44. doi:10.1177/15648265080292s129

[18] Institute of Medicine Panel on Dietary Antioxidants Related Compounds. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. National Academies Press (US); 2000.

[19] World Health Organization. Assessment of iodine deficiency disorders and monitoring their elimination : a guide for programme managers. 2nd ed ed. Geneva: World Health Organization; 2001.

[20] Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. Jul 2011;96(7):1911-30. doi:10.1210/jc.2011-0385

[21] Lips P. Vitamin D deficiency and secondary hyperparathyroidism in the elderly: consequences for bone loss and fractures and therapeutic implications. Endocr Rev. Aug 2001;22(4):477-501. doi:10.1210/edrv.22.4.0437

[22] Brown KH, Rivera JA, Bhutta Z, et al. International Zinc Nutrition Consultative Group (IZiNCG) technical document #1. Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr Bull. Mar 2004;25(1 Suppl 2):S99-203.

[23] Gibson R. Principles of nutritional assessment. Oxford University Press; 2005.

[24] Dunn JT, Haar Fvd, International Council for Control of Iodine Deficiency D, World Health O, United Nations Children's Fund. A practical guide to the correction of iodine deficiency / by John T. Dunn and Frits van der Haar. [S.l.] : International Council for Control of Iodine Deficiency Disorders; 1990.

APPENDIX 3. CUT-OFFS FROM PREVIOUS STUDIES USING THE GSHS

This is the variables collected in all South Asian countries. Each variable includes the survey question and responses, cut-offs used in previous literature (references below) and the cut-offs used in this study.

- **Q7 Fruit consumption and Q8 vegetable consumption**: *During the past 30 days, how many times per day did you usually eat fruit (q7) / vegetables (q8)?*
    - GSHS responses: did not eat fruit/veg; <1/day; 1/day; 2/day; 3/day; 4/day; 5 or more/day
    - Cut-offs from previous literature: low fruit and vegetable intake was defined as intake of fruit and vegetables less than five times per day (Caleyachetty et al., 2015; WHO & FAO, 2003)
    - Cut-offs in this study: Q7+Q8 yes (5 or more/day) and no (<5/day)
- **Q11 Tooth brushing** : *During the past 30 days, how many times per day did you usually clean or brush your teeth?*
    - GSHS responses: did not brush my teeth; less than 1 time per day; 1 time per day; 2 times per day; 3 times per day; 4 or more times per day
    - Cut-offs from previous literature: recommendation of brushing the teeth twice a day (American Dental Association, 2013; British Dental Association, 2020; Pengpid & Peltzer, 2011)
    - Cut-offs from previous literature: one or more times per day (GSHS codebooks)
    - Cut-offs in this study: yes (2/day; 3/day;4 or more/day) and no (did not brush my teeth; less than 1 time per day; 1 time per day)
- **Q12 Washing hands before meals:** *During the past 30 days, how often did you wash your hands before eating?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks)
    - Cut-offs from previous literature: yes (always) and no (never, rarely, sometimes, most of the time) (Pengpid & Peltzer, 2011)
    - Cut-offs from previous literature: yes (sometimes; most of the time; always) and no (never; rarely) (Smith et al., 2020)
    - Cut-offs in this study: yes (sometimes; most of the time; always) and no (never; rarely)
- **Q13 Washing hands after toilet**: *During the past 30 days, how often did you wash your hands after using the toilet or latrine?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks)

    - Cut-offs from previous literature: yes (always) and no (never, rarely, sometimes, most of the time) (Pengpid & Peltzer, 2011)
    - Cut-offs from previous literature: yes (sometimes; most of the time; always) and no (never; rarely) (Smith et al., 2020)
    - Cut-offs in this study: yes (sometimes; most of the time; always) and no (never; rarely)
- **Q14 Washing hands with soap**: *During the past 30 days, how often did you use soap when washing your hands?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks)
    - Cut-offs from previous literature: yes (always) and no (never, rarely, sometimes, most of the time) (Pengpid & Peltzer, 2011)
    - Cut-offs from previous literature: yes (sometimes; most of the time; always) and no (never; rarely) (Smith et al., 2020)
    - Cut-offs in this study: yes (sometimes; most of the time; always) and no (never; rarely)
- **Q22 Loneliness**: *During the past 12 months, how often have you felt lonely?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks; (Wilson et al., 2012)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)
- **Q23 Anxiety**: *During the past 12 months, how often have you been so worried about something that you could not sleep at night?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks; (Wilson et al., 2012)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)
- **Q27 Friendships**: *How many close friends do you have?*
    - GSHS responses: 0; 1; 2; 3 or more
    - Cut-offs from previous literature: yes (1; 2; 3 or more) and no (0) (GSHS codebooks; (Wilson et al., 2012)
    - Cut-offs in this study: yes (1; 2; 3 or more) and no (0)
- **Q29 Tobacco use:** *During the past 30 days, on how many days did you smoke cigarettes (q29)?*
    - GSHS responses: 0 days; 1 or 2 days; 3 to 5 days; 6 to 9 days; 10 to 19 days; 20 to 29 days; all 30 days.
    - Cut-offs from previous literature: yes (1 or more days) and no (0 days) (GSHS codebooks; (Alwan et al., 2011; Peltzer & Pengpid, 2017; Pengpid & Peltzer, 2011)

    - Cut-offs in this study: yes (1 or more days) and no (0 days)
- **Q49 Physical activity**: *During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?*
    - GSHS responses: 0 days; 1; 2; 3; 4; 5; 6; 7 days
    - Cut-offs from previous literature: defined low physical activity among adolescents as having < 5 days/week of at least 60 minutes per week (Caleyachetty et al., 2015; Guthold et al., 2010)
    - Cut-offs from previous literature: adolescents were classified as 'physically active' if they engaged in physical activity for at least 60 min every day of the week (Aguilar-Farias et al., 2018; WHO, 2020a; Xu et al., 2020).
    - Cut-offs in this study: yes (7 days) and no (0; 1; 2; 3; 4; 5; 6)
- **Q50 Active transportation**: *During the past 7 days, on how many days did you walk or ride a bicycle to or from school?*
    - GSHS responses: 0 days; 1; 2; 3; 4; 5; 6; 7 days
    - Cut-offs from previous literature: adolescents were classified as 'active for transport' if they rode or walked to and from school on at least 3 days during the past 7 days (Aguilar-Farias et al., 2018; Xu et al., 2020).
    - Cut-offs from previous literature: were considered as ''active for transport'' if they engaged in this activity on at least 1 day during the past 7 days (GSHS codebooks; (Guthold et al., 2010)
    - Robustness test was conducted for this variable as it was difficult to decide what cut-off to use. The results obtain for cut-off on 1 day and cut-off on 3 days were not substantively different.
    - Cut-offs in this study: no (0 days; 1; 2) and yes (3 or more)
- **Q52 Sedentary behaviour**: How much time do you spend during a typical or usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities?
    - GSHS responses: less than 1 hour per day; 1 to 2 hours per day; 3 to 4 hours per day; 5 to 6 hours per day; 7 to 6 hours per day; more than 8 hours per day.
    - Cut-offs from previous literature: adolescents who spent 3 or more hours per day sitting down were classified as having sedentary behavior (GSHS codebooks; (Aguilar-Farias et al., 2018; Davis et al., 2020b; Guthold et al., 2010; Xu et al., 2020)
    - Cut-offs in this study: yes (3 to 4 hours per day; 5 to 6 hours per day; 7 to 6 hours per day; more than 8 hours per day) and no (less than 1 hour per day).
- **Q54 Peer support**: *During the past 30 days, how often were most of the students in your school kind and helpful?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks (Davis et al., 2020b; Peltzer & Pengpid, 2017)

    - Cut-offs from previous literature: yes (rarely, sometimes, most of the time and always) and no (never) (Siziya et al., 2007)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)
- **Q55 Parental involvement in school (parents check homework)**: *During the past 30 days, how often did your parents or guardians check to see if your homework was done?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks; (Abdirahman et al., 2012; Alwan et al., 2011; Kushal et al., 2021; Peltzer & Pengpid, 2017; Wilson et al., 2012)
    - Cut-offs from previous literature: yes (rarely, sometimes, most of the time and always) and no (never) (Siziya et al., 2007)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)
- **Q56 Parental understanding (parents understand problems)**: *During the past 30 days, how often did your parents or guardians understand your problems and worries?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks; (Abdirahman et al., 2012; Alwan et al., 2011; Davis et al., 2020b; Kushal et al., 2021; Peltzer & Pengpid, 2017; Shayo & Lawala, 2019; Wilson et al., 2012)
    - Cut-offs from previous literature: yes (rarely, sometimes, most of the time and always) and no (never) (Siziya et al., 2007)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)
- **Q57 Parental bonding (parents know what child is doing)**: *During the past 30 days, how often did your parents or guardians really know what you were doing with your free time?*
    - GSHS responses: never; rarely; sometimes; most of the time; always.
    - Cut-offs from previous literature: yes (most of the time and always) and no (never, rarely, sometimes) (GSHS codebooks; (Abdirahman et al., 2012; Alwan et al., 2011; Kushal et al., 2021; Peltzer & Pengpid, 2017; Wilson et al., 2012)
    - Cut-offs from previous literature: yes (rarely, sometimes, most of the time and always) and no (never) (Siziya et al., 2007)
    - Cut-offs in this study: yes (most of the time and always) and no (never, rarely, sometimes)

GSHS codebooks can be found in https://www.who.int/ncds/surveillance/gshs/datasets/en/

References of previous literature using GSHS cut-offs

Abdirahman, H.A., Bah, T.T., Shrestha, H.L. and Jacobsen, K.H. (2012) Bullying, mental health, and parental involvement among adolescents in the Caribbean, West Indian Med J, 61, 5, 504-8.

Aguilar-Farias, N., Martino-Fuentealba, P., Carcamo-Oyarzun, J., Cortinez-O'Ryan, A., Cristi-Montero, C., Von Oetinger, A. and Sadarangani, K.P. (2018) A regional vision of physical activity, sedentary behaviour and physical education in adolescents from Latin America and the Caribbean: results from 26 countries, Int J Epidemiol, 47, 3, 976-986.

Alwan, H., Viswanathan, B., Rousson, V., Paccaud, F. and Bovet, P. (2011) Association between substance use and psychosocial characteristics among adolescents of the Seychelles, BMC Pediatr, 11, 85.

American Dental Association (2013) American Dental Association Statement on Regular Brushing and Flossing to Help Prevent Oral Infections.

British Dental Association (2020) Brushing: top tips for your patients.

Caleyachetty, R., Echouffo-Tcheugui, J.B., Tait, C.A., Schilsky, S., Forrester, T. and Kengne, A.P. (2015) Prevalence of behavioural risk factors for cardiovascular disease in adolescents in low-income and middle-income countries: an individual participant data meta-analysis, Lancet Diabetes Endocrinol, 3, 7, 535-44.

Davis, L.E., Abio, A., Wilson, M.L. and Shaikh, M.A. (2020) Extent, patterns and demographic correlates for physical fighting among school-attending adolescents in Namibia: examination of the 2013 Global School-based Health Survey, PeerJ, 8, e9075.

Guthold, R., Cowan, M.J., Autenrieth, C.S., Kann, L. and Riley, L.M. (2010) Physical activity and sedentary behavior among schoolchildren: a 34-country comparison, J Pediatr, 157, 1, 43-49.e1.

Kushal, S.A., Amin, Y.M., Reza, S. and Shawon, M.S.R. (2021) Parent-adolescent relationships and their associations with adolescent suicidal behaviours: Secondary analysis of data from 52 countries using the Global School-based Health Survey, EClinicalMedicine, 31.

Peltzer, K. and Pengpid, S. (2017) Prevalence and Correlates of Physical Fighting Among School Going Students Aged 13 - 15 in the Association of Southeast Asian Nations (ASEAN) Member States, Iran J Pediatr, 27, 5, e8170.

Pengpid, S. and Peltzer, K. (2011) Hygiene behaviour and associated factors among in-school adolescents in nine African countries, Int J Behav Med, 18, 2, 150-9.

Shayo, F.K. and Lawala, P.S. (2019) Does food insecurity link to suicidal behaviors among in-school adolescents? Findings from the low-income country of sub-Saharan Africa, BMC Psychiatry, 19, 1, 227.

Siziya, S., Muula, A.S. and Rudatsikira, E. (2007) Prevalence and correlates of truancy among adolescents in Swaziland: findings from the Global School-Based Health Survey, Child and Adolescent Psychiatry and Mental Health, 1, 15.

Smith, L., Butler, L., Tully, M.A., Jacob, L., Barnett, Y., López-Sánchez, G.F., López-Bueno, R., Shin, J.I., McDermott, D., Pfeifer, B.A., Pizzol, D. and Koyanagi, A. (2020) Hand-Washing Practices among Adolescents Aged 12-15 Years from 80 Countries, Int J Environ Res Public Health, 18, 1.

Wilson, M.L., Dunlavy, A.C., Viswanathan, B. and Bovet, P. (2012) Suicidal expression among school-attending adolescents in a middle-income sub-Saharan country, Int J Environ Res Public Health, 9, 11, 4122-34.

World Health Organization (2020) Global strategy on diet, physical activity and health website. Physical activity and young people., In WHO (ed), Geneva: WHO.

World Health Organization and Food and Agriculture Organization (2003) Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation., In WHO (ed), Geneva: WHO.

Xu, G., Sun, N., Li, L., Qi, W., Li, C., Zhou, M., Chen, Z. and Han, L. (2020) Physical behaviors of 12-15 year-old adolescents in 54 low- and middle-income countries: Results from the Global School-based Student Health Survey, J Glob Health, 10, 1, 010423.

APPENDIX 4. BIVARIATE ANALYSIS USING THE GSHS DATASETS FROM SOUTH ASIA

Table 1: Bivariate relationships between stunting and health behaviours among adolescents aged 12-15 years old in South Asia, GSHS datasets.

	Stunting (height-for-age <2 SD)		
	No stunted, % (n^1/N^1)	Stunted, % (n^2/N^2)	p-value
5 fruits and vegs			
5 or more per day	16.15% (3,359/20,798)	14.03% (409/2,915)	0.391
Loneliness			
Often/always	10.43% (2,173/20,825)	10.56% (307/2,908)	0.173
Anxiety			
Often/always	7.35% (1,542/20,972)	7.56% (222/2,938)	0.034
Tobacco			
1 or more days	6.50 % (1,352/20,799)	4.18% (122/2,920)	0.039
Physically activity			
7 days per week	22.65% (4,692/20,713)	17.74% (516/2,909)	0.066
Active transportation			
3 or more days per week	48.76% (10,071/20,656)	46.64% (1,353/2,901)	0.750
Sedentary behaviour			
3 or more hours per day	18.85% (3,903/20,705)	17.98% (522/2,904)	0.489
Tooth brushing			
2 times or more per day	49.27% (10,329/20,963)	51.35% (1,507/2,935)	0.282
Washing hands before meals			
Sometimes/often/always	95.70% (19,978/20,875)	95.48% (2,787/2,919)	0.065
Washing hands after toilet			
Sometimes/often/always	96.45% (20,124/20,865)	96.27% (2,815/2,924)	0.469
Washing hands with soap			
Sometimes/often/always	91.72% (19,164/20,893)	92.39% (2,706/2,929)	0.052
Friendships			
1 or more friend	91.70% (19,107/20,836)	91.28% (2,659/2,913)	0.483
Peer support			
Often/always	47.39% (9,723/20,515)	48.23% (1,392/2,886)	0.226
Parental involvement			
Often/always	48.38% (9,974/20,614)	49.20% (1,417/2,880)	0.275
Parental understanding			
Often/always	54.13% (11,090/20,487)	54.24% (1,553/2,863)	0.906
Parental bonding			
Often/always	51.97% (10,564/20,328)	52.76% (1,499/2,841)	0.646

n^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted and fall into the health behaviour

N^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted

n^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted and fall into the health behaviour

N^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted

Table 2: Bivariate relationships between thinness and health behaviours among adolescents aged 12-15 years old in South Asia, GSHS datasets.

	Thinness (BMI-for-age <2 SD)		
	No thin, % (n/N)	**Thin, % (n/N)**	**p-value**
5 fruits and vegs			
5 or more per day	16.15% (3,467/21,466)	13.40% (301/2,247)	0.361
Loneliness			
Often/always	10.58% (2,272/21,478)	9.22% (208/2,255)	0.532
Anxiety			
Often/always	7.52% (1,628/21,644)	6.00% (136/2,266)	0.261
Tobacco			
1 or more days	6.37% (1,367/21,467)	4.75% (107/2,252)	0.457
Physically activity			
7 days per week	22.00% (4,706/21,387)	22.46% (502/2,235)	0.837
Active transportation			
3 or more days per week	48.24% (10,290/21,329)	50.90% (1,134/2,228)	0.311
Sedentary behaviour			
3 or more hours per day	18.90% (4,041/21,380)	17.23% (384/2,229)	0.012
Tooth brushing			
2 times or more per day	49.38% (10,679/21,627)	50.95% (1,157/2,271)	0.056
Washing hands before meals			
Sometimes/often/always	95.76% (20,622/21,534)	94.84% (2,146/2,260)	0.971
Washing hands after toilet			
Sometimes/often/always	96.38% (20,756/21,536)	96.89% (2,183/2,253)	0.553
Washing hands with soap			
Sometimes/often/always	91.91% (19,814/21,557)	90.77% (2,056/2,265)	0.984
Friendships			
1 or more friend	91.71% (19,716/21,498)	91,07% (2,050/2,251)	0.683
Peer support			
Often/always	47.81 (10,129/21,186)	44.51% (986/2,215)	0.304
Parental involvement			
Often/always	48.32% (10,277/21,269)	50.07% (1,114/2,225)	0.946
Parental understanding			
Often/always	54,01% (11,414/21,132)	55.41% (1,229/2,218)	0.990
Parental bonding			
Often/always	51.88% (10,888/20,985)	53.88% (1,175/2,184)	0.253

n^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted and fall into the health behaviour

N^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted

n^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted and fall into the health behaviour

N^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted

Table 3: Bivariate relationships between overweight and health behaviours among adolescents aged 12-15 years old in South Asia, GSHS datasets.

	Overweight (BMI-for-age >1 SD)		
	No overweight, % (n/N)	Overweight, % (n/N)	p-value
5 fruits and vegs			
5 or more per day	15.69% (3,313/21,118)	17.53% (455/2,595)	0.417
Loneliness			
Often/always	10.25% (2,167/21,142)	12.08% (313/2,591)	0.647
Anxiety			
Often/always	7.23% (1,539/21,293)	8.60% (225/2,617)	0.151
Tobacco			
1 or more days	6.26% (1,323/21,121)	5.81% (151/2,598)	0.001
Physically activity			
7 days per week	22.26% (4,684/21,046)	20.34% (524/2,576)	0.981
Active transportation			
3 or more days per week	48.84% (10,254/20,993)	45.63% (1,170/2,564)	0.972
Sedentary behaviour			
3 or more hours per day	18.17% (3,822/21,034)	23.42% (603/2,575)	0.009
Tooth brushing			
2 times or more per day	49.10% (10,450/21,284)	52.98% (1,385/2,614)	0.005
Washing hands before meals			
Sometimes/often/always	95.69% (20,274/21,187)	95.55% (2,491/2,607)	0.392
Washing hands after toilet			
Sometimes/often/always	96.45% (20,427/21,178)	96.21% (2,512/2,611)	0.091
Washing hands with soap			
Sometimes/often/always	91.71% (19,454/21,213)	92.60% (2,416/2,609)	0.102
Friendships			
1 or more friend	91% (19,406/21,148)	90.73% (2,360/2,601)	0.141
Peer support			
Often/always	47.78% (9,963/20,850)	45.16% (1,152/2,551)	0.610
Parental involvement			
Often/always	48.94% (10,247/20,939)	44.77% (1,144/2,555)	0.061
Parental understanding			
Often/always	54.40% (11,321/20,810)	52.05% (2,540/1,322)	0.832
Parental bonding			
Often/always	52.11% (10,764/20,655)	51.67% (1,299/2,514)	0.837

n^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted and fall into the health behaviour

N^1 refers to the number of South Asian adolescents based on GSHS datasets who are no stunted

n^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted and fall into the health behaviour

N^2 refers to the number of South Asian adolescents based on GSHS datasets who are stunted

APPENDIX 5. MULTIVARIABLE LOGISTIC REGRESSION MODELS USING THE GSHS DATASET FROM SOUTH ASIA

Table 1: Multivariable logistic regression model for adolescent stunting in Pakistan, GSHS Pakistan 2009 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					Stunting (height-for-age <2 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.16	0.13	0.208	0.92	1.46	1.16	0.14	0.211	0.92	1.47
Sex										
Boy	1.00					1.00				
Girl	3.08	0.75	0.000	1.91	4.98	2.79	0.72	0.000	1.69	4.63
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.19	0.32	0.512	0.71	2.00					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.00	0.20	0.998	0.67	1.48					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	1.30	0.48	0.484	0.63	2.69					
Tobacco										
0 days	1.00									
1 or more days	0.57	0.26	0.214	0.23	1.39					

Physically activity										
<7 days per week	1.00									
7 days per week	0.66	0.22	0.212	0.34	1.27					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.35	0.27	0.132	0.91	1.99					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.89	0.56	0.849	0.25	3.09					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.97	0.16	0.835	0.70	1.34					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.84	0.58	0.802	0.22	3.23					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.53	0.41	0.408	0.12	2.37					
Washing hands with soap										
Never/rarely	1.00					1.00				
Sometimes/often/always	3.44	2.21	0.053	0.98	12.08	1.54	0.95	0.485	0.46	5.18
Friendships										
no friends	1.00									
1 or more friend	0.69	0.31	0.404	0.28	1.66					
Peer support										
Never/rarely/sometimes	1.00									

Often/always	1.01	0.25	0.966	0.62	1.64	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.89	0.12	0.407	0.68	1.17	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	0.94	0.25	0.808	0.55	1.59	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	0.91	0.30	0.638	0.62	1.34	

Table 2: Multivariable logistic regression model for adolescent thinness in Pakistan, GSHS Pakistan 2009 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					**Thinness (BMI-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.90	0.08	0.267	0.75	1.08	0.92	0.09	0.367	0.76	1.11
Sex										
Boy	1.00					1.00				
Girl	1.00	0.28	0.998	0.58	1.73	0.86	0.23	0.571	0.51	1.45
5 fruits and vegs										
<5 per day	1.00									

5 or more per day	1.15	0.21	0.437	0.80	1.66					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.35	0.31	0.189	0.86	2.11					
Anxiety										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.55	0.12	0.007	0.36	0.85	0.64	0.15	0.063	0.40	1.03
Tobacco										
0 days	1.00									
1 or more days	1.37	0.31	0.161	0.88	2.13					
Physically activity										
<7 days per week	1.00									
7 days per week	1.08	0.26	0.753	0.67	1.72					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.02	0.17	0.894	0.74	1.41					
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	0.47	0.16	0.029	0.24	0.93	0.56	0.20	0.103	0.28	1.12
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.78	0.12	0.096	0.58	1.05					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.82	0.30	0.591	0.40	1.69					
Washing hands after toilet										

Never/rarely	1.00					
Sometimes/often/always	1.22	0.52	0.639	0.53	2.83	
Washing hands with soap						
Never/rarely	1.00					
Sometimes/often/always	0.91	0.24	0.726	0.54	1.54	
Friendships						
no friends	1.00					
1 or more friend	1.06	0.27	0.827	0.64	1.76	
Peer support						
Never/rarely/sometimes	1.00					
Often/always	1.20	0.16	0.178	0.92	1.56	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.81	0.12	0.147	0.62	1.08	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	1.03	0.18	0.858	0.73	1.46	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	1.15	0.14	0.243	0.91	1.46	

Table 3: Multivariable logistic regression model for adolescent overweight in Pakistan, GSHS Pakistan 2009 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL	**Overweight (BMI-for-age >1 SD) REDUCED MODEL**

	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.99	0.08	0.887	0.85	1.15	0.99	0.07	0.909	0.87	1.13
Sex										
Boy	1.00					1.00				
Girl	1.55	0.31	0.026	1.06	2.29	1.64	0.30	0.007	1.15	2.35
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.95	0.20	0.794	0.62	1.44					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.02	0.23	0.930	0.66	1.58					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.68	0.23	0.254	0.36	1.31					
Tobacco										
0 days	1.00									
1 or more days	0.90	0.34	0.776	0.42	1.90					
Physically activity										
<7 days per week	1.00									
7 days per week	0.73	0.21	0.279	0.41	1.29					
Active transportation										
<3 days per week	1.00									
3 or more days per week	0.88	0.11	0.305	0.70	1.12					

Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.27	0.25	0.225	0.86	1.86					
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	1.50	0.35	0.084	0.95	2.37	1.48	0.28	0.040	1.02	2.14
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.72	0.33	0.474	0.30	1.75					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	2.42	1.89	0.259	0.52	11.18					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.39	0.58	0.432	0.61	3.16					
Friendships										
no friends	1.00									
1 or more friend	1.22	0.38	0.530	0.66	2.24					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.82	0.15	0.272	0.58	1.17					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.13	0.17	0.418	0.84	1.52					
Parental understanding										
Never/rarely/sometimes	1.00					1.00				

Often/always	0.71	0.08	0.003	0.56	0.89	0.71	0.08	0.003	0.56	0.89
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.91	0.12	0.443	0.70	1.17					

Table 4: Multivariable logistic regression model for adolescent stunting in Afghanistan, GSHS Afghanistan 2014 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					**Stunting (height-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.93	0.11	0.560	0.74	1.17	0.93	0.10	0.535	0.75	1.16
Sex										
Boy	1.00					1.00				
Girl	0.32	0.14	0.008	0.13	0.74	0.42	0.18	0.048	0.18	0.99
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.67	0.30	0.369	0.29	1.59					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.06	0.19	0.756	0.74	1.50					
Anxiety										
Never/rarely/sometimes	1.00									

Often/always	1.58	0.60	0.230	0.75	3.34					
Tobacco										
0 days	1.00									
1 or more days	0.36	0.17	0.029	0.14	0.90					
Physically activity										
<7 days per week	1.00									
7 days per week	1.03	0.49	0.948	0.41	2.61					
Active transportation										
<3 days per week	1.00					1.00				
3 or more days per week	1.38	0.22	0.050	1.00	1.89	1.46	0.22	0.014	1.08	1.97
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	2.03	0.69	0.039	1.04	3.97	2.00	0.50	0.005	1.23	3.26
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	0.48	0.10	0.000	0.32	0.72	0.43	0.09	0.000	0.28	0.65
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.50	0.68	0.611	0.04	7.10					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.53	0.35	0.343	0.14	1.97					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.12	0.62	0.840	0.38	3.29					
Friendships										

no friends	1.00					
1 or more friend	0.95	0.58	0.927	0.29	3.13	
Peer support						
Never/rarely/sometimes	1.00					
Often/always	0.82	0.20	0.409	0.51	1.32	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.80	0.25	0.476	0.43	1.48	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	0.75	0.20	0.277	0.45	1.26	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	1.47	0.52	0.272	0.74	2.94	

Table 5: Multivariable logistic regression model for adolescent thinness in Afghanistan, GSHS Afghanistan 2014 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					**Thinness (BMI-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.40	0.56	0.399	0.64	3.08	1.38	0.27	0.099	0.94	2.03
Sex										

Boy	1.00					1.00				
Girl	1.37	1.11	0.695	0.28	6.73	1.13	0.63	0.830	0.38	3.38
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.93	0.81	0.931	0.17	5.10					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.45	0.36	0.318	0.10	2.15					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	1.25	1.05	0.788	0.24	6.47					
Tobacco										
0 days	1.00									
1 or more days	1.00	(omitted)								
Physically activity										
<7 days per week	1.00									
7 days per week	0.60	0.35	0.382	0.19	1.87					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.33	0.64	0.554	0.52	3.43					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.66	1.52	0.578	0.28	10.00					
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	2.53	1.51	0.120	0.79	8.16	2.43	0.69	0.002	1.39	4.25

Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.00	(omitted)								
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.00	(omitted)								
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.00	(omitted)								
Friendships										
no friends	1.00									
1 or more friend	1.00	(omitted)								
Peer support										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.21	0.13	0.014	0.06	0.73	0.38	0.14	0.009	0.18	0.78
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.64	1.03	0.432	0.48	5.61					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.75	1.28	0.446	0.42	7.31					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.29	0.94	0.732	0.30	5.43					

Table 6: Multivariable logistic regression model for adolescent overweight in Afghanistan, GSHS Afghanistan 2014 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					Overweight (BMI-for-age >1 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.78	0.14	0.166	0.55	1.11	0.83	0.14	0.282	0.59	1.17
Sex										
Boy	1.00					1.00				
Girl	0.56	0.19	0.092	0.29	1.10	0.65	0.20	0.159	0.36	1.18
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.92	0.32	0.805	0.46	1.83					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.84	0.16	0.350	0.58	1.22					
Anxiety										
Never/rarely/sometimes	1.00					1.00				
Often/always	2.26	0.85	0.031	1.08	4.73	1.60	0.40	0.062	0.98	2.61
Tobacco										
0 days	1.00									
1 or more days	0.67	0.54	0.618	0.14	3.28					
Physically activity										
<7 days per week	1.00									
7 days per week	1.44	0.47	0.260	0.76	2.72					

Active transportation										
<3 days per week	1.00									
3 or more days per week	0.86	0.14	0.343	0.63	1.18					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.92	0.31	0.796	0.47	1.78					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.82	0.18	0.371	0.54	1.26					
Washing hands before meals										
Never/rarely	1.00					1.00				
Sometimes/often/always	0.23	0.17	0.041	0.06	0.94	0.46	0.18	0.051	0.21	1.00
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.57	0.82	0.383	0.57	4.37					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	2.29	1.42	0.181	0.68	7.73					
Friendships										
no friends	1.00					1.00				
1 or more friend	0.46	0.12	0.004	0.28	0.78	0.71	0.18	0.182	0.43	1.17
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.15	0.18	0.353	0.85	1.56					
Parental involvement in school										
Never/rarely/sometimes	1.00									

Often/always	1.16	0.28	0.526	0.73	1.85					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	0.57	0.19	0.093	0.30	1.10					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.18	0.30	0.500	0.73	1.93					

Table 7: Multivariable logistic regression model for adolescent stunting in Bangladesh, GSHS Bangladesh 2014 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					**Stunting (height-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.74	0.39	0.014	1.12	2.70	1.61	0.36	0.036	1.03	2.50
Sex										
Boy	1.00					1.00				
Girl	1.12	0.43	0.766	0.53	2.38	1.31	0.44	0.411	0.68	2.52
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.76	0.32	0.509	0.33	1.72					
Loneliness										
Never/rarely/sometimes	1.00									

Often/always	0.68	0.30	0.376	0.29	1.59					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.64	0.44	0.514	0.17	2.42					
Tobacco										
0 days	1.00									
1 or more days	0.56	0.61	0.594	0.06	4.84					
Physically activity										
<7 days per week	1.00									
7 days per week	0.90	0.24	0.680	0.53	1.50					
Active transportation										
<3 days per week	1.00									
3 or more days per week	0.92	0.30	0.804	0.48	1.76					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.70	0.31	0.418	0.30	1.65					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.89	0.15	0.485	0.65	1.23					
Washing hands before meals										
Never/rarely	1.00					1.00				
Sometimes/often/always	4.48	2.73	0.014	1.35	14.80	4.76	3.02	0.014	1.37	16.53
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.54	1.16	0.568	0.35	6.74					
Washing hands with soap										

Never/rarely	1.00									
Sometimes/often/always	1.30	1.12	0.762	0.24	7.04					
Friendships										
no friends	1.00									
1 or more friend	0.87	0.32	0.706	0.42	1.79					
Peer support										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.56	0.10	0.002	0.39	0.81	0.57	0.12	0.007	0.38	0.86
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	0.88	0.18	0.536	0.60	1.31					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.25	0.24	0.255	0.85	1.82					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.28	0.43	0.462	0.67	2.46					

Table 8: Multivariable logistic regression model for adolescent thinness in Bangladesh, GSHS Bangladesh 2014 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL				**Thinness (BMI-for-age <2 SD) REDUCED MODEL**			
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**	**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**
Age								

12- 13 years	1.00					1.00				
14 - 15 years	0.69	0.17	0.120	0.43	1.10	0.71	0.14	0.092	0.48	1.06
Sex										
Boy	1.00					1.00				
Girl	0.67	0.27	0.317	0.31	1.46	0.65	0.23	0.219	0.32	1.30
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.67	0.22	0.223	0.35	1.28					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.13	0.48	0.765	0.50	2.59					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	1.84	0.71	0.115	0.86	3.93					
Tobacco										
0 days	1.00									
1 or more days	1.81	0.85	0.206	0.72	4.54					
Physically activity										
<7 days per week	1.00									
7 days per week	0.93	0.25	0.797	0.55	1.59					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.25	0.26	0.272	0.84	1.88					
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	0.46	0.19	0.060	0.20	1.03	0.40	0.15	0.012	0.20	0.82

Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	0.53	0.20	0.085	0.25	1.09	0.57	0.14	0.028	0.35	0.94
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.46	1.85	0.765	0.12	17.43					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.60	0.86	0.721	0.04	9.97					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.93	2.44	0.604	0.16	22.98					
Friendships										
no friends	1.00									
1 or more friend	1.15	0.51	0.754	0.48	2.72					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.03	0.19	0.855	0.72	1.49					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.00	0.25	0.997	0.62	1.62					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.12	0.23	0.595	0.74	1.69					
Parental bonding										
Never/rarely/sometimes	1.00									

Often/always	0.75	0.14	0.129	0.52	1.09	

Table 9: Multivariable logistic regression model for adolescent overweight in Bangladesh, GSHS Bangladesh 2014 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					Overweight (BMI-for-age >1 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.88	0.23	0.626	0.52	1.48	0.92	0.22	0.735	0.59	1.46
Sex										
Boy	1.00					1.00				
Girl	0.50	0.22	0.118	0.21	1.19	0.56	0.21	0.130	0.27	1.18
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.71	0.43	0.574	0.22	2.33					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.11	0.36	0.748	0.59	2.09					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.19	0.09	0.001	0.07	0.48					
Tobacco										
0 days	1.00					1.00				

1 or more days	0.28	0.17	0.033	0.09	0.91	0.20	0.09	0.000	0.08	0.46
Physically activity										
<7 days per week	1.00									
7 days per week	0.89	0.34	0.750	0.42	1.87					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.13	0.36	0.695	0.60	2.13					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.33	0.39	0.330	0.75	2.38					
Tooth brushing										
<2 times per day	1.00					1.00				
2 times or more per day	2.19	0.68	0.012	1.19	4.04	1.94	0.47	0.007	1.20	3.12
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.13	0.55	0.798	0.44	2.94					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.81	0.56	0.766	0.21	3.16					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	3.06	2.19	0.119	0.75	12.47					
Friendships										
no friends	1.00									
1 or more friend	0.71	0.31	0.429	0.30	1.67					
Peer support										

Never/rarely/sometimes	1.00					
Often/always	1.11	0.29	0.683	0.67	1.86	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.72	0.19	0.217	0.43	1.21	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	1.19	0.34	0.557	0.67	2.09	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	0.95	0.18	0.777	0.66	1.37	

Table 10: Multivariable logistic regression model for adolescent stunting in India, GSHS India 2007 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					**Stunting (height-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.34	0.09	0.000	1.17	1.53	1.34	0.09	0.000	1.17	1.54
Sex										
Boy	1.00					1.00				
Girl	1.33	0.25	0.134	0.92	1.93	1.39	0.27	0.091	0.95	2.03
5 fruits and vegs										

<5 per day	1.00									
5 or more per day	0.93	0.15	0.646	0.67	1.28					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.83	0.24	0.505	0.47	1.45					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.83	0.19	0.409	0.53	1.29					
Tobacco										
0 days	1.00									
1 or more days	1.11	0.53	0.822	0.44	2.83					
Physically activity										
<7 days per week	1.00									
7 days per week	0.84	0.12	0.218	0.63	1.11					
Active transportation										
<3 days per week	1.00					1.00				
3 or more days per week	1.53	0.17	0.000	1.23	1.91	1.58	0.16	0.000	1.29	1.92
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	0.83	0.08	0.064	0.68	1.01	0.77	0.07	0.007	0.64	0.93
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.89	0.10	0.316	0.72	1.11					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.78	0.20	0.324	0.47	1.28					

Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.86	0.25	0.615	0.49	1.53					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.11	0.16	0.494	0.83	1.47					
Friendships										
no friends	1.00									
1 or more friend	0.90	0.19	0.603	0.59	1.36					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.94	0.13	0.681	0.72	1.24					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.36	0.22	0.061	0.99	1.88					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.11	0.13	0.388	0.88	1.41					
Parental bonding										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.74	0.08	0.004	0.61	0.91	0.83	0.09	0.080	0.67	1.02

Table 11: Multivariable logistic regression model for adolescent thinness in India, GSHS India 2007 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					Thinness (BMI-for-age <2 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.10	0.06	0.086	0.99	1.22	1.09	0.05	0.057	1.00	1.20
Sex										
Boy	1.00					1.00				
Girl	0.86	0.11	0.248	0.67	1.11	0.86	0.11	0.270	0.67	1.12
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.90	0.10	0.303	0.73	1.10					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.08	0.21	0.697	0.74	1.57					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.78	0.17	0.271	0.51	1.21					
Tobacco										
0 days	1.00									
1 or more days	0.72	0.31	0.440	0.31	1.65					
Physically activity										
<7 days per week	1.00									
7 days per week	0.91	0.09	0.330	0.76	1.10					

Active transportation										
<3 days per week	1.00					1.00				
3 or more days per week	1.21	0.14	0.095	0.97	1.52	1.24	0.13	0.041	1.01	1.53
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	0.81	0.10	0.084	0.64	1.03	0.79	0.08	0.026	0.64	0.97
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.99	0.09	0.888	0.83	1.18					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.98	0.21	0.908	0.64	1.50					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.06	0.55	0.916	0.38	2.95					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	0.83	0.13	0.234	0.61	1.13					
Friendships										
no friends	1.00									
1 or more friend	0.88	0.11	0.325	0.69	1.13					
Peer support										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.73	0.08	0.005	0.58	0.91	0.71	0.07	0.001	0.57	0.87
Parental involvement in school										
Never/rarely/sometimes	1.00									

Often/always	1.03	0.13	0.824	0.80	1.33	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	1.03	0.10	0.778	0.85	1.24	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	0.95	0.11	0.667	0.75	1.20	

Table 12: Multivariable logistic regression model for adolescent overweight in India, GSHS India 2007 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					**Overweight (BMI-for-age >1 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.84	0.05	0.002	0.76	0.94	0.83	0.05	0.001	0.74	0.92
Sex										
Boy	1.00					1.00				
Girl	0.76	0.09	0.020	0.60	0.96	0.73	0.08	0.005	0.58	0.91
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.20	0.17	0.183	0.92	1.58					
Loneliness										
Never/rarely/sometimes	1.00									

Often/always	1.37	0.21	0.039	1.02	1.84	
Anxiety						
Never/rarely/sometimes	1.00					
Often/always	0.75	0.17	0.206	0.48	1.17	
Tobacco						
0 days	1.00					
1 or more days	0.90	0.45	0.835	0.34	2.40	
Physically activity						
<7 days per week	1.00					
7 days per week	1.15	0.18	0.360	0.85	1.55	
Active transportation						
<3 days per week	1.00					
3 or more days per week	0.87	0.12	0.304	0.67	1.14	
Sedentary behaviour						
<3 hours per day	1.00					
3 or more hours per day	1.11	0.13	0.378	0.88	1.38	
Tooth brushing						
<2 times per day	1.00					
2 times or more per day	0.96	0.09	0.705	0.80	1.16	
Washing hands before meals						
Never/rarely	1.00					
Sometimes/often/always	1.06	0.25	0.804	0.66	1.70	
Washing hands after toilet						
Never/rarely	1.00					
Sometimes/often/always	0.88	0.22	0.613	0.54	1.44	
Washing hands with soap						

Never/rarely	1.00					
Sometimes/often/always	1.15	0.20	0.447	0.81	1.63	
Friendships						
no friends	1.00					
1 or more friend	0.93	0.20	0.751	0.61	1.42	
Peer support						
Never/rarely/sometimes	1.00					
Often/always	0.96	0.09	0.663	0.79	1.16	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.94	0.10	0.572	0.76	1.16	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	0.90	0.13	0.438	0.68	1.18	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	1.13	0.12	0.249	0.92	1.39	

Table 13: Multivariable logistic regression model for adolescent stunting in Maldives, GSHS Maldives 2009 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL				**Stunting (height-for-age <2 SD) REDUCED MODEL**			
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**	**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**
Age								

12- 13 years	1.00					1.00				
14 - 15 years	1.73	0.19	0.000	1.39	2.15	1.67	0.23	0.000	1.28	2.20
Sex										
Boy	1.00					1.00				
Girl	1.66	0.53	0.113	0.89	3.09	1.48	0.46	0.206	0.81	2.72
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.01	0.38	0.987	0.48	2.11					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.07	0.25	0.774	0.68	1.68					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.93	0.31	0.835	0.48	1.81					
Tobacco										
0 days	1.00									
1 or more days	1.21	0.59	0.700	0.46	3.17					
Physically activity										
<7 days per week	1.00									
7 days per week	0.54	0.21	0.120	0.25	1.18					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.16	0.27	0.529	0.74	1.81					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.31	0.29	0.233	0.84	2.02					

Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.25	0.38	0.470	0.68	2.28					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.81	0.56	0.761	0.21	3.12					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.65	0.69	0.681	0.08	5.16					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	0.99	0.61	0.983	0.29	3.34					
Friendships										
no friends	1.00									
1 or more friend	1.15	0.65	0.799	0.39	3.45					
Peer support										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.67	0.16	0.086	0.42	1.06	0.60	0.12	0.011	0.40	0.89
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.02	0.27	0.936	0.61	1.72					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	0.94	0.25	0.810	0.55	1.59					
Parental bonding										
Never/rarely/sometimes	1.00									

Often/always	1.16	0.25	0.489	0.76	1.78	

Table 14: Multivariable logistic regression model for adolescent thinness in Maldives, GSHS Maldives 2009 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					Thinness (BMI-for-age <2 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.32	0.17	0.032	1.02	1.70	1.31	0.14	0.011	1.063	1.619
Sex										
Boy	1.00					1.00				
Girl	0.99	0.24	0.980	0.61	1.61	1.20	0.27	0.411	0.774	1.869
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.71	0.36	0.508	0.26	1.94					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.96	0.35	0.917	0.47	1.97					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.99	0.29	0.970	0.56	1.75					
Tobacco										
0 days	1.00									

1 or more days	1.18	0.58	0.736	0.45	3.08					
Physically activity										
<7 days per week	1.00									
7 days per week	0.88	0.21	0.600	0.55	1.42					
Active transportation										
<3 days per week	1.00									
3 or more days per week	0.75	0.18	0.215	0.47	1.18					
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	0.66	0.13	0.036	0.44	0.97	0.90	0.16	0.537	0.635	1.267
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.32	0.34	0.287	0.79	2.19					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.04	0.34	0.894	0.55	1.98					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.37	0.26	0.162	0.09	1.49					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	2.62	1.65	0.127	0.76	9.00					
Friendships										
no friends	1.00									
1 or more friend	0.73	0.21	0.284	0.41	1.30					
Peer support										

Never/rarely/sometimes	1.00									
Often/always	1.46	0.38	0.142	0.88	2.43					
Parental involvement in school										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.66	0.12	0.024	0.46	0.95	0.80	0.11	0.101	0.612	1.044
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	0.77	0.22	0.361	0.44	1.34					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.15	0.29	0.566	0.71	1.89					

Table 15: Multivariable logistic regression model for adolescent overweight in Maldives, GSHS Maldives 2009 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					**Overweight (BMI-for-age >1 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.68	0.10	0.007	0.51	0.90	0.72	0.11	0.025	0.53	0.96
Sex										
Boy	1.00					1.00				
Girl	0.44	0.14	0.012	0.23	0.84	0.47	0.16	0.023	0.25	0.90
5 fruits and vegs										

<5 per day	1.00					
5 or more per day	0.75	0.31	0.490	0.33	1.71	
Loneliness						
Never/rarely/sometimes	1.00					
Often/always	1.09	0.42	0.814	0.52	2.30	
Anxiety						
Never/rarely/sometimes	1.00					
Often/always	1.08	0.38	0.835	0.54	2.17	
Tobacco						
0 days	1.00					
1 or more days	0.54	0.47	0.477	0.10	2.92	
Physically activity						
<7 days per week	1.00					
7 days per week	0.86	0.20	0.533	0.55	1.37	
Active transportation						
<3 days per week	1.00					
3 or more days per week	0.89	0.16	0.524	0.62	1.28	
Sedentary behaviour						
<3 hours per day	1.00					
3 or more hours per day	1.18	0.29	0.491	0.73	1.91	
Tooth brushing						
<2 times per day	1.00					
2 times or more per day	0.74	0.22	0.301	0.42	1.31	
Washing hands before meals						
Never/rarely	1.00					
Sometimes/often/always	1.17	0.57	0.745	0.45	3.06	

Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.29	0.62	0.595	0.51	3.29					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.06	0.41	0.884	0.49	2.27					
Friendships										
no friends	1.00									
1 or more friend	1.42	0.72	0.495	0.52	3.84					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.99	0.28	0.982	0.57	1.73					
Parental involvement in school										
Never/rarely/sometimes	1.00					1.00				
Often/always	1.59	0.32	0.022	1.07	2.36	1.61	0.32	0.017	1.09	2.39
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.13	0.27	0.602	0.71	1.81					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.89	0.27	0.704	0.50	1.60					

Table 16: Multivariable logistic regression model for adolescent stunting in Nepal, GSHS Nepal 2015 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					Stunting (height-for-age <2 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.24	0.05	0.000	1.14	1.34	1.25	0.04	0.000	1.17	1.34
Sex										
Boy	1.00					1.00				
Girl	0.96	0.06	0.491	0.85	1.08	0.96	0.07	0.609	0.83	1.12
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.02	0.27	0.948	0.61	1.71					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.65	0.41	0.045	1.01	2.68					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.77	0.17	0.243	0.50	1.19					
Tobacco										
0 days	1.00									
1 or more days	0.65	0.20	0.158	0.36	1.18					
Physically activity										
<7 days per week	1.00									
7 days per week	0.71	0.15	0.113	0.47	1.08					

Active transportation										
<3 days per week	1.00					1.00				
3 or more days per week	0.79	0.12	0.110	0.59	1.06	0.69	0.11	0.021	0.51	0.95
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.76	0.17	0.216	0.49	1.18					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.96	0.10	0.714	0.79	1.18					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.64	0.83	0.333	0.60	4.43					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.28	0.53	0.546	0.57	2.87					
Washing hands with soap										
Never/rarely	1.00					1.00				
Sometimes/often/always	0.45	0.11	0.001	0.28	0.72	0.66	0.14	0.046	0.44	0.99
Friendships										
no friends	1.00									
1 or more friend	0.91	0.18	0.641	0.62	1.35					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.10	0.11	0.342	0.90	1.35					
Parental involvement in school										
Never/rarely/sometimes	1.00									

Often/always	1.00	0.12	0.972	0.79	1.27					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	0.89	0.09	0.232	0.73	1.08					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.04	0.11	0.720	0.84	1.28					

Table 17: Multivariable logistic regression model for adolescent thinness in Nepal, GSHS Nepal 2015 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					Thinness (BMI-for-age <2 SD) REDUCED MODEL				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.14	0.10	0.127	0.96	1.35	1.14	0.08	0.064	0.99	1.32
Sex										
Boy	1.00					1.00				
Girl	0.74	0.14	0.100	0.51	1.06	0.69	0.12	0.028	0.50	0.96
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.60	0.42	0.072	0.96	2.66					
Loneliness										
Never/rarely/sometimes	1.00									

Often/always	0.64	0.30	0.347	0.26	1.61					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.77	0.37	0.590	0.30	1.99					
Tobacco										
0 days	1.00									
1 or more days	1.25	0.43	0.518	0.64	2.43					
Physically activity										
<7 days per week	1.00									
7 days per week	1.10	0.24	0.666	0.72	1.68					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.27	0.22	0.170	0.90	1.77					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	1.06	0.25	0.794	0.67	1.68					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.83	0.12	0.175	0.63	1.09					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.89	0.29	0.726	0.47	1.70					
Washing hands after toilet										
Never/rarely	1.00					1.00				
Sometimes/often/always	0.66	0.23	0.235	0.33	1.31	0.63	0.20	0.144	0.34	1.17
Washing hands with soap										

Never/rarely	1.00					
Sometimes/often/always	1.21	0.49	0.642	0.54	2.68	
Friendships						
no friends	1.00					
1 or more friend	0.61	0.36	0.400	0.20	1.91	
Peer support						
Never/rarely/sometimes	1.00					
Often/always	0.94	0.10	0.588	0.76	1.17	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	1.18	0.20	0.326	0.85	1.65	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	0.95	0.20	0.789	0.62	1.43	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	0.92	0.13	0.559	0.69	1.22	

Table 18: Multivariable logistic regression model for adolescent overweight in Nepal, GSHS Nepal 2015 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL				**Overweight (BMI-for-age >1 SD) REDUCED MODEL**			
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**	**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**
Age								

12- 13 years	1.00					1.00				
14 - 15 years	0.65	0.05	0.000	0.56	0.75	0.67	0.05	0.000	0.58	0.79
Sex										
Boy	1.00					1.00				
Girl	0.59	0.12	0.009	0.40	0.88	0.65	0.11	0.010	0.47	0.90
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	0.54	0.24	0.169	0.22	1.30					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.67	0.54	0.622	0.14	3.25					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.80	0.50	0.720	0.23	2.75					
Tobacco										
0 days	1.00									
1 or more days	0.90	0.28	0.745	0.49	1.66					
Physically activity										
<7 days per week	1.00									
7 days per week	1.15	0.40	0.692	0.58	2.26					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.48	0.29	0.048	1.00	2.18					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.95	0.37	0.884	0.44	2.02					

Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.14	0.19	0.416	0.83	1.58					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	2.28	1.50	0.210	0.63	8.26					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	1.25	0.98	0.772	0.27	5.81					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	2.16	1.74	0.338	0.45	10.48					
Friendships										
no friends	1.00									
1 or more friend	0.65	0.33	0.401	0.24	1.77					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.25	0.24	0.241	0.86	1.81					
Parental involvement in school										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.59	0.12	0.012	0.39	0.89	0.67	0.14	0.046	0.45	0.99
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.06	0.25	0.816	0.66	1.68					
Parental bonding										
Never/rarely/sometimes	1.00									

Often/always	0.82	0.17	0.336	0.54	1.23					

Table 19: Multivariable logistic regression model for adolescent stunting in Sri Lanka, GSHS Sri Lanka 2016 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					Stunting (height-for-age <2 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.83	0.09	0.081	0.67	1.02	0.84	0.09	0.101	0.68	1.03
Sex										
Boy	1.00					1.00				
Girl	0.97	0.19	0.890	0.66	1.44	0.97	0.21	0.875	0.63	1.48
5 fruits and vegs										
<5 per day	1.00					1.00				
5 or more per day	1.46	0.31	0.076	0.96	2.21	1.56	0.29	0.019	1.07	2.26
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.65	0.27	0.310	0.29	1.49					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	1.38	0.62	0.475	0.57	3.33					
Tobacco										
0 days	1.00					1.00				

1 or more days	0.18	0.11	0.004	0.05	0.58	0.23	0.12	0.004	0.08	0.63
Physically activity										
<7 days per week	1.00									
7 days per week	0.76	0.16	0.179	0.51	1.14					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.26	0.23	0.202	0.88	1.81					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.79	0.18	0.283	0.51	1.22					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.00	0.17	0.984	0.73	1.39					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.00	0.77	0.995	0.22	4.52					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.72	0.54	0.657	0.16	3.14					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	0.64	0.22	0.202	0.32	1.27					
Friendships										
no friends	1.00					1.00				
1 or more friend	0.61	0.16	0.055	0.37	1.01	0.61	0.12	0.015	0.41	0.91
Peer support										

Never/rarely/sometimes	1.00									
Often/always	1.17	0.16	0.267	0.89	1.54					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.25	0.28	0.312	0.81	1.92					
Parental understanding										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.72	0.12	0.049	0.52	1.00	0.78	0.08	0.017	0.64	0.96
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.74	0.14	0.103	0.51	1.06					

Table 20: Multivariable logistic regression model for adolescent thinness in Sri Lanka, GSHS Sri Lanka 2016 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL					**Thinness (BMI-for-age <2 SD) REDUCED MODEL**				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	1.04	0.10	0.689	0.86	1.25	1.03	0.09	0.698	0.88	1.22
Sex										
Boy	1.00					1.00				
Girl	0.86	0.17	0.450	0.58	1.28	0.86	0.14	0.351	0.62	1.19
5 fruits and vegs										

<5 per day	1.00					1.00				
5 or more per day	0.79	0.11	0.092	0.60	1.04	0.78	0.11	0.085	0.58	1.04
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.51	0.47	0.181	0.83	2.76					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.71	0.50	0.629	0.18	2.79					
Tobacco										
0 days	1.00									
1 or more days	1.75	1.28	0.441	0.42	7.34					
Physically activity										
<7 days per week	1.00									
7 days per week	1.19	0.32	0.520	0.70	2.00					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.08	0.22	0.715	0.72	1.60					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.78	0.15	0.207	0.53	1.15					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.12	0.27	0.639	0.70	1.78					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	0.41	0.19	0.056	0.17	1.02					

Washing hands after toilet						
Never/rarely	1.00					
Sometimes/often/always	3.28	2.54	0.126	0.72	14.98	
Washing hands with soap						
Never/rarely	1.00					
Sometimes/often/always	1.15	0.62	0.793	0.40	3.28	
Friendships						
no friends	1.00					
1 or more friend	0.60	0.24	0.196	0.28	1.30	
Peer support						
Never/rarely/sometimes	1.00					
Often/always	0.88	0.16	0.480	0.62	1.25	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	0.84	0.19	0.419	0.54	1.29	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	1.05	0.19	0.808	0.73	1.50	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	0.92	0.22	0.733	0.58	1.47	

Table 21: Multivariable logistic regression model for adolescent overweight in Sri Lanka, GSHS Sri Lanka 2016 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					Overweight (BMI-for-age >1 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.91	0.11	0.435	0.72	1.15	0.91	0.12	0.472	0.70	1.18
Sex										
Boy	1.00					1.00				
Girl	0.91	0.19	0.650	0.61	1.37	0.86	0.17	0.458	0.59	1.27
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.23	0.27	0.353	0.80	1.88					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.19	0.55	0.707	0.48	2.93					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.80	0.45	0.688	0.27	2.39					
Tobacco										
0 days	1.00									
1 or more days	1.97	1.64	0.412	0.39	10.01					
Physically activity										
<7 days per week	1.00					1.00				
7 days per week	0.41	0.13	0.004	0.23	0.76	0.40	0.11	0.001	0.23	0.69

Active transportation										
<3 days per week	1.00									
3 or more days per week	0.73	0.18	0.216	0.45	1.20					
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	1.70	0.36	0.012	1.12	2.56	1.56	0.31	0.025	1.06	2.30
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.98	0.23	0.941	0.62	1.56					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	2.57	2.11	0.251	0.51	12.84					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.44	0.30	0.232	0.11	1.69					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.08	0.59	0.895	0.37	3.15					
Friendships										
no friends	1.00									
1 or more friend	0.82	0.35	0.639	0.35	1.91					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.99	0.17	0.948	0.70	1.40					
Parental involvement in school										
Never/rarely/sometimes	1.00					1.00				

Often/always	1.44	0.40	0.193	0.83	2.50	1.50	0.38	0.103	0.92	2.45
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	0.77	0.17	0.229	0.50	1.18					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	1.15	0.33	0.633	0.65	2.01					

Table 22: Multivariable logistic regression model for adolescent stunting in Bhutan, GSHS Bhutan 2016 dataset.

	Stunting (height-for-age <2 SD) FULL MODEL					Stunting (height-for-age <2 SD) REDUCED MODEL				
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**		**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.83	0.09	0.081	0.67	1.02	0.84	0.09	0.101	0.68	1.03
Sex										
Boy	1.00					1.00				
Girl	0.97	0.19	0.890	0.66	1.44	0.97	0.21	0.875	0.63	1.48
5 fruits and vegs										
<5 per day	1.00					1.00				
5 or more per day	1.46	0.31	0.076	0.96	2.21	1.56	0.29	0.019	1.07	2.26
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	0.65	0.27	0.310	0.29	1.49					

Anxiety										
Never/rarely/sometimes	1.00									
Often/always	1.38	0.62	0.475	0.57	3.33					
Tobacco										
0 days	1.00					1.00				
1 or more days	0.18	0.11	0.004	0.05	0.58	0.23	0.12	0.004	0.08	0.63
Physically activity										
<7 days per week	1.00									
7 days per week	0.76	0.16	0.179	0.51	1.14					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.26	0.23	0.202	0.88	1.81					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.79	0.18	0.283	0.51	1.22					
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	1.00	0.17	0.984	0.73	1.39					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	1.00	0.77	0.995	0.22	4.52					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.72	0.54	0.657	0.16	3.14					
Washing hands with soap										
Never/rarely	1.00									

Sometimes/often/always	0.64	0.22	0.202	0.32	1.27					
Friendships										
no friends	1.00					1.00				
1 or more friend	0.61	0.16	0.055	0.37	1.01	0.61	0.12	0.015	0.41	0.91
Peer support										
Never/rarely/sometimes	1.00									
Often/always	1.17	0.16	0.267	0.89	1.54					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	1.25	0.28	0.312	0.81	1.92					
Parental understanding										
Never/rarely/sometimes	1.00					1.00				
Often/always	0.72	0.12	0.049	0.52	1.00	0.78	0.08	0.017	0.64	0.96
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.74	0.14	0.103	0.51	1.06					

Table 27: Multivariable logistic regression model for adolescent thinness in Bhutan, GSHS Bhutan 2016 dataset.

	Thinness (BMI-for-age <2 SD) FULL MODEL				**Thinness (BMI-for-age <2 SD) REDUCED MODEL**			
	OR	**Bootstrap std.err.**	**p**	**95% conf. interval**	**OR**	**Bootstrap std.err.**	**p**	**95% conf. interval**
Age								
12- 13 years	1.00				1.00			

14 - 15 years	1.04	0.10	0.689	0.86	1.25	1.04	0.09	0.665	0.88	1.22
Sex										
Boy	1.00					1.00				
Girl	0.86	0.17	0.450	0.58	1.28	0.89	0.15	0.508	0.63	1.25
5 fruits and vegs										
<5 per day	1.00					1.00				
5 or more per day	0.79	0.11	0.092	0.60	1.04	0.78	0.11	0.094	0.59	1.04
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.51	0.47	0.181	0.83	2.76					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.71	0.50	0.629	0.18	2.79					
Tobacco										
0 days	1.00									
1 or more days	1.75	1.28	0.441	0.42	7.34					
Physically activity										
<7 days per week	1.00									
7 days per week	1.19	0.32	0.520	0.70	2.00					
Active transportation										
<3 days per week	1.00									
3 or more days per week	1.08	0.22	0.715	0.72	1.60					
Sedentary behaviour										
<3 hours per day	1.00									
3 or more hours per day	0.78	0.15	0.207	0.53	1.15					
Tooth brushing										

<2 times per day	1.00									
2 times or more per day	1.12	0.27	0.639	0.70	1.78					
Washing hands before meals										
Never/rarely	1.00					1.00				
Sometimes/often/always	0.41	0.19	0.056	0.17	1.02	0.63	0.29	0.311	0.25	1.55
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	3.28	2.54	0.126	0.72	14.98					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.15	0.62	0.793	0.40	3.28					
Friendships										
no friends	1.00									
1 or more friend	0.60	0.24	0.196	0.28	1.30					
Peer support										
Never/rarely/sometimes	1.00									
Often/always	0.88	0.16	0.480	0.62	1.25					
Parental involvement in school										
Never/rarely/sometimes	1.00									
Often/always	0.84	0.19	0.419	0.54	1.29					
Parental understanding										
Never/rarely/sometimes	1.00									
Often/always	1.05	0.19	0.808	0.73	1.50					
Parental bonding										
Never/rarely/sometimes	1.00									
Often/always	0.92	0.22	0.733	0.58	1.47					

Table 24: Multivariable logistic regression model for adolescent overweight in Bhutan, GSHS Bhutan 2016 dataset.

	Overweight (BMI-for-age >1 SD) FULL MODEL					Overweight (BMI-for-age >1 SD) REDUCED MODEL				
	OR	Bootstrap std.err.	p	95% conf. interval		OR	Bootstrap std.err.	p	95% conf. interval	
Age										
12- 13 years	1.00					1.00				
14 - 15 years	0.91	0.11	0.435	0.72	1.15	0.91	0.12	0.486	0.71	1.18
Sex										
Boy	1.00					1.00				
Girl	0.91	0.19	0.650	0.61	1.37	0.89	0.17	0.526	0.61	1.28
5 fruits and vegs										
<5 per day	1.00									
5 or more per day	1.23	0.27	0.353	0.80	1.88					
Loneliness										
Never/rarely/sometimes	1.00									
Often/always	1.19	0.55	0.707	0.48	2.93					
Anxiety										
Never/rarely/sometimes	1.00									
Often/always	0.80	0.45	0.688	0.27	2.39					
Tobacco										
0 days	1.00									
1 or more days	1.97	1.64	0.412	0.39	10.01					

Physically activity										
<7 days per week	1.00					1.00				
7 days per week	0.41	0.13	0.004	0.23	0.76	0.40	0.11	0.001	0.23	0.69
Active transportation										
<3 days per week	1.00									
3 or more days per week	0.73	0.18	0.216	0.45	1.20					
Sedentary behaviour										
<3 hours per day	1.00					1.00				
3 or more hours per day	1.70	0.36	0.012	1.12	2.56	1.46	0.30	0.068	0.97	2.19
Tooth brushing										
<2 times per day	1.00									
2 times or more per day	0.98	0.23	0.941	0.62	1.56					
Washing hands before meals										
Never/rarely	1.00									
Sometimes/often/always	2.57	2.11	0.251	0.51	12.84					
Washing hands after toilet										
Never/rarely	1.00									
Sometimes/often/always	0.44	0.30	0.232	0.11	1.69					
Washing hands with soap										
Never/rarely	1.00									
Sometimes/often/always	1.08	0.59	0.895	0.37	3.15					
Friendships										
no friends	1.00									
1 or more friend	0.82	0.35	0.639	0.35	1.91					
Peer support										
Never/rarely/sometimes	1.00									

Often/always	0.99	0.17	0.948	0.70	1.40	
Parental involvement in school						
Never/rarely/sometimes	1.00					
Often/always	1.44	0.40	0.193	0.83	2.50	
Parental understanding						
Never/rarely/sometimes	1.00					
Often/always	0.77	0.17	0.229	0.50	1.18	
Parental bonding						
Never/rarely/sometimes	1.00					
Often/always	1.15	0.33	0.633	0.65	2.01	

APPENDIX 6. PHOTOVOICE PROTOCOL

Study design and data collection methods

WHAT IS?: Photovoice method was first coined by Caroline Wang and Mary Burris in 1994. They describe it as "a process by which people can identify, represent, and enhance their community through a specific photographic technique" (Wang & Burris, 1997). Photovoice is a participatory action research method in which cameras are placed in the hand of the community so that their worldviews and feelings can be expressed (Israel, Eng, Schulz, Parker, & Satcher, 2005; Wang & Burris, 1997). The goals of photovoice are (Wang & Burris, 1997): 1) to enable people to record and reflect their community's strengths and concerns by taking photos, 2) to promote critical dialogue and knowledge about important issues through group discussion of their photos, 3) reach policymakers.

ADVANTAGES: Highly flexible and can be adapted to specific participatory goals, different groups and communities; participants are active subjects who can record and catalyse change in their communities; it values people's knowledge as a vital source of expertise; it legitimises and confronts the popular knowledge against the scientific understanding; the images are a powerful mean of communication; it is accessible to the most vulnerable and/or illiterate populations; it is an appealing tool and can boost community pride and ownership; it provides tangible and immediate benefits to the community; and it may stimulate social action (Wang & Burris, 1997).

DISADVANTAGES AND CHALLENGES: Censorship and self-censorship; it is hard to discover what has been left out or what has not been photographed; photos may be difficult to analyse and summarize; local and government authorities may not be willing to cooperate; limitations of resources (time and money) and communication; and training photovoice to the participants is needed: technical training of camera use, ethical issues associated with using a camera, and personal safety of the participants while taking photos (Wang & Burris, 1997).

PROCESS: The process of photovoice involves participants' photo production, reflection and collective interpretation of the images, and dissemination of the findings aimed to cause social change (Liebenberg, 2018). This photovoice project will be carried out in a school in the slum in Karachi (Pakistan) with adolescents aged between 10 to 18 years. It is worth to mention that SEQ attended to PhotoVoice training in London on the 9th – 11th December 2019 (https://photovoice.org/training/3-

day-training/) where she learned more about methods, ethics, design, planning, taking consent, participation, asses risk and other practicalities of photovoice. The photovoice process and the setting in which the project will be carried out will be observed by SEQ. The applicant (SEQ) will take some notes of the process and the surroundings in a fieldwork diary that will be used to set the scene as well as complement the data from the photovoice. Along with the fieldwork diary, the applicant will use a camera to snap the setting (school and surroundings) and some of the photovoice sessions. The applicant will not take pictures in which people can be recognized and will not note any name or a particular characteristic of the people so anonymity will be preserved. The observations will take place only during the photovoice process and any data (notes nor pictures) will be collected beyond the aims of the photovoice project. As the applicant does not speak the local language, a local research assistant will be hired to help to assist with the project. The applicant will train the assistant on the process and objectives of this project. The research team estimates that the fieldwork will last approximately 3 months. This photovoice project will follow 8 steps:

1. Partnerships and engagement with the community

Photovoice is a community-based participatory action research method that aims to involve community members in the research process to produce meaningful data for the community and ultimately cause social transformation (action) (Liebenberg, 2018). To effectively carry out this project, the research team will need to gain access to the school through community leaders and develop a research consensus with the collaborating community which will allow partnership and engagement. At this first stage, it is important to consider and minimize the power imbalances between the research team and the collaborating community (Liebenberg, 2018). In this collaborative and participative project, the participants will become co-researchers, so the distinction between researchers and participants will be minimized. Stakeholders may be contacted to engage with the project at this stage. Policymakers and community leaders may facilitate social change and knowledge dissemination (for more information, see below point 8. Dissemination of findings). Once the research team has gained access to the school, the recruitment and taking consent from participants will take place (see section Recruitment and Informed consent below). As participants are under 18 years and therefore parents/guardians need to give consent, we will potentially do a meeting with the parents/guardians to explain the project.

2. Photovoice workshop training

A photovoice project usually begins by building participation, photography skills and setting ground rules (PhotoVoice, 2019). After taking consent, the first session will be a workshop conducted by the applicant (SEQ), the local research assistant and an Aga Khan University student volunteer who has expertice in photography in which the basics of Photovoice and a brief on ethical matters will be explained to the 14 participants taking part on this project (for more details on the participant's characteristics and the recruitment, see section Recruitment). The workshop will take place at the school in a room facilitated by the school team. Participants will be trained on digital camera usage (Sharples, 2003): instruction in the mechanics of the camera, basic concepts of lighting, camera angle and placement of focal points. Examples will be given and discussed to demonstrate the use of a camera and how to get better results by applying basic instructions. Participants will also learn to read, analyse and interpret images (introduction to visual literacy). Besides the operation of the camera, the participants will be trained on visual ethics: photos with no faces or identifying characters, and if necessary getting consent from other individuals that may appear in the picture before taking it (for more detail, see section Informed consent). Researchers will emphasise participant' safety issues above spontaneity or power of the picture (Wang & Redwood-Jones, 2001). They will also highlight the authority and responsibility that come with camera usage. Researchers will make sure that the project is culturally sensitive and appropriate using a sensitive code of behaviour in the sessions and taking into account local customs around image content and image taking (PhotoVoice, 2019). Therefore, this first workshop aims to understand the foundations of the photovoice project, allow the group to develop, participants to gain confidence and empower creativity.

3. Focus group discussion on the photography mission

The second session with the participants will consist of a focus group discussion with 7 participants maximum (the 14 participants will be distributed into 2 groups which will remain the same for the whole photovoice project). Firstly, the participants will be trained according to research goals, community's specific goals, and culture/context. They will be therefore provided with a "photography mission" that suggests to participants take pictures of what they consider malnutrition to be, causes of malnutrition and health behaviours related to malnutrition. Participants will be encouraged to explore ideas about the topic and interpret the photography mission in whatever way makes the most sense for them. The researchers may provide general

suggestions in order to clarify the objective of the project. They will also be encouraged to develop their personal creative pictures. In order to understand better the objectives of the project, a discussion will take place. This discussion will try to brainstorm about the meaning of malnutrition and its direct and indirect causes affecting the participants. This group discussion will be lead by the local research assistant (as he/she will speak the local language) and assisted by SEQ. Participants will be prompted by the local research assistant to think about the concept of malnutrition and share their views with the rest of the group (supplementary material 1: topic guide focus group discussion 1). This group discussion – brainstorming exercise will take place at the school (in a room facilitated by the school team) with a maximum of 6 participants. It will be recorded with a digital voice recorder and participants will be aware when their voices will start to be recorded. We estimate that the focus group discussion will not last more than an hour. Thus, this second session aims to provide a "photography mission" and understand the aims of the project. At the end of this session, one digital camera will be delivered to each participant.

4. Photoshoot

Participants will be encouraged to take up to 30 pictures on the "photography mission" during 1 week. The researchers will visit the school during this week allowing the participants to review the "photography mission" and answer questions that may arise during the photo taken. The researchers will check and discuss the content of the pictures with the participants when necessary. Participants will only produce content that they feel comfortable with to snap, share and talk about. The images and the conversations around them will be restricted to the group and project researchers. After 1 week, the cameras will be collected and the pictures will be printed. Addicionally, participants will be allowed to take 3 pictures maximum of themselves, family or friends. These pictures won´t be used for research purposes but will be printed and given to the participant as a gift.

5. One to one semi-structured interviews

The pictures will be shared with the participant during the one to one interview (in person). The interviews with each participant will be lead by the local research assistant (as he/she will speak the local language) and assisted by SEQ. The interviews will take place at the school in a room facilitated by the school team. At the beginning of the interview, the participant will be asked to choose 3 of his/her pictures. The interviewer will encourage the participant to choose the pictures that are more

relevant for the project aim, more meaningful for him/her as well as the pictures that the participant feels comfortable commenting and sharing. Once the participant has chosen 3 pictures, a digital voice recorder will start recording the conversation between the participant, the local research assistant and SEQ. The local research assistant will use a topic guide interview asking questions about the participant' experience of taking photos (Nykiforuk et al., 2011) and then questions related to the meaning/importance of each picture (supplementary material 2: topic guide interview) such as "why did you choose this picture?". The one to one interviews are expected not to last more than 30 minutes. At the end of the interview, participants will be provided with a printed copy of all of their photographs to take home with them.

6. Pictures' selection

The research team will consider at this stage to remove similar pictures, so having a selection of the most meaningful pictures will facilitate the group discussion.

7. Focus group discussion: collective interpretation of the pictures

The group discussions will be lead by the local research assistant (as he/she will speak the local language) and assisted by SEQ. It will take place at the school (in a private room facilitated by the school team and will be recorded with a digital voice recorder. We estimate that the focus group discussion will not last more than an hour. Each group (formed by 7 participants) will be provided with 15 pictures, which are a summary selection of their work. The taking and sharing of images and experiences will be limited exclusively to the focus group. To facilitate the discussion of the pictures, the SHOWeD guide will be used (Wang & Burris, 1994; Wilson, 2007; Liebenberg, 2018). Supplementary material: topic guide focus group discussion 2.

8. Dissemination of findings

The last step of the photovoice process consists of sharing the knowledge with the participants, collaborating community, and policymakers as well as triggering social change. Presenting the photographs in an exposition will be one form of disseminating the findings. Firstly, the applicant (SEQ) will conduct a preliminary data analysis (see section Data Analysis). Secondly, the participants and collaborating community will be asked for feedback about the preliminary analysis as well as collaboration with the photo selection for the exposition since the dissemination aims to impact socially (Wang, 1999; Nykiforuk et al., 2011; Liebenberg, 2018). Quotes from the individual interviews or focus groups will accompany the pictures for a better comprehension of the visual data. The venue, attendance, and type of display will be also discussed with

the participants and collaborating community. A leaflet with the exposed pictures and quotes will be created and share with the attendance. This exposition may be shared at local events, public local places, and through local media. The display of the findings may grow excitement, feelings of pride and validation as well as strains regarding public exposure and privacy protection issues. To avoid any tensions, participants should be informed, encouraged to participate in decision making and preserve their ownership (PhotoVoice, 2019). Any photovoice project intends to accomplish social change but it is important that researchers handle participants' and collaborating community expectations in a realistic manner (PhotoVoice, 2019; Liebenberg, 2018). Expectations of an instantaneous and remarkable change should be avoided. It is the researchers' duty to inform participants what to expect from the project as well as prepare participants for the closure of the project.

Achieving social change with a Photovoice project is challenging, sometimes fruitless and difficult to evaluate (Liebenberg, 2018). This project will try to facilitate action-oriented discussion towards malnutrition awareness. The social change in this project, therefore, will be to raise awareness of adolescent malnutrition and its causes in the living context of a slum. Liebenberg (2018) listed four considerations in order to facilitate knowledge and social change in a Photovoice project: "Who are the power brokers necessary to bring about change? How can they be engaged in the research and related change process? What information will they need to do this? What are the best ways to share specific information with particular audiences?". These concerns will be taken into account in this project and discussed with the participants and collaborating community in order to trigger policymaking by stakeholders.

Besides dissemination through lay community, the findings will be presented at scientific conferences and scientific journals.

PREVIOUS RESEARCH: Photovoice has been used with adolescents living in slums across countries:

- Exploring the barriers to school continuation after pregnancy among young mothers living in a slum in Kenya (Nayriro, 2018).
- Understanding the unmet needs of adolescents living a slum in Zambia (Harris, 2018).
- Identifying barriers to health among out-of-school adolescents in North India (Mohajer & Earnest, 2010).

- Engaging adolescents from a slum in South India with disabilities in research (Kembhavi & Wirz, 2009)
- Understanding the concept of “the good Muslim girl” among young women in a slum in India (Chakraborty, 2009)

Kembhavi & Wirz (2009) highlighted some benefits and challenges experienced in their photovoice project conducted with adolescents. Their participants felt honored to be trusted with the task and pleased to be given the responsibility of producing research data. The project allowed adolescent participants to gain new experiences and photography skills since most of them had never used a camera or did not own photographs of themselves. The authors of this study reported that the adolescents were more than able to contribute in a meaningful way to the research study. They also reported some challenges. The use of disposable cameras seemed not to be ideal for this project as the pictures had low quality. Some of the photographs taken by the adolescents did not always directly address the research question. Some participants focused more on taking pictures of themselves or their families.

Data analysis

This photovoice project includes data from the pictures taken by the participants, interviews and focus groups, field notes collected by the applicant (SEQ) and pictures of the setting taken by the applicant. In addition, basic sociodemographic information such as name, age, sex and ethnicity of the project participants will be collected through questionnaires in paper form (supplementary material 4: sociodemographic information). The participants will fill out the questionnaire themselves.

For this study, Thematic Analysis will be used as a tool for data analysis of the focus groups and one to one interviews following Braun and Clarke's guidelines (Braun and Clarke 2006, Braun and Clarke 2013). Community-based participatory action research principles will underpin this Photovoice project. Furthermore, Freire’s critical pedagogy (1972, 1973/2002) and the principles of photography by Wang and Burris (1994) will be used as a theoretical framework to inform the data analysis of this Photovoice project on malnutrition in adolescents living in slums. The qualitative data analysis software NVivo will be used to support the data analysis of the audio files, pictures and field notes.

Audio files from the interviews and focus groups will be transcribed verbatim into the local language and also from the local language to English. The audio files will be

transcribed by the research assistant. The translation from Urdu to English will also be done by the research assistant.

In addition to qualitative data, weight and height from photovoice participants and other students in the same class will be collected. This data will be used to give some background information and will be combined with the qualitative findings. Those students whose weight and height will be taken will also be asked to fill out supplementary material 4: sociodemographic information.

The applicant (SEQ) will code and pseudononymize the data, i.e. a pseudonym will be given to each participant and the pictures, audio and sociodemographic information will be linked with the pertinent pseudonym. All data included in analysis and write-up will be pseudononymized, with removal of identifiable features, such as person names. The applicant will manage the storage of data and will be the only one having access to the raw data (data that has not been pseudononymized yet). Only the applicant will have access to the secure electronic file which links personal data to each pheudonim. The rest of the research team will be able to access the data using pheudonims. Data will be kept in locked filling cabinets and/ or electronically in password protected a secure file store in the Warwick University server (StorageNow). Audio files will be deleted from the recording devices and encrypted as soon as possible before electronic storage or transfer.

Recruitment

This study's sample size will be up to 14 schooled adolescents living in a slum in the city of Karachi. We will aim for 7 girls and 7 boys of 13 years old (grade 9) to ensure a diversity of experiences and gender balance in order to answer the research questions of the project. Photovoice studies in the adolescent population used a similar sample size (Chakraborty, 2009; Fournier, 2014; Nayriro, 2018). The participants will be split into 2 groups of 7 participants for steps numbers 2, 3 and 7 of the Photovoice process. The research team considers that a total sample of 14 participants and up to 6 participants per group will be comfortable to handle as well as provide enough data to answer the research questions. Classes tend to have around 30 students in grade 9. The research team in Pakistan predicts that the majority of students (and their parents) in the class will be interested in taking part in the study. As this photovoice project can only host 14 participants, the research assistant and SEQ will measure weight and height from all students in the class in order to avoid any student to feel left out.

Informed consent will be taken from the students and their parents/guardians to measure student's weight and height. These students will also be asked to fill out supplementary material 4: sociodemographic information. Weight and height measurements will also be useful for analysis purposes. Participants will be recruited from a school in a slum in Karachi. Adolescents enrolled in a school may be easily accessible to the research team as they will be attending daily to the same place at the same hours. The research team will ensure firstly a collaboration with the school team in order to gain access to the target population. The study will therefore involve convenience sampling (Etikan, 2016).

Inclusion criteria:

- Schooled adolescent
- Living in a slum in Karachi
- Aged 10 to 18 years old
- Cognitively competent
- Voluntary (chooses to participate)

Exclusion criteria:

- Pregnant / breastfeeding adolescents
- Adolescents with serious illnesses such as HIV, TB or diabetes.

The area of the study site has been mapped by the Aga Khan University. The research team in Pakistan has identified 6 potential secondary schools in the study site. The research assistant and SEQ will visit these secondary schools to present the photovoice project to the head of the school and ensure collaboration and willingness to participate in the study. After this first visit, the research team in Pakistan will choose one high school to conduct the photovoice project. The research team will ensure that the school team is clear and happy with the purpose of this research to allow access to the students in grade 9. Next, potential participants and their parents/guardians will be invited to a meeting held in the school where the project will be presented by SEQ and the research assistant. As mentioned previously, we expect a high participation rate. In the hypothetical scenario of obtaining more than 14 consents signed, participants will be chosen randomly by the research team. Ultimately, only 14 students will take part in the photovoice project. However, the students who have not been selected for taking part in the photovoice project will be asked for consent to measure their weight and height.

Informed consent

The applicant and a local research assistant will explain in more detail (using participant information leaflet) the project to those students (and their parents) who may express interest to take part in the study. Potential participants will be handed both participant information leaflet (supplementary material 5: Participant information leaflet) and consent forms (paper format) (supplementary material 6 and supplementary material 7) to take home and discuss it further with their parents or family. The applicant and the local research assistant will be taking consent and will make sure that the adolescent participant understands the aims and the process of the research study before they give consent. The applicant attended a training called “Gaining consent for research participation” on the 26th June 2019 at Warwick Medical School.

Regarding the process of obtaining consents, Wang and Redwood-Jones (2001) suggested collecting three types of consent: 1) consent from participants where rights and responsibilities are explained, 2) consent form for non-research participants who will be photographed by participants, and 3) consent from participants where they give permission for publishing the research findings. They also suggest that all consents require the signature of a parent or legal guardian if the participant or subject in a photograph is under 18 years old (Wang and Redwood-Jones, 2001). For this study, consents number 1 and 3 suggested by Wang and Redwood-Jones (2001) will be presented together in the Consent Form (supplementary material 6 Consent Form), where they confirm their participation as well as agree with the release of the participant-generated data.

Written consent from one of the parents or legal guardians of the participant will be required (supplementary material 6: Consent Form). Written consent from the adolescent will be also required in the Consent Form. Potential participants will be given one week to sign the required consents. The applicant (SEQ) and the local research assistant will be available to the adolescent participants and their parents/guardians during that week and throughout the data collection period for further discussion and answering any research related questions. If parents/guardians can’t read, the research assistant will read the participant information leaflet and the consent form for them. Consent will be also obtained to share and disseminate the data produced in the study (in supplementary material 6 Consent Form). Participants will give consent to use their photovoice pictures for the project interviews and focus group

discussions. Also, to use their photovoice pictures and quotes accompanying the pictures for manuscripts, conference presentations, and in-person and online exhibitions. In addition, it is important that participants understand that their photovoice pictures and annonymised quotes accompanying their pictures will be publicly exhibited (PhotoVoice, 2019). The research team does not anticipate any negative consequences to the participants in terms of safety and entitlement to privacy caused by the display of the PhotoVoice data. Participants will be able to choose where their photos will be displayed, who they want to invite to the exhibition and what photos they want to display.

Participants will be introduced to visual ethics in the photovoice workshop training. Participants will be encouraged to take photos with no faces or identifying characters. However, if the participant wants to actively and purposively take a picture of a person, a written consent will be needed (supplementary material 7: consent form for other people featuring in participant images). Since participants will be under 18, they can't take consent. Therefore, an adult (ideally either SEQ or the local research assistant) will inform and take consent of the person being photographed by the participant using the supplementary material 7 Consent form for other people featuring in participant images. If a participant takes a picture of a person and there is no written consent (that is, there is no supplementary material 7 signed), the person's face will be cropped/faded from the picture. Participants will be encouraged to use their photovoice peers as models in case they want to photograph a person. This will strengthen the group. In addition, there will be no need of using supplementary material 7, as participant's parent/guardian will potentially consent the participant to apear and be recognised in the pictures collected within the photovoice project.

Consent forms and participant information leaflets will be translated into Urdu (local language) by the research team in Pakistan and tailored in lay language for the target audience considering their age and sociocultural characteristics.

Participants will own the printed copy of the pictures that they took.

Participants will be free to withdraw from the study at any point of the Photovoice process. However, the data produced by any participant will not be possible to be removed from the study. Removing the data (audio and pictures) from a participant would be unfeasible as the project involves group discussions, which are embedded in

a particular context with other participants' interactions. Data therefore will be pseudonymised and kept for analysis.

Note:

The supplementary materials are not included in this thesis but they could be available upon request to the candidate.

References

Braun, V. and V. Clarke (2006). Using thematic analysis in psychology. Qualitative Research in Psychology 3(2): 77-101.

Braun, V. and V. Clarke (2013). Successful Qualitative Research: A Practical Guide for Beginners. London, SAGE Publications.

Chakraborty, K. (2009). 'The good Muslim girl': conducting qualitative participatory research to understand the lives of young Muslim women in the bustees of Kolkata. Children's Geographies, 7(4), 421-434.

Creighton, G., Oliffe, J. L., Ferlatte, O., Bottorff, J., Broom, A., & Jenkins, E. K. (2017). Photovoice Ethics: Critical Reflections From Men's Mental Health Research. Qualitative Health Research, 28(3), 446–455.

Etikan, I., Musa S.A., Alkassim, R.S. (2016) Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics, 5,1-4.

Freire, P. (1972). Pedagogy of the oppressed. New York, NY: Penguin Books.

Freire, P. (1973/2002). Education for critical consciousness. New York, NY: Continuum.

Fournier, B., Bridge, A., Mill, J., Alibhai, A., Kennedy, A. P., & Konde-Lule, J. (2014). Turning the Camera Back: A Photovoice Project With Ugandan Children who are Orphaned and Living with HIV. SAGE Open.

Harris, J. C. (2018). Vulnerable Youth's Perspectives and Priorities for Informal Settlements: Photovoice Evidence from Lusaka, Zambia. 38(4), 398-412

Israel, B., Eng, E., Schulz, A., Parker, E., & Satcher, D. (2005). Methods in Community-Based Participatory Research for Health. San Francisco: Jossey-Bass.

Kembhavi, G., & Wirz, S. (2009). Engaging adolescents with disabilities in research. Alter, 3(3), 286-296.

Liebenberg, L. (2018). Thinking Critically About Photovoice. International Journal of Qualitative Methods, 17(1).

Mohajer, N., & Earnest, J. (2010). The challenge of low literacy in health promotion: Using empowerment methods with out-of-school adolescents in North India. Vulnerable Children and Youth Studies, 5(1), 88-96.

Nayriro, M. (2018). Re-Conceptualizing School Continuation & Re-Entry Policy for Young Mothers Living in an Urban Slum Context in Nairobi, Kenya: A Participatory Approach. Studies in Social Justice, 12, 310-328.

Nykiforuk, C. I. J., Vallianatos, H., & Nieuwendyk, L. M. (2011). Photovoice as a Method for Revealing Community Perceptions of the Built and Social Environment. International Journal of Qualitative Methods, 10(2), 103–124.

Sharples, M., Davison, L., Thomas, G. V., & Rudman, P. D. (2003). Children as Photographers: An Analysis of Children's Photographic Behaviour and Intentions at Three Age Levels. *Visual Communication*, *2*(3), 303–330.

PhotoVoice (2019) Statement of Ethical Practice. Retrieved on 04/10/2019 from: https://photovoice.org/wp-content/uploads/2019/04/Ethical-Statement.pdf

Wang, C., & Burris, M. A. (1994). Empowerment through Photo Novella: Portraits of Participation. Health Education Quarterly, 21(2), 171–186.

Wang, C., & Burris, M. A. (1997). Photovoice: concept, methodology, and use for participatory needs assessment. Health Educ Behav, 24(3), 369-387.

Wang, C. C. (1999). Photovoice: A Participatory Action Research Strategy Applied to Women's Health. Journal of Women's Health, 8(2), 185–192.

Wang, C. C., & Redwood-Jones, Y. A. (2001). Photovoice Ethics: Perspectives from Flint Photovoice. Health Education & Behavior, 28(5), 560–572.

Wilson, N., Dasho, S., Martin, A. C., Wallerstein, N., Wang, C. C., & Minkler, M. (2007). Engaging Young Adolescents in Social Action Through Photovoice. The Journal of Early Adolescence, 27(2), 241–261.

APPENDIX 7. PHOTODIARY INSTRUCTIONS FOR PARTICIPANTS

First week instructions

Now that you know how your new Polaroid camera works… LET'S GET STARTED WITH THE PHOTO-DIARY!!!

A photo-diary is a record of your day to day life and experiences in which you use both photos and narrative. Entries report both mundane and unusual goings-on, your emotions, thoughts and feelings, your actions and reactions, as well as opinions.

A photo-diary could be a fun personal photography project for you: **write and photograph anything that you think is related to undernutrition, micronutrient deficiencies and over-nutrition (malnutrition) in the notebook** provided and coloured as much as you want with the pens.

How you create this photo-diary is completely up to you. Here you have the procedure usually followed to produce a photo-diary. However, feel free to follow these steps.

- Write down the date of the entry.
- Firstly, think about what is the issue that you want to talk about. For this photo-diary, **we are asking you to focus on these topics: undernutrition, micronutrient deficiencies and over-nutrition**.
- Photograph it and paste the photo in the notebook.
- Write some paragraphs about the photo: what do you see? Why it is important for you? How this is related to undernutrition, micronutrient deficiencies or over-nutrition? What are your feelings towards it?
- You can write your thoughts, reflections, feelings, and experiences towards undernutrition, micronutrient deficiencies and over-nutrition.
- Use some colours pens to draw something related with your ideas or highlight your points.

We want you to create your photo-diary as you like, but if you are looking for some inspiration, here you have some tips:

- You can write, draw, stick photograph, stick newspaper, write stories, magazine images, Rapper or anything related to undernutrition, micronutrient deficiencies or over-nutrition.
- You can take inspiration from TV, Radio, dramas, movies, advertisements and daily conversation etc.

Some things to bear in mind:

- Whenever you take anybody else's picture you will need to ask for their consent.
- When making your photo-diary, feel free to be as exhaustive and creative as you like.
- There is no wrong or right answer; everything you write, think, answer and ask is right!

Your questions answered:

How frequently should I make entries in my photo-diary?

As frequently as you like. However, we expect a minimum of 7 entries.

How much time do I have to produce my photo-diary?

You have two weeks. After these two weeks, you should bring your

We hope that you enjoy the creation of this photo-diary and thank you very much for participating.

Second week instructions

Dear participant,

Thank you so much for participating and creating this photo-diary. As you know, we asked you to write and photograph anything that you think is related to undernutrition, micronutrient deficiencies and over-nutrition in the notebook. Now, we want to ask you another question.

- What do you think that worsens and improves **undernutrition**? Why do you think so?
- What do you think that worsens and improves **micronutrient deficiencies**? Why do you think so?
- What do you think that worsens and improves **overnutrition**? Why do you think so?

We know that these questions are hard to answer so here you go some ideas of what can worsen or improve undernutrition, micronutrient deficiencies, and overnutrition:

Diet	**Washing habits, hygiene**	**Mental issues**
Smoking	**Alcohol use**	**Family**
Peer support and friendships	**Physical activity and sedentary behaviour**	**Education, schooling**
Other diseases	**Cultural norms**	**Food environment**
Gender norms		

Feel free to add or remove words from this list. You can choose which ones you want to talk about.

Please, write and photograph about these question in your diary following the same instructions that we gave you at the beginning of the study.

Bear in mind that we will collect your diary in a week from now.

We hope you enjoy creating this photo-diary!

APPENDIX 8. INTERVIEW TOPIC GUIDE

Tell me a bit about yourself (icebreaker questions).

- Can you talk me though a typical day? What do you like to do during the weekends? Leisure activities, school...

Tell me how the experience of writing a photo-diary was

- How was the experience of taking pictures? Did you like it? What did you like about this experience? Did you have any problem while taking pictures? Was the camera working well?

Now I am going to ask you some questions about your photodiary, so it would be great if you have it in front of you.

- 3th June page – side effect of tobacco: Why do you think that smoking is bad? How this affects your dad/granddad? How do you feel about it?
- How did you know about all this side effects? Did you look it up on the Internet? Why did you go to the Internet? Did anyone help you with the photo-diary and looking up things online? I see that you photographed your friends and family, how did you come up with the idea? Why did you choose to photograph people too?
- 8th June – benefits of milk: how did you learnt about these micronutrients?
- 9th June – side effect of bread & benefits: I am very interested to know what "antinutrients" are. Apart from bread, what food you know that is often enriched with "extra nutrients"? What extra nutrients are those? Where did you learn about enriched foods (media, school…)?
- 11th June – side effect of broast: where did you get this information from? Who are these scientists? you mentioned that friend foods can lead to obesity, can you name some other foods that can produce obesity?
- 21st June - Wine : how do you think that there is a relation between alcohol and malnutrition?
- 22nd June – hand wash: what happens if you don't wash your hands before eating food or after the toilet? How do you think that this has an impact on malnutrition?

I would like to know about undernutrition and overnutrition in your community, especially among adolescents.

<u>Meaning and awareness</u>:

- What do you understand by undernutrition? And overnutrition? (if the participant does know what undernutrition / overnutrition means, the research assistant will explain it to them so the participant is able to answer the rest of the questions) how do you know this?

Experience:

- How would you describe your experience with undernutrition? And with overnutrition? How does undernutrition affect your day to day? How does undernutrition relate to your life? How does undernutrition affect you? How do you feel about it?
- Do you think that undernutrition and overnutrition are somehow related?

Context:

- Where there is under and over? In what situation? (Does it happen in adolescents living in Pakistan? And in your area?) What are your thoughts on undernutrition in your school and community? And on overnutrition?

Determinants:

- To your understating, why do you think that undernutrition happens? (if needed, prompt factors / behaviours associated with undernutrition such as sanitation, gender, setting, age)
- In the second week instructions, there is a table with things that may worsen or improve malnutrition. In your experience, can you name what worsens undernutrition? And what improves undernutrition? What do you think that worsens and improves overnutrition? Ask for more factors if they only give one or two examples.
- What do you think they could do to improve malnutrition in adolescents? And in your community?

I think that's basically everything I had to ask you. Have you got anything else you would like to say or any kind of final thoughts or anything you would like to follow up that I haven't asked you

APPENDIX 9. PHONE-BASED VERBAL INFORMED CONSENT FOR ADOLESCENT PARTICIPANT

TELEPHONE SCRIPT:

Study Title: Exploring malnutrition in Pakistani adolescents through photo-diary and interviews _NIHR Improving Health in Slums

Asalam-o-Alaikum

I am _____(name of the local research assistant)_____ calling from The Aga Khan University. I am calling regarding a study which is being conducted by Dr.Romaina Iqbal, Associate Professor at the Department of Community Health Sciences in collaboration with University of Warwick,UK. We are conducting this study to explore the way undernutrition impacts adolescents' lives so that efforts can be made to improve nutritional status in this population.

Do you have a few minutes to discuss the study?

- If yes, continue below.
- If no, but the potential subject is interested in participating, determine a better time to call back to discuss the study.
- If no, thank them for their time.

You are being asked to participate in a research study that aims to explore the way undernutrition impacts adolescents' lives. Therefore, we are looking for adolescents who are willing to explain to us what undernutrition means for them. In this study we will ask you to produce a photo-diary with the topic of malnutrition and have a phone interview that will take no more than 40 minutes and will be audio recorded.

Expanding a bit more on the procedures of the study, I will explain you the steps that you will undergo through if you enrol in this study. First, you will receive at home a package with notebook, colour pens, glue scissors, a Polaroid camera, and instructions to complete the research project. After reading the instructions on how to use the Polaroid camera and how to produce a photo-diary, you are ready to start your own photo-diary. You will take photos and write notes on anything related with malnutrition. You have two weeks to create your photo-

diary. Once you have finished your photo-diary, I will pick up your photo-diary, scan it and give it back to you. Finally, I will call you and ask you questions about your photo-diary: which photographs you like the most and why. Also, I will ask you some basic information such as your gender, age, and religion. Also some questions about your daily life, school, etc. Then, I ask you some questions about malnutrition in your community.

Being in this study is completely voluntary. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the Aga Khan University. If you decide to take part in the study and then change your mind later, you are free to withdraw at any time.

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

You will learn how to use a Polaroid camera and will take pictures with a Polaroid camera. At the end of the study, you will be able to keep the camera and all the school materials. In addition, the results of this study will help in planning and development of public health programs for improving nutrition in adolescent living in slums.

Any information you provide will be stored securely and your identity/information will be kept strictly confidential, except as required by law. Nobody except principal investigator and the immediate research team will have an access to it. Study findings may be published, but you will not be individually identifiable in these publications. If you wish, we can share the study findings with you.

This study has been approved by The Aga Khan University and The University of Warwick Ethics Review Committees and will be conducted in accordance with the ethical principles.

Do you have any questions? Do you agree to participate in this study?

- Yes / No

Name of Adolescent Participant (verbal): _____

Person Obtaining Consent

I have read this form to the subject. An explanation of the research was given and questions from the subject were solicited and answered to the subject's satisfaction. In my judgment, the subject has demonstrated comprehension of the information. The subject has provided oral consent to participate in this study.

Name of person obtaining consent (research assistant): _____

Name and designation of witness (community healt worker): _____

Date: _____

APPENDIX 10. WRITTEN INFORMED CONSENT FOR ADOLESCENT PARTICIPANT

SHORT FORM WRITTEN CONSENT FOR ADOLESCENTS

PROJECT TITLE: Exploring malnutrition in Pakistani adolescents through photo-diary and interviews.

PROJECT INFORMATION:

Principal Investigator: Dr. Romaina Iqbal Other investigators: Sara Estecha Querol and Syeda Kisa Zehra Zaidi

Organizations: Department of Community Health Sciences, AKU, Karachi, Pakistan and Warwick Medical School, University of Warwick, Coventry, United Kingdom.

PURPOSE OF THIS RESEARCH STUDY:

This research study aims to explore the way under-nutrition and over-nutrition impacts adolescents' lives. Therefore, we are looking for participants aged between 12 and 15 years who are willing to explain to us what undernutrition and over-nutrition means for them.

PROCEDURES:

For this study, participants will be asked to produce a photo-diary with the topic of under-nutrition and over-nutrition. The participant of the research will go through the following steps.

- Participant will receive a package with notebook, color pens, glue scissors, a Polaroid camera, and instructions to complete the research project.
- Participant will take photos with the Polaroid camera/ instant camera and write notes on anything related with undernutrition, micronutrient deficiencies and overnutrition in order to produce the photo diary. Participant will have two weeks to create the photo-diary.
- The research assistant will pick up participant's photo-diary, scan it and give it back to the participant.
- The research assistant will call participant and ask him/her questions about your photo-diary, interview will be audio recorded and it will not be longer than 40 minutes.

Name of the adolescent participant: Name of the witness:

_____ _____

Signature of the adolescent participant: Signature of the witness:

_____ _____

Any further questions you have about this study will be answered by the Research Associate Syeda Kisa Zehra Zaidi. Phone number: _____

APPENDIX 11. CONSENT FORM FOR MODELS

CONSENT FORM for Models

Title of Project: Exploring malnutrition in Pakistani adolescents through photodiaries and interviews

Hi, I am participating in a photography project about issues surrounding youth and nutrition in my local community, in partnership with the Aga Khan University (Karachi) and the University of Warwick (United Kingdom). Would you mind if I took your photograph as part of the project? Please, note that this picture could potentially be published on the internet, in a book, or newspaper.

I allow _____ (the Photographer) to take a photo of me _____ (the Model) for this photography project.

I give my consent to use this photo for this project and be used:

- On websites
- In printed materials including leaflets, books, or postcards.
- In public exhibitions
- In newpapers or magazines
- In research articles

I understand that I will not be paid for any such use.

I agree that all rights to the picture belong to the Photographer and the photography project.

Model's full name	Date	Signature
Name of person taking consent	Date	Signature
Name of Model's parent/guardian (if the model is under 18 years)	Date	Signature

APPENDIX 12. BSREC UNIVERSITY OF WARWICK

Biomedical and Scientific Research Ethics Committee
Kirby Corner Road
Coventry
CV4 8UW

Wednesday, 24 March 2021

Sara Estecha Querol
WMS
University of Warwick
Coventry
CV4 7AL

Dear Sara,

Ethical Application Reference: BSREC 74/19-20 AM02
Amendment Number: 2
Title: Exploring undernutrition and overnutrition in Pakistani adolescents living in slums

Thank you for submitting your substantial amendment application to the Biomedical and Scientific Research Ethics Committee (BSREC) for consideration. We are pleased to advise you that, under the authority delegated to us by the University of Warwick Research Governance and Ethics Committee, **full ethical approval for your project is hereby granted, subject to the conditions outlined in Appendix 1.**

Any further substantial changes to any aspect of the project will require further review by BSREC and the PI is required to notify the BSREC as early as possible should they wish to make any such changes. The BSREC Secretary should be notified of any minor amendments to the study.

Should issues arise during the course of the project that present risks to the safety and wellbeing of participants, these must be reported to BSREC. In such an event, recruitment and research activity must be halted until the appropriate actions have been taken, as agreed in consultation with BSREC.

I would like to take this opportunity to wish you all the best with your study.

Yours sincerely,

[redacted]

Dr David Ellard
Chair, Biomedical and Scientific Research Ethics Committee

APPENDIX 13. ERC AGA KHAN UNIVERSITY

آغا خان یونیورسٹی

THE AGA KHAN UNIVERSITY

21-Mar-2021

Dr. Romaina Iqbal
Department of Community Health Sciences
The Aga Khan University
Karachi

Dear Dr. Romaina Iqbal,

Re: 2021-3717-16861, Romaina Iqbal: Exploring undernutrition in Pakistani adolescents living in slums through photo-diary and interviews

Thank you for your submission.

The proposed amendments have been reviewed and approved. Please note that this only constitutes an approval to your requested amendment(s) till the current validity period of your ERC approval. If any further extension is required, then kindly apply for an extension separately by creating a subform.

List of amended document(s) approved with this submission.

Submission Document Name	Submission Document Date	Submission Document Version
protocol_v5_amendment_SEQ) (2)	22-Feb-2021	5
Verbal consent parent_ urdu_v2	22-Feb-2021	2
Verbal consent - under 18 -Urdu_v2 (1)	22-Feb-2021	2
Topic guide_urdu_v3	22-Feb-2021	3
verbal Consent Form _ under 18_v2	22-Feb-2021	2
verbal Consent Form _ parent _v2	22-Feb-2021	2
Topic guide_English_v3 (2)	22-Feb-2021	3
Affidavit For Translation 2 (3) (1) (1)-3 (1)	22-Feb-2021	3

Any changes in the protocol or extension in the period of study should be notified to the committee for prior approval. All informed consents should be retained for future reference.

Thank you.

Sincerely,

[redacted]

Page 1 of 2

APPENDIX 14. NBC PAKISTAN

National Bioethics Committee (NBC) Pakistan

PHRC

Ref: No.4-87/NBC-630/21/1578 **Date: June 14, 2021**

Dr. Romaina Iqbal
Department of Community Health Sciences,
The Aga Khan University,
Karachi

Subject: **Exploring under nutrition and over nutrition in Pakistani adolescents living in slums through photo-diary and interviews, (NBC-630).**

Dear Dr. Romaina Iqbal

I am pleased to inform you that the above mentioned project has been cleared by the "Research Ethics Committee" of "National Bioethics Committee" **for a period of one year.**

For the continuation of project in the next years, you have to send a progress report and a formal request asking for continuation of projects (however, you do not need to submit REC application or pay any processing fee again).

Kindly keep the National Bioethics Committee, Secretariat updated about the progress of the project and submit the formal final report on completion.

Yours sincerely

[redacted]

(Prof. Dr. Saima Perwaiz Iqbal)
Chairperson
NBC-Research Ethics Committee

NBC Secretariat:
Pakistan Health Research Council, Shahrah-e-Jamhuriat, Off Constitution Avenue, Sector G-5/2, Islamabad
www.nbcpakistan.org.pk e-mail: nbcpakistan.org@gmail.com Tel: 92-51-9224325, 9216793, Fax 9216774.

APPENDIX 15. REFLEXIVE THEMATIC ANALYSIS PHASES

Figure 1. A visual thematic map for organising the codes into themes and a flow chart for illustrating the relationship between themes.

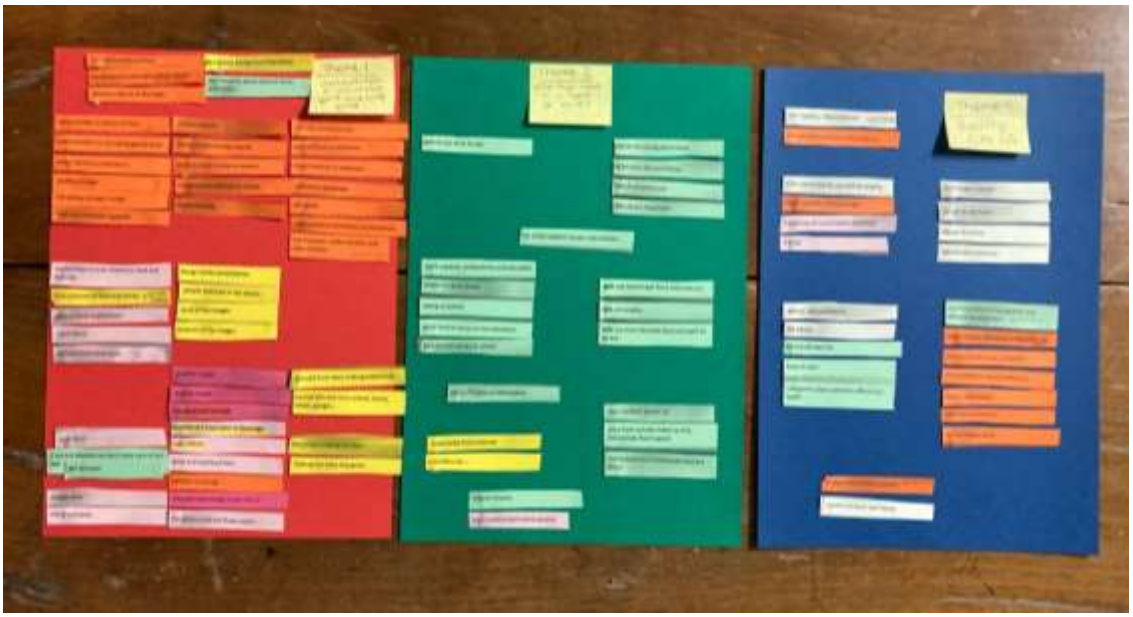

Figure 2. A visual thematic map with the three final themes.

APPENDIX 16. EXAMPLES OF PHOTODIARIES FROM PARTICIPANTS

Figure 1. Mary's photodiary: Apple can support a healthy immune system. Apple are rish in contain fiber, vitamins and minerals. Apple is good for our health. We should eat apple in our daily routine.

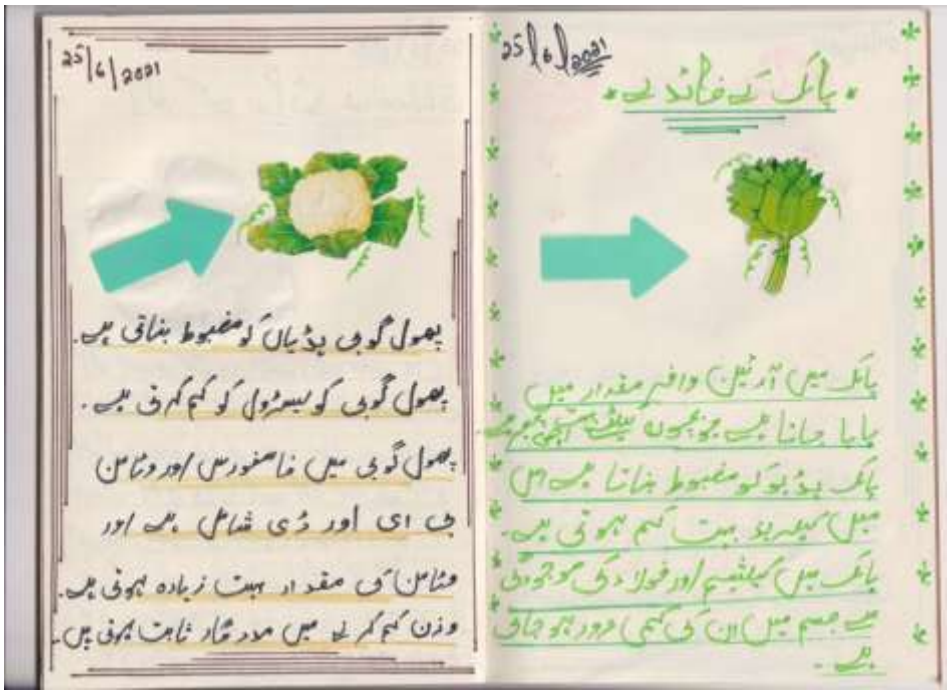

Figure 2. Qirat's photodiary: Benefits of spinach. Spinach is high in iron which is very beneficial for children. Spinach strengthen the bones and contains less calories. The calcium and iron content in spinach treats the calcium and iron deficiency in individuals. // Cauliflower strengthen the bones and reduces cholesterol. Phosphorous and vitamin B, E and D is present in cauliflower and have high amount of vitamins. It [cauliflower] also helps in weight loss.

Figure 3. Zainab's photodiary: Watermelon helps in overcoming the water loss in body. Watermelon helps in preventing eye diseases. Watermelon is not only a solution for thirst but also gives us energy and strength. // Banana makes our bones strong. Banana compensates for calcium deficiency. Banana shakes contains lots of nutrients.

Figure 4. Sulman's photodiary: Milk most benefits our bones. Milk is a very sensitive (perishable) food item. // Milk is a whole meal. High content of calcium is available in milk. ½ cup of milk contains 80 kcals. Milk is a sensitive (perishable) food item, so we should handle it properly. Due to our unawareness regarding milk handling, we catch lots of illness. Milk is health guarantor for both adults and kids. Milk contains all those proteins that a human needs.

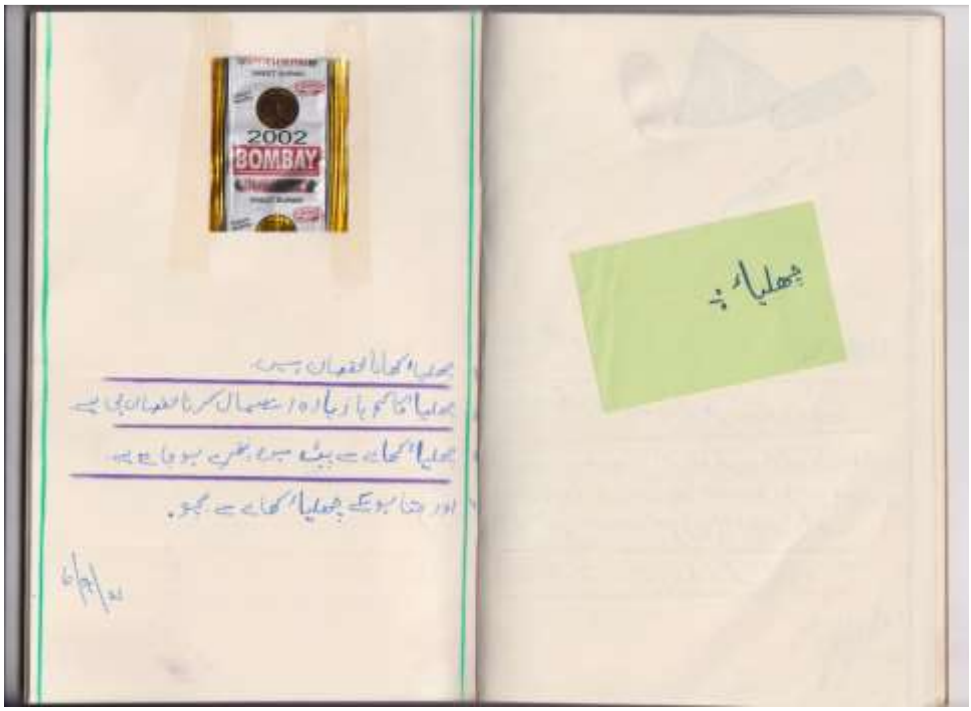

Figure 5. Ali's photodiary: Betel nut intake is harmful. Betel nut consumption cause negative impact even if consumed in small amount. Betel nut causes intestinal stones. Avoid betel nuts as much as possible.

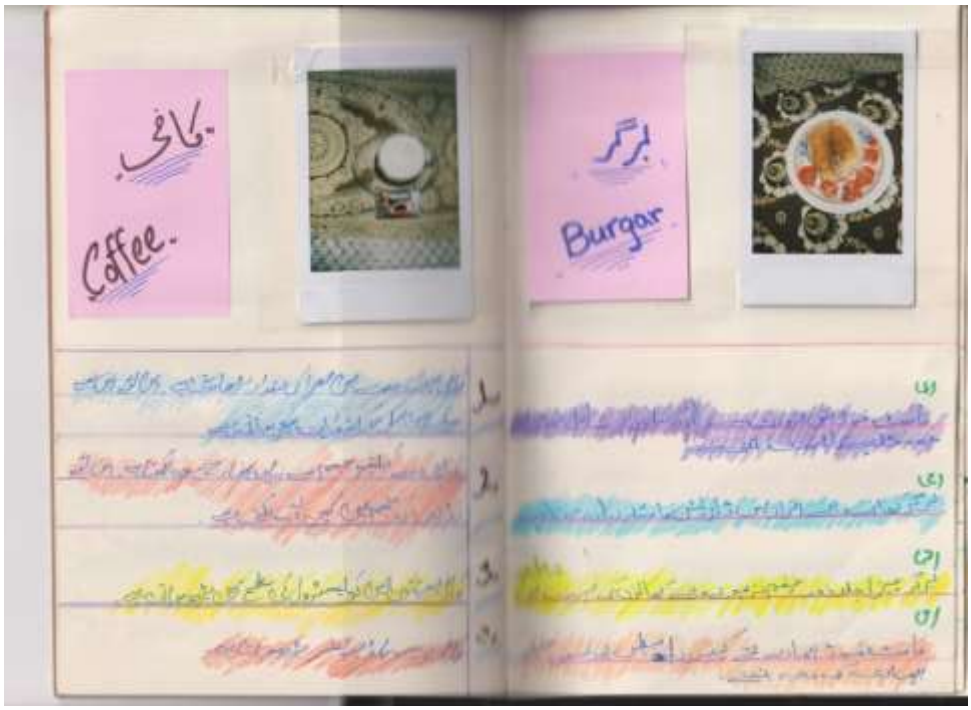

Figure 6. Laraib's photodiary: Fast food contains more than the required calories that causes obesity. Individuals that consume burgers are more prone to depression. Burger and pizza are included in the list of foods that digests slowly. Fast food is a cause of diseases like cancer, diabetes and constipation for us. // Coffee increases bile in stomach that's why it causes heartburn. Due to coffee, calcium excretes out of the body more often. That's why it decreases the bone volume. Due to coffee, cholesterol levels in blood increases. Coffee also increases the blood pressure.

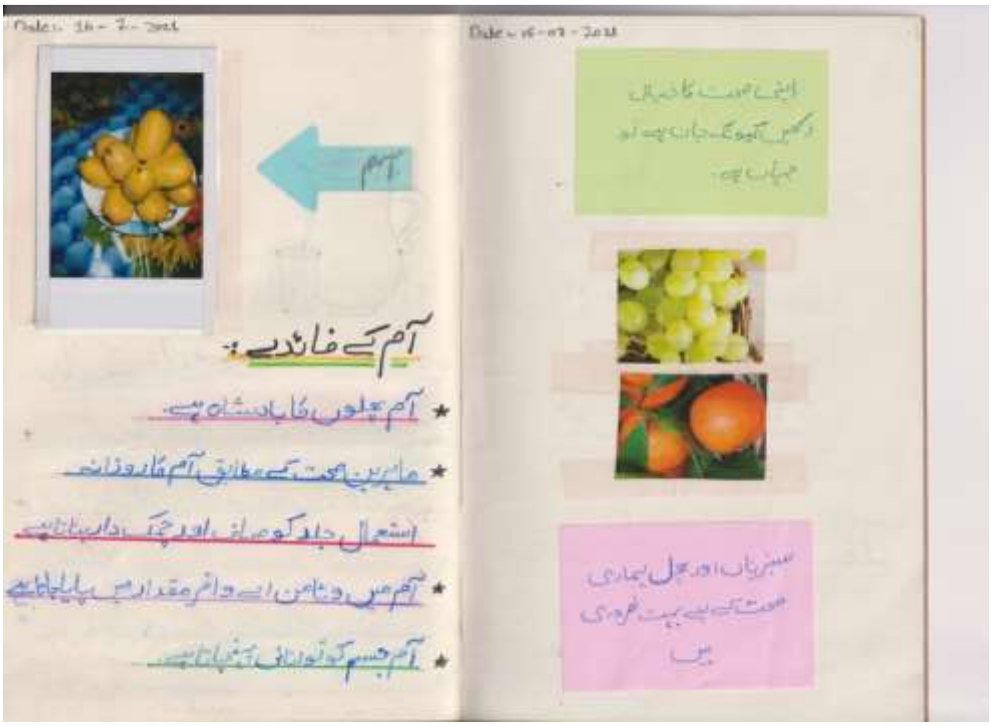

Figure 7. Rimsha's photodiary. Take care of your health because dead men are of no family and are akin to none (this means that nothing is more important that your life so you need to take care of your health). Vegetables and fruits are very necessary for health.// Benefits of Mango. Mango is the king of all fruits. According to experts, daily consumption of mango clears the skin and makes it glowing. Mango contains large amount of vitamin A. Mango provides energy to our body.

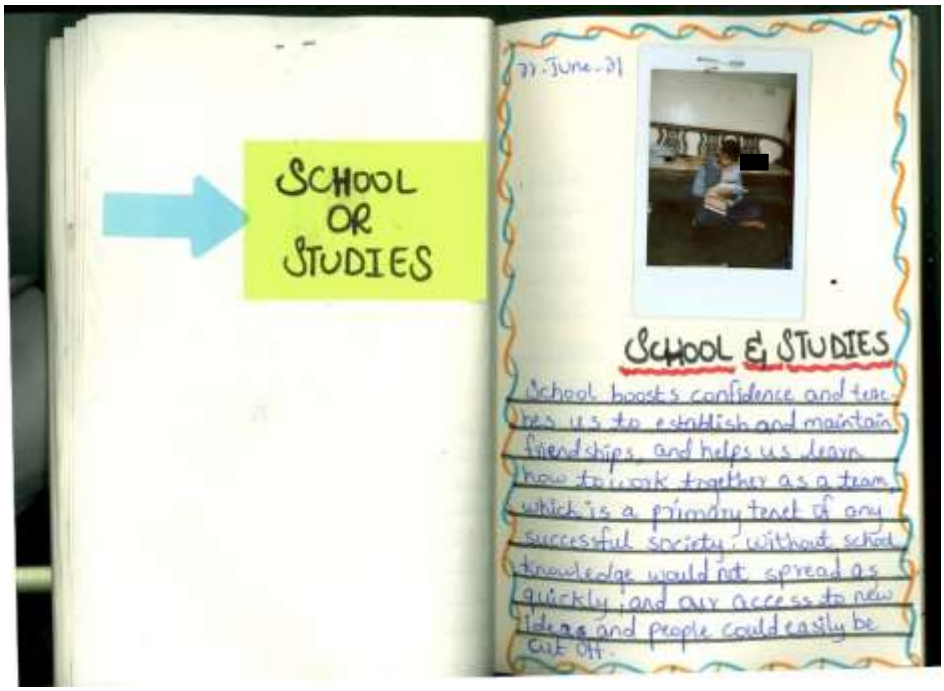

Figure 8. David's photodiary. School boosts confidence and teaches us to establish and maintain friendships, and helps us learn how to work together as a team which is a primary tenet of any successful society. Withoth school, knowledge would not spread as quickly, and our access to new ideas and people could easily be cut off.