Impact of a comprehensive multi-component health literacy module on dietary and physical activity patterns of adolescents studying in schools of Delhi, India

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Ph.D. Thesis, Maastricht University, the Netherlands

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CHAPTER 1

General Introduction

General Introduction

This thesis is about assessing the impact of a comprehensive, multicomponent school-based intervention with a focus on promoting a healthy food environment and the importance of being physically active. The chapter ends with the aim and outline of this dissertation.

Overweight and obesity

Worldwide, obesity and overweight are recognized to be significant public health problems and are known risk factors for major non-communicable diseases (NCDs) (1). In recent years, there is a paradoxical co-occurrence of under- and overweight/obesity in India (2). This is also known as the double burden of malnutrition. (3). On one hand, India continues to carry a huge burden of undernutrition, but on the other, changing lifestyles are contributing to the increasing burden of obesity and NCDs (4). NCDs account for more than 60% of all deaths in India (5). Global studies indicate that obesity and malnutrition lead to poor health, and this constitutes the 'Global Syndemic' (6). In this thesis, we focus on obesity, major risk factors including physical inactivity and unhealthy dietary practices (low intake of fruits, vegetables, and high intake of ultra-processed food [high in fat, salt, and sugar [HFSS])] (7). These risk factors are related to lifestyle and behaviour patterns, which are largely the result of practices adopted at an early age, as well as to the social, structural, and policy environment influences choices and behaviours (8). Adolescence presents an important opportunity to reduce these risk factors by becoming advocates for Health (9). However, their ongoing, psychological, and physical development makes them vulnerable to these risk factors (9). Adolescents constitute 21% of India's population (10). During adolescence, physical and emotional development involves nutritional and physiological requirements as well as complex psychosocial relationships (11). Personal factors affecting diet are taste, nutrition-related knowledge, and self-efficacy, which appear to influence the development of adolescents' dietary practices (12). According to the Comprehensive National Nutrition survey (2016–2018), 4% of children aged 5–9 years and 5% of adolescents were overweight (13). Overweight

and obese children are more likely to grow up into obese adults, who in turn are at greater risk of developing NCDs (14). A study shows that those who attend private schools in India (which typically admit children from higher socio-economic classes) are less active than those who attend government-funded public schools (15). Other studies in India show a higher prevalence of overweight among private school students and undernutrition among students in public schools (16, 17). It is well known that poor health outcomes can lead to reduced academic performance. Thus, there is a need to create a cohesive and efficient programme to address the double burden of malnutrition (18). Investment in health behaviour development during these formative years will lead to healthy and productive adults in the future and improved social and economic dividends nationally.

COVID-19 pandemic and the importance of healthy living practices

The outbreak of Coronavirus 2019 (COVID-19) brought the whole world to a standstill due to its rapid spread and severe health challenges. The World Health Organization (WHO) declared it a global pandemic (19). Measures to restrict the spread of the virus included self-isolation, quarantine, mask-wearing, hand washing, and social distancing (20). These measures forced everyone to change their routine and habits, including how we eat and our food preferences and choices (21). As lockdowns resulted in home confinement, it caused concerns because physical activity, eating behaviours, and mental health of people got impacted, which directly influenced their overall well-being (22). The two major outcomes due to home confinement were: staying at home for the major part of the day (due to restrictions on movement, more digital education, smart-working, and limitations in physical activity) and stockpiling food (due to restrictions on grocery shopping) (23). Unstructured schedules can come from a disrupted work pattern, leading to boredom and more screen time, which can contribute to overeating and increased energy intake (24). Unfortunately, unhealthy foods have a high glycaemic index, and intake of these leads to an increased risk of cardiovascular disease and obesity, which in turn has a relationship with getting serious COVID-19 infections and complications (25). Moreover, it became more

difficult to sustain adequate physical activity during the lockdown period.While the general population's incidence of unhealthy diets is already significant, regular disruptions due to the COVID-19 crisis may have exacerbated it even more (26). Hence, maintaining a healthy living practice that includes a proper diet and enough physical activity in a day is a challenging but important aspect of the healthy mental and physical well-being of individuals. It can be difficult to make lifestyle changes, and even more difficult to make it a habit, regardless of the moment and environment in which one resolves to eat better, exercise more, or be less stressed (27). At the same time, the COVID-19 pandemic posed a serious threat to the well-being of adolescents and made them more vulnerable (28). The pandemic caused significant changes in their lifestyle, including physical activity and dietary behaviour resulting in an increase in fat accumulation and low intake of essential nutrients, such as proteins, minerals, and vitamins (29). A recent study of adolescents found more stress, boredom, a sedentary lifestyle, and higher consumption of sweet foods, including sugar-sweetened beverages during the lockdown (30). A systematic review found a change in lifestyle behaviour due to COVID-19(31). Psychosocial or any kind of mental stress among the participants was found to be prevalent. Weight gain and decline in physical activity were also observed. In general, dietary habits changed into overeating.

Schools: Setting for health promotion and disease prevention

The school environment has the potential to impact NCD-related behavioural change in adolescents (32). Schools are an obvious place to facilitate this investment, given the inextricable links between education and health – both of them aim to create healthy, well-educated individuals who can contribute successfully to society(33). Report by the WHO expert committee emphasized that education cannot be achieved in poor health and related conditions (34). There is need for schools to be health-promoting for the holistic development of children and adolescents. Educational attainment is an important social determinant of health. The school represents an important setting for academic achievement and to facilitate the delivery of interventions related to the prevention and management of diseases. Results of a previous study

conducted in India showed that the awareness among schoolchildren regarding lifestyle-related risk factors of NCDs is not satisfactory; the study recommended the need for curriculum-based health education regarding the prevention aspects and motivation of the children to incorporate healthy lifestyle practices into their daily lives (35). Studies conducted in developed countries have shown that the school environment, including the nutrition and physical activity-related policies and practices in schools, greatly influence these behaviours in children and adolescents (36). School-based interventions including health education, canteen policies, and structured physical activity can prevent NCD risk factors. Such interventions should actively involve the participation of peers, teachers, school authorities, family members, and community members as they all play an important role in providing a supporting environment for sustaining healthy behaviours (37). The changes that are brought by lifestyle programmes in the early years of life are most likely to be carried into adulthood as healthy behaviours. Interventions at an early age can thus have a triple benefit of improving health during adolescence, enhancing health throughout life, and ultimately contributing to the health of the next generation of children.

Building on this background, this study aimed to assess the impact of a comprehensive school-based multicomponent module iPROMISe (**PROM**oting Health L**I**teracy in **S**chools) Plus on the dietary practices and physically activity of students studying in schools in Delhi.

Setting

All studies in this thesis were conducted in eight randomly selected private schools in Delhi from the list of schools governed by the Directorate of Education (DoE), Government of the National Capital Territory (NCT) of Delhi. The schools were recruited after they gave consent to participate in the study. The schools were then randomly assigned to the intervention or the control arm. A two-year intervention programme was implemented over consecutive academic years (2019–2020 and 2020–2021) with students who were in the 6th and 7th grades when the study began. These students were surveyed at the baseline and end-line. The baseline survey was

administered before the COVID-19 pandemic, and end-line surveys were administered during the COVID-19 pandemic.

Aim and Outline of this thesis

To be able to develop a comprehensive school-based intervention to foster healthy eating practices and emphasize the importance of being physically active, the first step was to conduct qualitative research to understand the needs of the school-going adolescents. Chapter 2 describes the steps involved in the development of a comprehensive intervention based on the Health Belief Model (HBM). Another goal was to pre-test the intervention with the target audience (schoolgoing students and teachers). These outcomes were important for understanding the acceptability of the intervention. The success of the HBM has been well-documented as an appropriate model for intervention development. Chapter 3 assesses the prevalence of excessive weight and underweight and its associated dietary and physical activity-related knowledge and behaviours among the urban private school-going adolescents (aged 11–12 years) in Delhi. The secondary objective was to study the correlates of BMI (body mass index) status with dietary and physical activity knowledge and behaviours among these participants. These outcomes were important for understanding whether the planned cluster randomized controlled trial (RCT) was justified. The planned trial was called the iPROMISe Plus, implemented over two years (2019–2021). In 2020, the outbreak of COVID-19 brought the whole world to a standstill. To contain the spread of COVID-19 infection and mitigate the pandemic risks, educational institutions were closed and school-age children were confined to their homes, posing an unprecedented challenge to their education and natural growth. It has greatly affected the lives of adolescents through restrictions such as less playtime, more screen time, and limited interaction with peers. Chapter 4 evaluates the impact of the COVID-19 pandemic on the dietary and physical activity-related behaviour of school students aged 10–16 years. Chapter 5 describes the effects of iPROMISe Plus intervention. This study was planned and started before the COVID-19 break-out; however, we decided to continue the study to investigate the effects of the intervention during the COVID-19 pandemic. Our research question was modified by assessing the effec-

tiveness of the comprehensive school-based intervention on diet and physical activity-related behaviour of school-going adolescents during the COVID19 pandemic. We hypothesized that the intervention would lead to a significant increase in the dietary and physical activity-related behaviours of the students in the intervention group after two years, compared to the control group.Chapter 5 provides the findings on the effect of this intervention on diet and physical activity-related knowledge and behaviour of school-going adolescents in Delhi, India. Very few studies have been conducted to explore the effectiveness of a school-based intervention focused on adolescents' dietary and physical activity behaviour during the COVID-19 pandemic.

In summary, the main objectives of this thesis were as follows:

1. To develop and pre-test the comprehensive intervention focused on improving diet and physical activity-related knowledge and behaviour among school-going adolescents. (Chapter 2)
2. To assess the prevalence of excessive weight and underweight and its associ ated knowl edge and lifestyle behaviours among the urban private school-going adolescents (aged 11–12 years) in Delhi. (Chapter 3)
3. To study the correlates of BMI status (underweight, normal, excessive weight) with dietary and physical activityrelated knowledge and behaviours among these participants. (Chapter 3)
4. To understand the impact of the COVID-19 measures on the dietary and physical activity behaviour of adolescents. (Chapter 4)
5. To study the factors that influence physical activity and diet-related behaviour in adole scents during COVID-19. (Chapter 4)
6. To assess the effectiveness of a comprehensive school-based intervention on diet and physical activity-related behaviour of school-aged adolescents during the COVID-19 pandemic. (Chapter 5) Chapter 6 discusses the results and strengths and limitations of this thesis. Finally, we share our conclusion, consider scientific and practical implications for practice, and give directions for future research.

Chapter 6 discusses the results and strengths and limitations of this thesis. Finally, we share our conclusion, consider scientific and practical implications for practice, and give directions for future research.

References:

1. WHO. Obesity and overweight 2021 [Available from: https://www.who.int/en/newsroom/factsheets/detail/obesity-and-overweight.
2. Gopalan C. The changing nutrition scenario. The Indian journal of medical research. 2013;138(3):392.
3. Sengupta A, Angeli F, Syamala TS, Van Schayck C, Dagnelie P. State-wise dynamics of the double burden of malnutrition among 15–49 year-old wom en in India: how much does the scenario change considering Asian populationspecific BMI cut-off values? Ecology of food and nutrition. 2014;53(6):618-38.
4. Stigler MH, Arora M, Dhavan P, Shrivastav R, Reddy KS, Perry CL. Weight-related on cerns and weight-control behaviors among overweight ad olescents in Delhi, India: a cross-sectional study. Int J Behav Nutr Phys Act. 2011;8:9.
5. WHO. Noncommunicable Diseases (NCD) Country Profiles, 2018 2018 [Available from: https://www.who.int/nmh/countries/2018/ind_en.pdf?ua=1.
6. Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, et al. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. The lancet. 2019;393(10173):791-846.
7. Khatib O. Noncommunicable diseases: risk factors and regional strategies for prevention and care. EMHJ-Eastern Mediterranean Health Journal, 10 (6),778-788,2004. 2004.
8. Angkurawaranon C, Jiraporncharoen W, Chenthanakij B, Doyle P, Nitsch D. Urban environments and obesity in southeast Asia: a systematic review, me ta-analysis and meta-regression. PloS one. 2014;9(11):e113547.
9. Baker R, Taylor E, Essafi S, Jarvis JD, Odok C. Engaging young people in the prevention of noncommunicable diseases. Bulletin of the World Health Organization.2016;94(7):484.
10. Dandona L, Dandona R, Kumar GA, Shukla D, Paul VK, Balakrishnan K, et al. Nations within a nation: variations in epidemiological transition across the

states of India, 1990–2016 in the Global Burzden of Disease Study. The Lan cet.2017;390(10111):2437-60.
11. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our fure: a Lancet commission on adolescent health and wellbeing. The Lancet. 2016;387(10036):2423-78.
12. Rathi N, Riddell L, Worsley A. Indian adolescents' perceptions of the home food environment. BMC Public Health. 2018;18(1):1-7.
13. Ministry of Health and Family Welfare (MoHFW) GoI, UNICEF , Council aP. Comprehensive National Nutrition Survey (CNNS) National Report 2019 [Avail able from: https://www.popcouncil.org/uploads/pdfs/2019RH_ CNNSreport.pdf.
14. WHO. Report of the commision on Ending Childhood Obesity - Implementa tion plan: Excecutive Summary 2017 [Available from: https://apps.who.int/iris/bitstream/handle/10665/259349/ WHO-NMH-PND-ECHO-17.1-eng.pdf.
15. George GM, Sharma KK, Ramakrishnan S, Gupta SK. A study of cardiovas cular risk factors and its knowledge among school children of Delhi. indian heart journal.2014;66(3):263-71.
16. Arora M, Mathur C, Rawal T, Bassi S, Lakshmy R, Nazar G, et al. Socioeco nomic differences in prevalence of biochemical, physiological, and metabolic risk factors for on-communicable diseases among urban youth in Delhi, India. Preventive medicine reports. 2018;12:33-9.
17. Stigler MH, Arora M, Dhavan P, Tripathy V, Shrivastav R, Reddy K, et al. Measuring obesity among school-aged youth in India: a comparison of three growth references. Indian Pediatrics. 2011;48(2):105-10.
18. Ruel Sr M, Hawkes C. Double duty actions to tackle all forms of malnutrition (P10-053-19). Current developments in nutrition. 2019;3(Sup plement_1):nzz034. P10-53-19.
19. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Biomed. 2020;91(1):157-60.
20. Lohi AS, Sawarkar G. Management of diet during Covid-19 pandemic. Int J Res Pharm Sci. 2020:154-7.

21. Chatterjee P, Nirgude A, Chatterjee PK. Healthy eating–a modifiable contributor to optimize healthy living in the COVID-19 pandemic: a review. Journal of the Science of Food and Agriculture. 2022;102(5):1751-8.
22. Yousef IA, Kilani HA, Mo'ath F, Al-Nawayseh A, Al-Za'abi A, Belghali M, et al. Social Issues During the COVID-19 Quarantine Period: Interaction of Physical Activity and Mental State. Planning. 2022;17(3):777-85.
23. Lucini D, Gandolfi CE, Antonucci C, Cavagna A, Valzano E, Botta E, et al. # Stay HomeStayFit: UNIMI's approach to online healthy lifestyle promotion during the COVID-19 pandemic. Acta Bio Medica: Atenei Parmensis. 2020;91(3):e2020037.
24. Moynihan AB, Tilburg WAv, Igou ER, Wisman A, Donnelly AE, Mulcaire JB. Eaten up by boredom: consuming food to escape awareness of the bored self. Frontiers in psychology. 2015;6:369.
25. Muscogiuri G, Pugliese G, Barrea L, Savastano S, Colao A. Commentary: obesity: the "Achilles heel" for COVID-19? Metabolism-Clinical and Experimental. 2020;108. pact. SAGE Publications Sage CA: Los Angeles, CA; 2021. p. 4-5.
27. Van der Werf ET, Busch M, Jong MC, Hoenders H. Lifestyle changes during the first wave of the COVID-19 pandemic: a cross-sectional survey in the Netherlands. BMC Public Health. 2021;21(1):1-11.
28. Albashir AAD. The potential impacts of obesity on COVID-19. Clin Med (Lond). 2020;20(4):e109-e13.
29. Nogueira-de-Almeida CA, Del Ciampo LA, Ferraz IS, Del Ciampo IR, Contini AA, UedFdV. COVID-19 and obesity in childhood and adolescence: a clinical review. Jornal de Pediatria. 2020;96:546-58.
30. Ruiz-Roso MB, de Carvalho Padilha P, Mantilla-Escalante DC, Ulloa N, Brun P, Acevedo-Correa D, et al. Covid19 confinement and changes of adolescent's dietary trends in Italy, Spain, Chile, Colombia and Brazil. Nutrients. 2020;12(6):1807.
31. González-Monroy C, Gómez-Gómez I, Olarte-Sánchez CM, Motrico E. Eating Behaviour Changes during the COVID-19 Pandemic: A Systematic Review of Longitudinal Studies. Int J Environ Res Health. 2021;18(21).

32. Skar M, Kirstein E, Kapur A. Lessons learnt from school-based health pro motion projects in low-and middle-income countries. Child: Care, Health and Development. 2015;41(6):1114-23.
33. Tountas Y, Dimitrakaki C. Health education for youth. Pediatr Endocrinol Rev. 2006;3 Suppl 1:222-5.
34. Promoting health through schools. Report of a WHO Expert Committee on Comprehensive School Health Education and Promotion. World Health Organ Tech Rep Ser. 1997;870:i-vi, 1-93.
35. Divakaran B, Muttapillymyalil J, Sreedharan J, Shalini K. Lifestyle riskfactors of non communicable diseases: awareness among school children. Indian journal of cancer. 2010;47(5):9.
36. Story M, Kaphingst KM, French S. The role of schools in obesity prevention. The future of children. 2006:109-42.
37. Goyal RK, Shah VN, Saboo BD, Phatak SR, Shah NN, Gohel MC, et al. Prevalence of overweight and obesity in Indian adolescent school going children: its relationship with socioeconomic status and associated lifestyle factors. The Journal of the Association of Physicians of India. 2010;58:151-8.
38. Kelsey MM, Zaepfel A, Bjornstad P, Nadeau KJ. Age-related consequences of childhood obesity. Gerontology. 2014;60(3):222-8.
39. Malik VS, Willett WC, Hu FB. Global obesity: trends, risk factors and policy implications. Nature Reviews Endocrinology. 2013;9(1):13-27.
40. Hayba N, Khalil C, Allman-Farinelli M. Enabling Better Nutrition and Physical Activity for Adolescents from Middle Eastern Backgrounds: Focus Groups. Nutrients. 2021;13(9).
41. Moore MM, Robinson JC, Rachel MM, Boss BJ. Barriers to physical activity and healthy diet among children ages 6 through 13 in a Mississippi elementary school. J Pediatr Nurs. 2014;29(1):74-82.
42. Bassi S, Bahl D, Harrell MB, Jain N, Kandasamy A, Salunke SR, et al. Knowledge, attitude, and behaviours on diet, physical activity, and tobacco use among school students: A cross-sectional study in two Indian states: F1000Res. 2021 Oct 15;10:544.doi 10.12688/f1000research.51136.2.

eCollection 2021.
43. Martin A, Booth JN, Laird Y, Sproule J, Reilly JJ, Saunders DH. Physical activity, diet and other behavioural interventions for improving cognition and school achievement in children and adolescents with obesity or overweight. Cochrane Database Syst Rev.2018;3(3):Cd009728.
44. Rawat D, Dixit V, Gulati S, Gulati S, Gulati A. Impact of COVID-19 out break on life style behaviour: A review of studies published in India. Diabetes Metab Syndr. 2021;15(1):331-6.
45. Rawal T, Bhaumik S, Shrivastav R, Nazar GP, Tandon N, Arora M. Kids and Diabetes in Schools (KiDS) intervention in India: Participants' perspectives. Health Education Journal. 2021;80(7):851-60.
46. Wolnicka K, Charzewska J, Taraszewska A, Czarniecka R, Jaczews ka-Schuetz J, Bieńko N, et al. Intervention for improvement the diet and physical activity of children and adolescents in Poland. Rocz Panstw Zakl Hig. 2020;71(4):383-91.
47. Moitra P, Madan J, Verma P. Impact of a behaviourally focused nutrition edu cation intervention on attitudes and practices related to eating habits and activity levels in Indian adolescents. Public Health Nutr. 2021;24(9):2715-26.
48. Rawal T, Shrivastav R, Nazar GP, Tandon N, Arora M. A school-based pro gram for diabetes prevention and management in India–project KiDS and diabetes in schools. International Journal of Noncommunicable Diseases. 2020;5(3):107.

CHAPTER 2

How to promote a healthy lifestyle among school-children: Development of an intervention module (i-PROMISe)

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How to promote a healthy lifestyle among school children

Abstract

Objective: Lifestyle preferences are inculcated in childhood and once established, persist into adulthood. The Project PROMoting Health LIteracy in School (i-PROMISe) aims to promote a healthy lifestyle among students for the universal prevention of non-communicable diseases (NCDs) like diabetes.

Study design: Qualitative study using focus-group-discussions (FGDs) and In-Depth Interviews (IDI).

Method: Project was undertaken in two-phases in two private schools in New Delhi, India. In phase-one, FGDs with students (grades IV to VIII) and IDIs with teachers were conducted to ascertain their perceptions of diabetes prevention and management according to the Health Belief Model. The data was analyzed using a thematic framework method. In phase-two, the resources were pre-tested and participants' feedback was requested on the duration, quality, and understanding of the resources.

Results: In total, 89 students and 17 teachers participated in phase-one (n = 54 [in FGDs] and n = 5 [in IDIs]) and phase-two (n = 35 students and n = 12 teachers in FGDs). In phase-one, themes that emerged included: diabetes was considered a disease of the elderly; misconceptions about susceptibility to these diseases were common; children were largely aware of measures to prevent these diseases, but barriers to adopting a healthy lifestyle existed. Based on the findings, a comprehensive module was developed, which consisted of a teacher's manual with interactive activities and short films. The resources (teacher's manual and short films) were well received and contributed to a better understanding of diabetes and other NCDs; myths/misconceptions were clarified.

Conclusion: Development of resources using participatory approach can be effective in promoting and reinforcing healthy behaviours among school going children to prevent and control NCDs in schools.

Keywords: Diabetes, NCD, Health belief model, Adolescents, Universal prevention, Lifestyle behaviors, Knowledge, India

1. Introduction

In India, an estimated 77 million adults live with diabetes and the country currently has the second highest number of people with diabetes in the world [1]. Rapid economic changes and consequent urbanization and lifestyle changes mean an epidemiological transition to an increased burden of NCDs such as diabetes [2,3]. By 2030, there are expected to be 101 million adults with diabetes in India [4].

Low awareness of healthy lifestyle choices that can prevent Type 2 diabetes is a major problem [4,5]. Lifestyle behaviors are established fairly early in life, in childhood and adolescence, and once established, they persist into adulthood [[5], [6], [7]]. Therefore, interventions to influence healthier lifestyles may be more effective if implemented in childhood, before unhealthy choices become entrenched in an individual's lifestyle [8,9].

It is therefore important to find an answer for the education sector in the form of a comprehensive diabetes education module that not only promotes healthy lifestyle choices to prevent or delay type 2 diabetes but also educates school children about type 1 diabetes. In India, there is a lack of awareness about the management of type 1 diabetes even among parents of children with type 1 diabetes, healthcare professionals, school staff as well as the general public [10]. Children with type 1 diabetes need a supportive environment around them, especially among their friends and teachers, free from stigma or negative attitudes [11]. It is crucial that teachers facilitate a supportive environment for children with type 1 diabetes.

To our knowledge, there are few projects that focus on the management and prevention of diabetes in India. The Kids and Diabetes in School (KiDS) project [12] is one example. Following the evaluation of the KiDS project, comprehensive materials and tools were developed for students aged 9–13 years (grade IV-VIII) under the PROMoting Health LIteracy in School (i-PROMISe) project. The i-PROMISe project aims to develop and pre-test a comprehensive intervention based on a theoretical model.

2. Methods

2.1. Theoretical framework

This study was designed taking into account feedback from an earlier study [13], conducted in schools of New Delhi, and then further developed in consultation with an expert group comprising clinicians, nutritionists, public health professionals, and health-communication experts. The need to base the module on a theoretical model of health promotion was a key input. The Health Belief Model (HBM) was considered appropriate because it matched our goal and focussed on the prevention of risk factors (Unhealthy diet and physical inactivity) related behavior initiation by taking into account both individual perceptions, external cues to action, and individual self-efficacy. The HBM focuses on four constructs: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. The success of the HBM has been well documented in childhood diabetes interventions and especially in lower-middle-income countries (LMICs), proving that it is an appropriate model for intervention development [14,15].

2.2. Participants

Earlier studies conducted in New Delhi reported a significantly higher prevalence of overweight and obesity among students of private schools in the focus age group compared to government (public) schools [16]. Therefore, we sent invitations to private schools in New Delhi and two schools agreed to participate in the study. Following the consent received from these two schools, students of grade IV - VIII (9–13 years) were recruited to participate in focus group discussions (FGDs) in con-

sultation with the school authorities using convenience sampling and based on the received consent from their parents. Parental consent and informed consent were obtained from the students. Class teachers of grades IV - VIII, and teacher coordinators in the participating schools were nominated by schools for unstructured in-depth interviews (IDIs) and consent was also obtained.

2.3. Phase 1

FGDs with students and IDIs with teachers were held in the school on the topic guide, that was based on the HBM (Annexure I, II, and III). The duration of FGDs and IDIs was 35–40 min. The topic guide was developed based on the HBM constructs, and then an iterative approach was followed whereby, if additional issues were discovered, they were explored and probed for in subsequent IDIs and FGDs. FGDs with students were conducted in two groups (one with each grade): grade IV–V (n = 2; aged 9–11 years) and VI–VIII (n = 3; aged 11–13 years). In total, there were 54 participants (29 boys and 25 girls) in five FGDs and five IDIs. The FGDs and IDI were led by two authors (TR, female and SB, male), who are experienced in qualitative research and worked primarily in English (Hindi was occasionally used for the convenience of the participants). Data saturation was observed in the sense that answers for most themes were repeated during subsequent discussions. Therefore, no repeated interviews were conducted. All interviews were audio-recorded. No one other than the participants was present during the FGDs and IDIs.

2.4. Phase 2

Based on the results of the first phase, two short audio-visuals (informative short films) and a manual of interactive classroom activities were developed and pre-tested in the same two private schools. Five separate FGDs were conducted with 35 students (16 boys and 19 girls) and 12 teachers. The duration of each FGD varied from 40 to 45 min. Separate FGD guidelines were developed to obtain feedback. Students were shown the draft of the film before the FGDs, and teachers were given the manual a day before and the informative short film before the FGDs.

2.5. Data analysis

The recorded FGDs and IDIs were transcribed verbatim. Each transcript was assigned a confidential identification code. In phase one, all transcripts were coded independently by two authors. These codes were then defined and grouped into categories to align with the HBM. In phase two, two authors independently coded all transcripts. A framework was then derived from this based on consensus and the transcripts were coded accordingly. Themes were then finalized in consultation with the principal investigator. Although the findings are presented under distinct thematic categories to facilitate interpretation, these are not very strict descriptions as participants often spoke about multiple themes at the same time. Atlas.ti 6.2 (release 2011, Atlas.ti, Berlin) was used for the thematic analysis.

3. Results

3.1. Phase 1 of the study

Responses obtained from FGDs and IDIs in phase one, are presented in Table 1.

Table 1 Constructs of HBM and themes emerged in phase 1.

Health Belief Model Construct	Themes
1. Perceived threat	1.1 Perceived susceptibility to diabetes (Participant's defined causes, risk factors) 1.2 Perceived severity (Awareness about symptoms and consequences of diabetes)
2. Perceived benefits and barriers	2.1 Perception towards adopting a healthy lifestyle (in cluding barriers; lack of motivation, complex lifestyle)
3. Self-efficacy	3.1 Self-efficacy to adopt healthy lifestyle
4. Cues to action	4.1 Experience/association with people with diabetes and source of information 4.2 Intervention perceived to be effective to promote a healthy lifestyle

3.1.1. Perceived susceptibility to diabetes Perceived susceptibility was discussed concerning the participant's notion about the risk of developing diabetes in relationship to age, gender, and socio-economic status (SES) of the individual. The majority of participants considered diabetes to be a disease that only affects older people and has serious consequences. Most children related diabetes to their own experiences with older relatives (mostly grandparents). Few students talked about the experiences of their friends and young relatives with diabetes. Very few teachers were aware of diabetes in younger populations.

"More aged people will be more affected" – Children-FGD

"It occurs mostly in the aged people" – Teacher-IDI
"Young people are affected but between 35 and 50 years, this disease starts." – Teazcher-IDI

Some teachers linked the development of diabetes to an individual's SES and lack of physical activity in daily living. These teachers believed that people belonging to middle to high SES are at high risk of developing diabetes. Few participants were not even sure about the fact that diabetes can occur in anyone, regardless of gender.

"I feel people who are socially or economically low in criteria and those who are earning their livelihood through vigorous physical activity like rick shaw puller, domestic help have fewer chances of developing diabetes." – Teacher-IDI

"Diabetes occurs as per age and gender of a person i.e., if the person is in the mid-40s and male they can have diabetes." – Child-FGD

3.1.2. Perceived severity Some of the participants perceived the consequences and complications of diabetes as very serious disease as they were aware of them. The vague knowledge of multi-morbidity, together with the need to take a large number of medicines as a result, was also identified as a cause of concern.

"My mother is now 65 and has developed diabetes which is affecting her kidneys so now she is having medicine for both." – Teacher-IDI

"I have heard somewhere it affects our eyes and causes harm to our body." – Child-FGD

The majority of the participants were not aware of the relevance of the type of diabetes. Very few children mentioned it.

"I don't know much about the type of diabetes …. , for more details, I have to search as not much aware about it". – Teacher-IDI

Misbeliefs about diabetes susceptibility were common among the participants. Most children associated diabetes with eating sugar and were unsure about the risk factors of diabetes. However, some children and teachers appeared to be aware.

"Diabetes is caused by eating sweet things. A lot of sweet and sugars." – Child-FGD

Many students were curious about the pathology of diabetes and its connection to other lifestyle diseases.

3.1.3. Perceptions towards adopting a healthy lifestyle Almost all participants highlighted the importance of adopting a healthy lifestyle and shared their personal experiences. Children were largely aware of measures to prevent diabetes but highlighted that barriers exist e.g. lack of motivation for children to perform physical activity and eat healthy food. A teacher during the IDI of phase one said: "In the curriculum, we don't touch upon the details of these lifestyle diseases. Also, I have seen students get pizzas or burgers for lunch and a pack of juice."
Both teachers and children mentioned academic pressure as one of the barriers to being physically active and the unavailability of healthy food in the school canteen.

"In India in most of the schools, we give more importance to education rather than physical activities." Teacher-IDI

"Study pressure should be decreased and due to pressure, we don't feel like playing." – Child-FGD

Few children thought that adults are not following healthy lifestyles because of their busy schedules and increasing dependence on technology. Some teachers also mentioned the increasing use of technology among children as a major barrier.

"Because everybody is busy in their life to earn more money and occupied with only phones." – Child-FGD

"Children are hooked on to video game. Young children might not be on Face book, but they are there on WhatsApp. And the computer games." – Teacher-IDI

3.1.4. Self-efficacy Participants have shown a sense of self-efficacy towards the importance of being physically active and following a healthy lifestyle. They also highlighted ways to overcome barriers, such as making High Fat, Sugar and Salt (HFSS) foods less available and choosing easier ways to be active, e.g., taking the stairs instead of the lift; using technology in a positive way instead of playing video games, home-made food instead of canteen food.

".. because they might live in a hostel or go out for higher studies. They will eat what ever is available there. But yes, a conscious effort has to be made to eat healthy food." – Teacher-IDI

"Children should eat a balanced healthy diet." – Child-FGD

"Children are sitting in front of the TV. They are in the trap of technology. They are not using technology for good or benefit but disadvantageous for them." – Child-FGD

3.1.5. Experience/association with people with diabetes and source of information
The source of information on diabetes varied: teachers cited the internet as the primary source of information, while children tended to see adults as the primary source of information. A teacher shared the experience of a child with diabetes at school and expressed concern about the child's poor attendance due to physical weakness.

> *"She is a very nice and well-behaved kid but her attendance is very low. I feel she is physically very weak also and that's why her attendance is very poor."*
> *– Teacher-IDI*

3.1.6. Intervention perceived to be effective in promoting a healthy lifestyle Most teachers suggested that resources are needed to educate in school about unhealthy lifestyles and related diseases. Their suggestions included organizing a workshop for teachers and children; developing short films, cooking sessions with parents.

> *"Whatever is required to know about diabetes is not talked about. Why can't we give students the required information once a week? If we make it a habit the students go on to adopt it for life." – Teacher-IDI*

> *"I think we can make short movies and can be shown in the schools through smart boards. I always think that visual aid is more effective." – Teacher-IDI*

Some children suggested the use of animated videos (cartoon) to attract more attention, while others mentioned the need for workshops, community-engagement, and the inclusion of activities.

3.8. Phase 2: Development and pre-testing of intervention
Following the results of phase one, informative and teaching-learning material were developed, which were reviewed by a technical expert group including nutritionists, public health, and communication specialists.
A short animation film was developed for screening in class. It focused on reinforcing healthy lifestyle practices through a character named Super Kid Aryan (see Fig. 1).

Fig.1 Glimpses from video developed for students.

An informative short film was developed for teachers on NCDs including diabetes, its prevention, and management. A renowned endocrinologist was used as a resource (see Fig. 2).

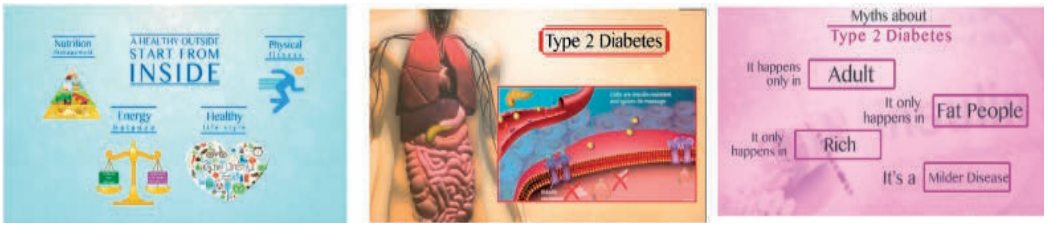

Fig.2 Glimpses from video developed for Teachers.

A teacher's manual (see Fig. 3) was developed with interactive theme-based activities, comic strips, information on the type, risk factors, consequences, management and prevention of diabetes, region-specific food preparation options to promote healthy eating, and guidelines for schools to promote regular physical activity/exercise and healthy eating.

The developed videos (supplementary file) contain sections on debunking diabetes myths.

The intervention was then pre-tested in the same two private schools in New Delhi. The developed intervention components were shown to the students and teachers and their feedback was sought through FGDs on the length, quality, understanding, and interpretation. The feedback could be grouped into three themes: satisfaction, awareness, and suggestions.

Fig.3 Glimpses from Teacher's Manual.

3.9. Satisfaction with the intervention

Intervention components were appreciated and well-received by participants. They found it much needed and important to fill gaps in knowledge. According to the children, the inclusion of information on healthy eating habits and recipes provides them the opportunity to discuss these topics with their parents and reinforce the concept at home. The teachers found the content of the video and manual simple, clear, and easy to understand. They found that the information is presented in an attractive, informative, and child-friendly way.

> *"It is quite informative, and it will encourage children to adopt a healthier lifestyle and they will become more conscious about their health."*
>
> *– Teacher-FGD*

"Manual is quite informative. Activities are good and merges well with the curriculum." – *Teacher-FGD*

"*People could relate to film. It was easily understandable. The video is useful for person who could not read also."* – *Child-FGD*

3.10. Raised awareness/Reinforcement of information

After watching the video, teachers reported that their knowledge of NCDs, especially diabetes, had improved. Teachers were made aware of their role in dealing with children with diabetes. Teachers stressed that including cartoons in the manual is a good approach to capture student's attention.

"Awareness was created among the teachers also. It was shown that this disease not only occurs among adults, but even children are also affected by this disease. Therefore, it is important to sensitize children and their parents also." – *Teacher-FGD*

The students stressed that the intervention emphasised the need for lifestyle changes to escape the threat of diabetes.

3.11. Suggestions of the participants

Both groups suggested adding an important myth that diabetes is caused by eating too much sugar, with the accompanying facts. Children suggested including information about how insulin works in the children's video. Few felt that for better understanding the intervention should be adapted in Hindi for the rural population. One teacher suggested including a case study of a person living with diabetes.

"It should be shown to all kinds of school, rural and urban Delhi, in private and government schools and can be modified accordingly." Child-FGD

Most of these suggestions were incorporated into the intervention. A separate video was developed for VII–VIII grade children, with additional information on the

the pathology of diabetes. Some suggestions, such as the adapting the intervention in Hindi and including a case study will be considered in the next phase.

4. Discussion

The results of the first phase highlighted the easy availability and accessibility of unhealthy food items and technological resources, including mobile and computer-based games, as risk factors for adopting an unhealthy lifestyle. Lack of knowledge and motivation were also seen as serious concerns and barriers. Regular reinforcement of messages focusing on the importance of physical activity and healthy eating habits was considered important for preventing or delaying NCDs in later life. Findings of phase two showed that the intervention was effective in conveying the importance of healthy lifestyles and are consistent with the literature that HBM is an effective framework for developing health interventions [17,18]. Components such as the organisation of sessions and the development of interactive resources were considered effective media for sensitization, when participants perceived NCDs, especially diabetes, as a disease that occurs only in the elderly and has serious consequences.

The findings indicate that the methodology of the present study was useful in obtaining input from students and teachers and gauging their perceptions to guide the development of resources/tools, which were ultimately based on the recommendations of the earlier study [13]. Perceived severity and susceptibility have been reporteDSd previously as the most influential constructs among the younger age group [19].

Regarding perceived susceptibility in relation to age, gender and SES, participants recounted their own experiences of dealing with such lifestyle diseases, especially in relation to elderly family members. Most participants associated diabetes with people with higher SES and the elderly. The views were similar to a finding from a study in Indonesia, conducted to explore the community's general perceptions of diabetes and its risk factors, which have shown that diabetes affects wealthy people and is considered a familial disease [20].

Adopting recommended health behaviors was discussed and participants demonstrated self-efficacy by sharing ways to improve practices to lead a healthy lifestyle. Thus, there was a reinforcement of the messages that were considered important to be confident in adopting a healthy lifestyle that would result in an improvement in overall health [21]. Most participants indicated the importance of being physically active and eating healthy as key to overall health. However, other risk factors discussed, including attractive advertising and the promotion of unhealthy foods, were considered the barriers, especially for children in grades VI–VIII. Similar findings were reported in other studies of adolescents [22,23].

The participants suggested that the message was considered more relevant and effective when it came from experts or through teachers. Results from a previous study have shown that teacher engagement can be more effective than information-only messaging in improving healthy living habits [24] Attractive and captivating messaging is an essential component of health communication and promotion [25]. The study found that teacher-led messaging can increase the relevance and credibility of the message relevance, although for some participants the use of experts to attract attention along with organizing workshops and developing audio-visual aids are important.

The majority of participants cited as sources of information on NCDs: teachers, media channels, parents, and grandparents. At the same time, the findings pointed to the need to develop innovative resources to emphasize the importance of practicing healthy behaviours, which are in line with other studies and highlight the need to raise awareness among adolescents at an early age to prevent or delay NCDs [26].

Understanding messages is a prerequisite for processing messages and acceptance to perform a behaviour. Individuals also need to understand what that behaviour is. Feedback obtained in phase two of the study indicated that the tools developed can regularly reinforce the adoption of healthy practices. Therefore, messages were designed to communicate and reinforce strategies for dealing with the barriers listed. Results from another study also showed the value of approaches to reducing expo-

sure to risk factors associated with NCDs and promoting healthy living practices through tailored interventions [22].

Pre-testing showed that participants were satisfied with the developed interventions in terms of content and presentation. Teachers were informed of their role in delivering the intervention and contributed enthusiastically to provide input.

This study used the HBM to develop an appropriate intervention to promote the importance of adopting healthy lifestyles through short informative films for students and teachers including interactive activities and an animated component (cartoon) for the student. The latter is novel in the promotion of preventive messages.

4.1. Strength and Limitations

Participants reported an increase in knowledge about NCDs; however, future studies should focus on assessing the impact of this intervention. Using qualitative methods such as FGDs and IDIs to explore the type of intervention to promote healthy lifestyles may elicit socially desirable responses. Therefore, FGD and IDI guides were designed and conducted to obtain detailed information, and the analysis was conducted independently by two trained researchers. The sample group was small and recruited using convenience sampling therefore, findings may not be generalizable to other parts of India. The findings of this study provide valuable insights i.e. prevention-oriented interventions and strategies that are based on behavioural theory can be used to promote preventive messages. In the study, lack of knowledge and motivation is reported as a serious concern and barrier to adapting healthy living practices. Thus, regular reinforcement of messages using such innovative strategies is an important factor in preventing NCDs.

4.2. Implications

The school environment has the potential to impact NCD-related behavioural change in children and adolescents. Educational resources to advance health literacy in school-going students can encourage healthy eating and have long-term implications later in adulthood. Positive feedback from the participant of this study suggests that

interactive modules including short films and follow-up interactive activities can be effective in promoting a healthy lifestyle among children and adolescents in schools. Such programs may be further strengthened by involving parents to reinforce the health messages at the home and community level. Further evaluation (e.g. RCT) of the intervention using a representative sample can be useful to assess its effectiveness and up-scaling it further at the regional and national levels. Along with such interventions, there is a need to strengthen policies for fostering an enabling food environment in and around the school for the student of this age group to be motivated for being physically active and eat healthy food.

5. Conclusion

Evidence-based interventions are seen as best practices to promote the adoption of healthy lifestyles. However, there are few published prevention-oriented interventions and strategies that are based on behavioural theory and scientific evaluation. This study fills an important gap in the literature. The findings provide valuable insight into possible messages and strategies that can be used to promote preventive messages among children and adolescents in schools. These include the use and reinforcement of simple messages through intervention including informative short films and interactive activities as strategies to address the problem. Positive feedback from the target audience including school-going students suggests that interactive modules to promote healthy behaviours fill an unmet need and can be effective in improving the perception of NCDs in schools.

Ethics statement

The study was approved and supervised by the institutional ethics committee of the Public Health Foundation of India (TRC-IEC-355/17). Permission was also sought from the school principal of the schools. Written informed consent obtained from all teachers and parents of the children. Written informed assent was obtained from the participating children, giving them the right to refuse participation even if their parents had given consent.

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Data availability statement
The data presented in this study are available on request from the corresponding author.

Authors' contributions
MA, SOV, MW, AB, SB, and TR conceptualized the study design. MA, SOV, and TR led the implementation of the study. TR and SB collected and organized the data and wrote the manuscript. SOV, MW, MA, JM, and NT critically revised the manuscript for intellectual content. All authors approved the final manuscript.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. None to declare.

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Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2022.100262.

References

1. International Diabetes Federation . ninth ed. 2019. IDF Diabetes Atlas. https://www.diabetesatlas.org/en/resources [cited 2020]. Available from: [Google Scholar]
2. Dandona L., Dandona R., Kumar G.A., Shukla D.K., Paul V.K., Balakrishnan K., et al. Nations within a nation: variations in epidemiologi cal transition across the states of India, 1990–2016 in the Global Burden of Disease Study. Lancet. 2018;390(10111):2437– 2460. doi: 10.1016/S0140-6736(17)32804-0. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
3. The Lancet, India—a tale of one country, but stories of many states [Editorial] Lancet. 2018;390(10111):2413. doi: 10.1016/S0140-6736(17)32867-2. [PubMed] [CrossRef] [Google Scholar]
4. Gillani A.H., Islam A., Mohammad F., Hayat K., Atif N., Yang C., et al. Knowledge, attitudes and practices regarding diabetes in the general population: a cross-sectional study from Pakistan. Int. J. Environ. Res. Publ. Health. 2018;15(9):1906. Https://pubmed.ncbi.nlm.nih.gov/30200534 Available from: [PMC free article] [PubMed] [Google Scholar]
5 Misra A., Khurana L. The metabolic syndrome in South Asians: epidemiology, determinants, and prevention. Metab. Syndr. Relat. Disord. 2009;7(6):497–514. https://pubmed.ncbi.nlm.nih.gov/19900153 Available from: [PubMed] [Google Scholar]
6. Kelder S.H., Perry C.L., Klepp K.-I., Lytle L.L. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. Am. J. Publ. Health.1994;84(7):1121–1126. https://pubmed.ncbi.nlm.nih.gov/8017536 Available from: [PMC free article] [PubMed] [Google Scholar]
7. Singh A.S., Mulder C., Twisk J.W.R., Van Mechelen W., Chinapaw M.J.M.

Tracking 2008;9(5):474–488. https://pubmed.ncbi.nlm.nih.gov/18331423 Available from: [PubMed] [Google Scholar]

8. Whitaker R.C., Wright J.A., Pepe M.S., Seidel K.D., Dietz W.H. Predicting obesity in young adulthood from childhood and parental obesity. N. Engl. J. Med. 1997;337(13):869–873. https://www.nejm.org/doi/full/10.1056/nejm199709253371301 Available from: [PubMed] [Google Scholar]
9. Van Sluijs E.M.F., McMinn A.M., Griffin S.J. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. Br. Med. J. 2007;335(7622):703. doi:10.1136/bmj.39320.843947.BE. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
10. Flynn M.A.T., McNeil D.A., Maloff B., Mutasingwa D., Wu M., Ford C., et al. Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with 'best practice' rec ommendations. Obes. Rev. 2006;7(Suppl 1):7–66. doi: 10.1111/j.1467-789X.2006.00242.x. [PubMed] [CrossRef] [Google Scholar]
11. Kumar K.M.P. Incidence trends for childhood type 1 diabetes in India. Indian J. End. Metab. 2015;19(Suppl S1):34–35. https://www.ijem.in/text.asp?2015/19/7/34/155378 [PMC free article] [PubMed] [Google Scholar]
12. Gellar L.A., Schrader K., Nansel T.R. Healthy eating practices: perceptions, facilitators, and barriers among youth with diabetes. Diabetes Educat. 2007;33(4) :671–679. doi: 10.1177/0145721707303807. [PMC free article] [PubMed] [Cross Ref] [Google Scholar]
13. Chinnici D., Middlehurst A., Tandon N., Arora M., Belton A., Reis Franco D., et al. Improving the school experience of children with diabetes: evaluation of the KiDS project. J. Clin. Transl. Endocri nol. 2019;15:70–75. doi: 10.1016/j.jcte.2018.12.001.[PMC free article] [PubMed] [CrossRef] [Google Scholar]

14. Rawal T., Bhaumik S., Shrivastav R., Nazar G.P., Tandon N., Arora M. Health Educ J.; 2021. Kids and Diabetes in Schools (KiDS) Intervention in India: Participants' Perspectives. 00178969211005499. [CrossRef] [Google Scholar]
15. Sharifirad G., Hasan Entezari M., Kamran A., Azadbakht L. The effectiveness of nutritional education on the knowledge of diabetic patients using the Health Belief Model. J. Res. Med. Sci. 2009;14(1):1–6. [PMC free article] [PubMed] [Google Scholar]
16. Karimy M., Araban M., Zareban I., Taher M., Abedi A. Determinants of adherence to self-care behavior among women with type 2 diabetes: an explanation based on health belief model. Med. J. Islam. Repub. Iran. 2016;30:368. [PMC free article] [PubMed] [Google Scholar]
17. Arora M., Nazar G.P., Gupta V.K., Perry C.L., Reddy K.S., Stigler M.H. Association of breakfast intake with obesity, dietary and physical activity behavior among urban school-aged adolescents in Delhi, India: results of a cross-section al study. BMC Publ. Health. 2012;12(1):881. doi: 10.1186/1471-2458-12-881. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
18. James D.C.S., Pobee J.W., Brown L., Joshi G. Using the health belief model to develop culturally appropriate weight-management materials for African-American women. J. Acad. Nutr. Diet. 2012;112(5):664–670. doi: 10.1016/j.jand.2012.02.003. [PubMed] [CrossRef] [Google Scholar]19.
19. Bogale B., Mørkrid K., O'Donnell B., Ghanem B., Ward I.A., Khader K.A., et al. Development of a targeted client communication intervention to women using an electronic maternal and child health registry: a qualitative study. BMC Med. Inf. Decis. Making. 2020;20(1) doi: 10.1186/s12911-019-1002-x. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
20. Abdeyazdan Z., Moshgdar H., Golshiri P. Evaluating the effect of lifestyle

education based on health belief model for mothers of obese and over weight school-age children on obesity-related behaviors. Iran. J. Nurs. Midwifery Res. 2017;22(3):248–252. doi:10.4103/1735-9066.208163. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

21. Pujilestari C.U., Ng N., Hakimi M., Eriksson M. It is not possible for me to have diabetes" - community perceptions on diabetes and its risk factors in Rural Purworejo District, Central Java, Indonesia. Global J. Health Sci. 2014;6(5):204–218. https://pubmed.ncbi.nlm.nih.gov/25168994 Available from: [PMC free article] [PubMed] [Google Scholar]
22. Keshani P., Hossein Kaveh M., Faghih S., Salehi M. Improving diet quality among adolescents, using health belief model in a collaborative learning context: a randomized field trial study. Health Educ. Res.2019;34(3):279–288. https://pubmed.ncbi.nlm.nih.gov/30915431 Available from: [PubMed] [Google Scholar]
23. Kebbe M., Perez A., Buchholz A., McHugh T.-L.F., Scott S.S., Richard C., et al. Barriers and enablers for adopting lifestyle behavior changes in adolescents with obesity: a multi-centre, qualitative study. PLoS One. 2018;13(12) https://pubmed.ncbi.nlm.nih.gov/30562377 Avail able from: [PMC free article] [PubMed] [Google Scholar]
24. Turconi G., Guarcello M., Maccarini L., Cignoli F., Setti S., Bazzano R., et al. Eating habits and behaviors, physical activity, nutritional and food safety knowledge and beliefs in an adolescent Italian population. J. Am. Coll. Nutr. 2008;27(1):31–43. https://pubmed.ncbi.nlm.nih.gov/18460479 Available from: [PubMed] [Google Scholar]
25. Shah P., Misra A., Gupta N., Hazra D.K., Gupta R., Seth P., et al. Improve ment in nutrition-related knowledge and behaviour of urban Asian Indian school children: findings from the 'Medical education for children/Ado lescents for Realistic prevention of obesity and diabetes and for healthy aGe

ing' (MARG) intervention study. Br. J. Nutr. 2010;104(3):427–436. https://pubmed.ncbi.nlm.nih.gov/20370939 2010, Available from: [PubMed] [Google Scholar] https://pubmed.ncbi.nlm.nih.gov/20370939 2010, Available from: [PubMed] [Google Scholar]

26. Rimal R.N., Lapinski M.K. Why health communication is important in public health. Bull. World Health Organ. 2009;87(4) https://pubmed.ncbi.nlm.nih.gov/19551226 247-247a, Available from: [PMC free article] [PubMed] [Google Scholar]

CHAPTER 3

Prevalence of Excessive Weight and Underweight and Its Associated Knowledge and Lifestyle Behaviors among Urban Private School-Going Adolescents in New Delhi

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Abstract

With rapid urbanization and the Indian nutrition transition, Indian adolescents face a high risk of developing an energy imbalance. This study aims to assess the prevalence of excessive weight, underweight, and associated knowledge and lifestyle behaviors among private school-going adolescents in Delhi. A cross-sectional study was conducted in students (6th–7th grades) of eight randomly selected private schools in Delhi, India in 2019. A self-administered survey was used to assess students' dietary-and-physical-activity-related knowledge and behavior. Anthropometric measurements (height, weight, and waist circumference) were also conducted. Out of 1567 participants, 7.2% were underweight, 61.3% normal, and 31.5% excess in weight. Underweight was associated with significantly more eating whilst studying for exams (relative risk ratio (RRR) 1.7 (1.0–2.9)). Excessive weight was associated with less incorrect knowledge on behaviors causing overweight (RRR 0.7 (0.5–0.9)), more often reading nutritional labels of packed food items (RRR 0.6 (0.4–0.9)), and less frequent vegetable-intake (RRR 0.7 (0.4–0.9)). Underweight students showed more suboptimal knowledge and unhealthy behaviors, whilst students with excessive weight showed more correct knowledge and healthy behaviors. This study highlights the immediate need for effective health-promoting interventions focused on the importance of healthy lifestyle at least in underweight adolescents.

Keywords:
lifestyle behaviors, knowledge, body mass index, excessive weight, underweight, adolescents, India

1. Introduction

Globally, in both developed and developing nations, rates of overweight and obesity continue to rise [1]. Environmental factors and lifestyle choices including urbanization play major roles in the rising prevalence of obesity, are responsible for non-communicable diseases (NCDs) [2], and are largely a result of practices adopted during early ages. Energy imbalance resulting from the consumption of excess calories and

inadequate physical activity is considered to be the major factor responsible for obesity [3]. Overweight and obese adolescents often grow into obese adults, who in turn are at higher risk of developing one or more NCDs [4]. Developing countries are experiencing an increase in overweight and obesity among all economic classes and all regions while being more prevalent in urban rather than rural areas [5,6]. In recent years, India has been facing a paradoxical co-occurrence of under- and over-nutrition as undernutrition continues to persist and causing both conditions to co-exist [7]. Regional studies conducted in India also highlighted the co-occurrence of over- and undernutrition among school-going adolescents [8,9]. A systematic review reported the combined prevalence of childhood overweight and obesity in India of 19.3%, which is a significant increase from the earlier prevalence of 16.3% reported in 2001–2005 [10]. Adolescents are exposed to an obesogenic environment, created by rapid urbanization and the nutrition transition (i.e., changes in dietary pattern due to increased accessibility, availability, and consumption of food high in fat, salt, and sugar) in India. Data from the Comprehensive National Nutrition Survey (CNNS, 2019) reported that every second child is affected by some form of over- or undernutrition and 1 in 10 adolescents have glycosylated HbA1c (between 5.7–6.4%) indicating high blood glucose values, which may be due to glucose disorders such as diabetes [11].

Several risk behaviors during the early years of life appear to be strongly correlated with both being underweight and excessive weight [12]. Both underweight and excessive weight students showed significantly vulnerable risk behaviors including substance use, mental health issues including depression, and violent behaviors. Suicide attempts were reported as critical risks for excessive students [13]. Therefore, it is imperative to monitor healthy living practices at an early age. Daily fruit/vegetable consumption and sufficient physical activity levels are good preventive factors for both underweight and excessive weight [14].

In India, there is a knowledge–practice gap among adolescents about eating and physical activity behaviors [15]. The lack of knowledge about healthy and unhealthy behaviors highlights the importance of carrying out regular surveillance for NCD risk factors and initiating educational programs for the prevention of NCDs amongst

inadequate physical activity is considered to be the major factor responsible for obesity [3]. Overweight and obese adolescents often grow into obese adults, who in turn are at higher risk of developing one or more NCDs [4]. Developing countries are experiencing an increase in overweight and obesity among all economic classes and all regions while being more prevalent in urban rather than rural areas [5,6]. In recent years, India has been facing a paradoxical co-occurrence of under- and over-nutrition as undernutrition continues to persist and causing both conditions to co-exist [7]. Regional studies conducted in India also highlighted the co-occurrence of over- and undernutrition among school-going adolescents [8,9]. A systematic review reported the combined prevalence of childhood overweight and obesity in India of 19.3%, which is a significant increase from the earlier prevalence of 16.3% reported in 2001–2005 [10]. Adolescents are exposed to an obesogenic environment, created by rapid urbanization and the nutrition transition (i.e., changes in dietary pattern due to increased accessibility, availability, and consumption of food high in fat, salt, and sugar) in India. Data from the Comprehensive National Nutrition Survey (CNNS, 2019) reported that every second child is affected by some form of over- or undernutrition and 1 in 10 adolescents have glycosylated HbA1c (between 5.7–6.4%) indicating high blood glucose values, which may be due to glucose disorders such as diabetes [11].

Several risk behaviors during the early years of life appear to be strongly correlated with both being underweight and excessive weight [12]. Both underweight and excessive weight students showed significantly vulnerable risk behaviors including substance use, mental health issues including depression, and violent behaviors. Suicide attempts were reported as critical risks for excessive students [13]. Therefore, it is imperative to monitor healthy living practices at an early age. Daily fruit/vegetable consumption and sufficient physical activity levels are good preventive factors for both underweight and excessive weight [14].

In India, there is a knowledge–practice gap among adolescents about eating and physical activity behaviors [15]. The lack of knowledge about healthy and unhealthy behaviors highlights the importance of carrying out regular surveillance for NCD risk factors and initiating educational programs for the prevention of NCDs amongst

adolescents [16].

The primary aim of this article is to assess the prevalence of excessive weight and underweight and its associated knowledge and lifestyle behaviors among the urban private school-going adolescents (aged 11–12 years), in New Delhi. Secondly, we aim to study the correlates of BMI status (underweight, normal, excessive weight) with dietary and physical activity knowledge and behaviors among these participants.

2. Methodology

2.1. Study Design

This cross-sectional study was conducted in eight private schools of Delhi, India in 2019. Schools were randomly selected from the list of private schools governed by the Directorate of Education (DoE), Government of National Capital Territory (NCT) of Delhi. This study was limited to private schools in Delhi, as previous studies conducted in Delhi reported that the prevalence of excessive weight is significantly higher in private school students as compared to government school students [17].

2.2. Participants

Of the n = 1817 students enrolled in 6th and 7th grades (aged 11–12 years) in the eight participating schools, n = 1635 (89.9%) students participated in this study. As data on BMI were missing for n = 71 students, data from n = 1564 (95.8%) students were used for analysis.

2.3. Measures

A self-administered survey was implemented in all the grades in these schools by a trained study team (convened under the guidance of the Principal Investigator) using a standardized protocol. The confidentially of responses was assured by using a unique ID not recognizable to the students. The survey was administered in English. The survey was adopted from other instruments that have been validated with adolescents and were extensively pilot-tested in India [6,17]. The survey assessed di-

etary knowledge; behavior including frequency of consumption of breakfast, fruits, vegetables, sugar-sweetened beverages, and energy-dense foods; food purchasing behavior; physical activity behavior including frequency of participation in 60 min per day of PA; use of available resources for physical activity; and duration of screen time.

In addition to the survey, anthropometric measurements of students were conducted by a trained study team using a standardized protocol. Anthropometric measurements included height to the nearest 0.1 cm, weight to the nearest 100 g on an electronic scale, and waist circumference (WC). The WC was measured using a non-stretchable measuring tape, at a level midway between the lower rib margin and iliac crest with participants in standing position; the measurements were done to the nearest 0.1 cm. For all anthropometric data, the average of two readings for each student was used for analyses, using a protocol adapted to suit the Indian context [18]. For all anthropometric measurements, the students were asked to remove all excess clothing other than their regular school uniform, shoes, all items from pockets, watches, eyeglasses, belts, necklaces, and other jewelry.

Students were grouped into five weight categories using the World Health Organization (WHO) age- and gender-specific body mass index (BMI) growth references [19]. These groups were underweight (thin BMI below −2 standard deviations (SD) and severe thin below −3 SD in the WHO reference population), normal (between −2 SD and 1 SD), overweight (between 1 SD and 2 SD), and obese (more than 2 SD). However, it was further categorized into three categories: normal; underweight (thin and severe thin); and excessive weight (overweight and obese). Students whose WC values were more than age- and gender-specific 70th percentile cut-off using Indian reference values were categorized as high WC [20].

2.4. Data Analysis

The descriptive analysis is presented using percentages and frequencies. Further, the potential correlates were assessed using exploratory data analysis. The dependent variable (BMI) was taken as a categorical variable with the categories underweight,

normal, and excessive weight (based on World Health Organization (WHO) age- and gender-specific BMI growth references [19]). The socio-demographic variables, knowledge, dietary, and behavior factors were taken as independent variables. Related questions (dietary knowledge (3) and behavior (9); physical activity-related knowledge (1) and behavior (3)) are provided in the supplementary file (Supplementary Table S1) Cross tabulations, using Fisher's exact/Chi-square were used to study bivariate associations between independent variables and BMI category. Where in the univariate analysis the associations were found to be significant, Tukey's posthoc test was used to further study the differences between the specific BMI categories. Variables found to be significantly associated ($p < 0.05$) with the different categories of BMI (underweight, normal, and excessive weight) in the univariate analysis were included in the regression analysis as independent variables to assess the potential correlates with the BMI category. Since the dependent variable BMI had three categories, a multinomial regression analysis model was used to study the correlates of respective BMI categories (underweight and excessive weight), where normal weight was taken as a reference. All the estimates with p-values ≤ 0.05 were considered significant. All data analyses were conducted using STATA v.13 (StataCorp, LP, College Station, TX, USA).

3. Results

3.1. Socio-Demographic Characteristics

Table 1 shows the descriptive statistics for socio-demographic variables and prevalence of under and excessive weight in the study sample. Overall, 1564 school-going adolescents participated in this study, of which 969 (61.9%) were boys and 595 (38.1%) were girls. In the sample, 7.2% of the students were underweight, 61.3% normal weight, and 31.5% were excess in weight. Around 17% of all adolescents had an unhealthy or increased WC as per their age. Socio-demographic variables were not different between participants of different weight categories, except for the father's education, which was slightly lower for underweight students ($p = 0.016$) (see Supplementary file Table S2).

Table 1 Socio-demographic variables of the study population.

Gender	**n = 1564(%)**
Boys	969 (61.9)
Girls	595 (38.1)
Age in years (SD)	12.5 (1.5)
Class 6	815 (52.1)
Class 7	749 (47.9)
WC based on age	
Increased WC in boys (n = 969)	165 (17.1)
Increased WC in girls (n = 595)	99 (16.6)
Mean BMI (SD) in kg/m2	18.9 (3.8)
BMI category	
Underweight (severe thin + thin) in n (%)	113 (7.2)
-Thin (n)	86
-Severe thin (n)	27
Normal in n (%)	959 (61.3)
Excessive weight (overweight + obese) in n (%)	492 (31.5)
-Overweight (n)	307
-Obese (n)	185

Abbreviations: SD—standard deviation, WC—waist circumference, BMI—body mass index.

3.2. Associations of Knowledge of Diet and Physical Activity with BMI Status

The percentage of students having the correct knowledge on healthy dietary and physical activity behaviors ranged between 27.8% and 76.3%. Three out of four knowledge variables differed significantly between groups (Figure 1). Participants with underweight had more often incorrect knowledge on diet and physical activity compared to normal weight students, as they had less knowledge on the recommended PA levels (37.8% vs. 47.3%, p = 0.003), and believed less often that ‘overweight or underweight students have more health problems’ (62.4% vs. 76.3% p = 0.004). Excessive weight students on the other hand, had more often correct knowledge on

'watching TV while eating might lead to overweight' (46.4% vs. 38.3%, p = 0.002). When comparing excessive weight with underweight students, excessive weight students had significantly more correct knowledge on three out of four knowledge variables. There were no significant associations in the physical activity behavior and BMI of the adolescents (p > 0.05).

Three out of nine dietary behaviors differed significantly between groups: daily vegetable intake (p = 0.015), eating more whilst studying for exams (p = 0.000), and studying nutrition labels on food packs (p = 0.002) (Table 2). Underweight participants reported eating more while studying for exams compared to normal-weight students (66.1 vs. 50.7%, p = 0.008). Excessive weight students showed healthier behaviors compared to normal weight students, as they less often reported they ate more while studying for exams (p = 0.05), and more often read nutritional labels of packaged food while purchasing them (p = 0.008).

3.3. Correlates of Excessive Weight and Underweight

In Table 3, further regression analyses are reported to identify the correlates of excessive weight and underweight. A total of 1198 observations could be included, as there were missing data in some of the independent variables. Most of the patterns observed in the univariate analyses were confirmed in the regression analyses. Students with mothers having senior secondary schooling were more likely to be underweight as compared to those with a professional degree (relative risk ratio (RRR) 2.6 (1.1–6.2)). Additionally, students with unhealthier eating behavior whilst studying for exams were more likely to be underweight as compared to those with healthier eating habits (RRR 1.7 (1.1–2.7)).

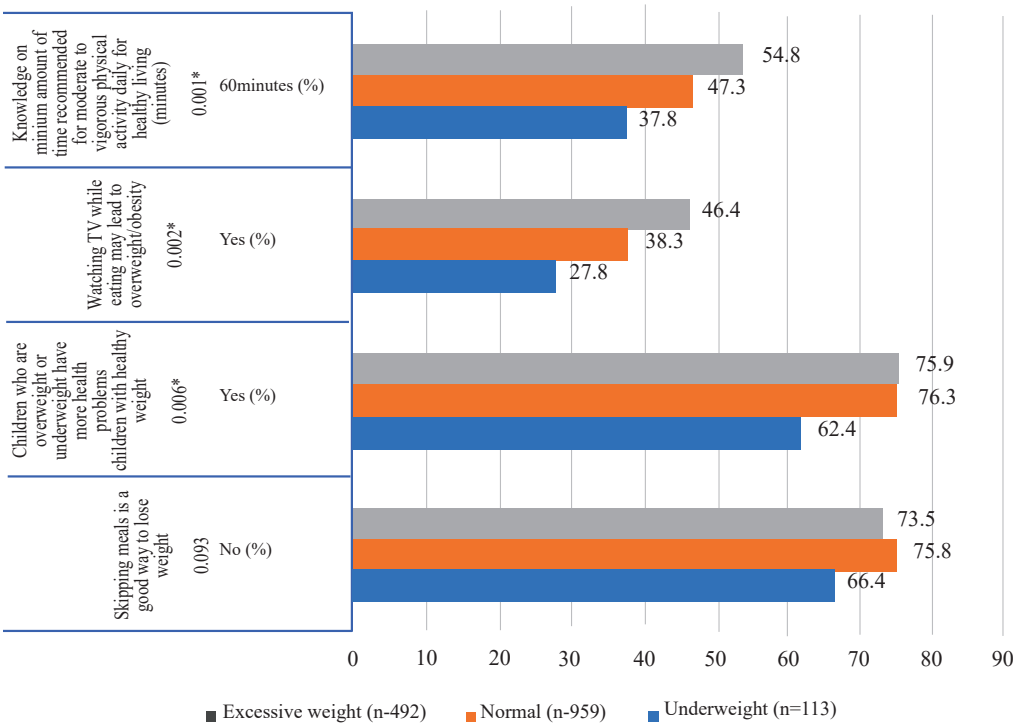

Figure 1 Univariate association of knowledge related to diet and physical activity and dietary behavior with BMI status of adolescence (* p values using Fisher's Chi square *) * Correct responses are presented. Tukey's post hoc test revealed that correct knowledge on the minimum amount of recommended moderate to vigorous physical activity was significantly lower in underweight vs. normal weight students (p = 0.003) and significantly higher in excessive weight vs. underweight students (p = 0.000); Correct knowledge on watching TV while eating may lead to overweight/obesity was significantly lower in normal vs. excessive weight students (p = 0.01) and underweight vs. excessive weight (p = 0.001); correct knowledge on health problems as a result of overweight was significantly lower for underweight vs. normal weight (p = 0.004) and underweight vs. excessive weight (0.009). See also Supplementary Table S2.

Table 2. Univariate associations of dietary and physical activity behaviors with BMI status of adolescents.

Dietary Behaviours	Answer Options	Underweight (n = 113) N(%)	Normal (n = 959) N(%)	Normal (n = 959) N(%)	p-Value
Daily vegetable intake	Never (135)	14 (12.7)	80 (8.9)	41 (8.7)	**0.015 ***
	Once a day (273)	24 (21.8)	151 (16.9)	98 (20.9)	
	At least twice a day (434)	23 (20.9)	294 (32.8)	117 (24.9)	
	At least thrice a day (634)	49 (44.6)	371 (41.4)	214 (45.5)	
Fast/junk food (e.g., burgers, pizza, noodles etc.) intake frequency	**Never (267)**	15 (5.6)	162 (60.7)	90 (33.7)	0.142
	1–2 times/week (420)	29 (25.7)	271 (29.1)	120 (24.9)	
	3–6 times/week (627)	52 (46.0)	360 (38.6)	215 (44.6)	
	≥7 times/week (214)	17 (15.0)	140 (15.01)	57 (11.8)	
Eating breakfast	Never (81)	5 (4.5)	41 (4.4)	35 (7.3)	0.199
	Few times in a week (287)	22 (19.6)	173 (18.5)	92 (19.2)	
	Every day (1160)	85 (75.9)	723 (77.2)	352 (73.5)	
Eat more when out with friends	**No (600)**	36 (33.0)	362 (40.7)	202 (44.4)	0.082
	Yes (853)	73 (66.9)	527 (59.3)	253 (55.6)	
Eat more when out with family	**No (271)**	17 (16.0)	155 (17.3)	99 (21.3)	0.153
	Yes (1195)	89 (84.0)	741 (82.7)	365 (78.7)	
Eat more while studying for exams	**No (724)**	36 (33.9)	433 (49.3)	255 (56.0)	**0.000 ***
	Yes (715)	70 (66.1)	445 (50.7)	200 (44.0)	
Eat more while studying for exams	**No (578)**	35 (35.4)	343 (39.1)	200 (45.2)	0.052
	Yes (841)	64 (64.7)	535 (60.9)	242 (54.8)	
Eat more when angry	**No (946)**	63 (61.8)	566 (64.4)	317 (70.3)	0.063
	Yes (486)	39 (38.2)	313 (35.6)	134 (29.7)	
Reading nutritional labels on food packs before purchasing them	Never (197)	17 (15.3)	127 (13.7)	53 (11.1)	**0.002 ***
	Rarely (269)	17 (15.3)	179 (19.2)	73 (15.1)	
	Sometimes (617)	58 (52.3)	371 (38.9)	188 (39.3)	
	Most of times (437)	19 (17.1)	253 (27.2)	165 (34.5)	
Apart from eating activities done during lunch break	Sat down and chat withfriends (508)	35 (35.4)	302 (33.6)	156 (34.1)	0.28
	Stood or walked around	16 (16.2)	162 (18.0)	93 (20.3)	
	Played active games (595)	37 (37.4)	360 (40.0)	173 (37.8)	
	Completed homework(95)	11 (11.0)	49 (5.5)	25 (5.5)	
	Others (40)	0	26 (2.9)	11 (2.4)	
Apart from eating activities done during lunch break	Every day (61)	2 (1.9)	44 (4.8)	15 (3.2)	0.35
	1–2 days (533)	29 (28.7)	333 (36.4)	171 (36.9)	
	3–4 days (234)	19 (18.8)	145 (15.8)	70 (15.1)	
	5–6 days (400)	27 (26.8)	241 (26.3)	132 (28.5)	
	Never (252)	24 (23.8)	153 (16.7)	75 (16.3)	
Duration of vigorous physical activity on a typical day	30 min–1 h (1123)	75 (70.1)	662 (72.9)	339 (72.3)	0.37
	2–3 h (235)	15 (14.0)	138 (15.2)	73 (15.6)	
	≥4 h (44)	1 (0.9)	22 (2.4)	17 (3.6)	
	Never (147)	16 (15.0)	86 (9.5)	40 (8.5)	

Preferred behaviors are expressed in bold. * Tukey's HSD test revealed that the average daily vegetable intake did not differ significantly among any of the three weight categories; reading nutritional labels of packaged food while purchasing was significantly more frequently done in excessive weight vs. normal ($p = 0.01$) and excessive weight vs. underweight ($p = 0.03$); eating more whilst studying during exams was significantly lowest in excessive weight students (excessive vs. normal weight ($p = 0.05$), excessive vs. underweight students ($p = 0.00$), and highest amongst underweight students (underweight vs. normal weight ($p = 0.008$). See also Supplementary Table S3.

Table 3. Correlates of excessive weight and underweight (relative to normal weight) for dietary and PA knowledge and dietary behaviors.

Base Outcome	Underweight RRR, (95% CI)	Excessive Weight RRR, (95% CI)
Education of mother		
Advanced professional degree (e.g., post-graduation, Ph.D., etc.)	Ref	Ref
Graduate	1.3 (0.6–2.9)	0.8 (0.6–1.2)
Up to senior secondary	2.6 (1.1–6.2)	0.9 (0.6–1.4)
Up to middle school	2.0 (0.7–5.6)	1.2 (0.7–2.0)
No formal schooling	1.8 (0.5–6.5)	0.7 (0.3–1.6)
Education of father		
Advanced professional degree (e.g., post-graduation, Ph.D., etc.)	Ref	Ref
Graduate	1.1 (0.6–1.9)	1.2 (0.9–1.7)
Up to senior secondary	0.7 (0.3–1.4)	0.6 (0.4–1.0)
Up to middle school	1.0 (0.4–2.4)	0.8 (0.5–1.4)
No formal schooling	0.3 (0.0–3.3)	0.8 (0.3–2.7)
Knowledge: Children who are overweight or underweight have more health problems than children with a healthy weight		
-Yes	Ref	Ref
-No	1.6 (0.9–2.6)	1.06 (0.8–1.5)
Knowledge: Watching TV while eating may lead to overweight/obesity		
-Yes	Ref	Ref
-No	1.5 (0.9–2.5)	0.7 (0.5–0.9)

Knowledge: Minimum amount of time recommended for moderate to vigorous physical activity daily for healthy living (minutes)			
	<60 min	Ref	Ref
	>60 min	0.7 (0.4–1.1)	1.3 (0.9–1.6)
Behavior: Read the nutritional labels of packed food items while purchasing them			
	Most of times	Ref	Ref
	Sometimes	1.7 (0.9–3.2)	0.9 (0.6–1.2)
	Rarely	0.9 (0.5–2.1)	0.6 (0.4–0.9)
	Never	1.5 (0.7–3.1)	0.7 (0.4–1.1)
Behaviour: Daily vegetable intake frequency			
	Once a day	Ref	Ref
	At least twice a day	0.6 (0.3–1.2)	0.7 (0.4–0.9)
	At least thrice a day	0.8 (0.4–1.5)	0.9 (0.7–1.3)
	Never	1.0 (0.4–2.2)	0.9 (0.5–1.5)
Behaviour: Eat more while studying for exams			
	No	Ref	Ref
	Yes	1.7 (1.1–2.7)	0.8 (0.6–1.0)

RRR: Relative risk ratio. Estimates derived using multinomial logistic regression taking normal weight as the reference category, the total included observations = 1163. p values less than 0.05 in the univariate associations were included in the regression analysis models. The bold estimates mean statistically significant differences compared to normal weight $p < 0.05$.

Students who had correct knowledge about the relation between watching TV while eating and overweight/obesity were less likely to be excessive in weight (RRR 0.7 (0.5–0.9)). Moreover, students with unhealthier eating behaviors whilst studying for exams were less likely to be excessive in weight as compared to those with healthier eating habits 0.8 (0.6–1.0). Students reading nutritional labels of packed food items were less likely to be excessive in weight (RRR for answer option rarely vs. most of the times 0.6 (0.4–0.9). Contrastingly, adolescents who consumed vegetables frequently (at least twice a day) were less likely to be excessive (RRR twice a day vs. once a day 0.7 (0.4–0.9)).

4. Discussion

The findings of this study show that 7.2% of the students were underweight, 61.3% normal weight, and 31.5% were excess in weight. The results highlighted that underweight students showed unhealthier dietary behaviors. Students who were eating more while studying for exams or having vegetable intake twice a day were less likely to be excessive in weight. However, there was no significant association between physical activity and weight of students. The percentage of students with excessive weight was alarmingly high, with 18.8% being overweight and 11.3% obese. The results of a study conducted in 2018 among Indian private school participants reported the percentage of overweight and obese students to be much lower with 13.2% overweight and 8.7% obese [6]. A systematic review conducted in 2016 reported the combined prevalence of overweight and obesity among children and adolescents in India as 19.3% [10]. In another recent study, the prevalence of overweight and obesity among school-going adolescents was found to be 9.9% and 14.0%, respectively [21]. The difference in the prevalence may be due to the regional difference between the states of India. However, it is most likely that currently, there is an increase in the prevalence of excess weight due to rapid economic and social transition which results in the nutrition transition, i.e., replacing traditional and healthier meals with fast food consumption including excess calories and food high in saturated and trans fats and sugar, and excessive use of technology leading to sedentary behavior. A systematic review also provides evidence for an overweight/obesity transition in school-aged children in Sub-Saharan Africa [22]. Another study conducted to understand the factors contributing to obesity in the early years in Latin America revealed that changes in socioeconomic conditions and urbanization have been the major contributors to the increasing prevalence in the region [23]. The COVID-19 crisis has led to even more unhealthy behaviors and a higher prevalence of overweight and obesity amongst adolescents, emphasizing the need to invest in effective interventions to prevent obesity starting at a young age [24]. Recently, a study conducted with adolescents during a lockdown period in Greece suggested prioritizing measures to increase physical activity, decrease sedentariness, and improve eating behavior for better well-being [25]. Findings of a systematic review emphasized the risk of ele-

vated stress among this age group and the need to develop strategies to support families to cope with the current pandemic situation and ensure their children's healthy development [26].

The present study emphasized that roughly 1/3 of participants have incorrect knowledge on very basic nutrition and physical activity-related behaviors, e.g., recommended physical activity guidelines. Other regional studies have also highlighted poor knowledge related to diet and exercise among school-going Indian adolescents [15,27]. In addition to the low knowledge levels, it was seen in all weight categories that dietary behaviors were mostly unhealthy. For example, more than half of all participants, irrespective of their BMI status, mentioned that they eat junk food multiple times a week. Findings of a study conducted with a sample of students from Central Michigan University also highlighted the need to improve physical activity, students' knowledge of healthy and unhealthy diet habits, and nutritional knowledge [28].

Findings of this study reported that underweight students have slightly less knowledge on healthy behaviors and show slightly more behaviors that are unhealthy. Students with excessive weight, on the other hand, have the more correct knowledge on healthy behaviors, and also show healthier behaviors compared to normal weight students. This finding might be explained by either higher self-awareness of their weight and/or a family history of obesity in excessive weight students [29], resulting in a higher eagerness to learn about healthy behaviors and weight implications. Possibly, excessive weight students are more involved in dieting and/or exercise regimes, explaining their higher levels of knowledge and healthier behaviors. What is also a possibility is that due to weight stigmatization and body shaming, excessive weight students tend to answer the behavior questions with more socially desirable answers [30]. Body dissatisfaction among adolescents is also a major reason for unhealthy behaviors among both categories, excessive weight and underweight [31].

Our results corroborate and extend the findings from previous studies in India [32,33] and emphasize the need for immediate attention to curb the increasing prevalence of excessive weight among school-going adolescents. The increased availability, af-

fordability, and accessibility to ready-to-eat food items including processed and energy-dense foods among adolescents living in urban areas result in almost all students showing high-risk factors of developing an imbalance in caloric intake. Decrease in physical activity and reduced energy expenditure along with television viewing and other sedentary behavior may also be significant factors that contribute to excessive weight in this age group [34]. Moreover, other studies show that the trend is more prevalent among families living in urban areas due to the easy availability and approachability of computer and mobile phone-based games and use the car or motor-bikes instead of walking or using a bicycle [30]. However, the findings of MyHeART (Malaysian Health and Adolescents longitudinal Research Team) study revealed that adolescents from rural areas are at higher risk of NCDs compared to their urban counterparts [35].

Risk factors for unhealthy behaviors including dietary and physical activity behavior are established in the early years of life [36]. Therefore, primordial prevention strategies must begin at a young age and continue into adolescence and preferably include all environments to which children are exposed. During adolescence, development and social changes take place which likely influence the dietary and physical activity patterns, including parent and peer influences, home and school food environments, and mass media [37]. As in adolescence, the immediate social group influence rises, schools might act as a facilitator and provide support by creating an enabling environment for healthy daily habits.

The strengths of this study include that schools were randomly selected, and anthropometrics were measures objectively. The sample size was big with over 1500 participants and the response rate was high with 89.9% of all eligible participants in schools participating in the study. Hence, the study findings are representative of urban school-going adolescents in private schools of Delhi and can be extrapolated to other urban areas in India. A limitation of this study is that it is restricted to one metropolitan city of India and responses to the questionnaire were self-reported. The findings may not be representative of rural areas, yet the large sample size makes the findings robust. Although knowledge is an important determinant for behavior

change, sufficient knowledge alone is often not enough to change behavior in daily life. This is also reflected by our findings, as knowledge on healthy behaviors was highest amongst excessive weight students; however, this was not always reflected in actual healthy dietary behaviors. Several other important determinants of behavior change were not included in this study, such as attitudes, self-efficacy, and skills to adhere to behaviors following the social cognitive theory [38]. In future studies, we recommend including more determinants of health behavior following a well-established behavior change theory, as this provides more opportunities to design effective dietary and physical activity interventions [39].

5. Implications

Policymakers must recognize that children and adolescents who consume unhealthy diets and follow unfavorable lifestyle behaviors may have long-term health effects including unhealthy weight, which may lead to chronic conditions later in life. This study emphasizes that knowledge and lifestyle behaviors are suboptimal among adolescents in urban settings and leading to either being underweight or excess in weight. Knowledge and behaviors associated with diet and physical activity are vital for weight management. Therefore, there is a need for effective interventions to battle this unhealthy lifestyle epidemic, such as contextual comprehensive school and community-based targeted interventions. Policies focused on the availability, accessibility, and affordability of healthy food options in and around schools need to be enforced and monitored regularly. Moreover, to foster a supportive environment to improve dietary and physical activity knowledge and behavior, there is a need to limit advertising around unhealthy food products and promote easy to comprehend nutritional labeling for all to understand and practice healthy eating choices. Policies around fostering an enabling environment in and around school need to be created for the student of this age group to be motivated for being physically active. This study also highlights the need for larger studies to assess the prevalence of excessive weight and underweight among this age group regularly to revisit the kind of intervention needed in the future. At the same time, we should continue studying influential determinants and effective multi-factorial strategies for reducing overweight

and obesity, to battle the steep increase in excessive weight amongst urban Indian adolescents.

6. Conclusions

The current study emphasized the co-occurrence of excessive weight and underweight amongst urban adolescents in India, and knowledge and behaviors on dietary and physical activity behaviors are often suboptimal in the entire population. Underweight students have slightly more often suboptimal knowledge and show unhealthier behaviors, whilst students with excessive weight have the more correct knowledge on healthy behaviors and also show healthier behaviors. Future studies should employ comprehensive theory-based interventions that target both underweight and excessive weight among adolescents and promote their overall well-being. Determining the prevalence and understanding the factors related to excessive weight and underweight among adolescents are vital for creating an enabling environment for them to foster healthy living practices. This study highlights the need for the stakeholders to reinforce the importance of a healthy lifestyle at home and school especially during the early years of life when lifestyle habits are being etched.

Supplementary Materials

The following are available online at https://www.mdpi.com/article/10.3390/nu13093296/s1 Table S1: Description of independent variables, Table S2: Differences in socio-demographic factors between overweight/obese adolescents and normal/underweight adolescents, Table S3: Tukey Post hoc tests for group differences in behavior and knowledge variables

Author Contributions

C.P.v.S., M.W., M.A. and T.R. conceptualized the study design and guided the implementation of the study. T.R. collected and organized data, and wrote the manuscript. G.P.N. and N.S. supported the analysis of the data with T.R. under the guidance of C.P.v.S., M.W.; C.P.v.S., M.W., M.A., G.P.N. and N.T. revised the manuscript critically for intellectual contents. All authors have read and agreed to the published

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Institutional Review Board Statement
Ethical clearance for the trial was obtained from the Public Health Foundation of India Institutional Ethics Committee (PHFI IEC) (TRC-IEC 407/19; 19/10, 2020).

Informed Consent Statement
Informed consent was obtained from the school and parents of students participating in the study, and a separate informed assent was obtained from students.

Data Availability Statement
The data presented in this study are available on request from the corresponding author.

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Conflicts of Interest
The authors declare no conflict of interest.

References

1. WHO Obesity and Overweight. [(accessed on 13 July 2021)]. Available on line: https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-over weight
2. Praveen P.A., Tandon N. Childhood obesity and type 2 diabetes in India. WHO South-East Asia J. Public Health. 2016;5:17. [PubMed] [Google Scholar]
3. Seth A., Sharma R. Childhood obesity. Indian J. Pediatrics. 2013;80:309–317. doi: 10.1007/s12098-012-0931-5. [PubMed] [CrossRef] [Google Scholar]
4. WHO Noncommunicable Diseases. [(accessed on 13 July 2021)]. Available online: http://www.who.int/mediacentre/factsheets/fs355/en/
5. Watkins D., Hale J., Hutchinson B., Kataria I., Kontis V., Nugent R. Invest ing in non-communicable disease risk factor control among adolescents worldwide: A modelling study. BMJ Glob. Health. 2019;4:e001335. doi: 10.1136/bmjgh-2018-001335. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
6. Arora M., Mathur C., Rawal T., Bassi S., Lakshmy R., Nazar G., Gupta V., Park M., Kinra S. Socioeconomic differences in prevalence of biochem ical, physiological, and metabolic risk factors for non-communicable diseases among urban youth in Delhi, India. Prev. Med. Rep. 2018;12:33–39. doi: 10.1016/j.pmedr.2018.08.006. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
7. Gopalan C. The changing nutrition scenario. Indian J. Med. Res. 2013;138:392. [PMC free article] [PubMed] [Google Scholar]
8. Verma M., Sharma P., Khanna P., Srivastava R., Sahoo S.S. Nutrition Status of School Children in Punjab, India: Findings from School Health Surveys. J. Trop. Pediatrics. 2021;67:fmaa068. doi: 10.1093/tropej/fmaa068. [PubMed] [CrossRef] [Google Scholar]
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. Trop. Dr.

2017;47:212–216. doi: 10.1177/0049475516668985. [PubMed] [CrossRef] [Google Scholar]
10. Ranjani H., Mehreen T., Pradeepa R., Anjana R.M., Garg R., Anand K., Mohan V. Epidemiology of childhood overweight & obesity in India: A systematic review. Indian J. Med. Res. 2016;143:160. [PMC free article] [PubMed] [Google Scholar]
11. Ministry of Health and Family Welfare (MoHFW) Government of India. UNICEF. Population Council . Comprehensive National Nutrition Sur vey (CNNS) Government of India; New Delhi, India: [(accessed on 13 July 2021)]. Available online: https://www.popcouncil.org/uploads/pdfs/2019RH_CNNSreport.pdf [Google Scholar]
12. Mistry S.K., Puthussery S. Risk factors of overweight and obesity in child hood and adolescence in South Asian countries: A systematic review of the evidence. Public Health. 2015;129:200–209. doi: 10.1016/j.puhe.2014.12.004. [PubMed] [CrossRef] [Google Scholar]
13. Yen Y., Shi Y., Soeung B., Seng R., Dy C., Suy R., Ngin K. The associated risk factors for underweight and overweight high school students in Cambodia. Diabetes Metab. Syndr. Clin. Res. Rev. 2018;12:737–742. doi: 10.1016/j.dsx.2018.04.016. [PubMed] [CrossRef] [Google Scholar]
14. Guthold R., Stevens G.A., Riley L.M., Bull F.C. Global trends in insuffi cient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. Lancet Child. Adolesc. Health. 2020;4:23–35. doi: 10.1016/S2352-4642(19)30323-2. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
15. Kumar S., Ray S., Roy D., Ganguly K., Dutta S., Mahapatra T., Mahapatra S., Gupta K., Chakraborty K., Das M.K. Exercise and eating habits among urban adolescents: A cross-sectional study in Kolkata, India. BMC Public Health. 2017;17:1–14. doi: 10.1186/s12889-017-4390-9. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
16. Kleinert S., Horton R. Adolescent health and wellbeing: A key to a sustain able future. Lancet. 2016;387:2355–2356. doi: 10.1016/S0140-6736(16)30297-5. [PubMed] [CrossRef] [Google Scholar]

17. Arora M., Nazar G.P., Gupta V.K., Perry C.L., Reddy K.S., Stigler M.H. Association of breakfast intake with obesity, dietary and physical activity behavior among urban school-aged adolescents in Delhi, India: Results of a cross-sectional study. BMC Public Health. 2012;12:881. doi: 10.1186/1471-2458-12-881. [PMC free article] [PubMed][CrossRef] [Google Scholar]
18. Lohman T.G., Roche A.F., Martorell R. Anthropometric Standardization Reference Manual. Human Kinetics Books; Champaign, IL, USA: 1988. [Google Scholar]
19. Onis M.d., Onyango A.W., Borghi E., Siyam A., Nishida C., Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull. World Health Organ. 2007;85:660–667. doi: 10.2471/BLT.07.043497. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
20. Khadilkar A., Ekbote V., Chiplonkar S., Khadilkar V., Kajale N., Kulkarni S., Parthasarathy L., Arya A., Bhattacharya A., Agarwal S. Waist circumference percentiles in 2–18 year old Indian children. J. Pediatrics. 2014;164:1358–1362.e2. doi: 10.1016/j.jpeds.2014.02.018. [PubMed] [CrossRef] [Google Scholar]
21. Singh D.P., Arya A., Kondepudi K.K., Bishnoi M., Boparai R.K. Prevalence and associated factors of overweight/obesity among school going children in Chandigarh, India. Child. Care Health Dev. 2020;46:571–575. doi: 10.1111/cch.12794. [PubMed] [CrossRef] [Google Scholar]
22. Muthuri S.K., Francis C.E., Wachira L.-J.M., LeBlanc A.G., Sampson M., Onywera V.O., Tremblay M.S. Evidence of an overweight/obesity transition among school-aged children and youth in Sub-Saharan Africa: A systematic review. PLoS ONE. 2014;9:e92846. doi: 10.1371/journal.pone.0092846. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
23. Corvalán C., Garmendia M., Jones-Smith J., Lutter C., Miranda J., Pedraza L., Popkin B., Ramirez-Zea M., Salvo D., Stein A. Nutrition status of children in Latin America. Obes. Rev. 2017;18:7–18. doi: 10.1111/obr.12571. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
24. Ammar A., Brach M., Trabelsi K., Chtourou H., Boukhris O., Masmoudi L.,Bouaziz B., Bentlage E., How D., Ahmed M., et al. Effects of COVID-19

Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. Nutrients.2020, 12, 1583. [Google Scholar] [CrossRef] [PubMed] [CrossRef] [Google Scholar]

25. Morres I.D., Galanis E., Hatzigeorgiadis A., Androutsos O., Theodorakis Y. Physical Activity, Sedentariness, Eating Behaviour and Well-Being during a COVID-19 Lockdown Period in Greek Adolescents. Nutrients. 2021;13:1449. doi: 10.3390/nu13051449. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
26. Araújo L.A.d., Veloso C.F., Souza M.d.C., Azevedo J.M.C.d., Tarro G. The potential impact of the COVID-19 pandemic on child growth and development: A systematic review. J. Pediatr. 2021;97:369–377. doi: 10.1016/j.jped.2020.08.008. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
27. Shah P., Misra A., Gupta N., Hazra D.K., Gupta R., Seth P., Agarwal A., Gupta A.K., Jain A., Kulshreshta A. Improvement in nutrition-related knowledge and behaviour of urban Asian Indian school children: Findings from the 'Medical education for children/Adolescents for Realistic prevention of obesity and diabetes and for healthy aGeing'(MARG) inter vention study. Br. J. Nutr. 2010;104:427–436. doi: 10.1017/S0007114510000681. [PubMed] [CrossRef] [Google Scholar]
28. Yahia N., Wang D., Rapley M., Dey R. Assessment of weight status, dietary habits and beliefs, physical activity, and nutritional knowledge among university students. Perspect. Public Health. 2016;136:231–244. doi: 10.1177/1757913915609945. [PubMed] [CrossRef] [Google Scholar]
29. Shaji G., Joseph N.C., Mathu A., Joshy V. A study to assess the knowledge and attitude of adolescents towards obesity in a private school in Thrissur district Kerala, India. Int. J. Community Med. Public Health. 2019;6:3140–3144. doi: 10.18203/2394-6040.ijcmph20192864. [CrossRef] [Google Scholar]
30. Nurwanti E., Hadi H., Chang J.S., Chao J.C., Paramashanti B.A., Gittelsohn

J., Bai C.H. Rural-Urban Differences in Dietary Behavior and Obesity: Results of the Riskesdas Study in 10–18-Year-Old Indonesian Children and Adolescents. Nutrients. 2019;11:2813. doi: 10.3390/nu11112813. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

31. Escrivá D., Moreno-Latorre E., Caplliure-Llopis J., Benet I., Barrios C. Relationship of Overweight and Obesity with Body Self-Image Dissatis faction in Urban Mediterranean Adolescents. Int. J. Environ. Res. Public Health. 2021;18:7770. doi: 10.3390/ijerph18157770. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
32. Rani M.A., Sathiyasekaran B. Behavioural determinants for obesity: A cross-sectional study among urban adolescents in India. J. Prev. Med. Public Health. 2013;46:192. doi: 10.3961/jpmph.2013.46.4.192. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
33. Rathi N., Riddell L., Worsley A. Food consumption patterns of adolescents aged 14–16 years in Kolkata, India. Nutr. J. 2017;16:1–12. doi: 10.1186/s12937-017-0272-3. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
34. Kuriyan R., Bhat S., Thomas T., Vaz M., Kurpad A.V. Television viewing and sleep are associated with overweight among urban and semi-urban South Indian children. Nutr. J. 2007;6:1–4. doi: 10.1186/1475-2891-6-25. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
35. Hazreen M.A., Su T.T., Jalaludin M.Y., Dahlui M., Chinna K., Ismail M., Murray L., Cantwell M., Al Sadat N. An exploratory study on risk factors for chronic non-communicable diseases among adolescents in Malaysia: Overview of the Malaysian Health and Adolescents Longitudinal Research Team study (The MyHeART study) BMC Public Health. 2014;14:1–10. doi: 10.1186/1471-2458-14-S3-S6. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
36. Lanigan J. Prevention of overweight and obesity in early life. Proc. Nutr Soc. 2018;77:247–256. doi: 10.1017/S0029665118000411. [PubMed] [CrossRef] [Google Scholar]
37. Rathi N., Riddell L., Worsley A. What influences urban Indian secondary

school students' food consumption?—A qualitative study. Appetite. 2016;105:790–797. doi: 10.1016/j.appet.2016.07.018. [PubMed] [CrossRef] [Google Scholar]

38. Jemmott J.B., III, Zhang J., Jemmott L.S., Icard L.D., Ngwane Z., Makiwane M., O'Leary A. Intervention increases physical activity and healthful diet among South African adolescents over 54 months: A randomized controlled trial. J. Adolesc. Health. 2019;65:139–146. doi: 10.1016/j.jadohealth.2019.01.027. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

39. Finck Barboza C., Monteiro S.M., Barradas S.C., Sarmiento O.L., Rios P., Ramirez A., Mahecha M.P., Pratt M. Physical activity, nutrition and behavior change in Latin America: A systematic review. Glob. Health Promot. 2013;20:65–81. doi: 10.1177/1757975913502240. [PubMed] [CrossRef] [Google Scholar]

CHAPTER 4

Impact of the COVID-19 Pandemic Measures on the Number of Meals and the Types of Physical Activity of Adolescents: Cross-Sectional Study in Delhi, India

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Abstract

COVID-19 greatly affected the lives of adolescents through restrictions such as less playtime, more screen time, and limited interaction with peers. In this study, we assessed the impact of the COVID-19 pandemic on the dietary and physical activity-related behavior of school students aged 10–16 years. This cross-sectional study was conducted with adolescents recruited from seven randomly selected private schools in Delhi, India, during 2021. A selfadministered web-based survey was conducted to evaluate the behavior of the participants before and during the pandemic. Of the 512 students (53% males) who participated in the survey, 39% gained weight during the COVID-19 pandemic. There was a significant increase in the number of meals per day ($p = 0.005$) and a reduction in physical activity ($p = 0.00$) compared to the situation before the pandemic. The percentage of students who played indoor board and computer games increased from 13% to 46%. Students's gender ($p = 0.007$) and parents' education (mother: $p = 0.003$; father: $p = 0.025$) were significantly associated with physical activity during the pandemic. Higher socioeconomic status was significantly associated with consumption of more than two meals per day. The students who had working fathers with advanced/professional degrees were three times more likely [AOR 3.24, 95% CI (0.91–11.53)] to be physically active and eat a minimum of three major meals per day [AOR 3.21, 95% CI (1.77–5.81)] during the pandemic compared to those whose fathers were unemployed. This study highlighted the need for innovative strategies for adolescents and parents to adopt and practice a healthy lifestyle, especially during public health crises, such as the COVID-19 pandemic.

Keywords
COVID-19; adolescents; nutrition; physical activity; behavior; pandemic

1. Introduction

The world is facing an unprecedented challenge due to the COVID-19 pandemic. Measures to contain the spread of COVID-19 infection, which can affect all age groups, and to mitigate the risks of the pandemic, include self-isolation, quarantine, wearing a mask, washing hands and maintaining social distance [1]. As a precautionary step, educational institutions were closed, confining schoolage children to their homes, posing an unprecedented challenge to their education and natural growth. Movement restrictions affected adolescents through online classes, less playtime, more screen time, and limited interaction with peers. Along with the closure of educational institutions, limited outdoor activities and stockpiling of food due to restricted grocery shopping influenced the overall dietary behavior [2] and physical activity. These measures exposed adolescents to various risk factors, including unhealthy lifestyle habits and mental health issues [3]. Studies conducted in middle-income and high-income countries reported a higher prevalence of inactivity among adolescents, high intake of ultra-processed foods [4], and poor sleep patterns, resulting in anxiety, exhaustion, emotional disturbance, and stress during the pandemic [5]. A sedentary lifestyle with little physical activity, watching television or playing computer games, and consuming foods high in salt, sugar, and fat, and carbonated drinks are determinants of overweight and obesity in adolescents from urban areas [6]. Little is known about the effect of COVID-19 measures on the physical activity and dietary behavior of adolescents in India. Our primary objective was to evaluate the impact of the COVID-19 measures on the dietary behavior and physical activity of adolescents.

We hypothesized that significant changes in the diet and physical activity of adolescents occurred during the pandemic.

Measures such as social distancing to contain COVID-19 infection resulted in limited mobility and availability of resources and affected the general well-being and economic conditions of people. A study conducted in Uruguay showed that parental jobs and loss of income are strongly associated zwith parents' depressive symptoms, stress, and negative interactions with children [7]. In the same study, participants reported experiencing changes in their daily life due to social distancing measures, including loss of jobs, difficulty in working, and working from home. In another study

conducted with families to determine social needs, COVID-19-related concerns, and diet-related behaviors, the respondents expressed concern about their inability to pay bills, rent, and get other basic needs, including access to food because of unemployment due to closure. A study conducted in Australia revealed that economically vulnerable households and people who lost income during the COVID-19 pandemic faced difficulty in purchasing food [8]. Parents with unskilled jobs might not pay much attention to the diet and physical activity of their family members. Therefore, the secondary objective of this study was to determine the factors that influenced physical activity and diet-related behavior among adolescents during the COVID-19 pandemic.

2. Methods

2.1 Study Design

This cross-sectional study was conducted with students from seven private schools in Delhi, India, in 2021. The schools were randomly selected from the list of private schools governed by the Directorate of Education (DoE), Government of National Capital Territory (NCT) of Delhi. This study was limited to students from private schools in Delhi because previous studies in this city showed that the prevalence of overweight and obesity was significantly higher in students of private schools than in students of government schools [9].

2.2 Participants

Students aged 10–16 years from the seven randomly selected schools were invited to participate in the study. They were already being followed as a cohort in a study entitled i-PROMISe [10], while the data were collected retrospectively during the COVID-19 pandemic. A total of 725 students were invited to participate in the survey; 213 of them had to be excluded due to no response/missing values or duplicates. Finally, 512 respondents were included whose data were complete.

2.3 Measures

A self-administered web-based survey was conducted in English. The link to the

survey was shared with the schools for dissemination among students. Consent and assent procedures were followed. The survey was adapted from other questionnaires that were previously validated with adolescents and were extensively pilot-tested in India [9, 11]. In previous studies, the survey was conducted in person. The survey assessed dietary knowledge and behavior, including food purchasing behavior and physical activity-related behavior, including the frequency of participation in physical activity for 60 min/day, the frequency of daily meals, the use of available resources for physical activity, duration of screen time, and anthropometric data. The questionnaire was pretested with participants from another school. The data were collected through a web-based survey. Recent Progress in Nutrition 2022; 2(1), doi:10.21926/rpn.2201010

2.4 Institutional Review Board Statement

Ethical clearance for the study was obtained from the Public Health Foundation of India Institutional Ethics Committee (PHFI IEC) (TRC-IEC 407/19; 19/10, 2020).

2.5 Informed Consent Statement

Informed consent was obtained from the schools and the parents of the students participating in the study; an informed assent was obtained separately from the students.

2.6 Outcome Variables

The outcome variable to evaluate the diet-related behavior was the ‘number of meals during COVID-19’, which was assessed through the question: ‘How many meals did you eat in a day during the COVID-19 lockdown?’ We dichotomized this variable into ‘2 or less than 2 meals = 0’ and ‘more than 2 meals = 1’. The second outcome variable, i.e., physical activity, was assessed through the question: ‘What activities did you perform during the COVID-19 lockdown period?’ The response categories to this question were: ‘indoor game’, ‘outdoor game’, ‘Physical Training (PT)’, ‘Yoga’, and ‘none of the above’. We dichotomized this variable into ‘active = 1’ and ‘not active = 0’. The category ‘active’ included outdoor games, Yoga, PT, and some indoor games (such as carom board, board games, e.g., ludo), while all other responses were clubbed into the ‘not active’ category. Possible effect-modifiers were the variables

'mother's education', 'father's education', 'mother's occupation', 'father's occupation', and 'change in weight during COVID-19'.

2.7 Data Analysis

Descriptive analyses, including exploratory graphs and percentage distribution of categorical variables, were performed to understand the distribution of data. Bivariate analysis was performed using the non-parametric Chi-square test at a level of significance of 5% to assess the association between outcome and exposure variables. Wilcoxon signed-rank test was conducted to determine significant differences in meal consumption ('number of meals taken per day' as an ordinal variable) before and during the COVID-19 pandemic. McNemar's test was performed to determine the differences in the proportion of physical activity of the respondents before and during the COVID19 pandemic. Bivariate logistic regression models were constructed to determine the strengths of association between predictors (education of mother, education of father, occupation of father, occupation of mother) and the primary outcome variables (meals during the COVID-19 pandemic and physical activity). Related questions (socio-demographic characteristics; frequency of meal and physical activity before and during the COVID-19 pandemic) are provided in Table 1. The age and gender of the participants were treated as the covariates in logistic regression models. We estimated crude, as well as age-adjusted (in continuous form) and gender-adjusted odds ratios (AOR). All statistical analyses were conducted in the Stata software (version-14.0, parallel edition).

Table 1 The list of questions in the questionnaire.

Socio-demographic	Q 1 Highest education attained by your mother Advanced professional degree (e.g., PG, PhD, etc.) Graduate Senior Secondary Certificate High School Certificate Middle School Primary School No formal schooling Q 2 Highest education attained by your father Advanced professional degree (e.g., PG, PhD, etc.) Graduate Senior Secondary Certificate High School Certificate Middle School Primary School No formal schooling Q 3 Occupation of your mother (skip if does not apply) Professional (e.g., doctor, nurse, lawyer, enginer, etc.) Semi-professional (technician, assistant, etc.) Clerical, shop owner, farmer Skilled worker (with formal training or certificate) Semi-skilled worker (without any formal training or certificate) Unskilled worker (laborer) Unemployed/homemaker Q 4 Occupation of your father (skip if does not apply) Professional (e.g., doctor, lawyer, engineer, etc.) Semi-professional (technician, assistant, etc.) Clerical, shop owner, farmer

	Skilled worker (with formal training or certificate) Semi-skilled worker (without any formal training or certificate) Unskilled worker (laborer) Unemployed Q5. What do you think about your weight during the covid-19 lockdown period? a. Gained weight b. Lost weight c. Maintained weight
Frequency of meals	Q 6 How many meals do you eat in a day?

Number of meals	Pre-coronavirus times	During coronaviru times
1		
2		
3		
More than 3		

Physical activity	Q 7 What kind of activities do you perform in the physical education/PT period in school? Mark all that apply

	Pre coronavirus times	During coronavirus times
Outdoor sports which involve running (e.g., football, basketball)		
Indoor games		
PT/drill		
None of the above		
Any other, please specify		

3. Results

A total of 512 students (52.7% males, 47.3% females) participated in the survey (Table 2). The mean age of the respondents was 12.8 years. About half of the students' mothers were homemakers or housewives (52.3%), while around 44% of the students' fathers were working as professionals in various organizations. Around 2.2% of the students' fathers were unemployed during the COVID-19 lockdown.

Table 2 The socio-demographic characteristics.

Socio-demographic characteristics	n (%)
Age, mean (SD)	12.8 (0.85)
Gender	
Female	242 (47.3)
Male	270 (52.7)
Highest education (educational level) attained by mother	
<=HSC (primary/secondary/higher)	228 (44.5)
Graduate	196 (38.3)
Advanced/professional degree	88 (17.2)
Highest education (educational level) attained by father	
<=HSC (primary/secondary/higher)	177 (34.6)
Graduate	233 (45.5)
Advanced/professional degree	102 (19.9)
Occupation of mother	
Homemaker or housewives	268 (52.3)
Skilled	27 (5.3
Professional	85 (16.6)
Other (freelancer/part-time)	132 (25.8)
Occupation of father	

Unemployed	11 (2.2)
Skilled	72 (14.1)
Professional (e.g., doctors, nurses, lawyers, engineers, etc.)	226 (44.1)
Other (freelancer/part-time)	203 (39.6)
Total	**512 (100**

We found that approximately half of the students (50.8%) maintained their weight during the COVID-19 pandemic, while 39.2% of the students gained weight (Figure 1). Nearly 10% of the students lost weight during the lockdown.

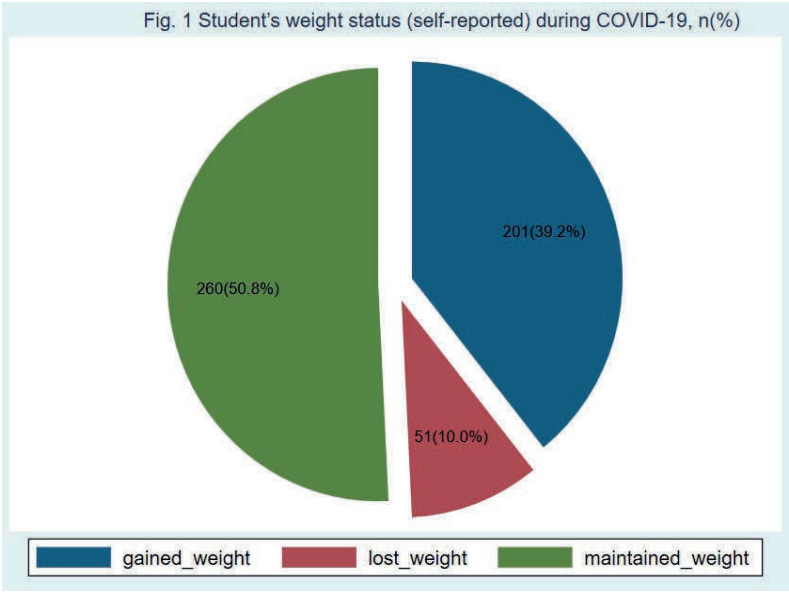

Figure 1 The status (self-reported) of the weight of the students during the COVID-19 pandemic, n (%)

The changes in the meal frequency of the students before and during the COVID-19 pandemic are presented in Table 3. The results of the Wilcoxon signed-rank test showed significant differences in meal consumption (no. of meals/day) before and during the COVID-19 pandemic ($p = 0.005$).

Table 3 The frequency of meals of the participants before and during the COVID-19 pandemic.

Number of meals taken per day	[Pre-COVID-19] n (%)	[During COVID-19] n (%)	p-value p = 0.005
1	45 (8.8)	47 (9.1)	
2	107 (20.9)	92 (18.0)	
3	295 (57.6)	286 (55.9)	
More than	3 65 (12.7)	87 (17.0)	
Total	512 (100.0)	512 (100.0	

Most students (73.1%) played outdoor sports before the COVID-19 pandemic (soccer, cricket, etc.), but this proportion dropped to 16% due to lockdown measures during the pandemic. The proportion of students playing indoor games increased from 13% (before the COVID-19 pandemic) to 45.5% (during the COVID-19 pandemic) (Figure 2). About 5.5% of the students performed Yoga before the COVID-19 pandemic, while about three times as many students (18.4%) performed Yoga during the pandemic. The proportion of the students who did PT/drills also increased from 5.1% to 10.7% (during the pandemic). Most students were engaged in less physical activity during the COVID-19 pandemic. The difference in the proportion of physical activity of the respondents before and during the COVID-19 pandemic was statistically significant (p = 0.00)

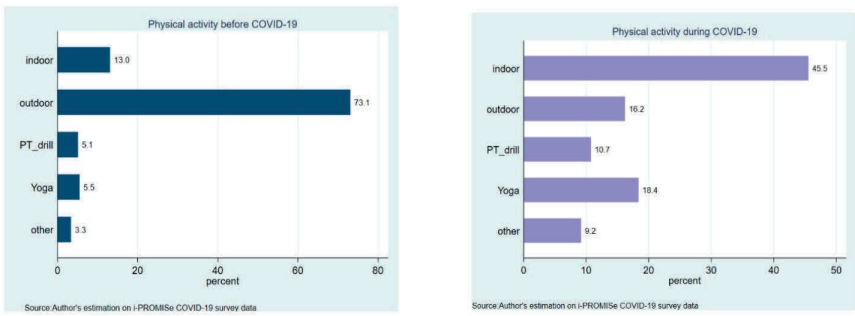

Figure 2 The physical activity of the participants before and during the COVID-19 pandemic.

Students' age, mother's occupation, and father's occupation were not significantly associated with the intensity of physical activity during the pandemic, while students' gender ($p = 0.007$), mother's education ($p = 0.003$), and father's education ($p = 0.025$) were significantly associated with physical activity during the pandemic. The details are provided in the supplementary files (Table S1& Table S2).

The results of the logistic regression analysis revealed that the students whose mothers had advanced/professional degrees were more likely [COR 2.39, 95% CI (1.32–4.33)] to eat three or more major meals during the pandemic compared to the students whose mothers only had a higher secondary certificate (HSC), while the adjusted odds ratio [AOR 2.28, 95% CI (1.25–4.15)] indicated almost similar significant results after controlling the effect of age and gender in the regression model (i.e., assuming age and gender as constants in the regression model). Similarly, the students whose fathers had advanced/professional degrees were three times more likely [AOR 3.21, 95% CI (1.77–5.81)] to eat three or more major meals during the pandemic. The students who had professional working fathers were more likely [COR 3.55, 95% CI (1.03–12.16)] to eat more than two meals per day compared to the students whose fathers were unemployed during the pandemic. After adjusting the model with age and gender, the AOR [AOR 3.13, 95% CI (0.90–10.9)] suggested almost similar significant results. The students who reported weight loss were less likely [COR 0.44, 95% CI (0.24–0.81)] to eat a minimum of three major meals in a day compared to those who gained weight during the pandemic, while after controlling for age and gender variables in the model, the adjusted odds ratio revealed almost similar results [AOR 0.45, 95% CI (0.24–0.85)] (Table 4).

Table 4 The results of the logistic regression for the factors associated with the frequency of meals during the COVID-19 pandemic

No. of meals per day (outcome variable)	COR	p-value	[95% Confidence Interval]		AOR	p-value	[95% Confidence Interval]	
Exposure variables								
Highest education (educational level) attained by mother								
<=Higher Secondary Certificate (HSC) (primary/secondary/higher)®	1.0				1.0			
Graduate	2.30	0.000	1.48	3.59	2.15	0.001	1.37	3.37
Advanced/professional degree	2.39	0.004	1.32	4.33	2.28	0.007	1.25	4.15
Highest education attained by father								
<=HSC primary/secondary/higher) ®	1.0				1.0			
Graduate	2.84	0.000	1.84	4.40	2.65	0.000	1.70	4.12
Advanced/professional degree	3.35	0.000	1.86	6.05	3.21	0.000	1.77	5.81
Occupation of mother								
Homemaker or housewives®	1.0				1.0			
Skilled	0.95	0.916	0.39	2.35	0.90	0.822	0.36	2.24
Professional	1.69	0.106	0.89	3.19	1.64	0.131	0.86	3.12
Other (freelancer/part-time)	0.53	0.005	0.34	0.83	0.54	0.008	0.35	0.85
Occupation of father								
Unemployed®	1.0				1.0			
Skilled	3.17	0.086	0.85	11.81	2.80	0.128	0.74	10.62
Professional	3.55	0.044	1.03	12.16	3.13	0.073	0.90	10.90
Other (freelancer, part-time)	1.39	0.595	0.41	4.72	1.27	0.700	0.37	4.38
Change in weight during COVID-19								
Maintained weight®	1.0				1.0			
Lost weight	0.44	0.008	0.24	0.81	0.45	0.013	0.24	0.85
Gained weight	1.48	0.078	0.96	2.28	1.50	0.070	0.97	2.33

Note: ®-Reference category; COR: crude odds ratio; AOR: age-adjusted and gender-adjusted

The results of the regression analysis showed that students with highly educated parents performed significantly more daily physical activity during the pandemic than those whose parents were less educated. The crude odds ratio [COR 2.33, 95% CI (1.35–4.01)] indicated that the students whose mothers had advanced/professional degrees were two times more likely to be physically active during the COVID-19 pandemic compared to the students whose mothers had a higher secondary certificate (HSC), while the adjusted odds ratio [AOR 2.27, 95% CI (1.32–3.92)] indicated the almost similar significant results after controlling the effect of age and gender in the regression model. The students who had professional working fathers were three times more likely [AOR 3.24, 95% CI (0.91–11.53)] to be physically active compared to those whose fathers were unemployed during the pandemic (Table 5).

Table 5 The results of the logistic regression for the factors associated with physical activity during the COVID-19 pandemic

Physical activity (outcome variable)	COR	p-value	[95% Confidence Interval]		AOR	p-value	[95% Confidence Interval]	
Exposure variables								
Highest education attained by mother								
<=HSC (primary/secondary/higher) ®	1.0							
Graduate	1.62	0.016	1.09	2.41	1.54	0.036	1.03	2.29
Advanced/professional degree	2.33	0.002	1.35	4.01	2.27	0.003	1.32	3.92
Highest education attained by father								
<=HSC primary/secondary/higher) ®	1.00							
Graduate	1.55	0.033	1.04	2.31	1.48	0.062	0.98	2.22
Advanced/professional degree	1.89	0.016	1.13	3.16	1.89	0.017	1.12	3.18
Occupation of mother								
Homemaker®	1.0							
Skilled	1.03	0.946	0.46	2.30	0.98	0.952	0.43	2.20

Professional (e.g., doctors, nurses, lawyers, engineers, etc.)	1.80	0.031	1.06	3.06	1.70	0.053	0.99	2.90
Other (freelancer, part-time)	1.32	0.206	0.86	2.04	1.31	0.225	0.85	2.03
Occupation of father								
Unemployed®	1.0							
Skilled	2.45	0.182	0.66	9.12	2.20	0.243	0.59	8.3
Professional (e.g., doctors, nurses, lawyers, engineers, etc.)	3.59	0.046	1.02	12.67	3.24	0.070	0.91	11.53
Other (freelancer, part-time)	2.64	0.132	0.75	9.29	2.37	0.183	0.67	8.44

Note: ®-Reference category; COR: crude odds ratio; AOR: age-adjusted and gender-adjusted odds ratio.z

4. Discussion

In this study, about half of the students (50.8%) maintained their weight during the COVID-19 pandemic, while 39.2% of the students gained weight. The proportion of students playing indoor board and computer games increased from 13% (before the COVID-19 pandemic) to 45.5% (during the COVID-19 pandemic). Socio-demographic characteristics (parents' education and occupation) were significantly associated with the consumption of at least three meals per day by the children. The students who had working fathers with advanced/professional degrees were three times more likely [AOR 3.24, 95% CI (0.91–11.53)] to be physically active and eat a minimum of three major meals daily [AOR 3.21, 95% CI (1.77–5.81)] during the pandemic compared to those whose fathers were unemployed during the pandemic.

A cross-sectional study conducted with participants aged 12–16 years in Yazd, Iran, found that sedentary behavior, screen time, overweight/obesity, and lack of physical activity were common in this age group [12]. A study conducted with adults in Spain showed a decrease in daily self-reported physical activity and an increase in sedentary time during COVID-19 confinement, especially in students and previously highly active men [13]. In another study, students reported that the median duration of their sleep was extended by 1.5 h during the lockdown [14]. The results of this study also showed that most of the students played (73.1%) outdoor sports (football, crick-

et, etc.) before the COVID-19 pandemic, while this proportion decreased considerably due to lockdown-related restrictions caused by the pandemic. The proportion of students playing indoor games increased during the COVID-19 pandemic. Studies conducted in Asian countries [15, 16] also showed a decrease in fruit consumption and physical activity, including exercise among adolescents and adults. Besides the impact on the changes in diet and physical activity due to the COVID-19 pandemic, a systematic review showed the impact on the behavior/psychological state in children/adolescents. The review showed that 79.4% of children were negatively affected by the pandemic, and at least 22.5% of children had a significant fear of COVID-19 [17].

Studies conducted with adolescents in Western countries showed that COVID-19 restrictions influenced their dietary habits, including altered consumption of fried foods, sweet foods, legumes, vegetables, and fruits. Adequate meal intake during the COVID-19 period was differently correlated with variables such as the number of family members at home (as the availability of resources reduced in larger families), watching TV during meals, and education of the mother [18]. Our study showed that the meal intake of participants was significantly associated with their parents' education. The students whose parents were highly educated were significantly more likely to take more than two meals per day during the pandemic compared to those whose parents were less educated.

The educational level of the parents can influence the feeding behavior of family members based on their awareness level and the availability of economic resources. The results of a population based study conducted with parents of adolescents indicated that parental access to economic resources may contribute to a parent's decision to employ specific feeding practices [19]. In another study, mothers with low educational attainment showed greater tendency to buy less healthy discounted products while shopping with a poorer quality of diet compared to mothers with higher educational attainment [20]. Our study showed that students whose parents were more educated and employed as skilled workers had at least three major meals in a day and were more likely to be physically active compared to the students whose

parents were less educated and employed aslessskilled workers.

A study conducted with 16–19-year-old participants in Latin America found a higher prevalence of inactivity during the pandemic. These adolescents had a high odds ratio (OR 2.98; CI 95% 1.80–4.94) of being inactive, and those adolescents whose mothers had a higher level of education were less active during the lockdown [OR 0.40 (CI 95% 0.20–0.84)] [4].

The factors influencing the behavior of the family included balancing work with childcare/homeschooling and financial instability during the COVID-19 pandemic [21]. A study conducted in Spain during the lockdown period investigating the social inequalities in housing conditions and healthrelated behaviors among children showed that children from families with low educational levels and financial difficulties were exposed to negative health determinants such as poor dietary patterns, sedentary lifestyle, and less social contact [22]. In our study, the age-and gender-AOR suggested that the students whose mothers had advanced/professional degrees were more likely [AOR 2.27, 95% CI (1.32–3.92)] to be physically active during the COVID-19 pandemic. The less educated parents might have low awareness regarding the importance of being physically active and eating a healthy diet regularly, especially during such public health emergencies. The students who had professional working fathers were three times more likely [AOR 3.24, 95% CI (0.91–11.53)] to be physically active compared to those whose fathers were unemployed during the pandemic, regardless of the age and gender of the students.

Policies to foster a supportive environment focused on the availability, accessibility, and affordability of healthy food options, including restrictions on advertising unhealthy food products, need to be enforced and monitored regularly, especially during such public health emergencies. Innovative strategies involving parents can effectively reinforce the importance of a healthy lifestyle, e.g., by using online platforms. It is imperative to continue studying influential determinants to strengthen multi-factorial strategies to promote healthy living practices among urban Indian adolescents.

5. Strengths and Limitations

The main limitation of this study was that the survey was based on self-reported information, which might lead to over-reporting or under-reporting of data. Other limitations were the possible recall bias of the participants, the cross-sectional design, and the fact that only the students who had access to the internet and who were comfortable completing an online survey using their device (e.g., mobile phone, computer) participated in the survey. Recall bias might have affected the responses, especially those related to the pre-lockdown period. Another limitation was that we could not assess the mental health of the students. A strength of our study was the fact that the survey was conducted during the pandemic. Very few studies have been conducted in India to assess the impact of COVID-19 on the dietary and physical activity-related behavior of adolescents.

6. Conclusion

In this study, almost 40% of the students reported weight gain and an increase in their dietary intake to some extent during the COVID-19 pandemic. The percentage of students playing indoor board and computer games also increased during the COVID-19 pandemic. Unhealthy diet and physical inactivity among adolescents worsened during the lockdown. Socio-demographic characteristics, including parents' education and occupation, were significantly associated with the meal intake and physical activity of their children. This study emphasizesthe need for interventions, programs, and policies for the benefit of adolescents and parents to adopt and practice a healthy lifestyle, including consumption of nutritious food and greater physical activity, especially during public health emergencies such as the COVID-19 pandemic.

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Author Contributions

CPS, MA, JM, and TR conceptualised the study design and provided guidance to implement the study. TR collected, organised and wrote the manuscript. VKM supported the data analysis with TR under the guidance of CPS and JM. CPS, JM, MA, and NT revised the manuscript critically for intellectual content. All authors approved the final manuscript.

Competing Interests

The authors have declared that no competing interests exist.

Additional Materials

The following additional materials are uploaded at the page of this paper.
1. Table S1: The percentage distribution of the meal intake of the students during the COVID-19 pandemic, based on certain background characteristics; statistically significant differences were determined by performing Chi-square tests.

2. Table S2: The percentage distribution of the physical activity of the students during the COVID19 pandemic, based on certain background characteristics; statistically significant differences were determined by performing Chi-square tests.

References

1. Khanna RC, Cicinelli MV, Gilbert SS, Honavar SG, Murthy GV. COVID-19 pandemic: Lessons learned and future directions. Indian J Oph thalmol. 2020;68: 703-710.
2. AlTarrah D, AlShami E, AlHamad N, AlBesher F, Devarajan S. The impact of coronavirus COVID19 pandemic on food purchasing, eating be havior, and perception of food safety in Kuwait. Sustainability. 2021; 13: 8987.
3. Pigaiani Y, Zoccante L, Zocca A, Arzenton A, Menegolli M, Fadel S, et al. Adolescent lifestyle behaviors, coping strategies and subjective wellbe ing during the COVID-19 pandemic: An online student survey. Health care. 2020;8: 472.
4. Ruíz-Roso MB, de Carvalho Padilha P, Matilla-Escalante DC, Brun P, Ulloa N, Acevedo-Correa D, et al. Changes of physical activity and ul tra-processed food consumption in adolescents from different countries during COVID-19pandemic: An observational study. Nutrients. 2020; 12: 2289.
5. Pietrobelli A, Pecoraro L, Ferruzzi A, Heo M, Faith M, Zoller T, et al. Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: A longitudinal study. Obesity. 2020; 28: 1382-1385.
6. Goyal JP, Kumar N, Parmar I, Shah VB, Patel B. Determinants of over weight and obesity in affluent adolescent in Surat City, South Gujarat re gion, India. Indian J Community Med. 2011; 36: 296-300.
7. Kalil A, Mayer S, Shah R. Impact of the COVID-19 crisis on family dynamics in economically vulnerable households. In: University of Chica

go, Becker Friedman Institute for Economics Working Paper No.2020-143.Chicago: University of Chicago, Becker Friedman Institute; 2020. Doi: 10.2139/ssrn.3705592.

8. Kent K, Murray S, Penrose B, Auckland S, Visentin D, Godrich S, et al. Prevalence and sociodemographic predictors of food insecurity in Austra lia during the COVID-19 pandemic. Nutrients. 2020; 12: 2682.
9. Arora M, Nazar GP, Gupta VK, Perry CL, Reddy KS, Stigler MH. Association of breakfast intake with obesity, dietary and physical activity behavior among urban school-aged adolescents in Delhi, India: Results of a cross-sectional study. BMC Public Health. 2012; 12: 881.
10. Rawal T, Willeboordse M, Arora M, Sharma N, Nazar GP, Tandon N, et al. Prevalence of excessive weight and underweight and its associated knowledge and lifestyle behaviors among urban private school-going adolescents in New Delhi. Nutrients. 2021; 13: 3296.
11. Arora M, Mathur C, Rawal T, Bassi S, Lakshmy R, Nazar GP, et al. Socio economic differences in prevalence of biochemical, physiological, and metabolic risk factors for non-communicable diseases among urban youth in Delhi, India. Prev Med Rep. 2018; 12: 33-39.
12. Hadianfard AM, Mozaffari-Khosravi H, Karandish M, Azhdari M. Physi cal activity and sedentary behaviors (screen time and homework) among overweight or obese adolescents: A crosssectional observational study in Yazd, Iran. BMC Pediatr. 2021; 21: 421.
13. Castañeda-Babarro A, Arbillaga-Etxarri A, Gutiérrez-Santamaría B, Coca A. Physical activity change during COVID-19 confinement. Int J Environ Res Public Health. 2020; 17: 6878.
14. Dragun R, Veček NN, Marendić M, Pribisalić A, Đivić G, Cena H, et al. Have lifestyle habits and psychological well-being changed among

adolescents and medical students due to COVID-19 lockdown in Croatia? Nutrients. 2020; 13: 97.

15. Yang GY, Lin XL, Fang AP, Zhu HL. Eating habits and lifestyles during the initial stage of the COVID-19 lockdown in China: A cross-sectional study. Nutrients. 2021; 13: 970.
16. Kim SY, Yoo DM, Min C, Choi HG. Changes in dietary habits and exer cise pattern of Korean adolescents from prior to during the COVID-19 pandemic. Nutrients. 2021; 13: 3314.
17. Panda PK, Gupta J, Chowdhury SR, Kumar R, Meena AK, Madaan P, et al. Psychological and behavioral impact of lockdown and quarantine mea sures for COVID-19 pandemic on children, adolescents and caregivers: A systematic review and meta-analysis. J Trop Pediatr. 2021; 67: fmaa122.
18. Ruiz-Roso MB, de Carvalho Padilha P, Mantilla-Escalante DC, Ulloa N, Brun P, Acevedo-Correa D, et al. COVID-19 confinement and changes of adolescent's dietary trends in Italy, Spain, Chile, Colombia and Brazil. Nutrients. 2020; 12: 1807.
19. Loth KA, MacLehose RF, Fulkerson JA, Crow S, Neumark-Sztainer D. Eat this, not that! Parental demographic correlates of food-related parent ing practices. Appetite. 2013; 60: 140-147.
20. Vogel C, Ntani G, Inskip H, Barker M, Cummins S, Cooper C, et al. Education and the relationship between supermarket environment and diet. Am J Prev Med. 2016; 51: e27-e34.
21. Carroll N, Sadowski A, Laila A, Hruska V, Nixon M, Ma DW, et al. The impact of COVID-19 on health behavior, stress, financial and food security among middle to high income Canadian families with young children. Nutrients. 2020; 12: 2352.
22. González-Rábago Y, Cabezas-Rodríguez A, Martín U. Social inequalities in health determinants in Spanish children during the COVID-19 lock-

down. IntJ Environ Res Public Health. 2021; 18: 4087.

CHAPTER 5

Effect of an educational intervention on diet and physical activity among school-aged adolescents in Delhi -The i-PROMISe (PROMoting health literacy in Schools) Plus Study

Under Review:

Tina Rawal, Jean W.M. Muris, Vijay Kumar Mishra, Monika Arora, Nikhil Tandon, Onno C.P. van Schayck. *Effect of an educational intervention on diet and physical activity among school-aged adolescents in Delhi -The i-PROMISe (PROMoting health literacy in Schools) Plus Study.* This chapter is under review by Dialogue in Health Journal

Abstract:

Purpose: Emerging lifestyle changes due to rapid urbanization have led to an epidemiological transition and the rising prevalence of obesity is responsible for major non-communicable diseases (NCDs) which have further aggravated due to the COVID-19 pandemic. This study aims to assess the effectiveness of a comprehensive school-based intervention on diet and physical activity-related behavior of adolescents.

Methods:
In 2019, a cluster-randomized controlled trial was conducted in randomly selected (n=8) private schools. A 2-year intervention program was implemented over consecutive academic years (2019-2020 and 2020-2021) with students who were in the 6th and 7th grades when the study began. Four schools were randomly assigned to the intervention (n=794) and four schools to the control group (n=774).

Results:
The difference in changes in diet and physical-activity-related behaviors of the students between the intervention and control schools were not significant in the intention to treat analysis probably due to the large drop-out due to COVID-19 measures: 304 students were available for follow-up in the intervention group and 122 in the control group (391 cases were excluded to make data comparable with baseline survey). The intake of vegetables (once a day) [β=0.35, OR=1.42, 95% CI (1.03, 1.95)] in the per-protocol analysis has increased among adolescents in the intervention group as compared to the control group.

Conclusion:
The findings of this study indicated a positive effect of the intervention on diet and physical-activity-related changes in the expected direction and highlights the importance of addressing such behavior to prevent obesity among adolescents and thus NCDs in the later stage of life.

Key Words:
School, COVID-19, Diet, Physical activity, India, Cluster RCT

Introduction:

Environmental factors and lifestyle choices play an important role in the increasing prevalence of obesity and are responsible for the major non-communicable diseases (NCDs) (1). NCDs are largely the result of practices adopted at a young age (2, 3). The COVID-19 pandemic posed a serious threat to the well-being of adolescents and made them more vulnerable, especially those with co-morbidities around the world (4). It forced adolescents to stay at home in isolation. 3 Furthermore, the pandemic caused significant changes in their lifestyle, including physical activity and dietary behavior. The dietary behaviour included an increase in consumption of food high in fat, salt and sugar, and a low intake of essential nutrients, such as proteins, minerals, and vitamins, which is of particular concern in obese individuals(5). A recent study of adolescents found more stress, boredom, a sedentary lifestyle, and higher consumption of sweet foods, including sugar-sweetened beverages during the lockdown (6). A survey of adolescents and young adults aged 13-29 in Latin America and the Caribbean shows a 32% increase in consumption of snacks and sweets and a 33% decrease in consumption of fruits and vegetables. The same survey reported that 52% of participants were less physically active (7). Adolescents' thoughts about diet and physical activity can have both negative and positive effects on their health, and therefore it is necessary to reinforce the importance of adopting healthy diety and physical activity behaviour (8). A healthy lifestyle including a healthy diet and being physically active is necessary for a strong immune system(9) throughout life. Change in behavior toward unhealthy foods should be prevented by parents, schools, media, and communities in general.

School health programmes may play an important role in minimizing risk factors for NCDs, nurturing healthy behaviour, and providing a protective environment for children and adolescents(10). Due to the closures of schools during the COVID-19 pandemic, school health programmes were established to varying degrees. Existing

programmes across the world need to be strengthened and effective ways to promote the importance of adopting a healthy lifestyle for adolescents must be explored especially during the period of school closures. Before the pandemic, about three-quarters of school-aged children and adolescents did not meet the physical activity guidelines(11). Pandemic-related stressors worsen the physical and mental condition of children and adolescents (12), both diet and physical activity are affected by quarantine or social isolation.

Currently, there are limited data available on the effects of interventions to improve the diet and physical activity behavior of Indian adolescents during the COVID-19 pandemic. The i-PROMISe (PROMoting health literacy in Schools) plus intervention (teacher-led module comprising interactive activities and short films) was developed following the Health Belief Model(13-16). The intervention, including sessions with teachers and dissemination of resources, took place online because schools were closed during the pandemic.

This paper presents the results of the evaluation of the i-PROMISe Plus cluster-randomized trial (16), aimed at promoting healthy lifestyles in adolescents for the prevention of NCDs, especially diabetes and obesity, an important and increasing health problem in urban areas (17) of India.

This study was planned and initiated before the outbreak of COVID-19. We decided to continue the study to investigate the effects of the COVID-19 pandemic.

Our research aim was to assess the effectiveness of a comprehensive school-based intervention on nutrition and physical activity-related behavior of adolescents. Our hypothesis was that the intervention would lead to a significant increase in the dietary and physical-activity-related behaviour of students in the intervention group after 2 years, compared with the control group.

Methods:

Study design and Setting:

This study was a cluster-randomized controlled trial. In 2019, eight private schools were randomly selected from the list of schools governed by the Directorate of Education (DoE), Government of National Capital Territory (NCT) of Delhi. Earlier studies in New Delhi reported a significantly higher prevalence of overweight and obesity among students of private schools in the same age group compared to those in government (public) schools(18).The schools were recruited after they gave consent to participate in the study. The schools were then randomly assigned to the intervention or control group using software generated random numbers. A 2-year intervention program was implemented over consecutive academic years (2019-2020 and 2020-2021) with students who were in the 6th and 7th grades when the study began. These students were surveyed at the baseline and end-line to evaluate the effect of the intervention: (a) at baseline before the intervention began (2019); (b) at follow-up, after the trial (2021). This study presents the results of the baseline vs follow-up. The baseline survey was administered before the COVID 19 pandemic and the follow-up survey was administered during the COVID 19 pandemic.

Study Sample:

The unit of randomization was school. Assuming 80% power, alpha of 0.05, design effect 1.0, and 15% attrition rate, and assuming no significant changes in the control group, the total needed sample size was estimated to be ≈1558 students (control-779, intervention-779). To reach 1558 students n=8 schools (4-control, 4-intervention) were recruited.

Study participants:

All schools enrolled in the study (n=8) participated in the baseline (paperbased) survey. In the follow-up (end-line), the same survey was used as a web-based survey due to COVID-19 pandemic restrictions. Two schools (one in each arm) did not respond, even after rigorous follow-up during the end-line survey, and therefore students from these schools had to be excluded from the analysis.

Institutional Review Board Statement:
Ethical clearance for the trial was obtained from the Public Health Foundation of India Institutional Ethics Committee (PHFI IEC) (TRC-IEC 407/19; 19/10, 2020).
Informed Consent Statement: Informed consent was obtained from the school and parents of students participating in the study, and a separately informed assent was obtained from the students.

Intervention:
i-PROMISe intervention was developed to promote a healthy lifestyle among students for primary prevention of NCDs following the Health Belief Model (HBM). The HBM focuses on four constructs: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. Focus Group Discussions (FGDs) with students and In-Depth interviews (IDIs) with teachers were held in the school on the topic guide, which was based on the HBM. The intervention was pre-tested in two schools in Delhi, India (16). Year 1 intervention components included: i) a short -animated video for display in class for students on the importance of being physically active and eating a balanced diet (https://youtu.be/k3qaucZFHYQ) and ii) a short video for teachers on information about NCDs including diabetes and its prevention (https://youtu.be/kA_TLtYQ_wc). The video included information from a renowned endocrinologist as a resource person; and iii) A teacher's manual comprised of interactive classroom activities; comic strips on the theme of a healthy lifestyle. Given the COVID-19 pandemic restrictions, virtual sessions were conducted with teachers from intervention schools to train them to carry out the follow-up activities with the students. Follow-up discussions were conducted to monitor the implementation of five activities with the students.

In year 2, components reinforcing the key messages were developed and disseminated under iPROMISe plus intervention. It included the dissemination of information flyers for the parents and posters for the schools to reinforce the key messages at the home and school level: energy balance; the importance of a healthy diet, physical activity, prevention and management of NCDs, especially diabetes and obesity and interlinkages between NCDs & COVID-19. Due to the closure of schools during the

pandemic, the implementation of the intervention and dissemination of resources took place using the online platform. A webinar and a live session with health experts were also held for parents and teachers during the pandemic. To ensure the implementation of activities and dissemination of the resources, follow-up calls were done with teacher coordinators.

Measure:

A self-completed paper survey was used to collect baseline data and after 2 years, the same (this time online) survey was administered as a follow-up measurement. Confidentiality of responses was ensured by using a unique ID that could not be traced back to specific students. The survey was administered in English. The survey was adapted from other instruments validated in adolescent-focused studies and extensively pilot-tested in India (18, 19). The survey assessed knowledge and behavior related to nutrition, including frequency of consumption of vegetables, soft drinks / aerated beverages, and high-energy foods; purchase of food; and behaviour related to physical activity, including time spent in vigorous/moderate/mild physical activity; and duration of screen time.

Outcome measures:

This trial aimed to compare the knowledge and behavior of adolescents in the intervention schools with those in the control schools with regard to 1) consumption of fruit (once per day/ 2 or 3 times/week); 2) vegetables/ green leafy vegetables (once per day/ 2 or 3 times/week), 3) reduction in consumption of soft drinks /aerated beverages (once per day/ 2 or 3 times/week), 4) intake of fruit juices (once per day/ 2 or 3 times/week), 4) consumption of fried food (once per day/ 2 or 3 times/week) and 5) time spent on physical activity (30/45/60 min/each day). The outcome variables relating to diet and physical activity were assessed throughquestions categorized into knowledge and behaviour. Each outcome was dichotomized through a question with a fixed response category.

Data analysis

The multiple imputation technique was utilized to account for the missing values in the outcome variables. This study followed the intention-to-treat analytic method to perform the primary data analysis with 1568 cases, while per-protocol analysis (secondary) based on matched cases (n=426) was done to follow up same participants throughout pre and post. We have estimated the mean and 95% confidence interval (CI) for the continuous variable (age), and percentage distribution of categorical variables, across intervention and control groups. Mixed-effects logistic regression modeling was performed to estimate beta coefficients and odds ratios for outcomes between groups. The age and gender of the trial participants were treated as covariates in the mixed-effect logistic regression modeling. All the statistical analyses were done using Stata software (version-14.0, parallel edition). We have done the mixed-effects logistic regression analysis, to calculate the changes in diet and physical-activity-related indicators among school students. We have also estimated the adjusted odds ratio (AOR), keeping age and gender constant in the regression modeling.

Results:

Background characteristics of participants

In the baseline survey, 1635 students completed the survey (before intervention), 67 cases were deleted listwise due to missing date of birth, date of survey, and non-response on gender and other key outcome variables. Data of 1568 (intervention=794, control=774) cases were utilized from the baseline survey. Due to the COVID-19 restrictions, only 817 students participated in the end-line measurement and 391 cases were excluded (list-wise deletion) to make data comparable with the participants who took part in the baseline survey. The overview of the study is provided in Fig. 1. Table 1 shows that the overall mean age of the respondents was 11.62 years (95% CI: 11.58-11.66). More than half of the adolescents were males in the control (64.86 %) as well as intervention (59.32%) groups.

Table.1 Socio-demographic characteristics of the students

Background characteristics	Control	Intervention	Total
Age: mean (95% CI)	11.58 (11.52-11.64)	11.66 (11.60-11.72)	11.62 (11.58-11.66)
Gender			
Female	272(35.14)	323(40.68)	595(37.95)
Male	502(64.86)	471(59.32)	973(62.05)
Highest education attained by mother, n(%)			
No formal schooling	64(8.27)	75(9.45)	139(8.86)
<=High Secondary Certificate (HSC) (primary/ secondary/higher)	382(49.35)	212(26.70)	594(37.88)
graduate	249(32.17)	323(40.68)	572(36.48)
Advanced/professional degree	79(10.21)	184(23.17)	263(16.77)
Highest education attained by father, n(%)			
No formal schooling	47(6.07)	77(9.70)	124(7.91)
<=HSC (primary/ secondary/higher)	338(43.67)	161(20.27)	499(31.82)
graduate	268(34.63)	287(36.15)	555(35.40)
Advanced/professional degree	121(15.63)	269(33.88)	390(24.87)
Occupation of mother, n(%)			
Homemaker or Housewives	636(82.17)	542(68.26)	1178(75.13)
skilled	18(2.33)	10(1.26)	28(1.79)
professional	48(6.20)	57(7.18)	105(6.7)
Other (own business/freelancer/part-time)	72(9.30)	185(23.30)	257(16.38)
Occupation of father, n(%)			
unemployed	129(16.67)	136(17.13)	265(16.90)
skilled	83(10.72)	40(5.04)	123(7.84)
Professional (e.g., doctors, nurses, lawyers, engineers etc.)	258(33.33)	138(17.38)	396(25.26)
Other (own business/freelancer/part-time)	304(39.28)	480(60.45)	784(50.00)
Total	774(100)	794 (100)	1568(100)

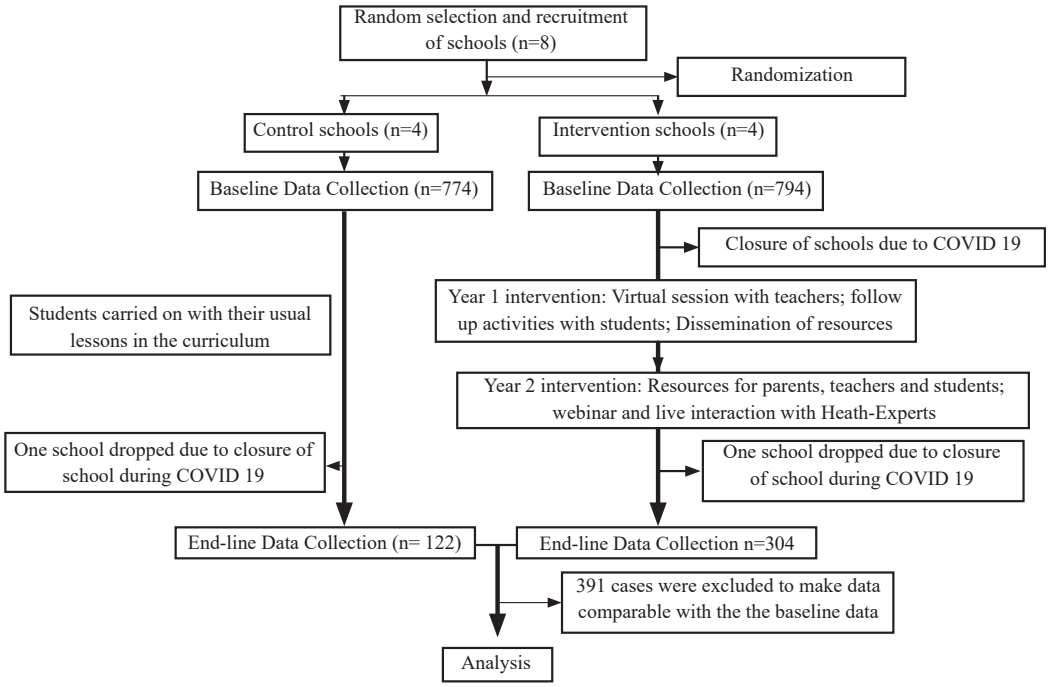

Figure 1: Overview of study

Table.2 Effect of intervention on the diet and physical-activity related indicators, as established with mixed-effect logistic regression correcting for age and gender, ITT (n=1568)

Variable	Intervention (%)	Control (%)	β	AOR	95% CI		p-value
					lower	upper	
Fruits							
Baseline	43.20	40.44	0.24	1.27	0.99	1.60	0.056
Endline	14.99	5.81					
Vegetables							
Baseline	66.37	60.98	0.38	1.46	0.95	2.23	0.082
Endline	27.33	11.24					
Fried foods							
Baseline	6.42	9.82	-0.38	0.68	0.43	1.07	0.09
Endline	68.39	87.21					
Soft drinks /aerated beverages							
Baseline	5.92	6.33	-0.25	0.78	0.44	1.37	0.379
Endline	65.99	85.79					
Fruit juices							
Baseline	46.98	44.06	0.15	1.16	0.83	1.61	0.378
Endline	9.19	5.94					
Time spent in physical activity							
Baseline	49.50	46.64	0.13	1.14	0.73	1.77	0.561
Endline	10.71	5.68					

Note: AOR-Adjusted odds ratio, CI-confidence interval

Table.2 reveals the difference between control and intervention groups for changes in dietary and physical-activity-related indicators based on the mixed-effects logistic regression model. The positive values of the beta-coefficient indicate an increase, while the negative value a decrease in diet and physical-activity-related indicators. Although all beta-coefficients were in the expected direction, no significant effects of the intervention were observed, probably due to dropout at follow-up due to COVID-19 measures. During the COVID-19 pandemic, 304 students participated in

the intervention group and 122 in the control group. Intake of vegetables (once a day) [β=0.35, OR=1.42, 95% CI (1.03, 1.95)] in the per-protocol analysis (Table 3) has increased among adolescents in intervention group compared with the control group.

Table.3 Effect of intervention on the diet and physical-activity related indicators, as established with mixed logistic regression correcting for age and gender, per protocol (n=426)

Variable	Intervent-ion (%)	Control (%)	β	AOR	95% CI		p-value
					lower	upper	
Fruits							
Baseline	47.04	41.80	0.15	1.16	0.85	1.58	0.325
Endline	40.79	37.7					
Vegetables							
Baseline	67.76	60.66	0.35	0.35	1.03	1.95	0.032
Endline	76.64	69.67					
Fried foods							
Baseline	7.89	9.84	-0.21	0.81	0.45	1.44	0.475
Endline	12.83	16.39					
Soft drinks /aerated beverages							
Baseline	4.28	9.02	-0.54	0.58	0.27	1.22	0.154
Endline	65.99	85.79					
Fruit juices							
Baseline	13.16	8.20	0.32	1.37	0.80	2.35	0.246
Endline	7.89	7.89					
Time spent in physical activity							
Baseline	41.12	41.80	0.23	1.26	0.93	1.71	0.130
Endline	64.14	54.10					

Note: AOR-Adjusted odds ratio, CI-confidence interval

Discussion:

This is one of the few trials that investigated the effectiveness of a school-based intervention during the COVID-19 pandemic using a cluster-randomized design. This study assessed, the difference in changes in diet and physical-activity-related behaviours of the students between the intervention and control schools. The findings tended to show a positive effect of the intervention on nutrition- and physical activity-related changes in the expected direction, but no significant effects were observed in the intention-to-treat analysis, probably due to loss to followup of schoolchildren due to COVID-19 measures, with the closure of educational institutions playing an important part. Results showed that the intake of vegetables (once a day) in the per-protocol analysis has significantly increased among adolescents in the intervention group as compared to the control group. These results highlighted that the comprehensive i-PROMISe plus intervention including the involvement of school staff and parents might be effective in improving diet-related behaviour.

The baseline data from this study confirmed the need for a comprehensive intervention to improve diet and physical-activity-related behaviours to address overweight and obesity in school-aged adolescents, which were further increased by the COVID-19 pandemic(8, 20).

Another review conducted to summarize the effect of the pandemic COVID-19 on the lifestyle behaviour of the Indian population highlighted the need for lifestyle behaviour interventions using an online-platform to disseminate health education (21). The findings of this study are in line with the result of a systematic review that highlighted the importance of comprehensive interventions focusing on nutrition combined with physical activity to address overweight and obesity-related indicators among adolescents (22). Adapting to a healthy lifestyle is important to combat overweight and obesity because it can lead to low self-esteem (23). Findings fromanother systematic review showed a significant effect of digital interventions that included education and parental involvement on health behaviour change in adolescents (24). Findings of a cluster-randomized feasibility study with school-aged children in the

UK showed similar trends in healthier eating and greater preference for fruit and vegetables in the intervention compared with the control group (25) as shown in our study also.

A school-based intervention randomised control trial conducted with school-going children in Mexico revealed that children did not engage in more moderate to vigorous physical activity (MVPA) in physical education (PE) class or recess but increased steps taken postintervention(26). The results of this study showed that all beta-coefficients were in the expected direction, including an increase in the time spent on physical activity. However, a review found that the COVID-19 pandemic had an effect on the decrease in physical activity especially in adolescents (27). Another study conducted to evaluate the impact of COVID-19 lockdown restrictions on the lifestyle of school-age children in India showed a significant decrease in the outdoor activity and an increase the screen time (28).

Studies conducted in western countries during the COVID-19 pandemic (29, 30) reported less frequent consumption of vegetables, fruit, and legumes during quarantine, and higher adherence to meat, dairy, fast foods, and ultra-processed consumption. However, post-intervention the consumption of vegetables seemed to increase in the present study. In addition to the effect of intervention, the other reason for this may be the influence of social media campaigns, parents/ peers, and/or public awareness messages through governmental and non-government health organisations (31) during the later period of the COVID-19 pandemic, which emphasized the importance of following a healthy lifestyle.

Strengths and Limitations

The main limitation of this study is that due to the closure of schools during the COVID-19 pandemic, the response rate of students was low. With strict follow-up with the schools, 304 students participated in the intervention group and 122 in the control group during the COVID-19 pandemic. We had hoped in vain that a high involvement of teacher coordinators in the implementation of the intervention and the dissemination of resources would lead to a higher participation rate. Other lim-

itations include the self-administered questionnaire, which may lead to over-or under-reporting of data, the possible recall bias of the participants, and the fact that the students had limited access to the internet. We did not measured anthropometry and therefore these results should be viewed with caution and confirmed with other studies before drawing firm conclusions. A strength of our study was the fact that it was conducted during the pandemic. Very few studies have been conducted to explore the effectiveness of a school-based intervention focused on adolescents' dietary and physical activity behaviour during the COVID-19 pandemic. The strength of this study includes the use of the Health Belief model integrated with the formative study.

Public Health Implications

It is well established that unhealthy diet and lack of exercise are major risk factors for NCDs. Increased knowledge and improved dietary and physical activity behaviour can reduce the risk of NCDs, especially diabetes. In a developing country like India, the prevalence of obesity and overweight coincides with demographic and epidemiological transitions. The findings of this study are encouraging and promising to address adolescent obesity and hence NCDs later in life. This intervention takes a whole-school approach, i.e. it involves all key stakeholders – teachers, students, and their parents. This has several advantages, as it can influence both school and home environments so that adolescents adopt healthy lifestyles. To more strongly reduce overweight and obesity, and thus NCDs, the intervention should be combined with other strategies, such as limiting marketing and advertising of unhealthy foods and a school canteen policy. A previous study found that family, school, and community involvement is important for long-term outcomes, and that government should be involved in developing policies that help create an environment and opportunities for healthy eating and physical activity (32).

Conclusion:

The iPROMISe plus intervention showed positive effects on diet and physical-activity-related behaviours in the expected direction. It suggests that a comprehensive school-based intervention might influence healthy eating behaviour and highlights

the importance of addressing such behaviours to prevent adolescent obesity and thus NCDs in the later life.

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References:

1. Angkurawaranon C, Jiraporncharoen W, Chenthanakij B, Doyle P, Nitsch D. Urban environments and obesity in southeast Asia: a systematic re view, meta-analysis and meta-regression. PloS one. 2014;9(11):e113547.
2. Di Cesare M, Sorić M, Bovet P, Miranda JJ, Bhutta Z, Stevens GA, et al. The epidemiological burden of obesity in childhood: a worldwide epi demic requiring urgent action. BMC Med. 2019;17(1):212.
3. Stigler MH, Arora M, Dhavan P, Shrivastav R, Reddy KS, Perry CL. Weight-related concerns and weight-control behaviors among overweight adolescents in Delhi, India: a cross-sectional study. Int J Behav Nutr Phys Act. 2011;8:9.
4. Albashir AAD. The potential impacts of obesity on COVID-19. Clin Med (Lond). 2020;20(4):e109-e13.
5. Nogueira-de-Almeida CA, Del Ciampo LA, Ferraz IS, Del Ciampo IR, Contini AA, Ued FdV. COVID-19 and obesity in childhood and adoles cence: a clinical review. Jornal de Pediatria. 2020;96:546-58.
6. Ruiz-Roso MB, de Carvalho Padilha P, Mantilla-Escalante DC, Ulloa N, Brun P, Acevedo-Correa D, et al. Covid-19 confinement and changes of adolescent's dietary trends in Italy, Spain, Chile, Colombia and Brazil. Nutrients. 2020;12(6):1807.Spain, Chile, Colombia and Brazil. Nutrients. 2020;12(6):1807.
7. UNICEF. U Report. Karimen León and Juan Pablo Arguello, Effect of the COVID-19 pandemic on adolescent and youth nutrition and phys ical activity. 2021 [Available from: https://www.unicef.org/lac/en/ef fects-of-covid-19-pandemic-on-adolescent-and-youth-nutrition-and-phys ical-activity 1. Angkurawaranon C, Jiraporncharoen W, Chenthanakij B, Doyle P, Nitsch

8. Carayanni V, Vlachopapadopoulou E, Koutsouki D, Bogdanis GC, Psaltopoulou T, Manios Y, et al. Effects of Nutrition, and Physical Activ ity Habits and Perceptions on Body Mass Index (BMI) in Children Aged 12-15 Years: A Cross-Sectional Study Comparing Boys and Girls. Chil dren (Basel). 2021;8(4).
9. Nations. FaAOotU. Maintaining a Healthy Diet during the COVID-19 pandemic. 2020 [Available from: https://www.fao.org/3/ca8380en/ca8380en.pdf.
10. Shah P, Misra A, Gupta N, Hazra DK, Gupta R, Seth P, et al. Improve ment in nutrition-related knowledge and behaviour of urban Asian Indian school children: findings from the 'Medical education for chil dren/Adolescents for Realistic prevention of obesity and diabetes and for healthy aGeing'(MARG) intervention study. British Journal of Nutri tion. 2010;104(3):427-36.
11. WHO. Physical Activity 2021 [Available from: https://www.who.int/news-room/fact-sheets/detail/physical-activity.
12. Tandon PS, Zhou C, Johnson AM, Gonzalez ES, Kroshus E. Association of children's physical activity and screen time with mental health during the COVID-19 pandemic. JAMA Network Open. 2021;4(10):e2127892-e.
13. Abdeyazdan Z, Moshgdar H, Golshiri P. Evaluating the effect of lifestyle education based on health belief model for mothers of obese and over weight school-age children on obesity-related behaviors. Iranian journal of nursing and midwifery research. 2017;22(3):248.
14. James DC, Pobee JW, Brown L, Joshi G. Using the health belief mod el to develop culturally appropriate weight-management materials for African-American women. Journal of the Academy of Nutrition and Di etetics. 2012;112(5):664-70.

15. Keshani P, Hossein Kaveh M, Faghih S, Salehi M. Improving diet quality among adolescents, using health belief model in a collaborative learning context: a randomized field trial study. Health Educ Res. 2019;34(3):279-88.
16. Rawal T, van Schayck OC, Willeboordse M, Arora M, Bhaumik S, Bhagra A, et al. How to promote a healthy lifestyle among schoolchil dren: Development of an intervention module (i-PROMISe). Public Health in Practice. 2022:100262.
17. Hayashi F, Takemi Y. Why Is Creating a Healthy Food Environment So Crucial to Making Improvements in Diet-Related NCDs? J Nutr Sci Vita minol (Tokyo). 2015;61 Suppl:S36-8.
18. Arora M, Nazar GP, Gupta VK, Perry CL, Reddy KS, Stigler MH. Asso ciation of breakfast intake with obesity, dietary and physical activity behavior among urban school-aged adolescents in Delhi, India: results of a cross-sectional study. BMC Public Health. 2012;12(1):1-12.
19. Arora M, Mathur C, Rawal T, Bassi S, Lakshmy R, Nazar G, et al. Socio economic differences in prevalence of biochemical, physiological, and metabolic risk factors for non-communicable diseases among urban youth in Delhi, India. Preventive medicine reports. 2018;12:33-9.
20. Boukrim M, Obtel M, Kasouati J, Achbani A, Razine R. Covid-19 and Confinement: Effect on Weight Load, Physical Activity and Eating Be havior of Higher Education Students in Southern Morocco. Ann Glob Health. 2021;87(1):7.
21. Rawat D, Dixit V, Gulati S, Gulati S, Gulati A. Impact of COVID-19 out break on lifestyle behaviour: A review of studies published in India. Dia betes Metab Syndr. 2021;15(1):331-6.
22. Brown T, Moore TH, Hooper L, Gao Y, Zayegh A Ijaz S, et al. Inter ventions for preventing obesity in children. Cochrane Database of Sys

tematic Reviews. 2019(7).
23. Sarwer DB, Polonsky HM. The psychosocial burden of obesity. Endocri nology and Metabolism Clinics. 2016;45(3):677-88.
24. Rose T, Barker M, Jacob CM, Morrison L, Lawrence W, Strömmer S, et al. A systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents. Journal of Adolescent Health. 2017;61(6):669-77.
25. Sahota P, Christian M, Day R, Cocks K. The feasibility and acceptability of a primary school-based programme targeting diet and physical activi ty: the PhunkyFoods Programme. Pilot and feasibility studies. 2019;5(1):1-15.
26. Janssen I, Lopez-Olmedo N, Tania Aburto B. Impact of a school-based intervention program on obesity risk factors in Mexican children. CHILDHOOD OBESITY PREVENTION INTERVENTION AND POLI CY IN THE MEXICAN SCHOOL SYSTEM. 2013:108.
27. Rajmil L, Hjern A, Boran P, Gunnlaugsson G, Kraus de Camargo O, Raman S. Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a narrative review. BMJ Paediatr Open. 2021;5(1):e001043.
28. Saxena R, Gupta V, Rakheja V, Dhiman R, Bhardawaj A, Vashist P. Life style modification in school-going children before and after COVID-19 lockdown. Indian J Ophthalmol. 2021;69(12):3623-9.
29. Sidor A, Rzymski P. Dietary choices and habits during COVID-19 lock down: experience from Poland. Nutrients. 2020;12(6):1657.
30. Ruíz-Roso MB, de Carvalho Padilha P, Matilla-Escalante DC, Brun P, Ulloa N, Acevedo-Correa D, et al. Changes of physical activity and ul tra-processed food consumption in adolescents from different coun tries during Covid-19 pandemic: An observational study. Nutrients.

2020;12(8):2289.

31. Goodyear VA, Boardley I, Chiou S-Y, Fenton SAM, Makopoulou K, Sta thi A, et al. Social media use informing behaviours related to physical ac tivity, diet and quality of life during COVID-19: a mixed methods study. BMC Public Health. 2021;21(1):1333.
32. Dabas A, Seth A. Prevention and management of childhood obesity. The Indian Journal of Pediatrics. 2018;85(7):546-53.

CHAPTER 6

General Discussion

Lifestyle behaviours are established fairly early in life, in childhood and adolescence, and once established, they persist into adulthood (38). The likely reasons for the rising prevalence of obesity and overweight at an early age are physical inactivity and unhealthy dietary practices (39). Therefore, interventions to promote healthy environments and influence healthier lifestyles may be more effective if implemented at an early age, before unhealthy choices become entrenched in an individual's lifestyle. The studies described in this thesis focused on assessing the effect of the iPROMISe Plus intervention on diet and physical activity-related knowledge and behaviour of school-going adolescents in Delhi, India. This discussion section summarizes the main findings of these studies, describes the interpretations of these findings, and sets out directions for future research.

Main findings of this thesis in relation to the present knowledge

Need for a comprehensive school-based intervention

Major barriers to adopting healthy lifestyle practices include the easy availability and accessibility of unhealthy food items and technological resources, including mobile games and computer-based games (Chapter 2). Lack of knowledge and motivation to follow healthy dietary practices and be physically active were seen as serious concerns and barriers. Regular reinforcement of messages focusing on the importance of physical activity and healthy eating habits was considered by teachers and students as an important component for preventing or delaying NCDs in later life (Chapter 2). Results of a study conducted in Australia among adolescents reported limited nutritional knowledge as influencing factors for food choices (40). Another study conducted among young adolescents in Mississippi emphasized that perceived barriers to physical activity were knowledge-related, and access to healthy food is related to the availability of a healthy diet (41). Findings of our cross-sectional study (Chapter 3) emphasized that knowledge and lifestyle behaviours are suboptimal among adolescents in urban settings and lead to either being underweight or excess weight. Out of 1567 study participants, 7.2% were underweight, 61.3% normal, and 31.5% excess in weight. Underweight students showed suboptimal knowledge and unhealthy behaviours. Excessive weight was also associated with incorrect knowledge about

the behaviours causing overweight (RRR 0.7 [0.5–0.9]), and less frequent vegetable intake (RRR 0.7 [0.4–0.9]). Knowledge is an important determinant for behaviour change, however sufficient knowledge alone is often not enough to change behaviour in daily life. Therefore, there is a need to reinforce the information to attain practice healthy behaviours in daily routine. At the same time, home and school environment also plays important role in inculcating and fostering healthy behavior.

Results of a study conducted with 6th-grade students in 20 schools in two Indian cities in 2019 reported that the knowledge of school-going students about a healthy diet and the importance of physical activity was low (42). Results of another study emphasized the need for a school-based diet and physical activity-related interventions to improve school achievements,especially for students with overweight and obesity (43). Thus, these findings highlight the need to employ comprehensive theory-based interventions that target both underweight and excessive weight among adolescents and can effectively encourage children to adopt healthy behaviours and/or refrain from unhealthy ones and promote their overall well-being.

Impact of the COVID-19 pandemic

The COVID-19 pandemic changed the daily lives of many across the globe. From masking mandates and stay-at-home orders to scarcity in supplies and care, instability has been commonplace. This instability has not only brought on concernsfor people's risk for infection but also concerns regarding behaviours that impact the prevalence of lifestyle diseases and risk for others. Along with this abrupt change in daily life, changes in healthy behaviour were also observed. Studies revealed drastic decreases in physical activity frequency and increased meal frequency (44). To assess the impact of the COVID-19 pandemic on the dietary and physical activity-related behaviour of schoolchildren aged between 10 and16 years, a crosssectional study of adolescents from seven randomly selected private schools in Delhi, India, was conducted in 2021 (Chapter 4). Of the 512 students (53% males) who participated in the survey, 39% reported that they have gained weight during the COVID-19 pandemic. There was a significant increase in the number of meals per day ($p=0.005$) and a reduction in physical activity ($p=0.00$) compared to the situation before the pandemic. The percentage of students who played indoor board and computer games increased

from 13% to 46%. Students' gender (p=0.007) and parents' education (mother: p=0.003; father: p=0.025) were significantly associated with physical activity during the pandemic. The proportion of physically active female were higher as compare to the male students. Similarly, students having parents with advanced/professional degree were more physically active. Higher socioeconomic status was significantly associated with the consumption of more than two meals per day. The students who had working fathers with advanced/professional degrees were three times more likely (AOR 3.24, 95% CI [0.91–11.53]) to be physically active and eat a minimum of three major meals per day (AOR 3.21, 95% CI [1.77–5.81]) during the pandemic compared to those whose fathers were unemployed. This study highlights the need for innovative strategies for adolescents and parents to adopt and practice a healthy lifestyle, especially during public health crises, such as the COVID-19 pandemic.

Effectiveness of the comprehensive school-based intervention on diet and physical activity-related knowledge and behaviour

Feedback from earlier studies emphasized the need to develop a comprehensive module including audio-visual resources to promote the importance of healthy dietary practices and being physically active (45). Considering the importance of adopting healthy lifestyle practices at an early age, a comprehensive school-based intervention was developed. The intervention was further refined in consultation with an expert group comprising clinicians, nutritionists, public health professionals, and health communication experts. The need to base the module on a theoretical model of health promotion was a key input. The Health Belief Model (HBM) was considered appropriate because it matched our goal and focused on the prevention of risk factors (unhealthy diet and physical inactivity) related to behaviour initiation by taking into account both individual perceptions, and external cues to action, and individual self-efficacy (Chapter 2). The results of pre-testing the intervention highlight that the intervention was likely to be effective in conveying the importance of healthy lifestyles and is consistent with the literature that HBM is an effective framework for developing health interventions. The findings indicate that the methodology of the study was useful in obtaining input from students and teachers and gauging their

perceptions to guide the development of resources/tools. Following the successful pre-testing of the intervention, a clusterRCT was conducted in randomly selected (n=8) schools to assess the effectiveness of the comprehensive school-based intervention on diet and physical activity-related behaviour of school-aged adolescents during the COVID-19 pandemic (Chapter 6). The findings indicated a positive effect of the intervention on diet and physical activity-related changes in the expected direction, but no significant effects were observed (in the intention-to-treat analysis), probably due to a large dropout among schoolchildren due to various COVID-19 measures, including the closure of educational institutions. Results showed that the intake of vegetables (once a day) in the per-protocol analysis has significantly increased among adolescents in the intervention group compared to the control group. Findings of a study conducted with 400,000 pupils/students from
1600 educational units in Poland, has shown a 20% increase in knowledge in the scope of nutrition and a 5% increase in physical activity through a school-based intervention (46). The effectiveness of another intervention based on the HBM showed improved knowledge and facilitated better eating and activity-related practices in Indian adolescents (47).

Strengths and limitations

The strengths of this study include that schools were randomly selected. The sample size was big with over 1500 participants, and the response rate was high with almost 90% of all eligible participants in schools participating in the study at the baseline. Hence, the study findings are representative of urban school-going adolescents in private schools in Delhi and might be extrapolated to other urban areas in India. The findings may not be representative of rural areas. Another strength of our study was the fact that the survey was conducted during the pandemic. Very few studies have been conducted in India to assess the impact of COVID-19 on the dietary and physical activity-related behaviour of adolescents. However, the study was restricted to one metropolitan city in India, and responses to the questionnaire were self-reported, which might lead to over-reporting or under-reporting of data. Other limitations were the possible recall bias of the participants and the fact that only students who had internet access and who were comfortable completing an online survey using their

device (e.g. mobile phone, computer) participated in the follow-up survey. However, the findings of this study provide valuable insights, i.e. prevention-oriented interventions and strategies that are based on behavioural theory.

Implications (Scientific and Practical)

The school environment has the potential to impact NCD-related behavioural change in children and adolescents. Interventions to advance health literacy in children can encourage healthy eating and have long-term implications later in adulthood. Positive feedback from the participants in the formative study suggests that interactive modules including a short film and follow-up interactive activities can be effective in promoting a healthy lifestyle among children and adolescents in schools. Further evaluation of the intervention using a cluster RCT was useful to assess its effectiveness on knowledge and behaviours related to diet and physical activity of school-going adolescents and upscaling it at the regional and national levels. Given the effect of the COVID-19 pandemic in our study, we recommend a repeat of our RCT in the future to assess the effect of the intervention in schools outside COVID periods. This could further substantiate the evidence for this school-based intervention. However, along with such interventions, there is a need to strengthen policies for fostering an enabling food environment in and around the school for the student of this age group to be motivated for being physically active and healthy.

Policy-makers must recognize that children and adolescents who consume unhealthy diets and follow unfavourable lifestyle behaviours may have long-term health effects including unhealthy weight, which may lead to chronic diseases later in life. Knowledge and behaviours associated with diet and physical activity are vital for weight management.

Therefore, there is a need for effective interventions to battle this unhealthy lifestyle epidemic, such as contextual comprehensive school and community-based targeted interventions. Policies focused on the availability, accessibility, and affordability of healthy food options in and around schools need to be enforced and monitored regularly. Moreover, to foster a supportive environment to improve dietary and physical activity knowledge and behaviour, there is a need to limit advertisements promoting

unhealthy food products. Policies about fostering an enabling environment in and around school need to be created for the student of this age group to be motivated for being physically active. At the same time, we should continue studying influential determinants and effective multi-factorial strategies for reducing overweight and obesity, to battle the steep increase in excessive weight among urban Indian adolescents. This study emphasizes the need for interventions, programmes, and policies for the benefit of adolescents and parents to adopt and practice a healthy lifestyle, including the consumption of nutritious food and greater physical activity, especially during public health emergencies such as the COVID-19 pandemic.

VALORIZATION

In this thesis, we aimed to provide insight into the impact of comprehensive intervention on the dietary practices and physical activity-related knowledge and behavior of school-going adolescents. Below is the summary of the scientific and social impact of this thesis.

Scientific Impact: The scientific impact of this thesis lies mainly in the development and assessing the effectiveness of a comprehensive intervention to improve the dietary practices and physical activity-related knowledge and behavior of school-going adolescents. The intervention development was guided by the principles of the Health Belief Model. The findings suggest that the intervention including audio-visual modules for students and teachers and follow-up interactive activities can be effective in promoting a healthy lifestyle among children and adolescents in schools. This study emphasized that prevention-oriented interventions and strategies that are based on behavioural theory can be used to promote preventive messages. There are very few studies that assessed the impact of the intervention on dietary practices and physical activity-related behaviour during the COVID-19 pandemic. The major challenge that schools faced was increased screen time for students during the COVID-19 Pandemic. Considering the impact of COVID-19, future studies may assess the effect of such interventions on school achievement or cognitive skills of school-going children and adolescents.

Social impact: The research findings described in this thesis are important for different stakeholders to foster a healthy environment in the school setting. . The participation of teachers, school authorities, and family members played an important role in providing a supportive environment for fostering positive behaviours. However, curriculum-based health education regarding the prevention aspects and motivation of the children needs to incorporate sustaining healthy lifestyle practices into their daily lives.

Implementation of results

Children and adolescents should be the primary target groups of health promotion interventions, as they are at an impressionable age and can be motivated to make appropriate adjustment to their behaviour. This is primarily attributed to personal choices, environmental influences, and lifestyle changes. Our intervention was

developed following the guiding principles of the Health Belief Model (HBM), as the intervention was focused on the prevention of risk factors (unhealthy diet and physical inactivity) by taking into account both individual perceptions, and external cues to action, and individual self-efficacy (Chapter 2). The results of pre-testing the intervention highlighted that it was likely to be effective in conveying the importance of healthy lifestyles. The findings indicate that the methodology of the study was useful in obtaining input from students and teachers and gauging their perceptions to guide the development of resources/tools. The intervention included a short animation film for students. It focused on reinforcing healthy lifestyle practices through a character named Super Kid Aryan (https://youtu.be/k3qaucZFHYQ). An informative short film (https://youtu.be/kA_TLtYQ_wc) was developed for teachers on NCDs including diabetes, its prevention, and management. A renowned endocrinologist was used as a resource. A teacher's manual was developed including interactive theme-based activities, comic strips, information on the type, risk factors, consequences, management and prevention of diabetes, region-specific food preparation options to promote healthy eating, and guidelines for schools to promote regular physical activity/exercise and healthy eating. The developed videos contain sections on debunking diabetes myths. (chapter 2). Such educational resources which were co-created in consultation with different stakeholders to advance health literacy in school-going students can encourage healthy eating and have long-term implications later in adulthood. The findings of this study provide valuable insights i.e. prevention-oriented interventions and strategies that are based on behavioural theory can be used to promote preventive messages (Chapter 5) even in public health emergencies like the COVID-19 pandemic. Nonetheless, despite evidence of some positive results of this intervention, efforts are needed to motivate and reinforce healthy lifestyle practices and to foster a healthy environment in daily life.

The result of this thesis will be shared with others in several ways. Three chapters of this thesis have already been published in peer-reviewed journals which are openly accessible online. This thesis will be published online, to make it readable for everyone interested. We will present the results of this thesis at scientific meetings, congress, or webinars.

SUMMARY

Summary

Obesity has been linked to various NCDs such as type 2 diabetes mellitus, and coronary heart disease in previously conducted studies. There is evidence that health-related behaviours adopted at a young age carries over into adulthood and even to subsequent generations. Overweight and obese children and adolescents are more likely to grow up into obese adults, who in turn are at higher risk of developing chronic diseases. Environmental factors including urbanization and lifestyle choices play major roles and are largely a result of practices adopted during early ages. Comprehensive adolescent health promotion measures are crucial for promoting healthy lifestyles and creating an enabling environment for sustainable behavioural change. Such interventions should be evidence-based and tailored to the needs of the community. Over the years, health promotion interventions have evolved due to technological advancements that have integrated new media with traditional communication channels.

We believe that there is a need to develop a comprehensive school-based intervention to foster healthy eating practices and emphasize the importance of being physically active. The same has been emphasised in earlier studies (45, 48). The development of the intervention started with focus-group discussions with students and in-depth interviews with teachers to understand the needs of the school-age youth. Our research question was to assess the effectiveness of the comprehensive school-based intervention on diet and physical activity-related behaviour of school-going adolescents during the COVID-19 pandemic. We hypothesized that the intervention would lead to a significant increase in the dietary and physical activity-related behaviours of the students in the intervention group after two years, compared to the control group. Chapter 2 describes the process of developing the comprehensive intervention based on the Health Belief Model (HBM), which has been well documented as an appropriate model for intervention development. The intervention development was guided by an expert group comprising a public health practitioner, a nutritionist, and communication professional. The intervention was pre-tested with the target audience (school-going students and teachers) to understand the acceptability of the intervention. Quantitative data at the baseline confirmed the need to implement the intervention to improve the knowledge and behaviour of school-going adolescents,

especially in urban settings. Chapter 3 assesses the prevalence of excessive weight and underweight and its associated dietary and physical activity-related knowledge and behaviours among the urban private school-going adolescents (aged 11–12 years) in Delhi. The secondary objective was to study the correlates of BMI status – underweight, normal, excessive weight – with dietary and physical activity knowledge and behaviours among these participants. These outcomes were important for understanding whether the planned cluster RCT was justified. The planned trial was the iPROMISe Plus, performed over two years (2019–2021). In 2020, the outbreak of COVID-19 brought the whole world to a standstill. Considering the measures to contain the spread of COVID-19 infection and mitigate the pandemic risks, educational institutions were closed and school-age children were confined to their homes, posing an unprecedented challenge to their education and natural growth. It has greatly affected the lives of adolescents through restrictions such as less playtime, more screen time, and limited interaction with peers. Chapter 4 evaluates the impact of the COVID-19 pandemic on the dietary and physical activity-related behaviour of school students. The secondary objective was to determine the factors that influenced physical activity and diet-related behaviour among adolescents during the COVID-19 pandemic. Chapter 5 describes the effects of the iPROMISe Plus intervention. The findings indicated that the intervention resulted in changes in the expected direction, but no significant effects were observed in the intention-to-treat analysis, probably due to reduced follow-up among schoolchildren due to COVID-19 measures, including the closure of educational institutions. Results showed that the intake of vegetables (once a day) in the per-protocol analysis has significantly increased among adolescents in the intervention group compared to the control group. This result highlighted that the comprehensive iPROMISe Plus intervention including the involvement of school staff and parents might be effective in improving diet-related behaviour. Along with such interventions, policies should be strengthened to create a stimulating environment in and around the school such that students of this age group are enticed to be more physically active and aware of healthy eating.

ABOUT THE AUTHOR

About the Author

Tina Rawal completed her schooling in four different states of India. She has completed graduation (B.Sc.; Hons) and post-graduation (M.Sc.) from Delhi University with distinctions in subjects - Food Science, Biochemistry, and Microbiology. She has qualified for the NET-Exam of UGC for the fulfillment of the eligibility–appointment for Lecturer-Ship in 2008. She also completed the Bachler of Education (B.Ed.) from Delhi University and a post-graduate diploma (DL) in epidemiology from the Indian Institute of Public Health (IIPH). She has been working in the field of nutrition and public health for more than 15 years, including establishing and managing various health programmes for the prevention and management of non-communicable diseases (NCDs) and associated risk factors. At present, she is working as Research Scientist at the Health Promotion Division of the Public Health Foundation of India (PHFI). She has been associated with PHFI since 2013. Before joining PHFI, she worked with HRIDAY (Health Related Information Dissemination Amongst Youth) managing school health programs for NCDs prevention and management from 2008 and worked as a senior Dietician at Indraprasth Hospitals for more than three years.

PUBLICATIONS

- Bassi S, Rawal T, Nazar GP, Dhore PB, Bhatt AA, Deshpande SR, Unnikrish nan AG, Arora M. Empowering Accredited Social Health Activist (ASHA) in a rural communities of Pune (Maharashtra): Process evaluation of a commu nity-based intervention for diabetes care. International Journal of Noncommu nicable Diseases. 2022 Apr 1;7(2):63.
- Rawal T, Mishra VK, Sharda SG, Sharma K, Mehta R, Kulkarni MM, Goel S, Arora M. Impact of closure of educational institutions due to COVID-19 lockdown on overall subjective wellbeing of adolescents and youth: Cross-sectional survey, India. Front Psychol. 2022 Aug 12;13:903044. doi: 10.3389/fpsyg.2022.903044. PMID: 36033008; PMCID: PMC9415378..
- Rawal T, van Schayck OC, Willeboordse M, Arora M, Bhaumik S, Bhagra A, Bhagra S, Muris JW, Tandon N. How to promote a healthy lifestyle among schoolchildren: Development of an intervention module (i-PROMISe). Public Health in Practice. 2022 Apr 28:100262.
- Rawal T, Muris JWM, Mishra VK, Arora M, Tandon N, van Schayck OCP. Impact of the COVID-19 Pandemic Measures on the Number of Meals and the Types of Physical Activity of Adolescents: Cross-Sectional Study in Delhi, India. Recent Progress in Nutrition 2022;2(1):15; doi:10.21926/rpn.2201010.
- Rawal T, Kathuria P, Shrivastav R, Bassi S, Chugh A, Joshi N, Mehta R, Arora M. Meaningful Engagement of Adolescents Through Global Youth Meet on Health 2021. J Adolesc Health. 2022;70(1):167-8 https://www.ncbi.nlm.nih.gov/pubmed/34930567
- Nazar, G.P.; Arora, M.; Gupta, V.K.; Rawal, T.; Chugh, A.; Shrivastava, S.; Dhore, P.; Bhatt, A.; Deshpande, S.R.; Unnikrishnan, A. The impact of project diabetes with dignity intervention on knowledge and quality of life among adults with diabetes in a rural Indian setting. International Journal of Noncommunicable Diseases 2021, 6, 129
- Afaq S, Upho E, Borle AL, Brown JV, Coales K, Dawson S, Elduma AH, Iqbal M, Jarde A, Koly KN, Murthy NSrinivas, Rahman FN, Rajan S, Rana R, Rawal T, Siddiqi N, Zavala GA. Behavioural activation therapy for anxiety disorders in adults (Protocol). Cochrane Database of

Systematic Reviews 2021, Issue 11. Art. No.: CD015026.

- Rawal T, Willeboordse M, Arora M, Sharma N, Nazar GP, Tandon N, van Schayck CP. Prevalence of Excessive Weight and Underweight and Its Associated Knowledge and Lifestyle Behaviors among Urban Private School-Going Adolescents in New Delhi. Nutrients. 2021;13(9):1-12 https://www.ncbi.nlm.nih.gov/pubmed/34579174
- Rawal T, Bhaumik S, Shrivastav R, Nazar GP, Tandon N, Arora M. Kids and Diabetes in Schools (KiDS) intervention in India: Participants' perspectives. Health Education Journal. 2021 Mar 28:00178969211005499.
- Nazar GP, Arora M, Sharma N, Shrivastava S, Rawal T, Chugh A, Sinha P, Munish VG, Tullu FT, Schotte K, Polansky JR. Changes in tobacco depictions after implementation of tobacco-free film and TV rules in Bollywood films in India: a trend analysis. Tobacco Control. 2021 Jul 26.
- Amanda Mason-Jones, Marlon Freeman, Tina Rawal, Shalini Bassi, Theo Lorenc, Monika Arora. Peer-based interventions to improve adolescent health: an overview of systematic reviews. PROSPERO 2017 CRD42017076290 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42017076290
- Rawal T, Shrivastav R, Nazar GP, Tandon N, Arora M. A school-based pro gram for diabetes prevention and management in India – project Kids and diabetes in schools. Int J Non- Commun Dis 2020; 5:107-13.
- Arora M, Nazar GP, Chugh A, Rawal T, Shrivastava S, Sinha P, Munish VG, Tullu FT, Schotte K, Polansky JR, Glantz SA. Tobacco imagery in on-demand streaming content popular among adolescents and young adults in India: Implications for global tobacco control. Tob Control. 2020Apr 9. doi: 10.1136/tobaccocontrol-2019-055360.
- Nazar, G. P., Arora, M., Gupta, V. K., Rawal, T., Yadav, A., Kannuri, N. K. ... Webster, P. (2019). Adolescent and adult perceptions of the effects of larger size graphic health warnings on conventional and plain tobacco packs in India: A community-based cross-sectional study. Tobacco Induced Diseases, 17(October), 70.

- Bassi S, Gupta VK, Park M, Nazar GP, Rawal T, Bhaumik S, et al. (2019) School policies, built environment and practices for noncommunicable disease (NCD) prevention and control in schools of Delhi, India. PLoS ONE 14(4): e0215365.
- Chinnici D., Middlehurst A., Tandon N., Arora M., Belton A., Franco D.R., Bechara G.M., Rawal T., Shrivastav R., Sung E. and Germe M., 2018. Improving the School Experience of Children with Diabetes: Evaluation of the KiDS Project. Journal of Clinical & Translational Endocrinology.
- Arora, M., Mathur, C., Rawal, T., Bassi, S., Lakshmy, R., Nazar, G. P., Kinra, S. (2018). Socioeconomic differences in prevalence of biochemical, physio logical, and metabolic risk factors for non-communicable diseases among urban youth in Delhi, India. Preventive Medicine Reports, 12, 33–39.
- Yadav A, Nazar GP, Rawal T, Arora M, Webster P, Grills N. Plain packaging of tobacco products: the logical next step for tobacco control policy in India. BMJ Global Health
- Saluja K, Rawal T, Bassi S, Bhaumik S, Singh A, Park MH, Kinra S, Arora M. School environment assessment tools to address behavioural risk factors of non-communicable diseases: A scoping review. Preventive Medi cine Reports. 2018 Jan 31.
- Tarun S, Arora M, Rawal T, Benjamin Neelon SE. An evaluation of outdoor school environments to promote physical activity in Delhi, India. BMC Pub lic Health. 2017; 17:11.

Major abstracts from Conferences

- Tina Rawal, Soumyadeep Bhaumik, Anjali Bhagra, Sumit Bhagra, Monika Arora. PO550 Project I-Promise: Development of a Comprehensive Module to Promote Healthy Lifestyle Among School Children Using a Theory Based Model. Global Heart. 2018; 13:494-5
- Tina Rawal; Gaurang P. Nazar; Radhika Shrivastav; Monika Arora. Monitoring of implementation of India's Smoke-free Movie Rules by youth. 12th APACT organized at Bali, Indonesia, from 13 to 15 September

2018. (Abstract selected for oral session)

- Tina Rawal, Gaurang P Nazar, Sindhu Ravishankar, Amit Yadav, Nathan Grills, Premila Webster, Monika Arora. Perceived effectiveness of larger graphic health warnings and plain packaging among urban and rural adolescents and adults, India. 17th World Conference on Tobacco or Health, March 7-9, 2018
- Tina Rawal, Radhika Shrivastav, Shikha Bhasin, Monika Arora, On behalf of KiDS Advisory Committee. Project KiDS (Kids and Diabetes in Schools) in India: an evaluation to support scaleup. 6th Annual PHFI Research Symposium, 16th– 18th March 2016
- Tina Rawal, Gaurang Nazar, Abhinav Bassi, Radhika Shrivastav, Kiran Saluja, David Chaney, Monika Arora. A School Based Program for the Prevention and Management of Diabetes –Project KiDS. 5th Annual PHFI Research Symposium, 11th – 13th March, 2015
- Nikhil Tandon, Kiran Saluja, Tina Rawal, Radhika Shrivastav, David Chaney, Monika Arora, Daniela Chinnici, Maeva Germe, on behalf of the KiDS Advisory committee. Profiling Project KiDS: Kids and Diabetes in School. 6th World Congress on Diabetes in Chennai, 9th – 12th April 2015
- Rawal T, Singh A, Nazar G, Saluja K, Bassi S, Park M, Arora M. Impact of School Policies on NCD Risk Factors-A Systematic Review. Asia-Pacific Journal of Clinical Oncology 2014 Dec 1 (Vol. 10, Pp. 242-243). 111 River St, Hoboken 07030-5774, NJ USA: Wiley-Blackwell.
- Saluja K, Bassi S, Singh A, Rawal T, Nazar GP, Park M, Arora M. Systematic Review of School Environment Assessment Tools (Sea). Asia-Pacific Journal of Clinical Oncology 2014 Dec 1 (Vol. 10, Pp. 244-244). 111 River St, Hoboken 07030-5774, NJ USA: Wiley-Blackwell.
- Abhinav Bassi, Radhika Shrivastav, Nikunj Sharma, Tina Rawal, Monika Arora. Engaging policy makers, civil society and youth for Prevention and control of cancer and other NCDs in India. Asia-Pac J Clin Oncol 2014; 10(Suppl. 9): 1–264

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