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MAPPING NUTRITIONAL INTERVENTIONS FOR LIFESTYLE MODIFICATION AMONG SCHOOL ADOLESCENTS: A SCOPING REVIEW

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ABSTRACT:
In the realm of adolescent health, evidence-based nutritional interventions for lifestyle modification are increasingly recognized as crucial. This scoping review maps the range of such interventions among school adolescents, providing an overview of current strategies, research gaps, and opportunities for enhancing their effectiveness. The review adhered to the PRISMA-ScR checklist for transparency and comprehensive documentation of the methodology. A systematic search was conducted across PubMed, Cochrane Library, Taylor & Francis databases, and Google Scholar for literature on lifestyle modification through nutritional interventions among school adolescents. Two reviewers independently screened titles and abstracts for relevance using predefined criteria. Data extracted included author, title, year of publication, region, and document type. The findings underscore the complexity and interconnectivity of various factors influencing adolescent health, ranging from individual behaviors to broader socioeconomic and environmental contexts. Key insights reveal that while numerous interventions have demonstrated effectiveness in improving specific health outcomes, there remains significant variability in their design, implementation, and overall impact. The review highlights that there is paucity of good quality literature from LMIC. There is need for future research to identify cost effective , multisectoral approaches involving latest technology to bring about sustained behaviour change.

Key Words: School adolescents, nutrition, Lifestyles

INTRODUCTION

Background:

In the realm of adolescent health, the importance of evidence-based nutritional interventions for lifestyle modification is increasingly recognized (1)(2). Adolescence is a critical period for promoting healthy dietary habits that can have long-term impacts on health and well-being(3). Various school based interventions and community-based programs, have shown promise in

improving adolescents' dietary behaviors and physical activity levels (4)(5). Understanding adolescents' perceptions of sustainable diets and barriers to adopting them is crucial for designing effective interventions that resonate with this age group(6). By mapping the range of nutritional interventions and their effectiveness among school adolescents, this scoping review aims to provide a comprehensive overview of current strategies, research gaps, and opportunities for enhancing lifestyle modifications in this important demographic group.

Objectives: The primary objective of the review was to examine the extent, range and nature of available research on lifestyle modifications through healthy dietary practices among school going adolescents between Jan 2019 to July 2024 and to identify research gaps in the literature to aid planning and commissioning of future research.

METHODS

Protocol

The reporting of this review adhered to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) checklist to ensure transparency and comprehensive documentation of the methodology(7). This scoping review has not been registered as it did not include any hypothesis or meta-analysis

Data sources and search strategy

We conducted a systematic search of the PubMed, Cochrane Library, Taylor & Francis databases as well as Google Scholar for articles about lifestyle modification through nutritional interventions among school adolescents. The search query was structured by identifying the keywords and synonyms. Identified keywords and synonyms were as follows.

Table 1: Keywords & synonyms used for literature search

Key words	Synonyms
Lifestyle modification	Lifestyle behaviour, healthy behaviour, healthy choices, , lifestyle approach, obesity
Diet	Nutrition, food choices
Adolescents	School adolescents, adolescents, teenagers, teens, students, young adults, youth, children, boys,girls,juvenile, youngsters
School	University, institutuion

Search results

A purposive literature search using the keywords and synonyms yielded the following results
Search results according to Boolean Operators,

("life style"[All Fields] OR "healthy behaviour"[All Fields]) AND (y_5[Filter]) AND **((Diet*) OR (nutrition*)) OR (food) Filters: in the last 5 years AND** (adolescents) OR ("young adults") Filters: in the last 5 years ("life style"[All Fields] OR "healthy behaviour"[All Fields]) AND (y_5[Filter]) AND **((Diet*) OR (nutrition*)) OR (food) Filters: in the last 5 years AND** (adolescents) OR ("young adults") Filters: in the last 5 years AND school Filters: in the last 5 years

Study Selection and Screening

Two reviewers (HM and FP) independently screened the titles and abstracts of the documents for relevance. We used the following criteria for screening as shown in table 4. For the selection of the relevant studies, all the titles and abstracts generated from the searches were examined. The articles were rejected on initial screening if the title and abstract did not meet the inclusion criteria or the exclusion criteria. If abstracts did not provide enough exclusion information or were not available, then the full text was obtained for evaluation. The evaluation of the full text was done to refine the results using the following inclusion and exclusion criteria. Thus, those studies that met predefined inclusion criteria were selected for this review.

PICOS Criteria		Inclusion Criteria	Exclusion Criteria
P	Participants	Adolescents (10 to 19 years) population , both sexes ,	Adolescents with special needs, vulnerable or marginalized groups
I	Intervention	Nutritional Interventions with focus on behaviour change	Interventions offering School meals, market involvement e.g. fruits n vegetables, only parent based interventions
C	Comparisons	-	
O	Outcome	Behaviour change regarding diet , Obesity reduction	
S	Studydesign	Systemetic reviews /meta analysis or multi centered study,Randomized controlled Trials	

If the two reviewers disagreed about the relevance of a document, or if either reviewer was uncertain about its relevance, the document was jointly discussed by the reviewers to achieve consensus. A small number of documents for which we did not reach a consensus were retained for full document review.

Data Extraction /Charting:

During the full-text review, we extracted the following data about the study characteristics: author, document title, year of publication, region (US/Europe, Africa, Asia, Latin America), document type (systematic review, interventional study , impact evaluation, etc.). For categorization and reference, the selected articles were imported into Endnote referencing software.

We extracted the information about study population and sample size, the type of intervention (mode of delivery; name or description of any tools or aids used), and key findings. For the key findings, we used the effect measures as reported in the document (e.g., odds ratios, and percentage differences). One reviewer collected data from each report, which was subsequently checked by the second reviewer. No bias assessment was conducted.

The review team developed and piloted a data charting form to extract relevant information from included studies. Key data items included:

- Study characteristics (author, year, country, setting)
- Population characteristics (sample size , demographics, setting)
- Description of interventional strategies
- Outcomes of interventions
- Limitations and recommendations
- Quality of the included studies by applying Qualisys criteria

Two reviewers performed data extraction independently, with regular meetings to discuss and resolve any discrepancies.

Qualsyst Criteria

This is a typical strategy for promoting repeatability and providing a quantitative means of measuring the quality of research across a wide range of study designs. This will help in reporting the quality standard of included studies. (Kmet, Cook, & Lee, 2004)

Data Synthesis

The data were synthesized using a narrative approach, categorizing the nutritional interventions for lifestyle modification of adolescents across studies. A thematic analysis was conducted to identify common themes and gaps in the literature. The results were presented in the form of tables to provide a comprehensive overview of the findings.

PRISMA (Preferred Reporting Items for Systemic Review and Meta-Analysis)

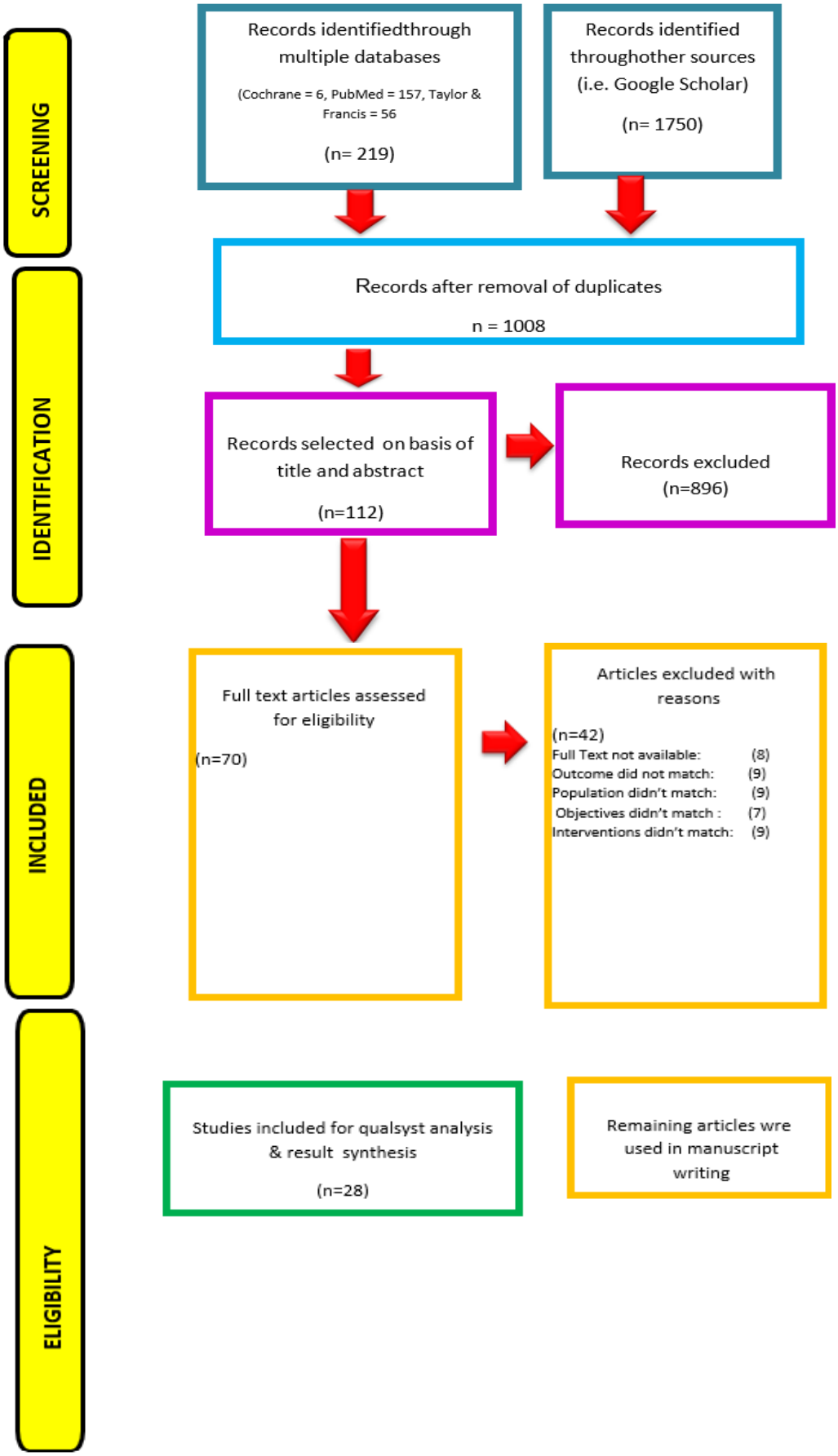

Figure 0-1:: PRISMA 2009 categorization

DATA SYNTHESIS AND RESULTS :

The data were synthesized using a narrative approach . A thematic analysis was conducted to identify common themes and gaps in the literature. The results were presented in the form of tables to provide a comprehensive overview of the findings. The following themes emerged ,

1. Adolescents Lifestyles in LMIC

In a Systematic Review consisting of Eleven publications (qualitative) , Leandro et al. concludes that determinants of obesity among adolescents were poor diet as well as physical inactivity. Identified factors include skipping meals, consumption of fast food and soft beverages, poor intake of legumes, and vegetables, along with sedentary lifestyles and little physical activity, These findings could contribute to a better understanding of the growing issue of childhood overweight and obesity in developing nations, where the focus is typically solely on preventing under nutrition(8).

In the review comprising of 15 articles , with studies conducted in schools on a sample of 10651 students Imtiaz et al, , concludes that the prevalence of PA among school adolescents in Pakistan is quite low and stressed on the need of formal interventions for lifestyle modification among adolescents for improving health and for reducing future burden of NCDs (9) . In another study for LMIC by Solimen et al. suggested that for improving adolescent nutrition a social marketing approach and behaviour change communication is required along with adolescent friendly health services (10).

2. Lifestyle Modification through behaviour change Intervention in adolescent and children

A considerable number of systematic reviews have discussed the role of various intervention for change in dietary behaviours of adolescents. A systematic review and meta analysis of RCTs by (11) comprising of 54 studies on 16383 adults highlights the potential of behavioural interventions to improve fruit and vegetable of young adults for habit formation intake but was less convincing for other dietary outcomes. Nutritional interventions to change dietary behaviours of adolescents are quite effective, especially combined interventions including physical activity and nutrition(12). Similar findings have been reported by other high quality reviews (13), (14) (15).

In a review of reviews in two meta-analyses came to conclusion that exercise lowered BMI scores. However, the remaining three investigations reported that physical activity interventions were either ineffective or, at most, had only modest benefits in preventing overweight and obesity among adolescents. The review was of moderate quality (16), Similar findings were reported in another good quality review (17). There is limited evidence of quite a low quality available from LMIC (18) (10)

3. School health interventions for lifestyle modifications

(19)conducted a systematic review comprising of 24 articles (and 11 articles in meta-analysis) to evaluate the effects of school-based food and nutrition education interventions on food consumption of adolescents based on behaviour change communication models. Most studies (67%) performed the intervention with more than one component. Interventions based on food and nutrition education among school adolescents showed good results in the food consumption with significant improvement in vegetable intake.

Similarly in their reviews (20) and (21) investigated the effectiveness of school-based food and nutrition interventions on health outcome through improving children's dietary behaviour and health and finally body composition . The effect size was dependent on the design of the intervention.

(22) in Indonesia conducted a pre-post design study aimed to evaluate the changes in knowledge, attitudes, and behaviors among school-going adolescents through multicomponent intervention. The package of interventions was found to be associated with greater knowledge, overall, and changes in physical activity and nutritional behaviors. (23) conducted a Systematic Review & Meta Analysis on digital interventions for universal health promotion in school-aged children, in which 74

randomized controlled trials and quasi experimental studies were included. Digital interventions were found to be useful for increasing fruit and vegetable consumption .
(24) conducted a retrospective correlation study in Hongkong. The aim of the study was to identify the key indicators for implementation of Health Promoting initiatives in School by analyzing the findings of the school health profile based on the structured framework of Hong Kong Healthy School Award Scheme (HKHSA) that covers six key areas (healthy policies, physical environment, social environment, community links, action competencies for healthy living, and school health care and promotion services) suggested by WHO Guidelines. It concluded that nutrition knowledge transmitted through traditional means alone might not be sufficient to make sensible food choices , adolescents also need a supportive and enabling physical and social environment . (25) conducted a non-randomized controlled interventional study, in selected schools on an urban area of West Bengal, India The study showed the effectiveness of health promotion intervention for healthy dietary practices .

4. E-Health nutritional Interventions

(26)conducted a systematic review and meta analysis aimed at E-health interventions that target children or agents of change (parents or careers) Studies also covered a variety of e-health intervention delivery methods (such as SMS, WhatsApp, wearable sensors, telemedicine, mobile apps, social media, emails, active video games, and web-based software). Eight of the 19 included studies reported significant results .The majority of the studies in this systematic review, which only included RCTs and classified the studies as high-quality, indicated that use of e-health for treating childhood and teenage obesity and overweight were quite effective.
In a systematic scoping review comprising of 42 eligible studies on children or adolescents with overweight or obesity by (27) aimed to synthesize the evidence regarding mobile health (mHealth) for the treatment of childhood overweight and obesity and to map the breadth of literature in this field. They concluded that there is a need for generating further high quality evidence in this field which employ valid outcome measures.
Another Review comprising of 22 publications assessed 16 interventions, including 18 873 students by (28) aimed to assess the effectiveness of eHealth school-based interventions targeting multiple lifestyle risk behaviours. However, effects were small and mostly short term. Whereas a systematic review & meta analysis by (29) comprising of RCTs (11 studies) on Adults (18 years +) showed the long term effectiveness of internet-based interventions on health related behaviors in adults . According to a systematic review & meta analysis by (23) in high income countries , digital-based interventions resulted in a small but significant uptake in fruit and vegetable consumption, and a small but significant reduction in both body fat percentage and sedentary behavior.

5. Behavior change theories for lifestyle modification

As per (4) constituting 14 articles Trans Theoretical Model used alone or combined with other behavior change theories seems to be a successful strategy for improving dietary intake in adolescents. Its application in different contexts shows that the TTM is flexible and therefore can be implemented in many settings. The use of the model is shown to be restricted to the stage of change' construct.
In a study (30) used HBM as a framework for targeting determinants of 7dietary behavior, the intervention was performed in a collaborative learning context during the educational year .All HBM's constructs and knowledge had significantly improved in the experimental group and mean differences were increased after the intervention. Findings of this study support the use of appropriate educational techniques such as collaborative learning methods that will help to implement behavioral theories/models to increase the effectiveness of theory-based educational interventions.

Discussion

1. Adolescents Lifestyles in LMIC

In a high quality systematic review Leandro et al(8) , identified that the main things that prevented people from controlling their weight increased consumption of fast food, snacks and sugary drinks and eating less fruit and vegetable along with being inactive. The ability to control body weight growth was facilitated by modifications to eating patterns, perceptions of eating healthily, physical activity, and participation in lifestyle modification programs One of the review's limitations is the limited number of relevant studies, which might not accurately describe the issue of teenage obesity and overweight in all lower-middle income nations. Furthermore, six out of the eleven studies that were reviewed came from India, which complicates cross-cultural comparisons. A precise interpretation of the data was not possible due to the variations in the methods employed throughout the 11 studies (self-report, focus groups, food frequency questionnaires, and 24-hour recall) (8)

Soliman et al, suggested that strategies for improving adolescent nutrition should address behaviour modification using a social marketing approach, behaviour change through communication and mobilizing families and communities and intersectoral linkages at community level and with adolescent friendly health services. Though the review was of very low quality , there were no mention of search strategy but it was included because limited research is available in LMIC. However publication bias is a serious limitation and could have affected the summary of the literature and the conclusions reached(10).

In a moderate quality review by Imtiaz et al, recommends that there is need of research through objective measures on adolescent lifestyles as the biggest limitation of the review was non availability of high quality studies . Moreover, the studies' inability to account for significant confounding variables restricted the applicability of findings(9). Same has been discussed in Lancet strategic paper for prevention of NCD (31).

2. Lifestyle Modification through Behaviorial Interventions in adolescent and children

Very high quality evidence by Ashton et al suggests that future research should include a checklist of specific BCTs in order to better understand link of BCT to intervention efficacy. It would help in designing intervention , based on a solid evidence . This will also help develop effective and replicable interventions, nutritional guidelines and policies . The review had the limitation that only studies in English were included in it and long term effectiveness of BCT was not taken into consideration (32)

Another very high quality evidence in a systematic review has been published by Psaltopoulou et al ,. It comprised of 66 meta-analyses of interventional studies corresponding to more than 900,000 children and adolescents. It covered a wide range of potential approaches to combat childhood and teenage obesity. Results show that nutritional interventions to change dietary behaviours of adolescents are quite effective, especially combined interventions including physical activity and nutrition. Methodological issues and potential publication bias were the reported limitations of the review. As a result, future research should address this issue to identify the most successful age-appropriate interventions and identify any potential differentiations in the outcomes. (12)

There is a mismatch between the risk of NCDs in vulnerable populations and the evidence available to inform policy and practice regarding feasible and effective, despite substantial global efforts to curb overweight and obesity. Based on the good quality reviews of systematic review of, it is recommended that better quality evidence must be generated for informed policy making. It should be highlighted that two of the three reviews that focused on physical activity interventions also included diet/nutrition and physical activity components. It is unable to properly compare intervention components across reviews due to the absence of differentiation between combination and single interventions (33).

It is worth noting that there was hardly any evidence from LMIC for nutritional interventions for dietary modifications aiming at weight management . A review of excellent quality and another of low quality reported that most of studies by LMIC are about therapeutic interventions for malnutrition (18) (10). Soliman recommended that suggested strategies for improving adolescent

nutrition include food fortification and dietary modification using behaviour change communication which should include mobilization of families and communities through intersectoral linkages, though the quality of evidence was quite poor. Salam et al. reports the paucity of data from LMIC regarding large-scale programs for effectiveness of nutritional in teens (18) (34). Similarly , in another Systematic Review of very high quality by Salam et al., comprising of 654 studies, it was noted that the majority of the studies (81%) were from HIC while only 2% of the studies were conducted in LMICs, concludes that there is lack of research on obesity prevention and management especially from LMICs, despite the fact that burden of obesity is increasing. This review recommended that future research in this area should focus on combinations of interventions with a suitable follow-up duration, including data from LMICs (34).

3. School health interventions for lifestyle modifications

(19) in a high quality evidence highlighted that there is need for new interventions and also of the strategies that focus on sustainability of changes in behavior regarding healthy food choices to foster healthy eating habits in adulthood. One of the limitation of the review was that it included interventions in which food consumption was estimated using a food frequency questionnaire or 24 h dietary recall, thus increasing the potential for measurement error and selective underestimation or overestimation of intake, which may compromise the validity of the questionnaire.

The study by (20) which is a moderate quality evidence suggests that applying multicomponent interventions (environmental, educational, and physical strategies) along with parental involvement may be promising for healthy dietary habits among elementary school children. Although the major limitation was publication bias (English language articles) and geographically restricted to southern and northern Europe.

Moderate quality evidence by (22) suggested that further research should test the effect of multi component interventions on adolescent nutritional status. There also remains a need for interventions that aim to improve the school food environment, which may further support the positive behavior of teens towards healthier lifestyles. Time constraints ,reporting and recall bias were the major limitations of the study due to its pre and post design. (Oh et al., 2022) suggested that standardisation of study design methodology and reporting be taken into account for future research and evaluate the obstacles and additional variables that restrict such kind of studies and programme execution in low- and middle-class communities and environments. It is also necessary to pay more attention to interventions that evaluate the risks associated with online media, such as cyberbullying, sexual content, exploitation, and violence, in order to better inform policies and programmes and support global efforts to promote universal health coverage under SACA. The study was a low quality evidence and had limitations due to data heterogeneity, stemming from varied interventions, non-standardized outcome metrics, vague methodologies, and subjective tools like self-reporting, hinders the generalizability of findings in this review. The majority of included studies lack robust methodologies, limiting their quality and consistency with existing literature.

(24) in a low quality evidence suggested that nutrition knowledge transmitted through traditional means alone might not be sufficient to make sensible food choices , adolescents also need a supportive and enabling physical and social environment . the study findings were limited by the fact that this review only included schools that were more committed to implement Health Promotion School (HPS) program .

A moderate quality of evidence study by (25) recommended that the interventions package based upon BCC theories and models brought about a positive change toward healthy dietary behaviours among adolescents. To promote healthy behaviours model-based and construct-oriented interventions should be designed. The study findings are limited by the fact that Intention status change is influenced by external and environmental factors not considered in the study due to the model's focused use. The participants' self-reported data on constructs may be biased by social desirability, even with confidentiality protocols in place.

4. E-Health nutritional Interventions

According to (35) a high quality systematic review e-health should be taken into consideration by practitioners, physicians, and legislators as a paradigm for changing children's behavior. The review had certain limitations, such as moderate heterogeneity and different approaches taken by different studies to determine BMI-z scores. Subgroup analyses were carried out; however, due to small study samples, some elements such as settings, population subgroups, and modes of intervention were not thoroughly investigated. Furthermore, the analysis is limited in its applicability to low- and middle-income countries because it solely incorporates studies that are published in English, and the majority of these studies were carried out in high-income nations.

(36) The study highlights that the treatment of childhood overweight and obesity through mHealth is a new and emerging field, and certainly a rapidly developing research area. This poses a difficult challenge for researchers to design and test technology using robust methods. Although the review was of high quality but Web 2.0 interventions (e.g., Facebook) were not included in the review because of concerns about mobile device usage. By incorporating conference proceedings and grey literature, it attempted to reduce publication bias; however, abstracts may have been omitted. In line with these recommendation a high quality review by (Champion et al., 2019) also suggests that future research is needed to develop eHealth interventions that can bring about sustainable changes in the lifestyles of adolescents .

(29) in a high quality evidence and (37) in a low quality evidence also recommended the need for future research to assess the long-term effectiveness of internet-based interventions on diverse population groups and settings and countries (eg, low- and middle-income) to strengthen the evidence base and improve the generalizability of the findings.

According to (38) multi sectoral, multifunctional, and multilevel policies will be necessary for effective interventions and policies that span digital media, education, health, food systems, social protection, and other domains.Adolescent food choices are influenced by autonomy food environments, peer approval and societal norms. Understanding and harnessing these factors is of utmost importance for designing effective nutrition policies and programmes. In the past decade , a number of nations have created and evaluated novel strategies for school food programs. These strategies include policy directives (such as Mexico's prohibition on sugar-sweetened beverages), menu modifications (such as Brazil's inclusion of fortified foods or improved food options , and choice architecture (such as the USA's enhancement of the prominence, appeal, and selection of healthier food options). The school curriculum can also teach students useful skills related to food preparation and gardening. There is an increasing impact of social media on eating habits, body image, marketing and advertising directed towards teenagers, It serves as an opportunity for use of e-health and m-health for fostering healthy eating behaviours in adolescents . This is a quickly evolving subject where interventions range from knowledge-based programs to self-monitoring apps.

5. Behavior change theories for lifestyle modification

(4) in a low quality evidence suggests that application of TTM in different contexts shows that it is flexible and therefore can be implemented in many settings. The use of the model is shown to be restricted to the stage of change' construct. Further studies should use all constructs of the TTM in the design and compare the TTM with other behavior change theories to better understand its effectiveness. Further studies should use all constructs of the TTM in the design and compare the TTM with other behavior change theories to better understand its effectiveness.

Similarly according to a high quality evidence (11) it is recommended that further high-quality research is required to ascertain longer-term efficacy while taking the general quality of diet into account. This is particularly crucial because young adults throughout the world have terrible eating habits. Additionally, this review illustrated the potential of the subsequent BCTs. Due to the review's restriction on including only English-language publications, it's possible that pertinent studies were overlooked. Young adults were defined using a broad age range (aged 17–35) in order to produce a large volume of literature.

(30) in a moderate quality evidence supported the use of appropriate educational techniques such as collaborative learning methods that will help to implement behavioral theories/models to increase the effectiveness of theory-based educational interventions but it also reccommends to use a mixed method approach in future research. Additionally, group education may enhance autonomous, self-directed learning. To better understand the beneficial effects of these techniques on teaching adolescents to adopt healthy eating and lifestyle habits, a study comparing traditional and team-based educational techniques to apply health-promoting and health education theories and models would be beneficial. Findings are supported by another review(22). Social Ecological models are considered best for lifestyle interventions in school(39) Another study based upon multi-center community-based survey Monthly mean consumption of oil per house hold was found 5.49 ± 5.39 ltr while monthly mean consumption of ghee per house hold was found to be 1.830 ± 4.87 Kg. These findings facilitate quantitative assessment of consumption of dietary fats attributable to dietary factors and in future can be used to inform national and global efforts to alter diet, reduce disease, and improve population health. (40) Another study conducted in Pakistan medical and allied health sciences colleges highlights a lack of awareness regarding NCDs risk factors among students of allied health sciences (17%) as compared to the MBBS, BDS, Nursing and Pharm-D students. They emphasize that ministry of health (MONHRS) and education needs to re-organize teaching and training programs for various disciplines in medical education. (41) A study conducted to assess the psychosocial impact of school environment for improvement of child mental health found that There is a need to improve quality area of providing friendly, rewarding and supportive atmosphere in school, cooperative and active learning and valuing development of creative activities. (42)

CONCLUSION

This scoping review comprehensively examined the multifaceted dimensions of adolescent health, with a particular focus on dietary behaviors, physical activity, and interventions aimed at promoting healthier lifestyles. The findings underscore the complexity and interconnectivity of various factors influencing adolescent health, ranging from individual behaviors to broader socioeconomic and environmental contexts. Key insights reveal that while numerous interventions have demonstrated effectiveness in improving specific health outcomes, there remains significant variability in their design, implementation, and overall impact.

SIGNIFICANCE

The significance of this review lies in its holistic approach to synthesizing existing literature on adolescent health. By incorporating diverse studies and methodologies, it provides a robust foundation for understanding the current landscape of health interventions targeting adolescents. This review highlights critical gaps in knowledge, particularly in the context of low- and middle-income countries (LMICs), where data on preventive nutrition interventions and their long-term efficacy are sparse. The evidence presented emphasizes the importance of tailored, context-specific strategies that consider the unique challenges faced by adolescents in different regions.

RECOMMENDATIONS:

Future research should prioritize the following areas to enhance the effectiveness of adolescent health interventions:

Comprehensive Behavioral Models: Incorporate all constructs of behavioral change theories such as the Transtheoretical Model (TTM) and compare their efficacy against other models to gain deeper insights into their applicability and impact.

Longitudinal Studies: Conduct high-quality, long-term studies to assess the sustained impact of health interventions, particularly in LMICs where short-term data are more prevalent.

Holistic Approaches: Develop and evaluate multifaceted interventions that integrate nutrition, physical activity, and psychosocial support, ensuring they are adaptable to the specific cultural and socioeconomic contexts of the target populations.
Technology Integration: Explore the potential of e-health and m-health interventions to reach adolescents through platforms they frequently use, such as social media and mobile applications.
Policy and Environmental Changes: Advocate for policies that create supportive environments for healthy behaviors, including school-based programs, community initiatives, and national health policies that prioritize adolescent health.

Equity and Inclusion: Ensure interventions are inclusive, addressing the needs of marginalized and vulnerable adolescent populations to reduce health disparities.
By addressing these areas, future research can contribute to the development of more effective, sustainable, and equitable health interventions for adolescents, ultimately improving health outcomes on a global scale.

LIMITATIONS :
The scoping review on nutritional interventions for lifestyle modification among school adolescents has several limitations. First, the included studies exhibited significant heterogeneity in terms of design, population, intervention type, and outcomes measured, making it challenging to synthesize results and draw general conclusions. Second, the review may be subject to publication bias, as studies with positive results are more likely to be published than those with negative or null findings. Additionally, only studies published in English and available through selected databases were included, potentially omitting relevant research published in other languages or less accessible sources. The quality of the evidence was not assessed, which may vary significantly, affecting the reliability and validity of the findings. Although several major databases were searched, it is possible that some relevant studies were not identified due to the limited scope of the databases used. Moreover, without conducting a meta-analysis, the review does not provide a quantitative synthesis of the effectiveness of the interventions, limiting the ability to draw definitive conclusions about their impact. Changes in dietary guidelines, school policies, and public health initiatives over time were not accounted for, which may influence the relevance and applicability of older studies to current contexts. Lastly, variations in cultural, socioeconomic, and educational contexts across different regions may affect the generalizability of the findings to all school adolescents.

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