



A systematic review exploring evidence for adolescent understanding of concepts related to the developmental origins of health and disease

Review

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Abstract

The developmental origins of health and disease (DOHaD) framework has highlighted the importance of the early life period on disease risk in later life with impacts that can span generations. A primary focus to date has been around maternal health and the 'First Thousand Days' as a key developmental window whereby an adverse environment can have lasting impacts on both mother and offspring. More recently, the impact of paternal health has gathered increasing traction as a key window for early life developmental programming. However, to date, adolescents, the next generation of parents, have attracted less attention as a key DOHaD window although many behavioural traits become entrained during adolescence and track into adulthood. This systematic review examined literature focused on identifying adolescent understanding of DOHaD concepts. Consistent across the eligible articles was that overall understanding of DOHaD-related concepts in adolescents was low. Three key themes emerged: 1. Individual-level awareness of DOHaD concepts (cognitive engagement and action of the adolescents themselves); 2. Interpersonal communication and social awareness of DOHaD concepts (cognitive engagement and communication of the DOHaD concepts to family and wider community); and 3. Health literacy and the promotion of adolescence as a key DOHaD life stage. These findings highlight the need to develop strategic approaches to increase DOHaD awareness that are not only appealing to adolescents but can also support sustained changes in health behaviour. Investment in today's adolescents has the potential to act as a NCD 'circuit breaker' and thus will yield significant dividends for future generations.

Introduction

Epidemiological, clinical and experimental evidence has clearly shown that health across the lifecourse can be impacted by environmental factors during the early life period from preconception right through to infancy, including poor nutrition and a range of other adverse environmental exposures.¹ Early work around the developmental origins of health and disease (DOHaD) demonstrated an association between birthweight and increased risk of later disease² and identified a range of early developmental factors that could potentiate disease risk across the lifecourse.^{3,4} A particular early focus was that of poor maternal nutrition including that highlighted via studies of the Dutch Famine Cohort where prenatal famine exposure had lasting consequences for health of offspring in later life.⁵ Over time, the concept has expanded its focus to incorporate different areas of expertise including clinical perspectives, epigenetics, and social sciences.

The early work of Barker and colleagues focussed on the role of maternal health, particularly maternal nutrition, on the programming of later disease risk in offspring.⁶ More recently, the importance of paternal health and wellbeing on the health of offspring has been increasingly recognised.⁷ However, the DOHaD framework requires a lifecourse approach and, in this context, there is increasing recognition of the period of adolescence as a key developmental window.^{8–10} Adolescence should not be considered simply as a transitional phase between childhood and adulthood but as a key lifecourse window stage where lifestyle behaviours become entrained and typically track into adulthood. This period of increased freedom and choice allows the opportunity for adolescents to make informed decisions about their own health.¹¹ As such, there is a range of potentially modifiable behaviours that start during adolescence that will not only impact on their own health, but that of their future offspring.

Improving health literacy in adolescents has been regarded as a key intervention strategy to break the cycle of NCDs,^{12,13} by empowering adolescents to engage in evidence-based decision making and informed actions related to the prevention and control of non-communicable diseases (NCDs) worldwide.¹⁴ Since the establishment of DOHaD, research has informed the

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Table 1. Inclusion and exclusion criteria via PICOS for the selection of studies

Criteria	Inclusion criteria	Exclusion criteria
Participants	Adolescents aged 10 to 24 years old.	>24 years old, infants or children < 10 years old.
Intervention	Investigates the DOHaD paradigm in relation to adolescent understanding of DOHaD concepts.	Studies which do not identify a DOHaD link
Comparison	Not applicable	Not applicable
Outcomes of Interest	Quantitative and/or qualitative studies that focussed on adolescent understanding of concepts related to NCDs, DOHaD and the First 1000 Days and the roles of the early life environment on disease risk across the lifecourse.	Studies focused on anything else that is NOT listed in the inclusion outcomes of interest.
Study design	Peer-reviewed articles, primary research (qualitative, quantitative, or mixed methods), book chapters (with quantifiable data) and reports with human participants	Articles that are NOT peer-reviewed, protocols, literature and systematic reviews, conference proceedings, scoping articles, poster abstracts and abstract only articles, graduate dissertation, commentary, and clinical trials.

development of interventions to reinforce, complement and support the evidence presented.¹⁵ In the non-DOHaD setting, interventions related to health literacy have taken shape in different learning environments such as after-school programmes,¹⁶ summer camps, community centres, libraries, and grocery stores.^{17,18} The process of empowerment considers the application of both scientific literacy and health literacy^{19,20} at a personal, community or societal level to be vital.^{21,22}

Ensuring the widespread recognition of adolescence as a critical window of opportunity for health interventions holds potential for contextualised and co-designed interventions to manoeuvre the lifelong health trajectory of not only the individual but their future children. This can help shape future interventions that are not only effective in improving ways of life²³ but prevent the traditional ‘top-down approach’ of health promotion.²⁴ Health promotion is most effective when there is increased interaction and true engagement with affected communities such as those living with a high prevalence of NCDs.²⁵

Although there is an increasing literature base recognising the period of adolescence as a key DOHaD window, there remains paucity of data that has examined DOHaD awareness in adolescents themselves. More attention to this critical lifecourse window is required to provide adolescents with the knowledge that could influence their attitudes to become agents of change in health outcomes and working towards breaking the cycle of disease across generations. The aim of this review was to examine peer-reviewed scientific literature that investigated understanding of DOHaD concepts by adolescents themselves and their role, as future parents, to help mitigate the transmission of disease traits across generations. As an extension of this work, we also wanted to highlight potential directions for DOHaD researchers to consider moving forward with regards to how adolescents themselves view how messaging around DOHaD concepts and the importance of the adolescent period is best conveyed to them.

Methods

This systematic review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement²⁶ and used the participants, intervention/exposure, comparison, outcome, study design (PICOS) structure via the Covidence software platform²⁷ to identify eligible studies.

Eligibility criteria

Reports of studies focusing on adolescent understanding of DOHaD concepts were sought for this review. Table 1 outlines the inclusion and exclusion criteria, including information on the participants, exposure, outcome of interest and study design. Peer-reviewed articles published from 2013 to the 22nd of March 2023 (day of search) were eligible to be considered. Articles that were not in English, based on animal subjects (such as mice, rats, rodents, sheep, ovine or other non-human primates) or were not published within the specified time frame of this search were excluded.

Studies were included in the current review if they: (1) measured DOHaD awareness, (2) examined knowledge or understanding of DOHaD-related concepts, (3) included an analysis of participant appreciation of associations between nutritional environment and later life health, and (4) reported on ways adolescents suggest DOHaD-related messages be conveyed to them which can lead to the optimisation of health in the adolescents themselves, their future children and the next generation.

Data sources and search strategy

The systematic search covered publications from 2013 until 22nd March 2023 across three electronic databases: PubMed, Scopus, and EMBASE (accessed via Ovid). All searches comprised of three main groups of concepts: DOHaD, adolescence (10–24 years old)²⁸ as a critical life stage and later life outcomes in relation to the prevention of NCDs. Note that although a typical definition of adolescence spans the ages 10–19, it has recently been proposed that a broader definition of 10–24 years better corresponds to adolescent growth and general understandings of this life phase.²⁸ The DOHaD keywords included developmental origins of health and disease, DOHaD, FOAD, fetal origins, first 1000 days, first thousand days, early life, and early-life. The adolescence life stage keywords included adolescent*, adolescent, youth, juvenile and teen. Keywords related to later life outcomes included non-communicable disease, non-communicable disease, later life, later-life, NCD, overweight, obesity, diabetes, diabetes mellitus, cardiovascular disease, CVD, heart disease and metabolic syndrome. The Boolean operator ‘AND’ was used between each of the three concepts, and ‘OR’ was used within each concept. Filters and limits were applied to ensure each search included only

journal articles written in the English language and published from 2013 onwards.

Database results were imported into Covidence for screening.²⁷ Duplicates that were not automatically identified by Covidence due to slight discrepancies in title, author, year, and volume were manually removed. Reviewers M.T, M.H.V and S.T independently screened the articles, achieving 89% agreement. Any studies that could not have eligibility fully confirmed during the title and abstract screening stage were held for the next stage. The full texts of the remaining articles were then independently screened for eligibility. No further information was requested from authors and articles were excluded if the full text was inaccessible or author details were unavailable.

Data extraction and risk of bias assessment

Data were extracted from each article regarding the study (setting) variable of interest, DOHaD concept, age of participants, later life outcomes linking metabolic health to NCD risk prevention and main study findings. Although a comprehensive search across databases was conducted, publication bias was a potential limitation. This saw an effort to retrieve full texts from beyond the database, such as through university library networks. The quality of each study was assessed using an adapted version of the Critical Appraisal Skills Programme Quality Assessment tool which allowed evaluation of cohort, cross-sectional studies, longitudinal studies, case-control and observational studies.²⁹ The checklist was only used to critically appraise the quality of the papers included in this review and given the number and source of the relevant research papers identified, there was no need for a formalised score to be attributed to each paper.

Study analysis

Investigating the DOHaD paradigm in relation to adolescent understanding of DOHaD concepts was the primary outcome of interest for this review. Variables within the studies had to show links to DOHaD and later life health outcomes to be included. If the study variables lacked this link, the article was removed from analysis. The remaining studies were systematically reviewed to determine the themes in the data. Full reading of all eligible articles resulted in the following themes being identified: (i) Individual-level awareness of DOHaD concepts (cognitive engagement and action of the adolescents themselves); (ii) Interpersonal communication and social awareness of DOHaD concepts (cognitive engagement and communication of the DOHaD concepts to family and wider community); and (iii) Health literacy and the promotion of adolescence as a key life stage in the DOHaD field. The themes were reviewed by M.H.V and S.T for consistency with the data prior to final analysis.

Results

Study selection

Figure 1 outlines a flow diagram for the process of selecting studies. Based on the search criteria, a total of 2992 records were identified through three databases. Three articles were also retrieved from other sources through citation searching. Internal and external duplicates ($n = 1323$ system detected duplicates and $n = 209$ manually marked duplicates) were removed via the Covidence software. Using Covidence, the remaining 1460 records were screened for eligibility by title and abstract using the PICOS criteria

outlined in Table 1. This resulted in the exclusion of 1415 records. Full-text articles were then assessed for the remaining records, with a further 40 records excluded (reasonings published in Fig. 1) and only five studies deemed eligible for inclusion in this review.

Study characteristics

Table 2 outlines the main characteristics of the five studies included in this review. Of note, although there are an increasing number of review articles recognising the importance of the adolescent window, our search revealed that very little work has been undertaken with adolescents themselves around their understanding of DOHaD concepts. The articles included in this review spanned the years 2017–2021 and were conducted in geographical locations including England, Japan, New Zealand, and Uganda. The participants were all adolescents with ages ranging from 11 to 24 years old.

All eligible studies were intervention studies³⁰ that set out to either determine levels of awareness of DOHaD concepts in adolescent participants and to evaluate the effects of intervention in this demographic group. Thus, focusing on engagement and improvement of health behaviours driven by awareness of DOHaD-related terms and concepts.

Of the five studies, four used a questionnaire tool to assess adolescents' understanding of DOHaD concepts^{31–34} and one used discussion groups³⁵ to get a sense of what adolescents perceived as relevant with regards to DOHaD. The four studies that used questionnaires featured Likert-style responses asking adolescents to indicate how strongly they agreed or disagreed with statements such as 'the food a father eats before having a baby will affect the health of his children'.^{31–34} Of the four questionnaire studies, one was a post-intervention study with the aim to assess the impact of the Healthy Start to Life Education for Adolescents Project in New Zealand.³¹

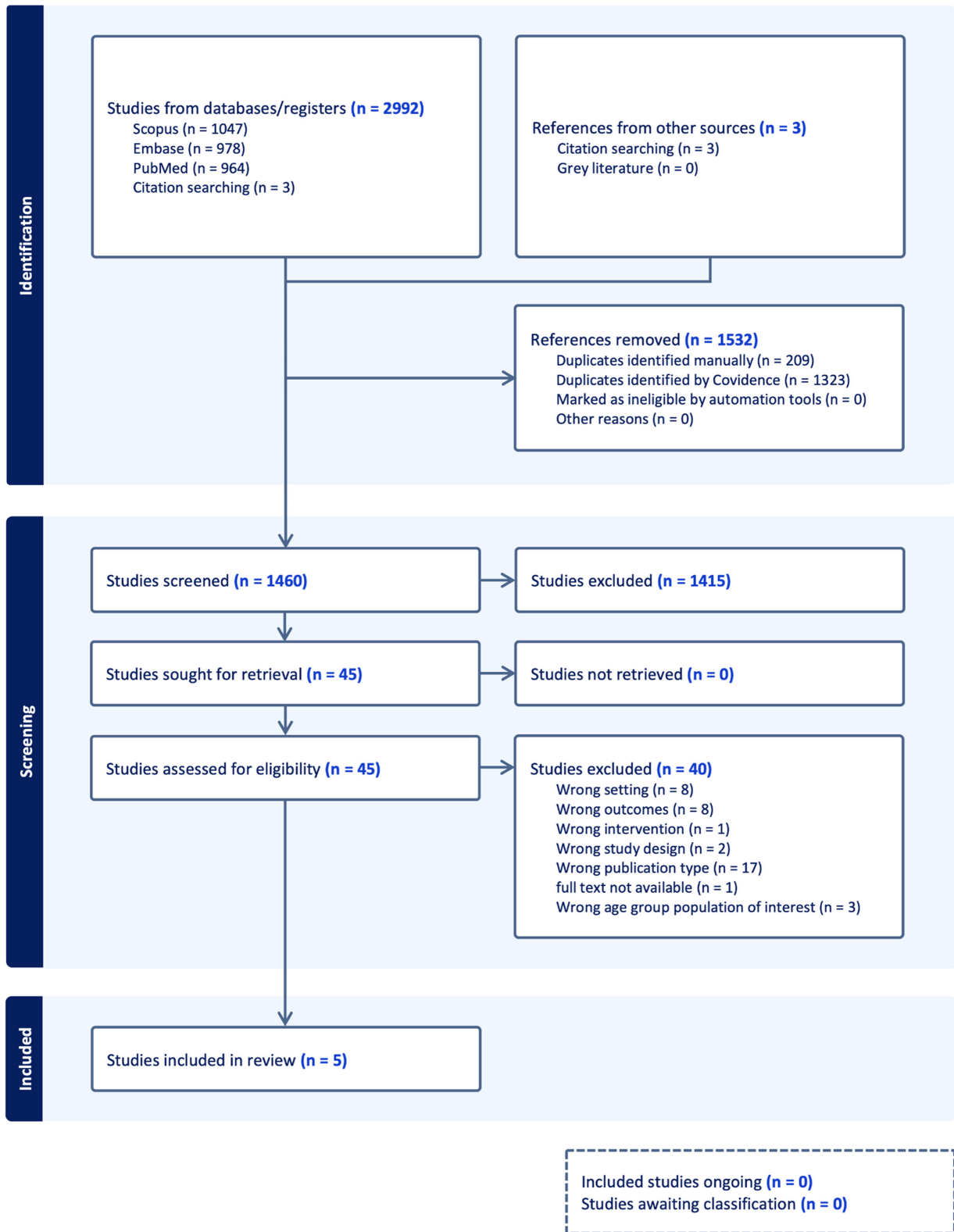
Although Macnab *et al.*, did not use a Likert-style questionnaire method, opting instead for discussion groups, the questions posed were similar to other studies. The discussion group method provided adolescents with an opportunity to rank what was relevant and most interesting to them with regards to DOHaD. Statements such as 'importance of nutrients for health during pregnancy'³⁵ were supported by statements that ranked suggestions of messages, messengers and methods of promoting and engaging with the DOHaD concepts.

Across all studies, three themes (i)–(iii) were identified and discussed below.

(i) Individual or primary level awareness of DOHaD concepts

All studies included in this review focused on exploring adolescents' understanding of DOHaD concepts at a primary level.^{31–35} This included building awareness and engagement around DOHaD concepts including understanding by adolescents of their own behaviours. Examples of adolescent variables explored in these studies included dietary behaviour change, overall adolescent health behavioural change, engagement in science learning as an indication of scientific literacy level and changes in DOHaD concept awareness.

A ranking system was used by researchers in Uganda³⁵ to explore adolescent perspectives of DOHaD relevance, showing that nutrition (health benefits of eating a variety of foods) and responsive caregiving (how to feed your baby in a healthy way) were prioritised by participants (68% and 65%, respectively ranked as number 1). Following this idea of the importance of early life



21st September 2023



Figure 1. PRISMA flow diagram for the selection of studies.

Table 2. Characteristics of the final studies included in the review

Year	Author	Location	Participants	Method	Intervention
2017	Bay <i>et al.</i>	New Zealand	Adolescents (<i>n</i> = 241)	Questionnaire	Yes
2017	Macnab <i>et al.</i>	Uganda	Adolescents (<i>n</i> = 151)	Discussion Groups	Yes
2018	Woods-Townsend <i>et al.</i>	England	Adolescents (<i>n</i> = 333)	Questionnaire	Yes
2018	Oyamada <i>et al.</i>	Japan & New Zealand	Adolescents (<i>n</i> = 460)	Questionnaire	Yes
2021	Woods-Townsend <i>et al.</i>	England	Adolescents (<i>n</i> = 2929)	Questionnaire	Yes

nutrition for lifelong health, the United Kingdom-based study LifeLab also showed that adolescent participants post-intervention were most likely to understand that the age in which nutrition starts to affect future health is before birth.^{33,34} A similar trend was interpreted when dietary behaviour and overall health behaviour were assessed using matched self-reported evidence relating to key food categories ranging from snacks to vegetables and fruits.³¹ Programme participation yielded a change in adolescent's nutritional behaviour post-intervention with a Year 9 student sharing:

I had thought about it, but I had never really done healthy eating before. Now I pay attention to healthy eating and exercise . . . Before, I was ashamed but now I enjoy it . . . I eat vegetables.

Additionally, students with identified nutritional behaviours that could increase later risk of overweight/obesity and NCD at 12 weeks post-intervention showed positive behaviour change at 12 months post-intervention. However, those identified as 'not at risk' 12 weeks post-intervention showed negative behaviour change a year later.³¹

Moreover, Oyamada *et al.* reported on undergraduate students in both Japan and New Zealand where, on entry to their tertiary studies, most displayed no awareness of the term 'DOHaD'.³² While 95% of students in Year 1 had an appreciation of the link between maternal nutrition and fetal health, their awareness of the association between maternal/paternal health status and/or the nutritional environment and later life disease risk was low. By Year 3, awareness of DOHaD concepts had increased to 60% for students attending courses that contained a DOHaD-related teaching element although the authors recognised that this was still inadequate.³² This study concluded that while awareness of DOHaD did improve over the course, there remained a need for further DOHaD curriculum development.

(ii) Interpersonal communication and social awareness of DOHaD concepts

Another key theme identified in this review was interpersonal communication and social awareness of DOHaD concepts among adolescent participants. This displayed awareness beyond one's individual health to include impacts on not only their future health but also for the next generation.

DOHaD awareness holds potential to not only better the health of people in the society but its impact can also contribute to the economy. Adolescent participants in the Uganda study ranked the economic outcome 'if your child grows up healthy he/she will be able to earn more money' to be of most interest with 82% of participants ranking it as the highest priority.³⁵ This was supported by a supplementary comment 'money talks' from one of the participants and highlighted how financial consideration can also be a factor in DOHaD message deliverance to adolescents.³⁵

Bay and colleagues reported an increase in awareness of the associations between nutrition and future health among adolescent

participants in New Zealand.³¹ This study underscored the positive responses by the majority of participants toward statements such as 'the food I eat now will affect my health in the future' and 'the food I eat now will affect the health of any children I have in the future'.³¹ Findings from the LifeLab study similarly showed increased adolescent awareness in how individual diet affects future health, parental diet impacting the health of the fetus during pregnancy and the contribution of diet to future generation's health.^{33,34} Findings from both studies highlighted that empowering adolescents to relate their current health to their potential future offspring can be challenging.

Learning was not confined to adolescents themselves. There was a strong emphasis among studies in this review on how health literacy among adolescents can be communicated to parents and wider family networks. This was highlighted by Bay *et al.*³¹ with parents feeding back examples such as the following:

'Back in my day science at school was not so relevant to the children's world. My daughter is now telling me about what she is doing (learning). Her interest changed my mind on what science is in relation to everyday life . . .'

This parent reflected on the relevance of science to everyday life, showing the development of understanding from the past in comparison to now. Science is made meaningful through the empowerment of adolescents to be science communicators and pass on the message to their families.

Another testimony in this study from a school leader also highlighted the value of science education within communities:³¹

'The value of the program for parents in our community is that they have begun to see what science is a little more. The students are taking back ideas to their families and their communities. We are getting a lot more understanding about how science is impacting the community . . .'

The improved health literacy of the adolescents at follow-up studies suggested that enhanced health literacy may be connected to better health outcomes.

Overall, studies in this review showed that adolescents were more aware of the links between a mother's health and nutrition with regards to their baby than the association between paternal health before conception in relation to the health of the fetus.³² Bay *et al.*, reported that although 50% of adolescents in their study cohort were aware of the link between maternal nutrition and health of baby, only 4% acknowledged the role of the father. Moreover, only 9% of adolescents in the Macnab & Mukisa study emphasised the importance of nutrients for health during pregnancy, ranking it as the lowest priority for the nutrition aspect of DOHaD. The impact of paternal diet on the health of future children was also an important aspect of DOHaD that was not well understood by the adolescents in work by Woods-Townsend and colleagues. The researchers reported that at baseline, adolescents in both the intervention and control groups (only 15% and 17% respectively) acknowledged the association between paternal diet and the health of future children.

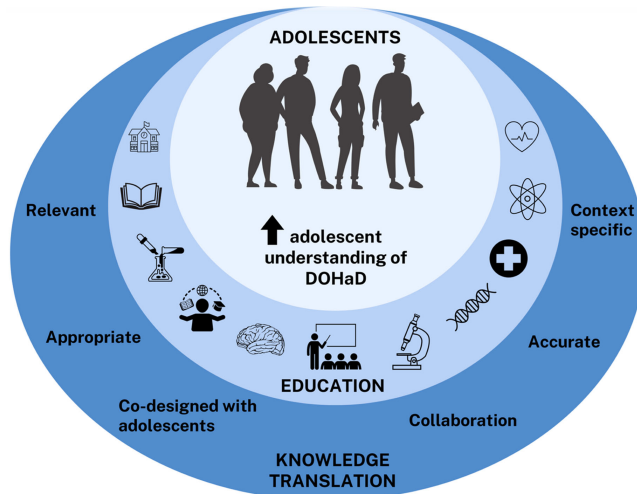


Figure 2. Characteristics to the process of DOHaD concept promotion and uptake in adolescents. Health promotion messages that are DOHaD-related should be co-designed with adolescents, relevant, appropriate, accurate, context specific and collaboration must be established for overall understanding of these concepts to be maximised in the adolescent demographic.

(iii) Health literacy in adolescence as a key DOHaD life stage

All studies in this review recognised adolescence as a key life stage with respect to the DOHaD framework with each article presenting a unique way of addressing promotion of adolescent health as suggested by the adolescents themselves. Collectively, the articles focused on health literacy and its potential impacts on trans-generational health outcomes.

Bay *et al.*, showed that exposing adolescents to learning resources that are innovative and content-specific can empower them to explore evidence about their health. This exploration of evidence created opportunities for positive classroom discussions that challenged individual blame responses to NCD-related health issues.³¹ Adolescent awareness of DOHaD as explored in other studies has also shown that engaging adolescents in education is important.^{32–35} As emphasised in the findings of this review, information sharing without examination of evidence can be seen as detached.^{31,34} Thus, if adolescents themselves do not understand the concepts of DOHaD with regards to their health, behavioural changes become challenging and may be difficult to sustain.

All the included studies concluded their findings with recommendations for future research in this area and the promotion of adolescence as a key DOHaD life stage for improvement of transgenerational health through health intervention in education (Fig. 2).

A common element noted across the studies was the need for DOHaD concepts to be embedded in school curricula to allow for wider opportunities to engage in and explore such concepts.^{31–35} This also links into how the messages around the importance of adolescence as a lifecourse window as delivered both to the adolescents themselves and the wider community through health promotion initiatives. Six important factors were highlighted by the studies as crucial for effective message deliverance. These included the use of appropriate messaging and ensuring messages were context specific, accurate and relevant. They also highlighted that collaboration with adolescents to co-design these health interventions should be established from the very beginning – this allows for empowerment and effective capturing of the adolescent ‘voice’.

Discussion

This systematic review aimed to gather evidence on published studies in the scientific literature that explored adolescent understanding of the DOHaD concept. In the DOHaD field, there is an increasing recognition of the adolescent period as a key lifecourse window. However, very few studies were identified that had directly examined adolescent understanding of DOHaD concepts. Of the studies detailed in this review, a common theme portrayed was the different levels of DOHaD awareness (concentric ecosystem levels) that work together to strengthen health literacy in adolescence as a key DOHaD life stage.

Post-intervention follow-up studies in this review indicated that there were some positive changes in level of awareness, although sustainability of change remained an issue. However, general awareness of the DOHaD concept remained low in adolescents, particularly knowledge about the contribution of paternal health before conception to the health of the offspring as well as the mother’s nutrition during pregnancy.^{31–34} Other factors such as physiological changes during adolescence^{36,37} may have also contributed to the positive health behaviour changes³⁸ observed by Bay and colleagues. The lack of awareness in adolescents highlight an important opportunity for DOHaD health promotion among youth as suggested by previous studies^{39,40} to improve health literacy.^{41,42} This could be undertaken by integrating health literacy around DOHaD into the education curriculum⁴³ as it has been shown to improve adolescent health literacy. Although nutritional behaviours can change due to engagement in science learning and scientific literacy, present education courses that encompass DOHaD concepts are still insufficient.³² A solid foundation for this change would not only rely on the individual but would also include their surroundings. The environment that an individual is exposed to is known as a key determinant of health,^{44,45} thus it is important that this is conducive to healthy choices in order to support the optimisation of individual choices.^{34,46}

When intervention programmes are engaging for adolescents, it can empower them⁴⁷ to be the science communicators within their families.³¹ As an example, LifeLab provided adolescents with experimental learning opportunities to increase their knowledge and to enable them to access, understand and reflect on what they can do to live healthier lives.^{33,34} In today’s world, this can be difficult due to the rate at which information (and misinformation) is disseminated online. Healthy lifestyle and diet choices in adolescents can be obscured by the influences of social media.⁴⁸ Social media is being used by consumers to inform others about what they eat through posts, restaurant reviews, recipes and pictures.⁴⁹ Opportunities where both adolescents and families are learning together are advantageous as it supports parents to develop their own understanding of science and engage in health-promoting behaviours.^{50,51} When groups in society are given such an opportunity to learn about evidence and examine its relevance to their health, community-led actions can be facilitated.⁴⁷

Good health not only supports active and productive populations, but can reduce inequities and poverty.⁵² Thus, health promotion interventions in the context of DOHaD are fundamental to minimise preventable health conditions and the long term care costs that can burden healthcare systems and weigh down economies.^{53,54} Investing in the health of adolescents as a means for reducing the disease risk of generations to come has been well documented and proven efficacy.⁸ There is also a strong economic case in stating that the implementation of the Global

Strategy (a roadmap for ending preventable deaths of women, children and adolescents) would yield significant returns by 2030.²⁴ It is this transitional phase between childhood and adulthood where early steps can be taken to improve health outcomes for the next generation.¹⁵ Along with this shift towards early interventions, support from the community, society, physical environment and infrastructures will all be critical for driving adolescent health promotion.⁵⁵

Health promotion for the adolescent life period should be co-designed with adolescents themselves.³⁵ One of the success stories of meaningful health intervention co-designed with and for adolescents is that of LifeLab.⁵⁶ In this evaluation study of LifeLab, participants offered suggestions and details to maximise the potential for LifeLab to be contextually relevant and engaging for socioeconomically disadvantaged adolescents. Co-design should also facilitate the development of young people as they prepare to assume their place as adults in society.⁵⁷ Adolescent-centred health promotion encourages longevity of health programmes co-designed and built together with the adolescents for themselves.³¹ Ensuring that adolescents understand the underlying factors around their own health can empower them to take ownership of and act on knowledge to support their future health and that of their future children are eminently translatable to different settings.^{32,33} Although health promotion in adolescence can be challenging as it is influenced by cultural, social and economic factors, it must still be tailored to the values, resources and sociocultural patterns of the adolescent population.⁵⁷ For DOHaD messages to be meaningful and empowering,⁵⁸ they should be tailored by adolescents,³⁵ information should be accurate³⁴ and content should fit the context.³¹ Educational approaches such as those captured across the eligible studies are great examples of the types of prevention initiatives that adolescents need to increase their knowledge of DOHaD. These approaches, and ones moving forward, should be innovative, adolescent-centred and school-based⁵⁹ with a view of helping to tackle health challenges faced by young people noted by the World Health Organization commission.⁶⁰

Limitations

Although a comprehensive range of DOHaD-related search terms were used, it is possible that some articles were missed that are in this research space but not directly relayed in the DOHaD context, i.e. a lack of explicit DOHaD-related terminology in their title or abstract. Further, the exclusion of randomised controlled trials (RCTs) in the search criteria could potentially have led to articles being overlooked. However, such articles were likely captured in the detailed citation searching process that followed the formalised search process, including review article citation lists. An example of this was the Woods-Townsend *et al.* study which was initially filtered out but then identified via citation searching RCTs in the school-based setting are unusual given ethical consideration as well as being difficult to reliably implement due to carry over effects.

Conclusion

Although the period of adolescence is increasingly recognised as a potential DOHaD circuit breaker, the literature that has directly explored this area remains limited. The studies that were identified served to highlight a generally low understanding of DOHaD concepts in this key demographic. The utilisation of mixed methods approaches has enabled student, teacher, and parent voices to identify associations between observed knowledge,

attitude and behaviour changes and programme participation although, more collaboration with the education sector is required to improve health behaviours in line with knowledge. Moreover, the combination of school-based dissemination of key knowledge and promotion of health practices can positively impact future behaviours. While there is some evidence for short term behavioural changes based on health literacy interventions, whether these changes persist over time has yet to be determined. Empowering this knowledge in adolescents is important for future health as it promotes independence, responsibility, and risk avoidance, which in turn encourages them to care for their own health and help safeguard the next generation.

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Competing interests. None.

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