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RESEARCH

Relating aspects of adolescents' critical nutrition literacy at the personal level

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Abstract

Efforts targeting adolescents' dietary behaviour have often focused on improving their access to nutrition information; however, adolescents report finding nutrition information difficult to understand. Exploring adolescents' critical nutrition literacy might provide insight into how best to improve their use of available nutrition information.

Purpose The purpose of this article is to explore how the two aspects of the critical nutrition literacy - critical evaluation of nutrition information' and 'engagement in dietary behaviour' are linked at personal level. Additionally, the study sought to establish the association between critical nutrition literacy and self-efficacy in nutrition related subjects.

Methods Applying a cross-sectional study design, the study sampled 1622 adolescents aged 15-16years, enrolled in 58 secondary schools in Norway. The adolescents responded to scales measuring self-efficacy and CNL. Using Lisrel 9.30, the study evaluated a structural equation model linking CNL and SEBH.

Results The study yielded a simple yet theoretically sound model depicting the link between CNL and self-efficacy.

Conclusion Efforts promoting adolescents' nutrition literacy might benefit from increasing their self-efficacy in nutrition-related subjects.

Keywords Adolescents · Critical nutrition literacy · Self-efficacy · Structural equation modelling

Health literacy (HL) has fast become an area of interest within the broader scope of public health. Defined as the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use health information in ways which promote and maintain good health, HL has been identified as one of the building blocks of health and a significant influence of health outcomes [1]. The consequences of low health literacy are varied and include among others, low responsiveness to available health services, poor self-management of disease, and low participation of communities in population health programs, among others [2]. HL is context-specific, taking different forms within the field of health; one such important domain is nutrition literacy (NL) defined as 'the capacity to obtain, process and understand nutrition information needed to make appropriate decisions regarding one's health' [3, 4]. There are three domains of NL namely, functional nutrition literacy (FNL), interactive nutrition literacy (INL) and critical nutrition literacy (CNL) [5, 6]. FNL refers to the basic writing and reading skills that are required to access information about nutrition, while INL is comprised of the interpersonal communication and cognitive skills which enable individuals to translate and apply information in their daily lives with the aim of improving their overall nutritional status. CNL refers to proficiency in critically analysing nutrition information and advice, alongside increased awareness and engaging in action to address barriers to sufficient nutrition at personal, social and global levels [6, 7]. At the individual level, CNL might be assessed by the two aspects, 'critical evaluation of nutrition information' (CNL-E) and 'engagement in dietary behaviour' (CNLEng) [8].

During adolescence individuals develop their dietary behaviours. It is therefore plausible that improving NL during adolescence might increase their chances of developing

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healthy dietary behaviours and prevent health risks during adulthood. Studies show that adolescents generally find nutrition information difficult to understand, they inadequately interpret nutrition information and are unable to establish the credibility of the sources of this information [9–11]. Therefore, it is not surprising that in spite of having increased access to nutrition information, adolescents rarely use this information properly when making dietary choices [12, 13]. Other studies indicate that individuals engage in a more detailed process of information-appraisal in order to sustain or enhance their state of well-being [14]. This might suggest that in order to improve the NL of adolescents, it is important to provide nutrition information that they can comprehend. By exploring the 'critical' dimension of nutrition literacy, stakeholders might be better informed about how adolescents understand nutrition information, what cues they use to interpret the information, and can therefore tailor the information accordingly. Presently, there are only a few scales for assessing NL, and even fewer for assessing CNL [11, 15]. Moreover, existing CNL instruments have mainly been validated using classical test theory (CTT) techniques. While CTT has long-standing benefits, researchers are adopting the use of modern measurement validation approaches like Rasch modelling which yields psychometrically defendable scales [16].

Self-efficacy refers to the judgements that one holds of one's capabilities to organize and execute actions to achieve designated goals [17]. Accordingly, an individual's self-efficacy perceptions determine one's behaviour such as participation in activities that require the use of the knowledge and skills attained. Self-efficacy influences the choices that adolescents make when faced with options and how they use their cognitive resources and strategies. For example, when making dietary choices, studies show that adolescents that are confident in their ability to apply the information that they have to make dietary-related choices (high self-efficacy) are more likely to make healthier food choices based on detailed comprehension of the nutrition-related cues [9]. Relatedly, studies show that adolescents' self-efficacy in science subjects is associated with their engagement in dietary behaviour (CNLEng) [8]. This finding is judicious as nutrition is a science [18]. Therefore, in the present study we anticipated that the adolescents' self-efficacy in the science subject topic of 'body and health'—one of the main five subject topics in the broader subject of 'nature science', 'body and health' focuses on the structure of the human body, and the impact of lifestyle on an individual's physical and mental health. One of the key elements within 'Body and Health' is nutrition. Herein, the subject topic is concerned with how an individual's lifestyle and health specifically relating to nutrition, diet, dietary patterns and eating disorders will influence how the adolescents comprehend the nutrition information that they encounter (CNL-E) and how they apply this information to achieve their dietary goals (CNLEng).

Methods

We randomly selected 200 schools from the list of lower secondary schools in Norway and contacted the respective school principals via email and telephone, seeking consent to volunteer in the study. Of these, 58 schools (approx. 30%) accepted and were included in the study. During the period of April to May 2015, we collected data from 1622 tenth grade students aged 15–16 years who responded using an electronic survey system.

Analyses

We used three scales measuring each of the three traits of interest to the study, namely, SEBH, CNL-E and CNLEng. Following this, we were able to explore the associations among these traits. The study applied the five-item CNL-E scale to measure the adolescents' perceived proficiency in evaluating nutrition information from various sources [19]. The scale uses a six-point rating scale and captures skills required for evaluating the 'consistency' and 'trustworthiness' of nutrition information. To measure adolescents' engagement in dietary behaviour, we used the two items of the 'engagement in dietary behaviour (EDB) scale' that measures adolescents' engagement in dietary behaviour at the *personal* level [20]. These items relate to how concerned the respondents are about eating healthy foods and having a variety of healthy foods available to them [8]. In order to measure the adolescents' perceived self-efficacy in mastering the health content taught in the science subject topic of 'body and health' in the Norwegian science curriculum, we used the five-item SEBH scale [20].

As we measured the three latent traits (SEBH, CNL-E and CNLEng) using twelve six-point rating scale items we treated all items as categorical variables at the ordinal level. Using the structural equation modelling (SEM) framework to test the hypothesized model, we therefore applied the "diagonally weighted least square" (DWLS) estimator–an asymptotically distribution free estimator available in the Lisrel 9.30 software package. "Asymptotically" refer to "large sample size" $N > 1000$. We followed the steps in conducting a SEM analysis. In the section that follows, we describe the rationale behind the SEM models shown in Fig. 1 and 2.

The model in Fig. 1 shows the measurement models of each of the three latent variables (CNL-E, CNLEng and SEBH) and depicts the hypothesized relationships between them when they are allowed to freely covary.

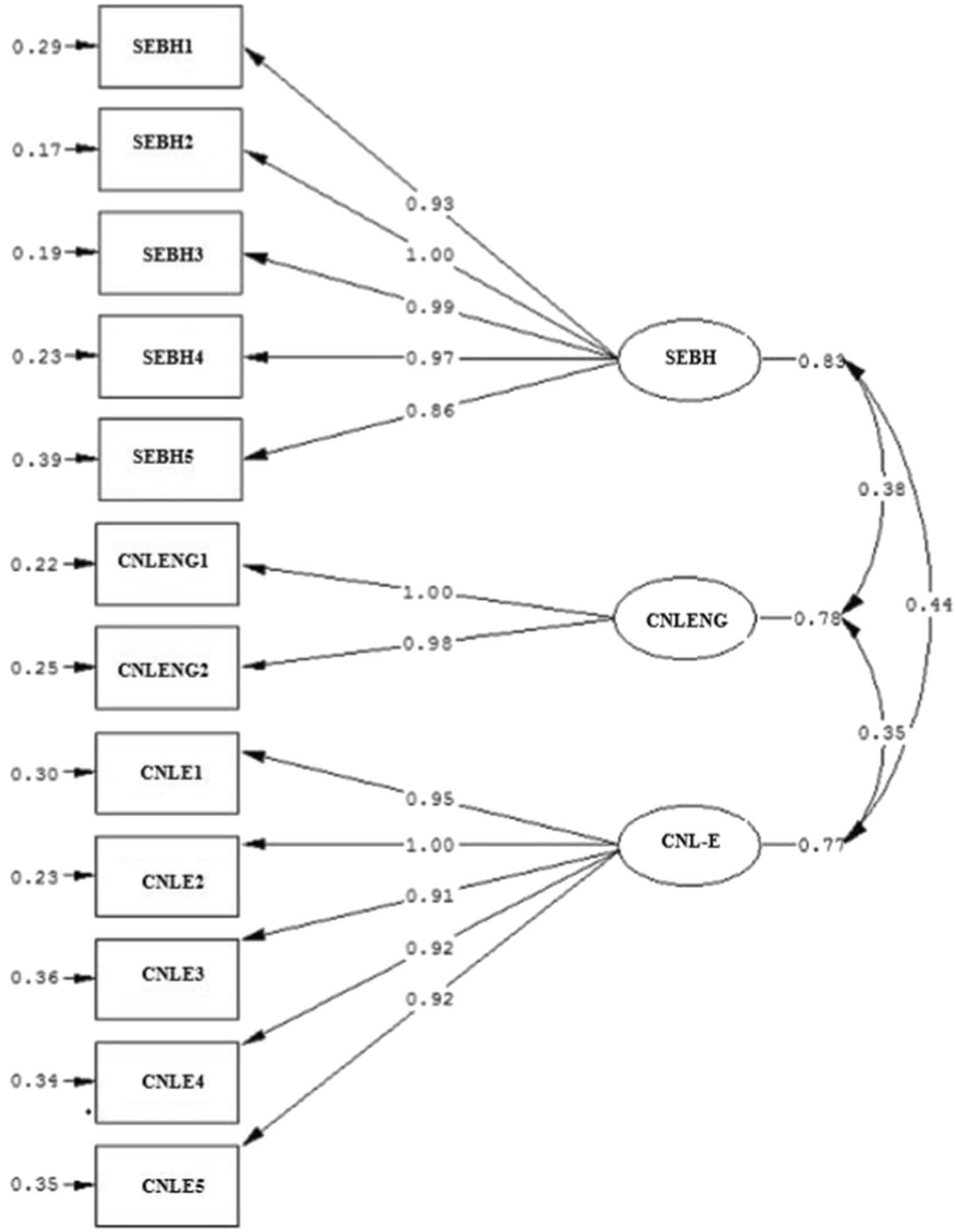

Fig. 1 Structural equation model linking CNL and SEBH using DWLS estimation in which the latent variables are free to covary

In Fig. 2, we specify that adolescents' perceived SEBH explains a portion of the variability in CNL-E and CNLEng. Herein, SEBH serves as an independent latent variable, and CNL-E and CNLEng are dependent latent variables. In the model shown in Fig. 2, we modelled the association between SEBH and CNLEng as a direct effect, the association between SEBH and CNL-E as a direct effect, and an indirect effect where CNL-E facilitates or "mediates" the relationship between SEBH and CNLEng; herein, CNL-E is both an independent variable and a mediator variable.

The SEM model shown in Fig. 2 has $p(p + 1)/2 = 12(12 + 1)/2 = 78$ distinct values (DV), where $p = 12$ is the number of items or indicators in the measurement models. We identified the 27 free parameters (FP) to be estimated (Table 1).

Therefore, the specified model is 'over-identified' with DV-FP = 78 – 27 = 51 degrees of freedom (df). As DV > FP the *order condition* is fulfilled and there are degrees of freedom available to estimate "goodness-of-fit" indexes (GOFI). As all indicators were categorical rating scale items, we estimated all FP by applying the DWLS estimator. As "target values" for GOFI refer to simulation studies using maximum likelihood (ML) estimation, and we want to compare our GOFI up against these target values, we estimated the model in Fig. 2 by also applying ML estimator. GOFI depict the degree to which the model implied variance-covariance

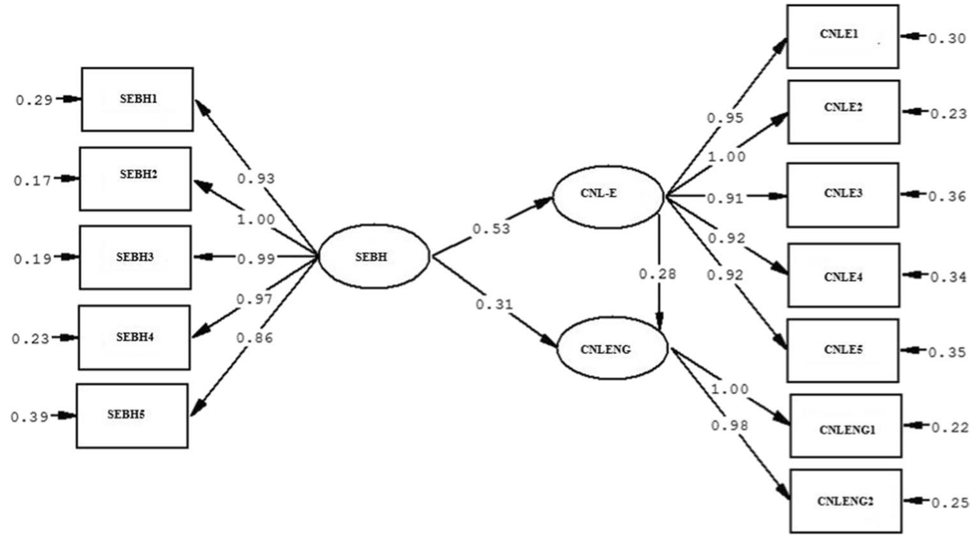

Fig. 2 Structural equation model linking CNL and SEBH using DWLS estimation

matrix ($\boldsymbol{\Sigma}$), which is based on our model in Fig. 2, is able to re-create the "actual" or observed variance-covariance matrix ($\boldsymbol{S}$), which we estimate from the observed empirical data. The smaller the elements in the residual matrix are ($\boldsymbol{R} = \boldsymbol{S} - \boldsymbol{\Sigma}$), the better the $\boldsymbol{\Sigma}$ re-creates the $\boldsymbol{S}$, the more the GOFI estimates approach their target values, and hence the better the "fit". There are three categories of GOFI namely, absolute, parsimony-adjusted and comparative GOFI.

Examples of absolute GOFI considered in the present study include the Satorra-Bentler (SB) scaled chi-square test (χ^2), which is robust to non-normality (we do not assume that categorical indicators based on rating scales are normally distributed), the reduced chi-square (χ^2/df), and the standardized root-mean-square residual (SRMR). SB (χ^2) values > 0.05 point to a good model fit; (χ^2/df) values < 3 suggest good fit; SRMR values < 0.05 suggest a well-fitting model, and value of 0.00 indicates 'perfect' fit; however, values as high as 0.08 also point to 'acceptable' model fit [21]. As other GOFI are derived using the chi-squared test, they also become robust to non-normality. Although SB chi-square values are not MLE-based, they may be comparable to the target values based on MLE [22].

The parsimony-adjusted GOFI considered in the present study is the root mean square error of approximation (RMSEA) with its associated "close" fit (Cfit) value at a 90% confidence interval. RMSEA values < 0.06 suggest good fit, values 0.08–0.10 suggest mediocre fit, while values > 0.10 point to poor fit; C-Fit values < 0.05 suggest acceptable fit [14]. Comparative fit GOFI applied in the present study were the comparative fit index (CFI) and the non-normed fit index (NNFI)–also known as the Tucker-Lewis index (TLI), CFI, and NNFI values ≥ 0.95 suggest good fit [21].

In addition to assessing overall model fit, we evaluated the fit of the three measurement models for each factor (Fig. 1). To do this, we examined the factor loadings, each factor loading should exceed 0.70 i.e., $0.71^2 = 0.50$ meaning that the latent variable explains at least 50% of the common variance in each item or indicator. As all scales were validated using RM prior to the SEM analysis, we expect that all factor loadings exceed 0.70 by a good margin [19, 20]. We also evaluated the SEM model using local fit indices, where insignificant residual matrix (R) elements (values exceeding 2.56) may indicate substantial specification and prediction error.

Results

As all DWLS-based *standardized* factor loadings exceed 0.78, we may conclude that all items are valid indicators for their respective latent factors i.e., the respective latent factor "governs the responses to the items" and can explain more than 0.78^2 or at least 60% of the variance in the responses to the items. Further, this means that less than 40% of the variance in any of our indicators is "unique variance", that is, "specific variance" caused by latent traits not included in our model or "error variance" caused by measurement error. All DWLS-based unique variances are smaller than 0.40. The smaller the uniqueness, the more of the variance that is common with the other items (communality).

The standardized residual matrix indicated that all but four elements had z-values smaller than − 2.56 or z-values larger than + 2.56, suggesting that there are small differences between the elements of the sample variance-covariance matrix $\boldsymbol{S}$ and the model implied variance-covariance matrix $\boldsymbol{\Sigma}$. This indicates that the specified SEM-model describes the patterns in the observed data quite well. One may reduce the size of these standardized residuals by defining "correlated error terms", that is, allowing items' specific variances to correlate (i.e., we state that items have

Table 1 Parameters estimated in the hypothesized model in Fig. 1

Observed variable	Model identification	Model estimation			
		Unstandardized solution		Completely standardized solution	
	Free parameter	ML	DWLS	ML	DWLS
Factor loadings		estimate (SE)	estimate (SE)	estimate	estimate
CNLE1	1	.98 (.02)	.95 (.02)	.85	.84
CNLE2		*1.000	*1.000	.87	.88
CNLE3	2	.94 (.02)	.91 (.02)	.82	.80
CNLE4	3	.93 (.02)	.92 (.02)	.80	.81
CNLE5	4	.92 (.02)	.92 (.02)	.80	.81
CNLENG1		*1.000	*1.000	.88	.88
CNLENG2	5	.99 (.04)	.98 (.04)	.87	.87
SEBH1	6	.92 (.01)	.93 (.02)	.85	.84
SEBH2		*1.000	*1.000	.92	.91
SEBH3	7	.99 (.01)	.99 (.01)	.91	.90
SEBH4	8	.95 (.02)	.97 (.02)	.87	.88
SEBH5	9	.83 (.02)	.86 (.02)	.76	.78
Unique variances (sum of specific variance and error variance)					
CNLE1	10	.28 (.04)	.30 (.06)	.28	.30
CNLE2	11	.25 (.04)	.23 (.06)	.25	.23
CNLE3	12	.33 (.04)	.36 (.06)	.33	.36
CNLE4	13	.36 (.04)	.34 (.06)	.36	.34
CNLE5	14	.37 (.04)	.35 (.06)	.37	.35
CNLENG1	15	.23 (.04)	.22 (.06)	.23	.22
CNLENG2	16	.24 (.05)	.25 (.06)	.24	.25
SEBH1	17	.28 (.03)	.29 (.06)	.28	.29
SEBH2	18	.16 (.03)	.17 (.06)	.16	.17
SEBH3	19	.17 (.03)	.19 (.06)	.17	.19
SEBH4	20	.25 (.03)	.23 (.06)	.25	.23
SEBH5	21	.42 (.04)	.39 (.06)	.42	.39
Latent factor associations (structural coefficients)					
SEBH-CNL-E	22	.52 (.03)	.53 (.03)	.54	.55
SEBH-CNLENG	23	.31 (.03)	.31 (.03)	.32	.32
CNL-E-CNLENG	24	.29 (.04)	.28 (.04)	.28	.28
Prediction residual of latent dependent factors					
CNL-E	25	53 (.03)	.54 (.03)	.70	.70
CNLENG	26	.56 (.03)	.56 (.03)	.72	.72
Variance of latent independent variable					
SEBH	27	.84 (.02)	.83 (.02)	1.000	1.000

DWLS = diagonally weighted least squares, *ML* = robust maximum likelihood estimation

*The factor loading of the variable is fixed to 1 on the independent latent variable. All other observed variables for that latent variable are interpreted in relation to the unit of measurement for this *reference variable*

"common variance" that refer to factors or constructs not being part of our model). However, such post hoc model modifications may be sample-dependent due to some bias in the specific sample.

Evaluating the DWLS-based standardized structural coefficients, we found that SEBH acts as a substantial "predictor" of students' CNL-E (standardized total effect = standardized direct effect = .552) and of students' CNLEng (standardized total effect = standardized direct effect + standardized indirect effect = .319 + (.552 × .281) = .319 + .155 = .475). Table 2 reports the GOFI for the models depicted in Figs. 1 and 2 based on ML estimation.

An inspection of the GOFI between models depicted in Figs. 1 and 2 shows that the model arising from specification

Table 2 Model evaluation by goodness-of-fit (GOF) indexes based on ML estimation

Model	Absolute GOF			Parsimony-adjusted GOF		Incremental GOF	
	SB-scaled χ^2	Reduced chi-square χ^2/df	SRMR	RMSEA (90% CI)	Cfit	CFI	NNFI
Model in Fig. 1 (df = 51, N = 1453)	164.543 $\boldsymbol{p = 0.000}$	**3.226**	0.025	0.067 (**0.061;** 0.073)	**0.000**	0.991	0.989
Model in Fig. 2 (df = 51, N = 1453)	158.765 $\boldsymbol{p = 0.000}$	**3.113**	0.027	0.065 (0.059; 0.071)	**0.000**	0.977	0.970
Target value	$p > .05$	< 3	< .05	< .06 (< .05; < .08)	> .05	> .95	> .95

SRMR = standardized root mean square residual, *Cfit* = closeness of fit, *CFI* = comparative fit index, *NNFI* = non-normed fit index, df = degrees of freedom, *N* = effective sample size, defined as the number of cases with responses on all 12 items/indicators

Model-fit values in bold deviate from the target values in the literature

in which the latent variables were associated based on theory (in Fig. 2) had better fit than the model in which the latent variables were free to covary (Fig. 1). Therefore, I conclude that the specified SEM model depicted in Fig. 2 sufficiently describes the observed structure of the sample data.

Discussion of findings

Empirical findings supported the hypothesis that self-efficacy in the science subject ‘body and health’ (SEBH) was associated with the two aspects of critical nutrition literacy (CNLEng, CNL-E). This significant positive association is similar to findings from a study conducted on young adolescents in Norway in which students that expected to perform well on the science test reported higher levels of engagement in dietary behaviours than their counterparts [8].

Similarly, consumer research shows that for individuals who are concerned about their health, the extent to which they engage in actions that promote their health depends on their ‘nutrition self-efficacy’ [14]. ‘Nutrition self-efficacy’ refers to a person’s belief in his or her ability to overcome the barriers that are associated with healthy eating and is often associated with healthy dietary behaviour [14].

The extent to which young adolescents undertake positive dietary behaviours depends on their perceptions of competency to accomplish the task (self-efficacy) and understanding of the information relating to the task. Similarly, Mai and Hoffmann [14] suggest that self-efficacy which influences the extent of elaboration in information processing, determines food decision strategies. While there is no obvious directional association, findings in the present study support this notion, as shown by the stronger relationship between self-efficacy in ‘Body and Health’ (SEBH) and critical ‘evaluation of nutrition information’ (CNL-E) in comparison to that between SEBH and CNLEng, and CNL-E and CNLEng. It is for this reason that studies exploring the level of engagement in positive practices, such as using nutrition labels during shopping, suggest a two-tiered approach to increasing adolescents’ use of nutrition labels: through enhancing adolescents’ confidence in understanding nutrition labels and simplifying the information on the nutrition labels [23, 24].

Compared to self-efficacy, there are fewer instruments for measuring CNL; the present study showed that health-related self-efficacy in a science subject topic is related to CNL. Thus, in the absence of instruments specifically measuring CNL, it may be possible to use existing measures of self-efficacy during screening to forecast the adolescents’ possible outcomes of nutrition interventions and improve the efficacy of nutrition interventions targeting adolescents.

Findings from the present study suggest that the extent to which adolescents are engaged in participating in dietary-related practices (CNLEng) may influence their food consumption decisions such as the use of available information and knowledge for the development of the skills required to execute positive dietary practices. This result finds support in a previous study in which children that closely participated in practical food preparation reported an increase in the consumption of vegetables, an example of positive dietary practice [23].

Whereas the present study showed a significant direct effect of SEBH on the two aspects of CNL, this result differs from previous studies in which engagement in household food tasks contributed to increased self-efficacy [23]. They argue that perceived self-efficacy is greater when individuals have practical experience with the necessary skills for completion. This exhibits the interconnected nature of psychosocial attributes and the skills associated with the critical domain of nutrition literacy, a notion that is consistent with Nutbeam’s description of the skills associated with the critical level of health literacy namely higher-level cognitive and interactive social skills [5]. Therefore, when planning for and evaluating the outcome of health or nutrition programs, it will be beneficial to consider psychosocial attributes such as self-efficacy in related disciplines. In addition, developing nutrition-related science topics such as ‘body and health’ could benefit from taking into consideration how students understand the information therein, and what this could mean for their application of this knowledge in their daily life.

Conclusion

Evidence presented in this paper highlights the need to incorporate self-efficacy interventions in nutrition-related interventions targeting adolescents.

Implications and contributions

This study gives insight into the relations of psychosocial attributes (self-efficacy) and critical nutrition literacy in adolescents. These findings are particularly important for informing policy makers on how to develop tailored and targeted nutrition information, for adolescents' health and nutrition-related curricula and interventions addressing critical nutrition literacy needs of adolescents within the larger scope of media use and educational settings.

Abbreviations CNL-E: Critical Evaluation of Nutrition information; CNLEng: Engagement in dietary behaviour; DWLS: Diagonally weighted least squares; GOFI: Goodness-Of-Fit Indexes; CTT : Classical test theory; CNL: Critical nutrition literacy; DV: Distinct values; FP: Free parameters; FNL: Functional nutrition literacy; HL: Health literacy; INL: Interactive nutrition literacy; ML: Maximum likelihood; NNFI: Non-normed fit index; NL: Nutrition literacy; RM: Rasch modelling; RMSEA: Root mean square error of approximation; SB: Satorra-Bentler; SEBH: Self-efficacy in 'body and health'; SEM: Structural equation modelling; TLI: Tucker-Lewis Index

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Authors' contributions Desire Alice Naigaga conducted the statistical analysis and drafted the manuscript. Kjell Sverre Pettersen offered guidance on the contents of the manuscript and read through the manuscript. Sigrun Henjum read through and contributed towards the manuscript. Kjell Sverre Pettersen developed the items that were included in the scales applied in the study. Øystein Guttersrud participated in the collection of data, statistical analysis, and drafting of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials The data supporting the findings of this study is available from the Norwegian Directory for Education but restrictions apply to the availability of this data, and so are not publicly available. Data is however available from the authors upon reasonable request and with permission from the Norwegian Directory for Education.

Code availability Not applicable

Declarations

Ethics approval This study was approved by the Norwegian Centre for Research (NSD).

Consent to participate All data were anonymized by assigning code values for the name of the school and respondent. The students were also informed that the data provided could be used for further research.

Consent for publication: All authors have consented to the publication of the manuscript.

Competing interests All authors declare that they have no competing interests.

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